RED DOG MINE EXTENSION

AQQALUK PROJECT

FINAL SUPPLEMENTAL

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1

OCTOBER 2009

Cooperating Agencies:

US Army Corps of Engineers

NATIONAL PARK SERVICE

THE SEAL OF THE STATE OF ALASKA

NORTHWEST ARCTIC BOROUGH INCORPORATED JUNE 2, 1986

Maniilaq Association represents the cooperating agency interests and responsibilities of the Native communities of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak

PREPARED BY:

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

Reply To: OWW-135

September 24, 2009

To: Residents and Communities, Government Officials, Public Officials, and Groups Interested in the Red Dog Mine Extension Aqqaluk Project Supplemental Environmental Impact Statement (SEIS)

From: Patty McGrath, Red Dog Mine SEIS Project Manager
U.S. Environmental Protection Agency, Region 10

RE: Red Dog Mine Extension Aqqaluk Project Final SEIS

Please find enclosed the U.S. Environmental Protection Agency's (EPA) Final Supplemental Environmental Impact Statement (FSEIS) for the Red Dog Mine Extension Aqqaluk Project. This document is available for a 30-day review period, beginning October 9, 2009, with the announcement of the availability of the FSEIS in the Federal Register. EPA, the lead federal agency for the SEIS process, will not issue our Record of Decision (ROD) or final National Pollutant Discharge Elimination System (NPDES) permit until after the 30-day period, which ends on **November 9, 2009**. Any input received will be considered by EPA in developing our ROD.

EPA has worked with the following cooperating agencies to develop the FSEIS: U.S. Army Corps of Engineers, National Park Service, State of Alaska Department of Natural Resources, Northwest Arctic Borough, and the tribal governments representing the Native communities of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak. The tribal governments authorized the Maniilaq Association to represent their cooperating agency interests.

During the 60-day comment period on the Draft SEIS (DSEIS), numerous comments were received in writing, via email, and orally at the public hearings. The comments and responses to comments are found in Appendix H of the FSEIS. As noted in the responses to comments in Appendix H, some of the comments resulted in changes between the DSEIS and FSEIS.

The public notice of an application for a Department of Army Clean Water Act Section 404 permit has been published by the U.S. Army Corps of Engineers. The public notice is included in Appendix A of the FSEIS. The public notice establishes a concurrent 30-day public review along with the FSEIS, and also ends on **November 9, 2009**. Comments on the 404 permit application will be accepted by the U.S. Army Corps of Engineers at the following address:

Department of the Army
U.S. Army Corps of Engineers
Regulatory Branch
P.O. Box 6898
Elmendorf Air Force Base, Alaska 99506-6898
Attention: Don Kuhle
Don.p.kuhle@poa02.usace.army.mil

Input on the FSEIS, and requests for copies of the FSEIS in executive summary, CD, and paper bound format, are to be mailed, e-mailed, or faxed to me at the following contact information:

Patty McGrath
Red Dog Mine SEIS Project Manager
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EPA greatly appreciates the input from the cooperating agencies in developing the DSEIS and FSEIS. We also appreciate the public interest in the SEIS and comments submitted on the DSEIS. Please feel free to contact me per the information above if you have questions.

Abstract

The Red Dog Mine is an open pit zinc and lead mine, located in northwestern Alaska on private land owned by the NANA Regional Corporation with some support facilities located on lands owned by the state of Alaska and U.S. Department of Interior. Teck Cominco Alaska Incorporated (Teck) has been mining and processing ore from the Red Dog Mine Main Deposit since 1989. An EIS developed under the National Environmental Policy Act (NEPA) by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of the Interior in 1984 evaluated the initial development of the mine. This final supplemental EIS (SEIS) supplements the 1984 EIS in evaluating the environmental effects associated with development of a new ore deposit (Aqqaluk Deposit) while considering the environmental effects of activities that have occurred since the 1984 EIS was finalized.

The Red Dog Mine currently consists of an open pit mine, a mill for processing ore, a tailings impoundment, waste rock storage areas, and support facilities. Processed ore (lead and zinc concentrates) is transported from the mine facilities via the 52-mile DeLong Mountain Regional Transportation System (DMTS) road to a port facility located on the Chukchi Sea.

The purpose and need for the federal actions covered by this SEIS is to act on permit applications and new information that Teck submitted to EPA under Clean Water Act (CWA) Section 402 and to the U.S. Army Corps of Engineers (Corps) under CWA Section 404. The purpose of the applications is to seek federal authorization for certain discharges and activities in connection with ongoing and future mining operations at the Red Dog Mine, including the Aqqaluk Deposit. The cooperating agencies participating in the SEIS process include the Corps, National Park Service, the State of Alaska, the Northwest Arctic Borough, and the tribal governments representing the Native communities of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak. The tribal governments authorized the Maniilaq Association to represent their cooperating agency interests and responsibilities.

Significant issues identified during scoping focused on concerns about: (1) water quality in Red Dog Creek and downstream; (2) the storage capacity and stability of the tailings impoundment; (3) mine-related fugitive dust contamination of resources resulting from the DMTS; and, (4) the mine's impact on subsistence resources.

The final SEIS evaluates the proposed action and three alternatives, including the no action alternative. The proposed action includes developing the Aqqaluk Deposit which would extend existing operations for another 20 years; the proposed action includes reissuing the NPDES permit for the Red Dog Mine with the inclusion of additional treatment of the discharge, during certain time periods, to meet water quality standards. The no action alternative would involve no reissuance of the NPDES permit or issuance of 404 permits and no extension of mining operations. Other action alternatives would address water quality, fugitive dust, and subsistence issues by employing a combination of pipelines to move wastewater and, under one alternative, concentrates from the mine to the port facilities. Temporary closure of the DMTS road and port during caribou and beluga migrations and use of additional truck washing are components of one of the alternatives.

Fugitive dust from mine operations, primarily concentrate haul truck traffic, has affected soils, vegetation, and wetlands along the DMTS. Existing operations have also affected subsistence resources including caribou, beluga, and berries for subsistence users in Kivalina.

Impacts to various resources would occur under all alternatives. The mine provides a large socioeconomic contribution to the region and closure under the no action would result in substantial financial losses for employees and the region. Alternatively, the continuance of operations under the other alternatives would provide economic benefit for an additional 20 years. Ongoing operations would extend effects on subsistence through mine closure although two alternatives include project components that would reduce these impacts.

Red Dog Mine Extension – Aqqaluk Project

Supplemental Environmental Impact Statement

Volume 1

***Submitted To*:**

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October 2009

Executive Summary

1.0 Purpose and Need For the Proposed Action

Background

The Red Dog Mine is an open pit zinc and lead mine, located in northwestern Alaska, approximately 46 miles inland from the coast of the Chukchi Sea, and 82 miles north of Kotzebue (see Figure ES-1). The mine is on private land owned by the NANA Regional Corporation (NANA), while some of the support facilities for the mine are located on both state and NANA lands. Teck Cominco Alaska Incorporated (Teck) operates the mine under a 1982 Operating Agreement with NANA, and has been mining and processing ore from the Red Dog Mine Main Deposit since 1989.

The U.S. Environmental Protection Agency (EPA) and the U.S. Department of the Interior developed an environmental impact statement (EIS) for the Red Dog Mine in 1984. The Red Dog Mine Main Deposit is expected to be depleted between 2011 and 2012. Teck proposes to begin mining the Aqqaluk Deposit, which is adjacent to the Main Deposit, by 2010, to ensure continuing operations through 2031. This Supplemental EIS (SEIS) supplements the 1984 EIS in evaluating the environmental effects associated with development of the Aqqaluk Deposit while considering the environmental effects of activities that have occurred since the 1984 EIS was finalized. The Red Dog Mine Extension Aqqaluk Project (Aqqaluk Project) encompasses the activities required to develop and mine the Aqqaluk Deposit.

The Red Dog Mine currently consists of an open pit mine, a mill for processing ore, a tailings impoundment, waste rock storage areas, and support facilities (see Figure ES-2). The processed ore (lead and zinc concentrates) is transported from the mine facilities via the 52-mile DeLong Mountain Regional Transportation System (DMTS) haul road to the DMTS port facility located on the Chukchi Sea. Lead and zinc concentrates are shipped to markets in North America, Europe, and Asia.

The cooperating agencies participating in the SEIS process include the U.S. Army Corps of Engineers (Corps), National Park Service (NPS), the state of Alaska (Department of Natural Resources [ADNR] as lead for the State), the Northwest Arctic Borough, and the tribal governments representing the Native communities of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak. The tribal governments authorized the Maniilaq Association to represent their cooperating agency interests and responsibilities.

Purpose and Need

The purpose and need for the federal actions covered by this SEIS is to act on permit applications and new information that Teck submitted to EPA under Clean Water Act (CWA) Section 402 and to the Corps under CWA Section 404, seeking federal authorization for certain discharges and activities in connection with ongoing and future mining operations at the Red Dog Mine.

Decisions to Be Made

EPA will make a decision on Teck's application to reissue the CWA Section 402 National Pollutant Discharge Elimination System (NPDES) permit for the Red Dog Mine. EPA's decision will be documented in a Record of Decision (ROD), which will include the reasons for the decision based on the analysis presented in this SEIS. The Corps needs to make decisions to issue or deny 404 permits for placement of fill material in jurisdictional wetlands associated with mining the Aqqaluk Deposit and increasing the height of the tailings impoundment to hold additional tailings and wastewater from the Aqqaluk Deposit.

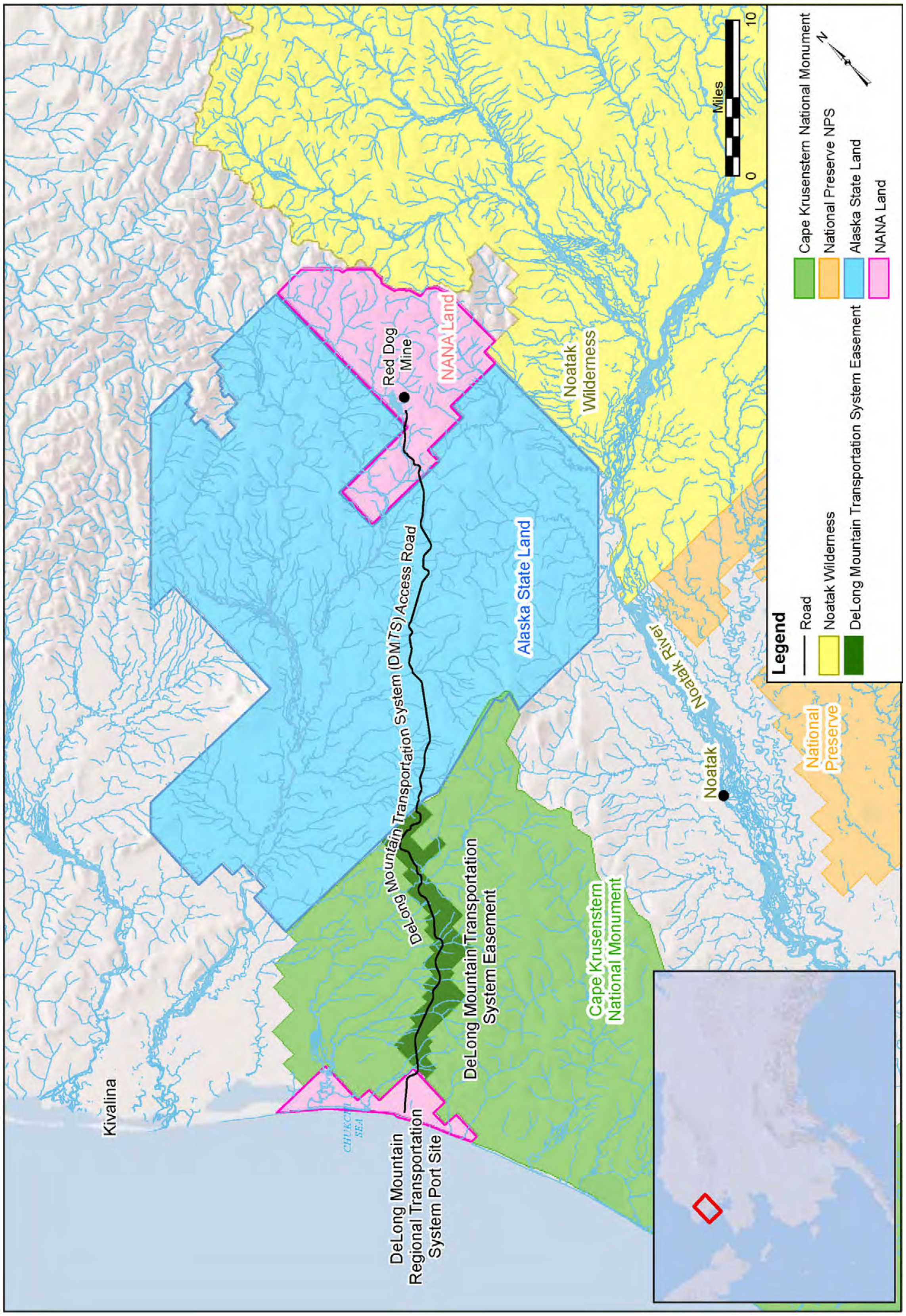

Figure ES.1 General Project Area

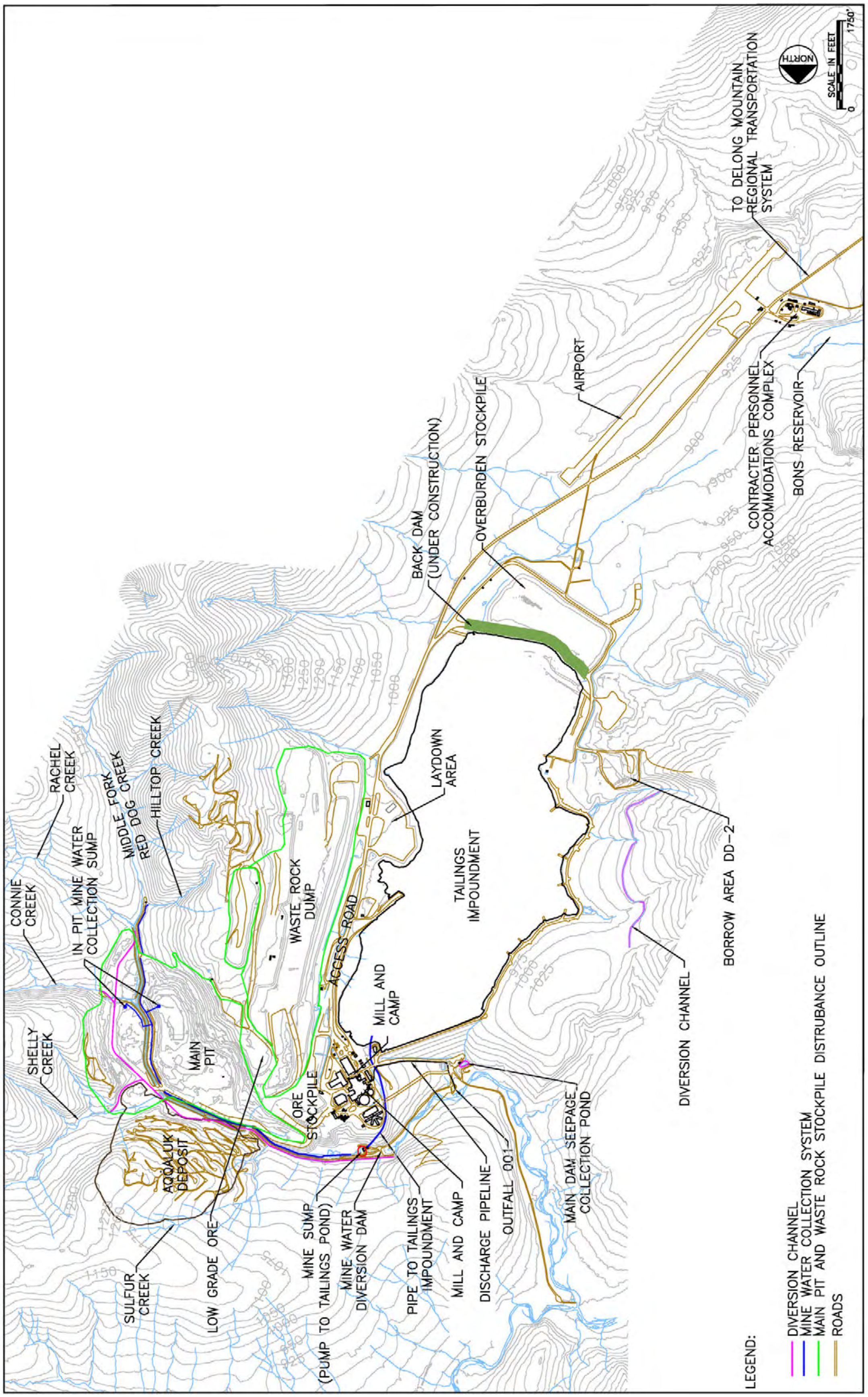

Figure ES.2 Existing Facilities and Aqqaluk Deposit

Scoping and Public Involvement

The Notice of Intent (NOI) to prepare the SEIS for the Red Dog Mine Aqqaluk Project was published in the *Federal Register* on August 31, 2007. The publication of the NOI initiated the scoping process and a public review and comment period required under NEPA at 40 CFR Part 1501.7. Scoping is a process intended to assist EPA and the cooperating agencies in identifying areas and issues of concern associated with the proposed Aqqaluk Project, and is designed to ensure that all significant issues are fully addressed during the course of the SEIS process. Scoping meetings were held on October 2 through October 5, 2007, in Anchorage, Kotzebue, Noatak, and Kivalina. Throughout the scoping process, EPA collected comments from the public; local, state, and federal agencies; non-governmental organizations; professional and trade organizations; and native corporations and tribal organizations. The formal scoping period ended on October 15, 2007.

EPA published a notice of availability for the Red Dog Mine Extension Aqqaluk Project Draft SEIS on December 5, 2008 and simultaneously delivered the draft SEIS to parties that had expressed interest in receiving a copy. Post cards were also mailed to all parties who had expressed interest in the project or submitted scoping comments, and all post office box holders in Noatak and Kivalina. The post card noted that the draft SEIS was available for viewing on the project website and offered paper or digital versions on request. EPA and the cooperating agencies hosted public meetings to solicit comments on the draft SEIS in Kivalina on January 12, 2009, Noatak on January 13, 2009, Kotzebue on January 14, 2009 and Anchorage on January 15, 2009. Public comments and EPA’s responses are presented in Appendix H. As noted in the comment responses, some comments resulted in changes to the text in the final SEIS although EPA does not consider any of the changes substantive.

Significant Issues

The following significant issues of public concern were identified by EPA for developing this SEIS.

Issue 1: Discharges from the mine during operations and after closure can affect water quality downstream in Red Dog Creek, Ikalukrok Creek, and the Wulik River. These effects could cause adverse impacts on aquatic life and the drinking water supply for the village of Kivalina.

Issue 2: The water management system must have adequate storage capacity during operations and closure under all climatic conditions, including potential long-term changes in permafrost. Water storage requirements could have impacts on geotechnical stability of the main tailings dam and ground and surface water resources.

Issue 3: Metals have been carried in dust from the Red Dog Mine, DMTS, and the port onto adjacent lands, including property within the Cape Krusenstern National Monument. These metals have the potential to affect vegetation, wildlife, water quality (i.e., aquatic habitat), fish, and people.

Issue 4: Mining operations may be affecting subsistence users in the Northwest Arctic Borough, who have expressed concerns about the availability and quality of subsistence resources (such as caribou, fish, beluga, waterfowl, seal, walrus, bowhead whale, and berries).

2.0 Alternatives

Significant issues derived from the scoping process shaped the content of the alternatives and the comparison among the Applicant’s proposed action, no action alternative, and other “action” alternatives. Each alternative is made up of a number of components related to wastewater management, closure, concentrate transport, etc.

The issues drove the development of individual components in a number of ways. Wastewater management components, including a pipeline to the Chukchi Sea, are considered because of concerns with the quality of the effluent being discharged into Red Dog Creek and concerns with the tailing impoundment water balance. Long-term stability of engineered structures and water quality issues led to the inclusion of different closure options. Concerns about the effect of the operation on subsistence resources and contamination of areas surrounding the DMTS resulted in a consideration of changes in operations during caribou and beluga whale migrations as well as the use of a pipeline (in lieu of haul trucks along the DMTS road) to transport slurried concentrate. The use of a concentrate pipeline and truck washes are also included as alternative components to address concerns about fugitive dust.

Alternative A – No Action Alternative

The no action alternative represents no reissued NPDES permit for the Red Dog Mine and no new Section 404 permits associated with development of the Aqqaluk Project. The no action alternative includes continued mining in the Main Pit until the projected closure date of 2012 but does not include development of the Aqqaluk Project. The facility would continue to operate under the 1998 NPDES permit. In order to meet the total dissolved solids (TDS) wastewater discharge limitations in the 1998 permit, the wastewater treatment system would need to be modified to include pre-treatment followed by reverse osmosis. The discharge would continue to be to Red Dog Creek. The site would be reclaimed beginning in 2012 and the closure plan put in place.

At mine closure, a shallow (two-foot) layer of water would be maintained over the tailings. Seepage from the waste rock dump and tailings impoundment would be pumped to the Main Pit. Water in both the Main Pit and tailings impoundment would be treated and discharged to Red Dog Creek. Wastewater treatment processes would need to continue in perpetuity with discharges of approximately 1.5 billion gallons annually to Red Dog Creek, similar to the existing discharge volume.

Alternative B – Applicant’s Proposed Action

The proposed action alternative includes reissuing the Red Dog Mine NPDES permit and issuing a Section 404 permit for fill placement associated with development of the Aqqaluk Project. Stripping of waste material overlying the Aqqaluk Deposit would begin in 2010. Mining operations in the Main Pit would be completed while developing the initial stages of the Aqqaluk Deposit. After the Main Deposit was mined out, waste rock removed from the Aqqaluk Deposit would be placed in the Main Pit. Ore from the Aqqaluk Deposit would be processed in the existing mill and tailings would be disposed in the existing impoundment. The height of the tailings impoundment would be raised 16 feet to accommodate the additional tailings. Wastewater from the tailings impoundment would be treated via the existing high density sludge process to reduce metals concentrations with additional treatment (e.g., barium hydroxide precipitation), as necessary, to reduce TDS levels in the discharge. The wastewater discharge location would remain in Red Dog Creek. All other activities would continue to occur consistent with current operations for the life of the operation with final closure occurring in 2031.

At mine closure, the tailings impoundment would be managed to keep a shallow layer of water over the tailings. Seepage from mine facilities including waste rock dump and tailings impoundment would be pumped to the Aqqaluk Pit and water in both the Aqqaluk Pit and tailings impoundment would be treated and discharged to Red Dog Creek. Wastewater treatment processes would need to continue in perpetuity.

Alternative C – Concentrate and Wastewater Pipelines

Under Alternative C, mining operations would be the same as Alternative B. However, instead of using haul trucks, zinc and lead concentrates would be transported from the mill to the port through a 52-mile slurry pipeline. Filter presses at the port would separate the concentrate from wastewater. The concentrates would continue to be stored at the port site. Concentrate wastewater would be treated via lime precipitation to reduce metals concentrations. Wastewater from the tailings impoundment water treatment facility would also be transported to the port site via a pipeline. The treated concentrate and tailings wastewaters would be combined at the port site and discharged to the Chukchi Sea. Alternative C also includes a third pipeline to carry diesel fuel from the port to the mine. All pipelines would be buried in a berm built adjacent to the DMTS.

The filter plant and diesel pump would require approximately three megawatts of additional power. While additional generators would need to be installed, the increased energy demand would be supplemented with installation of a 100 kilowatt (kW) wind turbine.

The closure scenario is different from Alternative B and is designed to minimize long-term wastewater treatment needs. Closure would include regrading the waste rock dump to a 5:1 slope with excess material moved back into the Aqqaluk Pit beginning in 2031. A synthetic liner would be installed over the dump to minimize long-term seepage. Water remaining over the tailings would be drawn down and a dry cover, including a synthetic liner, would be placed over the tailings. All pipelines would be removed, at closure, including the wastewater discharge to the Chukchi Sea. Wastewater would still be generated after closure that would be treated in perpetuity and discharged into Red Dog Creek.

Alternative D – Wastewater Pipeline and Additional Measures

Alternative D would include some components from alternatives B and C. Alternative D includes one pipeline; a wastewater pipeline that would transport treated wastewater from the tailings impoundment to the Chukchi Sea (instead of Red Dog Creek). Haul trucks would carry concentrates from the mine to the port, per current operations, although year-round vehicle washes would be added at each end of the road to reduce fugitive dust. To address subsistence concerns, the DMTS road would be closed in the fall during the caribou migration and the port site would be opened in summer after the June migration of beluga whales.

Reclamation and closure of the mine facilities would be the same as described in Alternative B. However, rather than discharging treated wastewater to Red Dog Creek, as would occur under Alternative B, the wastewater pipeline and discharge to the Chukchi Sea under Alternative D would remain for as long as the need for water treatment remained.

Environmentally Preferable and Preferred Alternatives

NEPA requires the lead federal agency to identify both an Environmentally Preferable Alternative and a Preferred Alternative. Based on the results of the SEIS impact analysis, EPA identified the Environmentally Preferable Alternative as Alternative C, except for the mine closure component. Under Alternative C, the concentrate pipeline would eliminate concentrate truck traffic on the DMTS and, therefore, reduce fugitive dust emissions and future effects on soils, vegetation, and wetlands along the DMTS. Elimination of concentrate truck traffic could also reduce effects on caribou movement and Kivalina’s subsistence harvest of caribou. It would also reduce the potential for caribou mortality as well as risk to ptarmigan and small mammals. Moving the wastewater discharge from Red Dog Creek to the Chukchi Sea will allow Teck to discharge more wastewater and better maintain the site-wide water balance. EPA has determined that the environmental benefits associated with Alternative C outweigh the impacts on wetlands from construction of the pipeline bench and the potential affects on aquatic life in Main Stem Red Dog Creek associated with loss of the dilution provided by the treated discharge. Although aquatic life would be impacted in Red Dog Creek, impacts are not expected to occur downstream in Ikalukrok Creek or the Wulik River.

The determination of the Preferred Alternative takes into account other factors beyond environmental impacts, including an agency’s statutory mission and responsibilities. In this case, EPA’s responsibility is to approve or deny Teck’s application for reissuance of its NPDES permit for the discharge to Red Dog Creek. EPA has determined that Teck can meet the draft NPDES permit limits under Alternative B for the Red Dog Creek outfall, therefore Alternative B is EPA’s Preferred Alternative. EPA does not have the authority to require construction of the concentrate or wastewater pipelines include in Alternative C.

A number of mitigation and monitoring measures were identified in the SEIS analysis. These measures and a summary of whether/how they can be implemented by EPA and the cooperating agencies is included in Chapter 2 of the SEIS.

3.0 Affected Environment and Environmental Consequences

Chapter 3 of the Draft SEIS describes the pre-mining environment, current (baseline) condition, and environmental consequences for each resource considered in the analysis. The description of the pre-mining environment generally summarizes information presented in the 1984 EIS. Since the mine has been in operations for 20 years, the baseline conditions include impacts that have occurred as a result of existing operations in comparison to the effects that were projected in the 1984 EIS. The environmental consequences sections consider the future impacts that would occur for each of the alternatives based on current conditions. A summary of the environmental effects for each resource area predicted for the proposed action and alternatives is presented in Table ES-1.

Table ES-1 Summary of Potential Impacts of Each Alternative by Resource

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Air quality	Stack and fugitive emissions	Higher stack emissions due to 10MW generator for reverse osmosis system; will continue to be required after closure. Duration of fugitive emissions minimized after end of mining in 2011.	Stack emissions comply with all Federal and State air quality standards. Fugitive dust emissions along DMTS road continue at current levels through 2031, unless controls implemented through the draft fugitive dust risk management plan. Elevated metals levels in soils extend >50 miles.	Same stack emissions as Alternative B. Fugitive dust emissions associated with DMTS road traffic largely eliminated by pipeline construction. Additional fugitive dust emissions associated with the dry cover over the tailings impoundment and cover material stockpiles	Same stack emissions as Alternative B. Fugitive dust emissions associated with DMTS road greater than Alternative C but less than Alternative B.
Geochemistry	Acid rock drainage and metal loadings	Acid drainage will continue during operations. After closure, wet cover over tailings should minimize acid generation potential and could lead to reduced wastewater treatment requirements over long term.	Same as Alternative A for acid generation potential although a larger volume of source material. Metals loadings from fugitive dust emissions continue through 2031 with increased metals concentrations in downwind soils and plants.	Dry closure of waste rock and tailings impoundment would reduce flow volumes requiring treatment but acid generation expected over long term. Metals loadings to soils and plants from fugitive dust emissions along DMTS road greatly reduced.	Same as Alternative A for acid generation. Metals loadings from fugitive dust emissions along DMTS road reduced more than Alternative B, but less than alternatives A and C.
Geotechnical stability	Probability of failure	Risk of failure of tailings dam low. However, long-term concerns due to the level of the phreatic surface and dam design below proposed safety factor. ADNR will implement mitigation measures during final dam design to remedy concerns and ensure long-term stability. Stability of waste rock pile also ensured through permitting and ongoing oversight by ADNR.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Water Resources – Surface Water	Stream flow	No changes from current conditions.	Stream flow in Red Dog Creek may be slightly greater than current conditions since additional wastewater can be discharged during times when barium hydroxide is used to lower TDS in the effluent and increase discharge rates.	Changing to marine discharge reduces stream flow in Main Stem Red Dog Creek by 18 to 38 percent during operations. In Ikalukrok Creek average flows would be reduced by less than 5 percent below the confluence with Red Dog Creek.	Same as Alternative C except stream flow reductions continue after closure.
	Water Quality	TDS levels in Main Stem Red Dog Creek reduced to below 170 mg/L. Lower TDS levels in Ikalukrok Creek. No change at Kivalina water supply intake; meets drinking water standards. For metals and cyanide; no change from current conditions.	No change from current conditions for metals, cyanide, and TDS Kivalina water supply intake meets drinking water standards. For DMTS streams, no water quality impacts identified, although additional monitoring is warranted.	Change to marine discharge during operations will decrease TDS concentrations to below water quality standard levels in Red Dog Creek. Lower TDS levels in Ikalukrok Creek. No detectable change in metals or TDS concentrations at Kivalina's water supply. Metals levels in Main Stem Red Dog Creek, which are already above aquatic life standards, will increase, although levels will be lower than pre-mining conditions. Small (less than 10 feet) marine mixing zone around the Chukchi Sea discharge. After closure, same as Alternative B. Reduced risk of metal loadings to DMTS streams from dust as compared to other alternatives.	Same as Alternative C during operations; effects continue after closure. Risk of metals loadings from dust along DMTS lower than Alternative B but higher than Alternative C.
	Spills	Spill risk associated with vehicle transport greater than Alternative C but lower than alternatives B and D considering the shorter duration of operations.	Similar to Alternative A, except longer duration of risk.	Lower risk of a truck transport related spill with pipeline. However, a pipeline rupture could have impacts, depending upon location and duration.	Similar to Alternative B.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
	Water Management	Reverse osmosis treatment system needed until closure and in perpetuity to meet TDS limits. At closure, tailings impoundment and Main Pit used for water management. Water discharge would continue in perpetuity.	Continued use of existing water management and treatment systems with addition of enhanced treatment (barium precipitation) to reduce TDS levels and maintain water balance, as needed. Wet closure involves water management in the Aqqaluk Pit and tailings impoundment. Water quality in tailings impoundment expected to improve over the long term although perpetual treatment and discharge still expected.	Continued use of existing water management system and treatment of tailings impoundment wastewater, except the wastewater would be piped to the port site, combined with treated concentrate wastewater and discharged to the Chukchi Sea. A new treatment plant would be built at the port site for treatment of concentrate wastewater. After dry closure of the tailings impoundment, the wastewater pipeline would be removed with contaminated water managed in the Aqqaluk Pit. Reduced volume of water (compared to other alternatives) would require treatment in perpetuity.	Same as Alternative C during operations with pipeline to ocean; pipeline maintained after closure. Closure plan for impoundment, pits and waste rock stockpiles same as Alternative B.
Water Resources -Groundwater	Groundwater hydrology and quality	Limited and localized impacts on ground water, including loss of permafrost. Pit lake created in Main Pit.	Similar to Alternative A, except Main Pit backfilled and pit lake forms in Aqqaluk Pit.	Same as Alternative B, although permafrost could be restored more quickly under tailings impoundment (with dry closure).	Same as Alternative B.
Vegetation	Acres of Disturbance	28 acres of new disturbance associated with the expansion of the waste rock dump and roads/ditches. Reclamation begins in 2011, including revegetation where practicable.	406.5 acres of new disturbance associated with developing Aqqaluk Deposit including tailings impoundment expansion and new roads/ditches. Closure in 2031, although ongoing reclamation of main waste rock dump when backfilling begins.	Similar to Alternative B with 145 acres of additional disturbance associated with pipeline bench, reclaimed after closure. Stockpiles for the tailings impoundment cover material would affect 80 acres until reclamation was completed.	Similar to Alternative C, except for pipeline bench remains after closure. No additional stockpiles would be required for reclamation.
	Dust impacts	Fugitive dust emissions and vegetation impacts, primarily to mosses and lichens, would continue at current levels through 2011.	At mine site, additional dust impacts (changes in species composition/cover) from Aqqaluk Pit development. Along DMTS	Same as Alternative B at mine site. Along DMTS road, fugitive emissions greatly reduced by concentrate pipeline. Future metals loadings lowered but	Similar to Alternative B except some reductions in fugitive emissions and metal loadings along DMTS road resulting from truck washes.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
			road, emissions and effects continue through 2031.	effects on previously impacted vegetation uncertain.	
Wetlands	Acres and Types Disturbed	No impacts beyond currently permitted levels.	Additional 144.9 acres disturbed at mine site. No additional impacts along DMTS road. Loss of function and value minor at regional level.	Same as Alternative B at mine site. 125.5 acres of additional wetlands disturbed by pipeline bench – function may already be affected by fugitive dust. Some level of function would be recovered after closure.	Same as Alternative B at mine site. Same as Alternative C along DMTS road except pipeline bench remains after closure.
Wildlife	Impacts	No impacts beyond current levels, some risk from dust emissions to ptarmigan and small mammals. Localized impacts on beluga whale movements and caribou migration.	Similar in magnitude to Alternative A except longer duration of operational impacts.	Lower risk to ptarmigan and small mammals from reduced dust emissions as compared to alternatives B and D. Reduced caribou mortality as compared to alternatives B and D due to elimination of truck traffic as well as less impact on caribou migration. Localized impacts to beluga due to port activities similar to Alternative B. No impacts to marine mammals from wastewater discharge.	Risk to ptarmigans and small mammals from fugitive dust emissions lower than Alternative B but higher than Alternative C. Impacts on caribou migration and beluga whale movement reduced by road closure and delayed port opening. Caribou migration impact lower than Alternative B, but not as low as Alternative C. Beluga movement impact lower then other action alternatives. No impacts to marine mammals from wastewater discharge.
Aquatic Resources	Freshwater	No change from current conditions. Lowered TDS levels in the discharge will not have an affect on aquatic life. Metals concentrations and arctic grayling spawning in Red Dog Creek are improved compared to pre-mining conditions. Based on current data, no change from current conditions in streams along DMTS road, although additional monitoring is	Same as Alternative A. The difference in TDS levels between alternatives would not result in effects on aquatic life downstream. Metals concentrations and arctic grayling spawning in Red Dog Creek are improved compared to pre-mining conditions. Based on current data, no change from current conditions in streams along DMTS road, although	Removal of discharge from Red Dog Creek would result in impacts to aquatic life during operations because of increased metal concentrations and reduced flow. Water quality will be better than pre-mining conditions but worse than current conditions (except for reduction in TDS levels). No changes in Ikalukrok Creek or Wulik River. No impacts on DMTS road observed in fish monitoring, but	Same as Alternative C except impacts to Red Dog Creek from the loss of dilution from the outfall would continue after closure. Impacts on aquatic life in DMTS streams similar to Alternative B although less risk of exposure to concentrate within fugitive dust.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
		warranted.	additional monitoring is warranted.	sporadic tissue concentrations above effects levels warrant future monitoring. Any future impacts due to truck traffic less under Alternative C than other alternatives.	
	Marine	No discharges from mining operations and no impacts beyond current conditions.	Same as Alternative A.	Short-term, adverse impacts on algae, invertebrates, and fish during pipeline construction and removal. Construction should be timed to avoid fish migration periods (through Corps' Section 10 permit). Because of limited mixing zone size (10 feet around outfall) and discharge would meet marine water quality standards at edge of mixing zone; no impacts from marine discharge.	Same as Alternative C.
Land Use and Recreation	Land Use	Site reclamation begins in 2011.	Site reclamation begins in 2031.	Similar to Alternative B.	Similar to Alternative B.
	Recreation	No direct impacts on recreational use because of limited access to site. Some visual impacts to hikers and recreationists flying over site on way to destinations.	Similar to Alternative A although development of the Aqqaluk Pit would result in additional disturbance.	Similar to Alternative B, although pipeline bench could slightly increase visual effects.	Similar to Alternative C.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Health	Public Health	Existing operations affect presence of caribou and beluga whale in vicinity of Kivalina with some reduction in harvest levels. Harvest change could affect diet and health; therefore, a diet survey is recommended. Adverse impacts related to employment and income could occur with mine closure in 2011. Some benefits from reduced impacts on subsistence, less employee separation, and potential for reduced spread of infectious disease. Effects of contaminant exposure are limited under all alternatives.	Allows for continued mining through 2031 and associated economic and employment benefits with more time to plan for eventual mine closure. Continued effects of dust emissions on some subsistence resources to users in Kivalina. Mine activities have similar effect on subsistence in Kivalina as under current conditions but extend through 2031.	Similar to Alternative B, except subsistence impacts are reduced by lower dust emissions and elimination of concentrate truck traffic (less displacement of caribou).	Similar to Alternative C, although less reduction in dust emissions, subsistence benefits associated with road closure during caribou migration and delayed port opening during whale movement.
	Industrial Health	Current accident rates and worker exposure would continue through 2011. Teck would continue to implement and refine, as necessary, its health and safety program to prevent exposure and monitor worker health.	Current accident rates and worker exposure would continue through 2031. Teck would continue to implement and refine, as necessary, its health and safety program to prevent exposure and monitor worker health.	Similar to Alternative B, except reduced exposure to the contaminants in dust from workers associated with concentrate transport (minor effect).	Similar to Alternative B.
Subsistence	Land Mammals	Mine has not caused effects on overall caribou migration patterns, but localized changes primarily from mine activities (including the DMTS road) have occurred and subsistence harvest has decreased. Such impacts should be greatly decreased after closure with traffic reductions. Effects mitigated by management practices to stop traffic when large-scale caribou herd movement has	Similar in magnitude to Alternative A, except operational impacts would continue through 2031.	Construction of the concentrate pipelines would substantially reduce truck traffic and thereby lessen impacts on caribou and subsistence harvest in terms of displacement.	Closure of the road during the caribou migration may lessen impacts (though not as much as Alternative C) on subsistence by reducing localized displacement of caribou.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
		right-of-way.			
	Marine Mammals	Localized displacement of beluga whales at port site could be contributing to reduced harvests by Kivalina residents. Impacts from port activity would be eliminated after closure in 2011.	Similar in magnitude to Alternative A except operational impacts continue through 2031.	Similar to Alternative B in terms of port site activity displacing beluga whales. Impacts from construction of the discharge pipeline outfall could be minimized by timing restrictions. Discharge should not affect marine mammals.	Impacts to whale movement and subsistence reduced by closing the port during the annual June beluga whale migration. Impacts related to construction of marine outfall is the same as Alternative C.
	Fugitive Dust	No actual risk identified but perceived contamination of berries leading to changes in use areas and reduced harvest from pre-mining conditions.	Same as Alternative A in magnitude except fugitive emissions continue through 2031.	Reduced fugitive emissions, since traffic would be eliminated due to concentrate pipeline, could lead to increase in berry harvest and less concern about dust contamination of other resources.	Less dust emissions than alternatives A and B, but more than Alternative C. Effects on subsistence uncertain.
Cultural Resources	Effects on historic properties	At mine site, up to 17 sites have been affected by existing activities or will be affected by additional operations through 2011. No sites identified along DMTS road. All effects mitigated by *Integrated Plan for the Management of Cultural Resources in the Red Mine Project Areas, 2006 (Integrated Plan)*.	Development of Aqqaluk Pit could impact 2 additional sites, direct and indirect effects mitigated by *Integrated Plan*.	Similar to Alternative B.	Similar to Alternative B.
Transportation	Traffic	Marine and DMTS road traffic continues at current levels through 2011.	Same traffic levels as Alternative A except operational impacts extend through 2031.	Traffic along DMTS road greatly reduced by concentrate pipeline (36 fewer round trips per day by concentrate trucks). Number of diesel fuel trucks also reduced. Traffic greatly reduced compared to alternatives B and C.	Same as Alternative B except reduced fugitive emissions from truck traffic. Also, although same number of trips, traffic frequency per month differs from Alternative B due to road closure during caribou

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Acronyms and Abbreviations

µg	microgram
AAAQS	Alaska Ambient Air Quality Standards
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADHSS	Alaska Department of Health and Social Services
ADNR	Alaska Department of Natural Resources
ADLWD	Alaska Department of Labor and Workforce Development
AIDEA	Alaska Industrial Development and Export Authority
Al	aluminum
ANILCA	Alaska National Interest Lands Conservation Act
ANCSA	Alaska Native Claim Settlement Act
AP	acid reducing potential
ATC	Alaska Technical Center
BEA	Bureau of Economic Analysis
BLL	blood lead level
BLM	Bureau of Land Management
BMP	best management practices
BTUs	British Thermal Units
Ca	calcium
Cd	cadmium
CD	Consent Decree
CEQ	Council on Environmental Quality
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
Co	cobalt
CO	carbon monoxide
Corps	U.S. Army Corps of Engineers
COS	carbonyl sulfide
CS_2	carbon disulfide
CSB	concentrate storage building
Cu	copper
CWA	Clean Water Act
dB	decibel
DMTS	DeLong Mountain Regional Transportation System

EA	environmental assessment
EAB	Environmental Appeals Board
EFH	essential fish habitat
EID	environmental information document
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plectoptera, and Tricoptera
ESA	Endangered Species Act
Fe	iron
FeS_2	pyrite
FONSI	Finding of No Significant Impact
FRP	Facility Response Plan
FY	fiscal year
GC	General Conservation (Zone District)
GMU	game management unit
H_2S	hydrogen sulfide
hp	horsepower
HQ	Hazard Quotient
Hz	hertz
IMPLAN	Impact Analysis for Planning
IRA	Indian Reorganization Act
ISCST3	Industrial Source Complex Short-Term (EPA's model)
kW	kilowatt
KIC	Kikiktagruk Inupiat Corporation
LOAEL	Lowest Observable Adverse Effects Level
LOEC	lowest observable effects concentrations
Mg	magnesium
mg/l	milligrams per liter
MGD	million gallons per day
Mn	manganese
MOU	Memorandum of Understanding
MW	megawatt
NAAQS	National Ambient Air Quality Standards
NANA	NANA Regional Corporation
NEPA	National Environmental Policy Act
Ni	nickel

NMFS	National Marine Fisheries Service
NNP	net neutralizing potential
NO2	nitrogen dioxide
NOAEL	No Observable Adverse Effects Level
NOEC	no observable effects concentration
NOI	Notice of Intent
NOx	nitrogen oxide
NP	neutralization potential
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NPS	National Park Service
NWAB	Northwest Arctic Borough
NWI	National Wetland Inventory
ºF	degrees Fahrenheit
Pa	Pascal
PAC	personnel accommodations complex
Pb	lead
PbS	Galena (lead sulfide)
PFD	Permanent Fund Dividend
PILT	Payments in Lieu of Taxes
PM10	particulate matter with diameter less than 10 microns in size
PM2.5	particulate matter with diameter less than 2.5 microns in size
ppm	parts per million
PSD	Prevention of Significant Deterioration
RD	Resource Development (Zone District)
ROD	Record of Decision
SC	Subsistence Conservation (Zone District)
SEIS	Supplemental Environmental Impact Statement
SMV	species mean value
SO2	sulfur dioxide
SPARRO	slurry precipitation and recycle reverse osmosis
SPCC	Spill Prevention, Containment, and Countermeasure Plan
TC	Transportation Corridor (Zone District)
TCAK	Teck Cominco Alaska Incorporated
TDS	total dissolved solids
TRV	toxicity reference value

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAH	Western Arctic Caribou Herd
WQS	water quality standards
Zn	zinc
ZnS	sphalerite

Chapter 1

Purpose and Need for the Proposed Action

CHAPTER 1 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Background

The Red Dog Mine is an open pit zinc and lead mine, located in northwestern Alaska, approximately 46 miles inland from the coast of the Chukchi Sea, and 82 miles north of Kotzebue (Figure 1.1). The mine is situated in the DeLong Mountains of the Western Brooks Range, near Middle Fork Red Dog Creek. The mine is on private land owned by the NANA Regional Corporation (NANA), while some of the support facilities for the mine are located on U.S. Department of the Interior National Park Service (NPS), State of Alaska, and NANA lands. Teck Alaska Incorporated (Teck) operates the mine under a 1982 Operating Agreement with NANA, and has been mining and processing ore from the Red Dog Mine Main Deposit since 1989.

The U.S. Environmental Protection Agency (EPA) and the U.S. Department of the Interior developed an environmental impact statement (EIS) for the Red Dog Mine in 1984. The Red Dog Mine Main Deposit is expected to be depleted between 2011 and 2012. Teck proposes to begin mining the Aqqaluk Deposit, which is adjacent to the Main Deposit, by 2010, to ensure continuing operations through 2031. This supplemental EIS (SEIS) supplements the 1984 EIS in evaluating the environmental effects associated with development of the Aqqaluk Deposit while considering the effects of activities that have occurred since the 1984 EIS was finalized. The Red Dog Mine Extension Aqqaluk Project (Aqqaluk Project) encompasses the activities required to develop and mine the Aqqaluk Deposit (Figure 1.2).

The Red Dog Mine currently consists of an open pit mine, a mill for processing ore, a tailings impoundment, waste rock storage areas, and support facilities. The processed ore is transported from the mine facilities via the 52-mile DeLong Mountain Regional Transportation System (DMTS) road to the DMTS port facility located on the Chukchi Sea. From the port facility, the ore concentrates are shipped to markets in North America, Europe, and Asia. The DMTS road and port facility are both owned by the Alaska Industrial Development and Export Authority (AIDEA). Congress granted to NANA, a 100-year easement through Cape Krusenstern National Monument to make land available for the DMTS to be sufficient to secure financing to construct, operate, maintain, and expand the transportation system by the State of Alaska and the AIDEA (Public law 99-96 of September 25, 1985 [Statute 460]).

Prior to mine development, in the early 1980s, Teck first submitted an application to EPA for a Clean Water Act (CWA) Section 402 National Pollutant Discharge Elimination System (NPDES) permit for the discharge of mining related wastewater to Middle Fork Red Dog Creek. The Red Dog Mine was considered a new source in accordance with CWA Section 306 and Title 40 of the Code of Federal Regulations (CFR), Section 122.2. EPA and the U.S. Department of Interior prepared an EIS on the potential environmental impacts of the proposed operation in compliance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality's and EPA's implementing regulations (43 U.S.C. § 4321, *et seq.*, 40 CFR §§ 1500–1508, and 40 CFR § 6). The final EIS was issued in 1984, and EPA issued the first NPDES permit in 1985.

The original NPDES permit expired in 1990, and was reissued with revisions on August 28, 1998. This permit was subsequently modified on July 17, 2003. The NPDES permit was again reissued on March 7, 2007. Prior to each permit reissuance and modification, EPA, in compliance with NEPA, prepared an environmental assessment (EA) that evaluated the potential impacts of the permit action, and each resulted in a Finding of No Significant Impact (FONSI). Following appeals of the 2003 and 2007 permit actions to EPA's Environmental Appeals Board, EPA withdrew the 2007 NPDES permit on September 27, 2007, to revise the NEPA analysis associated with that permit. As a result of the appeals, the permit

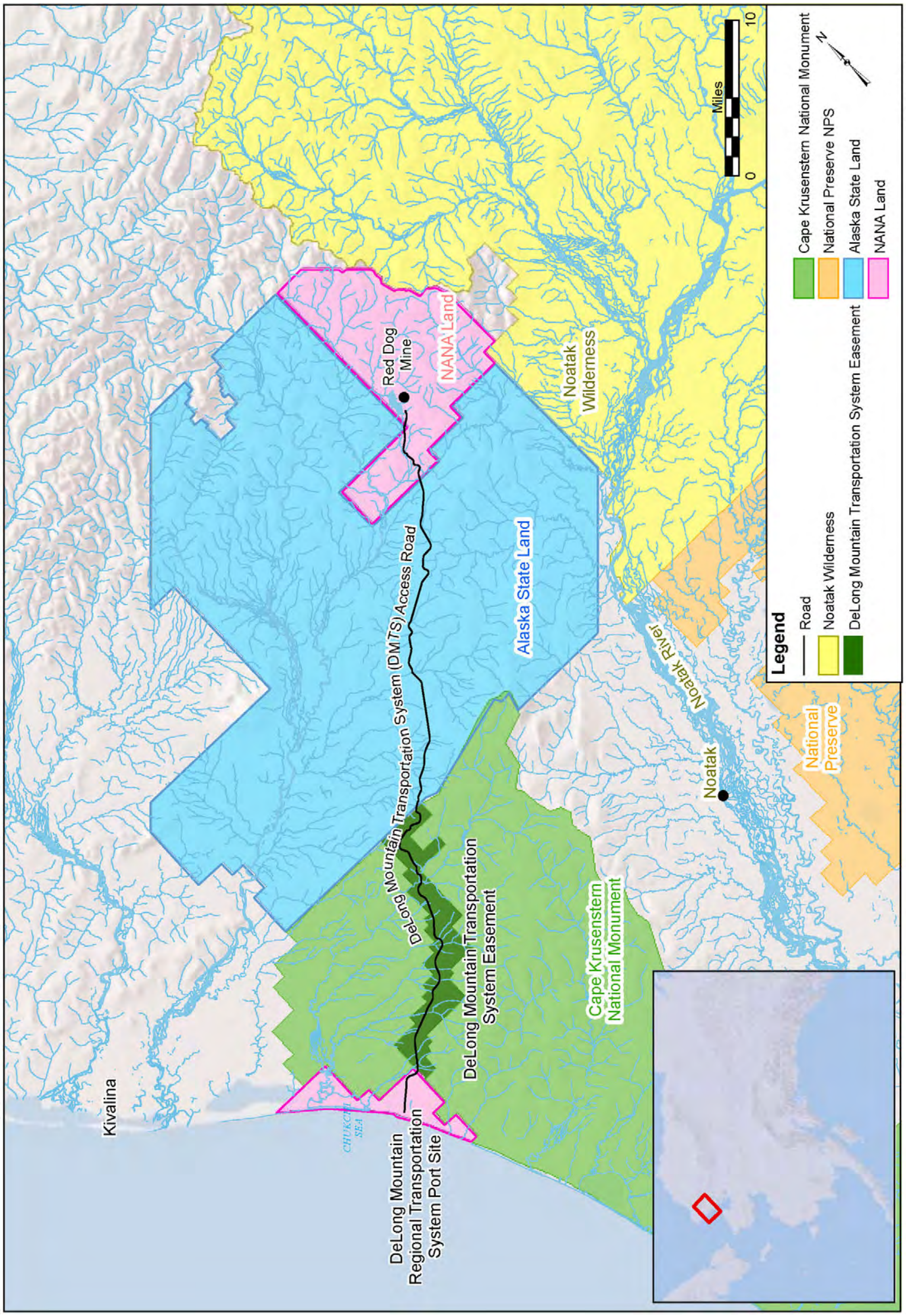


FIGURE 1.1

GENERAL PROJECT AREA

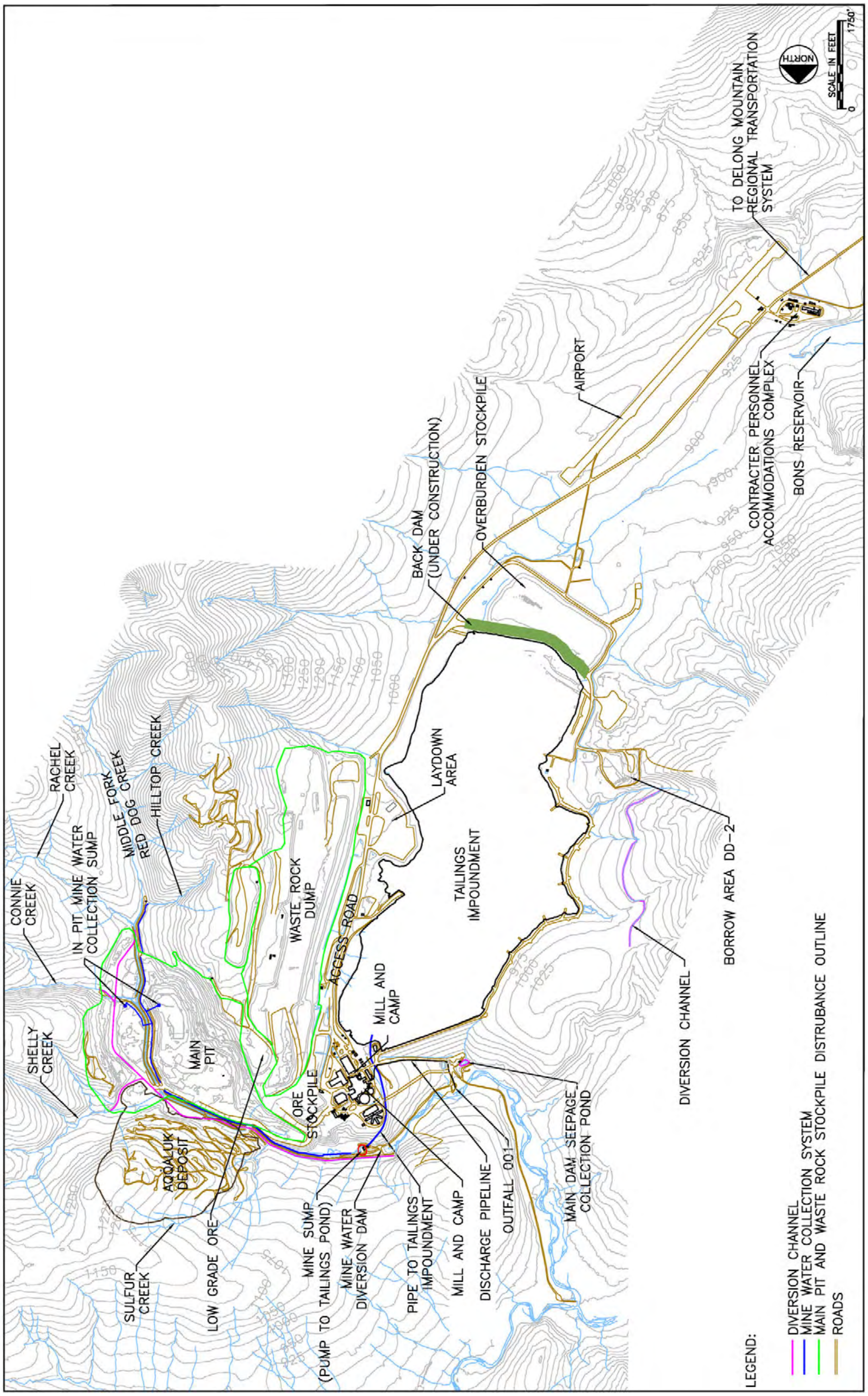


FIGURE 1.2
EXISTING FACILITIES AND AQQALUK DEPOSIT

actions did not take effect and Teck has in the meantime been discharging under the conditions of the 1998 NPDES permit, which has been administratively extended.

On April 16, 2007, Teck submitted an environmental information document (EID) to EPA, in support of a request to modify the NPDES permit for the Red Dog Mine to include the Aqqaluk Project. Teck submitted a formal modification request on May 4, 2007. On March 15, 2008, Teck withdrew the permit modification submissions and requested that EPA consider the Aqqaluk Project EID an addendum to Teck's earlier (February 23, 2003) permit reissuance application. EPA will make a decision on Teck's pending permit application for the Red Dog Mine, including the Aqqaluk Project.

In a letter dated April 18, 2008, Teck requested EPA approval for a plan to use barium hydroxide either alone or in conjunction with their existing water treatment system to reduce total dissolved solids (TDS) in the discharge. Teck proposed to use the barium hydroxide treatment for selected seasons or portions of discharge seasons as necessary to achieve discharge needs. EPA subsequently approved Teck's proposal to implement the barium hydroxide treatment process.

The proposed Aqqaluk Project (project) includes new impacts on wetland areas, and therefore would require modification of the facility's existing permit or issuance of new permits by the U.S. Army Corps of Engineers (Corps) under CWA Section 404. The existing Section 404 permit was originally issued in November 1985 and has been modified numerous times since. If the project would require work below the high tide line in the Chukchi Sea, the Corps would also need to issue a Rivers and Harbors Act Section 10 permit. The Corps is participating as a cooperating agency for this SEIS.

On May 17, 2007, EPA entered into a Memorandum of Understanding (MOU) with Teck that sets out the terms of cooperation between Teck and EPA in the development of this SEIS. The MOU sets forth the third-party arrangement whereby EPA directs the preparation of this Aqqaluk Project SEIS by a third-party contractor while the contractor fees are paid by Teck. EPA selected Tetra Tech as the third-party contractor.

In addition to the Corps, other cooperating agencies participating in the SEIS process include NPS, the State of Alaska (Department of Natural Resources [ADNR] as lead for the State), the Northwest Arctic Borough (NWAB), and the tribal governments representing the Native communities of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak. The tribal governments authorized the Maniilaq Association to represent their cooperating agency interests and responsibilities. An MOU outlining the roles and responsibilities of the lead and cooperating agencies was finalized in September 2007.

On October 23, 2008, Teck entered into a Consent Decree (CD) in Alaska District Court with individuals that had filed a CWA complaint against Teck for numerous violations of the Red Dog Mine NPDES permit. The CD settles the plaintiff's claims and requires, among other conditions, that Teck construct and operate a pipeline to carry Red Dog Mine effluent from the mine site through the DMTS corridor right-of-way to an outfall to be constructed in the Chukchi Sea at or near the DMTS port facility. The CD includes conditions whereby Teck may elect not to proceed with the pipeline. The schedule attached to the CD indicates that Teck will submit an NPDES application for the Chukchi Sea outfall after this SEIS is completed and the Red Dog Mine NPDES permit is reissued and in effect. Because Teck has not yet applied for the wastewater discharge pipeline and Chukchi Sea outfall, the wastewater discharge pipeline is not the proposed action in this SEIS. The wastewater pipeline is, however, evaluated as a component of two alternatives in this SEIS. Additional NEPA analysis of the pipeline may be needed in the future.

1.2 Purpose and Need

The purpose and need for the federal actions covered by this SEIS is to act on permit applications and new information (the EID) that Teck submitted under CWA sections 402 and 404. These applications seek federal authorization for certain discharges and activities in connection with ongoing and future mining operations at the Red Dog Mine. In acting on these applications, EPA and the Corps need to take into account new information about mining operations, including the proposed Aqqaluk Project, and its effects on the environment, which neither EPA nor the Corps had considered in prior actions.

As discussed in Section 1.1, the Red Dog Mine is defined as a new source by the NPDES regulations, and NPDES permit reissuance is subject to compliance with NEPA. EPA has determined that its permit decision is a major federal action with the potential to significantly affect the quality of the human environment. Therefore, EPA, as the lead federal agency, is preparing this SEIS to analyze the impacts of reissuing the NPDES permit for the Red Dog Mine, including development of the Aqqaluk Project, and reasonable alternatives. This SEIS supplements the 1984 EIS, and also evaluates new circumstances and information relevant to environmental concerns that have arisen since the 1984 EIS.

1.3 Decisions to Be Made

EPA will make a decision on Teck's application to reissue the NPDES permit for the Red Dog Mine. The currently effective permit was issued in 1998. In reissuing the permit, EPA will consider updated permit conditions based on new information and analysis about the mine's wastewater discharges and environmental effects, and also will determine whether the Aqqaluk Project warrants any new or different permit conditions. The 1998 permit and EA did not take into consideration development and mining of the Aqqaluk Deposit. The EPA Region 10 Administrator, or as delegated to the Director of EPA's Office of Water and Watersheds, is the responsible official for deciding whether to select the no action alternative, the proposed action, or another alternative for implementation. The Administrator's decision will be documented in a Record of Decision, which will include the reasons for the decision based on the analysis presented in this SEIS.

The Corps needs to make decisions to issue or deny Section 404 permits for placement of fill material in jurisdictional wetlands associated with mining the Aqqaluk Deposit and for increasing the height of the tailings impoundment dam to hold additional tailings and wastewater from processing the Aqqaluk ore. The Section 404 permit application to develop the Aqqaluk Pit has been submitted to the Corps. The permit to further raise the tailings dam would not be necessary until approximately 2016; therefore, an application for that action would be submitted at some point in the future. The Corps would need to make a decision to issue or deny a Rivers and Harbor Act Section 10 permit for any work or structures in or over navigable waters of the U.S. The Corps official with responsibility for making these decisions is the District Engineer. The District Engineer will decide whether to issue permits under Rivers and Harbors Act Section 10 and CWA Section 404. As a cooperating agency, the Corps participated in identification of alternatives and development of the SEIS. The Corps' decision whether to issue the 404 permit for fill deposition from the Aqqaluk Deposit will be based upon the analysis in the SEIS. The Corps may also use this SEIS for its future Section 404 permit decision for fill associated with increasing the tailings dam.

The no action alternative in this SEIS represents no NPDES permit reissuance, which means continuation of the administratively extended 1998 NPDES permit, and no new Section 404 permits associated with development of the Aqqaluk Deposit. Since the development of the Aqqaluk Project would require new Section 404 permits, and possibly changes to the NPDES permit as well, the impacts analysis for the no action alternative assumes no development of the Aqqaluk Project. The proposed action represents development of the Aqqaluk Project as proposed by Teck and reissuance of the Red Dog Mine NPDES permit and issuance of Section 404 permits for Aqqaluk Project related construction. Other alternatives consist of project modifications to address significant issues identified during SEIS scoping that also include development of the Aqqaluk Deposit. EPA and the Corps will further identify any mitigation measures and monitoring requirements for this project that would be required through permit conditions.

1.4 Scoping and Public Involvement

The Notice of Intent (NOI) to prepare the SEIS for the Red Dog Mine Aqqaluk Project was published in the *Federal Register* on August 31, 2007. The publication of the NOI initiated the scoping process and a public review and comment period required under NEPA at 40 CFR § 1501.7. The *Scoping Document for the Red Dog Mine Extension – Aqqaluk Project Supplemental Environmental Impact Statement* was distributed at the same time. The scoping document was distributed to a mailing list developed in conjunction with the cooperating agencies and to residences in Noatak and Kivalina with assistance from the Maniilaq Association. The formal scoping period ended on October 15, 2007.

Scoping is a process intended to assist EPA and the cooperating agencies in identifying areas and issues of concern associated with the proposed Aqqaluk Project, and is designed to ensure that all significant issues are fully addressed during the course of the SEIS process. The main objectives of the scoping process are to:

- Provide the public, regional stakeholders, and regulatory agencies with a basic understanding of the existing Red Dog Mine and proposed Aqqaluk Project;
- Provide a framework for the public to ask questions, raise concerns, and identify specific issues with the proposed options; and recommend options other than those currently proposed; and
- Explain where to find additional information about the project.

The scoping document provided a brief background on the Red Dog Mine; discussions on the proposed action, agency involvement, permits and authorizations, and the scoping process; an SEIS preparation schedule; and information sources. In addition to the NOI, EPA placed a public notice in the *Arctic Sounder* on September 6, 2007, and used email to advertise the scoping meetings. The scoping meetings included open-house information sessions followed by public hearings. The scoping meetings were held from October 2 through October 5, 2007, in Anchorage, Kotzebue, Noatak, and Kivalina. The purposes of the scoping meetings were to listen to and record the public's comments about the Aqqaluk Project and to respond to the public's requests for background information needed to fully understand the project description and proposed scope of the SEIS.

Throughout the scoping process, EPA collected comments from the public; local, state, and federal agencies; non-governmental organizations; professional and trade organizations; and native corporations and tribal organizations. Attendance at the public meetings varied, and most, but not all, adults signed in. The following presents the minimum number of attendees at each of the meetings:

Anchorage	21
Kotzebue	29
Noatak	116
Kivalina	57

The scoping process produced 23 comment submittals in the form of letters, emails, or written comment forms. Many comment submittals included more than one comment. Oral testimony through the public hearing process was provided by 18 speakers who identified themselves, and at least one speaker who did not identify him/herself. The speakers often provided more than one comment. The Tetra Tech interdisciplinary team worked with EPA to review the comment submittals and transcripts of testimony to identify and catalog individual comments. A total of 229 comments were identified. EPA released a document that summarized the nature of the scoping comments received during this process and in which part of the draft SEIS the comments will be addressed. The scoping responsiveness summary is available on the project website (www.reddogseis.com).

EPA published a notice of availability for the Red Dog Mine Extension Aqqaluk Project Draft SEIS on December 5, 2008 and simultaneously delivered the draft SEIS to parties that had expressed interest in receiving a copy. Post cards were also mailed to all parties on the mailing list, including individuals who had submitted scoping comments and all post office box holders in Noatak and Kivalina. The post card noted that the draft SEIS was available for viewing on the project website and offered paper or digital (compact disk) versions on request. EPA and the cooperating agencies hosted public meetings to solicit comments on the draft SEIS in Kivalina on January 12, 2009, Noatak on January 13, 2009, Kotzebue on January 14, 2009 and Anchorage on January 15, 2009. EPA received 585 written comments from 59 commenters representing the general public, industry groups, non-governmental organizations, and other agencies. Twenty-two commenters at the four public meetings provided an additional 44 comments. Public comments and EPA's responses are presented in Appendix H.

1.4.1 Government-to-Government Consultations

Pursuant to Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments), EPA undertook a concerted effort by contacting the tribal governments (Indian Reorganization Act [IRA] council and traditional councils) of each Native village in the NWAB to determine if the tribal governments were interested in engaging in government-to-government consultation and/or participation as a cooperating agency in developing the SEIS. EPA considered that each of the 11 villages (IRA council: Buckland, Deering, Kivalina, Kotzebue, Noatak, Noorvik, Selawik, Shugnak; traditional council: Ambler, Kiana, Kobuk) within the NWAB could potentially be affected by the proposed action. The nine tribal villages listed in Section 1.1 expressed interest in participating as cooperating agencies.

In addition, the Kivalina IRA council requested government-to-government consultation. EPA, NPS, and the Corps met with the Kivalina IRA council on October 5, 2007, before the Kivalina public scoping meeting and on January 12, 2009, before the Kivalina public meeting on the draft SEIS and draft NPDES permit. Comments received during the scoping meeting were used to develop the significant issues and alternatives for evaluation in the SEIS. None of the other NWAB villages requested government-to-government consultation.

Following issuance of the draft SEIS, the Point Hope IRA council requested government-to-government consultation in a comment letter on the draft SEIS and draft NPDES permit submitted on its behalf by Trustees for Alaska. EPA responded by letter and email agreeing to a consultation meeting and requested that the council contact EPA regarding possible meeting dates. In June, EPA was sent an email by the Point Hope Indian General Assistance Program coordinator requesting EPA's attendance at a meeting two days hence. EPA was unable to attend the meeting and requested that EPA and the Point Hope council work together to set up another date. To date there has been no response to that communication.

1.5 Significant Issues

The scoping process was used to determine the range of actions, alternatives, and impacts that are considered in this SEIS. Significant issues identified during scoping often present the issues of the greatest concern or complexity and may involve multiple resource areas. Significant issues may also drive some or all action alternatives considered in the analysis. After considering scoping comments, public testimony, and government-to-government consultation, the following significant issues of public concern were identified by EPA for developing this SEIS.

Issue 1: Discharges from the mine during operations and after closure can affect water quality downstream in Red Dog Creek, Ikalukrok Creek, and the Wulik River. These effects could cause adverse impacts on aquatic life and the drinking water supply for the village of Kivalina.

Issue 2: The water management system must have adequate storage capacity during operations and closure under all climatic conditions, including potential long-term changes in permafrost. Water storage requirements could have impacts on geotechnical stability of the main tailings dam and ground and surface water resources.

Issue 3: Metals have been carried in dust from the Red Dog Mine, DMTS road, and the port onto adjacent lands, including property within the Cape Krusenstern National Monument. These metals have the potential to affect vegetation, wildlife, water quality (i.e., aquatic habitat), fish, and people.

Issue 4: Mining operations may be affecting subsistence users in the NWAB, who have expressed concerns about the availability and quality of subsistence resources (such as caribou, fish, beluga whale, waterfowl, seal, walrus, bowhead whale, and berries).

1.6 Agency Responsibilities, Approvals, and Compliance

This section describes the primary roles of each agency involved in the Aqqaluk Project. The discussion includes a description of the major permits and authorizations required for the project. It also addresses applicable environmental laws as they pertain to the responsible agencies and the SEIS process.

1.6.1 Federal Agencies

U.S. Environmental Protection Agency

- Lead NEPA agency
- NEPA compliance for new source NPDES permits
- Issuance of CWA Section 402 (NPDES) permit
- Review of the Corps CWA Section 404 (dredge and fill) permit
- CWA Section 311 oversight (Spill Prevention, Containment, and Countermeasure Plan)
- Coordination with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA)
- National Historic Preservation Act (NHPA) Section 106 Historical and Cultural Resources Protection
- Coordination with NMFS under the Magnuson-Stevens Fishery Conservation and Management Act

In accordance with CWA Section 511(c)(1), NPDES permit actions for new sources, including the Red Dog Mine, may be defined as major federal actions subject to NEPA. Under this authority, EPA determined that preparation of this SEIS was necessary in order to support reissuance of the NPDES permit for the Red Dog Mine; this includes evaluating new information and circumstances since the 1984 EIS was issued and evaluating impacts of the Aqqaluk Project.

EPA has primary responsibility for implementation of Sections 301, 306, 311, and 402 of the CWA. EPA shares responsibility for Section 404 with the Corps. Sections 301 and 306 of the CWA require EPA to establish numeric limits or criteria for discharges of water pollutants. Section 301 specifically requires

EPA to establish technology-based effluent guidelines for new sources. These guidelines must be met at the “end of pipe” where the discharge occurs. The new source performance standards applicable to this facility are described in 40 CFR § 440.104. In addition, Section 301 requires that all NPDES permits include effluent limitations protective of water quality.

Section 311 of the CWA establishes requirements relating to discharge or spills of oil or hazardous substances. EPA requires defined facilities to prepare a Spill Prevention, Containment, and Countermeasure (SPCC) Plan and/or a Facility Response Plan (FRP)

Section 402 of the CWA established the NPDES program. This program authorizes EPA to permit point source discharges of pollutants included in wastewater and storm water. Discharges must meet all effluent limitations, including ensuring compliance with water quality standards.

EPA has authority under CWA Section 404 for reviewing compliance with the Section 404(b)(1) guidelines, 40 CFR § 230. In addition, under Section 404(c), EPA may prohibit or withdraw the specification (permitting) of a site upon determination that the use of the site would have an unacceptable adverse effect on municipal water supplies, shellfish beds, fishery areas, wildlife, or recreational areas.

Section 110 of the Clean Air Act designates the approval authority to EPA for state implementation plans for air quality. EPA reviews Air Quality Control Permit to Operate applications, including prevention of significant deterioration requirements.

Section 106 of the NHPA and its implementing regulations (36 CFR 800) require federal agencies to consider the effects of their undertakings on cultural resources that are eligible for the National Register of Historic Places and consult with the State Historic Preservation Office (SHPO) regarding the means to avoid, minimize, or mitigate any impacts. The term “undertaking” includes issuance of federal permits or other authorizations. The SEIS analyzed the impacts of the Red Dog Mine permit reissuance on historical, cultural, and archaeological resources. As the lead federal agency, EPA is consulting with SHPO.

The Magnuson-Stevens Fishery Conservation and Management Act requires EPA to consult with NMFS prior to issuance of an NPDES permit if the permit could impact essential fish habitat (EFH).

In accordance with the ESA, EPA must coordinate and consult with NMFS and USFWS if the NPDES permit could impact listed threatened and endangered species.

U.S. Army Corps of Engineers

- Participation as a cooperating agency in preparation of the SEIS
- NEPA compliance for Section 404 permit
- Issuance of the CWA Section 404 (dredge and fill) permit
- Rivers and Harbor Act Section 10 permit, if necessary
- Coordination with USFWS and NMFS under the ESA
- National Historic Preservation Act (NHPA) Section 106 Historical and Cultural Resources Protection
- Coordination with NMFS under the Magnuson-Stevens Fishery Conservation and Management Act
- Alaska National Interest Lands Conservation Act (ANILCA)

Because of its NEPA responsibilities, the Corps is a cooperating agency on this SEIS. Section 404 of the CWA authorizes the Corps to issue permits for discharge of dredged or fill material into waters of the United States. The CWA prohibits such a discharge except pursuant to a Section 404 permit. To the degree that they affect waters of the United States, various activities undertaken in connection with mining operations could require a Section 404 permit (see Appendix A for details on the permitting and review process). Such activities associated with the Aqqaluk Project include placement of fill in jurisdictional wetlands or other waters of the U.S. associated with stripping of overburden and subsequent mining, placement of fill to increase the height of the tailings dam, and fill placed for stream diversions and various construction activities that would be required to support ongoing operations.

The Corps is responsible for determining whether an action complies with the CWA Section 404(b)(1) guidelines that require the Corps to evaluate alternatives and permit the least environmentally damaging practicable alternative. A Section 404 permit cannot be issued without such compliance.

Some of the SEIS alternatives entail construction of pipelines that would require Section 404 permits. Since the pipelines would cross a “conservation system unit” (Cape Krusenstern National Monument), the Corps would also need to comply with transportation and utility line requirements under ANILCA Title XI (discussed in more detail below). In addition, these alternatives may require Section 10 permits under the Rivers and Harbors Act. Activities requiring Rivers and Harbors Act Section 10 permits include construction of any structure in or over any navigable water of the U.S., the excavation from or deposition of material in such waters, or those activities otherwise affecting the course, location, condition, or capacity of such waters.

Similar to EPA, the Corps needs to comply with Section 106 of the NHPA and consider the effects of it’s issuance of the Section 404 permit on cultural resources and consult with SHPO. EPA and the Corps are coordinating efforts, with EPA taking the lead in consultation with SHPO.

The Magnuson-Stevens Fishery Conservation and Management Act requires the Corps to consult with NMFS regarding the protection of EFH prior to issuance of a Section 10 or Section 404 permit. In addition, the ESA requires consultation with NMFS and USFWS if the 404 permit issuance could impact listed threatened and endangered species.

National Park Service

- Participation as a cooperating agency in preparation of the SEIS
- ANILCA Title XI and Section 810 requirements, if necessary

NPS is participating as a cooperating agency because of area expertise and management responsibility for the Cape Krusenstern National Monument through which the DMTS road passes. NPS has authority to monitor effects to the monument along the DMTS road pursuant to P.L. 99-96, Section 34(h)(2), which states, “… the Secretary of the Interior through NPS … shall monitor the construction, operation, maintenance, expansion and reclamation of the transportation system as provided in the (Road) Agreement.” NPS involvement relates to effects on natural resources (including vegetation and fauna), cultural resources, and subsistence use within Cape Krusenstern National Monument.

If an alternative involving a pipeline across Cape Krusenstern National Monument were to be selected, NPS has stated that it would need to receive a formal application for the pipeline under ANILCA Title XI. Title XI, and its implementing regulations at 43 CFR § 36, establish specific NEPA requirements. NPS has indicated that should a pipeline alternative be selected, these NEPA requirements would need to be met under a separate NEPA action with NPS as lead (or co-lead) agency. The Title XI application would also require an ANILCA Section 810 evaluation of effects of the pipeline on subsistence resources including a hearing held in the vicinity of the area involved.

National Marine Fisheries Service

- Threatened and Endangered Species Consultation under ESA
- Marine Mammal Protection Act
- EFH consultation

EPA must consult with NMFS regarding reissuance of the Red Dog Mine NPDES permit in accordance with the ESA and the Marine Mammal Protection Act. Likewise, the Corps must consult with NMFS regarding issuance of its 404 permit. At this time, the polar bear (*Ursus maritimus*), is the only threatened and endangered species known to occur at the Red Dog Mine Project site (mine site, DMTS port site, and DMTS road). While the polar bear is considered a marine mammal, it is managed by USFWS. In addition to the polar bear, other marine mammals occur in the vicinity of the port; however, most activity by these species occurs outside the summer shipping season while the port is closed. Therefore, activities at the port are consistent with Marine Mammal Protection Act requirements which prohibit the “take” of marine mammals (“take” is defined as “harass, hunt, capture, kill, or collect, or attempt to harass, hunt, capture, kill, or collect”). The Magnuson-Stevens Fishery Conservation and Management Act establishes consultation responsibilities for NMFS for projects that could impact EFH. If any impacts are projected to any threatened or endangered marine species, marine mammals, or EFH, specific design measures must be developed to protect the affected species.

U.S. Fish and Wildlife Service

- Threatened and Endangered Species Consultation under ESA

EPA and the Corps must consult with USFWS regarding any threatened or endangered species under USFWS jurisdiction that might be impacted by reissuance of the Red Dog Mine NPDES permit or issuance of a 404 permit. If any impacts are projected, specific design measures must be developed to protect the affected species. The polar bear has been listed as threatened and has been observed near the port when sea ice was present. No other threatened or endangered species under USFWS jurisdiction occur either at the port or in the vicinity of the Red Dog Mine itself.

1.6.2 State and Local Government

Alaska Department of Natural Resources

- Participation as a cooperating agency in preparation of the SEIS
- Water rights authorizations
- Tideland leases for marine facilities
- Coastal zone consistency review certificates of approval to construct and operate a dam
- Reclamation and closure plan approval
- Reclamation, closure, and post-closure financial assurance approval

ADNR is the lead State agency involved in permitting mining projects in the State of Alaska. In addition to ADNR, State agencies involved in the Aqqaluk Project include the departments of Environmental Conservation (ADEC), Fish and Game (ADF&G), and Law. The State established a large mine project team from these agencies to coordinate permitting activities for the Aqqaluk Project.

ADNR is responsible for issuing water rights authorizations for the use of surface and subsurface waters of the State. These permits require compliance with instream flow requirements. ADNR is also responsible for issuing tideland leases for permanent improvements to tidelands such as marine terminals, fuel transfer facilities, and concentrate transfer facilities.

In accordance with ADNR and ADEC statutory and regulatory requirements, Teck must provide financial assurance that reclamation work and post-closure care and maintenance, including water treatment, can be adequately funded. The closure and post-closure activities, including reclamation and long-term water treatment, and the financial assurance for these activities are addressed in Teck's *Proposed Reclamation and Closure Plan for the Red Dog Mine Including Development of the Aqqaluk Deposit*, which is currently under review by the State of Alaska. Once approved, the plan, including the level of financial assurance, will be reviewed and subject to modification every five years, or at any time that the State determines that the financial assurance is inadequate. ADNR will also need to issue Certificates of Approval for construction and operation of any dams.

The type of financial assurance will be the subject of an agreement between Teck, the State of Alaska, and NANA (as the landowner), but will likely be a combination of letters of credit and a trust fund to finance long-term closure costs such as water treatment. The agreement will be subject to state law, which specifies the types of financial assurance that are legally allowed. Currently, the State of Alaska holds an interim financial assurance from Teck in the amount of $154.9 million in letters of credit. This amount will be adjusted once the closure and reclamation plan is complete. On June 11, 2009, the State issued a draft reclamation plan approval and a draft waste management permit for public comment. The State also proposed a revised financial assurance amount of $304,520,000.

ADNR's Division of Coastal & Ocean Management will conduct the Coastal Zone Consistency Review.

Alaska Department of Environmental Conservation

- CWA Section 401 certification of the Corps CWA Section 404 permit
- CWA Section 401 certification of the EPA CWA Section 402 permit
- Integrated waste management permit regulating solid waste disposal, groundwater quality, financial responsibility, mine reclamation and closure, and monitoring
- Approval of Oil Discharge Prevention and Contingency Plan
- Air quality control permit
- Engineering review/approval of the sanitary wastewater treatment and disposal systems
- Engineering review and operating approval of the drinking water system
- Food safety permit
- Public facility permit for lodging facilities

ADEC is responsible for certain water quality issues and air quality permits. Under Section 401 of the CWA, ADEC responsibilities include certification of EPA's NPDES permit and the Corps' Section 404 permit. ADEC must certify that the requirements of these permits comply with state water quality standards. These standards protect designated water uses through numerical and narrative water quality criteria.

ADEC is responsible for issuing the facility's air quality permits for construction activities and operations at the port and the mine. ADEC will evaluate the changes to emissions sources associated with development of the Aqqaluk Project and, based on the review, require new permits or modification of existing permits as applicable.

ADEC is responsible for issuing an integrated waste management permit that includes requirements for solid waste disposal, groundwater protection, mine reclamation and closure, financial assurance, and monitoring. The facility is in the process of applying for a waste management permit, and the Aqqaluk Project is being considered in that permit action. The waste management permit is currently under review by the State of Alaska and should be in place by the fall of 2009.

From September 2005 to December 2007, ADEC and Teck had a memorandum of understanding relating to dust originating from the Red Dog Mine Site. The MOU addressed baseline monitoring, evaluation of control options, and measurement of improvements. The voluntary fugitive dust risk management plan discussed in Section 1.7 will include follow-up actions related to the MOU.

Alaska Department of Fish and Game

- Alaska Statutes, Title 16 authorizations for fish passage and fish habitat

The ADF&G does not anticipate that any Title 16 permits will be needed for the Aqqaluk Project. There are no known fish resources in Middle Fork Red Dog Creek or its tributaries in the immediate vicinity of the Aqqaluk ore body. The ADF&G's authority to issue permits covers a variety of activities (instream work, water removal, etc.) in anadromous water bodies and in resident fish streams.

Northwest Arctic Borough

- Participation as cooperating agency in preparation of the SEIS
- Title 9 zoning permits under the NWAB code
- Master Plan or Revised Master Plan compliance

NWAB is participating as a cooperating agency. The borough exercises land use planning and related zoning powers under the terms of state law and the borough home rule charter. The borough permitting process is codified in Title 9 of the NWAB code, which intends to promote and protect the public health, safety, morals, and general welfare, as well as the historic, economic, social, and cultural interests of the borough's residents, particularly as these are related to the subsistence way of life of the great majority of the borough residents.

The Red Dog Mine, Aqqaluk Project, and DMTS road and port are within the municipal boundaries of the NWAB and subject to borough permitting under Title 9 as an amendment to Teck's master plan for mine development and operations. The borough planning commission will approve the amendment to the master plan permit for the project.

Tribal Governments of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shungnak, and the Maniilaq Association

Nine tribal governments are participating in the SEIS process as cooperating agencies: the Native Village of Buckland, the Native Village of Kiana, the Native Village of Kivalina, the Native Village of Kobuk, the Native Village of Kotzebue, the Native Village of Noatak, the Noorvik Native Community, the Native Village of Selawik, and the Native Village of Shungnak. The tribal governments have authorized the Maniilaq Association to represent their cooperating agency interests and responsibilities. The Maniilaq Association provides health, social, and tribal services to the region. Each individual entity provides expertise to the SEIS process, and the information in the SEIS may inform their decisions regarding the Aqqaluk Project.

1.6.3 Compliance with Executive Orders

All federal agencies must comply with Executive Orders 11990 and 11988, which address minimizing impacts to the Nation's wetlands and/or floodplains respectively. Executive Order 12962 requires federal agencies to evaluate the potential effects of proposed federal actions on recreational fisheries. Recreational fishing (along with subsistence fishing) occurs downstream from the mine in Ikalukrok Creek and the Wulik River. This SEIS complies with these Executive Orders by considering the potential impacts of each alternative on wetlands and floodplains, as well as water quality and fish habitat downstream of the mine.

Executive Order 12898 requires federal agencies to identify and address disproportionately high and adverse human health or environmental effects of proposed activities on minority and low-income populations. The NWAB native villages consist of minority and low-income populations in terms of populations within the U.S. The Native villages of Noatak and Kivalina are closest to the mine site. This SEIS complies with Executive Order 12898 since impacts to people in the villages have been considered for each alternative across a range of resource areas including subsistence, socioeconomics, public health, and environmental justice.

1.7 DMTS Risk Assessment and Fugitive Dust Risk Management Plan

On a voluntary basis, Teck undertook a human health and ecological risk assessment for the areas around the DMTS road and port and is in the process of voluntarily preparing a fugitive dust risk management plan that addresses fugitive emissions from the mine and the DMTS.

DMTS Risk Assessment

A human health and ecological risk assessment (DMTS risk assessment) (Exponent 2007a, 2007b) was conducted to estimate possible risks to human and ecological receptors posed by exposure to metals in soil, water, sediments, and biota in areas surrounding the DMTS, and in areas surrounding the Red Dog Mine ambient air/solid waste permit boundary associated with fugitive dust emissions along the DMTS. The human health component of the DMTS risk assessment evaluated potential exposure to DMTS related metals through incidental soil ingestion, water ingestion, and subsistence food consumption under three scenarios: (1) child subsistence use; (2) adult subsistence use; and (3) combined worker/subsistence user. The ecological component of the DMTS risk assessment evaluated potential risks to ecological receptors inhabiting terrestrial, freshwater stream and pond, coastal lagoon, and marine environments from exposure to DMTS related metals. The conclusions of the DMTS risk assessment (see sections 3.2, 3.7, and 3.9) led to the development of an overall goal for the fugitive dust risk management plan to minimize risk to human health and the environment surrounding the DMTS and Red Dog Mine over the life of the mine and post-closure operations.

Draft Fugitive Dust Risk Management Plan

In August 2008, a draft fugitive dust risk management plan was released for public comment (TCAK 2008). The fugitive dust risk management plan is part of a process intended to minimize risks associated with fugitive dust emissions from operations at Red Dog Mine. The fugitive dust risk management plan addresses issues identified by several different studies and programs, including the DMTS risk assessment, the mine-area ecological risk evaluation conducted as part of the closure and reclamation planning process, the MOU between ADEC and Teck, and this SEIS. The fugitive dust risk management plan also incorporates stakeholder input obtained during a three-day risk management workshop held in Kotzebue, Alaska.

The fugitive dust risk management plan identifies and describes seven fundamental risk management objectives that address the overall goal of minimizing risk to human health and the environment surrounding the mine, road, and port, over the life of the mine and post-closure operation. These include

- Objective 1: Continue reducing fugitive metals emissions and dust emissions
- Objective 2: Conduct remediation or reclamation in selected areas
- Objective 3: Verify continued safety of caribou, other representative subsistence foods, and water
- Objective 4: Monitor conditions in various ecological environments and habitats, and implement corrective measures when action levels are triggered
- Objective 5: Conduct research or studies to reduce uncertainties in the assessment of effects to humans and the environment
- Objective 6: Improve collaboration and communication among all stakeholders to increase the level of awareness and understanding of fugitive dust issues
- Objective 7: Protect worker health

The fugitive dust risk management plan also identifies and evaluates risk management options to achieve those objectives, and describes a process for developing implementation plans to achieve the fundamental objectives. Part of that process is the development of six individual risk management implementation plans that will incorporate high-priority actions identified in the fugitive dust risk management plan to more specifically describe how the fundamental objectives will be met. The plans to be developed include the following:

- Communication plan (addressing Objective 6, and integral to all efforts)
- Dust emissions reduction plan (addressing Objective 1)
- Remediation plan (addressing Objective 2)
- Monitoring plan (addressing Objectives 1, 3, and 4)
- Uncertainty reduction plan (addressing Objective 5)
- Worker dust protection plan (addressing Objective 7).

The draft communication plan was released for public review in summer 2009. Other draft plans are planned for public review in fall 2009.

Chapter 2
Proposed Action and Alternatives

CHAPTER 2 PROPOSED ACTION AND ALTERNATIVES

The Applicant (Teck) plans to develop an ore deposit (the Aqqaluk Deposit) adjacent to the Main Deposit, which is currently being mined. As discussed in Chapter 1, EPA will make a decision whether to reissue the Red Dog Mine NPDES permit authorizing discharges for the Red Dog Mine including the Aqqaluk Project. The Corps will make decisions whether to issue new permits for fill activities associated with development of the Aqqaluk Project. EPA determined, in consultation with the Corps, that an SEIS is needed to evaluate the environmental impacts of these decisions. NEPA requires an evaluation of the agencies' decisions on the Applicant's proposed action to extend the life of the Red Dog Mine with the Aqqaluk Project, including an evaluation of all reasonable alternatives.

The proposed action, including issuance of permits related to development of Aqqaluk Project, the no action alternative, and two additional alternatives are described in this chapter and evaluated in Chapter 3. Each alternative consists of a number of components that reflect different aspects of the mining operation. Components include items such as wastewater treatment technologies and transportation methods. Some components of various alternatives were developed to address public comments received during the scoping process. Logical combinations of components are grouped together to form alternatives.

EPA received a number of comments on the draft SEIS. The components and alternatives were not fundamentally revised based on the comments, although some of the alternative descriptions were expanded or clarified.

The following sections describe how various components and alternatives were developed, details of individual components, and how components are bundled into alternatives. The final sections provide a description of components considered but not carried forward, a tabular comparison of alternatives, and summaries of monitoring and mitigation measures.

2.1 Issues and Component Development

Significant issues (see Section 1.5) derived from the scoping process shaped the content of the alternatives and the comparison among the Applicant's proposed action, no action alternative, and other action alternatives. The issues drove the development of individual components in a number of ways. Wastewater management components, including a pipeline to the Chukchi Sea, are considered because of concerns with the quality of the effluent being discharged into Red Dog Creek and maintenance of the site water balance. Long-term stability of engineered structures and water quality issues led to the inclusion of different closure options. Concerns about the effect of the operation on subsistence resources and contamination of areas surrounding the DMTS resulted in consideration of changes in operations during caribou and beluga whale migrations, as well as the use of a pipeline to transport slurried concentrate. The use of a concentrate pipeline and truck washes are also included as alternative components to address concerns about fugitive dust.

2.2 Overview of Project Alternatives

Since the Red Dog Mine has been in operation for nearly 20 years, the range of alternatives is limited. Facilities, including the DMTS port and road, mill, and personnel accommodations complex (PAC) have already been built and are in operation (Figures 2.1 through 2.3). The analysis, therefore, does not consider alternative locations for any of these facilities.

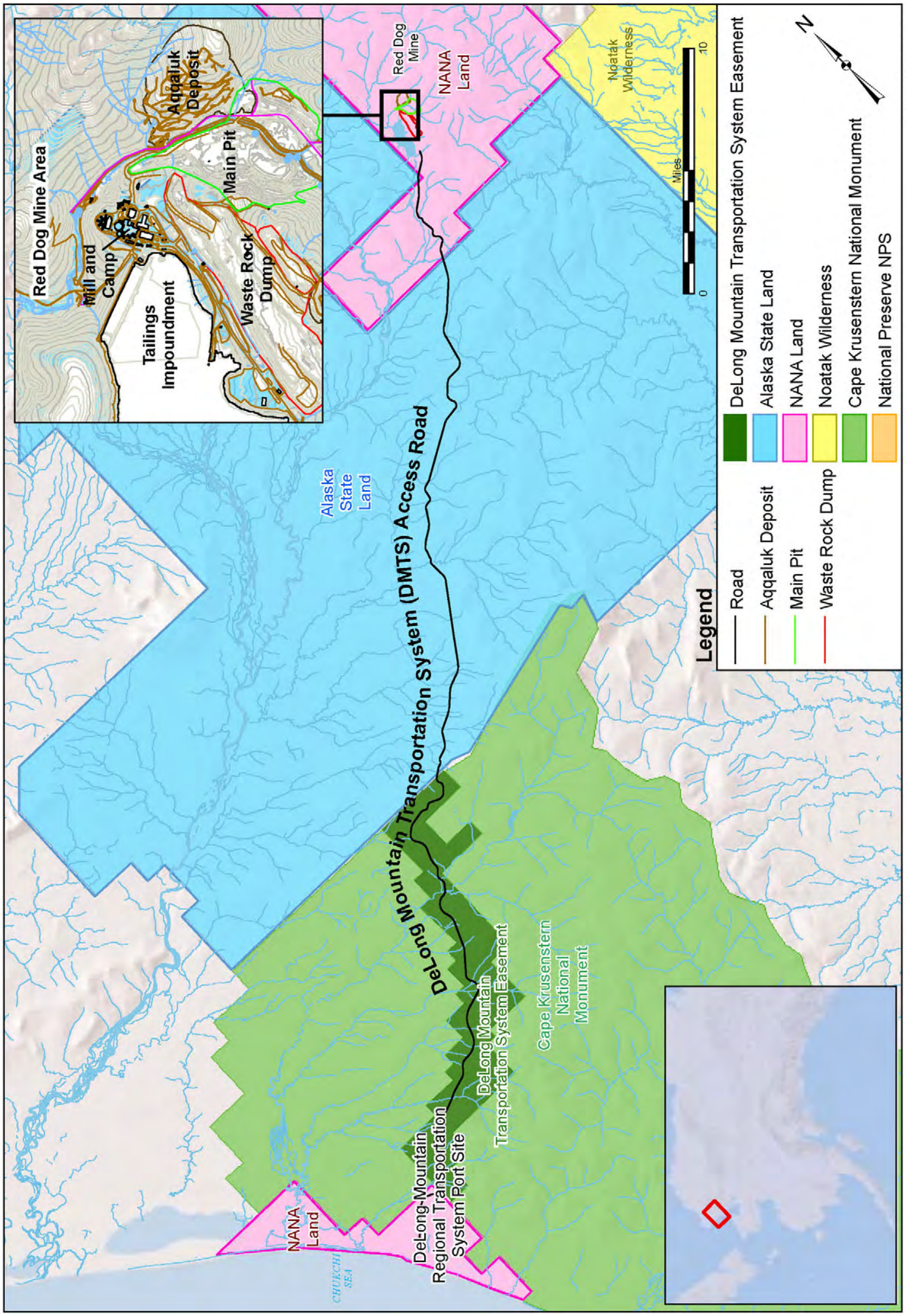


FIGURE 2.1

RED DOG MINE, PORT & DMTS ROAD

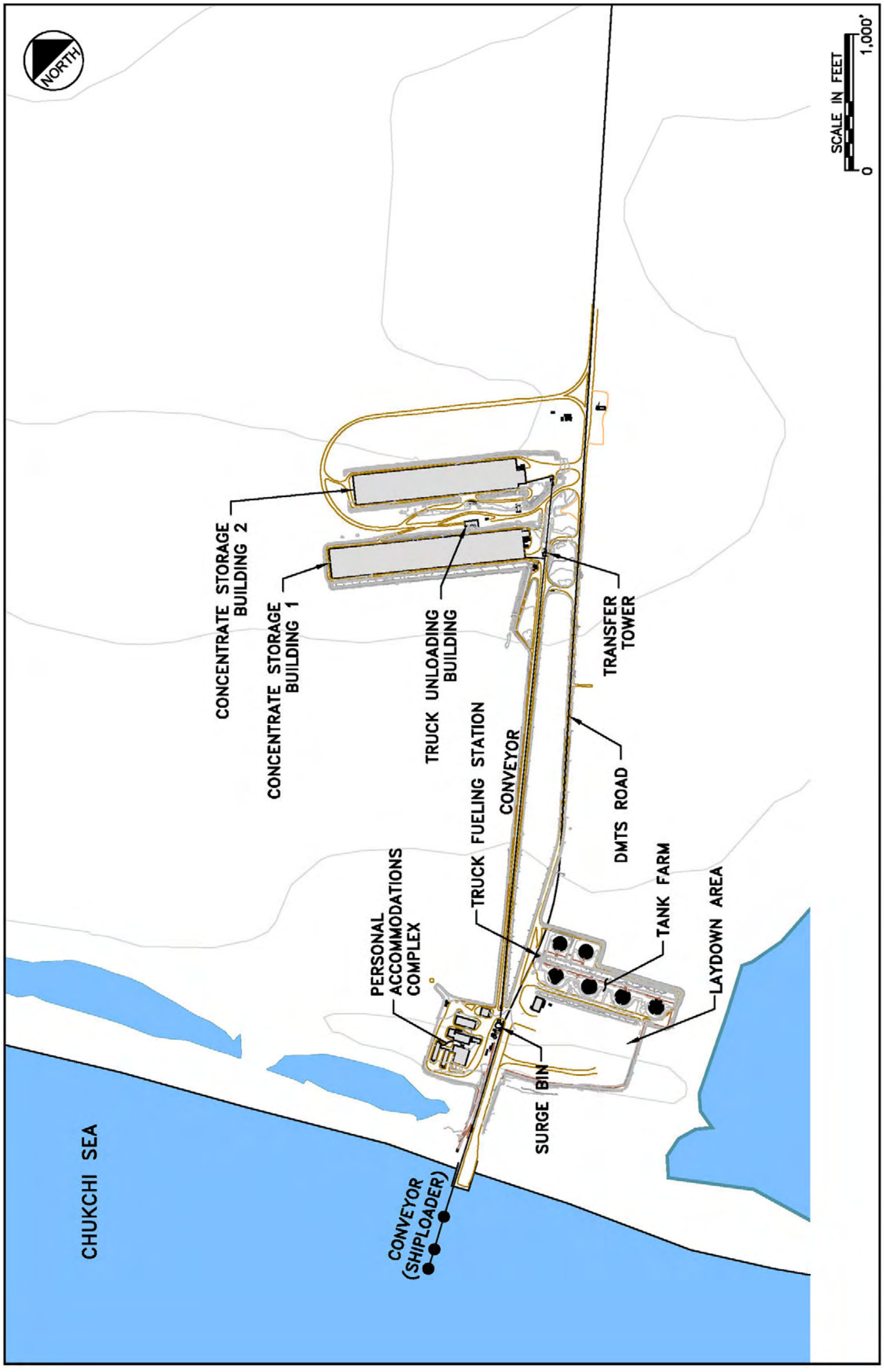


FIGURE 2.2
DELONG MOUNTAIN REGIONAL TRANSPORTATION SYSTEM PORT SITE

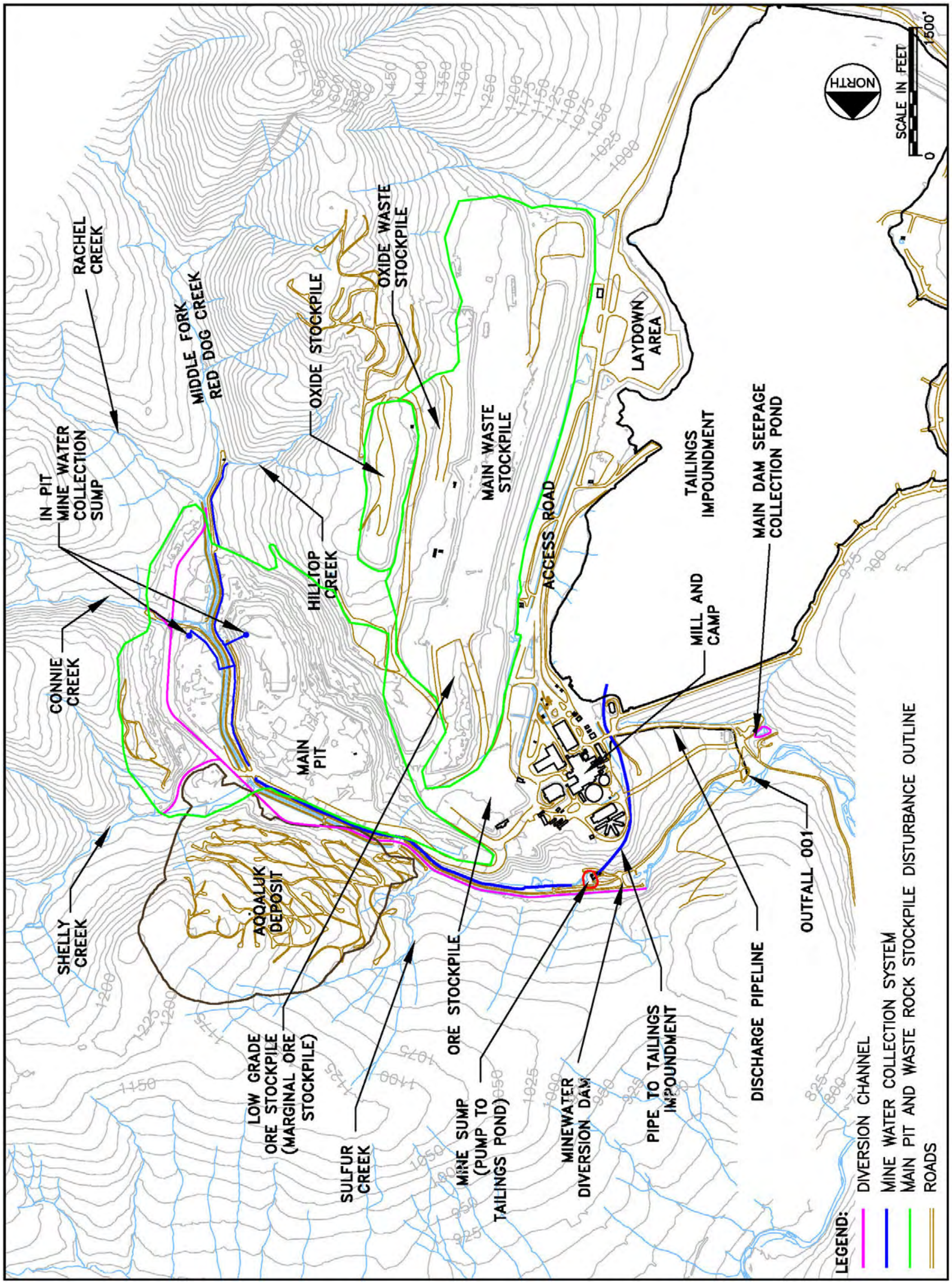


FIGURE 2.3
MINE FACILITIES

2.2.1 Alternative A – No Action Alternative

The no action alternative represents no reissued NPDES permit for the Red Dog Mine and no new Section 404 permits associated with development of the Aqqaluk Project. Therefore, the no action alternative includes continued mining in the Main Pit until the projected closure date of 2011 but does not include development of the Aqqaluk Project (Figure 2.4). The facility would continue to operate under the 1998 NPDES permit. This alternative involves completion of open pit mining of the Main Pit (including the continued removal and disposal of waste rock, storage of ore, and milling). The tailings would be deposited in the existing tailings impoundment. Concentrate would continue to be transported from the mill to the port by concentrate trucks. In order to meet the TDS discharge limitations in the 1998 permit, the wastewater treatment system would need to be modified to include pre-treatment by aluminum or barium precipitation followed by reverse osmosis. The discharge would continue to be to Red Dog Creek. Upon completion of mining activities, the site would be reclaimed beginning in 2011 and the State-approved closure plan would be implemented. Closure would include regrading the slopes of the waste rock dump (Figure 2.4) and covering the waste rock with an engineered soil cover.

The tailings impoundment would be managed to keep a shallow (two-foot) layer of water over the tailings. Seepage from the waste rock dump and tailings impoundment would be pumped to the Main Pit. Water in the Main Pit would not be allowed to rise above the 845-foot level to prevent an overflow into Red Dog Creek. Water in the Main Pit and tailings impoundment would be treated and discharged to Red Dog Creek. The treatment system would incorporate the existing treatment system reengineered to include barium or aluminum precipitation, as well as reverse osmosis. The treated wastewater discharge is estimated to be approximately 1.5 billion gallons annually to Red Dog Creek. Sludge from the barium or aluminum precipitation process would be disposed of in the Main Pit. Brine from the reverse osmosis system would be dried and then encapsulated in a lined waste facility, also within the Main Pit. Water treatment is expected to be necessary into the foreseeable future.

2.2.2 Alternative B – Applicant's Proposed Action

The proposed action alternative includes reissuing the Red Dog Mine NPDES permit and issuing a Section 404 permit for fill placement associated with development of the Aqqaluk Project. Following is a description of the proposed action based on information in the Applicant's EID. The Applicant proposes stripping waste material overlying the Aqqaluk Deposit beginning in 2010. The project would involve finishing open-pit mining operations in the Main Pit while starting the initial stages of developing the Aqqaluk Deposit. After the Main Deposit is mined out (in 2012 if the Aqqaluk Deposit is developed), waste rock removed from the Aqqaluk Deposit would be disposed in the mined-out Main Pit. Ore storage, milling of ore, and tailings disposal would continue to occur consistent with current operations and the wastewater discharge would continue in Red Dog Creek. Wastewater treatment would include the existing high-density sludge process, which effectively treats metals. An additional treatment step, consisting of barium hydroxide precipitation, would be used as needed to reduce TDS and metals levels in the discharge. Mine water from the Aqqaluk Pit would be pumped to the tailings impoundment. Zinc and lead concentrates would be trucked from the mill to the port as is currently done. Reclamation of the existing waste rock dump would occur throughout the life of the operation. Final closure according to a State-approved closure plan would occur after mining of the Aqqaluk Deposit was finished in 2031 (Figures 2.5 and 2.6).

Tailings from processing Aqqaluk ore would be placed in the existing tailings impoundment. The dam for the tailings impoundment is currently in the process of being raised from an elevation of 965 feet to 970 feet (dam height of 182 to 192 feet). To accommodate tailings from milling the Aqqaluk ore, the dam would ultimately be raised to 986 feet (dam height of 208 feet) with tailings deposited to the 976-foot elevation.

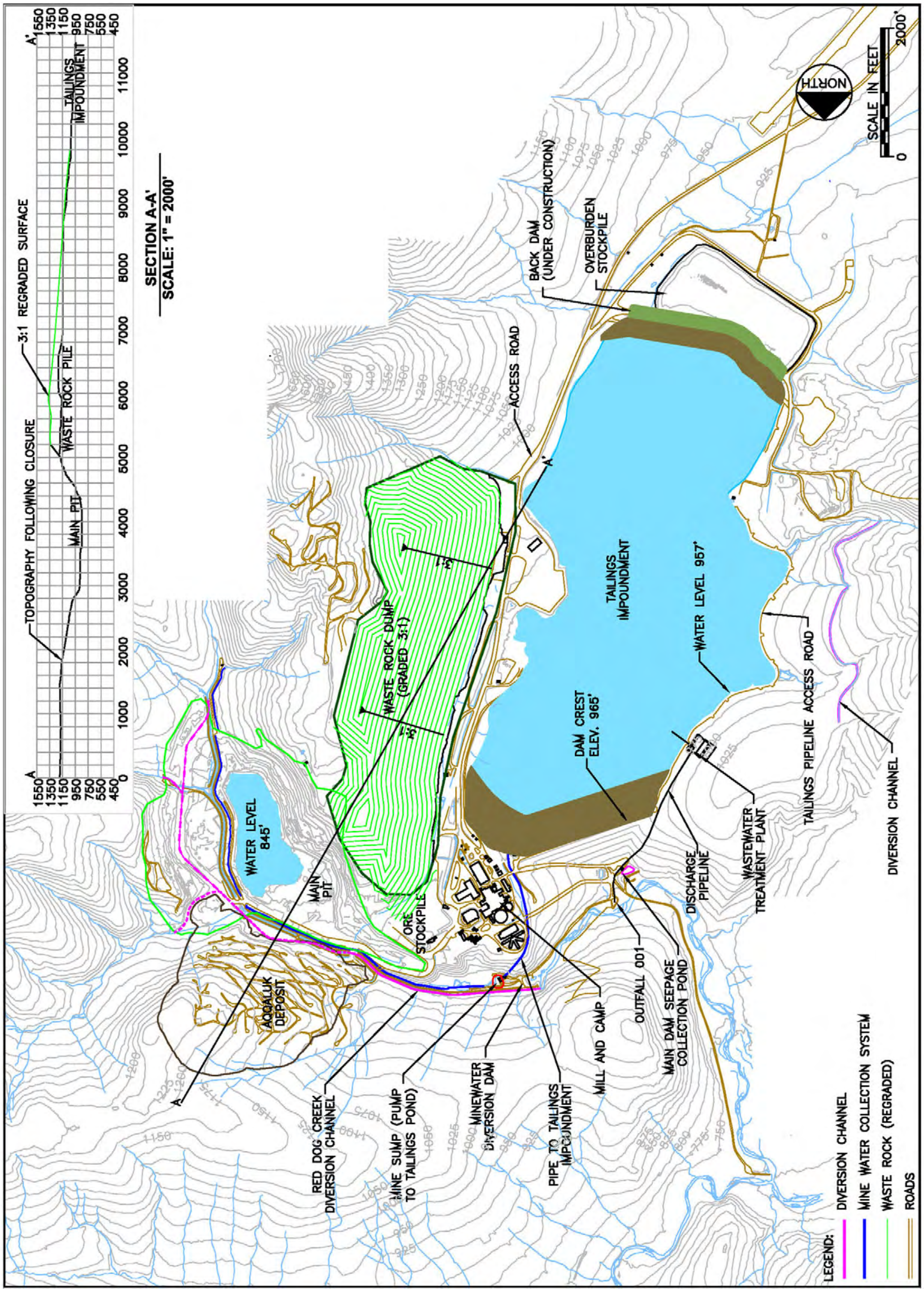


FIGURE 2.4
ALTERNATIVE A - AFTER CLOSURE 2012

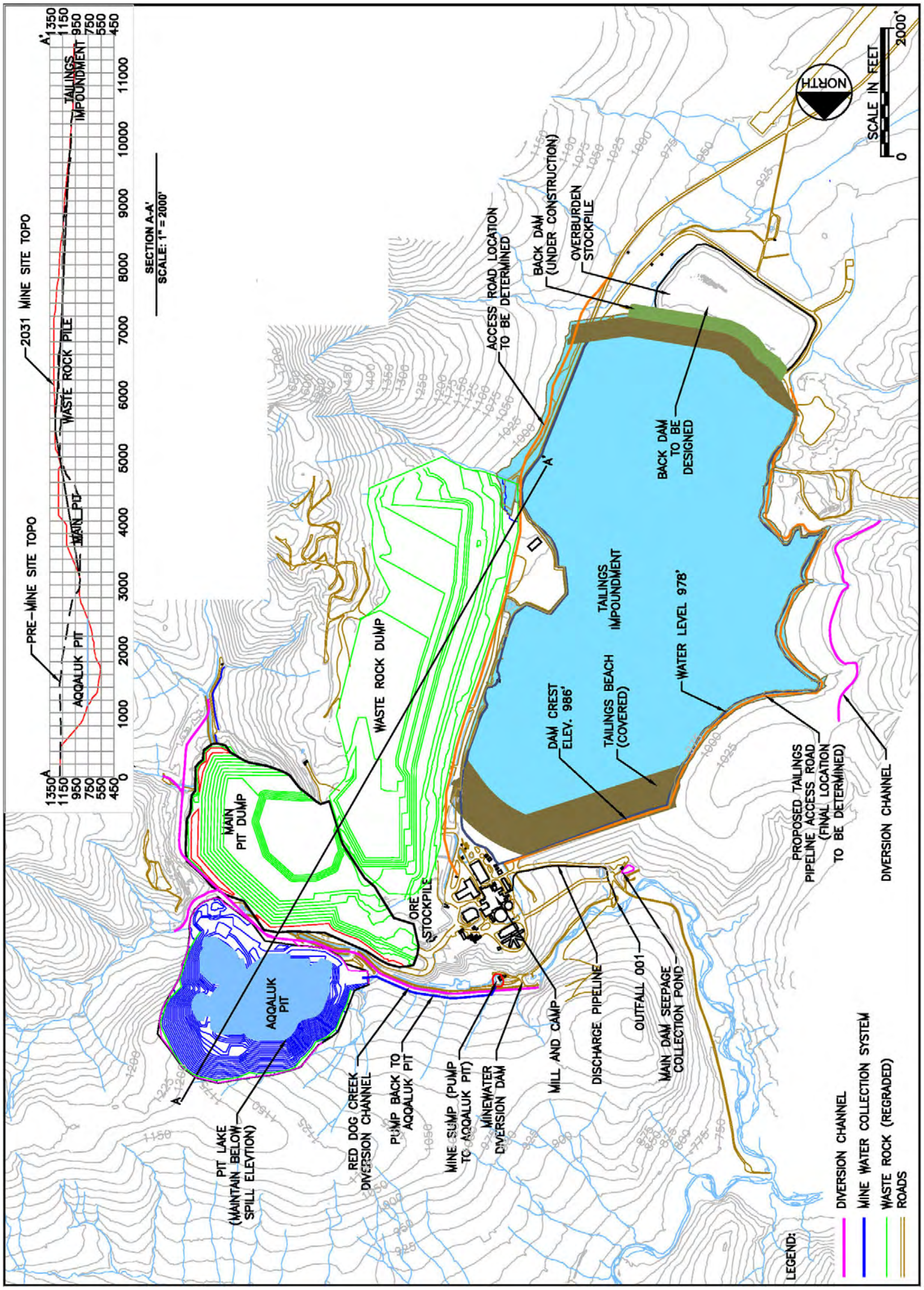


FIGURE 2.5
ALTERNATIVE B - END OF MINING 2031

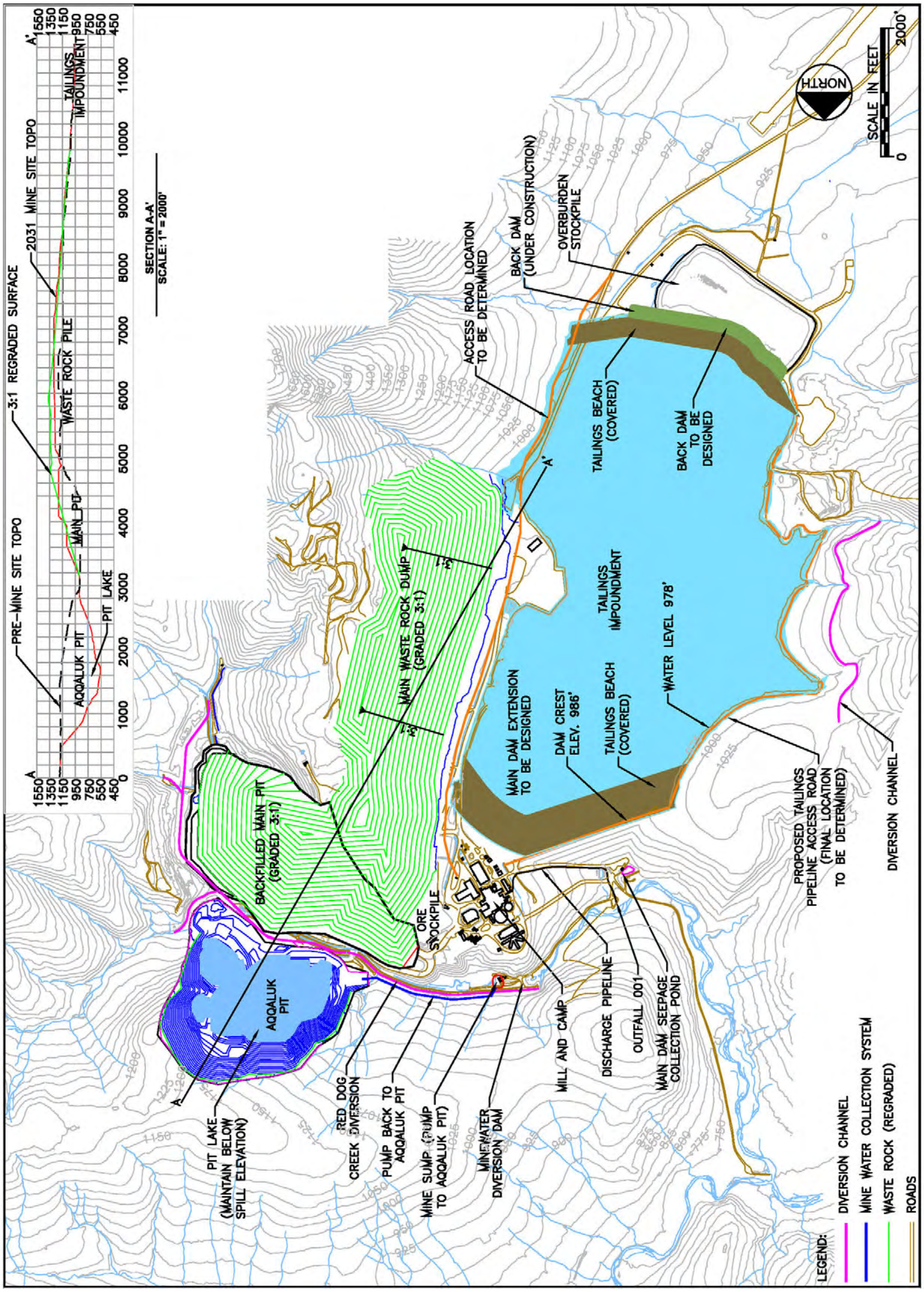


FIGURE 2.6
ALTERNATIVE B - AFTER CLOSURE 2031

Closure of the waste rock dump would involve regrading it to a slope of 3:1 (horizontal:vertical) and covering the waste rock with an engineered soil cover (Figure 2.7). Tailings impoundment closure would include maintaining a shallow (two-foot) water cover. After closure, the Aqqaluk Pit would fill with water and also be used to manage other impacted water from the site. Water would be pumped from both the Aqqaluk Pit and the tailings impoundment to the wastewater treatment system and discharged to Red Dog Creek. Water treatment is always expected to be necessary. Table 2.2-1 summarizes the additional disturbance areas of the Applicant's proposed action.

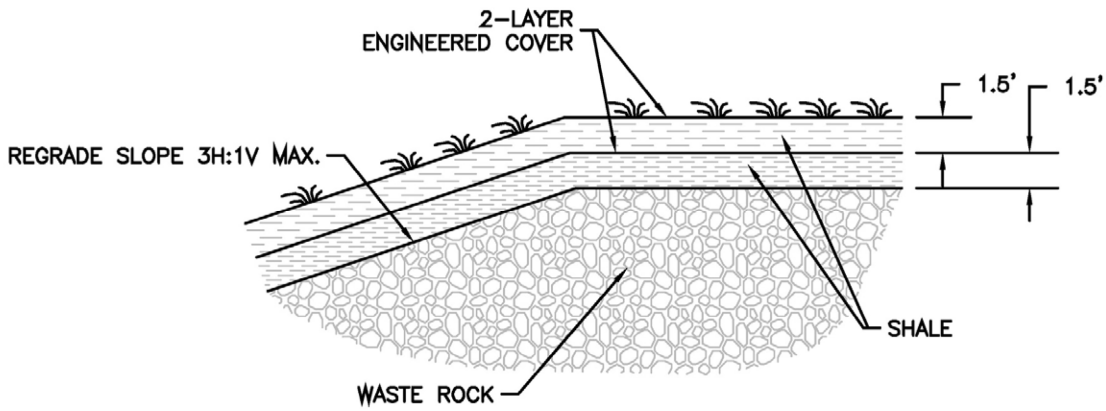


Figure 2.7 Engineered Soil Cover

Table 2.2-1 Disturbance Areas of Alternatives

Facility	Disturbance Area (Acres) 2006	Additional Disturbance (Acres)				
		Alternative A		Alternative B	Alternative C	Alternative D
		2006–2012	2012–2031	2009–2031	2009–2031	2009–2031
Main Pit	189	–	–	–	–	–
Aqqaluk Pit	N/A	–	–	135	135	135
Disturbance Area around Pit	N/A	–	–	111	111	111
Waste Rock Dump	245	15	–	15	15	15
Tailings Area (includes pumpback)	605 [a]	–	–	142[b]	142[b]	142[b]
Overburden Stockpile	62	–	–	–	80[c]	–
Mill Site	49	–	–	–	–	–
Red Dog Creek	63	–	–	–	–	–
Airport	34	–	–	–	–	–
Freshwater Supply	31	–	–	–	–	–
Ore Stockpiles	41	–	–	–	–	–
Ancillary	112	–	–	–	–	–
Borrow Area	65[d]	–	–	–	–	–
Mine Site Roads and Ditches	35	3.5[e]	–	3.5[e]	3.5[e]	3.5[e]
DMTS Road and Port[f]	616	–	–	–	145	145
Total	2,147	18.5	–	406.5	631.5	551.5

[a] Includes permitted raise to 965 feet in elevation
[b] Area between an elevation of 965 and 978 feet
[c] Cover material stockpiles for tailings impoundment closure
[d] Based on extent of permitted disturbance.
[e] Based on an estimated increase of 10 percent over current areas.
[f] Includes estimated increase of 10 percent over current areas not included in pipeline disturbance.
– = no additional disturbance predicted
Source: Unpublished AutoCAD files provided by Teck

2.2.3 Alternative C – Concentrate and Wastewater Pipelines

Alternative C is different from Alternative B in four regards: concentrate would be transported to the port site via a slurry pipeline instead of concentrate trucks, tailings impoundment wastewater would be discharged at the port site instead of Red Dog Creek through a separate wastewater pipeline, diesel would be pumped from the port to the mine via a third pipeline, and closure would be designed to minimize water treatment needs at the mine site by placing a dry cover over the tailings.

Stripping waste material overlying the Aqqaluk Deposit, mining the deposit, waste rock handling, milling operations, and tailings disposal would be the same as described in Alternative B; however, cover material stockpiles would need to be developed (Figure 2.8). As in Alternative B, tailings would continue to be placed in the existing tailings impoundment and the dam for the tailings impoundment would be raised to 986 feet in elevation (208 feet tall) to account for the increased volume of tailings and water.

Under Alternative C, the NPDES permit would be revised to change the discharge location from Red Dog Creek to the Chukchi Sea at the port site as well as incorporating any changes associated with development of the Aqqaluk Deposit. Changing the discharge location would result in a change in the permit limits (discussed in more detail in section 3.5). Section 404 permits would be needed from the Corps to authorize placement of fill for construction of the pipeline routes, raising the tailings dam, and filling wetlands in the process of developing the Aqqaluk Deposit.

Under Alternative C, wastewater from the tailings impoundment water treatment facility would be transported to the port site via a 52-mile pipeline. Wastewater in the pipeline would move from the mine site to the port by gravity. The existing high-density sludge treatment would be needed to reduce metals, but enhanced treatment for TDS removal (per Alternative B) would not be required since TDS limits would not apply to the discharge. A Corps Section 10 permit would be required for installation of the treated wastewater outfall.

The zinc and lead concentrates would be transported from the mill to the port through a slurry pipeline (Figure 2.9). The slurry pipeline would require a high-pressure pump to move the concentrate from the mill to the port. The lead and zinc concentrates would be filtered at the port site in a new building adjacent to the concentrate storage building (CSB) that would cover less than one acre. The filtered concentrates would be stored in the port site CSBs. The concentrate wastewater remaining after the filter process would be treated by a new high-density sludge wastewater treatment system also located adjacent to the CSB. The treated concentrate filtrate wastewater would be combined with the treated tailings impoundment wastewater. The combined wastewater stream would be subject to a pH adjustment step and then discharged to the Chukchi Sea. Sludge from the wastewater treatment process would be combined with the concentrates and stored in the CSBs.

Alternative C also includes a pipeline to carry diesel fuel from the port to the mine. Power demands for the filter plant and diesel pump would be approximately three megawatts. While additional generators would need to be installed to ensure that the demands were met year-round, the increased energy demand at the port would be supplemented with installation of a 100 kilowatt (kW) wind turbine, which would reduce demand for diesel fuel up to an estimated 60,000 gallons annually during operations.

All three pipelines would be buried in a bench incorporated into the DMTS road.

The closure scenario for Alternative C differs from Alternative B because the waste rock dump would be temporarily reclaimed throughout the life of the operation. Beginning in 2031, the waste rock dump would be regraded to a 5:1 slope with excess material moved back into the Aqqaluk Pit (Figure 2.10). The water in the tailings impoundment would be drawn down and a dry cover would be placed over the tailings. All pipelines would be removed, at closure, including the wastewater discharge to the Chukchi Sea. Removal of the pipeline bench would reduce the long-term impact on wetlands and eliminate the

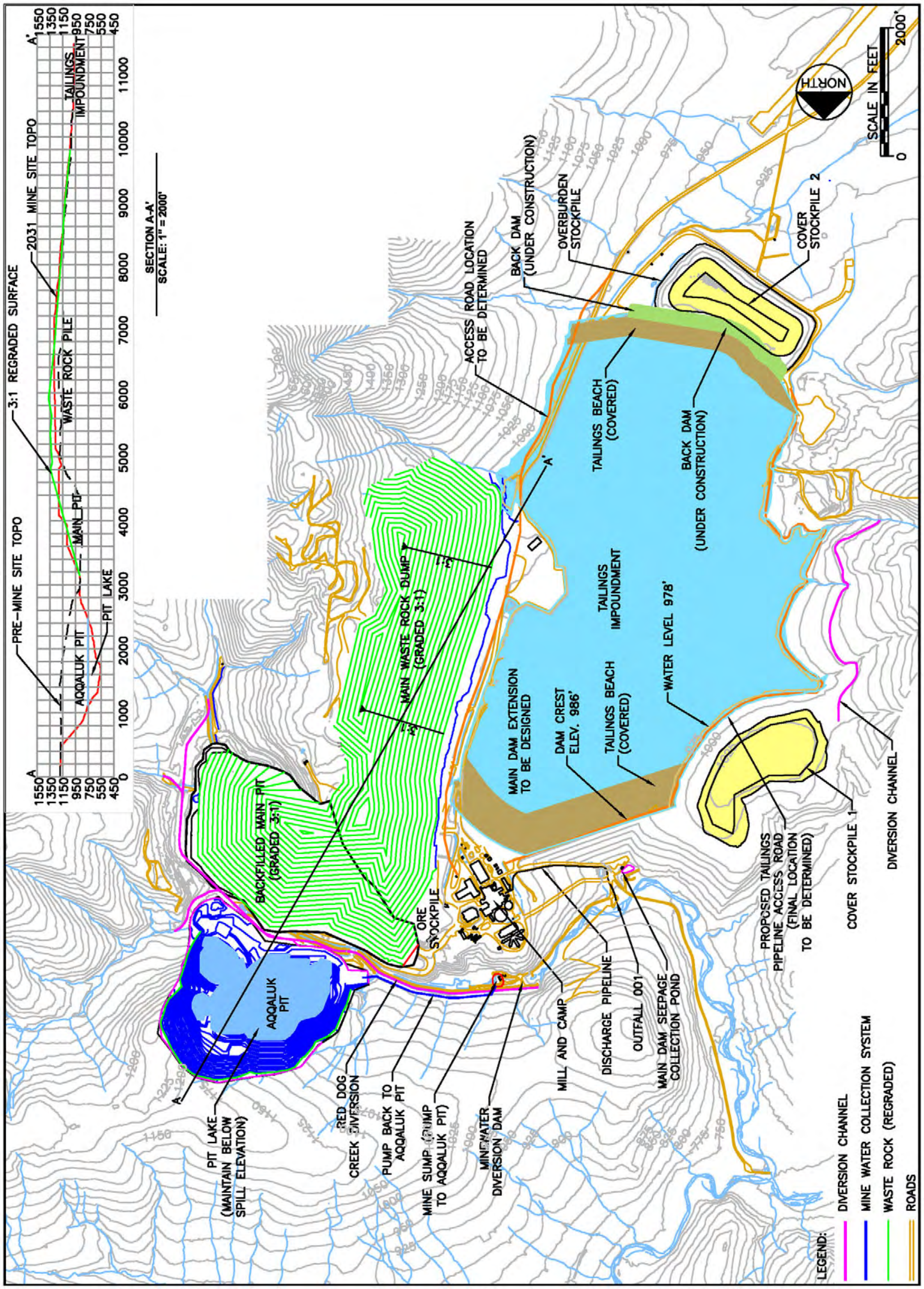


FIGURE 2.8
ALTERNATIVE C - END OF MINING 2031

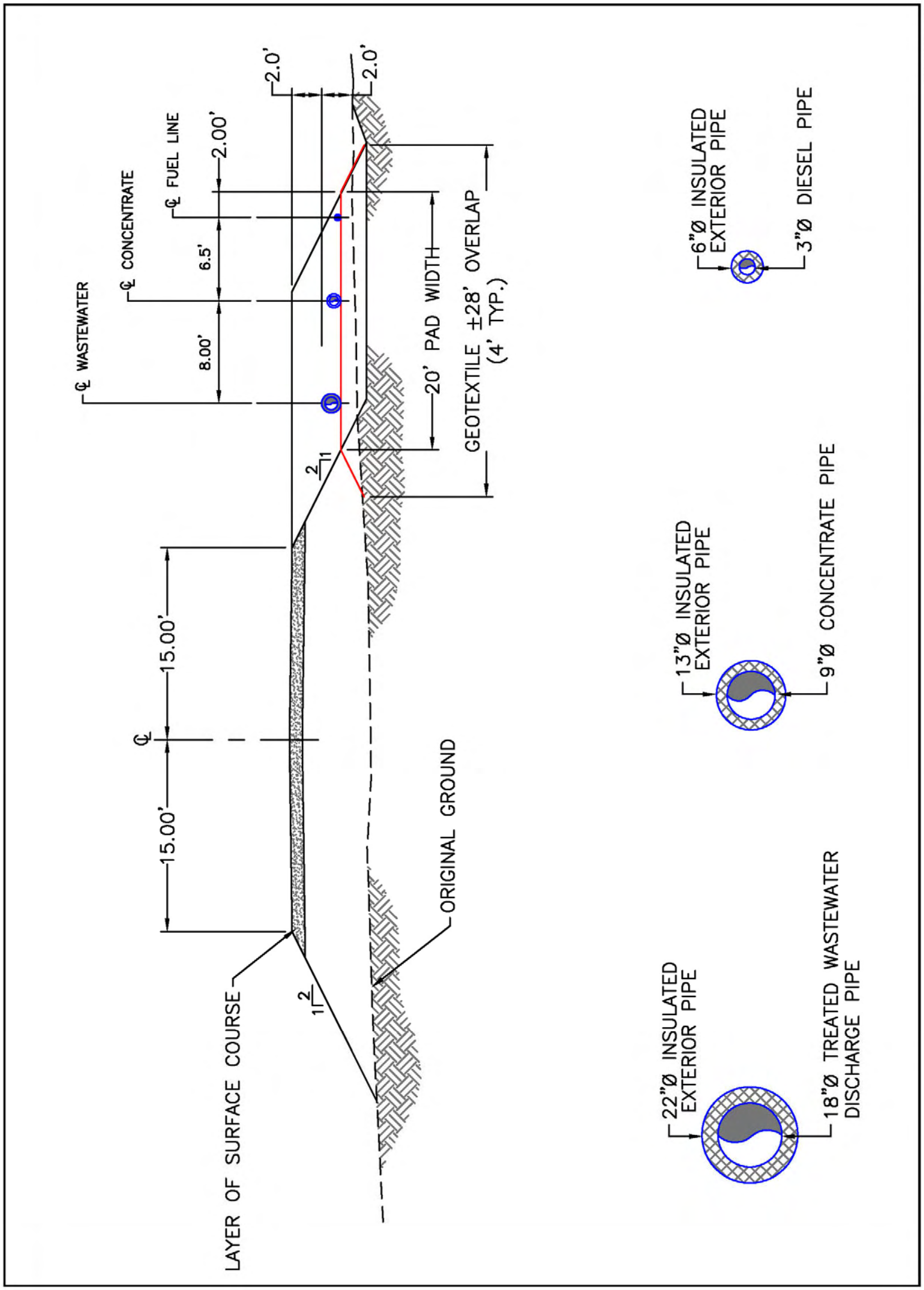


FIGURE 2.9
ALTERNATIVE C - TYPICAL ROAD FILL SECTION

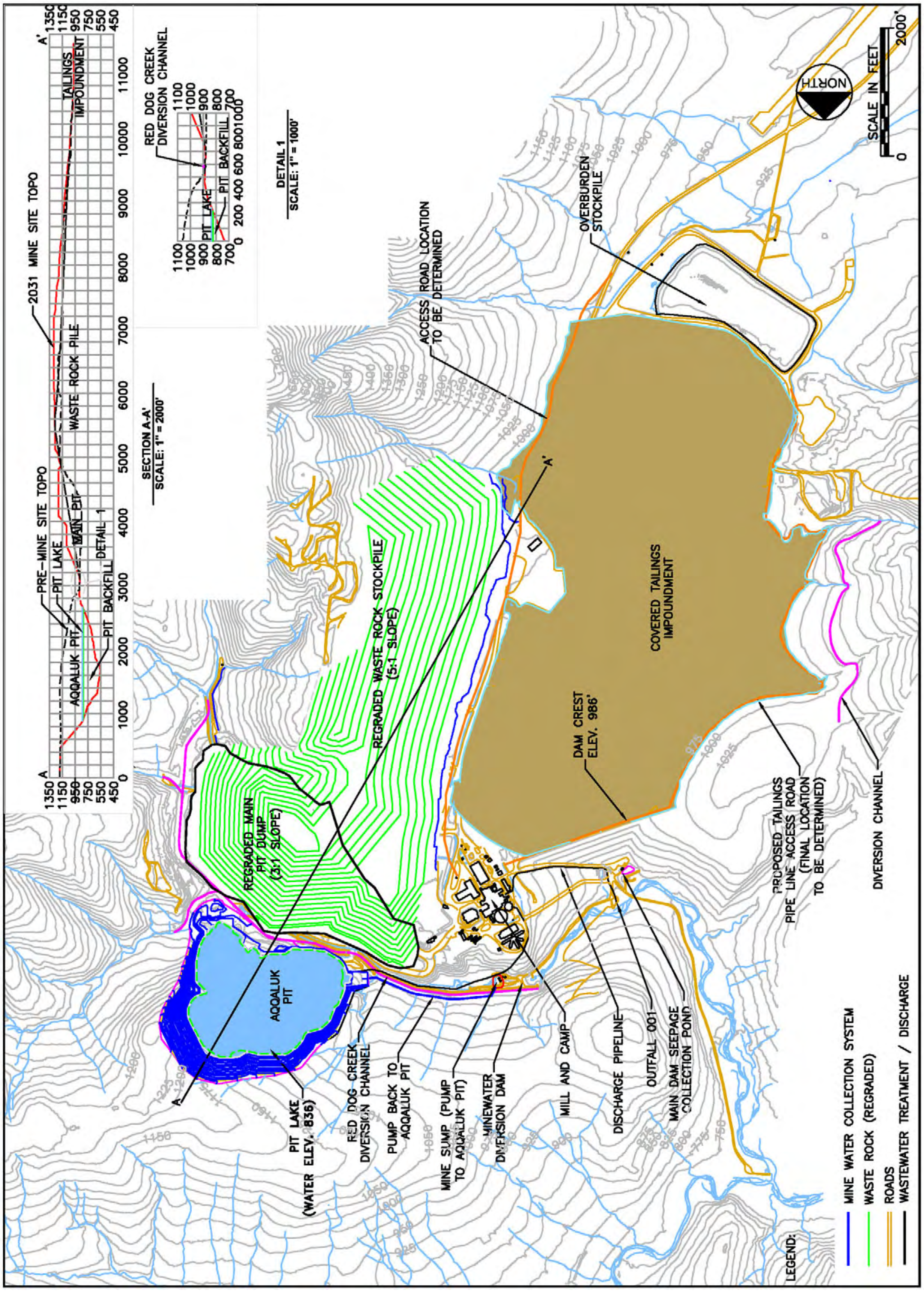


FIGURE 2.10
ALTERNATIVE C - AFTER CLOSURE 2031

need to maintain the wastewater discharge pipeline into the future. Wastewater from the mine and tailings impoundment generated after closure would be treated and discharged into Red Dog Creek. Water treatment is always expected to be necessary. Table 2-1 summarizes the additional disturbance areas resulting from Alternative C.

2.2.4 Alternative D – Wastewater Pipeline and Additional Measures

Alternative D is different from Alternative B in three regards: tailings impoundment wastewater would be discharged to the Chukchi Sea via a wastewater pipeline instead of to Red Dog Creek (similar to Alternative C), enhanced dust control measures would be implemented, and the road and port site would be closed during certain times of year to reduce subsistence impacts.

Stripping of waste material overlying the Aqqaluk Deposit, waste rock handling, milling operations, and tailings disposal would be the same as described in Alternative B. Zinc and lead concentrates would continue to be trucked from the mill to the port. To accommodate closure of the DMTS road during caribou migration, the size of the mine site CSB would need to be increased four fold. The analysis assumes this would be done within the existing disturbance footprint. As in Alternative B, tailings would continue to be placed in the existing tailings impoundment and the dam for the tailings impoundment would be raised to 986 feet in elevation (208 feet tall) to account for the increased volume of tailings and water.

Under Alternative D, the NPDES permit would be revised to change the discharge location from Red Dog Creek to the Chukchi Sea at the port site and to incorporate any changes from mining the Aqqaluk Deposit. Section 404 permits would be needed from the Corps authorizing placement of fill for construction of the pipeline route, raising the tailings dam, and authorizing fill associated with developing the Aqqaluk Deposit. Wastewater treatment would be the same as described in Alternative B, except that enhanced treatment for TDS removal would not be required. The discharge would be via a gravity-fed pipeline to the Chukchi Sea. The pipeline would be buried in a bench incorporated into the DMTS road (Figure 2.11) and would remain there in perpetuity.

Fugitive dust emissions would be reduced by the installation of two “enhanced” truck washes, one at the mine site, located near the contractor PAC and the other near the exit from the CSBs at the port site (Figure 2.12). All vehicles leaving the mine site would be required to drive through the truck wash; vehicles passing through the truck unloading building at the port would be required to pass through the truck wash prior to returning to the mine. The truck washes would include high pressure jets directed at the top, sides and undercarriage of the trucks and trailers. During the winter, a drying shed would be operated to ensure that water from the truck wash did not cause icing of brakes or other hydraulic systems on the trucks.

A “subsistence component” is incorporated into this alternative, requiring the closure of the port throughout the annual June beluga whale migration (through July 1) and closure of the DMTS road during the fall caribou migration. Reclamation and closure of the mine facilities would be the same as described in Alternative B. However, rather than discharging treated wastewater to Red Dog Creek, as in Alternative B, the discharge to the Chukchi Sea under Alternative D would remain for as long as the need for water treatment remained (Figure 2.13). Water treatment is always expected to be necessary.
Table 2-1 summarizes the additional disturbance areas of Alternative D.

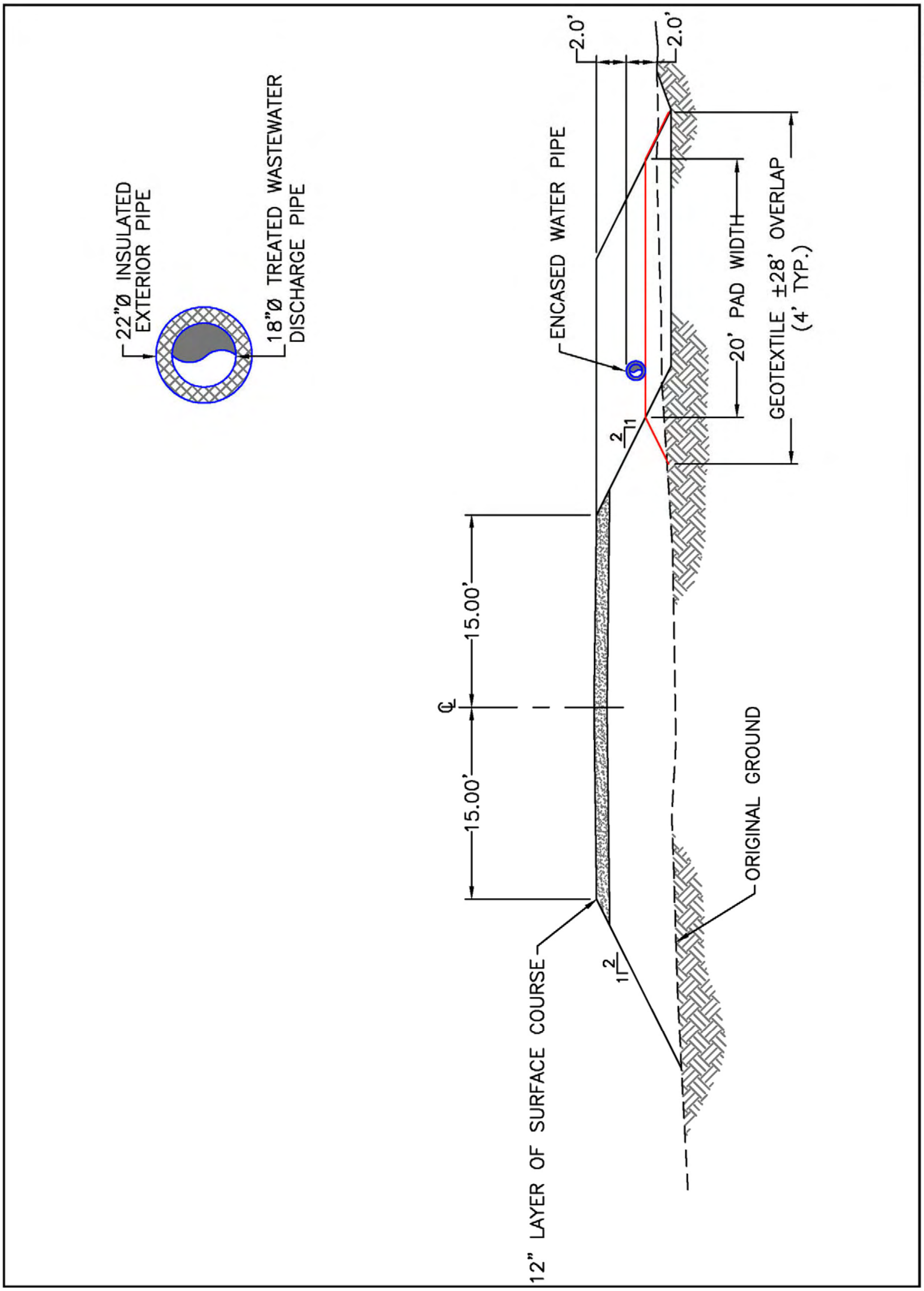


FIGURE 2.11
ALTERNATIVE D - TYPICAL ROAD FILL SECTION

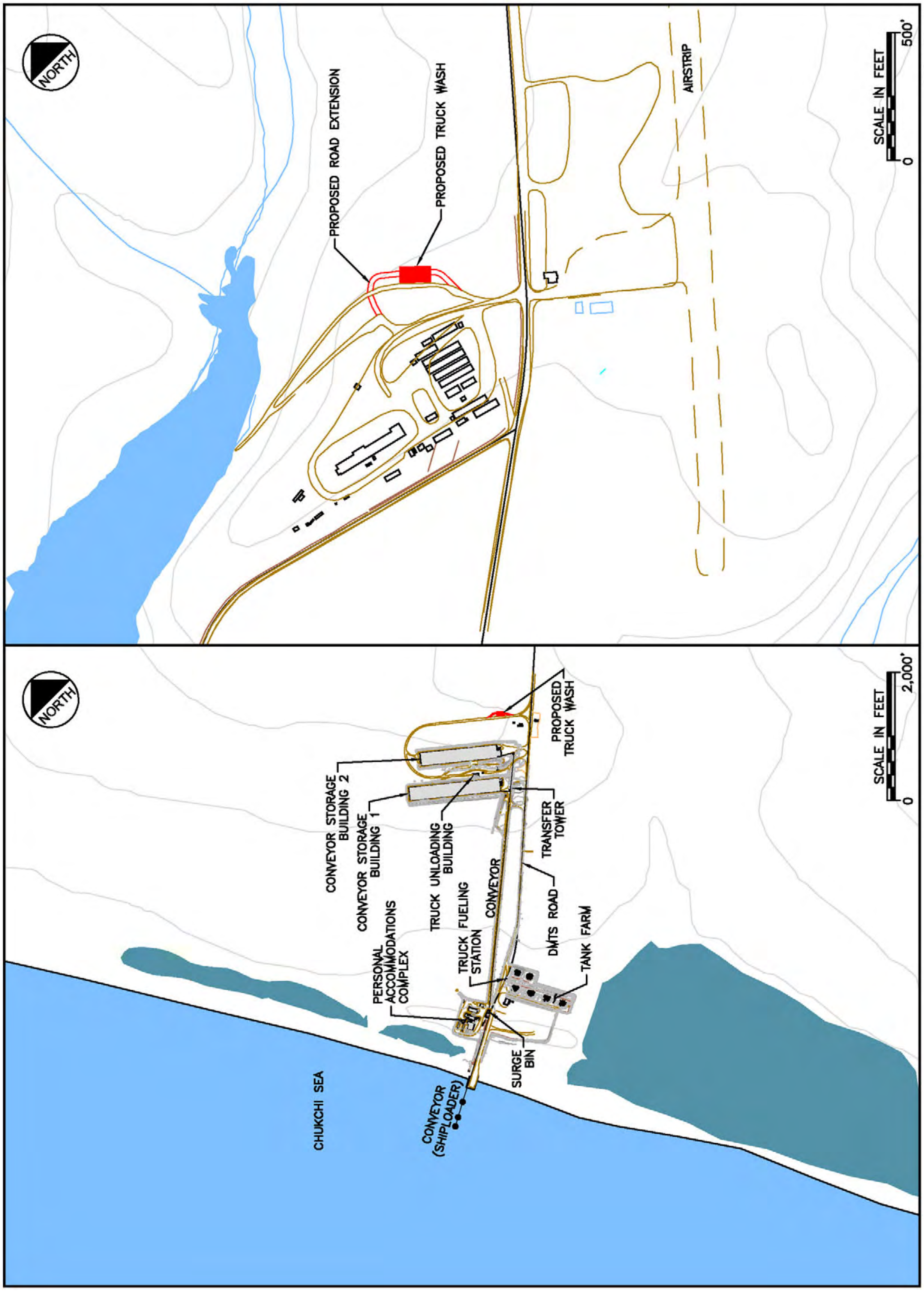


FIGURE 2.12
TRUCK WASH LOCATIONS

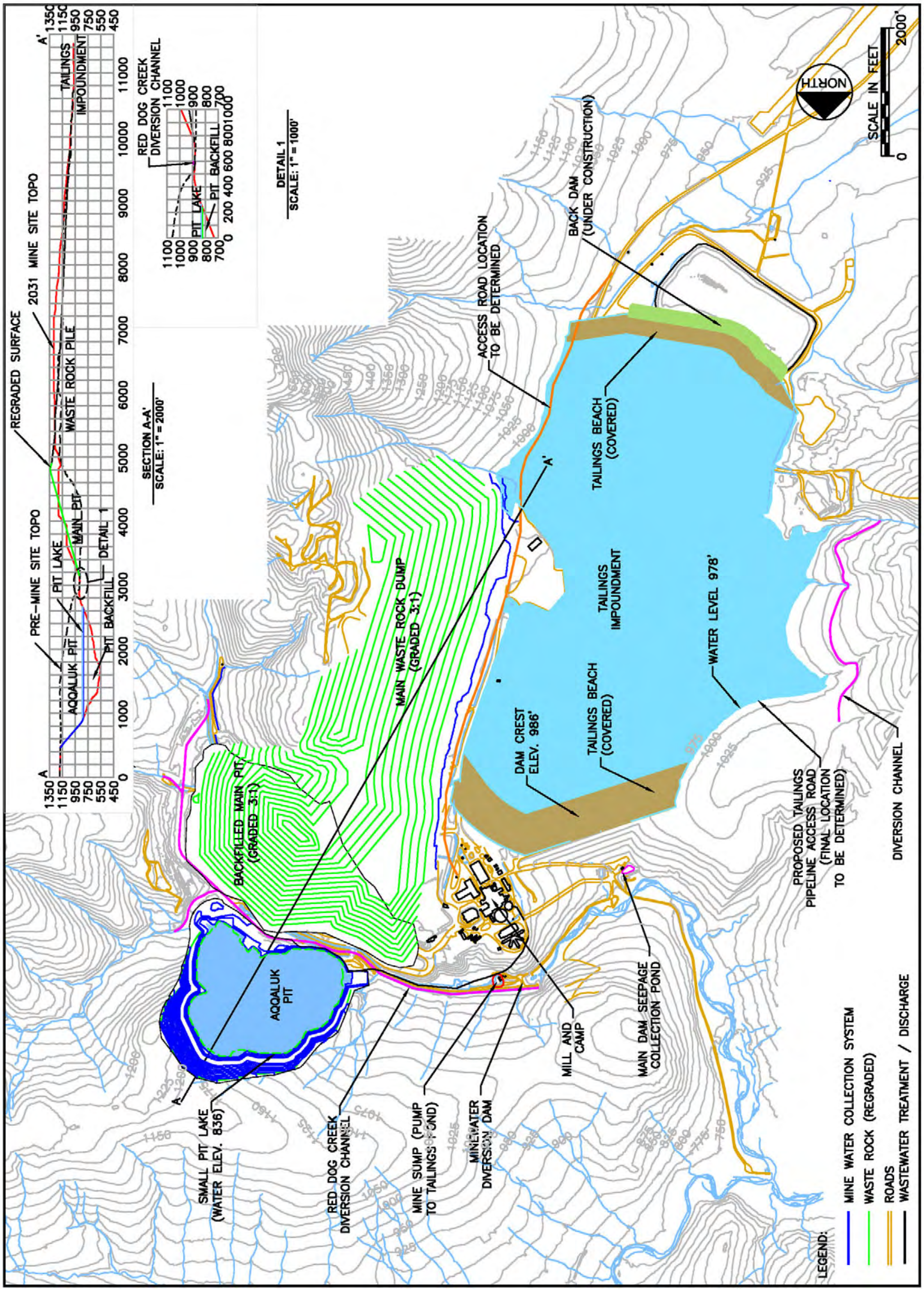


FIGURE 2.13
ALTERNATIVE D - AFTER CLOSURE 2031

2.3 Project Components in Detail

2.3.1 Project Location / Duration

The Red Dog Mine is located in northwest Alaska in the DeLong Mountains, an area that is remote and otherwise undeveloped. The location is approximately 82 miles north of the town of Kotzebue, and 46 miles inland from the coast of the Chukchi Sea. Figure 2.3 shows the location of the Aqqaluk Deposit in reference to existing mine operations. The Aqqaluk Deposit is immediately adjacent to the Main Deposit (the deposit currently being mined) to the northeast.

The Red Dog Mine began operations in 1989. At the current mining rate, the Applicant projects that the Main Deposit will be mined out in 2012 if mining extends into the Aqqaluk Deposit and in 2011 if the Aqqaluk Deposit is not developed. Development of the Aqqaluk Deposit is projected to begin in 2010 and end in 2031.

The overall location of the project would remain the same under all alternatives. However, the Aqqaluk Pit would not be developed under Alternative A and mining would end with the removal of the final ore from the Main Pit in approximately 2011.

2.3.2 Mining Methods

Mining at Red Dog currently occurs in the Main Pit. The Main Pit is an open pit mine where ore and waste rock are removed by a typical blast-shovel-truck operation. The pit is developed as a series of benches where waste material is removed to access the ore. Diesel-powered drills are used to drill a series of holes in either waste rock or ore. Depending on the objective, blasts may range from just a few drill holes to 350 holes. Blasting is carried out by filling the drill holes with a mixture of ammonium nitrate/fuel oil and emulsion blasting agents. The subsequent blast loosens the material, which is then loaded by a front-end loader into a haul truck. The current mining fleet consists of two drills, three 12-yard loaders, and seven 100-ton haul trucks. Ore is initially hauled to ore stockpiles within the Main Pit. The stockpiles allow the ore from different parts of the pit to be blended prior to being fed into the milling process. From the stockpile, haul trucks carry ore to a gyratory crusher, which is connected to the coarse-ore stockpile building via an enclosed conveyor. At the end of 2007, the Main Pit was approximately 5,200 feet long and 3,000 feet wide, extending to a depth of 220 feet below Middle Fork Red Dog Creek. At the end of mining in the Main Pit in 2011 or 2012 (depending on alternative), it will cover approximately the same area; however, the Main Pit will be deepened to 400 feet below Middle Fork Red Dog Creek.

The Aqqaluk Deposit would be mined using the same approach used in the Main Pit. Stripping waste material would begin in late 2009, after which an initial pit would be developed in 2010 within an area containing a high-grade zinc ore. Mining operations would use existing facilities and equipment with the exception of the addition of one drill, one loader, and two haul trucks that would be necessary to handle the increase in waste rock production. Ultimately, the Aqqaluk Pit would be approximately 3,400 feet wide by 2,950 feet long and 435 feet below Middle Fork Red Dog Creek.

The projected total tonnage of ore mined from the Aqqaluk Deposit is 61.4 million short tons (tons). The project would result in the production of approximately 94.7 million tons of waste rock. No additional mining method components are being considered.

2.3.3 Waste Material Disposal

Waste material is defined as rock with sub-economic value, meaning that it may contain lead and zinc minerals but the concentrations are too low to be processed economically. Currently, waste material is hauled to the waste rock dump (see Figure 2.3). The waste rock dump would remain in operation until mining in the Main Pit is completed. Under the action alternatives, waste rock would continue to be placed into the waste rock dump during initial phases of developing the Aqqaluk Pit and then backfilled into the Main Pit. During the first two years of mining of the Aqqaluk Deposit, waste rock with a high metal leaching potential (i.e., material with greater than 6 percent sulfides based on drill core samples) would be placed in the northeast end of the Main Pit below an elevation of 850 feet. (The groundwater level in the backfilled Main Pit would ultimately reach an elevation of 850 feet.)

At the end of operations in the Main Pit in 2011 or 2012 (depending on alternative), the waste rock dump would contain approximately 61.7 million tons of waste rock and encompass 260 acres (SRK 2007). Under alternatives B and D, closure (discussed in more detail in Section 2.3.18) of the waste rock dump would begin as soon as possible so that areas no longer receiving waste material would be regraded, covered, and revegetated while areas actively receiving new waste rock would remain open. Since the Aqqaluk Pit would be partially backfilled under Alternative C, some waste material would need to be moved from the waste rock dump to the Aqqaluk Pit at the end of mining operations. In this case, the dump would not be reclaimed until the backfilling operations were completed.

Low grade ore would be placed in the existing low grade ore stockpile (see Figure 2.3), for future processing if economically feasible. An estimated 94.7 million tons of waste rock and 7.7 million tons of low grade ore would be produced over the duration of mining of the Aqqaluk Deposit.

The overburden stockpile is located at the south end of the tailings impoundment. This waste material dump was created during the initial stripping of the Main Deposit. The approximately 8.6 million tons of material in the overburden stockpile has weathered and is a potential source of growth media for reclamation of the waste rock dump and other disturbed areas. The overburden stockpile was regraded in l998/1999 and seeded with native grasses from 1999 through 2001. No additional material would be added to the overburden stockpile under any alternative.

The oxide stockpiles (see Figure 2.3) consist of oxidized ore and oxidized waste that may have future value, although the processing technology needed to produce a concentrate is not currently available. The oxide ore stockpile contains approximately 4.2 million tons of material. No additional material is expected to be added to this stockpile under any alternative.

2.3.4 Ore Processing

Initially, ore from the Aqqaluk Deposit would be blended with ore from the Main Deposit for processing until the Main Deposit had been depleted in 2012. From that point until mine closure, all ore would be from the Aqqaluk Deposit.

Under alternatives B, C, and D, processing ore from the Aqqaluk Deposit is proposed to be the same as in current operations. Ore would continue to be hauled from stockpiles to the gyratory crusher. The gyratory crusher is fit with an apron feeder and a conveyor belt to transport the crushed ore to the coarse ore stockpile building, where the crushed ore is stored until milling. The crushed ore is processed at the mill, which uses grinding and conventional froth flotation to recover sphalerite (zinc sulfide) and galena (lead sulfide) that contains silver. In the primary grinding circuit, the crushed ore is mixed with process water and wet ground in semi-autogenous mills or ball mills to particles less than 65 microns in size (220 mesh). Several stages of froth flotation are employed to maximize recovery and allow efficient separation of the lead and zinc minerals. Chemicals are added during the froth flotation process to enhance recovery of the lead and zinc minerals. The undesired minerals, or tailings, are discharged as a slurry to the tailings impoundment for permanent disposal.

The resulting zinc and lead mineral concentrates are thickened and filtered to a moisture content of about 9 percent, then moved to the mill site CSB by an enclosed conveyor belt. The mill site CSB has a capacity to hold 32,000 tons of the concentrate. Concentrates are loaded onto concentrate trucks in a structure adjacent to the CSB. The trucks enter and exit the building through doors that are closed when not in use. About 120 tons of concentrate is loaded onto the truck by a front-end loader. The trucks deliver the concentrate to the port site where it is stored in two large CSBs until shipment. Currently, mineral concentrates are shipped to markets outside the State of Alaska. Under Alternative C, the concentrates would not be thickened and filtered for hauling to the port; instead the concentrate slurry would be piped to the port where filter presses would remove excess water prior to storage. This process is described in more detail in Section 2.3.9.

It is expected that the Aqqaluk ore hardness will increase after the first several years of mining, such that two of the semi-autogenous grinding mills would require upgrading to increase the motor size from 2000 horsepower (hp) to 2750 hp.

2.3.5 Tailings Disposal

Tailings are currently pumped from the mill to the tailings impoundment via a 6,500-foot pipeline. The tailings impoundment is located in South Fork Red Dog Creek, and is bordered on the north end by the main dam and on the south end by the overburden stockpile. A concrete curtain, which will function as a back dam, is under construction as of summer 2008; final construction to an elevation of 970 feet is anticipated in 2010. The main dam is currently being raised to an elevation of 970 feet, which corresponds to a total height of 192 feet. The upstream face of the dam is covered with 100-mil high-density polyethylene geomembrane to minimize seepage loss. A gravel drain that follows a former stream channel lies beneath the dam. The tailings disposal pipeline follows along the dam from the east to the west. The location of the tailings deposition is changed frequently to allow for the uniform subaqueous filling of the impoundment.

A seepage collection and pumpback system is located about 250 feet downstream from the main dam. The system is an impoundment created by a small lined dam and three pumps connected in parallel to a 14-inch high-density polyethylene pipe that discharges to the tailings impoundment. Any water from the dam underdrain and precipitation that collects in the seepage collection system is pumped back to the tailings impoundment. A secondary pumpback system composed of a sump and a well is situated downstream from the seepage collection system and pumps water from the well back to the seepage collection system.

Under alternatives B through D, tailings created from mining of the Aqqaluk Deposit would be placed in the existing tailings impoundment. To accommodate the additional tailings volume, and a freeboard requirement of five feet, the main dam would need to be raised 16 feet to an elevation of 986 feet (208 feet tall at its maximum). The maximum water level in the impoundment would reach an elevation of 978 feet with the final tailings level (“struck level”) reaching an elevation of 976 feet. The mine access/haul road and the access road around the tailings impoundment would also need to be raised to accommodate the higher water levels in the impoundment.

2.3.6 Wastewater and Storm Water Management

Water management practices include diversion of clean runoff and drainage areas to natural water courses to prevent contamination. The Red Dog Creek Diversion diverts Middle Fork Red Dog Creek (the main drainage in the mine area) and tributary creeks around the mine area. The diversion consists of three sections (see Figure 2.3). The first section channels clean water from Middle Fork Red Dog Creek and Rachel Creek around the east and northeast sides of the Main Pit in a 72-inch culvert that extends to the confluence with Connie Creek. A 96-inch culvert extends from that point to the confluence with Shelly Creek between the Main Pit and the Aqqaluk Deposit. The third diversion section is a lined channel that runs from the mouth of the 96-inch culvert to the Red Dog Creek Diversion dam, where it re-enters the original stream bed. Sulfur Creek enters the diversion within the third section. The Red Dog Creek Diversion can accommodate in excess of 100-year flows.

Any contaminated or potentially contaminated water from the mine is directed to the tailings impoundment, which is currently holding approximately 4.2 billion gallons of water. Sources of water that are directed to the impoundment include mine drainage from the Main Pit, runoff from the waste rock dump, and process water entrained in the tailings slurry.

Water that enters the Main Pit becomes contaminated with suspended solids, dissolved solids, and metals via contact with mined materials and surfaces. The water collects in low areas of the pit, or sumps, and is pumped to the mine water sump, from which it is pumped to the tailings impoundment. The mine water sump contains eight pumps to pump water to the tailings impoundment.

The mine water collection system also collects water from Hilltop Creek, which drains the east side of the ridge below the oxide ore stockpile and drains to the mine water sump by a ditch. Leakage from the Red Dog Creek Diversion and areas downstream of the diversion intake points for Connie Creek and Shelly Creek are directed to the collection system either by gravity flow, or by French drains under the diversions that direct the water that is not captured to the mine water sump. Storm water that drains from the exploration areas associated with the Aqqaluk Deposit is collected by French drains that pass underneath the Red Dog Creek Diversion and is directed to the mine water sump.

Runoff from stockpile areas originates from the area of the waste rock dump, the low-grade ore stockpile, the oxide-ore stockpile, and portions of the Qanaiyaq Deposit. The runoff contains elevated levels of TDS, sulfate, and metals. The majority of this runoff is directed to the tailings impoundment, but during the summer months, a portion is collected and treated at Water Treatment Plant 3 (see description below) prior to discharge to the tailings impoundment.

Three water treatment plants treat contaminated water at the mine site. Water Treatment Plant 1 treats water reclaimed from the tailings impoundment for use in the mill. At the treatment plant, lime (alkaline) is added to reclaimed water to elevate the pH levels and precipitate out metal hydroxides and gypsum. Sludge from the treatment plant is disposed in the tailings impoundment.

Water Treatment Plant 2 treats water from the tailings impoundment prior to discharge to Red Dog Creek at Outfall 001 during the summer months. Metals are removed using a high density sludge system. Sodium sulfide is first added to the feed water to enhance cadmium precipitation. The feed water is mixed with flocculant in agitator tanks and the precipitate is separated from the treated water in a clarifier. Lime is added to raise the pH and precipitate metal hydroxides. Most of the clarifier sludge is recycled back to the inlet, although a small portion of the sludge is discharged to the tailings impoundment. The treated water is passed through sand filters for further removal of zinc hydroxide and other suspended solids prior to discharge.

Water Treatment Plant 3 treats runoff and seepage from the waste rock dump and mine sump before discharge to the tailings impoundment during the summer months. Treatment of the runoff is expected to reduce TDS and sulfate levels in the tailings impoundment, and improve the performance of the first two treatment plants. Lime is added to raise pH and precipitate metal hydroxides and gypsum (sulfate). Treatment plant sludge is disposed in the tailings impoundment.

The Applicant has been collecting the storm water runoff associated with the Aqqaluk Pit since 1991. During development at the Aqqaluk Pit, storm water and seepage from the area would be collected and pumped to the tailings impoundment. As the depth of the pit descends below the permafrost level, there is potential for seepage of the underlying groundwater. Water that enters the pit and contacts pit walls is expected to have high concentrations of dissolved salts and metals. The infiltrating groundwater would be collected and pumped to the tailings impoundment for treatment. A diversion of Sulfur Creek would be necessary at some point in the process of developing the Aqqaluk Deposit.

Partial covering of the waste rock dump would occur during mining of the Aqqaluk Deposit, which would reduce the amount of contaminated mine water needing to be managed. Water management for all other areas of the site would continue as currently practiced. The following sections describe the differences in wastewater treatment for the alternatives.

2.3.6.1 Alternative A – No Action Alternative

Under Alternative A, the no action alternative, the NPDES permit would not be reissued. Therefore, Teck would need to comply with the limits in the 1998 permit. Teck's existing water treatment is capable of producing an effluent that complies with the metal limits in the 1998 permit. However, the water treatment plant is not adequate to meet the low TDS limits. The TDS limits in the 1998 permit are 170 milligrams per liter (mg/L) monthly average and 198 mg/L daily maximum. Alternative A includes installation of a modified water treatment process adequate to meet these limits. TDS is comprised of a range of different materials that dissolve in water. In the Red Dog Mine tailings impoundment, the TDS primarily consists of sulfate, magnesium, and calcium although other materials are also found. The viable treatment processes must remove each of these materials at sufficient levels to ensure compliance with the 1998 permit limits. Reverse osmosis with pretreatment for gypsum removal is the only proven treatment option that can achieve this requirement.

Reverse osmosis is a membrane treatment process in which wastewater is forced through a semi-permeable membrane under pressure. The pressure required depends on the TDS concentration and must be greater than the osmotic pressure for the solution. Typical pressures for reverse osmosis applications range from 300 to 1,200 pounds per square inch to create a flow of clean water from low TDS concentration to high TDS concentration through the membrane. Reverse osmosis systems have been operated at sizes much greater than what is required for the Red Dog Mine and should be capable of removing up to 98 percent of the TDS, so discharge limits can be achieved.

The current high TDS concentrations in the tailings reclaim water (4,000 mg/L), would reduce the effectiveness of a reverse osmosis system alone. As noted above, the mine has been disposing of sludge generated from Water Treatment Plant 2 in the tailings impoundment since the start of operations, contributing to gypsum levels near saturation in the pond water. Using gypsum saturation as the design point for the reverse osmosis process, the maximum recovery of clean water would likely be in the range of 30 to 50 percent. Therefore, to discharge 15 million gallons per day (MGD) of treated water during the discharge season, 30 to 50 MGD would need to be processed creating a brine wastestream of 15 to 35 MGD. With the reverse osmosis influent at the gypsum saturation concentration, the membranes are highly likely to foul or clog, resulting in unreliable performance. A form of pretreatment to reduce TDS levels influent to the reverse osmosis system would be necessary for the system to function properly.

Pretreatment would consist of adding barium hydroxide or aluminum hydroxide to remove gypsum from the reverse osmosis influent. Assuming pretreatment of the entire discharge, TDS levels would be reduced to 1,500 mg/L in the influent to the reverse osmosis system. At this level, maximum recovery would be increased to approximately 75 percent, i.e., to discharge 15 MGD, 20 MGD would need to be treated resulting in a brine wastestream of approximately 5 MGD.

Sludge from the barium or aluminum hydroxide pretreatment process would be chemically stable and would be disposed in the tailings impoundment during operations and in the Main Pit after closure for the reasonably foreseeable future.

To permanently reduce TDS levels in the impoundment, the brine wastestream cannot be disposed of in the tailings impoundment. Disposal of brine in the waste rock dump and Main Pit would present similar challenges because the brine could be resolublized into the water draining from these disposal facilities, which is pumped to the tailings impoundment. Therefore, an encapsulated disposal area able to contain 100 tons per day of brine during the operating discharge season and for the foreseeable future after closure would be built in a portion of the Main Pit. The Main Pit would have the capacity to hold more than 50 years of both precipitation sludge and brine.

The use of barium or aluminum hydroxide and reverse osmosis would require a larger footprint for the treatment plant. The required space is not available at the mill. Under this alternative, it is assumed that a new treatment facility would be constructed at the northeast edge of the impoundment. This would include a thermal evaporation system to consolidate reverse osmosis solids in the brine prior to disposal. Based on the conceptual design, the new facility is estimated to encompass an area of 250 by 150 feet. This area, however, could vary greatly depending on the final design configuration.

Reverse osmosis systems are in place at other mines and other industrial facilities, and are used on wastewaters with metals loadings comparable to the Red Dog Mine. However, the specific reverse osmosis treatment system combined with barium hydroxide pretreatment proposed for the Red Dog Mine has not been used at other locations. While it is technically feasible, the high TDS levels in the influent and the adverse climatic conditions will present challenges for successful design and operation. The system would, therefore, require an extended timeframe for pilot-testing and full-scale optimization.

The treated wastewater would be discharged to Red Dog Creek seasonally, when there is flow in the Creek. The discharge season typically begins in May and ends in October.

2.3.6.2 Alternative B – Applicant's Proposed Action

Under Alternative B, the reissued NPDES permit requires compliance with instream TDS limits of 1,500 mg/L in Main Stem Red Dog Creek, 1,000 mg/L in Ikalukrok Creek immediately downstream of the confluence with Red Dog Creek and, after July 25 of each discharge season, 500 mg/L approximately 10 miles downstream of the confluence. The water treatment facilities would be unchanged from the current system. However, Teck has proposed to use additional treatment using barium hydroxide, in place of calcium hydroxide, as needed throughout the discharge season to lower TDS levels and ensure that there is no excess water accumulating in the impoundment.

Both calcium and barium hydroxide are added as reagents to produce insoluble calcium and barium sulfate; the precipitation of which reduces TDS. Because barium sulfate is more insoluble than calcium sulfate, it is more easily removed from the wastewater and therefore more effective in TDS removal. Use of barium hydroxide would reduce sulfate levels in the Outfall 001 discharge from 2,500 mg/L to approximately 800 mg/L with a corresponding decrease in TDS concentrations. Barium precipitation would increase the sludge volume requiring disposal by as much as 50 to 100 tons per day. Barium sludges are generally stable and would be placed in the tailings impoundment during operations and the pits after closure for the reasonably foreseeable future without a concern about metals release. Under Alternative B, the Main Pit would have the capacity to store 50 years of sludge generated at a rate of 100 – 200 tons per day after mine closure. Beyond this time, the Aqqaluk Pit would also provide long-term capacity.

For the past 10 years, Teck has investigated a range of different operational and water treatment measures to reduce TDS levels in the tailings impoundment and the discharge from Outfall 001. These studies led to the design and installation of Water Treatment Plant 3 to pretreat waste rock dump seepage that has the highest TDS concentrations. During 2007, Teck changed the intake location from the surface of the pond to the bottom of the pond. This resulted in a higher TDS feed to the water treatment plant and a higher amount of TDS discharged from the tailings impoundment. Other ongoing studies include ways to optimize the volume of effluent that is discharged during high-flow periods (when the highest dilution is available) and measures to reduce gypsum saturation in the impoundment.

In the near term, the use of barium hydroxide treatment provides a proven approach to increase discharge volumes and reduce water levels in the impoundment. The reissued NPDES permit for this alternative includes a special condition that requires Teck to develop and implement a plan to permanently ensure compliance with TDS limits while maintaining a positive water balance, i.e., the annual discharge from the impoundment is at least as great as the inflows to the impoundment. EPA will review the plan prior to implementation. EPA anticipates that the plan will include a combination of source control and water treatment measures, including barium hydroxide addition.

Per current operations, the treated wastewater would be discharged to Red Dog Creek when there is flow in the Creek.

2.3.6.3 Alternative C – Concentrate and Wastewater Pipelines

Under Alternative C, treated wastewater from the tailings impoundment would be transported to the port site via a pipeline, combined with the concentrate filtrate, and discharged to the Chukchi Sea. The reissued NPDES permit would change the outfall location from Red Dog Creek to a location in the Chukchi Sea and would include limits protective of marine aquatic life.

Tailings impoundment wastewater would continue to be treated in Water Treatment Plant 2; however the use of barium hydroxide to reduce TDS levels would not be necessary. Wastewater would be transported to the port site in an 18-inch diameter pipeline that would be built in a bench incorporated into the DMTS road. Wastewater would be carried through the pipeline at a rate of approximately 3,000 gallons per minute.

As described below in Section 2.3.9, under Alternative C the lead and zinc concentrates would be transported to the port site via a slurry pipeline. The concentrate slurry would be pumped to a filter where the dry concentrates would be collected and the wastewater sent to a new treatment plant constructed at the port site. The estimated volume of concentrate wastewater generated in the filtration process is 800 gallons per minute. The treatment system would be comparable to the existing high-density sludge system at the mine site. The treated concentrate wastewater would be combined with the treated tailings impoundment wastewater and subjected to a pH adjustment step to meet the pH limits in the NPDES permit. The combined wastewater would be discharged to the Chukchi Sea. Unlike alternatives A and B, the discharge would be year-round.

Sludge from the concentrate wastewater treatment process at the port would be mixed with the concentrate. At the mine, tailings impoundment wastewater treatment sludge would continue to be disposed in the tailings impoundment during operations and would be disposed of in the Main Pit after closure.

2.3.6.4 Alternative D – Wastewater Pipeline and Additional Measures

Alternative D includes the pipeline transport of treated tailings impoundment wastewater to the port site as described for Alternative C. Therefore, under Alternative D the reissued NPDES permit would change the outfall location from Red Dog Creek to a location in the Chukchi Sea and permit limits would be revised based on marine water quality standards. As in Alternative C, the discharge would be year-round. Under this alternative, concentrate would continue to be transported to the port site via trucks. Therefore, this alternative does not include the concentrate wastewater treatment component as described for Alternative C. Wastewater sludge management would be the same as described in Alternative B.

2.3.7 Sanitary Wastewater

Domestic wastewater from the mill, mine site PAC, and the services complex is currently collected and treated at the sewage treatment plant by solids/liquids separation and disinfection prior to discharge to the tailings impoundment. The average annual flow is approximately 17 millions gallons (47,000 gallons per day). A similar water treatment plant located at the port site treats domestic wastewater from the port site PAC. The port site water treatment plant discharges between 6,000 to 7,500 gallons per day to the Chukchi Sea during the shipping season and averages about 2,500 gallons per day during the winter. The design capacity is 12,000 gallons per day (approximately 4.4 million gallons per year). No changes in either system are expected under any of the alternatives during operations. The volume of discharge at both locations would decrease dramatically following closure in all cases.

2.3.8 Water Supply

Potable water is provided by a potable water treatment plant. Raw water is provided from the Bons Creek Reservoir near the contractor PAC. The reservoir was created by building a small dam across Bons Creek; water is replenished in the reservoir each spring by snow melt and precipitation. Water is pumped to the potable treatment plant through insulated, heat-traced pipes and treated with a polymer addition for flocculation, a two-stage sand filter, and calcium hypochlorite for disinfection. The treated water is pumped from a holding tank within the treatment plant to the mine site PAC, mill complex, services complex, and to other small buildings on the mill site. At the port site, drinking water is generated using a desalinization unit consisting of a filter, reverse osmosis, and chemical treatment. No changes in either system are expected with implementation of any of the alternatives. Like the sanitary wastewater system, the demand for fresh water at both locations would decrease following closure under all alternatives.

2.3.9 Concentrate Transportation

Concentrate is moved from the mine site to the port site in 130-ton concentrate trucks (Figure 2.14). The trucks consist of tandem self-rotating trailers equipped with hydraulically operated covers. Unloading of the trailers is accomplished by opening the cover and rotating the trailer sideways on its long axis. A fleet of 11 trucks operates at the mine although only seven or eight trucks are active at any one time. On average, the eight trucks complete a total of 36 round trips per day. Trucking is scheduled 24 hours a day, 365 days a year, although weather conditions occasionally close the DMTS road for varying periods of time. The DMTS road may also be closed for caribou crossings.

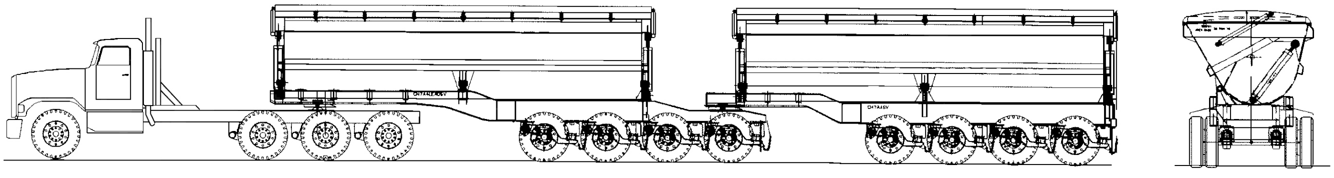


Figure 2.14 Concentrate Truck

The loading process consists of trucks entering and exiting a separate loading area attached to the mill site CSB. Trucks pass into the loading area through doors that are closed while the loading process is underway. A front end loader loads the concentrate into each trailer. During the summer, trucks exit the CSB and drive through a truck wash that sprays water on the top and sides of the truck and trailer. Washing is not used in the winter because of safety concerns associated with freezing brakes and hydraulics. The concentrate is then hauled down the DMTS road to the port site where the trailers are emptied one at a time in the truck unloading building. The truck unloading building is designed to minimize the escape of concentrate during the unloading process. The unloading building includes an enclosed dumping area where a bag house and a negative air system create enough negative air pressure to ensure that airborne particles are deposited within the building. The hopper receiving the concentrate is connected to the port site CSBs through an enclosed conveyor system.

Concentrate trucks operating along the haul road would continue to be used to transport concentrates from the mill area to the port under alternatives A, B, and D. Alternative C includes concentrate transport via slurry pipeline as described below.

Under Alternative C, concentrates would be moved as a slurry (55 percent solids) from the mine to the port site via a 9-inch diameter pipeline located in a pipeline bench that would be incorporated into the DMTS road (see Figure 2-9). The lead and zinc concentrate slurries would be carried as alternating “slugs.” Two inches of insulation would encase the slurry pipeline to protect it from freezing as well as minimizing the influence of the pipeline on permafrost. The top of the bench would need to be approximately 20 feet wide so that adequate space could be maintained between the pipelines to allow maintenance. The bench would also need to be wide enough that equipment could operate on it during construction (a total disturbance footprint approximately 24 feet wide in a bench incorporated into the DMTS road). The bench would impact approximately 145 acres. Approximately 976,000 cubic yards of fill material would be required. Similar to the DMTS road construction methods, a geomembrane material would be placed over the tundra and backfilled to a height of three feet. The pipes would be placed on the bench and then an additional two feet of material placed on top of the pipes to serve as an insulating layer and also to protect the pipes from traffic. A Section 404 permit from the Corps would be required to authorize placement of fill for construction of the pipeline bench within jurisdictional wetlands.

Where the pipeline would cross streams with bridges, the pipes would be cantilevered from the bridges. Where the pipeline would cross streams carried by culverts, the culverts would be extended and the pipeline placed on fill on top of the culverts. This approach would also be used for the wastewater pipelines under alternatives C and D and the diesel pipeline under Alternative C.

Under Alternative C, the concentrate slurry would be filtered at the port site. Concentrates would be stored in the port site CSBs prior to shipping. The wastewater filtered from the concentrates would be managed as described in Section 2.3.6.3.

Alternative D includes the installation of two high pressure truck washes, one at the mine site, located near the contractor PAC and the other near the exit from the CSBs at the port site (see Figure 2.12). The truck washes would include high pressure jets directed at the top, sides and undercarriage of the trucks and trailers. The truck washes would be paired with dryers designed to remove all the moisture from the trucks and trailers in the winter to avoid problems of freezing brakes and hydraulics. Also under Alternative D, concentrate truck traffic would need to be increased from 36 to 54 round trips per day for a period of 60 days prior to DMTS road closure during caribou migration.

2.3.10 Power Supply

Electric power to the site is provided with eight 5-megawatt diesel-powered generators that are housed within two power houses. The power houses are located next to the mill. The generators use No. 1 and

No. 2 diesel fuel, and small quantities of used oil. Three 650-kW diesel generators supply emergency power. The power generators are equipped with air pollution control measures to reduce emissions of nitrogen oxides.

Heat for mine site buildings is generated by heating a glycol/water mixture with recovered diesel engine heat and circulating the mixture by pumps to mine site buildings. Emergency heat is provided by three standby glycol/water heaters rated at 8,000,000 British Thermal Units (BTUs).

Under Alternative A, the use of a reverse osmosis wastewater treatment system is expected to increase power demand by an additional 10 megawatts. The increase in power demand would require the construction of an additional power distribution system and installation of three 5-megawatt generators. Two of the new generators would be in operation at any given time with the third available as a back-up.

Power requirements under alternatives B and D are similar to current conditions and would continue through mining of the Aqqaluk Deposit. Under Alternative C, pipelines would transport concentrates from the mine to the port, and fuel from the port to the mine. Transporting the concentrates as a slurry would require an active pumping system, filtering of the ore concentrate at the port facility, and treatment of the contaminated water prior to discharge into the Chukchi Sea. The pipeline for treated wastewater from the mine to the port would be gravity fed, but transporting fuel to the mine would require active pumping. Under Alternative C, power requirements would increase from current conditions by approximately three megawatts because of the power required to pump the concentrate slurry and diesel, filter the concentrate at the port, and operate the wastewater treatment plant at the port.

Wind power would supplement power under Alternative C to reduce the amount of diesel fuel needed. Alternative C would include the initial installation of one 100-kW turbine with additional turbines being added as they could be practicably integrated into the power supply and distribution system. The wind turbine would be located at the port site at a location to be determined. The disturbance footprint would be less than one acre.

Under all alternatives, power would be required after closure for the wastewater treatment system. The amount of generation capacity needed at that point would be substantially less than during operations.

2.3.11 Fuel Use and Storage

Diesel fuel is used daily for power generation, equipment operation, and vehicle use. Jet A fuel is used for air transportation services. Diesel fuel is shipped to the port facility each summer by barges directly and by tanker with lightering to the port by barge. Fuel is pumped from the barge to the storage tanks and transported daily from the tanks to the mine site by a 25,000-gallon tanker truck. Diesel fuel is stored at the mine site in two single-walled tanks, with a combined holding capacity of 2.3 million gallons, set within a lined basin for secondary containment. Jet A fuel is stored on site in two double-walled tanks, which have a storage capacity of 200,000 gallons each. Approximately 46,000 gallons of diesel fuel are used daily, and 150,000 gallons of jet fuel are used annually. Table 2.3-1 presents the average volume of diesel fuel consumed at the Red Dog Mine under current conditions.

Alternative A would require an increase in the annual use of approximately 6 million gallons to supply the additional generators for the reverse osmosis system. The additional fuel would require two additional 200,000-gallon storage tanks to be installed at the port. That rate of fuel consumption would continue until closure in 2011. Under alternatives B through D, an increase in the mining equipment required because of the increase in waste rock generation would correspond to an increase of fuel required, at least for the two years when the Main Pit and the Aqqaluk Pit would be mined concurrently. Daily fuel use would then be similar to current fuel consumption. However, under alternatives C and D, additional fuel would be necessary for the installation of the pipeline benches, which would involve transport of construction materials, and the equipment required for pipeline installation.

Table 2.3-1 Average Volume of Diesel used in Existing Operations

Application	Volume of Diesel Consumed (gallons/year*)
Generators, Mine	13,353,820
Generators, Port	1,950,675
Mobile Sources, Mine	741,694
Material Transportation (concentrate, fuel, supplies)	664,691
Total	16,710,880

*Numbers represent the average use between 2000 and 2006

Source: Teck 2008 (Fuel)

Under Alternative C, the use of pipelines would eliminate the concentrate truck and fuel tanker truck traffic between the mine and the port, and reduce traffic related fuel use during the life of the operation. As discussed above under power supply, additional power would be necessary for the pumps, filter presses, and water treatment that would be necessary with a concentrate slurry pipeline. The fuel needed to provide the power for these uses would offset the fuel saved by not using concentrate trucks to move the concentrate. Similar to pipeline construction under Alternative C, additional fuel would be required during construction of the pipeline bench under Alternative D. The estimated fuel consumption by alternative is presented in Table 2.3-2.

Table 2.3-2 Projected Annual Diesel Use during Operations

Alternative	Volume of Diesel Consumed (gallons/year)
Alternative A	22,710,880
Alternative B	16,710,880
Alternative C	16,710,880 [a,b]
Alternative D	16,710,880 [a]

[a] Diesel consumption would increase during construction of the pipe bench

[b] Data provided by Teck indicates that diesel saved by eliminating the concentrate trucks would be offset by additional demand in generators.

The subsistence closure of the DMTS road during the fall caribou migration would require the construction of an additional 200,000-gallon diesel storage tank at the mine site. The additional storage capacity would allow diesel transportation between the port and the mine to cease for 30 days.

2.3.12 Handling and Storage of Reagents and Hazardous Materials

The majority of chemicals used on the site are required for the froth flotation process. The reagents used in the froth flotation processes are summarized in Table 2.3-3. The reagents are stored in the reagent building, located west of the mill. The mill and reagent building are connected by an enclosed walkway. The reagent building provides temporary storage of reagents and facilities to mix the reagents. The reagents are mixed with water in mixing tanks, and transferred to day tanks, where they flow to holding tanks in the mill. The reagents are transferred to the mill by pipeline through the enclosed walkway. No changes in reagent use are expected.

Table 2.3-3 Reagents used in Froth Flotation Processes

Reagent	Consumption (tons/year)	Use
Lime	8,400	pH modifier, water treatment
Copper Sulfate ($CuSO_4$)	4,900	Activator in the zinc circuit
Sodium Isobutyl Xanthate (SIBX)	660	Collector in the zinc circuit
Potassium Ethyl Xanthate (PEX)	450	Collector in lead circuit
Zinc Sulfate ($ZnSO_4$)	360	Depressant in the lead circuit
Sodium Meta Bi-Sulfite (SMBS)	310	Scavenger
Sodium Sulfide (Na_2S)	250	Precipitation agent
Sodium Cyanide (NaCN)	200	Depressant
Dextrin	127	Organic depressor
Methyl Isobutyl Carbinol (MIBC)	77	Frother
Magnafloc	69	Clarification in water treatment and thickening
Antiscalent	38	Dispersant for process water

Under Alternative B, assuming treatment of 30 percent of water using barium hydroxide, lime usage would be reduced by about 600 tons per year. This corresponds to the amount of barium hydroxide that would be used.

Hazardous wastes are shipped offsite for disposal at a permitted treatment, storage and disposal facility. Glycols are either cleaned or recycled when possible, and used oil is mixed with diesel fuel and burned on site for energy recovery. Byproducts of the used oil recovery process are stored in shipping containers prior to shipping off site as used oil.

2.3.13 Non-process Waste Disposal

Two on-site landfills are used for solid waste disposal. Solid waste is initially segregated between putrescible waste, such as kitchen wastes, and other waste. Putrescible waste is collected in closed dumpsters and incinerated. Oil contaminated solid waste is collected separately and incinerated. Ash from the incinerator, other solid waste, construction waste, and burn pit ash are disposed of in the two permitted landfills on site. One landfill is near the incinerator and the other is in the waste rock dump.

2.3.14 Borrow Areas

The borrow areas (material sites) used to raise the tailings impoundment dam and build the DMTS road and conduct ongoing maintenance activities were assessed in the 1984 EIS. While additional material would need to be removed from them in developing the pipeline benches under alternatives C and D, they would not need to be expanded beyond the boundaries initially covered in the 1984 EIS. Currently Teck estimates that cover material for reclamation and closure can be obtained from material stripped in developing the Aqqaluk Pit. Therefore no additional borrow areas are expected to be developed for this project. Refer to Section 2.3.18 for a discussion of mine reclamation and closure.

2.3.15 Roads

Internal roads provide access to all major facilities on the site. The DMTS road is a 52-mile long, gravel surfaced access road from the mine site to the port facility for the transportation of concentrates, fuel, and supplies. It was built over geotextile material covered by a minimum of five feet of fill plus an additional 12 inches of 1-inch minus surface material. The DMTS road is treated annually with calcium chloride to reduce the amount of traffic-generated fugitive dust. Teck conducts ongoing testing with different dust control agents in an effort to minimize both dust generation and road maintenance. The road includes nine bridges, four major culvert crossings and 451 minor culvert crossings (PN&D undated).

The road to the tailings impoundment and the DMTS road between the mine and the airstrip would be slightly realigned to accommodate the higher water level of the tailings impoundment associated with raises of the tailings dam that would occur under alternatives B through D. Table 2.3-4 presents the extent of daily traffic expected on the DMTS road.

Table 2.3-4 Daily DMTS Road Traffic Estimate

Traffic Category	Number of Units in Use/Day per Unit*	Average Trips/Day per Unit	Maximum Trips/Day	Total Average Trips/Day*	Percentage of Total Daily Trips
Concentrate Trucks	7 or 8	5	6	36	73.6
Fuel Trucks	Up to 2	1.7	4	1.7	3.5
Supply Trucks	1 to 2	1.2	4	1.2	2.5
Maintenance Equipment	Up to 5	N/A	N/A	N/A	N/A
Light Vehicles	3 to 10	1	2	10	20.4
Total				**48.9**	**100**

*Based on NANA/Lynden shipping records for 2003.

N/A = not applicable. Maintenance equipment generally does not make “trips,” but remains in its working area.

2.3.16 Mine Site Employee Housing and Transportation

The mine site PAC can accommodate up to 365 employees. The complex includes kitchen, laundry, and recreation facilities. It is located next to the mill and connects to the mill by an elevated enclosed walkway. A contractor PAC is available for construction contractors, and is operated when construction and exploration activity is ongoing. The contractor PAC was decommissioned in 2001, but was reopened in 2007 and is used for housing in the summer season. The mine currently provides employment for approximately 360 people. Under alternatives B and D, employment would be extended with approximately the same number of employees for an additional 20 years. Under Alternative C, the number of drivers employed by NANA/Lynden, a contractor, would decrease since trucking of concentrate and diesel fuel would be eliminated in favor of pipeline transportation.

Year-round transportation to and from the mine site for personnel, equipment, supplies, and perishables is provided by an airstrip with capabilities to handle commercial jet aircraft. The paved airstrip is located approximately three miles south-southwest of the mill (see Figure 1.2). Unpaved roads provide access to each of the major facilities on site.

2.3.17 Port Facility

The DeLong Mountain Terminal (port site) is located on the Chukchi Sea, nearly 52 miles from the mine site. The facility, owned by AIDEA and managed by Teck, consists of a housing unit (PAC), six diesel storage tanks, two CSBs, a laydown area, and a concentrate conveyor/ship loading system. Shipping of the concentrate is only possible for a few months when the waters are not ice-covered (generally July through October). The concentrate is transported year-round from the mine site to the CSBs, which can store up to nine months of concentrate production. The concentrate conveyor system that transfers the concentrates from the CSBs to the barge loader is fully enclosed. The canvas tube that directs concentrate from the conveyor to the barge, combined with curtains and bag houses on the barges limit the amount of fugitive dust released during loading operations. Once filled, tug boats tow the barge from the shallow water of the port to deep sea cargo ships anchored approximately three miles offshore. Barges use a built in conveyor (also equipped with a bag house) to transfer the concentrates to the cargo ships. The port site includes a small domestic wastewater treatment system that discharges to the Chukchi Sea under a separate NPDES permit (see Section 2.3.7).

Up to 1.5 million tons of concentrate are shipped from the port site annually. The annual volumes would not change under any of the alternatives. Under Alternative A, Teck's concentrate loading activities would only continue through 2011, after which the only annual shipping requirements would be those necessary to maintain the long-term wastewater treatment operations at the mine. Under alternatives B and D, operations at the port site would remain the same as under current conditions and concentrate shipments would continue through 2031. Under Alternative C, a filter press operation would be installed at the port site to dewater the slurried concentrates. A new conveyor would carry concentrates from the filter press to the CSBs. Wastewater collected from the filter press would be treated, combined with the tailings impoundment wastewater, and discharged to the Chukchi Sea as described in Section 2.3.6. A 100-kW wind turbine would initially be added to the port facilities under Alternative C to offset some of the three megawatts of power required for the filter press operation and the pumps (see Section 2.3.10).

2.3.18 Reclamation and Closure

Teck developed a draft detailed reclamation and closure plan that is being reviewed for approval by the State of Alaska that includes the reclamation and closure of the Aqqaluk Deposit. According to Teck's plan, the waste rock dump will be reclaimed during operations, and the remainder of the closure plan would be implemented after the end of mining operations in 2031. The plan describes closure procedures for the waste material dumps, tailings impoundment, and water management systems (SRK 2008). Alternatives A, B, and D reflect the reclamation and closure plans developed by Teck. The Alternative C closure plan was developed by EPA to minimize the amount of water needing treatment over the long term after closure. The State of Alaska currently holds a $154.6 million financial assurance to ensure reclamation and post-closure activities, including long-term water treatment. The State is proposing to increase the financial assurance amount to $304.5 million.

Under Alternative A, the Aqqaluk Deposit would not be developed so closure includes facilities associated with the Main Pit, existing waste rock dump, and the tailings impoundment. The waste rock dump, including waste rock placed and any contaminated soil excavated from the tailings and mill areas, would be covered with two-layer soil covers graded to 3:1 (horizontal:vertical) to reduce infiltration and contamination of runoff. Covers would be constructed using unmineralized materials that are non-acid generating and with a zinc content of less than 0.1 percent. An 18-inch layer of shale would be spread over the waste rock dump, graded, and compacted. Depending on the level of weathering of shale, the first layer may be allowed further weathering time prior to final grading and compaction of the first layer. A second 18-inch layer of the shale would be placed as the growth media. If necessary, borrow areas would be developed to provide the volume of soil needed, and vegetation would be established on the upper layer to reduce erosion consistent with surrounding vegetation coverage (SRK 2007). Contaminated seepage from the covered stockpiles would be directed to the Main Pit. Water levels in the Main Pit would be maintained at an elevation of 850 feet by pumping it through the treatment system prior to discharge to Red Dog Creek. A shallow water cover would be maintained over the tailings impoundment. The beaches of the tailings impoundment would be covered with a geosynthetic liner and soil cover (Figure 2.15). All excess water from the tailings impoundment would be treated for the foreseeable future prior to discharge.

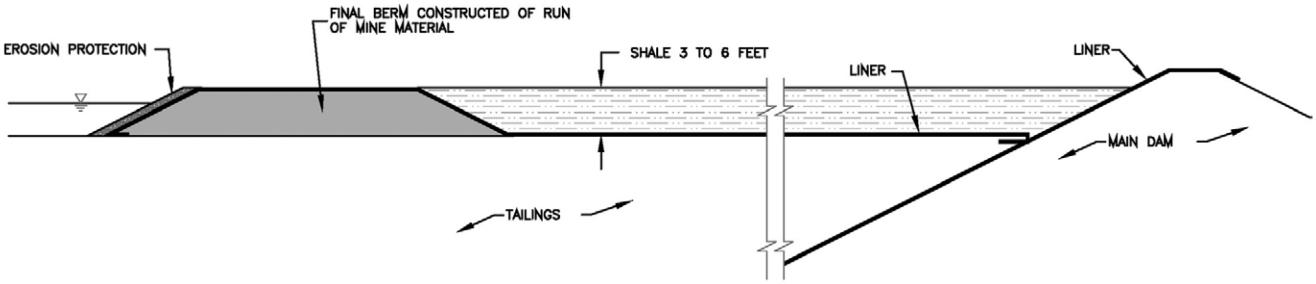


Figure 2.15 Conceptual Tailings Impoundment Closure Design

Berms and reflectors would be placed on the pit rim to prevent humans and wildlife from entering the pit. Buildings, equipment, yards, and roads no longer necessary for long-term maintenance could be decommissioned, and either buried or removed from the site. Disturbed areas would be covered if necessary and revegetated. NANA, as the land owner, will decide on the final dispensation of the buildings.

Under Alternative B, reclamation of the mine site would be similar to that proposed under Alternative A for the tailings impoundment, waste rock dump, and outfall location. Covers on the oxide stockpile and portions of the waste rock dump would be placed during operations, with completion expected by 2020. Covers would be installed so that final surfaces would have slopes of approximately 3:1. Waste rock from the Aqqaluk Pit would be placed in the Main Pit with the Main Pit eventually being fully backfilled. Material from the Aqqaluk Pit containing high sulfide concentrations would be placed below the ultimate water level in the Main Pit, with less reactive material making up the remainder of the backfill. Following the end of mining in the Aqqaluk Pit, the pit would be used for water storage prior to treatment and discharge. A shallow water cover would be maintained over the tailings impoundment to minimize the potential for metal leaching and generation of acid mine drainage. Contaminated seepage from the waste rock dump, the tailings dam, and other covered waste material would be intercepted and directed to the Aqqaluk Pit until long-term monitoring indicated the water quality allows for direct discharge. Periodically, contaminated water from the Main Pit would be withdrawn and transferred to the Aqqaluk Pit for seasonal storage. The water level of the Aqqaluk Pit would be maintained below an elevation of 760 feet to prevent possible contamination of the Red Dog Creek Diversion. Water would be withdrawn seasonally and treated to applicable permit limitations with either currently existing water treatment facilities or new facilities before discharge to Red Dog Creek. The anticipated discharge volume is 1.5 billion gallons per year.

Closure plans under Alternative C would focus on reducing the volume of water that would need long-term treatment. The main waste rock dump would be regraded to a 5:1 slope so that the area could be covered with a geosynthetic liner before soil-cover placement. The Aqqaluk Pit would be partially backfilled with the material that would need to be removed from the existing waste rock dump to achieve the 5:1 regrading. Approximately 40 million tons of waste rock would remain in the waste rock dump and 30 million tons would be backfilled. Under Alternative C, the Main Pit, backfilled with waste rock from the Aqqaluk Pit, would be covered with two layers of shale as described under Alternative A. The volume of water requiring treatment would be reduced from approximately 1,400 to 700 gallons per minute. Upon closure, the water cover over the tailings would be drawn down and the surface of the tailings would be hydraulically resloped to achieve the desired final slopes. A geosynthetic liner would be installed over the tailings. A dry soil cover would then be placed over the liner. The soil material would consist of overburden from the Aqqaluk Pit, which would be stockpiled in the two locations shown on Figure 2.8. The stockpiles would disturb approximately 80 acres of previously undisturbed ground. After placement, the cover would be revegetated. In addition to eliminating water on top of the tailings, the dry cover over the tailings impoundment would also reduce the potential for the tailings to become exposed to wind erosion. The anticipated life span of the geosynthetic liner is more than 400 years. After this period the liner may need to be replaced.

Dry closure of the tailings impoundment and waste rock pile presents several technical challenges that could affect the performance of the covers in reducing infiltration and seepage and minimizing long-term oxidation. The placement of a liner and soil cover over the tailings would present construction challenges. After the impoundment was drained, the liner and soil cover would likely have to be placed during winter when the tailings surface was frozen. In addition, the tailings would consolidate over time. While such consolidation would be taken into account during facility design, it is uncertain how settling of the underlying material could affect the integrity of the geomembrane liner. Settling could continue to occur for decades after closure until a final configuration is reached. A monitoring program would need to be conducted to ensure the liner and soil cover remained intact. In the main waste rock dump, the surficial materials are highly reactive, which creates very high temperature conditions in some parts of the waste rock dump. While the liner should ultimately reduce oxidation and reactivity, the near-term integrity of the liner could be affected by these reactive materials.

The backfilled Aqqaluk Pit would include a lake to contain contaminated water from both pits and seepage from the waste rock dump and tailings impoundment. Because of the backfilling under this alternative, the maximum elevation of the lake would be 836 feet (compared to the Red Dog Creek Diversion elevation of 850 feet) with a capacity of over 900 acre-feet. This capacity is sufficient to hold the average flows from each source plus the flow from the estimated probable maximum flood within the diversion (a total of approximately 750 acre-feet). The contributing flows are expected to decrease over time after closure as the covered waste rock and tailings would continue to drain, reducing the volume of seepage.

Under Alternative C, the pipeline used for discharging treated wastewater to the Chukchi Sea would be removed at closure with treated wastewater being discharged through the Red Dog Creek outfall. The concentrate and diesel pipelines would also be removed. This approach would avoid long-term maintenance issues associated with the pipelines and allow for the removal of fill from 125.5 acres of wetlands. The volume of wastewater discharged to Red Dog creek would be less than current volumes and less than the volumes under the other alternatives.

Under Alternative D, the discharge of treated wastewater from the Aqqaluk Pit lake would continue through the wastewater pipeline to the Chukchi Sea outfall.

Under all alternatives the wastewater would require long-term treatment and the discharge would need to meet NPDES permit limits.

2.4 Project Alternatives and Components Considered But Not Studied in Detail

A number of components were considered in developing alternatives for the SEIS, including mining methods, water treatment, tailings disposal methods, and concentrate transportation. The following discussion provides details on each component considered and why those components were not carried forward.

2.4.1 Mining Method

Mining the Aqqaluk Deposit using underground mining methods would have reduced the potential for fugitive dust generation, one of the issues identified during the scoping process. However, underground mining methods would not be appropriate for the Aqqaluk Deposit since it lies so close to the surface.

There would be insufficient structure in the overlying material to support underground mining methods, therefore this component was not carried forward for consideration in detail.

2.4.2 Wastewater Treatment

A range of wastewater treatment options were considered for inclusion in Alternative A to achieve discharge limits established in the 1998 NPDES permit. These included membrane processes, ion exchange, and biological treatment.

Membrane Processes. As discussed in Section 2.3.6, a reverse osmosis system alone (without treatment) could not be reliably used to meet the 1998 permit limits for TDS. The current level of gypsum saturation in tailings reclaim water would cause fouling and clogging of the membranes. In addition, a high percentage of waste, 50 to 70 percent of the influent flow, would require evaporation and disposal in an isolated facility. Reverse osmosis without pretreatment, therefore, was not evaluated in detail.

A modified reverse osmosis treatment system has been developed for use on waters with high scaling potential and can be used to improve water recovery rates, lower fouling potential, and reduce energy consumption. This process, known as the slurry precipitation and recycle reverse osmosis (SPARRO) system, uses a slurry of gypsum seed crystals to force the precipitation of gypsum and other materials in solution rather than on the membrane surfaces. These seed crystals are introduced to the feed water upstream of the reverse osmosis unit and can then be recycled. There is virtually no full-scale experience with the SPARRO system and pilot-scale testing has shown issues with membrane fouling that would affect long-term reliability and performance. As a result, operation of such a system at the scale required is not proven to be feasible and has not been evaluated in detail.

Nanofiltration is a membrane process similar to reverse osmosis except the membrane has a higher particle size cutoff; up to 0.005 µm for nanofiltration compared to less than 0.002 µm for reverse osmosis. Typical pressures for nanofiltration applications range from 50 to 200 pounds per square inch. Nanofiltration membranes can be effective for calcium and sulfate removal but removal levels are lower than reverse osmosis. Such systems are unlikely to ensure compliance with the 1998 NPDES permit limits. Nanofiltration has, therefore, not been considered in detail.

Electrodialysis is another membrane treatment technology where electricity is used as the driving force for separation instead of pressure. An electrical current is used to move the ions through a series of anion and cation selective membranes. The consecutive membranes concentrate the ions in a wastestream and away from the treated water. Electrodialysis reversal is a modification of the process that switches charges during operation to promote cleaning. This technology is applicable for treatment of high TDS water because it is less susceptible to plugging and is easily cleaned. The downside to this process is the high energy use and the large volume of concentrate requiring disposal (typically more volume than reverse osmosis). Electrodialysis does not have a unique advantage over the proposed reverse osmosis system with pretreatment included in Alternative A, would demand more power, and would generate more waste. Therefore, electrodialysis was not evaluated in detail.

Ion Exchange. Ion exchange is a process where water flows through an ion exchange resin and undesirable ions in the water are exchanged for more benign ions on the resin. The ion exchange process would be a sequential process with strong acid cation resin to remove calcium followed by weak base anion resin to remove sulfate. The columns would be regenerated with sulfuric acid and caustic material, so the process would be removing TDS in exchange for water. Since there is no experience operating ion exchange systems of this type at the anticipated volumes (15 MGD), and because of the large amount of sulfuric acid and caustic required, ion exchange was not evaluated in detail.

Biological Treatment. Biological processes are used for sulfate removal in mine wastewaters by reducing sulfate to sulfide. The result is a change from calcium sulfate to calcium carbonate; however, both of these compounds contribute to TDS. Biological processes change the form of sulfur but do not provide for TDS removal and were not evaluated in detail.

2.4.3 Concentrate Transport Methods

A small number of mining operations move concentrate from mill to smelter in sealed containers. The use of containers would substantially reduce the potential for release of fugitive dust outside the loading area assuming the exterior of the container was clean before starting the transportation process. Implementing use of containers to ship ore from the Red Dog Mine would require a complete redesign of the current loading facility which handles bulk concentrate using conveyor belts. A change in shipping methods would also require a shift from bulk carriers to barges and ultimately, container ships for moving the concentrate to smelters. Use of containers to transport concentrate from the mill to cargo ships was assessed but not carried forward.

Weight restrictions would limit the use of standard shipping containers to the 20-foot variety. Each 20-foot (20 x 8.5 x 8.5 feet) container would have the capacity to hold approximately 24 tons of concentrate. Hauling the equivalent amount of concentrate over an annual basis would require 65,700 containers while additional empty containers would need to be stored at the site prior to being filled.

Based on the capacity of the CSBs (nine months of concentrate production), more than 49,000 containers would be necessary to hold the volume of concentrate normally stored in the port CSBs. The CSBs are 140 feet high and designed for bulk (non-containerized) storage. Standard shipping containers can generally be stacked eight high (70 feet) for storage. Assuming the CSBs would be reconfigured with an overhead crane system, fewer than half of the containers could be stored within the CSBs. The remaining containers full of concentrate would need to be stored outside or additional storage facilities would need to be built, creating a minimum additional disturbance of 13 acres. Empty containers would be stored outdoors and managed using fork lifts rather than a crane. Since fork lifts can only stack containers 4 high, the area needed for an empty container yard would cover approximately an additional 13 acres.

A crane system would need to be used to move empty containers off of and loaded containers onto sea-going barges. Barges would carry the concentrate to Anchorage where containers could be transferred to container ships. Supply barges currently servicing the site have a maximum capacity of 14,000 tons or 600 containers. Moving the 65,700 containers during the shipping season (100 days) would require offloading 600 empty containers from 1.125 barges each day followed by loading of 600 full containers to the barges. Loading at this rate would require handling 50 containers each hour throughout the entire shipping season. Meeting these logistical constraints is unrealistic in the arctic environment.

Moving the containers between the port and the mine site would more than double the amount of traffic on the DMTS road. Based on the design of the road and the weight of the containers, concentrate trucks would be limited to carrying two containers in tandem. Transporting containerized concentrate at a level equal to existing operations would require 180 containers (90 round trips) per day with trucks moving full containers from the mine to the port and returning to the mill load-out storage area with empty containers. While concentrate related fugitive dust would be reduced with the use of containers, traffic-induced dust would increase with the number of concentrate truck round trips increasing from 36 to 90. Since the existing level of traffic was identified as a concern because of potential impacts to wildlife along with concerns about the generation of fugitive dust, increasing the volume of traffic on the DMTS road would not address these significant issues.

The alternative is not considered for detailed analysis for two reasons. First, moving the containers between the port and mine site would generate additional traffic on the DMTS road. Second, the logistical requirements involved with containerized shipping are unlikely to meet the needs of the operation. While the use of containers may provide an incremental improvement in concentrate related fugitive dust, the increase in traffic would exacerbate the concerns related to traffic.

The use of sealed containers just between the mine and port site CSBs was also considered. The trailers currently in use employ hydraulic covers but are still subject to attracting dust during the loading and unloading process. Containers that could be loaded and emptied within the CSBs where the exterior could be cleaned prior to loading onto trailers for the trip to the port could reduce the amount of concentrate dust tracked outside of the loading facilities and onto the DMTS road. The difference in dust control between using sealed containers compared to using the two truck washes proposed in Alternative D would be indistinguishable in terms of the NEPA analysis. Since Alternative D includes the trucks and trailers that are already in use at the site, that approach is considered in detail for this analysis while the use of containers between the mine site and port is not.

2.4.4 Paving the DeLong Mountain Regional Transportation System

The dust generated as a result of traffic on the existing gravel surface of the DMTS road could be reduced by paving the road. Paving the road surface would also prevent any contaminants that may already be present in the surface from being entrained in the wind and carried into the adjacent landscape. In terms of use and management, a paved surface would reduce wear and tear on the concentrate trucks and reduce the frequency of maintenance. The drawbacks of a paved road include an increased concern about winter maintenance when ice could accumulate more readily on pavement compared to a gravel surface. While road maintenance would be less frequent, repairing a paved surface would be more complicated and expensive than the relatively simple process of grading a gravel road.

Regardless of the pros and cons of paving the DMTS road, the design of the existing roadway would preclude paving it without substantial reconstruction of the entire road bed. For pavement to be effective, it must be placed over a firm roadbed. Much of the DMTS road was built by placing construction materials on top of geosynthetic fabric which in turn was placed directly on tundra soils. The result is that the road “floats” on the tundra surface and is subject to vertical movement under traffic. The 400 plus culverts under the DMTS road also contribute to differential heating and cooling of the road that results in vertical and horizontal movement. The appropriate method to build a road with a paved surface would involve stripping the upper layers of soil to bedrock (or permafrost) and then building up from a solid base.

Teck attempted to pave approximately five miles of the DMTS road near the port facility. The paving effort was short-lived because of the development of cracks and potholes. An alternative that would involve paving the road was considered as a method to reduce the amount of dust generated by transportation activities along the road. However, the alternative is not carried forward because of the significant redesign and reconstruction activities required to pave the road and the associated maintenance issues.

2.4.5 Tailings Disposal Methods

A concern over water chemistry in the tailings impoundment led to a consideration of alternative tailings disposal methods, including paste tailings and dry stack tailings. Paste tailings disposal is a method that involves mixing thickened tailings with cement to form a paste. The paste, which solidifies similarly to concrete, allows wet tailings to be disposed of outside a traditional impoundment. No technological reasons exist to prevent paste tailings disposal at the Red Dog Mine; however, paste tailings disposal does not appear to provide any benefit in terms of addressing significant issues. A disposal site would need to be located for the paste tailings. With waste rock from the Aqqaluk Pit filling the Main Pit, there would be no room in the Main Pit for disposal of paste tailings. Adding paste tailings to the waste rock dump would increase the size of the waste rock dump while only minimally reducing the amount the tailings impoundment would need to be increased. Both materials (waste rock and tailings) are reactive and would need to be covered at closure. Seepage from the waste rock dump would need to be directed to the tailings impoundment for treatment prior to discharge. Since this alternative tailings disposal method would not bring a demonstrated reduction in environmental impacts nor address the significant issues, it is not carried forward for detailed consideration.

Alternative tailings disposal locations have also been considered as a method of reducing water management concerns within the existing tailings impoundment. Construction of either a second wet tailings impoundment or some type of dry (or paste) tailings facility could potentially ease the operational constraints on management of the existing impoundment. However, a new tailings facility would require the disturbance of new ground, result in additional surface area and potentially the need to capture additional precipitation, and require long-term management similar to other existing facilities. While the current operating scenario has resulted in water level increases within the impoundment, the proposed action using enhanced treatment (Alternative B) or marine discharge (alternatives C and D) would address the issue using the existing facilities. Since the existing range of alternatives addresses the concerns about the long-term water balance within the system, without the additional surface area and facility requirements of a paste or dry tailings disposal facility or a new tailings impoundment, these alternative tailings disposal methods were not carried forward for detailed analysis as alternatives.

2.4.6 Waste Disposal

The possibility of shipping the ore and contaminated waste materials (i.e., waste rock and tailings) off site was identified as a potential option to reduce the volume of tailings to be treated, long-term water treatment requirements, and the volume of potentially reactive materials that would need to be stored at the site over the long term. While off-site ore processing is possible for some operations, this approach would be prohibitively expensive at Red Dog Mine. The port facility already runs at near capacity to keep up with the current level of concentrate production. Adding additional shipment capacity to handle the ore alone would require more than doubling traffic (barge and truck) and storage capacity at the port. Further, exporting ore for processing off site would export the environmental concern to another location rather than eliminate it. Finally, unless all existing tailings and waste rock were removed from the site, reactive materials would still need to be handled at the site over the long term. For this combination of reasons, off-site processing of ore and management of tailings and waste rock was not considered in detail.

Backfilling the waste rock dump into the Aqqaluk Pit after mining would be a way of eliminating the footprint impacted by waste facilities at the mine site, improving post-mining habitat, and reducing the amount of wastewater needing treatment over the long term. Most of the waste rock generated during the process of developing the Aqqaluk Pit would be placed in the mined-out Main Pit. At the end of mining, a void will remain in the Aqqaluk Pit. However, based on calculations of the volume of material in the waste rock dump, there would be insufficient space to backfill all the material from the dump into the Aqqaluk Pit. Backfilling the Aqqaluk Pit was therefore not carried forward as an alternative evaluated in detail.

2.4.7 Above-Ground Pipelines

Pipelines for the concentrate, diesel, and wastewater, under alternatives C and D could potentially be elevated above ground rather than being buried. Above-ground pipelines would typically result in a smaller overall footprint and reduction in impacts on wetlands and wildlife habitat. The use of above-ground pipelines was not considered as part of the analysis for a number of reasons. The NWAB's Title 9 Areawide Standards require that onshore uses within areas of caribou or other species migration shall not significantly interfere with subsistence activities. Concerns about the road and its effect on caribou migration have been identified through the scoping process and in subsistence interviews (see Section 3.12). The addition of above-ground pipelines would exacerbate this issue. Each of the pipelines would be critical to operation of the mine and providing adequate insulation for an above-ground pipeline to assure reliable year-round performance is considered much more difficult than insulating pipes buried within a bench. For this combination of reasons, the use of an above-ground pipeline was not considered for detailed analysis.

2.4.8 Reduction in Production Rates

A reduction in production rates was suggested as a method to address concerns about the water balance in the tailings impoundment and the increase in TDS concentrations. A reduction in production rates was not considered further for three reasons. First, the production rate represents a minor contribution to the TDS levels in the impoundment. The highest TDS concentrations are associated with seepage collected from the waste rock dump and Main Pit, conditions that would not change with a reduction in the mining rate. Second, operation of the mill at reduced production rates decreases efficiency of the mill, resulting in an increased cost of operations, increased diesel consumption and increased particulate emissions on a per unit basis with no measurable reduction in TDS levels over the long term. Finally, the existing range of alternatives including enhanced treatment and Chukchi Sea discharge options address the water balance concern without requiring a modification of production rates.

2.5 Mitigation and Monitoring

The descriptions of baseline conditions and impact assessments presented in Chapter 3 identify a number of mitigation measures to address potential impacts and monitoring for areas where there are uncertainties. Table 2.5-1 summarizes the mitigation measures identified in the analysis. As noted in the table, EPA and the cooperating agencies have limited authority to incorporate some of these measures into their permits and/or decisions.

Teck currently undertakes a complex monitoring program in support of its existing permits and authorizations. Teck is also in the process of finalizing a fugitive dust risk management plan, as an outcome of their ecological and human health risk assessment (DMTS risk assessment) completed in 2008, to address issues related to fugitive dust. Once completed, the plan may include additional monitoring objectives, some of which would be applicable to monitoring needs identified in the SEIS. Table 2.5-2 presents selected monitoring measures that were identified through the process of reviewing baseline data and conducting the impact analyses. Again, some of these measures would be required by new or existing permits while others would be voluntary. All monitoring measures identified would be in addition to the ongoing Red Dog Mine monitoring programs.

Table 2.5-1 Mitigation Measures by Resource

Resource	Measure	Section	Comment	Authority [a] / Likelihood of Implementation
Air	Install truck washes at both ends of the DMTS road.	3.2.4	Applicable to alternatives A and B (included as part of Alternative D).	None / Under evaluation as part of the draft fugitive dust risk management plan; likelihood of implementation uncertain.
Geotechnical Stability	Evaluate dam design prior to final raise to address potential long-term stability concerns.	3.4.2.5	All alternatives.	ADNR's Dam Safety Program / Reviews of dam raises would be conducted under all alternatives.
	Conduct engineering study to determine amount of movement that could occur within berm and incorporate into pipeline design parameters accordingly.	3.4.3.3	Alternatives C and D	None / Likelihood of implementation unknown.
Water Resources	Use BMPs (e.g., silt fences) at road crossings during construction of pipeline bench to minimize sediment input at DMTS road/pipeline bench stream crossings.	3.5.3.3 and 3.5.3.4	Alternatives C and D.	NPDES Permit (Storm water) / Measure would be required for construction under all alternatives.
	Develop long-term TDS management plan.	3.5.3.2	Applicable to alternatives A and B and included in the draft NPDES permit. Additional TDS control would not be necessary with a marine outfall.	Red Dog Mine NPDES Permit / Included under alternatives A and B; unnecessary with marine discharge (alternatives C and D).
Wetlands	Develop mitigation plan for wetlands loss associated with development of Aqqaluk Deposit and fill to raise tailings dam.	3.8.3.3	Applicable to alternatives B, C, and D.	Section 404 Permit / Mitigation required under Corps regulations. Extent of proposed mitigation for Aqqaluk impacts disclosed in the SEIS although specific mitigation plans for dam raises would be determined in the future.
Wildlife	Continue to implement a hazing program to keep wildlife from using the tailings impoundment and Aqqaluk Pit lake.	3.9.3.2, 3.9.3.3, 3.9.3.3, and 3.9.3.4	All alternatives (applies to tailings impoundment only under Alternative A and Aqqaluk Pit lake under Alternative C).	None / Teck has committed to continuing the current hazing program being implemented voluntarily and will reevaluate the need at closure.
	Construction of marine outfall should avoid conflict with marine mammal use of the area.	3.9.3.4	Applies to alternatives C and D.	Sections 10 and 404 permits / Would be required for construction of the marine outfall under either alternative.
	Construction of pipeline bench should avoid major migratory movements of caribou.	3.9.3.4	Applies to alternatives C and D.	Section 404 Permit / Would be required for construction of the pipeline bench under either alternative.

Resource	Measure	Section	Comment	Authority [a] / Likelihood of Implementation
Subsistence	The Subsistence Committee should re-examine its procedures on minimizing the mine's effect on subsistence resources.	3.12.3.1	Applies to all alternatives.	None / Likelihood of implementation unknown. Function and responsibilities of the Subsistence Committee are established in an agreement between Teck and NANA.
	Have an "independent observer" party (not truck drivers) be responsible for determining when traffic should stop because of the proximity of caribou to the DMTS road.	3.12.3.1	Applies to alternatives A, B, and D.	None / Unlikely to be implemented as Teck has indicated it will not undertake the use of independent observers. Teck will develop additional documentation of caribou-related road closures in the future.
	Communicate how subsistence is addressed in existing company leave policy.	3.12.2.7	Applies to all alternatives.	None / Likely to be implemented as Teck has committed to reviewing its existing policy including how it is communicated to its workers within the region.
Socioeconomics	Initiate a regional long-term economic planning process to promote economic stability in the region beyond the closure of the Red Dog Mine.	3.17.4.1	Applies to all alternatives and should involve community input.	None / The NWAB has an Economic Development Commission that includes Teck as a formal member. This commission may meet the long-term planning needs identified in the socioeconomics section.

[a] "None" means that EPA and the cooperating agencies have not identified a regulatory authority or permit under their jurisdiction that can be utilized to require the mitigation measure.

Table 2.5-2 Selected Monitoring by Resource

Resource	Measure	Section	Comment	Authority [a] / Likelihood of Implementation [b]
Air	Implement operational monitoring program to evaluate effectiveness of dust control measures.	3.2.3.1	Applicable to all alternatives.	ADEC-Teck MOU / A specific Dust Emissions Reduction Plan is to be incorporated into the fugitive dust risk management plan to address operational monitoring.
Geochemistry	Monitor changes in mobility and migration of metals from oxidation or other changes in forms of minerals.	3.3.2.4	Applicable to all alternatives.	ADEC-Teck MOU / Based on comments from Teck, the Terrestrial Monitoring Plan to be incorporated into the fugitive dust risk management plan will include monitoring of vegetation tissue (see below under Vegetation).
Surface Water	Monitor water quality in streams at DMTS crossings to determine if DMTS is impacting water quality.	3.5.2.2	Applicable to Alternatives A, B, and D.	ADEC-Teck MOU / Per Teck, monitoring for metals in DMTS streams will be part of the Operational Monitoring Plan to be developed under the fugitive dust risk management plan.
	Monitor Red Dog Creek and Ikalukrok Creek for changes in water quality from relocation of Outfall 001 from Red Dog Creek to the Chukchi Sea.	3.5.3.3	Applicable to Alternatives C and D.	ADEC Waste Management Permit / Monitoring to be conducted under ADEC's Waste Management Permit.
Groundwater	Assess capability of existing meteorological, groundwater and permafrost monitoring system to detect changes due to climate change. Modify the plan, if needed, so that changes in the relationship between permafrost and groundwater behavior can be detected.	3.6.3.1 and 3.6.3.2	Applicable to all alternatives.	ADEC Waste Management Permit / The existing plan will be reviewed and modified periodically under the ADEC's Waste Management Permit.

Resource	Measure	Section	Comment	Authority [a] / Likelihood of Implementation [b]
Vegetation	Develop and implement monitoring plan to determine whether dust deposition from the Red Dog Mine is occurring within Noatak National Preserve.	3.7.2	Applicable to all alternatives.	None / Teck does not currently plan to conduct this monitoring.
	Monitor for changes in mobility and availability for the uptake of metals in tundra and underlying soils.	3.7.2	Applicable to all alternatives.	ADEC-Teck MOU / Per Teck, monitoring will be included in the Terrestrial Monitoring Plan to be developed under the fugitive dust risk management plan and will consist of monitoring vegetation tissue concentrations and plant community parameters.
	Monitor tissue concentrations in shrubs, herbaceous plants, mosses and lichens to track rate of changes (data collected at regular intervals).	3.7.2	Applicable to all alternatives.	ADEC-Teck MOU / Per Teck, this will be included in the Terrestrial Monitoring Plan to be developed under the draft fugitive dust risk management plan.
	Monitor composition of shrub, herbaceous, moss, and lichen communities to evaluate community health and identify changes in community composition.	3.7.2	Applicable to all alternatives.	ADEC-Teck MOU / Per Teck, this will be included in the Terrestrial Monitoring Plan to be developed under the fugitive dust risk management plan.
	Monitor remediated or reclaimed areas to ensure long-term effectiveness (at rollover sites and sites covered in the DMTS risk assessment).	3.7.3.1	Applicable to all alternatives.	ADEC-Teck MOU / Per Teck, monitoring of remediated/reclaimed sites will be included in the Remediation Plan to be developed under the fugitive dust risk management plan.
Wildlife	Monitor health of local populations of voles, shrews, and ptarmigan.	3.9.2.1	Applicable to all alternatives.	ADEC-Teck MOU / ADEC has suggested this be included in the fugitive dust risk management plan to supplement vegetation tissue monitoring data identified above. Uncertain if it will be included in the final fugitive dust risk management plan.
	Develop turbine-related mortality monitoring plan for birds.	3.9.3.4	Applicable to Alternative C — applicable to the wind turbine at the port.	None / No regulatory authority to require this, but commonly undertaken to advance database on effects to bird populations.
Aquatic Resources	Monitor Red Dog Creek and Ikalukrok Creek for changes in fish habitat based on changes from relocation of Outfall 001 from Red Dog Creek to the Chukchi Sea.	3.10.3.4	Applicable to Alternatives C and D.	ADEC Waste Management Permit / Some monitoring to be conducted under ADEC's Waste Management Permit.
	Monitor health of local populations of fish at DMTS road crossings that tend to be resident in the area (e.g., slimy sculpin).	3.10.3.2	Applicable to all alternatives.	ADEC-Teck MOU / Per Teck, monitoring of DMTS creeks will be included as part of the Operational Monitoring Plan to be developed under the fugitive dust risk management plan.

Resource	Measure	Section	Comment	Authority [a] / Likelihood of Implementation [b]
Health	Characterize the current nutritional health baseline by conducting a dietary survey to quantify the contribution of subsistence resources to the diet of residents of Kivalina.	3.13.2	Applicable to all alternatives. Data could be reviewed by Stakeholder Participatory Monitoring and Review Committee (see below).	None / No regulatory authority to require this and Teck has indicated that they will not fund such a study. Therefore, implementation is unlikely.
	Monitor metals concentrations in caribou to reduce uncertainty in the DMTS risk assessment regarding safe consumption levels. Recommend safe levels of consumption based on study results.	3.13.2	Applicable to all alternatives.	ADEC-Teck MOU / According to Teck, caribou tissue monitoring for metals will be conducted under the Monitoring Plan to be developed under the fugitive dust risk management plan.
	Form a Stakeholder Participatory Monitoring and Review Committee to coordinate and collaborate on ongoing health efforts and initiatives in the area, including those related to mining.	3.13.3	Applies to all alternatives although not driven solely by concerns related to operations at the Red Dog Mine.	None / No regulatory authority to require this and Teck has indicated they will not form the Stakeholder Committee. Teck is willing to expand the existing Ikayuqtit Team to include other groups. However, uncertain that this will address the health concerns.

[a] "None" means that EPA and the cooperating agencies have not identified a regulatory authority or permit under its jurisdiction that can be utilized to require the monitoring.

[b] Based on comments and a letter from Teck, some of the monitoring measures will be included in implementation plans developed under the fugitive dust risk management plan (which was developed per the ADEC-Teck MOU). However, until the implementation plans are finalized and approved by ADEC, the likelihood that these measures will be implemented as described in the SEIS is uncertain.

2.6 Comparison of Alternatives

Table 2.6-1 summarizes the various components associated with each alternative facilitating a side-by-side comparison of alternatives.

Table 2.6-1 Comparison of Alternatives

Component	Alternative A No Action	Alternative B Proposed Action	Alternative C Concentrate and Wastewater Pipelines	Alternative D Wastewater Pipeline and Additional Measures
Mining Method	No Aqqaluk Project.	Aqqaluk Open Pit.	Same as Alternative B.	Same as Alternative B.
Waste Rock Disposal	Waste rock dump.	Waste rock dump/Main Pit backfilled with Aqqaluk Pit waste rock.	Main Pit backfilled with Aqqaluk Pit waste rock/Aqqaluk Pit partially backfilled from existing waste rock dump.	Same as Alternative B.
Wastewater Treatment	Aluminum or barium hydroxide pretreatment, followed by reverse osmosis.	Existing high-density sludge/lime precipitation plus, as needed, barium hydroxide precipitation.	Existing high-density sludge/lime precipitation for mine. Barium hydroxide precipitation or other enhanced TDS treatment not needed. New sludge/lime system at port (different water quality permit limits for marine outfall).	Existing high-density sludge/lime precipitation for mine. Barium hydroxide precipitation or other enhanced TDS treatment not needed.
Wastewater Outfall Location	Red Dog Creek.	Same as Alternative A.	Chukchi Sea during operations. Red Dog Creek after closure.	Chukchi Sea.
Concentrate Transport	Concentrate truck.	Same as Alternative A (longer duration).	Slurry pipeline.	Same as Alternative B (plus truck washes).
Power	Additional 10 megawatts of power demand for wastewater treatment.	No change from existing operations.	Additional three megawatts of power at port for filter presses and pumps (supplemented with wind power).	No change from existing operations.
Subsistence Closures	None.	None.	None.	Late opening of port (July 1) and closure of DMTS road in fall.
New Construction	New water treatment plant and generator.	Aqqaluk Pit Development.	Same as Alternative B plus new pipeline bench incorporated into the DMTS road.	Same as Alternative C plus truck washes at contractor PAC and port site CSBs.
Fugitive Dust Control	Per draft fugitive dust risk management plan.	Per draft fugitive dust risk management plan.	Per draft fugitive dust risk management plan. Pipeline would eliminate concentrate truck and fuel truck traffic.	Per draft fugitive dust risk management plan plus enhanced truck washes.

Component	Alternative A No Action	Alternative B Proposed Action	Alternative C Concentrate and Wastewater Pipelines	Alternative D Wastewater Pipeline and Additional Measures
Reclamation/ Closure	Pit lake in Main Pit (below 850 feet); wet cover over tailings; soil cover over waste rock dumps (3:1 [horizontal:vertical] grading). Long-term wastewater treatment required.	Main Pit backfilled; pit lake in Aqqaluk Pit; wet cover over tailings; soil cover over waste rock dumps (3:1 grading) (oxide ore stockpile and waste rock dump ½ reclaimed by 2017, fully reclaimed by 2020). Long-term wastewater treatment required.	Main pit backfilled; partial backfill Aqqaluk Pit; geosynthetic dry liner cover over tailings impoundment and waste rock dump (regraded waste rock dump to 5:1). Long-term wastewater treatment required.	Same as Alternative B except continued wastewater pipeline and discharge to the Chukchi Sea. Long-term wastewater treatment required.

2.7 Identification of the Environmentally Preferable and Preferred Alternatives

EPA's Record of Decision must identify a preferred alternative and an environmentally preferable alternative (40 CFR §§ 1502.14(e), 1505.2(b)). The preferred alternative takes into account various considerations including such factors as the agency's statutory mission and responsibilities and economic, environmental, technical, and other factors (CEQ 1981: Forty most asked questions, No. 4a). NEPA also requires that the lead agency identify an environmentally preferable alternative, which ordinarily means "the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources" (CEQ 1981: Forty most asked questions, No. 6a). The environmentally preferable alternative can be the same as the preferred alternative or differ in some respects, depending on the analysis in the SEIS.

This section presents EPA's basis for determination of the preferred alternative and environmentally preferable alternative. As discussed below, these alternatives can be comprised of different components of each of the alternatives evaluated in the SEIS.

Preferred Alternative

As noted above, the determination of the Preferred Alternative may take into account other factors beyond environmental impacts, including an agency's statutory mission and responsibilities. In this case, EPA's responsibility is to approve or deny Teck's application to reissue the NPDES permit for the discharge to Red Dog Creek. The SEIS analysis indicates that Teck can meet the limits and conditions in the draft NPDES permit developed based on Teck's permit reissuance application, which is Alternative B in this SEIS. Even though EPA has identified the three pipelines and Chuckchi Sea discharge components of Alternative C as part of the environmentally preferable (best) alternative, EPA does not have the authority to require Teck to implement Alternative C. EPA's Preferred Alternative is, therefore, Alternative B. This will be discussed further in EPA's Record of Decision.

Teck has entered into a Consent Decree and Settlement Agreement to resolve a lawsuit regarding discharges to Red Dog Creek in exceedence of the existing NPDES permit limits. The Settlement Agreement includes construction of a pipeline similar to that under consideration under Alternative D. The impact analysis SEIS includes an assessment of impacts that would result from construction and operation of the pipeline; a pipeline is also considered reasonably foreseeable in terms of cumulative effects. Since EPA must act on the NPDES permit application that has been submitted, the preferred alternative is Alternative B as described above. The extent of permits and approvals for constructing and operating the wastewater discharge pipeline process has not been identified although it is likely that additional NEPA action would need to be completed in the future, at minimum for a revision to the existing Section 404 permit governing wetland fills. Once Teck finalizes its plans and submits an application to build and operate a wastewater pipeline; any future NEPA action could tier off of this Final SEIS.

Environmentally Preferable Alternative

Table 2.7-1 (Summary of Potential Impacts of Each Alternative) summarizes the results of the impact analysis for each alternative. Based on these results, EPA has identified Alternative C as the Environmentally Preferable Alternative, except for the closure component. EPA believes that wet closure included under Alternative B is environmentally preferable to the Alternative C dry closure.

Alternative C differs from Alternative B in that it includes construction and implementation of a wastewater discharge pipeline (instead of ongoing discharge to Red Dog Creek) and construction of a concentrate pipeline to transport concentrates (instead of concentrate trucks). As discussed below, EPA believes that these components of Alternative C are environmentally preferable to Alternative B and the other alternatives.

Alternative A is not the Environmentally Preferable Alternative because it would have broad, adverse economic and social impacts that outweigh the reduced environmental effects associated with ceasing mining in 2012. In addition, these effects would have negative impacts on human health in the NWAB. Specifically, more than 500 full- and part-time jobs would be lost with over $40 million in payroll, including more than 100 jobs and $8 million in payroll of NWAB residents. In addition, NANA businesses would forgo $71.3 million in revenue, other businesses would forgo $29 million revenue and the NWAB would forgo $8 million in PILT.

One primary difference between Alternative C and alternatives B and D is the construction of the concentrate pipeline under Alternative C, which would limit truck traffic on the DMTS road. While this would not address past effects associated with dust already in the environment, it would greatly reduce future dust emissions. In addition, eliminating concentrate truck traffic would have positive effects on impacts to caribou harvest and, potentially, berry harvests by Kivalina residents. It would also reduce the potential for caribou mortality from traffic, as well as risk to ptarmigan and small mammals from fugitive dust. Future impacts to vegetation from dust emissions would largely be eliminated.

Construction of the pipeline bench under Alternative C would cause the temporary loss of 125.5 acres of moderate value wetlands. Much of these wetlands have already been contaminated because of fugitive dust from the haul road and truck traffic. These wetlands could be restored after closure, although a mitigation plan has not yet been developed. These losses would be permanent under Alternative D, since the marine discharge pipeline would remain after closure.

Replacing the Red Dog Creek discharge with the marine discharge under alternatives C and D would cause TDS levels in Red Dog Creek to return to approximately pre-mining conditions in the downstream drainages. Moving the discharge from Red Dog Creek to the Chukchi Sea would also result in higher metals concentrations in Red Dog Creek, since the diluting effect of the treated effluent discharge would be lost. The higher metals concentrations would likely adversely affect water quality and aquatic life in Main Stem Red Dog Creek, including impacts on grayling spawning. The exact magnitude of these effects is unknown; however, as discussed in sections 3.5 and 3.10, conditions would be better than pre-mining conditions. Impacts should not extend to Ikalukrok Creek. Moving the discharge to the Chukchi Sea would allow Teck to discharge more wastewater, which would facilitate easier maintenance of the site-wide water balance and a safe water level behind the tailings impoundment dam. Under Alternative

C, the treated discharge would be returned to Red Dog Creek after closure and the stream would return to current conditions. This would not occur under Alternative D. No adverse effects on aquatic life in Ikalukrok Creek or the Wulik River are predicted under any of the alternatives.

Because of the limited size of the mixing zone (estimated at less than 10 feet) needed to meet water quality standards protective of aquatic life, the SEIS concluded that the discharge to the Chukchi Sea under alternatives C and D would not cause adverse impacts to aquatic life or marine mammals. Construction would be timed to avoid fish and mammal migration periods, although there would be localized, short-term impacts on invertebrates, algae, and fish.

Under Alternative D, the construction of the year-around truck washes would only eliminate some of the current dust emissions associated with truck transport of concentrate. Closure of the port during marine mammal migration may reduce subsistence impacts associated with beluga harvest. However, port closure would adversely impact Teck's ability to economically ship concentrate during the open water season, and may not be feasible. Teck currently opens the port only after being notified by the local Native Subsistence Committee that whale hunting activities have ceased. Economic and logistical effects would also arise from closing the DMTS road during caribou migration.

The impacts analysis indicated that the tailings dam is stable over the short term. The SEIS identified that a rise in the wetted level within the dam and a lower than accepted safety factor could impact the stability of the dam over the long term. ADNR has indicated that they will address these issues during their process for approving the final dam designs. In addition, the final dam design needs to account for the ways climate change and permafrost thawing would affect stability and water management requirements. The assumption that these concerns would be addressed under all alternatives is part of the environmentally preferred alternative.

EPA believes that the wet closure plan under Alternative B is environmentally preferable to the dry closure plan developed under Alternative C. While dry closure of the tailings impoundment under Alternative C could reduce the volume of water requiring long-term treatment, wet closure of the impoundment may lead to improved discharge quality. In addition, dry closure poses specific technical challenges, including a long and uncertain tailings compaction time and the difficulties in keeping the cover dry.

Table 2.7-1 Summary of Potential Impacts of Each Alternative by Resource

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Air quality	Stack and fugitive emissions	Higher stack emissions due to 10MW generator for reverse osmosis system; will continue to be required after closure. Duration of fugitive emissions minimized after end of mining in 2011.	Stack emissions comply with all Federal and State air quality standards. Fugitive dust emissions along DMTS road continue at current levels through 2031, unless controls implemented through the draft fugitive dust risk management plan. Elevated metals levels in soils extend >50 miles.	Same stack emissions as Alternative B. Fugitive dust emissions associated with DMTS road traffic largely eliminated by pipeline construction. Additional fugitive dust emissions associated with the dry cover over the tailings impoundment and cover material stockpiles	Same stack emissions as Alternative B. Fugitive dust emissions associated with DMTS road greater than Alternative C but less than Alternative B.
Geochemistry	Acid rock drainage and metal loadings	Acid drainage will continue during operations. After closure, wet cover over tailings should minimize acid generation potential and could lead to reduced wastewater treatment requirements over long term.	Same as Alternative A for acid generation potential although a larger volume of source material. Metals loadings from fugitive dust emissions continue through 2031 with increased metals concentrations in downwind soils and plants.	Dry closure of waste rock and tailings impoundment would reduce flow volumes requiring treatment but acid generation expected over long term. Metals loadings to soils and plants from fugitive dust emissions along DMTS road greatly reduced.	Same as Alternative A for acid generation. Metals loadings from fugitive dust emissions along DMTS road reduced more than Alternative B, but less than alternatives A and C.
Geotechnical stability	Probability of failure	Risk of failure of tailings dam low. However, long-term concerns due to the level of the phreatic surface and dam design below proposed safety factor. ADNR will implement mitigation measures during final dam design to remedy concerns and ensure long-term stability. Stability of waste rock pile also ensured through permitting and ongoing oversight by ADNR.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Water Resources – Surface Water	Stream flow	No changes from current conditions.	Stream flow in Red Dog Creek may be slightly greater than current conditions since additional wastewater can be discharged during times when barium hydroxide is used to lower TDS in the effluent and increase discharge rates.	Changing to marine discharge reduces stream flow in Main Stem Red Dog Creek by 18 to 38 percent during operations. In Ikalukrok Creek average flows would be reduced by less than 5 percent below the confluence with Red Dog Creek.	Same as Alternative C except stream flow reductions continue after closure.
	Water Quality	TDS levels in Main Stem Red Dog Creek reduced to below 170 mg/L. Lower TDS levels in Ikalukrok Creek. No change at Kivalina water supply intake; meets drinking water standards. For metals and cyanide; no change from current conditions.	No change from current conditions for metals, cyanide, and TDS Kivalina water supply intake meets drinking water standards. For DMTS streams, no water quality impacts identified, although additional monitoring is warranted.	Change to marine discharge during operations will decrease TDS concentrations to below water quality standard levels in Red Dog Creek. Lower TDS levels in Ikalukrok Creek. No detectable change in metals or TDS concentrations at Kivalina's water supply. Metals levels in Main Stem Red Dog Creek, which are already above aquatic life standards, will increase, although levels will be lower than pre-mining conditions. Small (less than 10 feet) marine mixing zone around the Chukchi Sea discharge. After closure, same as Alternative B. Reduced risk of metal loadings to DMTS streams from dust as compared to other alternatives.	Same as Alternative C during operations; effects continue after closure. Risk of metals loadings from dust along DMTS lower than Alternative B but higher than Alternative C.
	Spills	Spill risk associated with vehicle transport greater than Alternative C but lower than alternatives B and D considering the shorter duration of operations.	Similar to Alternative A, except longer duration of risk.	Lower risk of a truck transport related spill with pipeline. However, a pipeline rupture could have impacts, depending upon location and duration.	Similar to Alternative B.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
	Water Management	Reverse osmosis treatment system needed until closure and in perpetuity to meet TDS limits. At closure, tailings impoundment and Main Pit used for water management. Water discharge would continue in perpetuity.	Continued use of existing water management and treatment systems with addition of enhanced treatment (barium precipitation) to reduce TDS levels and maintain water balance, as needed. Wet closure involves water management in the Aqqaluk Pit and tailings impoundment. Water quality in tailings impoundment expected to improve over the long term although perpetual treatment and discharge still expected.	Continued use of existing water management system and treatment of tailings impoundment wastewater, except the wastewater would be piped to the port site, combined with treated concentrate wastewater and discharged to the Chukchi Sea. A new treatment plant would be built at the port site for treatment of concentrate wastewater. After dry closure of the tailings impoundment, the wastewater pipeline would be removed with contaminated water managed in the Aqqaluk Pit. Reduced volume of water (compared to other alternatives) would require treatment in perpetuity.	Same as Alternative C during operations with pipeline to ocean; pipeline maintained after closure. Closure plan for impoundment, pits and waste rock stockpiles same as Alternative B.
Water Resources -Groundwater	Groundwater hydrology and quality	Limited and localized impacts on ground water, including loss of permafrost. Pit lake created in Main Pit.	Similar to Alternative A, except Main Pit backfilled and pit lake forms in Aqqaluk Pit.	Same as Alternative B, although permafrost could be restored more quickly under tailings impoundment (with dry closure).	Same as Alternative B.
Vegetation	Acres of Disturbance	28 acres of new disturbance associated with the expansion of the waste rock dump and roads/ditches. Reclamation begins in 2011, including revegetation where practicable.	406.5 acres of new disturbance associated with developing Aqqaluk Deposit including tailings impoundment expansion and new roads/ditches. Closure in 2031, although ongoing reclamation of main waste rock dump when backfilling begins.	Similar to Alternative B with 145 acres of additional disturbance associated with pipeline bench, reclaimed after closure. Stockpiles for the tailings impoundment cover material would affect 80 acres until reclamation was completed.	Similar to Alternative C, except for pipeline bench remains after closure. No additional stockpiles would be required for reclamation.
	Dust impacts	Fugitive dust emissions and vegetation impacts, primarily to mosses and lichens, would continue at current levels through 2011.	At mine site, additional dust impacts (changes in species composition/cover) from Aqqaluk Pit development. Along DMTS road, emissions and effects continue through 2031.	Same as Alternative B at mine site. Along DMTS road, fugitive emissions greatly reduced by concentrate pipeline. Future metals loadings lowered but effects on previously impacted vegetation uncertain.	Similar to Alternative B except some reductions in fugitive emissions and metal loadings along DMTS road resulting from truck washes.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Wetlands	Acres and Types Disturbed	No impacts beyond currently permitted levels.	Additional 144.9 acres disturbed at mine site. No additional impacts along DMTS road. Loss of function and value minor at regional level.	Same as Alternative B at mine site. 125.5 acres of additional wetlands disturbed by pipeline bench – function may already be affected by fugitive dust. Some level of function would be recovered after closure.	Same as Alternative B at mine site. Same as Alternative C along DMTS road except pipeline bench remains after closure.
Wildlife	Impacts	No impacts beyond current levels, some risk from dust emissions to ptarmigan and small mammals. Localized impacts on beluga whale movements and caribou migration.	Similar in magnitude to Alternative A except longer duration of operational impacts.	Lower risk to ptarmigan and small mammals from reduced dust emissions as compared to alternatives B and D. Reduced caribou mortality as compared to alternatives B and D due to elimination of truck traffic as well as less impact on caribou migration. Localized impacts to beluga due to port activities similar to Alternative B. No impacts to marine mammals from wastewater discharge.	Risk to ptarmigans and small mammals from fugitive dust emissions lower than Alternative B but higher than Alternative C. Impacts on caribou migration and beluga whale movement reduced by road closure and delayed port opening. Caribou migration impact lower than Alternative B, but not as low as Alternative C. Beluga movement impact lower then other action alternatives. No impacts to marine mammals from wastewater discharge.
Aquatic Resources	Freshwater	No change from current conditions. Lowered TDS levels in the discharge will not have an affect on aquatic life. Metals concentrations and arctic grayling spawning in Red Dog Creek are improved compared to pre-mining conditions. Based on current data, no change from current conditions in streams along DMTS road, although additional monitoring is warranted.	Same as Alternative A. The difference in TDS levels between alternatives would not result in effects on aquatic life downstream. Metals concentrations and arctic grayling spawning in Red Dog Creek are improved compared to pre-mining conditions. Based on current data, no change from current conditions in streams along DMTS road, although additional monitoring is warranted.	Removal of discharge from Red Dog Creek would result in impacts to aquatic life during operations because of increased metal concentrations and reduced flow. Water quality will be better than pre-mining conditions but worse than current conditions (except for reduction in TDS levels). No changes in Ikalukrok Creek or Wulik River. No impacts on DMTS road observed in fish monitoring, but sporadic tissue concentrations above effects levels warrant future monitoring. Any future impacts due to truck traffic less under Alternative C than other alternatives.	Same as Alternative C except impacts to Red Dog Creek from the loss of dilution from the outfall would continue after closure. Impacts on aquatic life in DMTS streams similar to Alternative B although less risk of exposure to concentrate within fugitive dust.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
	Marine	No discharges from mining operations and no impacts beyond current conditions.	Same as Alternative A.	Short-term, adverse impacts on algae, invertebrates, and fish during pipeline construction and removal. Construction should be timed to avoid fish migration periods (through Corps' Section 10 permit). Because of limited mixing zone size (10 feet around outfall) and discharge would meet marine water quality standards at edge of mixing zone; no impacts from marine discharge.	Same as Alternative C.
Land Use and Recreation	Land Use	Site reclamation begins in 2011.	Site reclamation begins in 2031.	Similar to Alternative B.	Similar to Alternative B.
	Recreation	No direct impacts on recreational use because of limited access to site. Some visual impacts to hikers and recreationists flying over site on way to destinations.	Similar to Alternative A although development of the Aqqaluk Pit would result in additional disturbance.	Similar to Alternative B, although pipeline bench could slightly increase visual effects.	Similar to Alternative C.
Health	Public Health	Existing operations affect presence of caribou and beluga whale in vicinity of Kivalina with some reduction in harvest levels. Harvest change could affect diet and health; therefore, a diet survey is recommended. Adverse impacts related to employment and income could occur with mine closure in 2011. Some benefits from reduced impacts on subsistence, less employee separation, and potential for reduced spread of infectious disease. Effects of contaminant exposure are limited under all alternatives.	Allows for continued mining through 2031 and associated economic and employment benefits with more time to plan for eventual mine closure. Continued effects of dust emissions on some subsistence resources to users in Kivalina. Mine activities have similar effect on subsistence in Kivalina as under current conditions but extend through 2031.	Similar to Alternative B, except subsistence impacts are reduced by lower dust emissions and elimination of concentrate truck traffic (less displacement of caribou).	Similar to Alternative C, although less reduction in dust emissions, subsistence benefits associated with road closure during caribou migration and delayed port opening during whale movement.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
	Industrial Health	Current accident rates and worker exposure would continue through 2011. Teck would continue to implement and refine, as necessary, its health and safety program to prevent exposure and monitor worker health.	Current accident rates and worker exposure would continue through 2031. Teck would continue to implement and refine, as necessary, its health and safety program to prevent exposure and monitor worker health.	Similar to Alternative B, except reduced exposure to the contaminants in dust from workers associated with concentrate transport (minor effect).	Similar to Alternative B.
Subsistence	Land Mammals	Mine has not caused effects on overall caribou migration patterns, but localized changes primarily from mine activities (including the DMTS road) have occurred and subsistence harvest has decreased. Such impacts should be greatly decreased after closure with traffic reductions. Effects mitigated by management practices to stop traffic when large-scale caribou herd movement has right-of-way.	Similar in magnitude to Alternative A, except operational impacts would continue through 2031.	Construction of the concentrate pipelines would substantially reduce truck traffic and thereby lessen impacts on caribou and subsistence harvest in terms of displacement.	Closure of the road during the caribou migration may lessen impacts (though not as much as Alternative C) on subsistence by reducing localized displacement of caribou.
	Marine Mammals	Localized displacement of beluga whales at port site could be contributing to reduced harvests by Kivalina residents. Impacts from port activity would be eliminated after closure in 2011.	Similar in magnitude to Alternative A except operational impacts continue through 2031.	Similar to Alternative B in terms of port site activity displacing beluga whales. Impacts from construction of the discharge pipeline outfall could be minimized by timing restrictions. Discharge should not affect marine mammals.	Impacts to whale movement and subsistence reduced by closing the port during the annual June beluga whale migration. Impacts related to construction of marine outfall is the same as Alternative C.
	Fugitive Dust	No actual risk identified but perceived contamination of berries leading to changes in use areas and reduced harvest from pre-mining conditions.	Same as Alternative A in magnitude except fugitive emissions continue through 2031.	Reduced fugitive emissions, since traffic would be eliminated due to concentrate pipeline, could lead to increase in berry harvest and less concern about dust contamination of other resources.	Less dust emissions than alternatives A and B, but more than Alternative C. Effects on subsistence uncertain.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Cultural Resources	Effects on historic properties	At mine site, up to 17 sites have been affected by existing activities or will be affected by additional operations through 2011. No sites identified along DMTS road. All effects mitigated by *Integrated Plan for the Management of Cultural Resources in the Red Mine Project Areas, 2006 (Integrated Plan)*.	Development of Aqqaluk Pit could impact 2 additional sites, direct and indirect effects mitigated by *Integrated Plan*.	Similar to Alternative B.	Similar to Alternative B.
Transportation	Traffic	Marine and DMTS road traffic continues at current levels through 2011.	Same traffic levels as Alternative A except operational impacts extend through 2031.	Traffic along DMTS road greatly reduced by concentrate pipeline (36 fewer round trips per day by concentrate trucks). Number of diesel fuel trucks also reduced. Traffic greatly reduced compared to alternatives B and C.	Same as Alternative B except reduced fugitive emissions from truck traffic. Also, although same number of trips, traffic frequency per month differs from Alternative B due to road closure during caribou migration.
Noise	Effects on recreational users and wildlife	Infrequent (once per day) blasting would be the primary impact. Could affect the limited number of recreational users and subsistence activities. Noise levels greatly reduced after closure in 2011.	Similar in magnitude to Alternative A except operational effects occur through 2031.	Similar to Alternative B except pipeline noise would be less than truck traffic on DMTS road. Some additional blasting would occur in material borrow sites during bench construction. The additional facilities at the port would result in only a minimal increase in noise levels.	Similar to Alternative B except (1) limited noise disturbance along DMTS road during caribou migration; and (2) reduced noise at port during high subsistence harvest period for marine mammals.

Resource	Impact	Alternative A	Alternative B	Alternative C	Alternative D
Socioeconomic Resources	Effects on employment and revenues	Mining would end in 2011 with the reduction from 543 full- and part-time jobs to about 25 required for post-closure activities, including loss of 103 NWAB jobs. Payroll would be reduced from $45.8 million annually to approximately $2 million, including $8.3 million paid to NWAB residents. NANA businesses would forgo $71.3 million in revenue, other businesses would forgo $29 million, and the NWAB would forgo $8 million annually in PILT.	Economic effects of closure described under Alternative A would be delayed until 2031.	Similar to Alternative B, except that approximately $72 million of NANA royalty payments would be directed instead to pipeline construction costs and approximately 40 transportation-related jobs would be eliminated.	Similar to Alternative B except that approximately $22 million of NANA royalty payments would be directed instead to the costs of implementing dust control measures and wastewater pipeline.
Environmental Justice	Effects on Environmental Justice Populations	No significant disproportionate effects.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.

Chapter 3

Affected Environment/Environmental Consequences

CHAPTER 3 AFFECTED ENVIRONMENT/ ENVIRONMENTAL CONSEQUENCES

3.1 Introduction

Environmental impact statements often separate the discussions of the affected environment (baseline conditions) and environmental consequences into separate chapters. This SEIS combines these two chapters into one since the affected environment has already experienced environmental consequences from previous mining activities.

Chapter 3 describes each resource, beginning with an overview of that resource, a brief summary of pre-mining conditions (based on the 1984 EIS), a description of the current conditions (which is sometimes referred to as the current baseline), and finally, a description of the environmental consequences that would result from each alternative. Current conditions, including effects that have already occurred as a result of mine related activities, will serve as the baseline conditions against which environmental impacts from the alternatives will be compared. Where applicable, the environmental consequences sections describe effects that are common to all alternatives followed by descriptions of effects that are unique to each alternative. The discussions include descriptions of measures that could be implemented to avoid, minimize, or mitigate impacts.

3.2 Air Quality

Air quality and associated permitting for industrial air emission sources are regulated under the federal Clean Air Act. Industrial air emission sources may include stationary (or point) sources, mobile sources, and fugitive sources. EPA has delegated authority to ADEC to administer the air permit program for industrial emission sources. As such, emissions from regulated sources in the State of Alaska are addressed through air quality permits issued by ADEC. To obtain an air permit in the State of Alaska, an industrial source must identify all regulated air emissions associated with its operations and demonstrate compliance with ambient air quality standards. The National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS) with which the Red Dog Mine must comply are listed in Table 3.2-1. Units for the standards are micrograms per cubic meter of air ($\mu g/m^3$).

The NAAQS, developed by EPA and adopted by the State of Alaska, are intended to protect public health and welfare. Primary standards represent air quality levels, with an adequate safety margin, required to protect public health. Secondary standards represent air quality levels necessary to protect public welfare. These standards must be met outside a facility’s property boundary. NAAQS and AAAQS have been established for nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter with a diameter less than 10 microns in size (PM_{10}), lead, and ozone. The NAAQS also include a standard for particulate matter with a diameter less than 2.5 microns in size ($PM_{2.5}$). The AAAQS include standards for reduced sulfur compounds and ammonia. Reduced sulfur compounds include hydrogen sulfide (H_2S), carbon disulfide (CS_2), and carbonyl sulfide (COS).

In addition to the NAAQS, EPA has developed Prevention of Significant Deterioration (PSD) increment standards that limit the incremental increase in air pollutant concentrations above the concentrations as of a specific date, called a baseline date. Baseline dates are established when a PSD major source permit application is deemed complete by the permitting authority. The Red Dog Mine is located in an area designated by EPA as PSD Class II. This designation means that EPA allows moderate industrial growth in the area, yet protects the area from substantial industrial growth. PSD increments have been established for PM_{10}, SO_2, and NO_2. The Red Dog Mine is located in the Northern Alaska Intrastate Air Quality

Control Region, where baseline dates have been established for PM_{10}, SO_2, and NO_2. Thus, the incremental increases of PM_{10}, SO_2, and NO_2 must be below the levels set by EPA, shown in Table 3.2-2.

The minor source baseline dates for the Northern Alaska Intrastate Air Quality Control Region are:

- NO_2: February 8, 1988
- SO_2: June 1, 1979
- PM_{10}: November 13, 1978

As with the NAAQS, the PSD increments must be met outside a facility's property boundary.

Table 3.2-1 National and Alaska Ambient Air Quality Standards

Pollutant	Averaging Period	AAAQS (μg/m³)	National Standards	
			Primary Standard (μg/m³)	Secondary Standard (μg/m³)
NO_2	Annual	100	100	100
SO_2	3-Hour 24-Hour Annual	1,300[a] 365[a] 80	N/A 365[a] 80	1,300[a] N/A N/A
PM_{10}[c]	24-Hour Annual	150[a] 50	150[a] Revoked[c]	150[a] Revoked[c]
$PM_{2.5}$[d]	24-Hour Annual	 N/A	35 15	35 15
CO	1-Hour 8-Hour	40,000[a] 10,000[a]	40,000[a] 10,000[a]	N/A N/A
Lead	3-Month	0.15	0.15	0.15
Ozone	1-Hour 8-Hour	235[b] N/A	235[b] 150[d]	235[b] 150[d]
Reduced Sulfur Compounds	30-Minute	50[a]	N/A	N/A
Ammonia	8-Hour	2,100[a]	N/A	N/A

[a] Not to be exceeded more than once per calendar year
[b] Not to be exceeded more than one day per calendar year
[c] Federal standard was 50 μg/m³ before revocation
[d] Based on the 3-year average of the fourth highest daily maximum 8-hour average

N/A denotes that a standard is not applicable for that averaging period.

Table 3.2-2 Prevention of Significant Deterioration Increments

Pollutant	Averaging Period	PSD Class II Increment (μg/m³)
PM_{10}	24-Hour	30*
	Annual	17
NO_2	Annual	25
SO_2	3-Hour	512*
	24-Hour	91*
	Annual	20

*Not to be exceeded more than once per calendar year

3.2.1 Air Quality – Pre-mining Environment

The study area was almost entirely undeveloped before mining activities began at the Red Dog Mine. Prior to mining, no significant air emission sources existed in northwestern Alaska and, as a result, air quality in the study area was good (EPA 1984). Although pre-mining air pollutant monitoring was not conducted prior to commencement of mining operations, background pollutant concentrations were assumed to be negligible. Some elevated particulate concentrations were expected from natural sources because of occasional strong winds in the area and a lack of vegetation that would protect surface soils from becoming airborne. Still, air pollutant concentrations were likely well below established ambient air quality standards.

The climate at the Red Dog Mine site is continental. The port site is dominated by a polar maritime climate when the Chukchi Sea is mostly ice-free but is similar to the mine site's continental climate during winter months (EPA 1984). Temperatures at the mine site are characterized by large diurnal variations, with very cold nighttime temperatures and moderate daytime high temperatures. Meteorological data have been collected at the Bons Creek station located on the mine site (SRK 2007). The 1996 to 2005 dataset shows that the average annual temperature was 25 degrees Fahrenheit (ºF). Winter temperatures generally range from lows of −23 to −7 ºF, with highs near 30 ºF. Summer high temperatures are in the upper 60s to low 70s ºF, while the lows are typically around 30 ºF (SRK 2007).

The mine site receives approximately 18.5 inches of measured precipitation annually (data measured at Bons Creek station from July 1991 through March 2005) (SRK 2007). Most of the annual precipitation occurs in the summer months, with August receiving approximately 25 percent of the yearly total.

Winds in the area are influenced by topography and local circulation patterns. At the mine site, winds are predominantly from the north through northeast in winter months and variable in summer months (SRK 2007). Winds at the port site are typically easterly in winter months. In summer, port site winds are variable with strong winds occurring from the south through southwest directions (Corps 2005). Predominant winter winds are channeled by the valleys of the Wulik River, Ikalukrok Creek, and North Fork and South Fork Red Dog Creek (SRK 2007). Windy conditions in the winter result in blowing and drifting snow around the mine site.

The potential for dispersion of airborne pollutants at the mine site depends on several factors, including atmospheric turbulence, precipitation, wind speed and direction, and the depth of the atmospheric mixing zone. Low atmospheric turbulence and low wind speeds tend to reduce pollutant dispersion and increase ambient concentrations. High wind speeds and high turbulence dilute pollutants in the atmosphere but also can lead to higher fugitive dust emissions due to wind erosion.

3.2.2 Air Quality – Baseline Conditions

Air quality measurements have been made for PM_{10} at the mine site and are below levels set by EPA to protect human health and the environment. Concentrations of other common air pollutants such as sulfur dioxide and nitrogen dioxide have not been measured at the mine site. However, an air quality impact analysis (modeling) was conducted by Teck to demonstrate that these constituents would be in compliance with standards. Any area that does not meet ambient air quality standards is designated non-attainment by EPA and is subject to additional restrictions on industrial development.

ADEC has issued air quality permits to Teck that provide a framework for how Teck may operate the mine. ADEC has issued both construction permits and operating permits for the mine. Title V Operating Permit No. 9332-AA003 Amendment 2 and Air Quality Construction Permits 0032-AC018 Rev. 1 and 9932-AC005 Rev. 2 are currently in place to regulate air emissions at the mine. In addition, minor source permits AQ0290MSS01, AQ0290MSS02, AQ0290MSS03, AQ0290MSS05, and AQ0290MSS06 have been issued by ADEC. Operational restrictions are identified in the permits to ensure that air quality standards continue to be met at the Red Dog Mine property boundary while mining activities are ongoing. These restrictions are monitored through reporting requirements and inspections by ADEC personnel.

ADEC has conducted site inspections at the Red Dog Mine regularly throughout the life of the mine. Table 3.2-3 provides a list of ADEC inspections since 1999 and summarizes ADEC findings.

Table 3.2-3 Summary of ADEC Site Inspections at Red Dog Mine

Inspection Date	Summary of Inspection findings
March 16–17, 1999	– Facility found to be in compliance with all air quality permits
August 8–10, 2000	– Sources MG-4, MG-5 exceeded CO emission limit – Source MG-13 exceeded annual operation hours limit – Complete record-keeping not provided for several emission sources – Fuel sulfur content not provided on a monthly basis – Sources MG-2, MG-3, and MG-5 exceeded PM emission limit – Source MG-3 exceeded NOx emission limit – Visible emission observations were not made for some sources prior to the required deadline – Required source emission tests were not made on several sources prior to the deadline – Source tests for source MC-6 were not conducted with the source operating at full capacity – Excess emission reports were not filed in several cases where emissions exceeded permit limits – Failed to notify EPA of the installation and/or operation of the sewage sludge incinerator (PI-2).
October 14–15, 2005	– Facility found to be in compliance with all air quality permits
October 22–24, 2007	– MG-17 found to be exceeding ammonia permitted emission limit – MI-2 visible emission limit exceeded; missed visible emission scheduled reading

Air monitoring for PM_{10} was conducted at the Red Dog Mine property boundary in 2001 and 2002. Results from this monitoring demonstrate that the maximum measured PM_{10} concentrations at the monitor site are below the PM_{10} ambient air quality standards. Table 3.2-4 presents the measured PM_{10} concentrations (TCAK 2005a) and applicable air quality standards at the mine site. These results represent contributions from both non-anthropogenic (e.g., unvegetated areas) and anthropogenic sources (e.g., mining facilities). Air monitoring locations for PM_{10} and total suspended particulate matter (TSP) are presented in Figure 3.1.

Table 3.2-4 Baseline Particulate Matter Monitored Concentrations

Averaging Period	PM_{10} Concentration ($\mu g/m^3$)	PM_{10} NAAQS/AAAQS ($\mu g/m^3$)
24-Hour	61.2	150
Annual	28.2	50

Air monitoring was conducted in 2003 and 2004 to determine airborne lead concentrations in the villages of Noatak and Kivalina. Results from the one-year monitoring program show that the maximum three-month lead concentration in Noatak was 0.0078 $\mu g/m^3$, and the maximum three-month lead concentration in Kivalina was 0.0062 $\mu g/m^3$ (TCAK 2005a). These measured values are below the three-month National and Alaska ambient air quality standard (NAAQS and AAAQS) for lead of 1.5 $\mu g/m^3$.

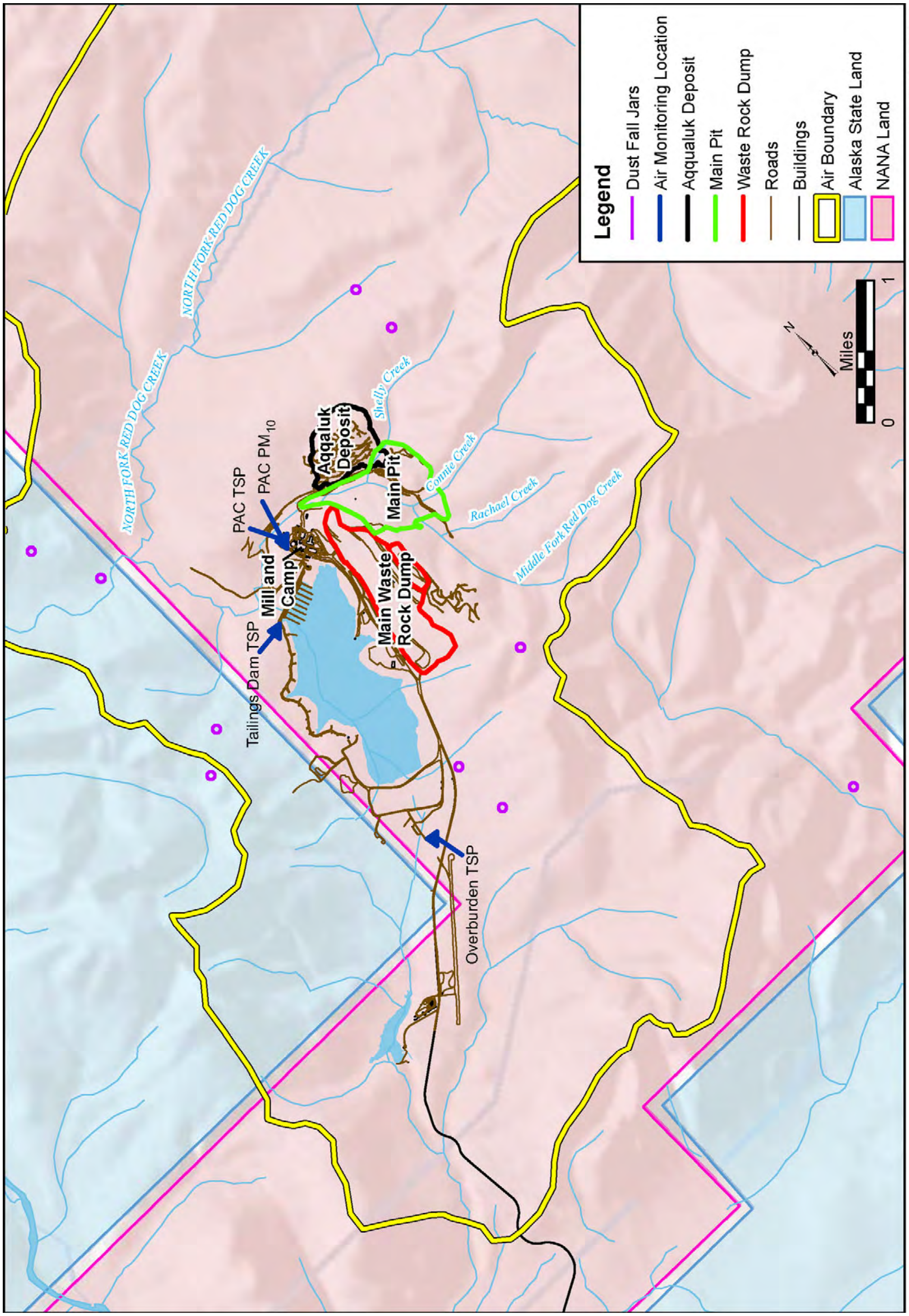


FIGURE 3.1
AIR MONITORING LOCATIONS

Zinc concentrations have not been measured in ambient air outside the Red Dog Mine site. The air permit boundary depicted in Figure 3.1 is the boundary at which ambient air quality standards must be met. The air permit boundary is identical to the mine site's solid waste permit boundary (TCAK 2005a). The air monitoring locations shown in Figure 3.1 were positioned near mine emission sources to increase understanding of mine operations.

Compliance with PSD increment standards is evaluated using computer modeling, which simulates the transport and dispersion of emitted pollutants and estimates downwind concentrations in the air. PSD increments cannot be directly compared to monitored air concentrations because only a portion of emitted pollutants are counted against the PSD increment consumption. Air monitoring equipment cannot distinguish between anthropogenic and non-anthropogenic sources of air pollutants.

A PSD increment modeling analysis was conducted for the Red Dog Mine in 2002. The modeling was associated with minor permit modifications requested by Teck. EPA's Industrial Source Complex Short-Term (ISCST3) model was used to estimate potential impacts from the air emission sources at the Red Dog Mine. At the time the modeling was completed, ISCST3 was the EPA-recommended model for evaluating industrial source air emissions. Model receptor points (where ambient impacts are calculated in the model) were identified along the air permit boundary line, and in a grid surrounding the mine site at locations outside the air permit boundary. Modeling was completed assuming the highest potential engine operations were occurring at the mine so that worst-case modeled impacts were calculated (Hoefler Consulting Group 2002). The modeling evaluated SO_2, NO_2, and PM_{10} increments and found that modeled concentrations were below the PSD increment levels (Hoefler Consulting Group 2002). Table 3.2-5 shows the PSD increment modeling results and compares them with PSD increment standards.

Table 3.2-5 Summary of PSD Increment Modeling Results

Pollutant	Averaging Period	Modeled Increment Consumption ($\mu g/m^3$)	PSD Class II Increment ($\mu g/m^3$)
PM_{10}	24-Hour	25.4	30*
	Annual	6.0	17
NO_2	Annual	24.2	25
SO_2	3-Hour	243.0	512*
	24-Hour	67.6	91*
	Annual	10.5	20

*Not to be exceeded more than once per calendar year

Compliance with other ambient standards (NAAQS/AAAQS) has also been demonstrated by Teck through computer modeling. Output from the model simulations is added to background concentrations, which represent pollutant concentrations from both anthropogenic and non-anthropogenic non-modeled sources. The sum of modeled and background concentrations for a given pollutant is compared to the applicable ambient air quality standard to evaluate the compliance status of the emission source. Table 3.2-6 shows the results from the most recent modeling completed for the Red Dog Mine (TCAK 2005a).

Table 3.2-6 Summary of Air Modeling Results

Pollutant	Averaging Period	Total Ambient Impact (μg/m3)	NAAQS/AAAQS (μg/m3)
NO_2	Annual	34.9	100
SO_2	3-Hour 24-Hour Annual	357.2 91.3 14.9	1,300[a] 365[a] 80
PM_{10}[c]	24-Hour Annual	55.0 9.5	150[a] 50
$PM_{2.5}$	24-Hour Annual	Not modeled Not modeled	65 15
CO	1-Hour 8-Hour	1,071 782	40,000[a] 10,000[a]
Lead	3-Month	0.02	0.15
Ozone[c]	1-Hour	Not modeled	235[b]
Reduced Sulfur Compounds[c]	30-Minute	Not modeled	50[a]
Ammonia	8-Hour	1.12	2,100[a]

[a] Not to be exceeded more than once per calendar year
[b] Not to be exceeded more than one day per calendar year
[c] Reduced sulfur compounds, $PM_{2.5}$, and ozone modeling were not required

3.2.2.1 Existing Mining Operations

The Red Dog Mine is located in a remote area of northwestern Alaska with little industrial development other than the mine itself. Mining operations result in air emissions from both point sources and fugitive sources. Point sources are those that emit air pollutants through a stack, vent, or other defined opening. Examples of point sources are generators, incinerators, and dust collectors. Fugitive air emission sources are those that emit air pollution in a way that cannot reasonably be routed through a stack or vent. Examples of fugitive air emission sources are vehicle traffic on unpaved haul roads, mining pit operations such as blasting, and wind erosion from exposed ore and waste rock piles. A summary of the air emission sources at the Red Dog Mine is shown in Table 3.2-7 (ADEC 2003a; Hoefler Consulting Group 1998). Annual emission limits are listed for PM_{10}, SO_2, nitrogen oxides (NO_x), CO, and volatile organic compounds (VOC). “N/A” indicates the category is not applicable. Note that the VOC emissions listed for MG-17 and MG-18 were not included in the 2003 Title V permit; to provide an estimate of what VOC emissions may be, these emissions were calculated using EPA AP 42 emission factors.

3.2.2.2 Fugitive Dust and Deposition

Although air monitoring and modeling have demonstrated that the mine operations meet the applicable ambient air quality standards, elevated metals concentrations on vegetation and in surface soils have been identified in areas surrounding the Red Dog Mine and the DMTS road (Exponent 2007a). The elevated metals concentrations result from fugitive dust deposition from mining operations (Exponent 2007a). Fugitive dust contains heavy metals, primarily lead, zinc, and cadmium. Elevated concentrations of all three metals have been identified in and around the Red Dog Mine Main Deposit site, including near the Main Pit, ore and waste stockpiles, the mine site CSB, tailings beaches, and along the DMTS road (TCAK 2005a).

Fugitive dust emissions from pit operations, material handling, milling, and ore transport can be carried by the wind outside the mine boundaries. Several sampling efforts have been completed to evaluate deposition of metals in dust surrounding the mining operations, as discussed below.

Table 3.2-7 Summary of Air Pollution Sources at the Red Dog Mine*

Air Emission Source	Rating/Size	Annual Emission Limits (tons per year)				
		PM_{10}	SO_2	NO_X	CO	VOC
Diesel Generators and Pumps						
Wartsila Primary Power #1 (MG-1)	5,000 kW	12.9	33.5	531.3	23.4	15.7
Wartsila Primary Power #2 (MG-2)	5,000 kW	20.5	53.5	531.3	37.2	26.7
Wartsila Primary Power #3 (MG-3)	5,000 kW	12.9	33.5	457.0	23.4	15.7
Wartsila Primary Power #4 (MG-4)	5,000 kW	20.5	53.5	531.3	37.2	26.7
Wartsila Primary Power #5 (MG-5)	5,000 kW	12.9	33.5	531.3	23.4	15.7
Wartsila Primary Power #6 (MG-6)	5,000 kW	20.5	53.5	531.3	37.2	26.7
Wartsila Primary Power #7 (MG-17)	5,000 kW	11.4	106.9	79.7	35.0	20.7
Wartsila Primary Power #8 (MG-18)	5,000 kW	11.4	106.9	531.3	35.0	20.7
Cat 3508TA #1 Supplemental Power (MG-7)	650 kW	0.3	0.7	10.3	2.1	0.3
Cat 3508TA #2 Supplemental Power (MG-8)	650 kW	0.3	0.7	10.3	2.1	0.3
Cat 3508TA #3 Supplemental Power (MG-9)	650 kW	0.3	0.7	10.3	2.1	0.3
Detroit Diesel ConPAC Backup Power (MG-10)	275 kW	1.1	2.9	50.0	8.9	2.8
Cat 3126 Diesel Backup Fire-Water Pump (MG-11)	195 hp	1.9	2.1	27.2	5.9	2.2
Detroit Diesel Reclaim Barge Backup Power (MG-12)	55 kW	0.6	0.5	9.1	2.0	0.7
Cat 3208TA Concrete Batch Plant Power (MG-13)	150 kW	0.5	0.4	7.5	1.6	0.6
Cat 3406 Portable Generator (MG14)	250 kW	3.2	2.7	45.5	9.8	3.6
Cat 3406 Portable Generator (MG-15)	250 kW	3.2	2.7	45.5	9.8	3.6
Cummins GCTA8.3 Portable Power (MG-16)	188 kW	2.4	2.0	34.2	7.4	2.7
Cat 3406TA Seepage Pond Backup Power (MG-19)	260 kW	0.2	0.3	2.7	0.6	0.2
Cat 3406B Red Dog Creek Backup Power (MG-20)	250 kW	0.2	0.3	2.6	0.6	0.2
Cat 3304 Kivalina Backup Power (MG-21)	90 kW	0.1	0.1	0.94	0.2	0.1
Cummins/Onan New Reclaim Barge Power (MG-22)	100 kW	0.1	0.1	1.0	0.2	0.1
Cummins/Onan Portable Generator (MG-23)	30 kW	0.05	0.1	0.6	0.1	0.05
Cummins/Onan Portable Generator (MG-24)	125 kW	1.3	1.9	18.2	3.9	1.4
John Deere Portable Generator (MG-25)	50 kW	0.5	0.7	6.2	1.3	0.5
Cat 3508 Portable Rock Crusher Generator (MXG-100)	850 kW	1.2	5.6	53.0	11.4	4.2
Heaters						
ABCO Standby Glycol/Water Heater (MH-1)	250 hp	1.1	16.8	11.0	2.7	0.3
ABCO Standby Glycol/Water Heater (MH-2)	250 hp	1.1	16.8	11.0	2.7	0.3
ABCO Standby Glycol/Water Heater (MH-3)	250 hp	1.1	16.8	11.0	2.7	0.3
Facility-Wide Small Heater Group (MH-4)	9.5 MMBtu/hr	1.0	14.1	8.5	2.1	0.3
Incinerators and Soil Remediation Unit						
John-Zink Comptro Incinerator (MI-2)	900 pounds/hr	29.6	5.7	13.0	39.4	29.6
Advanced Combustion Incinerator (MI-3)	625 pounds/hr	20.5	3.9	2.7	27.4	20.5
United Soil Recycling, ETC Unit (SRU-1)	2.2 MMBtu/hr	0.02	0.6	0.2	0.0	0.0
Dust Collectors						
Wheelabrator Baghouse 55W825 Primary Jaw Crusher (MD-1)	7,000 ACFM	1.9	N/A	N/A	N/A	N/A
Emtrol Wetscrubber 66W40 #1 Coarse Ore Conveyor A (MD-2)	12,500 ACFM	4.7	N/A	N/A	N/A	N/A
Emtrol Wetscrubber 66W40 #2 Coarse Ore Conveyor B (MD-3)	12,500 ACFM	4.7	N/A	N/A	N/A	N/A
Mikropul Baghouse 49S8-20 Assay Lab, Bucking Room (MD-4)	3,700 ACFM	1.4	N/A	N/A	N/A	N/A

Air Emission Source	Rating/Size	Annual Emission Limits (tons per year)				
		PM_{10}	SO_2	NO_X	CO	VOC
Mikropul Baghouse 48N4-B Reagent Mix Lime Room (MD-5)	1,200 ACFM	0.5	N/A	N/A	N/A	N/A
Wheelabrator Baghouse 46WCC Gyratory Crusher (MD-6)	9,000 ACFM	3.4	N/A	N/A	N/A	N/A
Tanks						
Diesel No.1 & 2 Fuel Storage Tank (MT-1)	230,000 gallons	N/A	N/A	N/A	N/A	0.1
Diesel No.1 & 2 Fuel Storage Tank (MT-2)	230,000 gallons	N/A	N/A	N/A	N/A	0.1
Diesel No.1 & 2 Fuel Storage Tank (MT-3)	1,200,000 gallons	N/A	N/A	N/A	N/A	0.1
Diesel No.1 & 2 Fuel Storage Tank (MT-4)	1,140,000 gallons	N/A	N/A	N/A	N/A	0.1
Fugitive and Miscellaneous						
Mill Building Exhausts and Vents (MF-1)	N/A	N/A	18.6	N/A	N/A	1.25
Ore Truck Unloading Station at Primary Jaw Crusher Drop Box (MF-2)	N/A	0.8	N/A	N/A	N/A	N/A
Ore Truck Unloading Station at Gyratory Crusher Drop Box (MF-3)	N/A	0.8	N/A	N/A	N/A	N/A
CSB, Truck Loading Bay Exterior Doors and Vents (MF-4)	N/A	0.0	N/A	N/A	N/A	N/A
Mine Roads Fugitive Dust within the Ambient Air Boundary (MF-5)	Area Source	105.8	N/A	N/A	N/A	N/A
Quarry Operations Fugitives (Dust and Methanol) within the Ambient Air Boundary (MF-6)	Area Source	12.2	N/A	N/A	N/A	N/A
Stockpiles and Exposed Areas within the Ambient Air Boundary (MF-7)	Area Source	25.4	N/A	N/A	N/A	N/A
Open Burning of Wood for Disposal and/or Fire-Fighter Training (MF-8)	Area Source	2.92	0.18	1.1	15.5	5.48
Fuel for Fire-Fighter Training Purposes (MF-9)	Area Source	0.0	0.01	0.01	0.0	0.0
Concrete Batch Plant Feed Material Fugitive Dust (MC-1)	N/A	4.71	N/A	N/A	N/A	N/A

Sources: ADEC 2003a; Hoefler Consulting Group 1998
N/A = not applicable
MMBTU/hr = million British thermal units per hour
ACFM = actual cubic feet per minute
*This table represents a list of the larger sources of emissions at the site but is not comprehensive.

Mine Area Tundra Moss Study

Tundra soil and moss concentrations were evaluated inside and outside the mine boundary in 2003 and 2004. The focus of the study was to evaluate lead and zinc concentrations on the surface of the tundra soil (TCAK 2005a). Approximately 478 soil and 73 moss samples were collected over the two-year period and analyzed to determine the amount of lead and zinc deposition that had taken place (TCAK 2005a).

The highest tundra soil concentrations were measured west of the accommodations complex and north of the tailings impoundment. Most of the high lead and zinc concentrations were measured inside the mine boundary and adjacent to mining operations. Elevated zinc concentrations were observed deeper in the soil than lead. The results suggest that zinc may be leaching into the soil more readily than lead. Vegetation within some of the sampled areas inside the mine boundary shows signs of stress. Teck has suggested that leaching zinc (and possibly cadmium) may be responsible for the stressed vegetation (TCAK 2005a). Lead and zinc concentrations in tundra soils decrease with distance from the mining operations.

Snow Drift Sampling

In April 2005 a sampling effort was completed to analyze metals concentrations in snow drift areas and non-drift areas surrounding the mining activities. As expected, lead and zinc concentrations in samples were the highest downwind of mining activities that generate fugitive dust. The highest calculated accumulation rates occurred near the tailings pond and were 51.7 milligrams per square meter per day (mg/m^2 per day) for zinc, and 13.1 mg/m^2 per day for lead. Lead and zinc concentrations were higher in non-drift snow samples than drift snow samples. This result is believed to be caused by higher dilution of the drift samples because of higher snow accumulation (Clark 2005). However, the total loading of metals was higher in snow drift areas.

Dustfall Jar Deposition

Dustfall jar deposition sampling began in 1999 and continues as an ongoing sampling effort. Dustfall jars are passive collectors of settling dust. Jar samples are typically collected over a 30-day period, but some have been collected for several months. Three separate dustfall jar sampling programs have been conducted at the mine. The first program collected samples from 1999 to 2003 in quadrants spaced within the mine boundary. The second program collected samples from 2001 to 2003 at locations west of the tailings impoundment.

The current sampling program includes 25 jars spread out over the mine site (see Figure 3.1). Sample results can be valuable for identifying deposition distributions, but results can be variable because of wind scouring of the jars and inconsistencies caused by precipitation.

Dustfall results indicate that the primary areas of fugitive dust deposition are near the pit, ore, and waste stockpiles; the mine site CSB; and the tailings beaches (TCAK 2005a). Metals accumulation rates from dustfall jars are lower than the non-drift snow samples collected near the dustfall jars (Clark 2005). The highest calculated accumulation rate for lead was 27.2 mg/m^2 per day and occurred near the main pit (TCAK 2005a).

A comparison of total dust deposition results between 2005 and 2006 was conducted to evaluate the change in particulate deposition over the one-year period (TCAK 2007). The results indicate a reduction in total deposition at 24 of the 25 sampling locations. One sampling location had an increase in deposition from 2005 to 2006. The dustfall jar with a deposition increase is the western-most location in the sampling network and located adjacent to an access road west of the mill site facilities. This sample site also had lower zinc and lead concentrations than most of the other sample sites.

The tundra moss study, snow drift sampling, and dustfall jar deposition sampling were designed to characterize the distribution and amount of metals contamination occurring around the mine site. The tundra moss study also evaluated the effect of contamination on the tundra moss at and around the mine site. Teck has used these studies to better understand air emission impacts at the site and to give focus to the dust control improvement efforts.

DeLong Mountain Regional Transportation System Deposition

In addition to metals deposition around the mine site, there is concern that metals deposition around the DMTS road and port from concentrate handling is causing adverse impacts to vegetation (see Section 3.7.2) and some wildlife species (see Section 3.9.2) occurring in the vicinity of the DMTS. The study area includes the DMTS corridor extending from the Red Dog Mine to the port, including the road, port facilities, and outlying tundra areas. Approximately 20 miles (32 kilometers) of the DMTS road passes through the Cape Krusenstern National Monument before reaching the port facility.

NPS conducted a moss study in 2000 to evaluate metals concentrations in tundra located near the DMTS road. Elevated concentrations of lead and zinc were identified in tundra and moss along the DMTS road (Ford and Hasselbach 2001). The primary source of elevated metals concentrations is deposition of fugitive dust generated during the transportation of zinc and lead ore concentrate from the mine (Exponent 2007a). NPS attributed the elevated metals concentrations to ore concentrate escapement from concentrate trucks as well as from residue on the outside surfaces of the trucks (Hasselbach et al. 2005).

A second moss study conducted by NPS in 2001 with publication of a technical paper in 2005 extended the sampling grid to 43 miles (70 kilometers) north and south of the DMTS road where the road passes through Cape Krusenstern National Monument. Results of this study suggest that lead deposition from the road may extend 15 miles (25 kilometers) north of the road and possibly further (Hasselbach et al. 2005). The study noted that lead concentrations on moss decreased more quickly on the south side of the DMTS road compared to the north side. Figure 3.2 illustrates lead concentrations in moss in the greater vicinity of the project area reported by Hasselbach et al. (2005) where measured lead concentrations ranged from 1.1 mg/kg to over 912.5 mg/kg (Hasselbach et al. 2005). Ford et al. (1995) estimated background lead concentrations on moss in the Alaskan arctic at 0.6 mg/kg. What the figure shows is that the concentrations of lead on moss in the immediate vicinity of the DMTS port and road are higher than concentrations on moss further from those facilities. All measured lead levels were above the level identified as background. Studies have not established a relationship between lead concentrations observed in moss compared to those observed in soils.

Mine Site Dust Deposition

Improvements made to mining operations have reduced fugitive dust emissions around the mine site (Table 3.2-8). It is uncertain when the majority of lead and zinc deposition occurred around the mine site. Mining operations continue to result in some levels of fugitive dust generation and subsequent deposition of metals within and outside the mine site. Stressed vegetation has been observed adjacent to mining activities within the mine site. The greatest degree of effects resulting from deposition have been observed within the mine's ambient air permit boundary. Figure 3.3 shows the general location of the air permit boundaries for the mine and port. Monitored PM_{10} concentrations at the mine air permit boundary are within air permit requirements.

Risk Assessment Sampling

The DMTS risk assessment was designed to evaluate whether metal-laden dust found in the tundra within and around the DMTS port and road, and outside the Red Dog Mine air permit boundary was likely to have adverse impacts on human health or the environment. The DMTS risk assessment, completed in 2007, estimates potential risks to human and ecological receptors resulting from fugitive dust impacts (Exponent 2007a, 2007b).

The DMTS risk assessment confirmed that metals concentrations were highest in soils within the mine and port air permit boundaries. Concentrations were lower along the DMTS road. Moss samples in the tundra showed the highest metals concentrations near the mine and DMTS port and road. The highest metals concentrations were found to the north and west of the CSBs, road, and mine, which is the prevailing downwind direction. Metals concentrations decrease with distance from these dust sources.

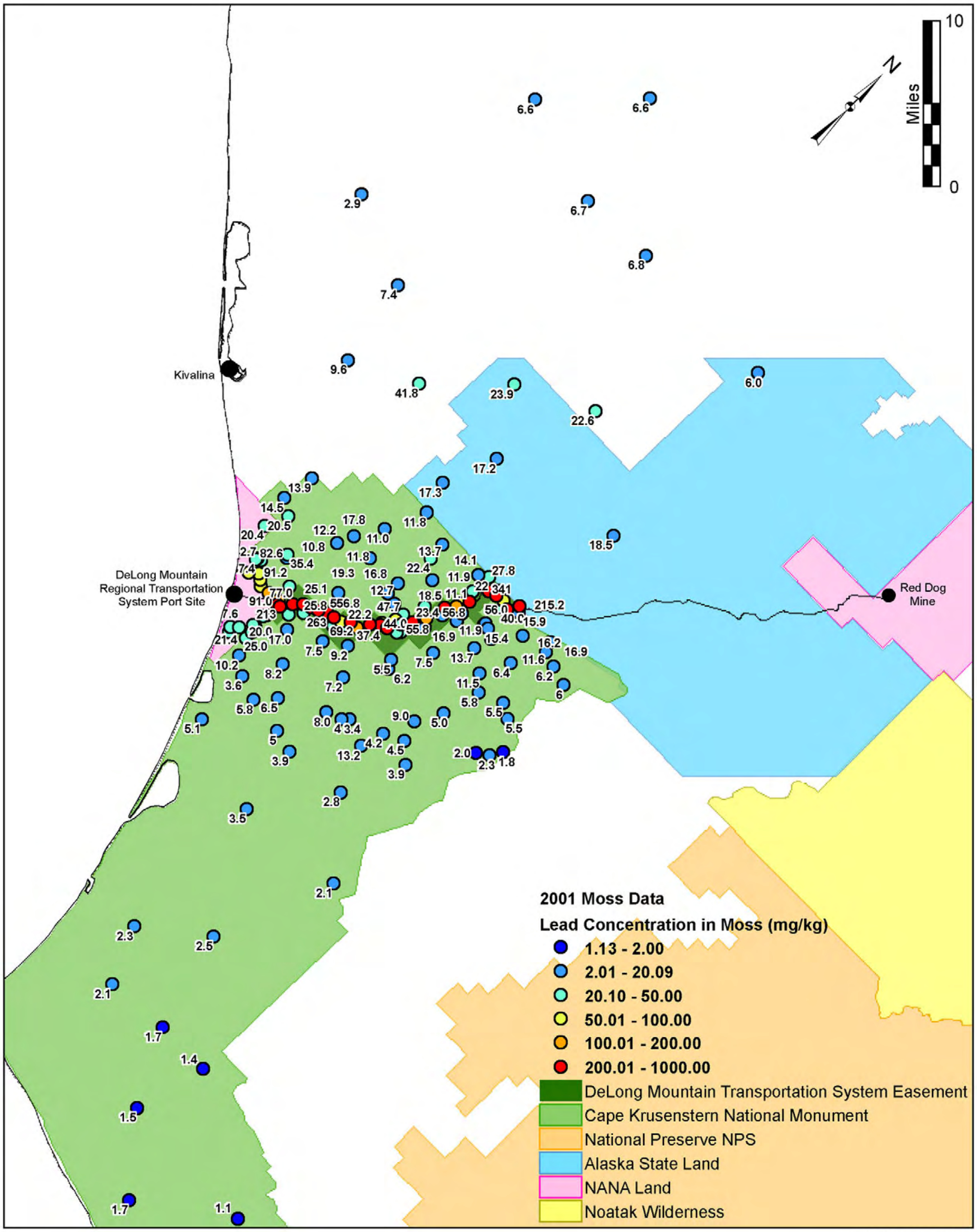


FIGURE 3.2

LEAD CONCENTRATIONS OBSERVED ON MOSS

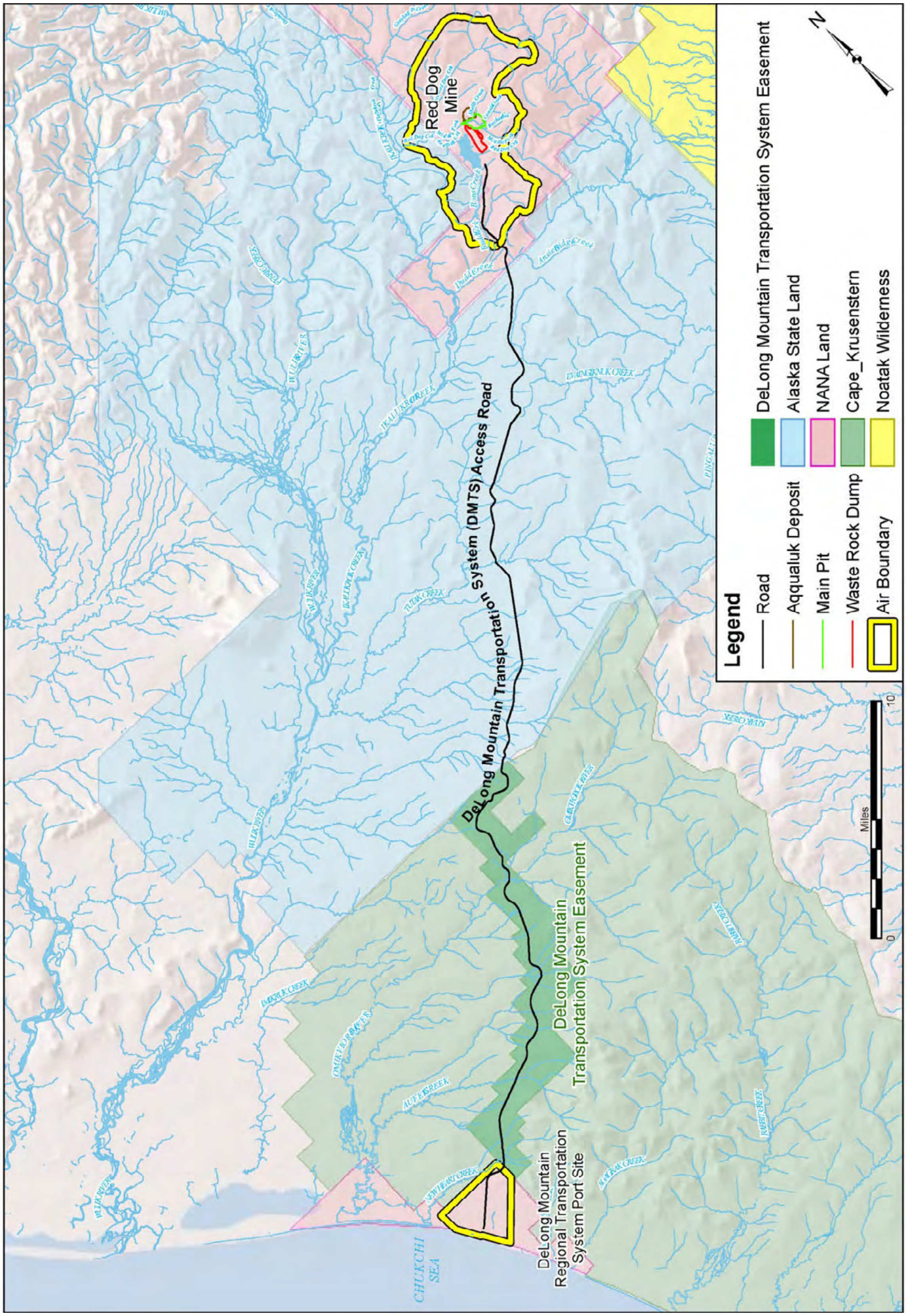


FIGURE 3.3
AMBIENT AIR BOUNDARY

Table 3.2-8 Dust Control Improvement Efforts*

Road Controls
1992 – Calcium chloride applications intensified for mine site roads and laydown areas
1992 – Addition of a water truck for roads; intensified watering of site
2001 – Addition of new design for concentrate trailers
2006 – New water truck fill station increases watering cycles
Crushers
1993 – Water sprays on jaw crusher drop box (abandoned due to freezing)
1995 – Jaw crusher baghouse replaced
2002 – Gyro crusher drop box stilling curtains installed
2002 – Crusher feed stockpiles moved into the pit
2006 – Installed stilling curtains, walls and baghouse on gyratory crusher
2006 – Installed stilling curtains, walls and baghouse on jaw crusher
Coarse Ore Stockpile
1991 – Coarse ore stockpile partially enclosed
1991–1992 Tarping installed (periodically repaired) to enclose stockpile
1992 – Water spray bar installed on belts dumping into enclosed ore stockpile
1992 – Permanent hard-sided coarse ore stockpile enclosure completed
2007 – Installed baghouse to generate negative pressure during truck loading
Concentrate Storage and Loadout
1992 – Concentrate truck loading bay fully enclosed
2001 – Summer concentrate truck wash system installed
2001 – Stilling curtains installed in concentrate truck loadout bay
2004 – Fans installed to draw entrained particulate matter from concentrate loadout bay
2008 – Installed baghouse to generate negative pressure throughout truck unloading building
Tailings Basin
2001 – Eight "windrows" of waste rock installed to mitigate wind erosion
2001 – Soil-Cement palliative added to a portion of the tailings beach
2003 – Tailings beach flooded
2005 – Some exposed tailings beach flooded

*Additional detail on dust control improvements are found in Exponent 2007a

Additional detail on the DMTS risk assessment findings is presented under applicable resource areas including vegetation (Section 3.7.2), wildlife (Section 3.9.2), and public health (Section 3.12.2).

3.2.3 Air Quality – Environmental Consequences

This section discusses the expected changes in air emissions associated with the Applicant's proposed action and alternatives, and the potential impact of these emissions. The existing sources of fugitive dust identified in Section 3.2.2 are compared to proposed sources of fugitive dust associated with each alternative. Expected changes in fugitive dust deposition patterns and the extent to which deposition of additional fugitive dust generated may impact off-site receptors are discussed. The analysis qualitatively describes the impacts associated with changes in the concentrations of various emissions and estimates the associated compliance with ambient air quality standards.

3.2.3.1 Effects Common to All Alternatives

Existing baseline conditions are described in Section 3.2.2. These baseline conditions describe current conditions of the mining operations. Under all alternatives identified, air emissions would continue from mining and support operations. Air emission sources associated with the mine include combustion sources, such as diesel generators, heaters, boilers, and mining equipment, and non-combustion sources including fugitive dust generating sources, dust collectors, fuel tanks, and other miscellaneous sources. Based on average annual consumption figures for diesel, annual CO_2 emissions from the operation account for 0.0027 percent of the annual U.S. CO_2 emissions and 0.34 percent of Alaska's annual CO_2 emissions.

Fugitive dust generation and subsequent deposition will continue as long as mining operations are ongoing. Teck has made efforts to reduce fugitive dust emissions at the Red Dog Mine. Teck and ADEC entered into an MOU in 2005. The MOU was updated in 2007, prior to the start of the SEIS process. The MOU describes the process Teck used to evaluate potential impacts from fugitive dust emissions and measures that can be implemented to reduce emissions. Under the MOU, Teck developed a draft fugitive dust risk management plan that was released by ADEC for comment on August 26, 2008. The draft fugitive dust risk management plan lists potential actions that Teck may take to reduce fugitive dust emissions. The plan identifies actions that Teck will develop to identify specifically which actions will be implemented. According to the MOU, the fugitive dust risk management plan will include the following information (ADEC 2007).

- Conduct tundra soil sampling to characterize possible effects of metals deposition on vegetation.
- Continue collecting ambient concentrations of particulates, lead, and zinc at the tailings impoundment and conPAC sampling sites. Teck and ADEC will work together to correlate historic ambient measurements with current measurements.
- Continue ongoing effort to study and implement engineered controls for dust generating activities at the mine.
- Develop historic and current source fugitive dust inventory.
- Conduct particle deposition modeling.
- Provide quarterly reports and attend semiannual meetings (and make reports available on the ADEC Red Dog Mine Website).

The MOU outlines the studies and potential improvements that have been made or may be made in the future to reduce impacts from fugitive dust. Efforts to incorporate these improvements would continue under all the alternatives. Specific areas of evaluation and potential upgrades include the crusher, coarse ore stockpile, concentrate storage area, concentrate truck loading dust control system, and the coarse ore stockpile building dust collection system (SRK 2007). Because the plan is a draft, it is not clear which dust reduction measures will be implemented. Regardless of the steps taken to reduce fugitive dust emissions, the plan should include a monitoring approach that (1) is adequate to quantify changes in emissions/deposition in response to the new dust control measures to determine whether they are having an effect; and (2) allows results to be shared with local communities so that they can be aware of changes in the status of fugitive dust from future operations.

3.2.3.2 Effects of Alternative A – No Action Alternative

Under the no action alternative, the existing mining conditions would continue through 2011. Currently, Teck employs eight 5-MW Wartsila diesel engines as the site's primary power source. Under Alternative A, three 5-MW engines (only two would be operational at any given time) would be added to the site's generating capacity to supply power for the reverse osmosis water treatment system. The reverse osmosis treatment system itself would not result in air emissions. Since the Aqqaluk Deposit would not be developed, fugitive dust sources would be limited to those associated with the continuation of existing operations through 2011. Table 3.2-9 includes an estimate of annual emissions associated with power generation.

Elevated concentrations of lead and zinc have been identified in and around the Red Dog Mine Main Deposit, including near the pit, ore and waste stockpiles, the mine site CSB, and the tailings beaches, primarily as a result of fugitive dust deposition (TCAK 2005a). Fugitive dust would continue to be generated and deposited throughout the mine's operational life. After mining is complete in 2011, reclamation activities would commence. It is anticipated that NAAQS will continue to be met based on historical monitoring results. The site would remain a source of fugitive dust until vegetation was re-established on disturbed areas.

Ongoing dust control measures presented in Table 3.2-8 will serve to reduce future adverse impacts from deposition of metal-bearing dust around the mine site and along the DMTS road. Fugitive dust and tailpipe emissions will continue to be generated along the DMTS road by concentrate trucks as well as other vehicles. Table 3.2-9 summarizes the estimated emissions that would be generated under each alternative by various vehicles along the DMTS road and by the main generators operating at the mine site. The values for mobile sources presented in Table 3.2-9 were estimated using EPA guidance for industrial unpaved roads and EPA's Mobile6 software for tailpipe emissions (EPA 1995; EPA 2003a). The dust emission calculations include the effects of fugitive dust mitigation efforts.

3.2.3.3 Effects of Alternative B – Applicant's Proposed Action

The Aqqaluk Deposit is located within the current ambient air boundary and north of the Main Pit. The nature of the effects on air quality from Alternative B will extend the duration and extent of impacts compared to Alternative A. However, operations at the Red Dog Mine would extend through 2031, or 20 years beyond the mine life under Alternative A. Mining operations would transition from the Main Pit to the Aqqaluk Deposit. The Aqqaluk expansion would result in approximately 406.5 additional acres being disturbed at the mine site over the life of the mine. Areas downwind of the pits subject to fugitive dust deposition would extend slightly to the north with the opening of the Aqqaluk Deposit.

No additional stationary equipment is proposed and mobile equipment is expected to increase only slightly. One new drill, two loaders, and two additional trucks would be needed initially for developing the Aqqaluk Pit in addition to existing equipment (SRK 2007). After the transition to the Aqqaluk Pit is complete, the extent of mobile equipment needed would return to the existing levels.

Stationary source effects would not change notably. Air emission sources associated with the Main Pit include drilling, blasting, dozer activity in the blast area, loader activity in the blast area, haul truck loading, and haul truck activity from the pit to the ore stockpile and waste rock area (SENES 2007). These operations would shift from the Main Pit to the Aqqaluk Pit, approximately 2,000 feet (910 meters) north of the Main Pit. Waste rock management from the Aqqaluk Pit would move from its existing location east of the tailings impoundment to the current Main Pit.

Construction of the Aqqaluk Project may result in a short-term adverse impact on ambient air quality from increased fugitive dust emissions during construction. Mining in the new location would produce a long-term adverse impact in terms of ambient air quality as fugitive dust would be produced for a longer period of time.

Since the Aqqaluk Pit lies partially in the prevailing upwind direction from existing mining operations, a portion of fugitive dust produced during Aqqaluk mining operations is expected to be deposited on areas that are already affected by dust from current mining operations. Based on prevailing wind directions and depositional patterns, additional areas in the vicinity of the mine site may experience fugitive dust deposition (Exponent 2007a; TCAK 2005a).

Table 3.2-9 Summary of Annual Emissions

	Vehicle Type	Load Type	Annual Emissions (tons per year)				
			Particulate Matter [a]	CO	VOC	SO_2	NO_X
Alternative A	Concentrate Trucks	Lead and Zinc Concentrate	730.29	2.94	0.65	0.02	10.51
	Fuel Trucks	Diesel/Gasoline	27.01	0.14	0.03	0.00	0.50
	Supply Trucks	Miscellaneous	12.01	0.07	0.02	0.00	0.28
	Maintenance Vehicles	N/A	34.03	0.17	0.06	0.00	0.79
	Light Vehicles	N/A	53.01	10.63	0.50	0.00	0.50
	Stationary Power [b]	Diesel	86	232	158	169 [c]	2,859 [d]
	Total		942.35	245.95	159.26	169.02	2,871.58
Alternative B	Concentrate Trucks	Lead and Zinc Concentrate	730.29	2.94	0.65	0.02	10.51
	Fuel Trucks	Diesel/Gasoline	27.01	0.14	0.03	0.00	0.50
	Supply Trucks	Miscellaneous	12.01	0.07	0.02	0.00	0.28
	Maintenance Vehicles	N/A	34.03	0.17	0.06	0.00	0.79
	Light Vehicles	N/A	53.01	10.63	0.50	0.00	0.50
	Stationary Power [e]	Diesel	67	206	150	151	2,800
	Total		923.35	219.95	151.26	151.02	2,812.58
Alternative C	Concentrate Trucks	Lead and Zinc Concentrate	—	—	—	—	—
	Fuel Trucks	Diesel/Gasoline	—	—	—	—	—
	Supply Trucks	Miscellaneous	12.01	0.07	0.02	0.00	0.28
	Maintenance Vehicles	N/A	34.03	0.17	0.06	0.00	0.79
	Light Vehicles	N/A	53.01	10.63	0.50	0.00	0.50
	Stationary Power [f]	Diesel	87	211	153	166 [c]	2,893
	Total		186.05	221.87	153.58	166.0	2,894.57
Alternative D	Concentrate Trucks	Lead and Zinc Concentrate	592.96	2.94	0.65	0.02	10.51
	Fuel Trucks	Diesel/Gasoline	22.29	0.14	0.03	0.00	0.50
	Supply Trucks	Miscellaneous	10.01	0.07	0.02	0.00	0.28
	Maintenance Vehicles	N/A	27.03	0.17	0.06	0.00	0.79
	Light Vehicles	N/A	43.01	10.63	0.50	0.00	0.50
	Stationary Power [e]	Diesel	67	206	150	151	2,800
	Total		762.3	219.95	151.26	151.02	2,812.58

[a] Particulate matter = total suspended particulate matter

[b] Based on 10 Wartsila diesel engines using average data for eight Wartsila diesel engines operating in 2008.

[c] SO_2 calculated using mass balance with average diesel sulfur content of 0.12% by weight.

[d] Assumes new engines will be fitted with selective catalytic reduction systems for NOx control.

[e] Based on data for 8 Wartsila diesel engines operating in 2008.

[f] Additional power (3 MW) provided by three 1.5-MW diesel generators, two in continuous operation. Emission factors for PM, NOx, VOC, and CO obtained from manufacturer specifications. SO_2 calculated using mass balance.

N/A = not applicable

— = not available

For example, during the summer and fall months when southwesterly winds are common, deposition may occur to the northeast of the Aqqaluk Pit. Because the Aqqaluk Pit is approximately 2,000 feet north of the current Main Pit, deposition of metals would be expected to extend roughly the same distance further north than current depositional patterns. However, because the predominant annual wind direction at the mine site is from the northeast, the majority of deposition would occur to the southwest in the area of the current Main Pit.

Trucks would travel along the DMTS road for a longer time period, though would not increase in volume; annual vehicle emissions would be similar to Alternative A (Table 3.2-9). The longer time frame of concentrate truck traffic may result in a long-term adverse impact on surrounding ambient air quality. The effects of heavy metals deposition near the DMTS road are described in sections 3.7 (Vegetation) and 3.9 (Wildlife). Concentrate hauling would continue for an additional 20 years under Alternative B, resulting in additional lead, zinc, cadmium, and sulfur deposition along the DMTS corridor. These metals would remain in the environment beyond the life of the mine and some could be re-entrained into the air through wind erosion along the road or other disturbed soil areas, and redistributed downwind from the original depositional area.

Additional ore would be placed in the low-grade ore stockpiles, which could result in additional fugitive emissions from the piles until they are reclaimed. The closure plan calls for reclamation of the waste rock dump beginning in 2012. Revegetation would minimize or eliminate future emissions from this area once vegetation was re-established.

Air effects from the port facility would be similar to those presently experienced; however, these effects would continue for a longer duration. Past investigations of the port facility identified elevated metal concentrations associated with fugitive dust emissions, which resulted in extensive equipment and operational improvements to reduce these emissions. It is anticipated that dust control efforts will continue to reduce the rates of dust release.

Other ongoing dust control measures presented in Table 3.2-8 will serve to reduce future emissions and deposition of metal-bearing fugitive dust. It is anticipated that NAAQS will continue to be met based on historical monitoring results and the fact that future emissions are not predicted to increase substantially, but current emission levels would occur for a longer period of time.

3.2.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Alternative C differs from Alternative B in that concentrate would be transported to the port site via a slurry pipeline instead of concentrate trucks. The pipeline would result in a long-term positive impact on surrounding ambient air quality from reduced fugitive dust emissions. Additional generators (point sources) would be necessary to meet the power demands of the filter presses and water treatment facilities that would be added at the port facility. This could reduce the power demands for the comparable facilities at the mine. However, additional power would be required for the concentrate and diesel pipelines. Building the pipeline bench would produce fugitive dust during construction but these effects would be localized and limited to 1 to 2 years. Since borrow materials are not known to contain elevated levels of metals, effects on adjacent vegetation would be related to dust deposition rather than metals contamination (see Section 3.7). Fugitive emissions associated with truck traffic would be greatly reduced as daily traffic on the DMTS road would be reduced from approximately 49 round trips per day to approximately 15, with most of those being light-duty vehicles. The light-vehicle traffic (e.g., pickup trucks) would increase by an estimated three round trips compared to alternatives A and B because of the need to monitor the pipelines. Table 3.2-9 summarizes the estimated emissions that would be generated under Alternative C by various sources. The dust emission calculations include the effects of fugitive dust mitigation efforts.

The additional power to operate the port site wastewater treatment plant and the diesel and slurry pumps would be provided by three 1.5-MW diesel generators with one reserve as backup. Point source emissions (e.g., exiting a stack or vent) would increase because of the additional generators that would be needed for the port site. These sources would need to meet PSD requirements and would not be expected to create an adverse long-term impact on ambient air quality. Also, fugitive dust emissions may increase temporarily during construction of the pipeline, causing a short-term adverse impact on surrounding ambient air quality.

Ongoing dust control measures presented in Table 3.2-8 will serve to reduce future adverse impacts from deposition of metal-bearing dust around the mine site and along the DMTS road. It is anticipated that NAAQS will continue to be met based on historic monitoring results and the fact that future emissions are not predicted to increase substantially (rather, emissions would occur for a longer period of time). Additionally, the application of water during pipeline construction may reduce fugitive dust emissions.

3.2.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Alternative D is similar to Alternative C in that the outfall would be moved from Red Dog Creek to the Chukchi Sea. Alternative D, however, does not include diesel or concentrate pipelines. Dust control would be enhanced using two enclosed, year-round truck washes to reduce fugitive dust emissions. The truck washes would result in a long-term positive impact on ambient air quality by reducing the concentrate component of fugitive dust emissions. Fugitive emissions associated with truck traffic would be slightly higher than Alternative B because of the need to monitor the pipeline. However, fugitive dust along the road would be slightly lower because the truck wash stations would reduce some of the mud/dirt trackout along the DMTS road. EPA recommends adjusting road emission calculations when mud/dirt trackout is a concern. Because mud/dirt trackout would be reduced by the wash stations, this adjustment was not made in the Alternative D haul road emission calculations. Table 3.2-9 summarizes the estimated fugitive emissions that would be generated under Alternative D by various vehicles along the DMTS road. The values presented in Table 3.2-9 were estimated using EPA guidance for industrial unpaved roads and EPA's Mobile6 software for tailpipe emissions (EPA 1995; EPA 2003a). The dust emission calculations include the effects of fugitive dust mitigation efforts. The waste rock dump would be revegetated as soon as possible, which would minimize or eliminate future emissions from the waste rock.

3.2.4 Air Quality – Summary

Under all alternatives, air emissions would continue from mining and support operations. Air emission sources associated with the mine include combustion sources such as diesel generators, heaters, boilers, and mining equipment, and non-combustion sources including fugitive dust generating sources, dust collectors, fuel tanks, and other miscellaneous sources. Under Alternative A, the reverse osmosis wastewater treatment system would require an additional 10-MW of power and thereby increase air emissions from the mine site. Emissions associated with water treatment would continue in perpetuity but fugitive dust emissions would be minimized after closure in 2011.

Under Alternative B, air emissions from mobile sources could have short-term increases because of activity in both pits but would return to levels comparable to existing conditions when mining of the Main Pit ceased. Mining in the Aqqaluk Pit would continue to produce fugitive dust that could affect other resources downwind. However, the new pit would be partially in the prevailing upwind direction from existing mining operations, suggesting that a portion of the fugitive air emissions would fall on areas already impacted by existing mine operations. Fugitive emissions along the DMTS road would continue at current levels through 2031 unless additional controls are implemented through the draft fugitive dust risk management plan currently in development.

Under Alternative C, concentrates would be transported to the port facility through a pipeline. Fugitive dust emissions may increase temporarily for a year or two during construction of the pipeline, causing a short-term adverse impact on surrounding vegetation and ambient air quality. Over the longer term, the pipeline would be expected to substantially diminish fugitive dust emissions along the DMTS road by reducing truck traffic. Approximately 36 round trips per day of concentrate truck traffic would be eliminated. Under this alternative, traffic would consist of two supply trucks and 13 round trips by light vehicles. Additional generators would be needed at the port facility to power the filter plant and diesel pump (approximately 3.0 MW) with associated increases in air emissions. Alternative C includes construction of a 100 kW wind turbine to reduce diesel fuel use by the generators.

Emissions under Alternative D would be comparable to Alternative C except that additional generators would not be needed at the port and no wind generators would be constructed. Fugitive emissions along the DMTS road under Alternative D would be higher than Alternative C but slightly less than Alternative B.

The truck washes at the port and mine loadout facility under Alternative D would reduce the amount of concentrate dust that could be released by the concentrate trucks. Implementing truck washes under alternatives A and B as a mitigation measure would also reduce the potential for releasing additional concentrate dust under those alternatives. While Teck could voluntarily establish year-round truck washes at both ends of the DMTS road, none of the cooperating agencies has indicated that they have the authority to require their construction and operation. Therefore, the effectiveness of this mitigation measure is based upon Teck's willingness to implement it.

3.3 Geochemistry

Geochemistry describes the distribution, movement, and chemical reactions of elements in the environment as well as the processes affecting distribution, movement and reactivity. Ore and non-ore minerals associated with a deposit weather in the presence of water and oxygen to release elements (e.g., lead, zinc, cadmium, and sulfur as sulfate [in the case of the minerals at and surrounding the Red Dog Mine]) to water resources. Such weathering also affects the bioavailability of these elements. Weathering of exposed minerals in outcrops occurred before the Red Dog Mine was developed and continues to occur both within the active mining areas (pit, waste rock dumps, and tailings impoundment) and in undisturbed mineralized areas surrounding the mine.

Water resources are affected when ore and non-ore minerals degrade in the presence of oxygen and water, and the weathering products are rinsed from those minerals by incidental precipitation, snow melt, surface water flows, or groundwater. This is evidenced by the red staining present in Red Dog Creek even before mining began and in Cub Creek, a mineralized but undisturbed watershed northwest of the Red Dog Mine. Active-zone groundwater as well as surface water may be affected (Dames & Moore 1983a).

The bioavailability of various elements of concern (e.g., lead, zinc, and cadmium) associated with ore and non-ore minerals is affected when minerals degrade to release those elements to water resources or transform from relatively less bioavailable forms (e.g., zinc sulfide) to relatively more bioavailable forms (e.g., zinc adsorbed onto soil particles). At the Red Dog Mine, this geochemistry analysis addresses short- and long-term water quality effects associated with the weathering of pit walls (Main and Aqqaluk pits), waste rock, tailings, and naturally occurring rock outcrops. Additionally, this evaluation addresses weathering of lead-, zinc-, and cadmium-containing fugitive dust over time, potentially altering the bioavailability of these elements.

3.3.1 Geochemistry – Pre-mining Environment

Before mining, there was obvious and pronounced weathering of sulfide minerals, including pyrite (iron sulfide [FeS_2]), galena (lead sulfide [PbS]) and sphalerite (zinc sulfide [ZnS]). The ore deposit was first described by Tailleur (1970) who was pointed to the Red Dog Deposit by a bush pilot who observed from the air the extensive red staining resulting from the oxidation and degradation of pyrite. The ore deposit was exposed at the earth's surface.

Pre-mining baseline characterization by Dames & Moore (1983a) documented metals concentrations in surface water surrounding the mine site. The concentrations in Red Dog Creek were observed to vary seasonally along with stream flow with maximum measurements reaching 2.25 mg/L for lead, 272 mg/L for zinc, and 0.8 mg/L for cadmium (Runnells et al. 1992; Dames & Moore 1983a). Such concentrations are high with respect to the range encountered for natural waters and are due to the weathering (oxidation) of minerals associated with the Red Dog Deposit. Section 3.5.1 provides more detailed information on pre-mining water quality in Red Dog and Ikalukrok creeks and the Wulik River. Physical weathering of the ore deposit may also have contributed to an uncharacterized wind dispersion of these elements in the vicinity of the deposit.

3.3.2 Geochemistry – Baseline Conditions

Baseline conditions refer to the current conditions at the site. In terms of geochemistry, current conditions represent materials that have been exposed to air and water as a result of mining activities. Materials subject to geochemical activity include the waste rock dump, Main Pit, tailings, and the mineral component of fugitive dust deposited adjacent to the mine site and throughout the DMTS corridor.

Overall, the rock associated with the Red Dog Deposit has a geochemical character that is likely to generate acidic drainage. Table 3.3-1 summarizes, in a very general manner, the types of rock occurring at the Red Dog Deposit, the total tonnages for each relative to the current mine plan, the average net neutralization potential (NNP) for each unit and a weighted NNP for each. Lastly, the composite weighted average for all rock is presented. NNP is calculated as the difference of laboratory measurements of neutralization potential (NP) and acid producing potential (AP), or NP-AP. Negative values for NNP indicate that there is more acid producing potential than neutralizing potential.

Table 3.3-1 Summary Acid–Base Accounting for the Red Dog Deposit

Rock Unit	Ultimate Tonnage (Current Permit) Millions of U.S. tons	% of Total	Net Neutralization Potential (NNP)	Unit Weighted NNP[a]
Silicious, Baritic and Sulfidic Ikalukrok	8.5	46.4	-100	-46
Siksikpuk Shale	3.5	19.1	-32	-6
Okpikruak Shale	2.4	13.1	35	5
Ikalukrok Shale	0.3	1.6	-160	-3
Kivalina Shale	2.0	10.9	206	23
Upper Melange	0.0	0	40	0
Basal Melange	1.6	8.7	48	4
Total[b]	**18.3**	**100**		**-23**

[a] Product of percent tonnage and NNP
[b] Total NNP calculated as sum of unit weighted NNP

3.3.2.1 Mine Rock Stockpiles

Several types of stockpiles occur at the mine:

- Ore,
- Overburden,
- Waste (sub-economic material in the waste rock dump, oxide ore or oxide waste piles), and
- Low-grade ore.

The ore stockpile contains the principal ore minerals from the Red Dog Deposit, galena and sphalerite. Since it consists of ore, this stockpile is a transient and dynamic feature. Because the material in the stockpile does not sit long enough to undergo a substantial degree of weathering, runoff and seeps from the ore stockpile are not monitored or chemically analyzed.

The overburden stockpile contains material that has less than 1 percent zinc, and is comprised of highly weathered rock and organic material. A survey of the stockpile surface in 2006 found it to be approximately 35 percent Kivalina shale, 25 percent melange, 20 percent Ikalukrok shale, 10 percent Okpikruak shale, and 10 percent Siksikpuk shale (SRK 2008). This material does have some iron sulfide content, but also contains excess neutralizing capacity as indicated by neutral pH seepage. Seeps from the overburden stockpile material show that the materials in solution are neutral in pH, are relatively high in TDS (1,700 mg/L), and contain some zinc (7.5 mg/L). Owing to the non-acidic, neutral pH, lead and cadmium should not be an issue as they have limited solubility at neutral pH.

Material in the waste rock dump contains primarily acid generating material. As documented in SRK 2007, waste dump seepage is typically strongly acidic (pH typically less than 3), with highly elevated TDS (typically 20,000 to 50,000 mg/L), sulfate (typically 20,000 to 35,000 mg/L), and metals (zinc is typically 5,000 to 10,000 mg/L) as illustrated in Figure 3.4. Since 1998, the quality of seepage from the waste rock dump has generally worsened, with concentrations of lead, zinc, iron, and TDS approximately doubling (SRK 2003, 2007a) over the period from 1998 through 2006.

In terms of TDS, sulfate, iron, and zinc, seep water quality does not generally appear to have reached a steady state composition, which would be reflected by the horizontal lines in Figure 3.4. Although the scatter in the data in Figure 3.4 obscures trends over time, there can be considerable differences in composition between seeps.

Oxide ore contains economic concentrations of zinc, but current metallurgical processes are unable to recover this resource, thus the material is stockpiled until such time that it might be processed. Oxide waste is rock with sub-economic zinc concentrations, and previous geologic weathering has depleted much or all of its sulfide mineral content. Because of their oxide nature and limited size (relative to waste stockpiles), neither of these materials would be expected to affect water quality, although specific data for this material is not available.

Low-grade ore is ore that does not currently meet process specifications for recovery of the resource. This material is stockpiled for potential use should economic conditions become more favorable.

3.3.2.2 Mine Pit Water

Currently the Main Pit does not recharge with groundwater and the water accumulating in the pit results from incidental precipitation, surface runoff, and leakage from the Red Dog Creek diversion. No pit lake is present. The chemical composition of the water that accumulates in the Main Pit sump reflects weathering of the minerals that are contained in the exposed surfaces of the pit, seepage from any materials that are placed in the pit, and anything dissolved in surface runoff.

Since 1998 when monitoring of the water quality of the Main Pit sump began, the water quality has always reflected elevated TDS (7,000 to 14,000 mg/L), zinc (1,000 to 2,000 mg/L) and iron (250 to 1,000 mg/L), as illustrated in Figure 3.5. The pH has typically been on the order of 3.5 and all parameters appear to vary seasonally, and are highest in June. Owing to the inflow of surface runoff, the water quality in the pit sump is better than if it contained only water seeping from the pit walls. The runoff is typically better quality and tends to dilute the contributions from the Main Pit walls. Since 1998, water quality in the pit sump has worsened. The worsening of water quality over time is believed to have two main causes. First, water quality would be expected to degrade with more active weathering of sulfide minerals in pit walls, additional exposed surfaces, and possible contributions from materials stockpiled in the pit. Second, improvements to the Red Dog Creek diversion have increased its conveyance efficiency during the operational life of the mine, which has reduced the amount of fresh water leaking into the pit.

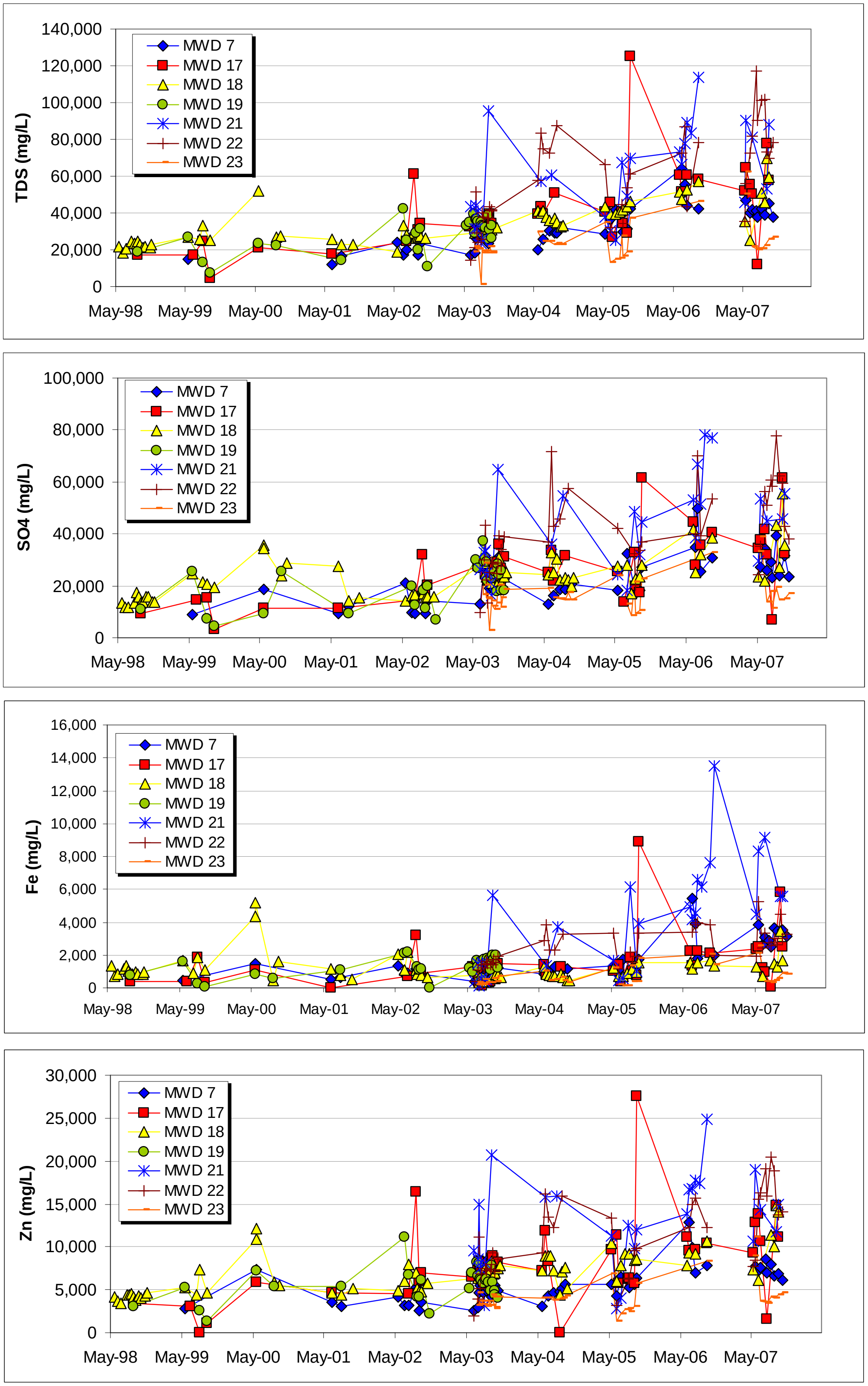


Figure 3.4 Waste Rock Dump Seepage Geochemical Composition

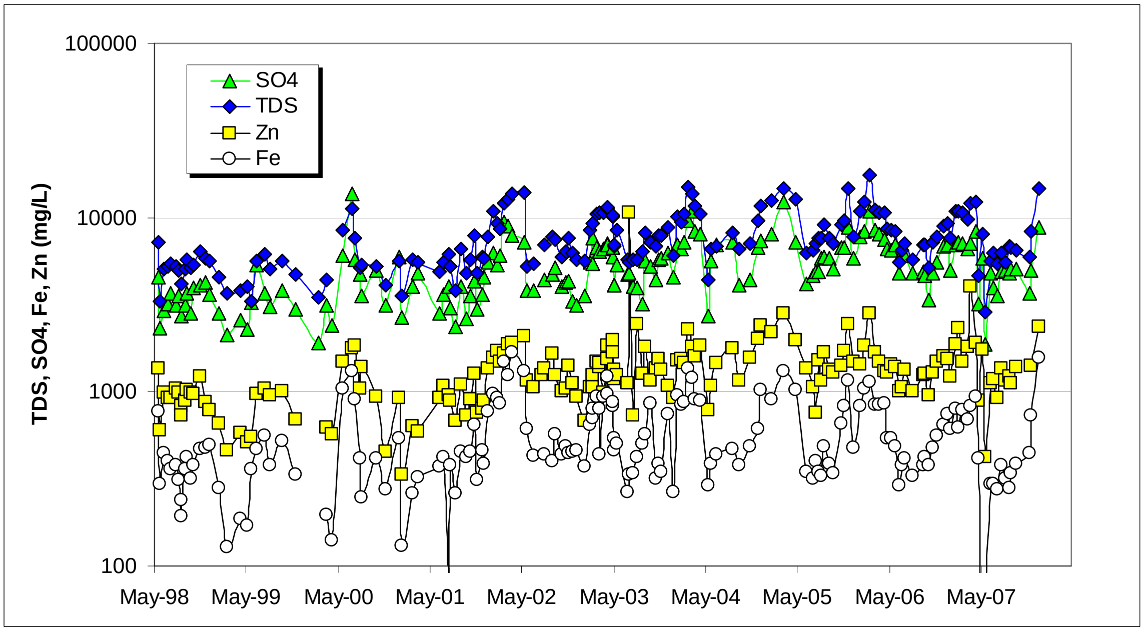


Figure 3.5 Geochemical Composition of Water Collected in the Mine Pit Sump

Not all sulfide minerals weather (oxidize) at the same rate (Rimstidt et al. 1993). In environments such as the Red Dog Deposit where pyrite occurs with other abundant sulfide minerals (e.g., sphalerite), there is the potential for one mineral to weather preferentially to another. In the specific case of Red Dog, sphalerite may oxidize preferentially to pyrite and provide a measure of protection against the development of low pH conditions. This (galvanic) protection is primarily offered when the sulfide minerals are in direct electrical contact with one another, either touching or through water saturated conditions.

When sphalerite oxidizes, zinc and sulfate are released but acidity is not generated. When pyrite oxidizes, low pH solutions are produced (acid rock drainage). At the Red Dog Mine, the widespread occurrence of low pH iron-bearing solutions is indicative of pronounced pyrite oxidation and any potential galvanic protection that may be offered by other sulfide minerals (such as sphalerite and galena) is either absent or undetectable. Various studies show mixed reports of the occurrence or significance of galvanic effects in mine waste. Regardless, the chemical quality of water associated with the mine rocks at the Red Dog Mine is driven by the rate of oxidation of sulfide minerals and results in low pH, which produces metal-bearing solutions that have an elevated TDS content.

3.3.2.3 Tailings

The tailings have been geochemically characterized as highly reactive material that has little acid NP (SRK 2003). Table 3.3-2 presents analyses for four tailings samples and shows that the tailings are very high in AP and very low in NP. The tailings are on the order of 10 percent sulfide, a very high value with respect to acid potential reflected in the AP values shown in Table 3.3-2. Correspondingly, the NNP is negative and the NP/AP ratio is less than one. Material with an NP/AP ratio less than one and an NNP less than –20 is considered likely to generate acid. Thus, the test results indicate a high likelihood of acid production from this material unless placed in unreactive settings (e.g., under a water cover; see below).

Table 3.3-2 Acid–Base Accounting on Red Dog Mine Tailings

Sample*	Acid–Base Accounting			
	Acid Potential (AP)	Neutralization Potential (NP)	Net Neutralization Potential (NNP)	NP/AP
RDPI-48	155	9.4	-146	0.06
RDPI-49	226	0.4	-226	0.002
RDPI-50	235	8	-227	0.034
Red Dog Mine Tailings	240	1	-239	0.005

* Data reported in SRK 2003

In laboratory humidity cell weathering tests, the sulfide mineral component of the tailings has been shown to rapidly oxidize to produce sulfate. The pH of leachate from the room temperature unsaturated experiments dropped rapidly to about 2, indicating a highly reactive, acid producing material (red dots in Figure 3.6). Tests at refrigerated temperatures showed a much slower pH drop, reaching a value as low as 4 (dark squares in Figure 3.6). Sulfate concentrations of the corresponding leachate showed consistent trends, with the lower temperature test producing sulfate at a lower rate than the room temperature test. The difference in the tests at different temperatures is consistent with the highly temperature dependent nature of sulfide mineral oxidation reactions (Williamson and Rimstidt 1994; Rimstidt et al. 1993). As temperature increases, sulfide mineral oxidation reaction rates increase.

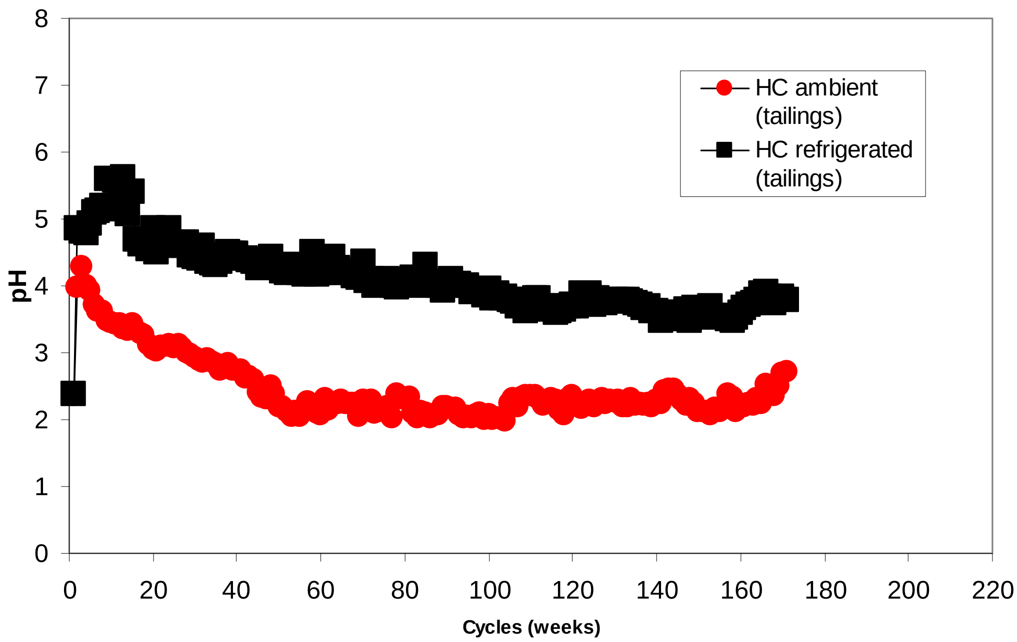


Figure 3.6 Humidity Cell pH Values for Red Dog Mine Tailings

In contrast to the unsaturated humidity cell tests, alternative subaqueous tests have also been conducted. Because the rate at which tailings may weather is defined by the site-specific conditions where the material occurs, these subaqueous tests are appropriate and useful. In these tests, about 10 pounds (5 kg) of tailings were covered by 20 inches (50 cm) of water, which was continuously aerated. The pH of the overlying water was shown to decrease rapidly to below 3.5 (Figure 3.7). The overlying water sulfate reached a long-term value of about 50 mg/L in room temperature tests and about 7 mg/L in refrigerated tests (Figure 3.8). The corresponding sulfate concentration in seepage leachate collected from the bottom of the subaqueous columns reached long-term values of 200 mg/L and 90 mg/L respectively (Figure 3.8) (SRK 2003).

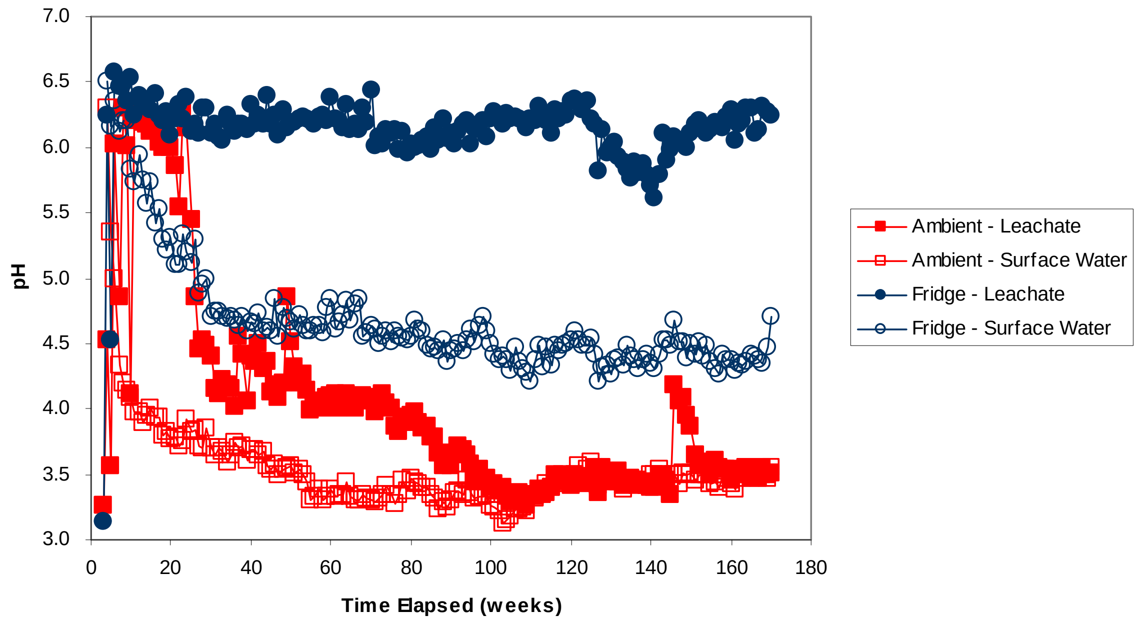


Figure 3.7 Subaqueous Tailings Test pH Results

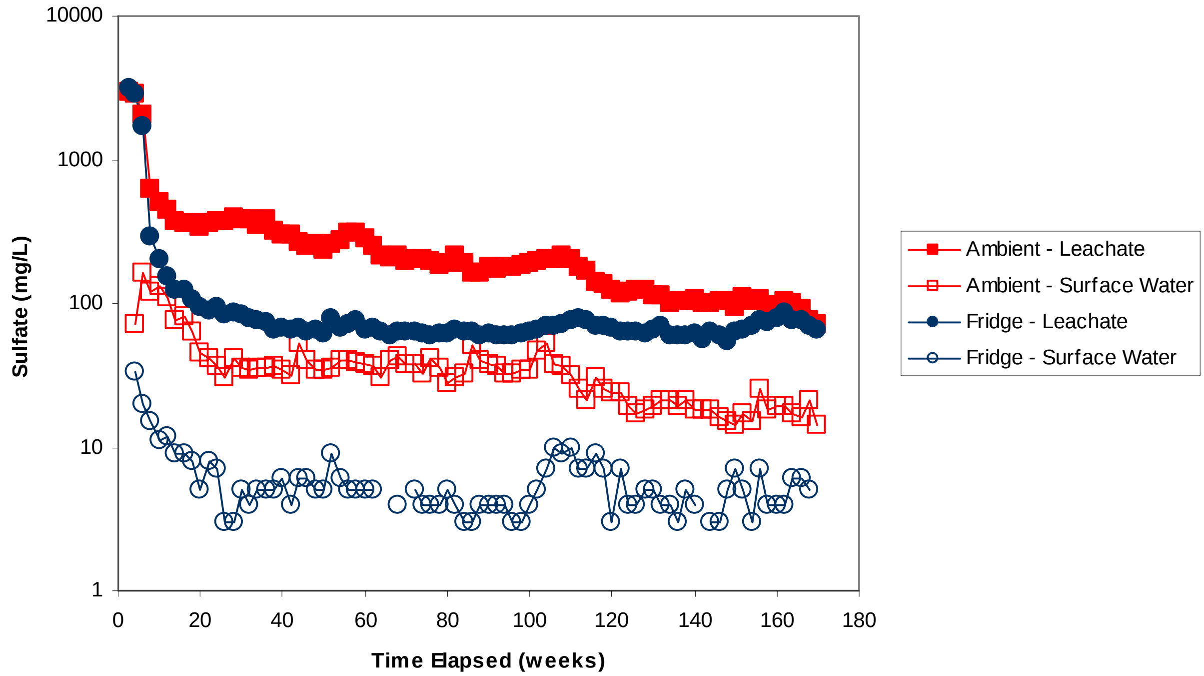


Figure 3.8 Subaqueous Tailings Test Sulfate Results

The contrast between the unsaturated and subaqueous tests is meaningful. Subaqueous tests demonstrated lower weathering rates. This is consistent with the relatively limited availability of oxygen to the sulfide minerals in the tailings in subaqueous conditions. Oxygen in the atmosphere (unsaturated tests) is

21 percent (210,000 parts per million [ppm]), while oxygen in the subaqueous tests is on the order of 10 ppm, several orders of magnitude less. The rate of weathering of the sulfide minerals proceeds in direct proportion to the concentration/availability of oxygen (Williamson and Rimstidt 1994; Williamson et al. 2006).

The present setting of the tailings below a water cover would, in light of the lab testing results, suggest that tailings are not currently weathering to a noticeable degree nor contributing to observed TDS increases in the tailings impoundment. Since the tailings impoundment receives contaminated seepage and runoff from the mine property in addition to the tailings, the water quality in the impoundment does not appear to directly reflect the chemical character of the tailings themselves. Although sulfate (proportional to TDS) is released to water overlying tailings through weathering reactions, the subaqueous tests have shown that such reactions produce only a few tens of parts per million of sulfate (TDS). This is a minor contribution relative to the thousands of parts per million of sulfate (TDS) in the water of the tailings impoundment water. Thus, any contributions from the tailings themselves to the overlying water in the impoundment appear to be minimal and masked by the contributions from other sources to the impoundment. The reactive tailings are under water, a cover that greatly restricts, or eliminates contact of the tailings with atmospheric oxygen. In such isolation from atmospheric oxygen, little geochemical degradation of submerged tailings occurs relative to the potential to degrade under a cycle of wet and dry conditions.

3.3.2.4 Fugitive Dust

Fugitive dust containing lead, zinc, cadmium, and sulfur as well as other metals and constituents, occurs around the mine site and along the haul road to the port. The dust generally comes from three sources: (1) relatively unmineralized material, including soils and road base; (2) mineralized materials including ore and some waste materials; and (3) concentrates produced by milling of the ore. Fugitive dust in the vicinity of the mine site includes a mixture of unmineralized materials, mineralized material from the Main Pit, waste material dumps, and concentrates. Along the DMTS corridor where concentrate is trucked from the mine to the port, fugitive dust sources include the unmineralized material in the road surface and ore concentrates from spills, the outside surfaces of the trucks, tracking, and releases from the CSBs at the port. All forms of fugitive dust have been dispersed as a result of wind as discussed in Section 3.2.2.

Teck conducted two studies of soil samples from the vicinity of the mine, evaluating mineral weathering by observing leachate and undertaking a microscopic examination. The Brienne 2007 microscopic examination showed the main zinc- and lead-bearing minerals were sphalerite and galena. Limited alteration products were observed on galena implying limited weathering in the samples examined. Jensen and Brienne (2007) performed simple leaching tests and kinetic humidity cell testing, comparable to those discussed in Section 3.3.2.3 for tailings. This study demonstrated that lead was less leachable than zinc; consistent with the known limited solubility of lead. Kinetic testing indicated relatively low metal leaching, which provides support for slow weathering of galena and sphalerite in soil environments.

NPS conducted a moss study in 2000 to measure metals concentrations in tundra located near the DMTS road (Ford and Hasselbach 2001). Subsequent studies have confirmed that elevated concentrations of lead and zinc occur in tundra and moss along the DMTS corridor (Hasselbach et al. 2005; Exponent 2007a).

Hasselbach et al. (2005) report analyses of moss and subsurface soil. Their data are presented in Table 3.3-3. As shown, Hasselbach et al. (2005) collected data for five elements: cadmium, lead, zinc, aluminum, and iron. While cadmium, lead, and zinc are closely tied to the Red Dog Mine, aluminum and iron are common soil-forming elements, as revealed in their elevated concentrations in soil compared to moss. Because aluminum and iron are common in unmineralized soils, the reported occurrence of these elements cannot be conclusively attributed to Red Dog Mine ore or concentrate.

Table 3.3-3 Elemental Analysis of Soil and Moss along the DMTS Road

Substrate (*n*)	Element	Median	Mean	Standard Deviation	Range
Moss (*n*=151)	Cadmium (Cd)	0.56	1.86	3.54	0.08–24.30
	Lead (Pb)	16.2	68.1	141.1	1.1–912.5
	Zinc (Zn)	92	292	518	2–3,207
	Aluminum (Al)	773	4,850	10,243	46–45,749
	Iron (Fe)	580	3,063	6,242	168–28,630
Soil (*n*=46)	Cadmium (Cd)	0.27	0.27	0.13	0.07–0.75
	Lead (Pb)	15.3	17.8	11.7	7.8–83.8
	Zinc (Zn)	96	96	24	49–164
	Aluminum (Al)	61,350	60,760	11,518	25,900–86,600
	Iron (Fe)	39,750	39,339	12,559	14,400–71,800

Source: Hasselbach et al. 2005
Units = mg/kg dry weight

Data are available for total concentrations of cadmium, lead, zinc, aluminum, and iron associated with moss and soil along the DMTS road. In general the geochemical forms of the weathering products of these metals are also known; however, the concentrations of these individual products have not been measured. The geochemical form of these elements strongly affects their bioavailability. The lead-, zinc-, and cadmium-containing dust is comprised primarily of the ore minerals galena and sphalerite, which also contains cadmium. In the terrestrial environment, in the presence of oxygen and moisture, these minerals oxidize to release lead, zinc, cadmium, and sulfate from the sulfide mineral structure. These elements are then redistributed among other forms and may be adsorbed onto clay minerals, taken up by plants, move into the soil pore water, or may form other discrete mineral phases such as lead carbonate. A better understanding of the site-specific geochemical behavior of the lead-, zinc- and cadmium-containing dust would improve the ability to predict and detect potential problems associated with weathering in the future. A one-time study of the geochemical weathering process would reduce the uncertainty associated with these materials in the environment. Since this type of study can be included within the ADEC Waste Management Permit, this data should be available for future analyses and therefore fill an existing data gap. USGS 2003 documents methodologies that can be used to distinguish naturally dispersed minerals from those originating from anthropogenic, fugitive dust emissions. These methodologies could also be incorporated into future dust studies. Teck has proposed to address this issue indirectly through vegetation monitoring in the draft fugitive dust risk management plan.

Lead and zinc sulfides will degrade at differing rates and to differing extents. Most of the lead sulfide will oxidize to lead sulfate (anglesite) and lead carbonate (cerrusite). These minerals have limited solubilities and may form a coating on the galena particle, having the effect of insulating the galena from water and oxygen and markedly slowing the rate of its further oxidation (Plumlee 1999; Nordstrom and Alpers 1999). USGS 2003 further notes that galena associated fugitive dust exhibits physical properties that limit weathering and oxidation.

Compared to the lead minerals, the sphalerite and its weathering products, including zinc sulfates and zinc carbonates, are relatively soluble and will not impede the weathering/oxidation process. Therefore, depending on how frequently they are exposed to precipitation, the zinc sulfide grains will tend to decompose in the soil environment more rapidly than lead sulfide.

The rate of oxidation of sphalerite has been measured in warm, moist air (Stegers and Desjardins 1980). Using this literature reported rate to provide scale, the typical lifetime of a sphalerite grain consistent with the size of fugitive dust (55 microns) can be estimated at about 14 years at the cold (average) temperatures of the project site (-4 ºC). The rates of oxidation of galena are not as clear as with sphalerite, but the relatively insoluble coating of sulfate and carbonates likely to form would cause complete oxidation of galena particles to be longer. The weathering of metals-containing fugitive dust has already occurred and will continue to occur to the material already present in the environment and any new material added to the environment over time.

The oxidation products of the lead and zinc sulfides have different levels of bioavailability, as noted above. While metals held in low solubility phases are somewhat unavailable relative to more soluble (bioavailable) phases such as lead carbonate, the existing load of these constituents will alter to more bioavailable forms over time. Because of the limited precipitation in the area, there is little evidence that these chemical constituents would be transported far from their original site of deposition. The reservoir of more bioavailable forms of cadmium, lead and zinc can reasonably be expected to increase over time, although the specific forms of these elements and their concentrations in the soil environment cannot be accurately predicted based on the information currently available. In terms of baseline conditions, the size of the "pool" of more bioavailable cadmium, lead and zinc is limited to the total load incurred to date. The DMTS risk assessment estimated potential exposures and risks of zinc and cadmium, among other contaminants, by assuming, conservatively, that the metals, with the exception of lead, were 100 percent bioavailable (Exponent 2007a). Risks associated with lead were determined using model default and site-specific values. Results of the risk assessments are further discussed in the following sections of this SEIS: 3.9.2.1 (Wildlife), 3.10.2.1 (Aquatic Resources), and 3.13.2.1 (Public Health).

3.3.3 Geochemistry – Environmental Consequences

Sulfide minerals associated with the Red Dog Deposit weather (oxidize) and lead, zinc, cadmium, other metals, sulfate, and TDS are released to water resources or to other forms in the soil environments. The more of these materials that are exposed to oxygen and water, the greater the potential environmental consequences. Therefore, the potential geochemical environmental consequences associated with each alternative may be assessed in terms of the amount of sulfide minerals that are exposed to weathering during operations and after closure. The accounting of exposure applies to pit wall surface areas, waste rock, tailings, and fugitive dust.

Although potential impacts may increase with increased exposure (material disturbance), real impacts may be limited by mitigation efforts and material handling. For example, expanding the size of the pit and the exposed area of pit walls can lead to increased oxidation of sulfide minerals. However, if the water contacting the exposed walls is collected and treated, impacts to the environment may be reduced or eliminated. Thus, assessment of geochemical impacts on the environment must take into consideration increased disturbance caused by material production, as well as the extent to which weathering products are contained, treated, naturally transformed, or are benign. Since the changes that would occur from the weathering process, including increased availability of metals and lower pH levels, are reflected in water quality, the effects of geochemical changes are discussed in greater detail under water quality (Section 3.5.3).

Geochemical environmental consequences are tied to several prominent components of the Red Dog Project, specifically the following:

- Main Pit
- Aqqaluk Pit
- Waste rock dump
- Overburden stockpile
- Tailings impoundment
- Fugitive dust

Each of these components is considered below relative to each alternative. It is important to note that under all alternatives, wastewater treatment will be required to meet NPDES permit limits during operations and over the long term after closure.

3.3.3.1 Effects Common to All Alternatives

Most facilities would experience somewhat different geochemical activity under each of the alternatives and are therefore discussed individually below. The overburden stockpile would behave similarly under all alternatives. During operation and closure, effects from the overburden stockpile will be similar. Water quality is anticipated to be essentially unchanged compared to current conditions. Under all alternatives, fugitive dust already deposited in the vicinity of the mine and DMTS corridor would weather as discussed above under the description of baseline conditions. While the amount of fugitive dust deposited in the future under each alternative would be somewhat different, the geochemical behavior of the material with respect to weathering would be similar under all alternatives. Water from the pit(s), waste rock dump, overburden stockpile, and tailings impoundment would need to be treated for the foreseeable future after closure.

3.3.3.2 Effects of Alternative A – No Action Alternative

Main Pit

Under Alternative A, water that accumulates in the pit sump during production would be pumped and transported to the tailings impoundment. As described in Section 3.3.2, water currently reporting to the mine pit sump is of very low quality. The overall quality of this water has deteriorated somewhat with time.

Post-closure, water would be allowed to accumulate in the Main Pit and would come principally from incidental precipitation, pit wall runoff, waste rock dump seepage, overburden stockpile seepage, and tailings impoundment seepage. The quality of the water accumulating in the Main Pit post-closure can reasonably be expected to be of poor quality as it would combine current low-quality contributions accumulating in the pit with flows that report to the tailings impoundment during operations that also have poor-quality water in that facility.

Post-closure, the water quality of the dominant flow to the Main Pit is expected to be represented by the water quality associated with the mine sump during operations, as this is the dominant flow into the Main Pit. This water quality is near steady-state composition. The precise concentrations of chemical constituents of concern cannot be predicted exactly, but the most recent measurements of the Main Pit sump provide reasonable estimates. Estimates for selected constituents are shown in Table 3.3-4.

Table 3.3-4 Representative Constituent Concentrations in the Main Pit Sump

Chemical Constituent	Concentration, mg/L except pH
Arsenic (total)	ND–0.98
Cadmium (total)	3–99
Copper (total)	0.19–3.8
Lead (total)	0.5–47
Zinc (total)	336–11,200
Sulfate	1,910–7,380
Total Dissolved Solids	3,300–11,200
pH (s.u.)	3–5

s.u. = standard units
ND = non detect

Aqqaluk Pit

Under this alternative, the Aqqaluk Pit would not be developed. Runoff from the area would continue to carry metals, released by weathering, from the deposit to Red Dog and Sulfur creeks.

Waste Rock Dump

During mining operations, the waste rock dump would continue to receive waste rock and can be expected to continue to produce low-quality water. The composition would be very similar to that currently observed and collected, but may deteriorate somewhat with additional waste rock. To the extent that the footprint of this facility would remain essentially the same, only slight increases in flow would be anticipated.

Upon closure, the waste rock dump would be covered with soil and vegetation to ultimately reclaim the surface. As a result, less water would be expected to infiltrate the waste rock (from precipitation) and seepage flow would diminish correspondingly over time. With the decrease in flow it is possible that water quality would deteriorate somewhat. However, the combination of reduced flow with potentially lower quality should not substantially alter the net mass flux of dissolved chemical constituents from the pile. As described in Section 3.3.2, the chemical composition of seeps associated with the waste rock dump vary and have worsened over the time period for which data has been collected.

Tailings Impoundment

As described in Section 3.3.2, tailings do not appear to be a major contributor to the TDS concentrations in the tailing impoundment water. This condition is anticipated to persist as long as a water cover is in place over the tailings. Therefore, the effects on the water quality in the tailings impoundment will be consistent with the quality of the various project site waters that are routed to the impoundment. Under this alternative, flows from the waste rock dump, overburden stockpile and Main Pit continue to report to the impoundment during operation.

Mass balance modeling of the tailings impoundment has been conducted by SRK (2007a) to evaluate the geochemical evolution of the water quality in the impoundment. The model incorporates the flow rate and associated chemical composition of all water directed to and discharged from the tailings impoundment. It is therefore capable of calculating water quality in the impoundment over time, under a range of user-specified scenarios such as the alternative considered here.

The forward-looking nature of such a mass balance model requires prediction/estimation of future flows and their associated chemical concentrations. The chemical compositions of flows that comprise the mass balance model for the Red Dog Mine were derived from review and evaluation of historic water quality data associated with various sources at the project site. As described in Section 3.5.2, water quality associated with principal components of the Red Dog Mine shows some variations that may be seasonal effects. Although water quality for the Main Pit sump and the waste rock dump has worsened over time, it appears to be approaching a steady state. Thus, the mass balance model establishes representative water quality characteristics for various sources.

In the short term, during operations, the mass balance analysis of the tailings impoundment indicates that under Alternative A, the water quality in the tailings impoundment will remain consistent with current conditions, but it is projected to rapidly improve after closure. Improved water quality post closure derive from diversion of current inflows to the tailings impoundment (e.g., waste rock dump seepage) to the Main Pit. Also, water that accumulates in the mine pit sump will be retained in the Main Pit rather than being pumped out and transferred to the tailings impoundment. The diversion of these flows restrict the chemical mass reporting to the impoundment. Table 3.3-5 summarizes the short-term values (during operations) and the long-term values (post closure) for chemical constituents in the impoundment under Alternative A.

Table 3.3-5 Short-term and Long-term Estimates of Chemical Concentrations in the Tailings Impoundment Derived from Mass Balance Modeling

Constituent	Concentration (in mg/L)	
	During Operations	Post Closure
TDS	4,000	1,000
Sulfate	2,600	650
Cadmium (total)	3.75	0.02
Zinc (total)	300	25

There is, however, uncertainty in these predictions and actual concentrations will only be known after closure when ongoing monitoring is conducted. Regardless, under Alternative A, it is assumed that the tailing impoundment water will continue to require water treatment for the long term after closure.

Fugitive Dust

Under Alternative A, fugitive dust emissions during operations along the transportation corridor would remain at levels that reflect the current level of dust control plus whatever measures are put in place as a result of the fugitive dust risk management plan. The net loading of cadmium, lead, zinc and sulfur would proceed at the present rate until the end of mining and transport activities, at which point fugitive dust loading would begin to decline. Loading of metals in the post-mining environment would occur at much lower rates than during operations as concentrates would no longer be conveyed along the DMTS road, eliminating further loading of cadmium, lead and zinc. Future concentrate-related sulfur loadings would likewise be reduced.

In the short term (during active operations) and in the long term (following closure) the mineralized material deposited along the DMTS corridor as fugitive dust will weather. As noted in the discussion of baseline conditions above, the cadmium, lead and zinc associated with the sulfides in the concentrate will not disappear, but rather continue to exist in different forms of varying bioavailability. Generally, the various weathering products will continue to undergo geochemical (and biogeochemical) processes and behave in various ways including becoming adsorbed onto solid phase soil components or being dissolved into water that might be taken up by plants or carried deeper into the soil profile.

The specific geochemical forms of cadmium, lead and zinc resulting from the oxidation of galena and sphalerite in soil environments are dependent on the actual soil conditions, such as temperature, pH, clay mineral content, types of soil minerals, organic matter content, moisture, etc. Sulfide minerals are, in general, unstable in soil environments and, by the same token, other minerals are very stable. Thus, as sulfide minerals weather, the metals that are released are taken up in stable minerals and adsorbed onto either organic material or soil minerals. For example, when galena weathers, the lead that is released can form anglesite (lead sulfate), cerrusite (lead carbonate), or litharge (lead oxide), or adsorb onto organic matter, iron oxides in soil or clay minerals. Predicting what forms will result, in a quantitative manner, is speculative. However, the types of forms described here are likely and routinely observed.

3.3.3.3 Effects of Alternative B – Applicant's Proposed Action

Main Pit

Under Alternative B, the Main Pit would be backfilled and no lake would form. Runoff from exposed pit walls can be expected to contribute to filling the voids within the waste rock that is placed there. Those voids would also be filled with water derived from precipitation that falls on the waste rock placed in the pit. That water is expected to be similar to water emanating from the current waste rock dump. Overall, the water reporting to fill the voids of waste rock placed in the Main Pit would be of low quality and similar to water currently pumped from the mine sump.

Aqqaluk Pit

Under Alternative B, given the similarity in wall rock composition and setting to the Main Pit, during mine operations the quality of water in the pit sump is expected to be similar to the water projected to accumulate in the Main Pit under Alternative A (see Table 3.3-5). This water will report to the tailings impoundment during operations.

At closure, a pit lake will ultimately form in the Aqqaluk Pit because of incidental precipitation, pit wall runoff, diversion of seepage from the waste rock dump and overburden stockpile, and groundwater inflow. Seepage from the tailings impoundment will also be pumped to the Aqqaluk Pit lake. The long-term water quality in the Aqqaluk Pit is expected to be very similar to the water quality associated with the current mine sump in the Main Pit.

Waste Rock Dump

Under this alternative the effects are the same as Alternative A.

Tailings Impoundment

Under this alternative, mass balance modeling indicates that water quality in the tailings impoundment is expected to remain similar to current conditions throughout operations. Some slight improvement is anticipated as the capacity of Water Treatment Plant 3 is increased in the year 2025.

Post closure, water quality in the tailings impoundment is projected to improve, which is similar to Alternative A. This improvement is associated with diversion of flows from the waste rock dump, the Aqqaluk Pit and other facilities away from the tailings impoundment and into the Aqqaluk Pit. Post-closure TDS are projected to decrease to about 1,000 mg/L (see Table 3.3-5 for water quality operational and post-closure estimates).

Fugitive Dust

Under this alternative, the rate of metals loading from fugitive dust would be the same as projected under Alternative A although the duration of the loading would extend for the additional life of operations. The additional loadings, resulting from the longer duration of mining activity, would mean a greater amount of mineralized material being deposited on plants and within the top layers of the soil than would occur under Alternative A. The greater amount of fugitive dust would mean higher concentrations of ore and concentrate minerals and their breakdown products, including bioavailable forms of lead, zinc, and cadmium. Increased metals concentrations would primarily occur in areas downwind of the mine and DMTS.

Similar to Alternative A, loading rates would be reduced after closure and continue to drop until reclamation activities have been completed.

3.3.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Main Pit

Under this alternative the effects would be the same as Alternative B.

Aqqaluk Pit

During operations, the effects on the Aqqaluk Pit would be very similar to the effects on the Main Pit under Alternative A. While there are some differences between waste rock seepage and mine drainage, both are acidic and have elevated levels of TDS and metals (see Sections 3.3.2.1 and 3.3.2.2). The partial backfill under Alternative C should not, therefore, substantially impact the quality of water in the pit compared to other alternatives.

Waste Rock Dump

Under this alternative, a low permeability cover over the waste rock dump would severely restrict the infiltration of precipitation. Although water quality cannot be expected to improve substantially, the flow of seeps and springs from this facility would decrease markedly. Overall, therefore, the net mass flux of chemicals of concern from this facility would decrease.

Tailings Impoundment

Under this alternative, effects related to the tailings impoundment would remain the same as all alternatives during operation. Mass balance modeling indicates that during operations, water quality can be expected to remain similar to current conditions.

Under this alternative, the tailings impoundment would have a dry cover post closure, rather than the water cover specified in alternatives A, B, and D. Following closure and installation of the dry cover, tailings would slowly drain. In time, accelerated weathering of tailings would be possible as tailings would not be as well isolated from oxygen as they would with a water cover. Tailings have been shown to rapidly oxidize when moist and exposed to air (Section 3.5.2). Ultimately, the release of chemical constituents of concern from the tailings would be driven by the effectiveness of the dry cover to restrict or eliminate infiltration of rain and snow melt which would pass through the tailings.

Fugitive Dust

Under this alternative ore concentrate would be transported by pipeline rather than by truck. The net effect would be the elimination of additional concentrate loading from the concentrate trucks. With the exception of spills from pipeline ruptures, loading to the landscape along the DMTS road would be limited to contaminants distributed by service vehicles. Loadings from mine related sources would continue at the same rate and duration as would occur under Alternative B. The rates of geochemical changes of materials already deposited in the environment would be the same as all other alternatives. Post-closure effects would be similar to Alternative B, with increases in more bioavailable forms of cadmium, lead, and zinc, although the total loading along the DMTS road would be lower than under alternatives B or D.

3.3.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Main Pit

Under this alternative the effects would be the same as Alternative B.

Aqqaluk Pit

Under this alternative the effects would be the same as Alternative B.

Waste Rock Dump

Under this alternative the effects would be the same as Alternative A.

Tailings Impoundment

Under this alternative the effects would be the same as Alternative B.

Fugitive Dust

Under Alternative D, enhanced truck washes would be installed. Loadings from mine related sources and rates of decomposition of materials already in the environment would again be the same as alternatives B and C. The short-term effect during mine life would be that loading along the DMTS corridor would be expected to be greater than Alternative C, but less than Alternative B. Post closure, effects would be similar to Alternative B, with increases in more bioavailable cadmium, lead, and zinc although the initial loads would be lower than Alternative B, corresponding to the overall decrease in net loading.

3.3.4 Geochemistry – Summary

During operations, the geochemistry of the mine workings, waste rock runoff, and tailings impoundment would be comparable to current conditions. Under alternatives A, B, and D, wet closure of the tailings impoundment would eventually lead to improvements in the impoundment water quality over time although long-term treatment would still be required. With dry closure under Alternative C, tailings seepage water quality would reflect current conditions over the long term although less water would require treatment. Under alternatives A and B, continued fugitive emissions from the mine and road would cause increasing concentrations of metals (some bioavailable) in the surrounding soils and vegetation. Deposition would continue through 2011 under Alternative A and 2031 under Alternative B. Under Alternative C, future loadings along the road would be minimized by the concentrate pipeline. Under Alternative D, fugitive emissions and metals levels would be lower than Alternative B but higher than Alternative C.

3.4 Geotechnical Stability

3.4.1 Geotechnical Stability – Pre-mining Environment

This section briefly summarizes the native materials and seismic conditions at the Red Dog Mine site to establish the baseline for the geotechnical resource evaluation presented in the followings sections. Surface and subsurface materials consist of native soil overburden over shale and siltstone bedrock. Native soils include organics; ice-rich soils; silty, clayey soils; and sandy, gravelly soils. The organics are fibrous peat, organic silt, and peat. Ice-rich soil is silty and clayey with visible ice inclusions. Sandy and gravelly soils consist of silty sands and gravels to poorly graded sands and gravels. The latter could be completely weathered bedrock and/or alluvium. Bedrock is typically highly to moderately weathered shale that becomes more durable with depth.

The Red Dog Mine is located in a region that has low seismicity and no known active faults. A site-specific probabilistic seismic hazard analysis was performed by URS and described in their 2008 report (URS 2008). An operating basis earthquake and maximum design earthquake were both determined. The operating basis earthquake has a 10 percent probability of exceedance in 50 years and the maximum design earthquake has a 2 percent probability of exceedance in 50 years. The probable ground accelerations from these events would be 0.11 g and 0.24 g, respectively. These values are used in the engineering design process to ensure that slope stability would be maintained if a seismic event were to occur.

3.4.2 Geotechnical Stability – Baseline Conditions

3.4.2.1 Background

At the Red Dog Mine, the tailings impoundment holds tailings and water in the South Fork Red Dog Creek valley that is now primarily filled with tailings. The main dam of the tailings impoundment consists of two parts: an embankment located in an approximately west-to-east alignment across the South Fork Red Dog Creek and a wing wall to the southeast that extends from the east end of the embankment.

The back dam is located at the southern end of the tailings impoundment near the top of the hydrologic divide between the South Fork Red Dog Creek and Bons Creek. The back dam became necessary to retain water from the tailings impoundment after the water level reached the divide between the Red Dog Creek catchment and the Bons Creek catchment. A new back dam is currently being constructed. The new back dam will control potential seepage from the tailings mass from entering the Bons Creek drainage basin with a vertical concrete barrier (cut-off wall) that extends into the underlying bedrock. The back dam is to be built to an elevation of 970 feet (295 meters), and subsequently raised to an elevation similar to the top of the final raise of the main dam (986 feet).

The overburden stockpile straddles the divide between the South Fork Red Dog Creek and Bons Creek drainages and reaches a maximum elevation of about 1,020 feet (310.9 meters). Prior to the stockpile construction, the lowest point of the divide was at an elevation of approximately 937.5 feet (285.8 meters). A system of ditches, sumps, and wells downstream of the overburden stockpile captures runoff from the overburden stockpile and seepage through the active zone above permafrost. Average flow rates from the overburden stockpile runoff collection system are 34 million gallons per year.

The waste rock dump is located on a hillside between the tailings impoundment and the Main Pit, adjacent to the access road to the mine facilities. The dump has been built in a series of lifts from waste materials removed from the Main Pit.

3.4.2.2 Main Tailings Dam Construction

The design and construction of the dam can be divided in two discrete phases: original stages I to VI and recently designed and constructed stages VII-A and B. Stages I to VI of the tailings main dam were constructed in phases between 1988 and 1993. The original design included a cutoff trench to bedrock, a geomembrane liner system, seepage collection system, permafrost freezeback, and a tailings beach for seepage control (URS 2007a).

The ice-rich soils in the starter dam footprint were removed before construction started and the starter dam was built on moderately weathered bedrock. Improved foundation conditions were encountered in the stage II to VI footprints. Therefore, the stage II to VI raises, except the cutoff system, were built directly on native ground.

The starter dam was completed in July 1988. The diversion pipe was plugged with grout in September 1988. As the tailings impoundment started to fill with water, more seepage through the main dam was observed flowing into the downstream seepage collection pond than was estimated during the design. Milling was not scheduled to start in time for tailings to be placed ahead of the rising water to help reduce the seepage. Methods to reduce seepage were developed in the winter of 1988/1989 for implementation in 1989.

Two methods of reducing seepage were developed. A blanket of shale was placed in the water over the cutoff trench upstream of the starter dam and a grouted high-density polyethylene geomembrane cutoff wall was installed below the cutoff trench for the future stage II to IV raises. A seepage cutoff wall was designed during the winter of 1988/1989 for the stage II to IV raises and the seepage collection dam. The same cutoff wall system was designed for the seepage collection dam. A gravel underdrain was installed downstream of the starter dam under stages II through VI, and the pumpback structures were increased from one to three. The stage V to VI design relied on a tailings beach to control seepage with no cutoff wall.

A 10-foot stage VII raise of the tailings main dam was planned in the mid-1990s to increase the dam height to 182 feet (55.5 meters) at the crest elevation of 960 feet (292.6 meters). URS completed stability analyses using geotechnical data from earlier dam and mill site investigations, and concluded that the stage VII embankment could have a steeper slope than stage VI, resulting in a “hinge” or slope change at the 960-foot elevation (292.6 meters) (URS 2007a).

The 10-foot stage VII concept was changed in 2003 to two 5-foot raises (VII-A and VII-B) because of construction window time constraints. Stage VII-A would raise the dam to 177 feet (53.9 meters) high at the crest elevation of 955 feet (291.1 meters). Stage VII-B would raise the dam to 182 feet (55.5 meters) high at the crest elevation of 960 feet (292.6 meters). The design included extending the seepage cutoff wall from its stage IV west and east terminations as an added seepage control measure because a tailings beach could not be continually maintained while tailings were deposited away from the dam.

The dam was constructed using conventional downstream methods. Stability analyses of the tailings main dam were completed during the design of stages I to VI, including modifications such as the pipe bench and dust control structures and the stages VII-A and B raises. Upstream and downstream slope configurations of the dam at various stages of construction were selected after verifying that the dam would be stable under long-term static and seismic stability loading conditions and at the short-term end-of-construction stability condition (URS 2008). Table 3.4-1 summarizes the downstream and upstream slopes for each stage of the dam and Figure 3.9 shows a cross section of the main dam.

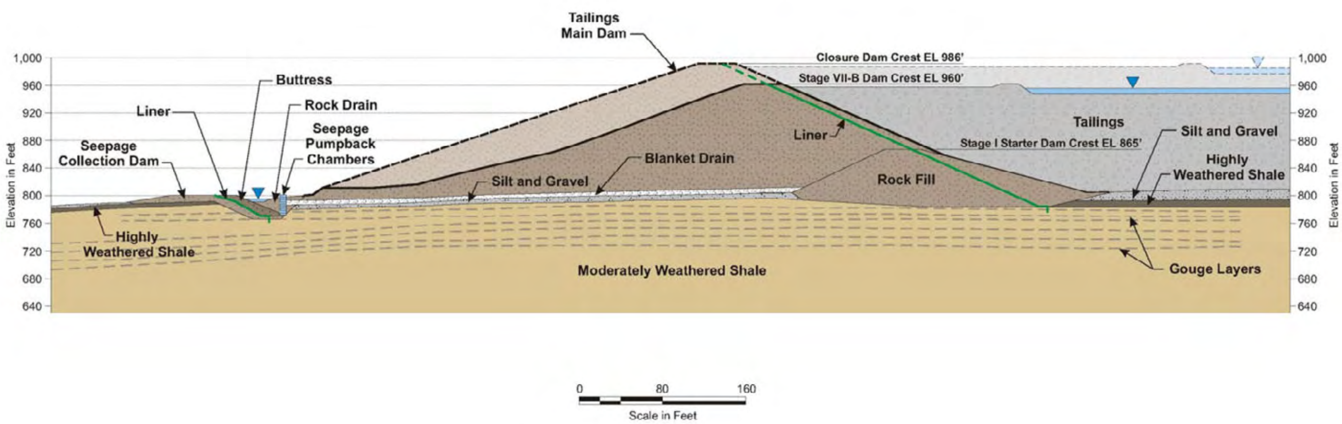
The main dam seepage is controlled through two control systems: a primary system and a secondary system. The primary seepage control system in the tailing main dam system includes:

- Liner system over the entire upstream face of the dam, protected by a rock buttress and continuing down to a cutoff trench to prevent seepage through the dam.
- Foundation cutoff (barrier) system consisting of a cutoff trench and a cutoff wall along the upstream toe of the dam to reduce seepage under and around the dam to Red Dog Creek.
- Curtain wall system consisting of a curtain wall embedded in a trench along the wing wall alignment to reduce the potential for seepage under the wing wall toward the mill.
- Drainage system consisting of a perforated pipe toe drain and a main pipe and blanket drain under the dam in the original creek channel to collect seepage from within and under the dam. The 36-inch diameter main pipe was plugged under the starter dam and was not extended as originally designed.
- Tailings management by beaching tailings along the upstream face of the dam and thereby keeping the impounded water away from the dam.
- Three seepage pumpback chambers that remove seepage from the blanket drain.

The secondary seepage control system for the tailings main dam is the seepage collection dam and seepage pumpback well located between the seepage collection dam and Red Dog Creek. The secondary seepage control system at the seepage collection dam was improved in 1989 by adding a vertical high-density polyethylene geomembrane cast into a grout cutoff wall installed in the same way as the improvement to the main tailings dam as described above.

Table 3.4-1 Summary of Upstream and Downstream Slopes of the Dam

Dam Stage	Upstream Slope (H:V)	Downstream Slope		
		Above hinge (H:V)	Hinge Elevation (feet [meters])	Below Hinge (H:V)
I (Starter dam)	3:1	2:1	no hinge	2:1
II	2.5:1	3:1	877.5 (267.5)	4:1
III	2.5:1	3:1	877.5 (267.5)	4:1
IV	2.5:1	3:1	895.0 (272.8)	4:1
V	2.5:1	3:1	902.5 (275.1)	4:1
VI	2.5:1	3:1	907.5 (276.6)	4:1
VII-A	2.5:1	3:1	880.0 (268)	4:1
VII-B	2.5:1	3:1	852.5 (259.8)	4:1

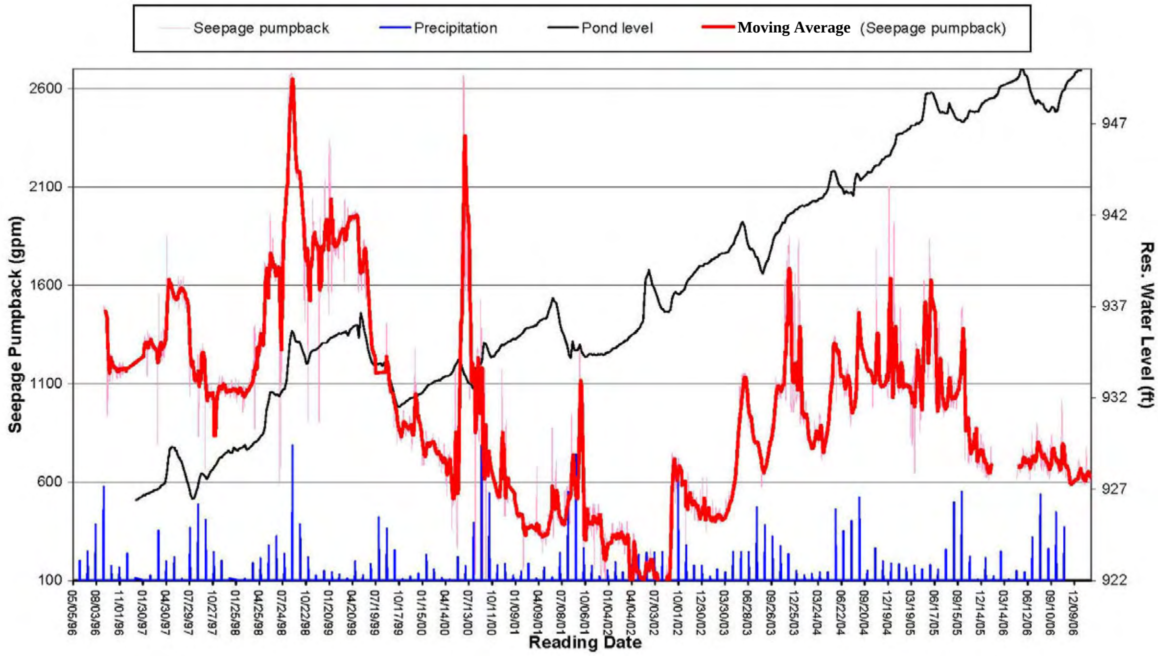


Source: URS 2007a

Figure 3.9 Cross Section of Main Dam

According to URS (2007a), a design seepage rate of 10 to 20 gallons per minute was estimated for a full tailings dam. When the dam initially filled, seepage rates up to 2,250 gallons per minute were observed, which is 112 to 225 times higher than estimated. When the water level had dropped by one foot, the seepage decreased to about 700 gallons per minute, or 35 to 70 times the estimate for a full dam. Based on their investigation, URS believed the primary seepage path existed between the geomembrane and the underlying, permanently frozen bedrock. They concluded that the upper bedrock contact had thawed, and water flowed through the rock joints under the contact and into the embankment rock fill. URS also concluded that the geomembrane was sound because of the construction controls. Figure 3.10 shows the pumpback records that reflect the total seepage reporting to the downstream dam from the tailings impoundment.

Before the tailings beach was started in 1997, the pumpback rates ranged from 850 to 1,600 gallons per minute. The average winter pumpback rate, or lower bound of the seepage range, was 1,050 gallons per minute. The average summer pumpback rate, or upper bound of the seepage range, was 1,600 gallons per minute. The average impoundment water level during this period was approximately 930 feet (283.5 meters) in elevation.



Source: URS 2007b

Figure 3.10 Seepage Pumpback Records

A 600- to 700-foot (182.9- to 213.3-meter) wide exposed tailings beach was developed by the year 2000 along the full length of the main dam. From December 2000 to May 2003, the pumpback rate dropped to an average of 400 gallons per minute. From April to September 2002, the average pumpback rate was 130 gallons per minute. The pumpback data shows that the average summer and winter seepage rates were about 750 and 300 gallons per minute, respectively. The average impoundment water level during this time was approximately 935 feet (285 meters) in elevation. Records show that the presence of the beach reduces seepage.

3.4.2.3 Tailings Impoundment Operation

The tailings impoundment provides storage for tailings, surface water runoff from the mill site, nearby developed areas, and surface water runoff from the Main Pit that is collected at the mine water diversion dam and pumped to the impoundment. The impoundment also receives seepage from the tailings facility itself and from the waste rock dump, and near-surface seepage from the overburden stockpile.

According to SRK (2007a), the in-situ dry bulk density of the tailings, after deposition, settling, and consolidation, has been estimated to range from 94.3 to 98.6 pounds per cubic foot. The value of 94.3 pounds per cubic foot, derived from the most recent bathymetric data, has been used for determining future storage requirements. The specific gravity of the tailings solids has been estimated at 2.93, based on composite samples generated from Main Deposit ore. The tailings are considered to be potentially acid generating, and react rapidly in laboratory tests. However, the water cover currently maintained over the tailings is preventing oxidation of sulfides and release of acidity and metals (see Section 3.5).

Water is removed from the tailings impoundment by a barge-mounted reclaim pump system located on the east side of the impoundment. This water passes through a treatment plant and sand filter before being discharged to Red Dog Creek.

3.4.2.4 Monitoring

Instrumentation has been installed throughout the tailings main dam to monitor pore pressures for dam stability and hydrologic characterization. The piezometers consist of 21 vibrating wire type transducers. Monitoring of the soil and rock temperature in the bedrock below or around the tailings impoundment is provided by eight thermistor strings. Piezometer properties, including tip depth, material properties, and tip thermal conditions, are summarized in Table 3.4-2 (URS 2007a).

Properties for each piezometer were obtained by consolidating data from several sources, including the geotechnical investigations, as-built drawings, stability analyses, and Teck's piezometer monitoring data. The tip soil formation was estimated from boring logs, if there was a log for the piezometer, or by using data from nearby borings, and design and construction reports (URS 2007a).

The piezometer tip thermal condition was determined by using the transducer temperature and checking it against the data notes included with the dataset URS has on file. In some cases there was a pressure reading for a piezometer when the transducer indicated that it was frozen.

Section 5.3.1.2 of the Operating and Maintenance Manual requires that the piezometer readings for dam stability should be checked if the following observations are made:

- Water level at piezometer P-10 exceeds elevation 813
- Water level at piezometer P-09 exceeds elevation 817
- Water level at piezometer P-08 exceeds elevation 825

None of the piezometer readings have exceeded these levels.

Table 3.4-2 Summary of Piezometer Information

Piezometer	Piezometer group	Surface elevation (feet)	Piezometer tip elevation (feet)	Tip condition
P-08A	underdrain	947.1	795.0	Always thawed
P-08B	underdrain	947.1	770.0	Always thawed
P-09A	underdrain	867.5	790.1	Always thawed
P-09B	underdrain	867.3	766.1	Always thawed
P-10A	underdrain	823.1	790.3	Always thawed
P-10B	underdrain	823.6	765.3	Always thawed
P-11	crest	949.4	900.2	Always thawed
P-12A	crest	947.7	829	Frozen from Oct to Dec 2003
P-12B	crest	947.6	808.2	Frozen since installed in Aug 1997
P-13	crest	948.8	830.9	Always thawed
P-14A	crest	947.7	881.2	Frozen since installed in Sep 1997
P-97-028	east buttress	809.4	760.9	Always thawed
P-97-029	east buttress	824.1	793.9	Frozen since Jan 2001
P-97-030	east buttress	862	809.0	Always thawed
P-97-031	east buttress	894.2	879.5	Periodically thawed from 2002 to 2006
P-05-62 (SS-05-05)	2005 piezometer	811.3	787.9	Always thawed
P-05-63 (SS-05-05)	2005 piezometer	970.3	929.6	Always thawed
P-05-65 (SS-05-05)	2005 piezometer	956.8	929.0	Always thawed
P-05-67 (SS-05-05)	2005 piezometer	983.2	954.9	Always thawed
P-05-68 (SS-05-05)	2005 piezometer	989.6	961.4	Always thawed
P-05-69 (SS-05-05)	2005 piezometer	831.3	823.6	Always thawed

3.4.2.5 Stability Evaluation

Tailings Impoundment

Overall, the risk of failure of the existing tailings embankments is considered to be low, given that embankments have been designed to meet commonly accepted standards of care for similar facilities. A comprehensive assessment of the static and dynamic stability of the main tailings embankment is described in URS 2007c.

Several potential concerns related to the stability of the main embankment follow. These concerns will be addressed during the final design and will be reviewed and approved by ADNR under the dam safety review and permitting process:

- The main embankment has an area near the toe that is discharging a substantial quantity of oxygen depleted water. As the water exits the toe of the embankment it comes in contact with oxygen in the atmosphere, and reacts immediately to form a ferricrete (iron oxide). This iron oxide precipitate ultimately seals the rock voids through which water flows, causing the phreatic (water) surface in the embankment to steadily rise as a new open discharge area is required. This will result in a phreatic surface in the embankment higher than was assumed in the original design and which could lead to instability.

  The level of risk of failure from a higher-than-expected water level in the dam is moderate. Stability analyses in the URS 2007c report demonstrate that the stability of the embankment is sensitive to the phreatic level in the downstream slope. The rise in the phreatic surface in the embankment should be easily detected via the installed piezometers and by observing the exit point on the downstream slope. Thus, the risk of non-detection is low. However, if the situation is not addressed, the embankment could experience a mass slope instability, leading to a loss of containment of both solids and tailings water. The corrective action likely would be to install a horizontal drain pipe with a water trap at the end to limit oxygen ingress in the toe of the embankment.

- In performing stability analyses for dams, a factor of safety is generally calculated to represent the risk of failure. As documented in URS 2007c, a stability analysis of the main tailings dam, assuming that the geomembrane liner has fully degraded, which is appropriate for long-term (e.g., post-closure) conditions, shows that the dam would have a factor of safety of 1.36. This would be below the minimum factor of safety of 1.5 that was proposed by URS. The degradation of the liner can be addressed by the placement of a wide tailing beach behind the dam, which Teck has done.

- The continued loss of permafrost could impact soil conditions underlying the dam. As such, this could cause settling of the existing dam and may cause additional settlement of future raises. As discussed in URS 2008, this settling potential has been taken into account in the design and stability calculations for the most recently proposed raises, Stages VIIIa and VIIIb (to 965 and 970 feet elevation respectively). The State of Alaska Dam Certification Program is reviewing the designs and calculations as part of approving the proposed raises. Because of this, EPA assumes that the effects of permafrost thawing will be considered and accounted for by Teck and the State in future raises to the proposed final elevation.

Dam stability is monitored by the Dam Certification Program under ADNR; therefore, the above concerns identified with the main dam will be addressed through ADNR's regulatory process. The back dam is also under the authority of ADNR and is considered to be stable under all conditions, assuming the overburden stockpile is not removed.

Waste Rock Dump

The waste rock dump is considered generally stable, and has a low probability of failure. The stability of the main waste rock pile has been evaluated several times during the history of the project. Most recently, this was assessed in 2002 by Golder & Associates (Golder 2003) as summarized in SRK 2005. The stability evaluation addressed both static and dynamic (seismic) conditions. The evaluation showed the pile was stable at the time of the analysis and provided recommendations to ensure stability in future construction. These recommendations have been adopted by Teck as the pile expands.

3.4.3 Geotechnical Stability – Environmental Consequences

3.4.3.1 Effects of Alternative A – No Action Alternative

Tailings Impoundment

Under Alternative A, the main tailings dam is stable under current conditions. As described in Section 3.4.2.5, there are concerns with long-term stability due to the rise in the phreatic surface within the dam and a lower than accepted safety factor. ADNR has indicated that they will address these issues in their dam safety approval process for the final lifts of the dam. Assuming these issues are addressed, the dam is expected to be stable over the long term.

Waste Rock Dump

The waste rock dump would continue to grow laterally and vertically as additional waste rock is placed into storage. At closure, the pile would be covered with soil and revegetated, limiting infiltration into the waste material. The pile would be stable throughout operations and after closure.

3.4.3.2 Effects of Alternative B – Applicant's Proposed Action

Tailings Impoundment

The dam for the tailings impoundment is currently in the process of being raised from 960 feet to 970 feet in elevation. To accommodate the Aqqaluk Deposit, the dam would need to be raised to 986 feet in elevation.

Under Alternative B, the existing tailings facility would be expanded to approximately 986 feet in elevation for a total height of 208 feet (63.4 meters) to provide adequate storage of the tailings and overlying water pool. During operations, water from the surface of the tailings facility would be treated under the reissued NPDES permit and discharged into Middle Fork Red Dog Creek. The tailings impoundment closure includes maintaining a two-foot water cover. After closure, the Aqqaluk Pit would fill with water and would be used to manage other impacted water from the site. Water would be pumped from both the Aqqaluk Pit and the tailings impoundment to the wastewater treatment system and discharged to Red Dog Creek. Assuming the issues identified in Section 3.4.2.5 are addressed through the State's Dam Certification Program, the dam is expected to be stable over the long term.

Waste Rock Dump

The waste rock dump would reach a maximum size of 260 acres from the current size of approximately 245 acres. On closure, the waste rock dump would be regraded to a slope of 3:1 (horizontal: vertical) and covered with two layers of soil (Figure 2.7). This design would ensure that the pile would be stable throughout operations and would be stable after closure.

3.4.3.3 Effects of Alternative C – Concentrate and Wastewater Pipelines

Tailings Impoundment

During operations under Alternative C, the tailings facility would be expanded to an approximate elevation of 986 feet to provide adequate storage of the tailings and overlying water pool.

At closure the tailings impoundment would be drained of water and covered. This cover would be revegetated, with any intercepted precipitation draining to the north, where it would be discharged into the South Fork Red Dog Creek. The underlying tailings would continue to drain and consolidate, with most of the water from the consolidation process flowing to the downstream seepage collection pond where it could be treated and discharged. All pipelines would be removed at closure, including the wastewater discharge to the Chukchi Sea. Wastewater generated after closure would be treated and discharged into Red Dog Creek. Assuming the issues identified in Section 3.4.2.5 are addressed through the State's Dam Certification Program, the dam is expected to be stable over the long term.

Waste Rock Dump

The waste rock dump closure scenario for Alternative C differs from Alternative B because the waste rock dump would be temporarily reclaimed throughout the life of the operation. Beginning in 2031, the waste rock dump would be regraded to a 5:1 slope with excess material moved back into the Aqqaluk Pit. The pile would be stable throughout operations and after closure.

Pipelines

Alternative C includes pipelines for wastewater, concentrate slurry, and diesel fuel. The wastewater pipeline would be a combination of steel, used for much of its length and high density polyethylene (HDPE), which would be used in low pressure sections. The entire length of the concentrate and diesel pipelines would be built of steel; the concentrate line would be lined with HDPE. As noted in Section 2.2.3, the pipelines would be buried within a berm built adjacent to the DMTS access road. While the berm would be built to minimize the possibility of movement and settling, like the DMTS, the berm would be subject to some movement associated with freeze/thaw action. An engineering study would be necessary to consider the extent of potential movement the pipelines might experience along with the internal pressures that would be expected. The berm would be monitored on a daily basis to ensure that any signs of movement would be identified and repaired as necessary to prevent the pipelines from being compromised. Assuming that the pipelines were adequately designed, they would be able to withstand the limited movement that they might experience within the berm.

3.4.3.4 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Tailings Impoundment

Effects would be the same as Alternative B except the treated water discharge would be to the Chukchi Sea. Assuming the issues identified in Section 3.4.2.5 are addressed through the State's Dam Certification Program, the dam is expected to be stable over the long term.

Waste Rock Dump

Effects would be the same as Alternative B.

Pipelines

Under Alternative D, only the wastewater pipeline would be installed and operated. As noted above, the limited movement that could occur within the berm would not be sufficient to compromise the integrity of the pipeline.

3.4.4 Geotechnical Stability – Summary

Minimal differences exist between the alternatives with respect to geotechnical stability. The tailings impoundment back dam and waste rock dump are considered stable under all conditions and alternatives. Under Alternative C, the impoundment would be drained and would not hold water over the long term. The main tailings dam is stable under current conditions. However, there are concerns with future, long-term stability. ADNR has indicated that they will address these issues in their dam safety approval process. Specific areas that should be addressed include dam stability after liner degradation and potential elevated water levels in the dam because of blockage in the drainage system.

3.5 Water Resources – Surface Water

3.5.1 Water Resources – Surface Water – Pre-mining Environment

Hydrologic and water quality data in the project area were limited prior to the development of the Red Dog Mine. The United States Geological Survey (USGS) monitored flows on the Noatak and Wulik rivers and these were the only available data to characterize seasonal flow regimes and runoff characteristics in the DeLong Mountains region. Hydrologic monitoring in the Wulik River specifically did not begin until after 1980. Baseline water quality studies were conducted in 1981 and 1982 with monthly samples taken during open water months at more than 35 stations (Dames & Moore 1983a). The 1984 EIS generally characterized the baseline water quality of the Wulik River as a clear water system typified by high dissolved oxygen and low levels of color, suspended solids, turbidity, and nutrients. The water was described as being moderately hard with a pH ranging from 7.1 to 8.1 standard units (s.u.).

Prior to mining, South Fork and Middle Fork Red Dog Creek were naturally acidic and commonly exhibited high levels of metals, including cadmium, lead, iron, and zinc. Iron precipitates, known as iron hydroxides, often caused the creek to appear a reddish or orange color. The iron hydroxides stained rocks within the streambed and drastically increased the stream turbidity. These characteristics were caused when Middle Fork Red Dog Creek flowed across the exposed ore bodies and associated soils of the Red Dog and Aqqaluk deposits. Table 3.5-1 shows arsenic, cadmium, lead, mercury, and zinc concentrations taken from sampling locations in the Red Dog and Ikalukrok drainages prior to mining (Peterson 1983). Figure 3.11 illustrates the locations of water bodies in the vicinity of the Red Dog Mine. Figure 3-12 illustrates all water monitoring stations within the project area, including the mine and DMTS road. Figure 3.13 provides more detail of important monitoring locations in the vicinity of the Red Dog Mine.

As described in the 1984 EIS, North Fork Red Dog Creek upstream of the ore body was relatively uncontaminated with metals (EPA 1984). However, a zone of water quality degradation began at the upper end of the ore body in Middle Fork Red Dog Creek and extended downstream from the confluence of Middle Fork and South Fork Red Dog Creek. As can be seen in Table 3.5-1, average dissolved metal concentrations for cadmium, lead, and zinc at Station 33 on Middle Fork Red Dog Creek were much higher than in the North Fork drainage. The average zinc concentration at this station was 16,911 µg/L, approximately 550 times higher than average value for the North Fork (31 µg/L). Dissolved lead was 166 times higher at this station. Water quality improved somewhat at Station 10 below this confluence because of the mixing with less mineralized water from the North Fork; however, downstream levels of metals, turbidity, suspended solids, and sulfate were higher than those found in adjacent streams.

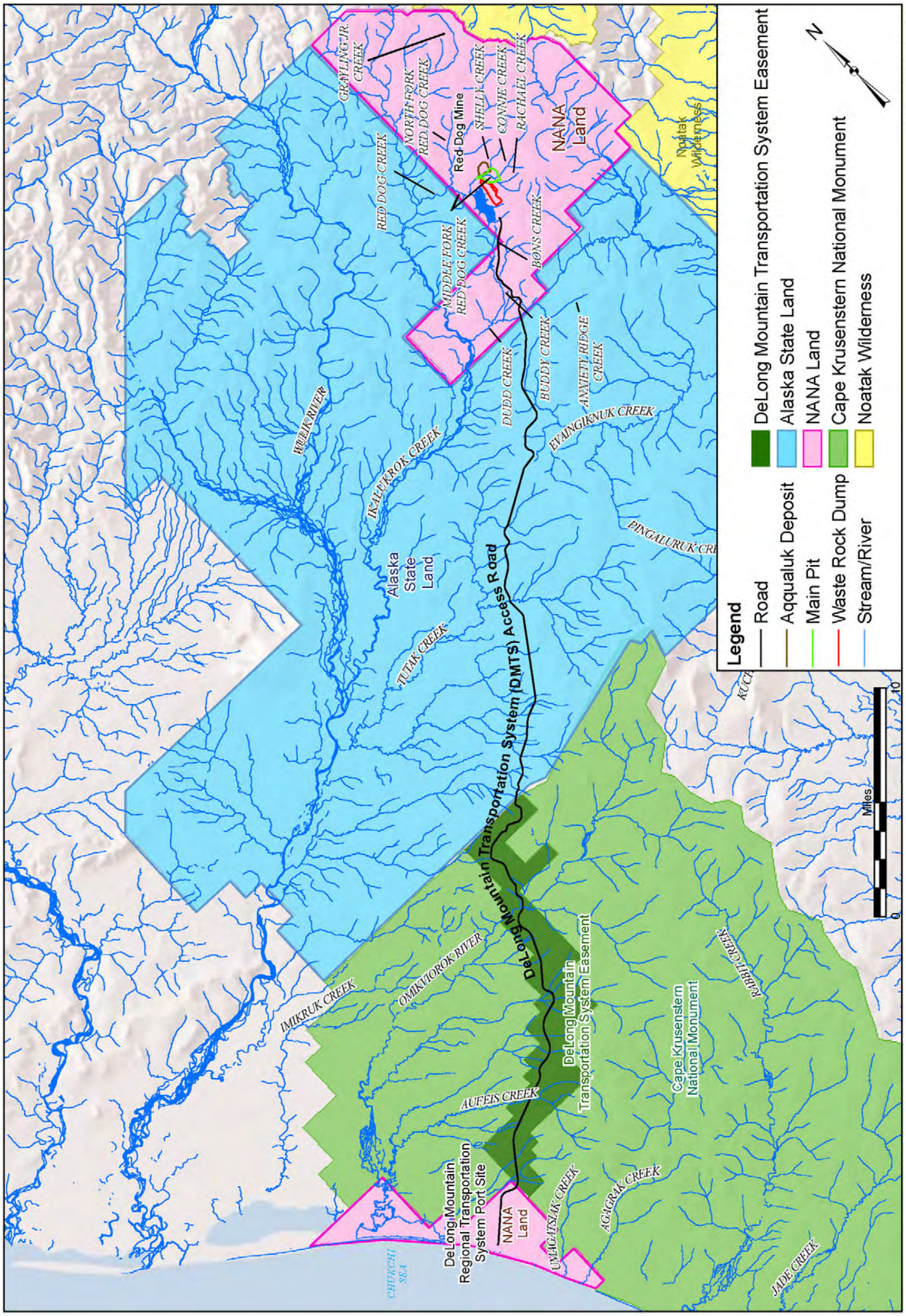


FIGURE 3.11

AREA WIDE STREAM RIVER MAP

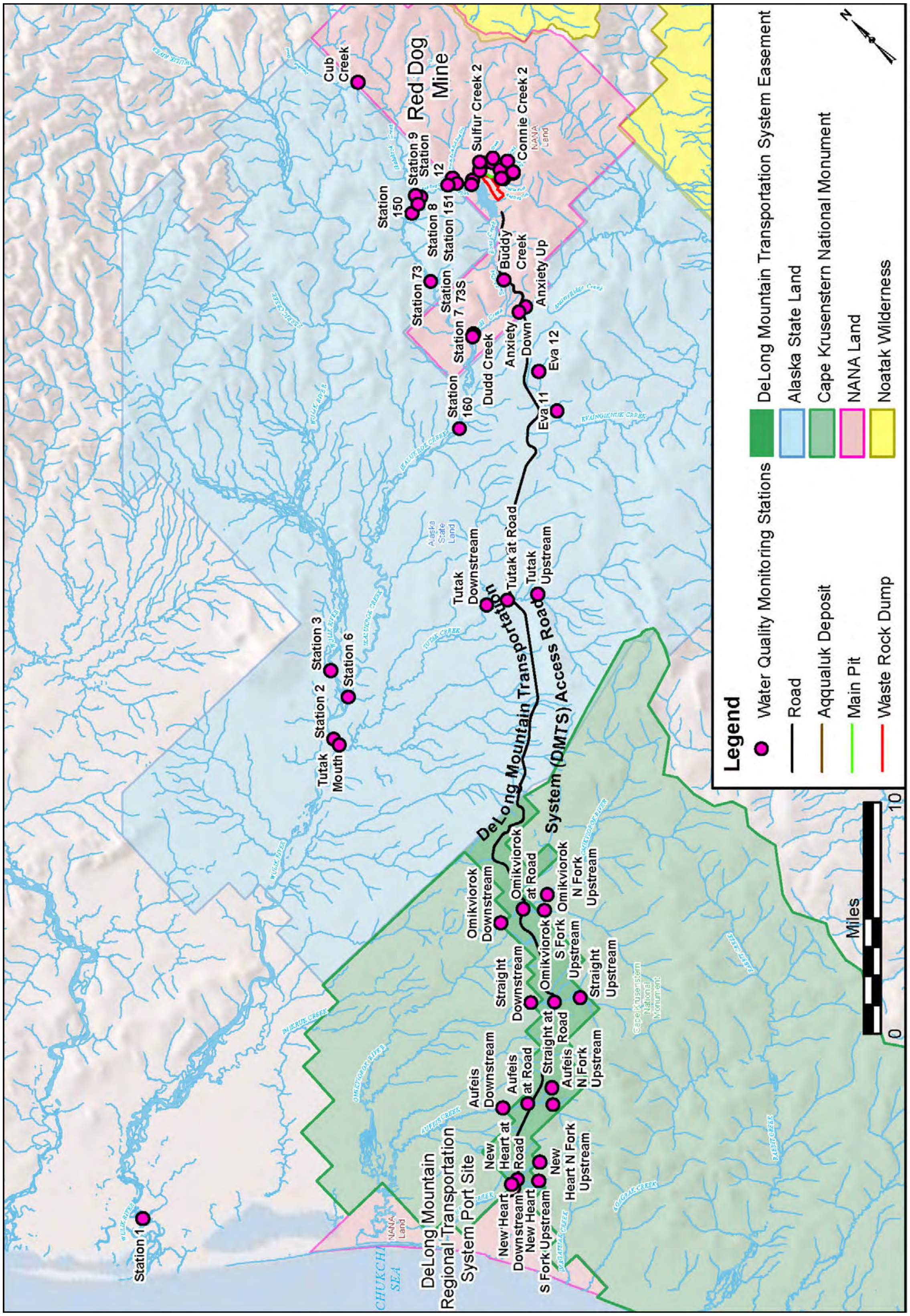


FIGURE 3.12
WATER QUALITY MONITORING LOCATIONS

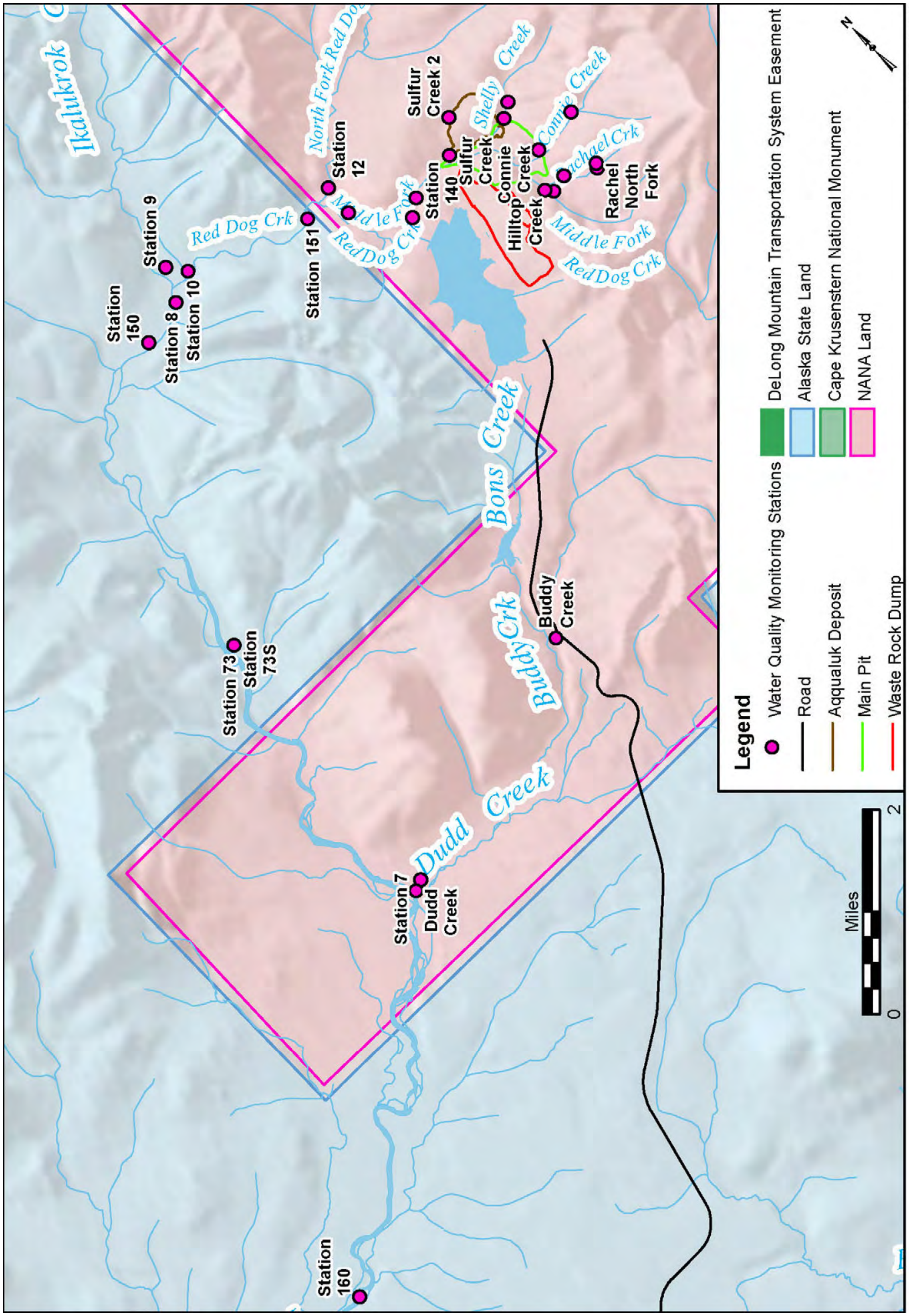


FIGURE 3.13
WATER QUALITY MONITORING LOCATIONS NEAR MINE SITE

Table 3.5-1 Summary of Water Quality Data Prior to Mining in Red Dog, Ikalukrok, and Wulik Drainages[a]

Station	Description	pH	TDS	Arsenic dissolved	Cadmium dissolved	Lead dissolved	Mercury dissolved	Zinc dissolved
		s.u.	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Station 12	North Fork Red Dog Creek (background station)	7.4	193	N/A	4.8	0.2	N/A	31
Station 22	South Fork Red Dog Creek near current location of the tailings dam	6.4	79	N/A	7.8	17.7	0.2	1,358
Station 33 (near current Station 140)	Middle Fork Red Dog Creek upstream of current Outfall 001	5.23	177	N/A	149	33.2	N/A	16,911
Station 10	Red Dog Creek downstream of North Fork Red Dog Creek	6.7	191	N/A	28.9	2.3	< 0.2	3,680
Station 9	Ikalukrok Creek upstream of Red Dog Creek (background station)	7.5	134	N/A	4.5	0.6	N/A	33
Station 8	Ikalukrok Creek downstream of Red Dog Creek confluence	7.3	149	N/A	13.0	4.5	N/A	1,187
Station 7 (near current Station 160)	Ikalukrok Creek approximately 9 miles below Red Dog Creek	7.6	N/A	N/A	9.5	2.5	N/A	316
Station 2	Wulik River downstream of Ikalukrok Creek confluence	7.7	162	N/A	4.0	3.1	N/A	39
Station 1	Wulik River upstream of Kivalina	7.4	151	< 0.2	2.8	0.7	< 0.2	17

[a] Values represent averages from monthly monitoring conducted in 1981 and 1982

Dissolved metals from Red Dog Creek affected the water quality in Ikalukrok Creek below the confluence with Red Dog Creek (EPA 1984). Concentrations of cadmium, lead, and zinc remained relatively high at Station 8 in Ikalukrok Creek immediately below the Red Dog Creek confluence. Impacts were decreasing to levels more typical of the Wulik River and other adjacent drainages by Station 7, nine miles downstream.

3.5.2 Water Resources – Surface Water – Baseline Conditions

In the arctic environment of the mine site, stream flows vary widely across the seasons and are extremely variable year to year. Virtually all flow occurs in the five-month period beginning with spring thaw in May and ending with winter freeze in October. Storm water runoff is also highly variable depending on topography, degree of soil saturation, and depth to permafrost. Small tributary streams typically freeze to the bottom in the winter months, whereas larger rivers can sometimes continue to flow beneath an ice covering.

Wulik River. All of the mine area and most of the DMTS road are located in the Wulik River Basin. The Wulik River drains the western DeLong Mountains and flows southwest approximately 80 miles before discharging to the Chukchi Sea at Kivalina. Flow data for the Wulik River demonstrates the extremely large seasonal and annual variation in surface water flow in the vicinity of the mine site (Table 3.5-2). Based on available data, May has the largest coefficient of variation (1.72) with recorded flows ranging from a low of 9 cubic feet per second (cfs) to a high of 19,000 cfs. The May variation can be attributed to the timing of freshet (spring snow melt). The highest recorded flow on the Wulik River, between 1984 and 2007, was 26,700 cfs in August 1989. This high flow was caused by a summer storm; summer storms typically occur in August.

Table 3.5-2 River Discharge from Station 2 on the Wulik River (1984–2007)

Month	Discharge			
	Average cfs	Coefficient of Variation [b]	Min. cfs	Max. cfs
May	1,693	1.72	9	19,000
June	3,175	0.80	180	15,000
July	1,574	1.50	277	19,700
August	2,433	1.24	203	26,700
September	1,661	1.03	255	13,400
October	558	1.14	100	8,250
November	136	0.51	44	470
Annual[a]	**1,603**	**1.19**		

[a] Average discharge from May 1 through November 30.
[b] Coefficient of variation shows relative variation in annual discharge; values > 1 indicate a high annual variation in river discharge.

Ikalukrok Creek. Ikalukrok Creek discharges into the Wulik River. The headwaters of Ikalukrok Creek are impacted by areas of natural mineralization (ADF&G 1999; Peterson 1983) and natural seepage of minerals from Cub Creek (ADNR-OHMP 2005). The confluence of Cub Creek with upper Ikalukrok Creek is approximately one mile upstream of the confluence with East Fork Ikalukrok Creek.

Ikalukrok Creek above the confluence with Main Stem Red Dog Creek, which includes the mine discharge, drains approximately 5.8 mi^2 (square miles). This reach of Ikalukrok Creek has not been disturbed by human activity and has a substrate of cobbles, gravel, and rocks. At Station 9, Ikalukrok Creek above the confluence of Main Stem Red Dog Creek, the rocks in the streambed are frequently stained orange from naturally occurring iron precipitate (ADF&G 1999). Staining on the rocks can be attributed to mineralized tributaries upstream including Cub Creek. In this reach, Ikalukrok Creek is typically 6 to 23 feet (1.8 to 7 meters) wide with depths of 6 inches to 4 feet (0.15 to 1.2 meters).

Below the confluence with Main Stem Red Dog Creek, Ikalukrok Creek is a comparatively fast-flowing stream with a substrate of small cobbles and gravel. ADF&G (1999) reported a dense growth of filamentous algae and iron precipitate on the stream bottom at Station 8, located in Ikalukrok Creek just below the confluence of Main Stem Red Dog Creek (see Figure 3.13). Gravel bars are exposed during low flow. Average seasonal flow at Station 150, in Ikalukrok Creek below the main stem confluence, is highly variable. Essentially all stream flow occurs from May through October. Because of shallow permafrost and saturated soils, rapid snow melt or rainfall results in rapid changes in stream discharge. Surface discharge volume peaks in late May during ice breakup and during summer storms. Peak flow volume may exceed 2,000 cfs during these periods. Flow decreases with the onset of winter (September/October) and by mid-winter the creek is substantially frozen, although intermittent aufeis fields commonly form in most of Ikalukrok Creek from ice pressure.

In Ikalukrok Creek downstream of Dudd Creek at Station 160, average summer monthly flows range from a low of 274 cfs in July to a high of 678 cfs in June (Table 3.5-3). Ikalukrok Creek below the Dudd Creek confluence ranges in wetted width from 12 to 130 feet (3.5 to 40 meters) and in depth from 1 to 4 feet (0.3 to 1.2 meters). The substrate in this location consists of small to medium sized gravel (ADF&G 1999).

Table 3.5-3 Average Monthly Discharge and Runoff Stations 150 and 160

Month	Station 150 – Ikalukrok Creek downstream of Red Dog Creek		Station 160 – Ikalukrok Creek downstream of Dudd Creek	
	Average Discharge (cfs)	Inches (cm) of Runoff	Average Discharge (cfs)	Inches (cm) of Runoff
June	379	3.4 (8.6)	678	5.3 (13.5)
July	205	1.8 (4.6)	274	2.5 (6.4)
August	282	2.5 (6.4)	417	3.8 (8.7)
September	298	2.7 (6.8)	338	3.0 (7.6)

Red Dog Creek. Red Dog Creek drains the western foothills of the DeLong Mountains and the Red Dog Mine site. Red Dog Creek flows into Ikalukrok Creek, a major tributary of the Wulik River. Middle Fork and North Fork Red Dog Creek combine to form Main Stem Red Dog Creek. Pre-mining, South Fork Red Dog Creek was a tributary to Middle Fork Red Dog Creek. South Fork Red Dog Creek was impounded in the late-1980s as a result of construction of the Red Dog Mine tailings impoundment. The Red Dog Mine facilities, including the Main Pit and Red Dog Creek diversion, are contained within the Middle Fork and South Fork Red Dog Creek watersheds.

North Fork Red Dog Creek drains approximately 15.8 mi^2. The stream is typically from 23 to 50 feet (7 to 15 meters) wide and from 4 inches to 6 feet (0.1 to 2 meters) deep (ADNR-OHMP 2005). It is characterized by abundant streamside vegetation, riffles, and pools that flow over a substrate of gravel and boulders. Middle Fork Red Dog Creek drains approximately 5.5 mi^2. This segment is a meandering channel that is 10 to 33 feet (3 to 10 meters) wide and 1 to 1.5 feet (0.3 to 0.5 meters) deep. Outfall 001, the mine discharge, discharges into Middle Fork Red Dog Creek approximately 3.2 miles upstream from the confluence of Main Stem Red Dog Creek and Ikalukrok Creek.

Main Stem Red Dog Creek drains approximately 25 mi^2 and flows across a substrate mostly of gravel, cobbles, and small boulders. The creek meanders, ranging in width from 12 to 60 feet (3.6 to 18.3 meters) and in depth between 6 and 7 feet (1.8 to 2.1 meters).

Table 3.5-4 presents average monthly discharge and average annual inches of runoff for Station 140 (Middle Fork Red Dog Creek upstream from Outfall 001) and Station 12 (North Fork Red Dog Creek) for the months of June through September.

Table 3.5-4 Average Monthly Discharge and Runoff Stations 140 and 12

Month	Station 140 – Middle Fork Red Dog Creek upstream from Outfall 001		Station 12 – North Fork Red Dog Creek	
	Average Discharge (cfs)	Inches (cm) of Runoff	Average Discharge (cfs)	Inches (cm) of Runoff
June	22	5.1 (13.0)	52	12.1 (30.7)
July	9	2.2 (5.6)	20	4.9 (12.4)
August	19	4.6 (11.7)	47	11.3 (28.7)
September	13	3.0 (7.6)	40	9.3 (23.6)

3.5.2.1 Overview of Water Management Systems

The Applicant uses the tailings impoundment to manage any contaminated or potentially contaminated water from the mine. To reduce the volume of water requiring treatment, clean runoff is directed around most mine site facilities into natural water courses. Key aspects of the water management system are the Red Dog Creek diversion, mine water collection system, waste rock dump, tailings impoundment and seepage collection system, overburden pile runoff and seepage collection system, and wastewater treatment facilities. The water management system is monitored in support of the mine water balance for the entire operation. Fresh water for the mine site is provided by the Bons Creek Reservoir.

Red Dog Creek Diversion

The primary drainage through the mine area is Middle Fork Red Dog Creek. Tributaries entering the Middle Fork within the mine area are Rachel Creek, Connie Creek, Shelly Creek, and Sulfur Creek. Stream flow is conveyed through the mine area in the Red Dog Creek diversion channel, the components of which are shown in Figure 2.3. The first section of the diversion consists of a 72-inch-diameter culvert that extends from the start of the diversion to the confluence with Connie Creek. A 90-inch diameter culvert conducts the stream flow between Connie and Shelly creeks. The second section consists of a 1,870-foot-long, 96-inch-diameter culvert running between the Main Pit and the Aqqaluk Deposit, downstream of Shelly Creek. The third section is a 3,200-foot-long lined channel that runs from the culvert mouth to the Red Dog Creek diversion dam, where the flow re-enters the original streambed. Intake weirs and/or pipelines direct Middle Fork, Rachel, Connie, and Shelly creeks into the first section of the diversion. Sulfur Creek enters the third section. A complete discussion of the diversion is provided in the *Red Dog Creek Re-diversion Design Criteria and Plan* (TCAK 2004b). The diversion is designed to pass the estimated 100-year flow, increased by a safety factor of 1.3. This means that the diversion can pass 30 percent more flow than the 100-year peak stream flow.

Mine Water Collection System

Precipitation and groundwater entering the Main Pit becomes contaminated with suspended solids, TDS, and metals. This is primarily caused by the oxidation of sulfide minerals in the exposed pit walls and ore stockpiles. The oxidation of sulfide minerals creates acid, which in turn dissolves metals and forms sulfate mineral salts. The contaminated water is collected in sumps within the pit and pumped to the mine water sump where it is collected and pumped to the tailings impoundment. Key components of the mine water collection system are shown in Figure 2.3. Other sources of water entering the mine water collection system are:

- Hilltop Creek, which drains the east side of the ridge below the oxide stockpile;
- Aeas downstream of the diversion intake points for Connie Creek and Shelly Creek;
- The Aqqaluk exploration area including drainage on the south bank of the diversion; and
- Leakage from the Red Dog Creek diversion.

Hilltop Creek is connected to the mine water system by an engineered ditch. Almost all of the water from the Connie and Shelly creek diversions joins the Red Dog Creek diversion. Small areas above the confluences of Connie Creek and Shelly Creek with the Red Dog Creek diversion are not captured. Drainage from those areas passes under the diversions and into the Main Pit through a series of French drains. Storm water from the Aqqaluk area is collected and also enters the Main Pit mine water collection system via French drains that pass under the Red Dog Creek diversion. The Red Dog Creek diversion is at all points higher than the mine water collection system. This ensures that any leakage from the diversion, which is unimpacted water, drains to the collection system.

Eight pumps are available at the mine water sump to pump water to the tailings impoundment. Two of the pumps are configured for winter operation. The total annual flow from the mine water sump ranged from 287 to 492 million gallons during 1999 through 2005. Typical ranges of constituent concentrations are 7,000 to 14,000 mg/L TDS, 5,000 to 8,000 mg/L sulfate, 1,000 to 2,000 mg/L zinc, and 250 to 1,000 mg/L iron (SRK 2007).

Waste Rock Dump Seepage Collection System

Runoff and seepage from the waste rock dump areas are also contaminated with TDS and metals that result from the oxidation of sulfides in the waste rock. Originally, the seep water was allowed to flow directly into the tailings impoundment. Beginning in 2006, a portion of this water was collected in sumps and pumped to the newly constructed Water Treatment Plant 3 from which it is then pumped to the tailings impoundment. Water Treatment Plant 3 operates during the summer months only. Seepage that is not collected flows directly into the tailings impoundment. Estimates derived from a water and load balance developed by Teck suggest that the total average, annual seepage flow from the waste rock dump catchment is 18 million gallons. That catchment includes the waste rock dump, the low grade ore stockpile, the oxide stockpile, and portions of the Qanaiyaq Deposit.

Seepage flows and water quality have been monitored at a number of locations down gradient of the waste rock dump. Flow measurements have been made since 2003, but are not thought to have been effective at recording the total amount of flow from this area because of the difficulty in recording early spring runoff when conditions are still icy. To date, the total annual flow measured in the seeps is less than half of the 18 million gallons predicted from the water balance. Typical concentrations during the past few years of monitoring were approximately 30,000 to 40,000 mg/L TDS, 20,000 to 30,000 mg/L sulfate, 5,000 to 10,000 mg/L zinc, and 500 to 1,000 mg/L iron (SRK 2007).

Tailings Impoundment and Wastewater Treatment

In addition to Water Treatment Plant 3, two other water treatment plants are currently in operation (1 and 2). Water Treatment Plant 1 treats water that is reclaimed from the tailings impoundment for use in the mill, with over 2.9 billion gallons of water treated each year. Most of the treated water comes back to the impoundment with the tailings, but a small amount, about 1 percent, leaves the site as moisture in the concentrate. Although it does not result in a noticeable net removal of water from the impoundment, Water Treatment Plant 1 is an important source of alkalinity. It treats all of the acidity in the reclaimed water and counteracts any additional acidity present in the ore.

During the summer months, typically late May to early October, Water Treatment Plant 2 treats water from the tailings impoundment for discharge to Red Dog Creek at NPDES Outfall 001. About 80 percent of the water treated by Water Treatment Plant 2 is released at the outfall. The remainder is returned to the impoundment along with the treatment sludge and filter backwash. The total annual discharge at Outfall 001 varies. The NPDES permit limits the discharge to 2.418 billion gallons per year. However, the annual discharge flow is more limited by Teck's management of TDS. Teck adjusts the flow from Outfall 001 to comply with instream TDS water quality standards (i.e., the mine only discharges up to the amount of water that ensures it meets water quality standards).

Water Treatment Plant 3 treats seepage from the waste rock dump during summer months, as described above.

Mine Water Balance

Teck has developed a water and chemical load balance model to evaluate mine water management, particularly management of the water and chemistry of the tailings impoundment and requirements for the treatment of waters for discharge. The model is used by Teck to assess and manage potential impacts to site hydrology and water quality associated with current and proposed future operations. The model uses actual metered water flows and measured water quality from mine sumps, pump back systems, runoff conveyance systems, area creeks, water treatment plants and the mine site meteorological station. These data are used for model input as well as ongoing model calibration and evaluation. The model is currently being used by Teck to evaluate and plan mine operations and to evaluate water treatment needs that will be required both during operations and after closure.

Tailings Impoundment Water Balance. To determine whether the tailings impoundment will have sufficient capacity to manage water until it can be discharged in compliance with NPDES permit limits, it is important to understand the site water balance (the inflows to and outflows from the tailings impoundment). Since the 1998 NPDES permit was issued, the Applicant has collected precipitation, evaporation, and mine sump flow rate data to better define the current site-wide water balance. The water balance for the facility for 1999–2005 is shown in Table 3.5-5. In this water balance the inflows to the tailings impoundment include:

- Runoff from the South Fork drainage, including water falling on the tailings impoundment (labeled "precipitation inflow"). This value is calculated annually based on the adjusted annual precipitation (see Table 3.5-5 and the discussion below) and an approximately 1,650-acre drainage area. The approximately 530-acre tailing impoundment area is a subset of this area.
- Metered mine sump water flow, which includes runoff from approximately 433 acres, which correlates to the 0.3 billion gallons per year.
- Metered clean, fresh water from Bons Creek Reservoir. This water ranges from 0.076 to 0.137 billion gallons per year and is not considered mineralized. Teck no longer adds Bons Creek water to the tailings impoundment or outfall.

Table 3.5-5 Tailings Impoundment Water Balance, 1999–2005

	Measured Precipitation (inches)	Adjusted Precipitation (inches)	Precipitation Inflow (million gallons)	Mine Sump (million gallons)	Bons Fresh Water (million gallons)	Total Inflow (million gallons)
1999	11.5	12.6	569	287	76	932
2000	21.7	23.4	1,057	348	77	1,482
2001	19.0	20.6	931	329	85	1,345
2002	20.7	23.6	1,066	433	126	1,625
2003	19.3	22.0	994	411	126	1,531
2004	20.3	22.4	1,012	394	98	1,504
2005	17.9	20.2	913	492	137	1,542

Between 1999 and 2005, the total inflow minus the total evaporation from the impoundment (9 inch annual average) yields a volume of 9.05 billion gallons. Comparing this value to the total discharge volume of 8.6 billion gallons per year between 1999 and 2005 explains why water levels have been rising in the impoundment.

Adjusted Precipitation. The majority of the water entering the tailings impoundment is precipitation falling directly it and runoff from adjacent areas. Runoff from snowmelt is directed to the tailing impoundment in the Middle Fork watershed, including the waste rock dump, Main Pit area, and Aqqaluk Deposit. Precipitation is measured at the Red Dog Mine at the main meteorological station located near the mine airport within the Bons Creek drainage. Site research and literature review has shown that the use of direct precipitation measurements in the water balance is unreliable during the winter months. A review of literature has shown that the catchment of snow in a precipitation gauge under windy conditions results in underestimating the amount of snowfall, and thus precipitation. This is because wind flow around a gauge prevents snow from entering the opening of the gauge. The under-catch (the under measurement) of precipitation and snow at meteorological stations, particularly in the State of Alaska, has been well documented (Black 1954; Benson 1982; Yang et al. 1998; Yang et al. 2000; Benning and Yang 2004; and Hanson et al. 2004). In evaluating water balance procedures at mine sites, EPA (2006b) also discussed errors and problems associated with precipitation measurement. A recent seven-year study by

Benning and Yang (2004) focused on developing daily adjustments of measured precipitation data for the National Weather Service stations at Barrow and Nome, Alaska. The results showed that precipitation was under measured between 20 and 180 percent for Barrow and 30 and 380 percent for Nome, with the larger percentages occurring in winter months. Hanson et al. (2004) showed that an average calibration factor of 1.8 was appropriate for calculating wind-adjusted snowfall amounts in Idaho.

Studies at the Red Dog Mine were conducted to compare measured precipitation versus the produced volume of runoff and inflows into the tailings impoundment. These studies were conducted by measuring changes in the impoundment's volume and comparing it to all other measured inflows (SRK 2007). The development of the calibration relied heavily on measurements during freshet (snow melt) in late spring. Rapid runoff and changes in the tailings impoundment volume were easily measured and correlated during this time. These studies show that snow catch is underestimated by an average of 40 percent. Therefore, a calibration factor of 1.4 to adjust winter (October through April) measured precipitation is applied to the water balance. No correction factor is required during the summer months. The average annual precipitation correction factor is between 1.1 and 1.2 and is reflected in the adjusted precipitation values shown in Table 3.5-5.

Bons Creek Reservoir. A fresh water reservoir and pumping system are located in the Bons Creek watershed near the airport. The reservoir was created by constructing a small dam across Bons Creek. The reservoir supplies water for drinking and other domestic uses as well as peripheral uses in the mill. The reservoir is filled during the summer by snow melt and precipitation. Fresh water is collected from the reservoir and pumped to the living facilities and mill site through insulated, heat-traced pipe.

3.5.2.2 Surface Water Quality

The Applicant has collected water quality samples in area streams, rivers, and at Kivalina's drinking water intake since 1983. As mining has progressed, the ambient water quality monitoring program has expanded to provide monitoring at additional stations.

Evaluations of water quality are generally conducted in comparison to Alaska Water Quality Standards (WQS). Alaska WQS include use classifications, numeric and/or narrative water quality criteria, and an antidegradation policy. The use classification system designates the beneficial uses that each water body within the state, such as Red Dog Creek, Ikalukrok Creek, and the Wulik River, is expected to achieve. The numeric and/or narrative water quality criteria are the criteria deemed necessary by the State to support the beneficial use designation.

The Middle Fork Red Dog Creek is protected in the WQS for freshwater industrial water supply use from the headwaters to the terminus of the Red Dog Mine water management system. Lower Middle Fork Red Dog Creek from the terminus of the Red Dog Mine water management system to the confluence with North Fork Red Dog Creek is protected in the WQS for freshwater industrial water supply, contact recreation (wading), and secondary recreation (except fishing). Main Stem Red Dog Creek from the confluence of the Middle Fork and North Fork Red Dog Creek to Ikalukrok Creek and Ikalukrok Creek itself are protected for the above listed uses and additionally for the growth and propagation of fish, shellfish, other aquatic life, and wildlife. The Wulik River below the confluence with Ikalukrok Creek is protected for the same designated uses as Ikalukrok Creek with the addition of water supply for drinking, culinary uses, and food processing.

The water quality criteria for protection of aquatic life in the vicinity of the Red Dog Mine and in the Wulik River are shown in Table 3.5-6. This table also provides the applicable drinking water standards at the Kivalina intake. Marine water quality criteria are discussed in Section 3.5.3 under alternatives C and D, which include discharges to the Chukchi Sea.

Table 3.5-6 State of Alaska Aquatic Life Water Quality Standards

Parameter, (in µg/L unless noted otherwise)	Aquatic Life Water Quality Standards[f] (Red Dog Creek)		Aquatic Life Water Quality Standards[f,g] (Wulik River)		Drinking Water/Human Health Standards[f,g] at Kivalina
	Acute	Chronic	Acute	Chronic	
Aluminum	750	87	750	87	—
Ammonia[a], mg/L	5.62	2.36	3.8	1.8	—
Cadmium [b]	2	2	1.6	0.21	5
Copper	34.4	21.1	10	7.1	1,300
Cyanide[c]	22	5.2	22	5.2	200
Iron	—	1,000	—	1000	—
Lead	276	11	55	2.1	—
Mercury[d]	2.4	0.012	2.4	0.012	0.050
Nickel	1,053	117	360	40	100
Selenium	20	5	20	5	50
Silver	21	—	2.4	—	—
Zinc	269	269	92	92	9,100
TDS[e]	1,500/1,000/500		1,000		500

[a] Ammonia aquatic life standards are dependent on the pH and temperature of the receiving water; the standards shown were determined from data collected between 2003 and 2007 in Red Dog Creek at Station 10 and Wulik River at Station 2.

[b] The State of Alaska adopted and EPA approved a single, site-specific aquatic life criterion of 2 µg/L for cadmium in Main Stem Red Dog Creek based on background conditions.

[c] The cyanide standard is for free cyanide sampled as Weak Acid Dissociable (WAD).

[d] Revised water quality standards for mercury have been adopted by the State but not approved by EPA.

[e] In Main Stem Red Dog Creek, the TDS standard is 1,500 mg/L. In Ikalukrok Creek the standard is 1,000 mg/L below Station 150 to the confluence with the Wulik River from the spring thaw until July 25 of each year. After July 25 TDS levels must be below 500 mg/L from Station 160 to the Wulik River confluence until freeze up.

[f] All standards are expressed as total recoverable values.

[g] Metals values are the most stringent of the primary maximum contaminant levels (MCLs) and water consumption criteria in Alaska's WQS. For TDS the criteria are the applicable drinking water supply value.

— = no standard

Some of the WQS for metals are hardness-based. Hardness is the measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentration of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions, because these are the most common polyvalent cations. Other ions, such as iron (Fe^{2+}) and manganese (Mn^{2+}), may also contribute to the hardness of water, but are generally present in much lower concentrations. Greater water hardness mitigates metals toxicity because polyvalent cations (Ca^{2+} and Mg^{2+}) help keep fish and other aquatic organisms from absorbing toxic metals such as cadmium, copper, and lead into their bloodstream through their gills. For this reason, a higher measured hardness in the ambient water results in a higher (less stringent) WQS for hardness-based metals. A lower measured hardness results in more stringent WQS for hardness-based metals. The hardness-based standards for Red Dog Creek in Table 3.5-7 were developed based on a hardness of 260 mg/L, which is in the 5th percentile of the measured hardness values at Station 10 in Main Stem Red Dog Creek. The hardness-based standards for the Wulik River were developed based on a hardness of 73 mg/L, in the 5th percentile of measured values at Station 2.

Table 3.5-7 shows the cumulative results of water quality sampling programs at major area streams near and below the Red Dog Mine. These data show median and maximum concentrations of total metals and other important parameters recorded between 1998 and 2007. Table 3.5-7 also shows pH ranges. As discussed in Section 3.5.1, Middle Fork Red Dog Creek prior to mining was naturally acidic and exhibited high levels of metals, including cadmium, zinc, and lead. This occurred from the oxidation of

Table 3.5-7 Summary of Water Quality Monitoring Data (1998–2007)

Station	Description	Statistics	pH	Alk	TDS	TSS	SO4	Hardness	Ca	Mg	Na	Al	Cd	Cu	Fe	Mn	Ni	Pb	Se	Zn
			s.u.	mg/L	mg/L	mg/L	mg/L	mg/L[2]	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Red Dog Creek and Tributaries Upstream of Mine																				
Station 145	Middle Fork	Median	6.9	46	205	5.0	116	185	33	15	4.9	75	13	3.0	50	143	18	35	1.7	2,940
	Red Dog Creek	Maximum	7.8	86	860	14	480	553	119	62	13	1,560	38	80	2,120	1,780	248	132	6.0	9,800
	upstream	*Count*	*56*	*73*	*74*	*58*	*74*	*31*	*73*	*74*	*74*	*111*	*128*	*111*	*111*	*111*	*111*	*127*	*86*	*111*
	of Hilltop Creek	*Count < DL*	*0*	*3*	*2*	*39*	*0*	*0*	*0*	*0*	*0*	*20*	*1*	*30*	*44*	*1*	*14*	*15*	*37*	*0*
Rachael	Tributary upstream	Median	6.2	3.0	326	6.0	219	308	42	29	3.4	915	1.7	45	1,430	1,040	156	2.0	2.0	428
	of the mine	Maximum	7.5	42	1,270	22	800	769	135	113	8.8	10,600	27	830	42,900	6,660	1,070	162	5.0	2,600
		Count	*56*	*72*	*73*	*57*	*73*	*29*	*72*	*72*	*72*	*109*	*125*	*109*	*109*	*109*	*109*	*124*	*85*	*109*
		Count < DL	*0*	*48*	*1*	*11*	*1*	*0*	*0*	*0*	*1*	*1*	*11*	*3*	*1*	*0*	*1*	*34*	*27*	*0*
Connie	Tributary upstream	Median	6.9	44	159	5.0	77	144	24	14	3.6	104	0.50	4.2	524	191	19	3.6	1.0	116
	of the mine	Maximum	7.7	70	610	34	400	432	82	55	8.7	3,440	13	93	9,160	3,180	160	3,030	3.0	1,240
		Count	*59*	*75*	*76*	*60*	*76*	*29*	*75*	*75*	*75*	*111*	*127*	*111*	*111*	*111*	*111*	*126*	*88*	*111*
		Count < DL	*0*	*2*	*0*	*33*	*0*	*0*	*0*	*0*	*0*	*10*	*26*	*25*	*9*	*0*	*12*	*31*	*58*	*0*
Shelly	Tributary upstream	Median	6.9	32	100	5.0	39	91	15	7.1	2.4	138	3.0	3.1	271	87	5.6	17	1.0	225
	of the mine	Maximum	7.6	64	997	64	534	380	53	51	5.6	14,700	816	412	7,350	11,100	498	3,514	2.2	65,800
		Count	*57*	*76*	*77*	*61*	*77*	*30*	*76*	*76*	*76*	*112*	*129*	*111*	*112*	*112*	*112*	*128*	*87*	*112*
		Count < DL	*0*	*2*	*4*	*34*	*0*	*0*	*0*	*0*	*1*	*2*	*8*	*13*	*5*	*1*	*22*	*7*	*71*	*0*
Sulfur	Tributary upstream	Median	7.0	69	160	5.0	30	112	38	3.6	0.70	58	4.2	1.8	159	14	5.3	362	1.0	784
	of the mine	Maximum	8.2	143	3,630	1,500	2,980	179	122	18	3.1	10,400	1,980	68	387,000	3,790	375	80,200	30	672,000
		Count	*37*	*44*	*45*	*33*	*45*	*14*	*44*	*44*	*43*	*72*	*83*	*72*	*72*	*72*	*72*	*82*	*54*	*72*
		Count < DL	*0*	*4*	*1*	*10*	*1*	*0*	*0*	*1*	*12*	*11*	*7*	*24*	*10*	*7*	*13*	*1*	*44*	*0*
Station 140	Middle Fork	Median	7.1	33	193	5.0	94	126	26	13	3.3	110	24	5.4	322	169	33	42	1.1	3,120
	Red Dog Creek	Maximum	8.4	61	790	101	510	504	107	58	8.3	1,860	391	33	6,350	1,860	218	1,660	5.0	42,700
	upstream	*Count*	*123*	*121*	*165*	*111*	*146*	*164*	*142*	*142*	*163*	*166*	*167*	*167*	*166*	*167*	*166*	*168*	*165*	*168*
	of Outfall 001	*Count < DL*	*0*	*3*	*1*	*62*	*0*	*0*	*0*	*0*	*2*	*18*	*0*	*27*	*14*	*0*	*12*	*0*	*79*	*0*
Discharge Stations																				
Outfall 001	Mine Discharge	Median	9.5[1]	27	3,580	5.0	2,165	2,110	777	44	60	20	0.70	1.0	35	7.9	5.7	0.90	2.9	56
		Maximum	10.2[1]	66	4,270	18	4,930	3,690	975	77	80	210	4.2	22	1,930	654	52	192	6.8	235
		Count	*N/A*	*81*	*360*	*168*	*101*	*145*	*108*	*139*	*103*	*78*	*189*	*154*	*114*	*173*	*145*	*179*	*141*	*191*
		Count < DL	*0*	*0*	*0*	*88*	*0*	*0*	*0*	*0*	*0*	*49*	*21*	*115*	*61*	*21*	*30*	*51*	*24*	*12*

Table 3.5-7 Summary of Water Quality Monitoring Data (1998–2007) (continued)

Station	Description	Statistics	pH	Alk	TDS	TSS	SO4	Hardness	Ca	Mg	Na	Al	Cd	Cu	Fe	Mn	Ni	Pb	Se	Zn
			s.u.	mg/L	mg/L	mg/L	mg/L	mg/L²	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Main Stem Red Dog Creek Downstream of Mine																				
Station 20	Red Dog Creek	Median	7.2	33	1,830	5.0	1,155	1,000	416	29	32	52	12	3.3	98	76	18	15	1.7	1,520
	Downstream	Maximum	9.3	85	2,750	115	2,100	1,760	641	67	64	1,610	169	32	5,410	983	134	1,020	5.7	9,450
	of Outfall 001	*Count*	*330*	*99*	*100*	*98*	*100*	*75*	*99*	*99*	*100*	*132*	*133*	*131*	*132*	*89*	*109*	*133*	*131*	*132*
		Count < DL	*0*	*1*	*0*	*48*	*0*	*0*	*0*	*0*	*0*	*31*	*0*	*41*	*31*	*0*	*9*	*0*	*2*	*0*
Station 12	North Fork	Median	7.5	117	290	5.0	103	229	71	9.1	2.3	32	0.10	1.0	80	13	6.8	0.40	1.7	14
	Red Dog Creek	Maximum	8.2	302	860	194	304	646	206	32	9.4	2,040	3.4	11	4,850	272	18	22	4.0	288
	(background	*Count*	*106*	*102*	*146*	*92*	*124*	*146*	*122*	*121*	*145*	*147*	*147*	*147*	*147*	*146*	*146*	*147*	*147*	*147*
	station)	*Count < DL*	*0*	*0*	*2*	*48*	*0*	*0*	*0*	*0*	*3*	*27*	*53*	*76*	*22*	*10*	*14*	*39*	*69*	*13*
Station 151	Red Dog Creek	Median	7.6	87	1,070	5.0	660	646	222	21	17	35	7.1	2.7	77	68	13	4.0	1.1	718
	downstream	Maximum	6.5	178	1,830	44	6,170	956	341	38	36	606	47	9.9	2,070	293	43	122	3.0	1,840
	of North Fork Red	*Count*	*210*	*202*	*219*	*55*	*202*	*64*	*200*	*200*	*200*	*53*	*53*	*53*	*53*	*53*	*53*	*53*	*52*	*53*
	Dog Creek	*Count < DL*	*0*	*0*	*0*	*34*	*0*	*0*	*0*	*0*	*0*	*4*	*0*	*16*	*6*	*0*	*0*	*0*	*16*	*0*
	(end of mixing zone)																			
Station 10	Red Dog Creek	Median	7.4	80	969	5.0	525	543	202	18	14	38	6.3	2.2	75	33	12	3.1	1.7	663
	downstream	Maximum	8.2	208	1,820	185	1,040	1,250	467	38	31	1,360	34	13	5,890	1,220	41	288	4.0	2,400
	of North Fork	*Count*	*515*	*165*	*256*	*90*	*190*	*136*	*188*	*188*	*196*	*129*	*129*	*129*	*129*	*128*	*129*	*129*	*129*	*129*
	Red Dog Creek	*Count < DL*	*0*	*0*	*1*	*47*	*0*	*0*	*0*	*0*	*2*	*33*	*0*	*46*	*28*	*5*	*13*	*7*	*47*	*0*
Ikalukrok Creek																				
Station 9	Ikalukrok Creek	Median	7.6	82	217	5.0	80	170	37	14	2.8	175	1.3	3.5	652	248	26	0.95	1.0	362
	upstream	Maximum	8.1	139	722	28	344	523	132	47	27	737	6.9	13	5,510	1.130	96	11	4.0	2,180
	of Red Dog Creek	*Count*	*106*	*100*	*150*	*109*	*125*	*149*	*124*	*125*	*139*	*151*	*150*	*139*	*151*	*138*	*138*	*150*	*139*	*151*
	(background station)	*Count < DL*	*0*	*0*	*1*	*53*	*1*	*0*	*0*	*0*	*1*	*3*	*2*	*24*	*0*	*0*	*10*	*28*	*74*	*0*
Station 150	Ikalukrok Creek	Median	7.5	89	405	5.0	212	261	87	18	6.0	99	2.3	2.6	347	157	17	1.3	1.0	332
	downstream	Maximum	9.4	309	900	160	580	1,080	309	75	19	8,640	27	163	53,400	592	44	90	3.0	4,930
	of Red Dog Creek	Count	279	233	299	90	235	*97*	*233*	*233*	*233*	*88*	*88*	*88*	*88*	*88*	*88*	*88*	*87*	*88*
	(end of mixing zone)	*Count < DL*	*0*	*0*	*0*	*39*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*12*	*0*	*0*	*0*	*4*	*30*	*0*
Station 73s	Ikalukrok Creek	Median	7.6	77	354	5.0	170	228	68	13	5.5	117	2.3	2.7	355	94	15	1.3	1.3	345
	downstream	Maximum	8.1	156	810	505	355	1,660	140	27	12	2,950	11	40	12,600	1,220	61	102	3.6	4,970
	of Red Dog Creek	*Count*	*78*	*44*	*129*	*50*	*44*	*98*	*54*	*54*	*49*	*100*	*100*	*92*	*100*	*91*	*92*	*100*	*92*	*100*
		Count < DL	*0*	*0*	*1*	*20*	*0*	*0*	*0*	*0*	*0*	*20*	*3*	*34*	*11*	*0*	*13*	*15*	*44*	*0*
Station 160	Ikalukrok Creek	Median	7.6	95	357	5.0	170	252	77	15	5.2	62	1.3	1.7	171	55	10	0.50	1.0	175
	downstream	Maximum	9.4	380	876	77	345	454	261	47	12	1,000	14	14	3,820	440	32	39	3.0	838
	of Dudd Creek	*Count*	*173*	*161*	*223*	*89*	*180*	*118*	*177*	*177*	*178*	*111*	*111*	*111*	*111*	*111*	*111*	*111*	*111*	*111*
	(replaced baseline station 7)	*Count < DL*	*0*	*0*	*2*	*49*	*0*	*0*	*0*	*0*	*1*	*18*	*6*	*36*	*21*	*7*	*12*	*27*	*51*	*1*

Table 3.5-7 Summary of Water Quality Monitoring Data (1998–2007) (continued)

Station	Description	Statistics	pH	Alk	TDS	TSS	SO4	Hardness	Ca	Mg	Na	Al	Cd	Cu	Fe	Mn	Ni	Pb	Se	Zn
			s.u.	mg/L	mg/L	mg/L	mg/L	mg/L[2]	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Wulik River																				
Station 3	Wulik River	Median	7.8	112	195	5.0	1.3	167	53	8.3	2.9	37	0.10	1.0	60	5.0	2.1	0.20	1.0	4.0
	3 miles upstream	Maximum	8.3	148	360	110	70	270	84	16	15	3,900	0.50	8.4	6,400	318	13	6.2	3.0	120
	of Ikalukrok Creek	*Count*	*62*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*63*	*64*	*63*
		Count < DL		*0*	*0*	*32*	*15*	*0*	*0*	*0*	*1*	*10*	*48*	*13*	*11*	*3*	*9*	*32*	*29*	*15*
Station 2	Wulik River	Median	7.5	111	200	5.0	61	165	53	9.1	2.9	54	0.10	1.0	96	8.0	2.8	0.40	1.0	15
	downstream	Maximum	8.3	152	373	118	180	281	91	18	7.6	2,330	2.8	13	5,220	169	10	6.1	3.1	129
	of Ikalukrok Creek	*Count*	*62*	*80*	*97*	*78*	*79*	*98*	*80*	*80*	*83*	*97*	*97*	*97*	*97*	*97*	*97*	*97*	*98*	*97*
		Count < DL	*0*	*0*	*1*	*35*	*1*	*0*	*0*	*0*	*0*	*15*	*33*	*1*	*19*	*8*	*17*	*36*	*59*	*4*
Station 1	Wulik River	Median	7.8	104	210	5	50	167	51	9.4	7.3	51	0.10	1.0	130	12	2.4	0.50	1.0	12
	upstream	Maximum	8.3	143	330	221	140	213	82	15	18	3,440	4.9	12	8,540	298	16	14	2.0	263
	of Kivalina	*Count*	*125*	*65*	*65*	*65*	*65*	*12*	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*65*	*66*	*65*
		Count < DL	*0*	*0*	*0*	*32*	*1*	*0*	*0*	*0*	*0*	*5*	*22*	*12*	*5*	*0*	*7*	*18*	*33*	*2*
Kivalina Water Supply																				
Kivalina Drinking Water Tank		Median	8.0	118	255	10	79	195	61	1	10	20	0.50	19	40	4.4	50	0.50	1.6	29
		Maximum	8.0	134	310	10	97	219	68	12	16	100	0.50	125	61	4.4	50	0.90	2.7	40
		Count	*10*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
		Count < DL	*0*	*0*	*0*	*4*	*0*	*0*	*0*	*0*	*0*	*4*	*4*	*0*	*2*	*1*	*5*	*3*	*0*	*0*

Count <DL – this value represents the number of samples that were determined to be below the analytical detection limit

N/A – data not available

[1]pH values for Outfall 001 are the median of monthly minimums and median of monthly maximums from NPDES Discharge Monitoring Reports for 1998 through 2007.

metal sulfides in the ore body, which impacted the water quality of the creek as it flowed through this area. In general, mining greatly accelerates the oxidation of metals by increasing the amount of surface area exposed to air by removing and crushing rocks containing high levels of sulfide minerals. However, the management of water flows at the mine and mill site have resulted in several positive effects to water quality of area streams.

First, the Red Dog Creek diversion system largely captures and transports the flows from creeks in the upper watershed around areas subject to oxidation in the Main Pit. Second, runoff from the Main Pit area and the seepage from the waste rock dump are captured and treated prior to discharge into Red Dog Creek. Diverting uncontaminated water and capturing and treating contaminated water has lowered the concentrations of metals and acid discharging from Main Stem Red Dog Creek to Ikalukrok Creek from those that naturally occurred before mining. Median metals levels are generally below aquatic life WQS except for cadmium and zinc. Maximum levels exceed the WQS for some additional metals (e.g., aluminum and lead).

TDS levels are much higher than natural conditions. Based on available analytical data, the median and maximum effluent TDS concentrations in 2007 were 4,120 mg/L and 4,270 mg/L, respectively. Sulfate and calcium are the predominant ions of the TDS in the effluent.

Generally, higher concentrations of TDS in Red Dog Creek can occur when mine effluent flow volumes are high compared to the stream flow. Because of the mine effluent, the concentrations of TDS are substantially higher in Main Stem Red Dog Creek (Station 20) than upstream in North Fork Red Dog Creek (Station 12). TDS concentrations in Main Stem Red Dog Creek vary substantially under the present discharge conditions. Since 1998, Teck has metered the discharge from Outfall 001 to ensure that instream TDS levels do not exceed 1,500 mg/L at Station 151. Decreases of metal loads at the outfall ensure reduced loads and concentrations at all points downstream. ADNR-OHMP (2005) has documented the reduced concentrations compared to pre-mining levels.

As Table 3.5-7 shows, in general, the median concentrations of total metals and TDS at stations 150 and 160 in Ikalukrok Creek are substantially lower than the concentrations found in Main Stem Red Dog Creek. None of the measurements at Station 150 exceeded the TDS WQS of 1,000 mg/L, and none of the measurements at Station 160 exceeded the TDS WQS of 500 mg/L that is applicable during salmonid spawning periods (after July 25 of each year until freeze up). Concentrations of metals in Ikalukrok Creek downstream of the confluence with Main Stem Red Dog Creek are generally lower than pre-mining levels.

In the Wulik River, concentrations of metals and TDS are highly variable both upstream and downstream of the confluence with Ikalukrok Creek. This is expected and is due to wide ranges in flow conditions. No evidence, however, suggests that the mine is having any effect on surface water quality other than TDS in the Wulik River. Metals levels at Station 2, immediately below the confluence with Ikalukrok Creek, are generally lower than pre-mining conditions. Median values are below aquatic life WQS, although maximum values for some metals (e.g., cadmium, lead and zinc) exceed the WQS. Maximum values at Station 3 upstream of the confluence with Ikalukrok Creek also exceed the WQS for some metals.

As expected, 2007 data presented in Table 3.5-8 show a slight elevation in median TDS levels below the confluence with Ikalukrok Creek. These effects are limited by the large flow volume of the Wulik River compared to the flow volumes in Red Dog and Ikalukrok creeks. Table 3.5-8 specifically shows TDS concentrations for seven dates in 2007 at stations 150 and 160 on Ikalukrok Creek and stations 1, 2, and 3 on the Wulik River. As illustrated in Table 3.5-8, the TDS concentration at Station 1, which is located immediately above the intake for the Kivalina drinking water supply, is similar to TDS concentrations at both Station 2 and Station 3. These data indicate that TDS concentrations downstream of the confluence of Ikalukrok Creek in the Wulik River are largely controlled by the upper drainage in the Wulik River.

Table 3.5-8 TDS Concentrations (in mg/L) for Seven Sampling Dates in 2007

Date	Station 1	Station 2	Station 3	Station 160	Station 150
5/26/2007	70	110	90	100	170
6/4/2007	152	138	127	209	263
7/2/2007	256	241	218	N/A	507
8/10/2007	297	302	280	420	455
8/23/2007	290	300	270	470	530
9/20/2007	320	370	360	500	600
10/14/2007	330	370	330	460	450

All units are mg/L
N/A - data not available

The National Primary Drinking Water Standards protect public health by limiting the level of contaminants in drinking water. EPA has not developed primary drinking water standards for TDS because TDS in drinking water is not considered a hazard to human health. The most important effect of TDS on drinking water quality is its effect on taste. The taste of drinking water with a TDS level less than or equal to 600 mg/L is generally considered good. EPA does recommend acceptable levels of TDS in drinking water in its National Secondary Drinking Water Regulations. These regulations provide non-mandatory recommendations for contaminants that can cause unpleasant taste and odor. EPA recommends TDS not exceed 500 mg/L in water used for drinking. During the Applicant's 2007 discharge season, generally from May to October, TDS levels in Ikalukrok Creek occasionally exceeded 500 mg/L; however, no TDS values exceeded 500 mg/L in the Wulik River. For metals, the median and maximum concentrations at Station 1 and Kivalina's drinking water intake are below the maximum contaminant levels intended to protect drinking water supplies.

Water Quality of Streams Adjacent to the DeLong Mountain Regional Transportation System Road

Trucks carrying concentrate from the mine to the port are the primary sources generating fugitive dust along the DMTS road. Fugitive road dust and concentrate on the tires and other surfaces of vehicles may be carried onto the road or into the surrounding environment. Surface water runoff from the road can carry metals-containing dust from the surface of the road to the tundra along the road shoulder and into adjacent streams. As shown on Figure 3.11, the DMTS road crosses a number of streams. With the exception of Evaingkruk Creek, all of these streams flow to the north draining into either the Wulik River or the Ipiavik Lagoon north of the port. Evaingkruk Creek flows to the south and drains into the Noatak River. Each of the streams crossed by the road has high flows in the spring because of runoff, and low flows in the winter when they freeze.

Surface water samples have been collected from nine creeks at locations along the DMTS road since 2001. Sampling stations have been established upstream, immediately downstream from the road, and further downstream from the road. When monitoring was initiated in 2001, no exceedances of hardness-dependent WQS were reported from four months (June through September) of data collection (ADEC 2002).

Table 3.5-9 shows median and maximum observed water quality values for metals and other major constituents for the nine creeks occurring along the DMTS road from 2001 through 2007. Temperature, pH, and hardness data are not available for these streams to calculate the stream-specific WQS for ammonia and some metals. Using the Wulik River WQS shown in Table 3.5-6, all median values are below applicable WQS for the growth and propagation of fish, shellfish, other aquatic life, and wildlife. Some maximum values at sites both upstream and downstream of the DMTS road exceed the lowest WQS. The data, however, are highly variable between sites and by individual pollutant. There are also no clear trends showing higher values downstream of the DMTS road compared to upstream sampling

Table 3.5-9 Summary of Water Quality Monitoring Data – Road Stations (2001–2007)

Station Road Crossings	Statistics	TSS mg/L	Ca mg/L	Mg mg/L	Al µg/L	Cd µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Se µg/L	Zn µg/L
Aufeis at Road	Median	5.0	29	5.0	20	0.10	0.80	40	2.0	1.0	0.15	0.20	3.0
	Maximum	41	58	7.0	450	0.50	1.2	756	30	2.0	2.5	0.40	49
	Count	*35*	*64*	*29*	*29*	*64*	8	*29*	*8*	*8*	*64*	*9*	*64*
	Count < DL	*24*	*0*	*0*	*16*	*55*	0	*12*	*0*	*0*	*38*	*1*	*22*
Aufeis Downstream	Median	2.2	26	4.4	20	0.10	0.70	40	1.3	0.87	0.18	0.16	2.2
	Maximum	31	57	7.2	145	0.50	1.7	475	8.2	2.0	1.2	0.32	108
	Count	*11*	*39*	*28*	*28*	*39*	8	*28*	*8*	*8*	*39*	*8*	*39*
	Count < DL	*10*	*0*	*0*	*15*	*35*	0	*12*	*0*	*0*	*25*	*1*	*17*
Newheart at Road	Median	12	51	6.5	23	0.1	0.94	75	6.2	4.0	0.35	0.21	10
	Maximum	12	112	11	94	0.50	3.6	260	16	6.7	10	0.27	113
	Count	*34*	*63*	*29*	*29*	*63*	8	*29*	*8*	*8*	*63*	*9*	*63*
	Count < DL	*25*	*0*	*0*	*10*	*45*	0	*3*	*0*	*0*	*19*	*2*	*3*
Newheart Downstream	Median	3.0	56	5.5	20	0.10	1.0	50	5.5	2.2	0.18	0.14	3.5
	Maximum	17	102	9.6	72	0.50	1.5	212	13	5.0	2.4	1.2	50
	Count	*11*	*38*	*27*	*27*	*38*	8	*27*	*8*	*8*	*38*	*8*	*38*
	Count < DL	*9*	*0*	*0*	*17*	*31*	0	*3*	*0*	*0*	*25*	*1*	*14*
Omikviorok at Road	Median	5.0	24	5.4	20	0.10	0.91	80	4.1	1.1	0.20	0.05	3.0
	Maximum	288	62	7.1	503	0.50	3.5	1,410	48	3.9	8.9	0.09	56
	Count	*35*	*64*	*29*	*29*	*64*	*8*	*29*	*8*	*8*	*64*	*9*	*64*
	Count < DL	*27*	*0*	*0*	*11*	*55*	*0*	*6*	*0*	*0*	*29*	*4*	*26*
Omikviorok Downstream	Median	5.0	22	5.0	21	0.10	0.95	109	12	1.9	0.29	0.04	2.0
	Maximum	205	62	7.3	600	0.70	3.8	1,390	51	7.8	5.0	0.07	87
	Count	*11*	*39*	*28*	*28*	*39*	*8*	*28*	*8*	*8*	*39*	*8*	*39*
	Count < DL	*7*	*0*	*0*	*12*	*34*	*0*	*2*	*0*	*0*	*19*	*5*	*15*
Straight at Road	Median	10	13	5.5	70	0.10	1.2	513	42	2.8	0.40	0.04	4.0
	Maximum	521	32	9.6	4,060	0.50	4.8	10,300	212	3.4	11	0.11	69
	Count	*27*	*49*	*22*	*22*	*49*	*6*	*22*	*6*	*6*	*49*	*8*	*49*
	Count < DL	*8*	*0*	*0*	*3*	*39*	*0*	*0*	*0*	*0*	*14*	*5*	*13*
Straight Downstream	Median	5.0	8.8	3.7	46	0.10	1.4	430	56	3.0	0.40	0.04	3.2
	Maximum	430	18	7.8	4,060	0.50	6.6	10,100	157	4.0	10	0.11	73
	Count	*9*	*32*	*23*	*23*	*32*	*6*	*23*	*6*	*6*	*32*	*7*	*32*
	Count < DL	*4*	*0*	*0*	*2*	*30*	*0*	*0*	*0*	*0*	*15*	*4*	*9*

Table 3.5-9 Summary of Water Quality Monitoring Data – Road Stations (2001–2007) (continued)

Station Road Crossings	Statistics	TSS mg/L	Ca mg/L	Mg mg/L	Al µg/L	Cd µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Se µg/L	Zn µg/L
Tutak at Road	Median	5.0	15	4.5	20	0.10	0.64	80	3.5	1.2	0.19	0.06	5.0
	Maximum	143	27	7.1	151	0.50	1.7	627	43	3.1	4.3	0.10	61
	Count	*36*	*65*	*29*	*29*	*65*	*7*	*29*	*7*	*7*	*65*	*9*	*65*
	Count < DL	*26*	*0*	*0*	*14*	*55*	*0*	*7*	*0*	*0*	*31*	*2*	*14*
Tutak Downstream	Median	5.0	15	4.5	20	0.10	0.8	78	14	1.3	0.30	0.07	4.2
	Maximum	120	51	6.6	189	0.50	1.4	709	34	3.1	3.9	0.46	60
	Count	*12*	*40*	*28*	*28*	*40*	*7*	*28*	*7*	*7*	*40*	*8*	*40*
	Count < DL	*8*	*0*	*0*	*11*	*33*	*0*	*5*	*0*	*0*	*17*	*3*	*14*
Buddy Downstream	Median	5.0	32	13	30	0.10	1.1	63	7.4	2.6	0.51	1.7	11
	Maximum	19	55	24	532	1.4	7.5	1,050	57	50	22	5.0	100
	Count	*78*	*81*	*81*	*86*	*86*	*39*	*86*	*39*	*39*	*86*	*87*	*85*
	Count < DL	*53*	*0*	*0*	*21*	*55*	*23*	*25*	*12*	*19*	*23*	*26*	*10*
Anxiety Ridge Creek Upstream	Median	5.0	8.7	3.6	26	0.10	1.0	73	5.0	2.7	0.39	1.0	3.6
	Maximum	33	15	6.4	469	1.0	15	1,850	83	50	46	5.0	100
	Count	*77*	*81*	*81*	*86*	*86*	*40*	*86*	*40*	*40*	*86*	*88*	*85*
	Count < DL	*50*	*0*	*0*	*22*	*72*	*25*	*22*	*16*	*24*	*33*	*59*	*30*
Anxiety Ridge Creek Downstream	Median	5.0	9.0	3.7	44	0.10	1.0	110	6.7	2.2	0.51	1.0	4.1
	Maximum	18	15	6.2	2,720	1.0	7.5	1,970	86	50	12	5.0	501
	Count	*76*	*81*	*81*	*86*	*86*	*40*	*86*	*40*	*40*	*86*	*86*	*85*
	Count < DL	*47*	*0*	*0*	*20*	*70*	*25*	*18*	*13*	*23*	*27*	*61*	*20*
Dudd Downstream of Anxiety Ridge Creek	Median	5.0	31	12	20	0.10	1.0	40	4.1	2.2	0.37	1.3	8.0
	Maximum	87	65	20	351	4.0	15	701	28	50	10	3	145
	Count	*80*	*98*	*97*	*85*	*99*	*37*	*100*	*37*	*37*	*98*	*87*	*101*
	Count < DL	*57*	*0*	*0*	*32*	*65*	*26*	*38*	*18*	*22*	*40*	*27*	*22*
Eva 12 Upstream	Median	3.0	4.6	2.0	56	0.10	1.0	1,145	81	3.0	0.21	1.0	47
	Maximum	70	31	11	2,450	9.4	7.5	15,200	1,350	50	5.9	8.6	711
	Count	*75*	*79*	*79*	*82*	*82*	*38*	*82*	*38*	*38*	*82*	*84*	*81*
	Count < DL	*41*	*0*	*1*	*10*	*45*	*30*	*3*	*2*	*17*	*31*	*73*	*7*
Eva 11 Downstream	Median	2.6	6.7	2.4	46	0.10	1.0	427	17	2.8	0.20	1.0	11
	Maximum	10	20	5.9	516	59	7.5	4,040	1,110	50	91	5.0	230
	Count	*76*	*80*	*80*	*84*	*84*	*39*	*84*	*39*	*39*	*84*	*84*	*83*
	Count < DL	*50*	*0*	*0*	*13*	*70*	*28*	*2*	*5*	*21*	*42*	*73*	*13*

locations. Because of the variability of the data and potential for future impacts, continued monitoring of the DMTS streams is recommended, particularly under alternatives B and D, which include ongoing truck transport of concentrate.

Near-Shore Marine Environment

The Applicant's NPDES permit for port site discharges includes requirements to conduct monitoring in the Chukchi Sea, including two locations that represent background water quality. The data from these stations are presented in Table 3.5-10.

Under Alaska WQS, unless a particular water body has been reclassified or redesignated, all marine waters of the state, including the Chukchi Sea, are to be protected for the following uses:

- Water supply (aquaculture, seafood processing and industrial uses);
- Water recreation (contact and secondary recreation);
- Growth and propagation of fish, shellfish, aquatic life and wildlife; and
- Harvesting for consumption of raw mollusks and other raw aquatic life.

Table 3.5-10 Chukchi Sea Background Water Quality Data, 2007 – 2008

		Cd µg/L	Cl- mg/L	Cu[a] µg/L	Hg µg/L	Pb µg/L	Salinity psu	Zn µg/L
Most Stringent Water Quality Standard		**8.8**	**N/A**	**3.7**	**0.051**	**8.5**	**N/A**	**86**
Station								
Chukchi 4	Median	0.041	16,300	0.744	0.0036	0.03	26.7	0.653
	Maximum	1	17,300	2.2	0.117	0.3	33.5	6.01
	Count	*21*	*4*	*21*	*21*	*21*	*13*	*21*
	Count < DL	*2*	*0*	*0*	*9*	*7*	*0*	*1*
Chukchi 5	Median	0.0465	14,700	0.681	0.004465	0.05	26.3	0.5755
	Maximum	0.232	17,700	1.75	0.0714	1.6	33.5	13.3
	Count	*22*	*5*	*17*	*22*	*22*	*14*	*22*
	Count < DL	*4*	*0*	*0*	*8*	*8*	*0*	*1*

psu = practical salinity
All metals are dissolved
Count < DL – this value represents the number of samples that were determined to be below the analytical detection limit.
[a]Difficulties were encountered in 2007 in accurately measuring copper in the ambient salt water. The analytical methods were improved in 2008 and only 2008 data are included in the table.

3.5.2.3 Oceanography Near the DeLong Mountain Terminal

Baseline oceanography and water quality are described in the 2005 draft EIS developed for the port expansion (Corps 2005). This information and data are summarized below. As noted above, the Applicant has performed water quality monitoring as required by the port site NPDES permit.

Bathymetry

In general, the Chukchi Sea is a shallow sea with an extensive continental shelf and no obvious basin. The embayed southeastern Chukchi Sea near the port is predominantly a flat, featureless plain with gradients rarely greater than 4 feet (1.2 meters) per mile and a maximum depth of 210 feet (64 meters). Well-defined shoals extend into the southern Chukchi Sea north of Cape Prince of Wales and west of Point

Hope, and an ill-defined shoal projects westward from Cape Krusenstern. Hope Submarine Valley, with a relief of only 30 feet (9 meters), is south and west of Point Hope. Near the port, the beach drops steeply to a depth of about 10 feet (3 meters). There, the sea floor slopes gently southwestward to a depth of about 50 feet (15 meters) at 3 miles and about 60 feet (18 meters) at 5 miles offshore. Beyond this point, the gentle seafloor slopes continue but shift to the west and then to the northwest to the edge of the Hope Basin about 31 miles from shore.

Offshore from some of the rivers in the region, submerged bars form relatively small areas of steeper relief that may shift from season to season. Local and traditional knowledge tells of channels extending offshore from some of the streams and rivers in the general vicinity of the port. Inflowing fresh water may create temporary channels, but freshwater inflow would be expected to move over the denser marine waters and have relatively little effect offshore from the beach. An exception might occur in the late spring when meltwater in the rivers flows under the ice offshore from the river mouth and scours a temporary channel. No channels offshore from streams near the port were identified with electronic depth finders during the bottom profiling associated with sampling and other data collection near the port.

The existing loading facilities are routinely dredged to maintain sufficient water depth for the operation of the port, slightly altering bathymetry. Water is a few feet deeper just off the dock face, where tugs tie up and the lightering barges are loaded with concentrate.

Waves, Tides, and Currents

Waves, tides, and currents influence the port area mostly during the open water season, which runs from about July through October. However, currents can also affect ice formation in the fall and ice movement in the spring and fall. The wave climate near the port can be complicated by variable meteorological conditions in seas far from the site, but it is typically characterized by a predominance of waves under 3.3 feet (1 meter). When waves higher than 6.6 feet (2 meters) occur, it is usually for short durations of 24 to 48 hours. Wave generation in the Chukchi Sea and the open Arctic Ocean north of the port affects wave height and produces the extreme waves recorded at the port.

The Corps developed a 16-year hindcast model of the wave conditions near the port between 1985 and 2000 (Corps 2005). The 16-year average mean wave heights for July, August, September, and October are 1.4 feet (0.4 meters), 1.9 feet (0.6 meters), 2.4 feet (0.7 meters), and 2.6 feet (0.8 meters), respectively. The wave heights at the port tend to increase over the four-month period from July through October. The average maximum wave heights over the 16 years for July, August, September, and October are 6.1 feet (1.9 meters), 7.9 feet (2.4 meters), 7.7 feet (2.3 meters), and 10.1 feet (3.1 meters), respectively.

Fast moving weather systems of short duration in the Chukchi Sea generate most of the larger waves at the port. The largest recorded waves occurred in November 1970 during a storm from the south. Waves peaked at 29.5 feet with a 12- to 13-second period. Waves of 19.7 feet from that storm were sustained for over 14 hours, and 13-foot waves were sustained for over 20 hours.

Marine currents in the port area of the Chukchi Sea are of two general types: offshore and near shore. Offshore currents in the Chukchi Sea can move both vertically and horizontally as temperature and salinity change, whereas near-shore currents generally move horizontally. Near-shore current patterns and velocities are complex and variable because of the influence of coastal configuration, bathymetry, and changing winds. These two types of currents are briefly discussed below.

Marine currents offshore of the port are primarily influenced by the Alaskan Coastal mass, originating in the eastern Bering Sea. This water mass and associated current are differentiated from other Chukchi Sea water masses by lower salinity and higher temperatures since they are seasonally fed by freshwater from large rivers flowing into the Bering Sea and Kotzebue Sound. The Alaskan coastal mass is also characterized by horizontal graduation from a relatively cold and saline fraction far offshore to the west, changing to a warm and less saline fraction closer to the coast of northwestern Alaska.

The *Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska Volume III* indicates that the warm current entering the Chukchi Sea via the Bering Strait concentrates near the surface and overlies dense, relic bottom water. According to the atlas, this current has a uniform velocity of 0.87 knots in the summer and 0.20 knots in the winter.

The (warmer) current generally moves from the Bering Sea to the Chukchi Sea because of a pressure head created by a 1.6-foot-height difference between the Bering Sea and the Arctic Ocean. (The Bering Sea is 1.6 feet higher than the Arctic Ocean). After entering the Chukchi Sea, the current generally circulates counterclockwise and is locally influenced by bathymetry and wind. Flow reversals from north to south in the eastern Chukchi Sea are rare and temporary. The flow of Bering Sea water north through the Bering Strait is reported to be declining since the 1940s, but the reason has not been determined.

To obtain near-shore current data, contractors and the Corps measured local currents at the port between 1998 and 2000. The data were recorded by a series of three Acoustic Doppler Profiler current meters. They were placed in shallower water (29 to 32 feet [8.8 to 9.7 meters]) during the open water season and then moved to deeper water (42 to 65 feet [12.8 to 19.5 meters]) before ice began forming. Data collected by the Corps were compiled into a database record of current velocities and directions. Based on the data, during the open water season, currents at the port site predominantly flow parallel to the coast, either northward or southward. According to the 1998–2000 data record, northward-flowing currents were recorded as occurring approximately 70 to 75 percent of the time, while southward-flowing currents occurred about 25 to 30 percent of the time. Other data and observations, however, indicate that the long-term drift of beach materials is southward. This suggests that southward-flowing currents could be stronger than northward-flowing currents and/or southward currents predominate more often than the 1998–2000 data show. Although the coastal water mass is predominately northward at a fairly steady rate, observations at Kivalina indicate that the net longshore drift of gravel on the beach is southward. These effects are due to large storms from the northwest that overpower the surface flow and direct it southward along the beach (Corps 2007).

3.5.3 Water Resources – Surface Water – Environmental Consequences

3.5.3.1 Effects of Alternative A – No Action Alternative

The lime treatment process currently used at the Red Dog Mine efficiently removes a majority of metals from the water, allowing the effluent to be discharged well within the required limits. However, the treatment process currently employed does not substantially reduce TDS in the effluent.

Under Alternative A, the Aqqaluk Deposit would not be developed and TDS limits in the NPDES permit would be the same as the 1998 permit. As a result, additional wastewater treatment would be required for the current system to ensure compliance with the 1998 NPDES permit TDS limits of 170 mg/L monthly average and 196 mg/L daily maximum. This would be accomplished by pretreating wastewater with barium or aluminum hydroxide to initially remove metals and reduce TDS levels followed by reverse osmosis. Since the treatment process would ensure compliance with permit limits, Teck could discharge up to the maximum capacity of Water Treatment Plant 2 and up to the volume limit in the 1998 permit. Therefore, under this alternative Teck could easily manage the predicted water balance for the mine and maintain a two-foot wet cover over the tailings in the impoundment. The reverse osmosis brine would be dried and the solids managed in an encapsulated unit west of the tailings impoundment. This would have no effect on the site water balance or the tailings impoundment discharge chemistry.

Under this alternative, the concentrations of metals in the treated discharge would be expected to be similar or slightly lower than current levels from the added reverse osmosis system. However, the TDS concentration of the effluent would be much lower than the ambient TDS concentrations occurring in the Middle Fork and Main Stem Red Dog Creek. Compared to current conditions, TDS concentration would not be a limiting factor to the volume of treated effluent that could be discharged. This would allow the mine to discharge a higher volume (potentially 15 to 20 MGD; 20 to 30 cfs) of water when it is required to meet water balance and management needs. During periods of low stream flow, a discharge of 25 to 30 cfs would have a positive diluting effect to the instream water quality in the Middle Fork and Main Stem Red Dog Creek. In addition, cadmium and zinc concentrations that are naturally high in Middle Fork Red Dog Creek would be reduced by the diluting natural flow. Table 3.5-11 shows the projected median concentrations of important water quality constituents in the effluent, at Station 151 in Red Dog Creek, and Station 150 in Ikalukrok Creek.

Because of the diluting effect described above, the water quality would improve over current conditions in the Middle Fork and Main Stem Red Dog Creek and in Ikalukrok Creek. Changes in the TDS concentrations of the effluent would not be expected to change the overall TDS concentrations in the Wulik River. This is because of the large flow volume of the Wulik River compared to the flow volumes in Red Dog and Ikalukrok creeks. Instream concentrations of metals and other constituents in the Wulik River, including the Kivalina drinking water intake, would be expected to remain at current levels.

Table 3.5-11 Projected Discharge Quality and Instream Water Quality for Alternative A

Parameter	Units	Most Stringent Water Quality Standard	Untreated Impoundment Water Quality	Treated Discharge Water Quality[c]	Down Stream Water Quality at Station 151[d]	Down Stream Water Quality at Station 150[d]
Total Aluminum	µg/L	87	23	8.3	16	57
Ammonia	mg/L	2.36	7.9	4.5	0.7	0.1
Dissolved Cadmium	µg/L	0.36/2[b]	4,715	0.1	3.3	1.17
Dissolved Copper	µg/L	20.3	8.95	5.1	1.7	1.6
Total Iron	µg/L	1,000	50.3	20	60	220
WAD Cyanide	µg/L	5.2	16.9	< 2.0	< 2.0	< 2.0
Dissolved Lead	µg/L	7.0	4,805	0.2	0.32	0.1
Total Mercury	µg/L	0.012	N/A	0.0008	0.001	< 0.0005
Dissolved Nickel	µg/L	117	1,195	11	18	28
Total Selenium	µg/L	5.0	6.4	2.3	1.4	1.5
Dissolved Silver	µg/L	17.8	< 0.05	< 0.05	< 0.05	< 0.05
Total Dissolved Solids	mg/L	1,500/1,000[a]	4,700	< 176 [c,d,e]	204	169
Dissolved Zinc	µg/L	263	368,000	61	442	214

all data are based on median 2007 values

< the value shown is the laboratory analytical detection limit; the actual value will be less than this amount

N/A - not available

[a]Instream standards for TDS are 1,500 mg/L at Station 151 in Red Dog Creek and 1,000 mg/L at Station 150 in Ikalukrok Creek.

[b]The site-specific criterion of 2 µg/L applies to Main Stem Red Dog Creek.

[c] Median values for 2007 at Outfall 001.

[d] Values for cadmium, TDS, and zinc were estimated using a flow-weighted mass balance approach and an assumed effluent discharge of 25 cfs.

[e] Treatment would be required to reduce TDS concentrations to levels below 176 mg/L as a monthly average.

Because water treatment and discharge would continue after closure, the instream constituent concentrations would be expected to be essentially the same as those occurring during mine operations. A small reduction in the dilution effect that occurs during low stream flows could be expected because the predicted annual discharge requirements are slightly less after closure (1,350 million gallons per year) than during active operations (1,527 million gallons per year).

Mixing zones are areas in the stream where discharges are authorized by the State to exceed applicable WQS. Under Alternative A, the 1998 NPDES permit discharge limits ensure instream compliance with WQS at the point of discharge since no mixing zones were authorized.

The DMTS road crosses a number of streams. As shown in Table 3.5-9, water quality at monitoring locations upstream and downstream of road crossings is generally comparable and median pollutant concentrations are below applicable Alaska WQS. Under Alternative A, transportation operations would remain the same as under the current mine operations and the water quality of the streams crossed by the DMTS road would not be expected to change for the duration of operations.

3.5.3.2 Effects of Alternative B – Applicant's Proposed Action

Under Alternative B, the Aqqaluk Deposit would be developed and the mine would continue to treat and discharge effluent from the tailings impoundment during operations. Under this alternative, enhanced wastewater treatment using barium hydroxide precipitation would be implemented to reduce TDS levels in the discharge. The barium hydroxide sludge that would be produced from the enhanced treatment operation could be disposed of in the tailings impoundment, the Main Pit, or both. The disposal of barium sulfate sludge in the tailings impoundment would not be expected to affect or change water quality. This type of sludge is chemically stable and insoluble under most conditions.

At closure, the primary location for contaminated water management would be the Aqqaluk Pit while a two-foot water level would be maintained in the tailings impoundment. The water level of the Aqqaluk Pit would be maintained below an elevation of 760 feet to allow for flood flows in Red Dog Creek above the 500-year-flood level to flow into the pit. During operations, wastewater in the tailings impoundment would be treated and discharged at the current location in Red Dog Creek. The volume of water that could be discharged at any given time would continue to be dependent on the amount of stream flow in Red Dog Creek and the ambient TDS levels in the creek. Treated effluent discharges to Red Dog Creek would be managed to maintain compliance with instream TDS standards of 1,500 mg/L at Station 151 in Main Stem Red Dog Creek, 1,000 mg/L at Station 150 in Ikalukrok Creek, and 500 mg/L at Station 160 in Ikalukrok Creek after July 25th of each year. With the enhanced barium treatment, the reduction in TDS concentrations would allow an increased volume of discharge to Red Dog Creek while still maintaining instream compliance with WQS (as required by the draft NPDES permit).

The Applicant's chemical and load balance model predicts that an average of 1,527 million gallons would need to be discharged annually until the year 2026 to maintain the water balance in the tailings impoundment. After that period, an average of 1,350 million gallons would need to be discharged annually. Under this alternative, these discharge rates would manage the water balance in the tailings impoundment during operations and closure.

As part of this SEIS, a study was designed to estimate the expected long-term annual volume of treated effluent that could be discharged under various water treatment alternatives, given the large annual variations in stream flow conditions. In effect, the study was designed to determine if the Applicant can expect to be able to discharge at least 1,527 million gallons of treated water as a long-term annual average, or if water treatment operations need to be modified to accommodate a different expected average discharge volume.

A stochastic Monte Carlo model was developed to predict average long-term flows that could be expected in Red Dog Creek, and thus the expected long-term annual volume of water that could be discharged. A stochastic model is a tool for estimating probability distributions of potential outcomes (in this case, the volume of effluent discharge) by allowing for random variation in one or more inputs over time (stream flow). A detailed description of this study is provided as Appendix B.

Using enhanced treatment (barium hydroxide), the annual average TDS concentration of the effluent can be reduced to 3,000 mg/L from the current level of 4,120 mg/L. The 3,000 mg/L concentration is a conservative (worst case) assumption based on the anticipated reduction of the sulfate portion of TDS to 2,000 mg/L. Results from the model indicate that the expected long-term average annual rate of discharge could be between 1,617 and 1,746 million gallons per year; again assuming the use of barium hydroxide treatment. This would be more than enough to meet the discharge need of 1,527 million gallons per year required to maintain the water balance in the tailings impoundment. As a result, the schedule for raising the main dam and its final height would only be dependent on the volume of tailings disposed and not on storage requirements for wastewater.

In the near term, the use of barium hydroxide treatment would provide a proven approach to increase discharge volumes and reduce water levels in the impoundment. The draft NPDES permit includes a special condition that requires the Applicant to develop and implement a plan to permanently ensure compliance with TDS limits while maintaining a positive water balance (i.e., the annual discharge from the impoundment is at least as great as the inflows to the impoundment). EPA will review the plan prior to its implementation. EPA expects that the plan will include a combination of source control and water treatment measures, including barium hydroxide addition.

Under this alternative, the concentrations of metals, except barium, in the treated discharge would be expected to be similar to current levels. The barium hydroxide treatment process will increase barium levels in the discharge, but pilot tests performed by the Applicant show levels below 1 mg/L and no exceedances of the State's drinking WQS of 2 mg/L are predicted in any of the drainages. Barium specifically does not cause effects on aquatic life.

The draft NPDES permit includes effluent limits that ensure compliance with applicable WQS for protection of designated uses in the creeks and rivers downstream of the discharge. Under Alternative B, for all parameters except ammonia, cyanide, TDS, and pH, the permit will specifically provide for compliance with all WQS, including aquatic life criteria, at the point of discharge as authorized by the State's CWA Section 401 certification. Based on the Section 401 certification, the draft permit includes mixing zones for ammonia and cyanide that extend 1,930 feet from the confluence of the Middle Fork and North Fork of Red Dog Creek to Station 151 in Main Stem Red Dog Creek. In the mixing zone, ammonia and cyanide levels can exceed the chronic aquatic life water quality criterion of 5.2 µg/L by a factor of 1.5 (i.e., up to 7.8 µg/L). Ammonia levels can similarly exceed the chronic water quality criterion of 7 µg/L by a factor of 1.5 (i.e., up to 10.5 µg/L). In neither case are ammonia or cyanide levels expected to exceed the acute aquatic life criteria that protect against lethal effects to aquatic organisms. The NPDES permit limit for pH is a range of 6.5 – 10.5 s.u., which is above the aquatic life water quality criteria of 6.5 – 8.5 s.u. With the available dilution, however, the pH will be below 8.5 s.u. (and above 6.5 s.u.) at the confluence with North Fork Red Dog Creek.

The draft NPDES permit and 401 certification establish requirements for TDS in Main Stem Red Dog Creek and Ikalukrok Creek. TDS levels can exceed 1,500 mg/L between the confluence of Middle Fork and North Fork Red Dog Creek and Station 151. In Ikalukrok Creek, between the confluence of Main Stem Red Dog Creek and Station 150 (3,420 feet), TDS levels may range between 1,500 mg/L and 1,000 mg/L. After July of each year when the spawning water quality criterion of 500 mg/L applies in Ikalukrok Creek at Station 160, TDS levels can be between 1,000 mg/L and 500 mg/L in the reach between stations 150 and 160.

Table 3.5-12 shows the projected median concentrations of important water quality constituents in the effluent, at Station 151 in Red Dog Creek, and Station 150 in Ikalukrok Creek. Instream water quality would be expected to be consistent with current levels in the Middle Fork and Main Stem Red Dog Creek and in Ikalukrok Creek. TDS concentrations of the effluent would be lower as a result of the enhanced water treatment, allowing a higher average volume of effluent to be discharged than under current conditions. Instream concentrations of cadmium, TDS, and zinc would be expected to be slightly higher during low flow periods than under Alternative A. This is because there would be only a minor diluting effect to the instream water quality from the discharge. TDS and metal concentrations in the Wulik River, including the Kivalina drinking water intake, would be expected to remain at current levels and not be impacted by mine discharges.

The discharges of treated effluent to Red Dog Creek would continue after closure because of the need to treat tailings dam seepage and other wastewater managed in the Aqqaluk Pit. The instream constituent concentrations would be expected to be approximately the same as those occurring during mine operations. After closure, a small reduction in the TDS and copper concentrations of the effluent could result if water quality in the Aqqaluk Pit improves over time. Copper sulfate is used as a flotation reagent in the mill and is a source of copper in the tailings impoundment. At closure, this will no longer be a source of copper; therefore, copper concentrations could decrease following closure. The TDS reduction at closure would provide the Applicant more flexibility in discharging water and managing the water level in the Aqqaluk Pit.

The use of the DMTS road would be consistent with current operations and Alternative A. As shown in Section 3.5, water quality at monitoring locations upstream and downstream of road crossings is generally comparable and median pollutant concentrations are below applicable Alaska WQS. The water quality of

Table 3.5-12 Projected Discharge Quality and Instream Water Quality for Alternative B

Parameter	Units	Most Stringent Water Quality Standard	Untreated Impoundment Water Quality	Treated Discharge Water Quality[c]	Down Stream Water Quality at Station 151[d]	Down Stream Water Quality at Station 150[d]
Total Aluminum	µg/L	87	23	8.3	16	57
Ammonia	mg/L	2.36	7.9	4.5	0.7	0.1
Dissolved Cadmium	µg/L	0.36/2[b]	4,715	0.1	3.6	1.18
Dissolved Copper	µg/L	20.3	8.95	5.1	1.7	1.6
Total Iron	µg/L	1,000	50.3	20	60	220
WAD Cyanide	µg/L	5.2	16.9	< 2.0	< 2.0	< 2.0
Dissolved Lead	µg/L	7.0	4,805	0.2	0.32	0.1
Total Mercury	µg/L	0.012	N/A	0.0008	0.001	< 0.0005
Dissolved Nickel	µg/L	117	1,195	11	18	28
Total Selenium	µg/L	5.0	6.4	2.3	1.4	1.5
Dissolved Silver	µg/L	17.8	< 0.05	< 0.05	< 0.05	< 0.05
Total Dissolved Solids	mg/L	1,500/1,000[a]	4,700	3,000[e]	976	339
Dissolved Zinc	µg/L	263	368,000	61	478	216

all data are based on median 2007 values

< the value shown is the laboratory analytical detection limit; the actual value will be less than this amount

N/A - not available

[a] Instream standards for TDS are 1,500 mg/L at Station 151 and 1,000 mg/L at Station 150

[b] The site-specific criterion of 2 µg/L applies to Main Stem Red Dog Creek.

[c] Median values for 2007 at Outfall 001.

[d] Values estimated for cadmium, TDS, and zinc were calculated using a flow-weighted mass balance approach and an assumed effluent discharge of 20 cfs.

[e] Conservative estimate of TDS concentration after enhanced water treatment.

the streams crossed by the DMTS road would not be expected to change under Alternative B, although ongoing water quality monitoring is recommended.

3.5.3.3 Effects of Alternative C – Concentrate and Wastewater Pipelines

Under Alternative C, treated tailings impoundment effluent from the high-density sludge process (without barium hydroxide treatment) would be transported to the port facility by pipeline. Lead and zinc concentrates would also be transported to the port facility by a separate pipeline. Concentrates would be filtered at the port. The wastewater from concentrate filtration is expected to have comparable metals concentrations as the influent to the existing wastewater treatment plants. The concentrate wastewater would be treated in a new high-density sludge plant at the port. This treated concentrate wastewater would be combined with the treated tailings impoundment effluent from the mine site. After pH adjustment, the combined effluent would be discharged to the Chukchi Sea. An additional pipeline would also be constructed to transport diesel to the mine site. All pipelines would be buried in a bench incorporated into the DMTS road.

Discharging the treated effluent to a saline receiving water (the Chukchi Sea) eliminates the need to provide an enhanced treatment mechanism to remove TDS. Under this alternative, the modified NPDES permit would specify effluent limits for pollutants based on the Alaska marine WQS for other parameters to protect the designated uses of the Chukchi Sea. Because the wastewater treatment processes will be the same as currently used at the mine site, the concentrations of metals and TDS in the treated discharge would be expected to be similar to current levels. Table 3.5-13 shows the projected maximum effluent concentrations compared to the lowest marine WQS. These data show that a mixing zone would likely be required for ammonia, copper, chlorine, cyanide, nickel, and zinc. Modeling was performed using

Table 3.5-13 Projected Marine Discharge Effluent Quality and Minimum Dilution Requirements

Parameter	Maximum Observed Effluent Concentration (µg/L unless otherwise noted)[a]	Maximum Projected Effluent Concentration (µg/L unless otherwise noted)[b]	Lowest WQS[c]	Ambient Background Concentration (µg/L unless otherwise noted)	Minimum Required Dilution Factor
Ammonia (mg/L)	10.7	12.3	4.3	N/A	2.89
Cadmium	1.8	2.5	8.8	1	–
Copper	22	39	3.7	1.52	16.69
Chlorine	35	39	7.5	N/A	5.19
Cyanide	12	14.6	1.0	N/A	14.63
Chromium VI	13	43.2	50	1.6	–
Lead	2.9	4.3	8.5	1.6	–
Mercury	0.0051	0.012	0.051	0.117	–
Nickel	78	141	8.3	N/A	16.95
Selenium	4.6	5.8	71	N/A	–
Silver	0.5	1.3	2.3	N/A	–
Zinc	158	205	86	13.3	2.17

N/A = not available

— = no dilution required

[a] Based on Outfall 001 data for 2003-2007.

[b] The calculated maximum projected effluent concentration is derived from the maximum observed concentration and the statistical distribution of the observed data. EPA uses this value to determine reasonable potential to exceed WQS and assess the need for mixing zones.

[c] All standards based on aquatic life, except mercury, which is based on the human health standard for consumption of aquatic organisms.

CORMIX to determine the size of the mixing zone; CORMIX is EPA's and the State of Alaska's accepted model for mixing zone analyses. The modeling results show that the WQS for nickel, the most critical constituent, will be met less than 10 feet (3 meters) from the discharge point. Mixing zone sizes for ammonia, chlorine, copper, cyanide, and zinc would be smaller than for nickel. Appendix C includes a summary of how the required dilution was determined.

During operations, discharges to the Chukchi Sea would eliminate any dilution effects that result from the treated effluent being discharged to Red Dog Creek. An evaluation using daily flow and water quality data for several dates between 2004 and 2007 and at various stations in Red Dog Creek and Ikalukrok Creek showed that instream concentrations for some metals could be substantially higher with the treated discharge removed. At Station 151, dissolved zinc concentrations would increase between 26 and 53 percent, depending on the specific data evaluated and the base flow in the creek. Dissolved cadmium concentrations had similar results. This analysis also showed that stream flow at Station 151 would be reduced between 18 and 38 percent. The highest estimated increased concentrations for metals and most impact to flow occurred on dates with low stream flow. TDS concentrations, however, would be substantially lower than current conditions. Table 3.5-14 shows estimated median concentrations of important water quality constituents at Station 151 in Red Dog Creek and Station 150 in Ikalukrok Creek with the treated effluent discharge removed.

During 1998–2007, only 2 of 123 measured pH levels at Station 140 were below 6.0 and 11 of 123 were below 6.5 s.u. The median was 7.1 s.u. Given these data and the higher levels of pH in the North Fork, the combined pH below the confluence should be between 6.5 and 8.5, the applicable aquatic life WQS.

A monitoring program would be developed to determine if changes in water quality and subsequent impacts to aquatic life were occurring downstream as a result of the relocation of the discharge (see Section 3.10.3.4 for further discussion).

Table 3.5-14 Projected Instream Water Quality for Alternative C

Parameter	Units	Most Stringent Water Quality Standard	Down Stream Water Quality at Station 151[c]	Down Stream Water Quality at Station 150[c]
Total Aluminum	µg/L	87	16	57
Ammonia	mg/L	2.36	0.7	0.1
Dissolved Cadmium	µg/L	0.36/2[b]	4.9	1.25
Dissolved Copper	µg/L	20.3	1.7	1.6
Total Iron	µg/L	1,000	60	220
WAD Cyanide	µg/L	5.2	< 2.0	< 2.0
Dissolved Lead	µg/L	7.0	0.32	0.1
Total Mercury	µg/L	0.012	0.001	< 0.0005
Dissolved Nickel	µg/L	117	18	28
Total Selenium	µg/L	5.0	1.4	1.5
Dissolved Silver	µg/L	17.8	< 0.05	< 0.05
Total Dissolved Solids	mg/L	1,500/1,000[a]	219	168
Dissolved Zinc	µg/L	263	619	226

All data are based on median 2007 values

< The value shown is the laboratory analytical detection limit; the actual value will be less than this amount

[a] Instream standards for TDS are 1,500 mg/L at Station 151 and 1,000 mg/L at Station 150

[b] The site-specific criterion of 2 µg/L applies to Main Stem Red Dog Creek.

[c] Values estimated for cadmium, TDS, and zinc were calculated using a flow-weighted mass balance approach and an assumed effluent discharge of zero.

At closure, the discharge pipeline would be removed and treated wastewater would again be discharged at its current location in Red Dog Creek. The treated volume of water would be approximately 50 percent of the current discharge flow. Runoff from the covered waste rock pile and tailings would flow into Red Dog Creek and should be comparable to current conditions. In addition, because the cover materials would be non-mineralized soils, the water quality in Red Dog and Ikalukrok creeks should be consistent with the conditions indicated for Alternative B.

As discussed in Chapter 2, the Aqqaluk Pit would have sufficient capacity to contain all of the contaminated water sources after closure. Unlike Alternative B, however, it does not have additional capacity to manage overflows from the Red Dog Creek diversion from a storm greater than the 500-year flood. The effects of such overflows on downstream water quality are difficult to predict given the flood flows that would be observed in the drainages.

Under this alternative, traffic on the DMTS road would be reduced because lead and zinc concentrate and diesel fuel would no longer be transported by truck. It is expected that construction of the pipelines would not impact water quality in streams crossed by the DMTS road if proper best management practices were applied to control fugitive dust and runoff. Storm water runoff is governed by the NPDES permit issued for the DMTS port. No changes to current water quality in the streams crossed by the DMTS road are expected under Alternative C. However, there would be a reduced risk of future concentrate truck spills that could impact surface waters as compared to alternatives A and B.

Spill prevention and emergency response plans would be developed by Teck for the pipelines. Under normal conditions, it is highly unlikely that the pipelines would be compromised and it is anticipated that the risk from a pipeline rupture would be less than the risk of a release of diesel or concentrate from a vehicle accident. However, impacts to water quality could occur to streams along the DMTS road should one or more of the pipelines become ruptured and if flows reached local streams. The severity of the impact would depend on which pipeline had been ruptured and the volume of material released. The slurry pipeline would carry liquids with extremely high levels of lead and zinc as well as other metals. Spilled diesel is also considered a hazardous waste. As a worst-case scenario, the unimpeded flow or runoff of pipeline contents to area streams would impact water quality at levels far exceeding acute water quality criteria. These impacts could be short term to long term, depending on volume of pollutants reaching streams and the effectiveness of mitigation efforts that would be employed.

3.5.3.4 Effects of Alternative D – Wastewater Pipeline and Additional Measures

As with Alternative C, treated effluent would be transported to the port facility by pipeline and discharged to the Chukchi Sea. Construction would be subject to the requirements established in the NPDES permit for the DMTS port as noted under Alternative C. Effects to water quality in the Chukchi Sea and in Red Dog Creek during operations would be the same as Alternative C.

Unlike Alternative C, the pipeline would remain in place after closure with the remaining components the same as Alternative B. As with Alternative B, the tailings dam would remain with an approximate two-foot water cover after closure and wastewater would be managed in the Aqqaluk Pit. Because discharge would continue to the Chukchi Sea after closure, the expected instream constituent concentrations would be expected to be essentially the same as those occurring during mine operations (see Table 3.5-14 for Alternative C). As described under Alternative C, a monitoring program would be implemented to determine the effects of the relocation of the discharge on aquatic life downstream.

3.5.4 Water Resources – Surface Water – Summary

Under all alternatives, metals levels in Red Dog Creek would be consistently lower than pre-mining conditions. The installation of reverse osmosis treatment under Alternative A would reduce TDS levels in Red Dog Creek and Ikalukrok Creek to pre-mining levels, although TDS levels at Kivalina’s drinking water intake would remain indistinguishable from background conditions under all alternatives. Under alternatives C (during operations) and D (during operations and after closure), removing the treated wastewater discharge point from Red Dog Creek would cause reduced flows and lower water quality in Main Stem Red Dog Creek and, to a lesser extent, Ikalukrok Creek. Under both these alternatives a small (less than 10 foot) marine mixing zone would be required at the discharge point in the Chukchi Sea. All alternatives would allow the Applicant greater discharge flexibility to reduce water volumes currently stored in the tailings impoundment.

Existing water quality data for streams along the DMTS road do not indicate that water quality standards are being exceeded. However, ongoing monitoring is recommended to verify that standards are not exceeded in the future. Alternative C would have the least impact to future DMTS stream quality since it eliminates risk of concentrate truck spills.

3.6 Water Resources – Groundwater

Groundwater in the project area encompasses three separate systems:

- Shallow groundwater in the shallow active layer (groundwater subject to seasonal freeze-thaw cycles);
- Confining permafrost layer; and
- Subpermafrost groundwater (groundwater below the permafrost zone).

3.6.1 Water Resources – Groundwater – Pre-mining Environment

Shallow Groundwater in the Shallow Active Layer

Relatively small quantities of shallow groundwater exist within the bedrock and soil deposits in the Red Dog Creek valley (EPA 1984). This zone is denoted as the “near-surface active layer” or the “shallow active layer.” The shallow active layer is subject to seasonal freeze-thaw cycles and exists across the project area, with varying depths from being almost non-existent to 100 feet (30.5 meters) in depth. Shallow groundwater in the project area is mostly ephemeral and moves only during the warmer months (generally July through September), when the active layer is thawed.

Shallow groundwater is closely associated with surface water flow, due to precipitation of snow and rain and snow melt during the warmer months. It acts more or less as a small component of rainfall and surface runoff (WMCI 1999), with eventual discharge into creeks. Shallow groundwater flow is minimal and is not considered an aquifer, because the maximum saturated thickness of the shallow active layer has been found to be less than 5 feet (1.5 meters) and the time period during which this saturated thickness exists and is not frozen is very short (WMCI 1999).

However, areas along streambeds (Red Dog Creek and the creeks surrounding the Main Pit) have thicker active layers that remain thawed for longer periods of time. Shallow groundwater flow occurs within streambed channels and streambed alluvium, with shallow flow following the general direction of the streams. Shallow groundwater flow in creek bed alluvial systems has generally greater volumes of flow than upland active layer flows and can sustain flows throughout the year. In rare situations, these alluvial flows can surface during the winter months causing aufeis (surface icing) conditions, as observed near the confluence of Rachel Creek and Red Dog Creek during the winter of 2003–2004 (SRK 2007).

Samples from two small seeps located along Red Dog Creek exceeded aquatic life WQS for cadmium, copper, iron, lead, nickel, phosphorus, and zinc (EPA 1984). The high metal content of shallow groundwater samples in the project area indicates that the source of the water is from mineralized rock or soils.

Permafrost Layer

The permafrost layer acts as a barrier to groundwater flow, isolating or confining the shallow groundwater and subpermafrost groundwater systems. The extent of the permafrost layer and the underlying subpermafrost groundwater were unknown until mining commenced. However, the extent of the permafrost was historically almost continuous across the project area, starting at or near the surface to about 100 feet (30.5 meters) below the ground surface, with an estimated thickness ranging from 200 to over 660 feet (61 to 201 meters). In general, thinner permafrost occurs within lowland areas and along creek beds, and thicker permafrost occurs within upland areas at higher topographic elevations and along north-facing slopes. Data from shallow temperature measurements along the original South Fork Red Dog Creek (the current location of the dam) indicate that permafrost was not present below the creek bed during dam construction (WMCI 1999).

Subpermafrost Groundwater

The subpermafrost groundwater system may be stagnant or connate and has very little or no flow component. Subpermafrost groundwater is held in a tightly confined condition within isolated horizontal and vertical fractures. Age dating indicates that the groundwater in the subpermafrost system, at the site of the age dating sample, has been isolated from the surface for approximately 20,000 years (WMCI 1999). It is believed that subpermafrost groundwater was primarily recharged in the distant past when the permafrost layer was discontinuous or prior to permafrost formation. Current recharge is nonexistent or very limited, with recharge possible only through infiltration in faults or fractures in areas where the permafrost layer is missing, possibly below the stream channels. Discharge from the subpermafrost groundwater system is also limited and localized, occurring primarily along stream courses and/or where springs or seeps are observed.

The confined nature of the subpermafrost groundwater system has resulted in a condition where any variation in surface loading is transmitted to the groundwater within the system, resulting in an instantaneous and complete water level response to the surface load (WMCI 1999).

Springs and Seeps

A spring and seep survey was conducted in September 1996 (WMCI 1997) (Figure 3.14). The closest springs and seeps found downstream of the mine occur on Ikalukrok Creek, approximately 5 miles downgradient of the mine site. Only one of the springs is named, Jakes Seep; the other spring is simply designated as Seep No.2. The flow of both seeps is milky-white in color. Jakes Seep has a sulfur smell, and occasional bubbles are observed in the pool. Seep No.2 has white precipitate on the bottom, with lesser amounts of rusty precipitates also occurring. The source of the seep water flow has not been determined. A series of seeps with a strong sulfur smell occurs on the east side of the Wulik River, and another spring occurs on Ferric Creek, a tributary of the Wulik River. Staining with white precipitate is apparent along exposed rock faces in the area surrounding the Ferric Creek springs. There are also springs in Anxiety Ridge and Buddy creeks. Increased winter flow in Bons and Buddy creeks and substantial aufeis formation is probably related in part to seepage flow from the freshwater dam (ADF&G pers. comm.).

Additional springs and seeps have been observed at locations upgradient from the mine. Mining related impacts to springs and seeps were considered unlikely to affect these springs; therefore, these springs have not been further inspected.

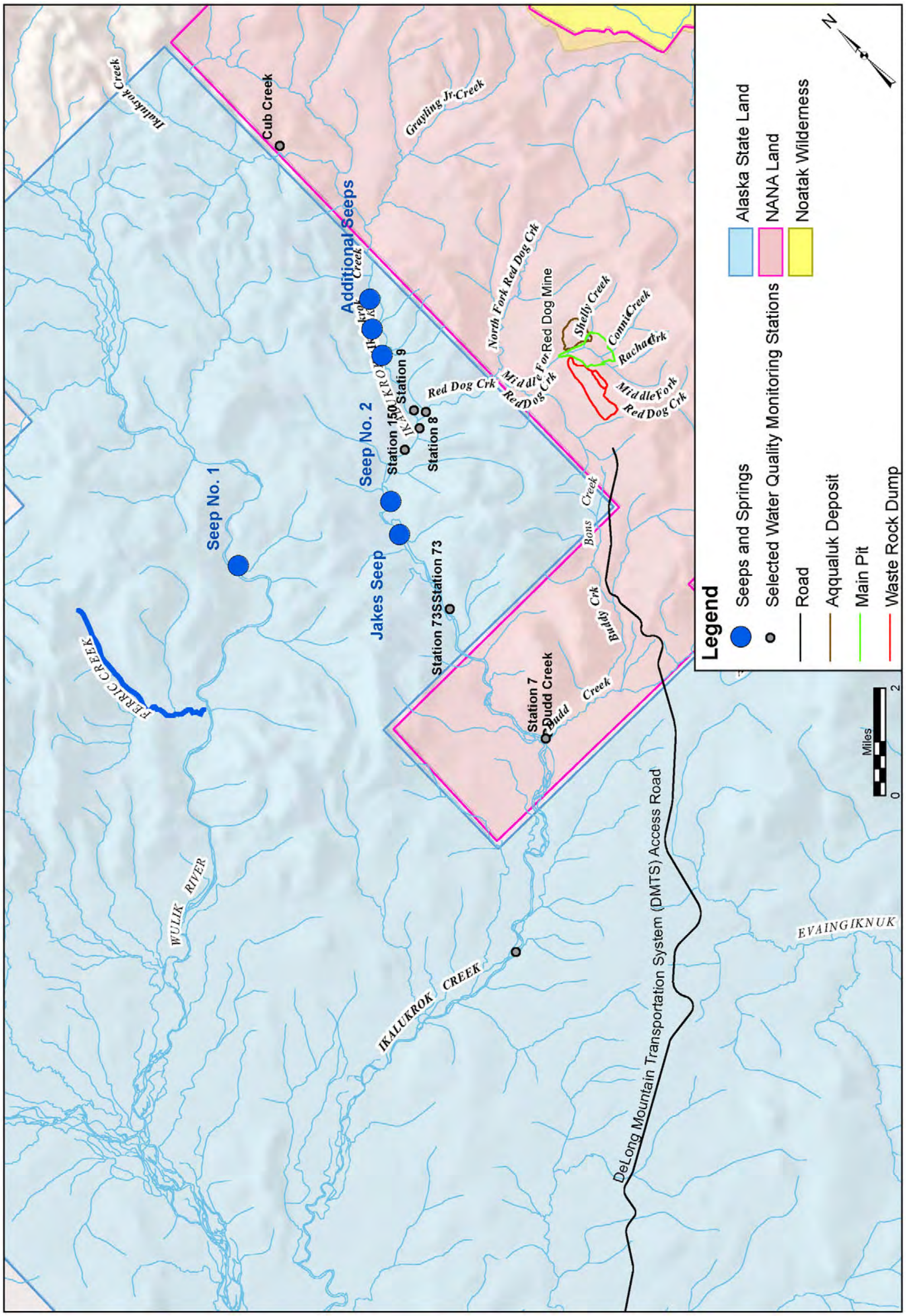


FIGURE 3.14
SEEPS AND SPRINGS NEAR RED DOG MINE

3.6.2 Water Resources – Groundwater – Baseline Conditions

A long-term permafrost and groundwater monitoring program at the Red Dog Mine was instituted following the Consent Decree between Cominco Alaska Incorporated (now Teck) and EPA, entered on November 25, 1997 (U.S. v. Cominco Alaska Incorporated, Civil Action A97-267CV). A three-phase hydrologic characterization was conducted by Water Management Consultants (WMCI 1997, 1999, 2001b), culminating in the "Long-Term Permafrost and Groundwater Monitoring Plan for the Tailing Impoundment" (WMCI 2001a). Annual reports based on the Groundwater Monitoring Plan are presented in Geomatrix (2003, 2004, 2005, and 2006). A five-year summary report presents the five-year analysis of permafrost and groundwater data collected from 2002 to 2006 (Geomatrix 2007).

Shallow Groundwater

The shallow groundwater (active) zone has been impacted by mining activities in the project area. Specifically, the shallow groundwater zone has been removed in the area of the Main Pit and has been impacted in the overburden and waste rock dump areas. In the overburden stockpile, the level of the permafrost has moved from the bottom upward into the stockpile, and the new shallow active layer follows the topography of the stockpile. Thus, the shallow active zone is at a higher level than it was prior to mining operations, thereby creating a shallow groundwater flow divide, which follows the top of the overburden stockpile. This flow divide precludes water from the tailings impoundment from flowing south into the Bons Creek drainage.

In the Main Pit area, subsurface thawed zones have increased in areal extent over time and are currently occurring in the pit walls and local creek beds. This has resulted in increased shallow groundwater flow within thawed zones near the Main Pit, as evidenced by increased seepage flows into the pit.

In the tailings and dam area, the shallow groundwater is collected by the seepage collection system. Water levels consistently show an upward pressure gradient into the dam underdrain, which indicates that all groundwater in the tailings area flows into the underdrain (Geomatrix 2007). However, the shallow groundwater zone is localized in nature and is not a regional aquifer; thus, any impacts are localized and restricted to the actual disturbed areas.

Permafrost Layer

Long-term warming of air temperatures, observed since the late 1990s, has resulted in overall warming of the permafrost in the vicinity of the mine. These climatic conditions observed at Red Dog are consistent with trends observed throughout the State of Alaska (Osterkamp, in press cited in Geomatrix 2007), and are not the result of mine operations.

Additional warming (above the warming observed in surrounding permafrost areas and regionally in the State of Alaska) has occurred underneath the tailings impoundment and dam. This additional warming has been caused by the presence of relatively warm waters in the tailings impoundment. As a result of the warm water, a zone approximately 400 feet (120 meters) wide where permafrost is completely absent has developed underneath the tailings dam. Permafrost is also absent along the original streambed of the South Fork Red Dog Creek along with an area along the dam, due to warm water flow through the dam underdrain and subsequent melting of the permafrost layer. The area where permafrost is completely absent increased in size and depth through 2000. Since 2000, no additional increases in the permafrost-absent area have been observed, based on thermistor monitoring data collected by the mine (Geomatrix 2007).

In the overburden stockpile, permafrost started aggrading into the material in most areas after the stockpile was created, while some warming (melting) of the permafrost has occurred as a result of exothermic chemical reactions within isolated areas of the stockpile. Since 2003, the warming trend in the stockpile has generally abated.

Subpermafrost Groundwater

Seasonal water pressure fluctuations in subpermafrost groundwater are known to occur, and are thought to be the result of shallow freezing and thawing, causing downward loading pressures, due to ice development in shallow soils (Geomatrix 2007).

Water pressures, as measured in a piezometer underneath the tailings dam, increased with the surface loading, which was produced by higher water levels on top of the tailings beach from 2002 to 2005. The reduction of water loading after 2005, due to the development of a 300-foot beach in late 2005, has resulted in decreased subpermafrost groundwater pressures. Lateral hydraulic gradients continue to show a gradient toward the tailings dam. Therefore, if isolated local subpermafrost groundwater flow in this area exists, flow would not be outward from the tailings impoundment; rather it would flow back toward the dam. Vertical gradients between the shallow groundwater flow in the dam underdrain and the subpermafrost groundwater system, in the area of the zone of absent permafrost underneath the dam, have remained relatively stable. This evidence suggests that vertical flow into the subpermafrost system is unlikely (Geomatrix 2007). Mining activities in the Main Pit have not yet extended down into the subpermafrost groundwater zone.

The subpermafrost water level elevation, as measured in a piezometer installed in the Aqqaluk Pit area, has been measured since 1999 and has averaged approximately 891 feet (SRK 2007c). A single water quality sample from subpermafrost groundwater was obtained from the site of the proposed Aqqaluk Pit. The chemical analysis results indicate the sample contains elevated concentrations of sulfate, and high concentrations of iron and zinc, which are the dominant cations, with a TDS level of 5,800 mg/L (SRK 2007c).

Springs and Seeps

The current water quality sampling program includes two seeps, Cub Creek Seep and Ikalukrok 207, both located approximately 5 miles north (upgradient) of the mine site (see Figure 3.14). Cub Creek Seep has been monitored since 2005 and Ikalukrok 207 since 2000. TDS values in both springs are below 300 mg/L. The iron concentration averages about 6 mg/L in Ikalukrok 207 and about 19 mg/L in Cub Creek Seep. Zinc concentrations in Ikalukrok 207 average about 3 mg/L and in Cub Creek Seep about 8 mg/L over the period of record.

3.6.3 Water Resources – Groundwater – Environmental Consequences

Groundwater movement in the project area is very restricted by the presence of permafrost and low permeable shale beds. Movement becomes measurable only in the shallow active layer above the permafrost zone in the summer, and in alluvial sediments under stream surfaces, where relatively warmer stream water keeps permafrost from forming. The subpermafrost groundwater system is thought to be stagnant with very little or no flow component based on the following observations:

- Groundwater in the fractured shale bedrock beneath the project area is confined by geologic faults that restrict lateral groundwater flow between the pit area and the regional groundwater system;
- Results from isotope dating of the subpermafrost groundwater indicate an average age of 20,000 years;
- In pump testing, the subpermafrost groundwater exhibited little or no water level recovery, indicating that no lateral or vertical flow is occurring within the zone influenced by the test; and

- Pressure changes at the ground surface result in pressure changes in the subpermafrost groundwater. The pressure changes in the subpermafrost groundwater are not dissipated, further demonstrating that no active flow is occurring within the system.

3.6.3.1 Effects Common to All Alternatives

Under all alternatives, mining in the Main Pit would continue through 2011 (Alternative A) or 2012 (alternatives B, C, and D) to a depth of 400 feet below ground surface at Middle Fork Red Dog Creek, or an elevation of 500 feet. In addition to permafrost lost to mining, additional subsurface thaw around the exposed pit walls is expected. Increased subsurface thaw around the pit would cause increased shallow groundwater flow into the pit. These flows would be collected in a sump and sent to the tailings impoundment for treatment and discharge during active mining. Water-bearing taliks (unfrozen zones within permafrost) would likely be encountered during mining. Groundwater flows from taliks would also be collected in the pit sump and sent to the tailings impoundment. At full development, the pit would extend below the current zone of permafrost, into the zone of subpermafrost groundwater. The bottom of the permafrost in the pit area is estimated to be at an elevation of approximately 650 feet or 150 feet above the bottom of the pit at full development (WMCI 1999). Subpermafrost groundwater potentiometric surface levels currently range from 850 to 950 feet in the pit area (WMCI 2001a). During mining, subpermafrost groundwater seepage into the pit would drain the interconnected fractures and fault-blocks encountered. After these isolated fault blocked units drain, water from surrounding blocks would begin to slowly drain across the lateral restrictions, because of increased hydraulic heads across the faults. Like the shallow groundwater, subpermafrost groundwater would be collected in the pit sump and also sent to the tailings impoundment. Current analyses estimate the subpermafrost groundwater inflow into the mine pit would be approximately 50 gallons per minute (SRK 2007, Spreadsheet, Red Dog Load Balance_EID Version_Tetratech.xls). However, limited information is available on actual groundwater flow rates across these fractures and fault blocks. Fault blocks with higher interconnectedness, creating large groundwater flows, might be encountered during mining.

Water collected and pumped from the pit during mining would be monitored, and if possible, determinations of the volume of water contributed from the various sources (subsurface groundwater versus spring seepage) would be estimated, to define the water balance and provide a better understanding of the groundwater system. Additional monitoring during mining of the subpermafrost groundwater potentiometric surface surrounding the pit is also recommended, to help determine the zone of influence of pit dewatering. Spring and seep monitoring would continue.

The overburden stockpile straddles the topographic divide between the tailings impoundment over South Fork Red Dog Creek and the Bons Creek drainage. The extent of the permafrost zone would continue to increase within the stockpile over time, causing an increase in the elevation of the top of the permafrost, until the shallow active layer is similar in depth to surrounding areas. Surface water would continue to infiltrate into the shallow active layer to the top of the permafrost layer in the overburden stockpile area, then flow either north or south, depending on the local gradient of the permafrost layer. Groundwater flowing north from the stockpile would be captured by the tailings impoundment and groundwater flowing south from the stockpile would be captured by the surface water collection system and returned to the tailings impoundment. However, the shallow active layer flow would continue to be a minor contributor of water to the surface water collection system (WMCI 1999).

Groundwater flow conditions at the Red Dog Mine are heavily influenced by the presence of permafrost. Should global or local climate change occur to such an extent that the permafrost zone would be further reduced or disappear from the mine site, the groundwater flow regime could change drastically. Currently, low permeability shale with compartmentalized fractures exists in the permafrost-free area below the tailings impoundment. A groundwater hydrology study for the tailings area (WMCI 1997, 1999, and 2001b; Geomatrix 2007) determined that the hydraulic regime in the tailings area is constrained by this low permeability shale, which minimize the impacts of the tailings impoundment on groundwater regardless of the presence or absence of permafrost. Elsewhere in the area, permafrost itself acts as a strongly confining layer separating the shallow active layer groundwater from the subpermafrost groundwater. The distribution of permafrost includes portions of the low permeability shale beds outside the tailings impoundment although the regional extent or continuity of the low permeability shale outside the tailings area has not been confirmed. If the permafrost layer was reduced or eliminated and the low permeability shale is discontinuous, it is possible that the shallow active layer groundwater and subpermafrost groundwater zones would be hydraulically connected as one large regional aquifer.

Further changes in the active layer thickness and permafrost continuity could affect the relationship between groundwater discharge and river base flow. In the areas that contain ice-rich permafrost and poor drainage conditions, permafrost degradation leads to ground surface subsidence and ponding ("wet thermokarst") (Romanovsky 2008). The ground would become over-saturated, with a water table near ground surface. Permafrost degradation on well-drained portions of slopes and highlands could create a form of "dry thermokarst" (Romanovsky 2008). The creation of "dry thermokarst" would further improve the drainage conditions and lead to a lowering of the groundwater table.

If permafrost melts, and the above mentioned changes occur to the local hydrology in the project area, mining activities would likely have much different and possibly greater impacts on groundwater. Some of the possible effects of permafrost degradation on mining activity impacts are as follows:

- Seepage from the tailings dam may increase substantially if permafrost does not exist as a confining layer;
- Groundwater may rise to a level where upwelling of groundwater into the tailings impoundment may occur;
- Groundwater flow into the pits might increase substantially because the interconnectedness of water-bearing fault blocks and fractures in the bedrock would be much greater without the presence of permafrost; and
- Pit dewatering activities would impact larger areas surrounding the pit and cause a more extensive drawdown cone, possibly influencing stream and spring flows in the project area.

Ultimately, however, estimating the exact impacts of a disappearing permafrost zone is extremely difficult. Continued monitoring of the climate and permafrost zone as well as groundwater levels will provide valuable data to resolve this uncertainty and better predict potential impacts. The addition of a pump-back system and/or seepage collection system may be necessary for the tailings impoundment to keep deep groundwater from mixing with tailings water. This type of activity would be governed under ADEC's waste management permit.

3.6.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A, current mining activities that were evaluated in the 1984 EIS (EPA 1984) would continue until 2011. Subsequent to the 1984 EIS, additional data collection and modeling were performed to estimate impacts of the permitted mining activities on the groundwater, according to the Consent Decree between Cominco Alaska Incorporated (now Teck) and EPA (U.S. v. Cominco Alaska Incorporated, Civil Action A97-267CV). Several computer models were constructed to predict potential mining related impacts to groundwater and permafrost. These models include a numerical seepage model to predict seepage from the tailings dam to the subpermafrost groundwater (WMCI 1999); a permafrost heat flow model to simulate warming of permafrost due to climatic warming and due to the relatively warm water in the tailings dam (WMCI 1999); and a numerical groundwater model to simulate three-dimensional flow among the tailings dam underdrain system, the shallow groundwater in the shallow active layer, and the subpermafrost groundwater zones (WMCI 2001a). The results of these models were used to predict the effects of Alternative A.

Development of the Main Pit would continue until the year 2011, with the effects described in “Effects Common to All Alternatives” (Section 3.6.1). After the end of active mining, subpermafrost groundwater combined with runoff and seepage would flow into and fill the pit, thus creating a pit lake. The pit lake water would be withdrawn seasonally from the Main Pit to maintain the 850 foot level and would be treated before being discharged to Main Stem Red Dog Creek. As a result, the water level in the pit lake would be maintained at an elevation of about 850 feet indefinitely.

Subpermafrost groundwater levels would be influenced by the pit lake water level. Modeling suggests that groundwater would continue to flow into the pit at a rate of approximately 50 gallons per minute (SRK, 2007, Spreadsheet, Red Dog Load Balance_EID Version_Tetratech.xls). At a maintained water level of below 850 feet, the water level in the pit would be lower than the potentiometric surface of the subpermafrost groundwater. Subpermafrost groundwater would continue to flow into the pit until the subpermafrost groundwater in the localized area around the pit is drained to the level of the pit lake. Water would also enter the pit from surface water runoff and spring seepage, and would cause the water level in the pit to rise faster than the surrounding groundwater recovers. In response, some water would flow from the pit into the surrounding subpermafrost groundwater system, filling up fractures and structural features drained during mining. Ultimately, all groundwater would flow toward the pit. The relatively warmer water present in the pit lake would also create a zone of melted permafrost around the perimeter of the pit.

A shallow water cover would be maintained over the tailings following closure to prevent oxidation of the tailings material. The permafrost-free zone in the tailings area has an approximate width of 400 feet (120 meters) near the tailings dam (WMCI 1999). The absent permafrost area would continue to increase in size and depth over time. The maximum modeled zone of absent permafrost beneath the tailings impoundment would have a width of approximately 1,000 feet at approximately 100 years after mining ends (WMCI 1999). One hundred years after the end of mining, the upper 15 feet of the tailings material column would have refrozen, and the zone of absent permafrost beneath the tailings impoundment would slowly shrink in size (WMCI 1999). Modeling indicates that long-term seepage rates from the tailings impoundment into the subpermafrost groundwater, where the permafrost layer is absent, would be about 0.07 gallons per minute per acre. All flows in the subpermafrost groundwater underneath the tailings impoundment are predicted to be captured by the existing underdrain system and would continue to be collected and pumped back to the tailings dam (WMCI 2001a). The seepage rate through the zone of absent permafrost is small because of the presence of low permeability shales underneath the tailings impoundment. Thus, even though the maximum width of the zone of absent permafrost would increase from 400 feet to 1,000 feet, the total seepage would be small and would be captured by the existing underdrain system without creating additional impacts on the groundwater system. Current extensive monitoring of temperatures and water levels in the tailings area would be continued according to the *Long-Term Permafrost and Groundwater Monitoring Plan for the Tailing Impoundment* (WMCI 2001a).

The long-term permafrost and groundwater monitoring plan is designed to monitor and predict certain specific potential effects of the tailings impoundment on the groundwater and permafrost. Because of the relationship between permafrost and the groundwater flow regime, the monitoring plan includes monitoring of permafrost related parameters. The monitoring plan consists of the following:

- Quarterly monitoring of 15 key background and dam area thermistors to assess currently observed trends in temperature changes in the permafrost;
- Quarterly monitoring of 10 key background and dam area piezometers to assess currently observed water levels and gradients;

- Ongoing data handling and management;
- An annual data report to EPA; and
- A detailed assessment of subsurface trends and conditions every five years including an evaluation of the requirement to update the thermal and numerical flow model (WMCI 2001a). The last five-year permafrost and groundwater data analysis report was published in 2007 (Geomatrix 2007).

To address future changes caused by shifts in global and local climate, the monitoring plan should assess the capability of the existing monitoring system to detect these types of changes in the local setting. If necessary, the monitoring plan should be modified so changes in the relationship between permafrost and groundwater behavior could be detected.

3.6.3.3 Effects of Alternative B – Applicant's Proposed Action

Mining of the Aqqaluk Deposit would start in 2010 resulting in the creation of a new pit, the Aqqaluk Pit. The effects of mining the Main Pit are described under Alternative A. After the Main Deposit is mined out (in about 2012 if the Aqqaluk Deposit is developed), waste rock removed from the Aqqaluk Deposit would be disposed of in the mined out Main Pit. Reclamation of the existing waste rock dump would occur throughout the life of the operation and final closure would occur after mining of the Aqqaluk Deposit was finished in 2031. Mining the Aqqaluk Deposit would result in additional impacts as discussed below.

After mining in the Main Pit is completed in 2012 and backfilling in the pit starts, the water level in the Main Pit would be allowed to rise, similar to Alternative A. However, with this alternative a pit lake would not form, but a saturated waste rock zone would be created. Similar to the hydrology of the pit lake under Alternative A, as the water level in the pit increases, some surface water and shallow groundwater seepage would enter the pit and infiltrate into the backfill and flow back into the surrounding subpermafrost groundwater system, filling up fractures and structural features that were drained during mining. Ultimately, the backfilled pit would return to a temperature gradation similar to the non-mined surrounding area, with an active, shallow freeze and thaw layer, a permafrost layer, and a subpermafrost layer with temperatures above freezing. Contaminated water within the covered and backfilled Main Pit would be allowed to collect at depth and would be transferred to the Aqqaluk Pit. Monitoring permafrost temperatures and the quality of the subpermafrost groundwater would be conducted to ensure that contaminated water had not moved from the waste rock zone through the permafrost into the subpermafrost groundwater. Water collected within the backfilled pit and background water would be monitored for water quality.

It is expected that the effects of mining the Aqqaluk Pit on permafrost and groundwater conditions would be similar to those of the Main Pit, described in Alternative A. The shallow active layer with shallow groundwater in the proposed Aqqaluk Pit area is relatively thin (generally less than 10 feet); thus there is currently no major shallow groundwater flow system in the vicinity of the Aqqaluk Pit. The shallow active layer would be removed during mining as the pit expands. Increased subsurface thaw outside and around the pit, as is currently being observed around the Main Pit, would occur and would result in increased shallow groundwater flow into the Aqqaluk Pit. This increased flow from the shallow active layer surrounding the pit would be collected in a mine pit sump and sent to the tailings impoundment for treatment and discharge. The volume of water pumped from the pit during mining would be monitored and, if possible, determination of the volume of water contributed from the various sources (subsurface groundwater versus spring seepage) would be estimated and/or measured to better define the mine's water balance and to provide a better understanding of the groundwater system. Additional monitoring of the subpermafrost groundwater potentiometric surface surrounding the Aqqaluk Pit is also recommended, to determine the extent of the zone of influence of pit dewatering.

As with Alternative A, permafrost would be lost because of mining. Additional thawing of the permafrost would occur locally around the Aqqaluk Pit area and exposed pit walls, with a thaw zone developing around the exposed pit walls. Water-bearing taliks would likely be encountered in the permafrost zone. All groundwater flows from taliks and additional thawing would be collected in the mine pit sumps and sent to the tailings impoundment.

Subpermafrost groundwater would enter the Aqqaluk Pit after advancing below the permafrost zone, sometime between the years 2015 and 2020. The Aqqaluk Pit would be mined to a minimum elevation of 425 feet. The bottom of the permafrost zone is at an elevation of approximately 650 feet. The potentiometric groundwater level of subpermafrost groundwater in the Aqqaluk Pit area is at an elevation of approximately 890 feet. Any water entering the Aqqaluk Pit would be collected in the mine pit sumps along with surface runoff and sent to the tailings impoundment, where it would be treated prior to discharge. The current conceptual model of the subpermafrost groundwater system throughout the Red Dog area suggests that groundwater is isolated to faults and fractures within the bedrock, and flow into the proposed Aqqaluk Pit would represent drainage of an isolated set of fractures in the bedrock located near the pit. The amount of subpermafrost groundwater flowing into the Aqqaluk Pit during mining is, therefore, expected to be minimal and similar to the Main Pit, around 50 gallons per minute (SRK, 2007, Spreadsheet, Red Dog Load Balance_EID Version_Tetratech.xls). This water is expected to have elevated TDS and metals concentrations, as measured in the sample taken from a borehole in the Aqqaluk Deposit.

After closure of the Aqqaluk Pit in 2031, a pit lake would be allowed to form. Surface water and groundwater would enter the pit following the cessation of mining activities. Fault blocks within the subpermafrost groundwater system that were drained during mining would slowly be recharged from water entering the pit and from inflows from surrounding fault blocks. As the water level in the pit increases, some water would flow back into the surrounding subpermafrost groundwater system, filling up fractures and structural features that were drained during mining. Given that the subpermafrost groundwater system is locally isolated and bounded by faults, it is unlikely that appreciable groundwater flow would occur away from the vicinity of the pit (water would not continue to flow out of the pit once near-pit fractures and pore space have been filled). Over the long term, the water levels in the Aqqaluk Pit would be maintained at lower levels than the surrounding groundwater levels, creating a cone of depression in the groundwater system, caused by pumping water to the water treatment plant and subsequent discharge to Red Dog Creek. The Aqqaluk Pit lake would be maintained at a maximum elevation well below the spill-over point to Red Dog Creek. The cone of depression created by the lower water elevation in the Aqqaluk Pit would ensure that both the shallow and subpermafrost groundwater flowing near the pit would flow into the pit, rather than outward from the pit.

Long-term water storage in the proposed Aqqaluk Pit would represent a thermal source that would likely increase the thaw zones around the pit. After some time, a new thermal equilibrium would form in the pit area.

Tailings would be deposited into the existing tailings impoundment. The tailings dam would need to be raised to accommodate the additional tailings. The tailings dam is currently being raised to an elevation of 970 feet, and would ultimately need to be raised to an elevation of 986 feet. The additional tailings deposition could cause an increase in the permafrost absent zone below the tailings. The additional volume of solid tailings would likely act as a temperature buffer between the warmer water in the tailings impoundment and the ground underneath. However, warming in the ground would likely occur because of the additional time period warmer tailings would be added to the impoundment, and the additional time period warmer water would flow through the underdrain system. Numeric modeling on the reduction of the permafrost zone under the tailings impoundment was not performed for Alternative B. Given the opposing effects of additional tailings solids acting as a buffer versus the additional time and volume of warmer water in the tailings impoundment, it is estimated that the impacts on permafrost would not be substantially different for Alternative B compared to Alternative A. Current extensive monitoring of temperatures and water levels in the tailings area would be continued according to the *Long-Term Permafrost and Groundwater Monitoring Plan for the Tailing Impoundment* (WMCI 2001a).

Reclamation of the waste rock dump would occur throughout the life of the operation and final closure would occur after mining of the Aqqaluk Deposit was finished in 2031. Post-closure water management and treatment would continue over the long term. Contaminated seepage from the tailings dams and the backfilled Main Pit would be intercepted and transferred to the Aqqaluk Pit for seasonal storage then treated and discharged to maintain a pit lake elevation of 850 feet.

3.6.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Impacts to groundwater resources during the active mining period for Alternative C would be the same as Alternative B. The waste rock dump would be temporarily reclaimed throughout the life of the operation. Beginning in 2031, the waste rock dump would be regraded to a 5:1 slope with excess material moved back into the Aqqaluk Pit beginning in 2031. Tailings would continue to be placed in the existing tailings impoundment. As with Alternative B, the dam elevation for the tailings impoundment would be raised to account for the increased volume of tailings and water. At the time of post-mining reclamation, the water in the tailings impoundment would be minimized and a dry cover placed over the tailings. Permafrost could be restored more quickly under the tailings impoundment than in alternatives A, B, and D.

Similar to the Main Pit under Alternative B, after the mining of the Aqqaluk Pit is complete and backfilling in the pit starts, the water level in the pit would be allowed to rise. Ultimately, the backfilled pit would also return to a temperature gradation similar to the surrounding non-mined area, with an active, shallow layer, a permafrost layer, and a subpermafrost layer. Contaminated water within the Aqqaluk Pit would be allowed to collect at depth, and would be transferred to a water treatment plant. Monitoring the permafrost layer temperatures and the subpermafrost groundwater would be conducted to ensure that contaminated water had not moved through the waste rock zone into the subpermafrost groundwater system.

After covering the tailings, the underdrain system would remain operational. If contaminated water from the tailings impoundment continues to be collected in the underdrain system, it may have to be operated indefinitely. Contaminated water from the underdrain would be transferred to the Aqqaluk Pit and ultimately treated and discharged.

Current extensive monitoring of temperatures and water levels in the tailings area would be continued according to the *Long-Term Permafrost and Groundwater Monitoring Plan for the Tailing Impoundment* (WMCI 2001a) as with Alternative A.

3.6.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

The effects of Alternative D with respect to groundwater resources would be the same as Alternative B.

3.6.4 Water Resources – Groundwater – Summary

Under the four alternatives, mining in the Main Pit would continue to a depth of 400 feet below ground surface at the Middle Fork Red Dog Creek or an elevation of 500 feet. In addition to permafrost lost to mining, additional subsurface thaw around the exposed pit walls is expected. Alternatives B, C, and D all result in additional permafrost loss between 2012 and 2031 through development of the Aqqaluk Pit. Post-closure, Alternative C is the alternative most likely to restore permafrost under the tailings to the pre-mining condition. Alternatives B and D would restore permafrost in the Main Pit and maintain a lake in the Aqqaluk Pit. Overall, the affects on groundwater under all alternatives would be limited and very localized. Climate change complicates the prediction of long-term impacts and monitoring needs to continue in order to predict impacts and make adaptations to the water management systems if needed.

3.7 Vegetation

This section describes vegetation resources within the vicinity of the mining operation beginning with the pre-mining environment, the current baseline conditions that include the construction and operation of the mine/DMTS, and the effects of each alternative under consideration. Concerns raised during public scoping include the effects of fugitive dust on vegetation and the need to use native species during reclamation.

3.7.1 Vegetation – Pre-mining Environment

Pre-mining descriptions of vegetation follow the Viereck et al. (1981) classification system. Prior to the mine's development, vegetation communities at the mine site and along the DMTS road ranged from xerophytic upland mat/cushion tundra to wet lowland sedge-grass marsh (Dames & Moore 1983a). The dominant vegetation types present consist of sedge-grass tundra and dwarf shrubs. Tussock tundra and low shrub communities form the dominant vegetation along the DMTS road (EPA 1984). Tall shrubs are present in the many drainages across the region.

Shrublands

Tall shrub vegetation types are defined as shrub communities greater than 5 feet (1.5 meters) tall. Both open and closed tall shrub communities occur within the project area. Closed (more than 75 percent foliar cover) tall shrub communities occur in relatively few locations, primarily as riparian or snowbank vegetation along streams. This vegetation type is dominated by grayleaf willow (*Salix glauca*) with a sweet coltsfoot (*Petasites frigidus*) understory component. Open (25 to 75 percent foliar cover) tall shrub communities are more abundant and more variable in species composition than closed tall shrub communities. This vegetation type consists of diamondleaf willow (*S. planifolia*), feltleaf willow (*S. alaxensis*), and bluejoint (*Calamagrostis canadensis*), and typically occurs along stream banks.

Low shrub (8 inches to 5 feet [0.2 to 1.5 meters] tall) communities are abundant in the project area and include tundra as well as closed and open low shrub types. Four-angled cassiope (*Cassiope tetragona*), crowberry (*Empetrum nigrum* ssp. *hermaphroditum*), and bog blueberry (*Vaccinium uliginosum*) dominate low shrub tundra communities. Other woody plants such as dwarf arctic birch (*Betula nana*) and various willow species are also present. Low shrub tundra vegetation is quite common on the upland rolling hills, where it forms a complex with cottongrass (*Eriophorum* spp.) and tussock tundra. Closed low shrub communities occur sporadically along the DMTS road; however, they occur more often near the coast. Dominant species in closed low shrub communities include dwarf arctic birch, diamondleaf willow, bog blueberry and narrow-leaf Labrador tea (*Rhododendron subarticum*). Open low shrub communities are common on upland rolling hills and riparian areas along the DMTS road. This vegetation type consists primarily of an assemblage of willow and heath species including dwarf arctic birch, bog blueberry, moss and herbaceous species.

Dwarf shrub (mat and cushion) tundra communities are associated with upland ridges located above 800 feet (244 meters) above sea level in the DeLong Mountains. This vegetation type consists of mountain-avens (*Dryas integrifolia*) in association with a variety of willow, heath, and lichens; the exact species composition varies depending on the moisture content of the soil.

Herbaceous

Tall grass (greater than 3 feet [1 meter] tall) communities occur along the coastal dune region. This vegetation type is dominated by lyme grass (*Elymus arenarius* ssp. *mollis*) in association with beach pea (*Lathyrus maritimus* ssp. *pubescens*).

Tussock tundra is the most abundant vegetation type along the DMTS road. Cottongrass, in association with various sedges, bog blueberry, narrow-leaf Labrador tea, dwarf arctic birch, and *Sphagnum* species dominate this vegetation type.

Sedge-grass communities within the project area consist of marsh, wet or bog meadow, and tundra types. Sedge-grass marsh communities typically occur near lakes or within areas containing at least 6 inches (15 centimeters) of surface water. This vegetation type is composed of pendant grass (*Arctophila fulva*) or water sedge (*Carex aquatilis*) in association with mare's tail (*Hippuris vulgaris*). Sedge-grass wet meadow communities are similar to sedge-grass marsh communities, except that they occur in infilled lake basins having less than 6 inches (15 centimeters) of surface water. Sedge-grass bog meadow communities differ from wet meadow communities in that they only occur in poorly drained lake basins containing peat soils that were at least 1 foot (30 centimeters) deep. Both wet and bog meadow communities are dominated by *Carex* species, cottongrass, bog blueberry, narrow-leaf Labrador tea, and *Sphagnum* species. Sedge-grass tundra communities have less than 1 foot (30 centimeters) of peat and no surface water. Soils are poorly drained; however, inundation occurs for only a small part of the growing season. This vegetation type consists of cottongrass, various species of *Carex*, willows and moss species.

Wetland herbaceous communities occur in small ephemeral ponds located between sand dunes and along coastal lagoons. Herbaceous communities in halophytic conditions consist primarily of arrow grass (*Triglochin maritimum*) and mare's tail, while communities in freshwater habitats consist predominantly of horsetail (*Equisetum* spp.). Wetlands are discussed in more detail within Section 3.8.

3.7.2 Vegetation – Baseline Conditions

The baseline condition for vegetation describes the current condition within the project area that has resulted from the construction and operation of the Red Dog Mine and DMTS. The discussion includes the effects of deposition of fugitive dust on vegetation downwind of mining operations and along the DMTS corridor.

The construction and operation of the mine, DMTS, and their associated facilities have resulted in changes from the pre-mining conditions, including direct impacts on vegetation communities and changes in plant community composition and a reduction in percent cover for some species. To date, approximately 1,823 acres of vegetation have been directly disturbed because of the construction and operation of mining facilities and the DMTS (EPA 1984). Table 3.7-1 lists the acres of disturbance that have occurred within each vegetation type. Of the total 1,823 acres of disturbance, approximately 580 acres were disturbed by the mine and storage areas, 585 acres by the tailings dam and impoundment, 65 acres by the mill and worker housing, 76 acres resulting from the construction of the Bons Creek water supply, and 30 acres as a result of the airstrip. The remaining 487 acres of disturbance are associated with the DMTS.

Indirect effects to vegetation have occurred outside areas of physical disturbance and are likely the result of the physical and chemical influences of the DMTS and mining operation. Increased pH, metal concentrations, and dust levels have been recorded near the DMTS and mining facilities (Ford and Hasselbach 2001; Hasselbach et al. 2005; Exponent 2001; 2007a; 2007b). Potential sources for these changes are road construction/maintenance/operation, lead and zinc concentrate spillage, gravel and dust spray from road traffic, and dust generated during mining operations. Fugitive dust is considered to be the major cause of the physical and chemical changes observed along the DMTS road; fugitive dust alters the physical and chemical environment through the synergistic effects of increased metals, dust on plants, and pH changes resulting from road dust, which can result regardless of the presence of metals (Exponent 2007a). The highest concentrations of fugitive dust are located at either end of the DMTS road (particularly near the port), with relatively consistent lower levels along the rest of the haul road (Hasselbach et al. 2005; Exponent 2007a, Figure 1-10). As a result of prevailing winds, dust deposition is

Table 3.7-1 Disturbance to Vegetation Types Resulting from Red Dog Mine and the DeLong Mountain Regional Transportation System

Vegetation Type	Mining Operations Disturbance (acres)	DMTS Disturbance (acres)	Total Disturbance (acres)
Dwarf Shrub	618	24	642
Low Shrub	379	136	515
Tall Shrub	0	5	5
Sedge-Grass Tundra	339	<5	344
Sedge-Grass Marsh	0	5	5
Sedge-Grass Wet Meadow	0	5	5
Sedge-Grass Bog Meadow	0	5	5
Tussock Tundra	0	273	273
Elymus (Leymus) Tall Grass	0	<5	<5
Wetland Herbaceous	0	<5	<5
Tussock Tundra/Low Shrub Complexes	0	29	29
Total	**1,336**	**487**	**1,823**

Source: EPA 1984

typically greater and extends farther on the northern side of the DMTS and mining facilities than to the south (Exponent 2001, 2007a, 2007b; Ford and Hasselbach 2001; Hasselbach et al. 2005). Prevailing winds near the mine site originate from the east (between the southeast and northeast quadrants depending on the season) resulting in the greatest dust deposition to the north and west of the DMTS and mine facility areas. NPS data suggest that some airborne contaminants may be reaching vegetation in the Noatak National Preserve and Wilderness, located east of the facility (NPS unpublished data). Although the amount of data is limited and other mineralized zones occur in the region, this area's inclusion in the World Network of Biosphere Reserves under the United Nations Educational, Scientific, and Cultural Organization warrants additional monitoring to determine whether elevated metals concentrations result from activities at the Red Dog Mine. Based on discussions with the cooperating agencies, monitoring of this nature cannot be required under the existing regulatory framework and the ADEC Air Quality Division would only become involved if evidence of deposition is collected and tied to operations at the mine. Therefore, the likelihood of successfully implementing a viable monitoring program within the Noatak National Preserve is limited within the context of this SEIS.

These changes (elevated pH, metal concentrations, and dust levels) are interrelated because the fugitive dust contains metals, road bed materials, and calcium chloride, all of which may be contributing to elevated tundra soil pH in areas surrounding the DMTS road and port facilities (Exponent 2007a). Tundra soil pH was found to decrease with distance from the DMTS and mining facilities. The pH ranges from 6.9 to 7.7 adjacent to the DMTS road and declines to below 6.0 by 0.37 mile (400 meters) from the DMTS road, below 5.0 by 0.47 mile (750 meters), and falls to 3.9 to 4.5 [the upper limits of the natural range] by 0.62 mile (1,000 meters) from the DMTS road (Exponent 2007a). Metal concentrations decline with distance from the haul road as well; however, their decline is more rapid than that recorded for pH (Exponent 2007a, Figure 4-13). The distances in which fugitive dust has spread from the DMTS road and mining facilities is uncertain; however, a study conducted along the Dalton Highway (a 360-mile [577-kilometer] long gravel road on the North Slope of Alaska) found that 70 to 75 percent of road dust was deposited within the first 30 feet (10 meters) from the road, 93 percent by 100 feet (30 meters), and 97 percent of the total load was deposited by 410 feet (125 meters) (Walker and Everett 1987). These findings were consistent with the results from other studies (Alexander and Miller 1978; Hoover 1981).

Observed changes in vegetation along areas near the DMTS and mining facilities include blackening of mosses and lichens, increased plant mortality, and a transition in dominant species. The reason for this transition in dominant species is that not all species are equally sensitive to these physical and chemical changes due to differences in their life history and morphology. Species that tend to be more sensitive include evergreens, those that grow as mats or have a prostrate stem habit, those lacking a protective leaf cuticle, and those having leaf or stem types that tend to trap dust (Walker and Everett 1987). The species most sensitive to these changes include mosses (such as *Sphagnum* spp.) and lichens (such as *Cladina* spp. and *Peltigera* spp.).

Teck contracted with Exponent to conduct a vegetation survey in 2004, the results of which were published as part of their DMTS risk assessment in 2007 (Exponent 2007a). The DMTS risk assessment grouped vegetation into three communities: coastal plain, tundra, and hillslope. Coastal plain communities are located adjacent to the port, tundra communities along the DMTS road, and hillslope communities adjacent to the mine. Both the coastal plain and tundra communities are dominated by cottongrass, dwarf arctic birch, diamondleaf willow, bog blueberry, salmonberry (*Rubus spectabilis*), Labrador tea, lingonberry (*V. vitis-idaea*), crowberry, and a variety of moss and lichen species. Much of the coastal plains and tundra communities of tussock tundra vegetation types, while portions of the tundra community contain areas that include birch and willow as dominants. Of the three communities surveyed, the coastal plains community had the lowest total living vascular plant cover. The hillslope communities consisted of a mesic open shrubland community containing a mix of low shrub and sedge-grass tundra vegetation types. Hillslope communities are dominated by birch, bog blueberry, and willow species, with non-tussock sedges, forbs, mosses, and lichens. Evergreen shrubs and graminoids are limited in their distribution within the hillslope communities.

Exponent's DMTS risk assessment found that vegetation communities in some areas were altered from reference sites used to estimate natural conditions as far out as 1.25 miles (2,000 meters) from the DMTS road (Exponent 2007a). Impacts were greater on the northern side of the DMTS road than on the southern side. In coastal plains communities, forb cover was greater near the DMTS road with forbs such as coltsfoot (*Petasites* spp.) and Jacob's ladder (*Polemonium acutiflorum*) found within the first 330 feet (100 meters) of the road, but not at greater distances. A shift in dominant deciduous shrub species occurs around 0.62 miles (1,000 meters) to 1.25 miles (2,000 meters) from the DMTS road, with diamondleaf willow transitioning to dwarf arctic birch and bog blueberry. In tundra communities, deciduous shrub cover (including salmonberry and various birch species) decreased with distance from the DMTS road; however, bog blueberry cover was found to increase in some tundra communities. In hillslope communities, willow species become more dominant at distances greater than 330 feet (100 meters) from the road, while dwarf arctic birch and bog blueberry are more dominant at distances less than 330 feet (100 meters). Evergreen shrubs, moss, and lichen cover increased significantly with distance from the road, with the exception of hillslope communities, where moss cover decreased with distance from the road. Moss species were either stressed or dead near the DMTS road, but appeared robust by 0.5 miles (800 meters) from the road. Lichen cover was found to be substantially lower than reference conditions at distances up to 0.62 miles (1,000 meters) to 1.25 miles (2,000 meters) of the DMTS and mine (Exponent 2007a, Figure 6-4). Unvegetated substrates occur at distances of 33 feet (10 meters) from the DMTS and mine, but were not found at greater distances. Exponent hypothesized that these changes may reflect a community shift toward species better adapted to the altered conditions found near the DMTS and mining facilities (Exponent 2007a).

Mosses and lichens were the most affected by the physical and chemical changes near the DMTS and mining facilities. This is likely because mosses and lichens are non-vascular and absorb water and nutrients directly from the air, making them more susceptible to atmospheric deposition (Auerbach et al. 1997). As these species lack a protective cuticle, dust on their surfaces can act as a desiccant drying out and destroying their tissues (Meininger and Spatt 1988). In addition, elevated pH levels, such as those found adjacent to the DMTS, can be detrimental to sphagnum mosses, which are normally found on acidic soils (Clymo 1973).

Studies on the effects of road dust conducted along the Dalton Highway found trends in vegetative composition that are comparable to some of the conditions observed at the DMTS and mining facilities (Walker and Everett 1987; Auerbach et al. 1997). Road dust along the Dalton Highway consisted of calcareous dust, bank-run gravel and crushed bedrock; therefore, the elevated metallic concentrations found in the dust at the Red Dog Mine and DMTS are not present in the dust at the Dalton Highway. Walker and Everett (1987) found that road dust resulted in substantially lower lichen and moss cover, and stressed ericaceous shrubs (including Labrador tea and bog blueberry) near the Dalton Highway. They also found that dust deposition near the road decreased the albedo effect, resulting in an early melting of snow and thawing of soils. This early melt off results in some species, such as cottongrasses (*E. vaginatum* and *E. angustifolium*), flowering earlier than those farther away from the road (in areas still covered in ice or snow). This early melt-off occurred within the first 330 feet (100 meters) of the road (Walker and Everett 1987). Auerbach et al. (1997) found that areas adjacent to the Dalton Highway had elevated pH, lower biomass, increased populations of graminoids (mostly cottongrass), increased deciduous cover, and decreased evergreen, lichen, and moss cover. Based on the results of these studies, the general effects of road dust is likely to be a major causative agent for some of the indirect effects observed at the Red Dog Mine, at least within the first 164 feet (50 meters) of the DMTS. In addition, portions of the region are naturally high in concentrated metal deposits, and weathering has resulted in dispersal of these metals to the general environment (Exponent 2007a; USGS 2003). While natural erosion/dispersion may contribute to the elevated metal concentrations in portions of the study area in addition to the mine related fugitive dust, metals from natural sources are unlikely to be the reason for the changes being observed in vegetation communities. The highest observed metal concentrations occur near the DMTS and mining facilities and decrease with distance from the road, indicating that mining operations have had an effect on the levels and distribution of fugitive dust, including metals, around the project area.

Concentrations of cadmium, lead, and zinc in moss samples collected along the DMTS road decreased with distance; however, they remained elevated above reference levels at 1 mile (1,600 meters) (Ford and Hasselbach 2001, Figure 3). Table 3.7-2 lists the metallic concentrations in moss samples reported in Ford and Hasselbach (2001). Moss samples collected within and adjacent to the Cape Krusenstern National Monument have indicated that cadmium levels can remain elevated at distances of 1.8 miles

Table 3.7-2 Cadmium, Lead, and Zinc Concentrations in Moss Samples

Distance from DMTS Road (meters)	Lead (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)
North Side of the DMTS Road			
3	430 (± 38)	1,962 (± 328)	12.0 (± 1.9)
50	299 (± 66)	1,252 (± 318)	7.2 (± 1.7)
100	159 (± 29)	763 (± 145)	4.1 (± 0.8)
250	71 (± 12)	370 (± 60)	1.8 (± 0.3)
1,000	33 (± 7)	187 (± 22)	0.8 (± 0.1)
1,600*	30	169	0.6
South Side of the DMTS Road			
3	363 (± 38)	1,853 (± 511)	11.2 (± 3.0)
50	97 (± 22)	475 (± 139)	2.6 (± 0.6)
100	55 (± 14)	305 (± 76)	1.6 (± 0.4)
250	29 (± 6)	169 (± 27)	0.9 (± 0.1)
1,000	12 (± 3)	114 (± 2)	0.5 (± 0.1)
1,600*	12	96	0.4

Adapted from Ford and Hasselbach 2001
*data for samples at distances of 1,600 m were collected on a single transect.

(3 kilometers) to the south and 7.5 miles (12 kilometers) to the north of the DMTS road, while elevated lead levels occur as far north as 15 miles (25 kilometers) (Hasselbach et al. 2005). Exponent (2007) found that cadmium levels in willow leaves level off to estimated background conditions around 330 feet (100 meters) from the DMTS road while lead concentrations can take up to 1.25 miles (2,000 meters) to decline to background levels (Exponent 2001). Concentrations of zinc in willow leaves leveled out to estimated background conditions by 0.62 miles (1,000 meters) from the DMTS road (Exponent 2001). Concentrations of cadmium, lead, and zinc in salmonberry samples leveled out to estimated background conditions around 330 feet (100 meters) from the DMTS road (Exponent 2001).

High levels of aluminum, cadmium, and lead can reduce plant growth and reproduction (ABR 2007a). Aluminum toxicity is generally associated with reduced growth, stunted roots, reduced uptake of essential minerals, and reduced photosynthetic rates (Mossor-Pietraszewska 2001). The solubility and bioavailability of aluminum is decreased as soil pH increases (Foy et al. 1978). EPA considers aluminum non-toxic to plants at soil pH levels of 5.5 or above (EPA 2003b). Because aluminum is not an essential mineral, it is not actively taken into most plants, and instead enters plant tissues through passive diffusion (Foy et al. 1978). Cadmium is a powerful enzyme inhibitor which can cause leaf mortality, and inhibit the uptake of water and essential nutrients (Das et al. 1997; Gough et al. 2003). Cadmium is leached from soils with a pH below 5.0 and becomes readily available for plant absorption (Gough et al. 2003). High concentrations of calcium chloride (dust palliative used on the DMTS road) have been shown to increase concentrations of cadmium in plants (McLaughlin et al. 1998). Zinc, an essential mineral that is actively taken up by plants, has been shown to ameliorate the effects of cadmium toxicity; however, in high enough concentrations, zinc can be toxic as well (Das et al. 1997; Aravind and Prasad 2005; ABR 2007a). Lead toxicity inhibits water uptake, germination, growth, and photosynthetic rates; it also upsets mineral nutrition and water balance (Sharma and Dubey 2005; ABR 2007a). Lead has been shown to absorb into plants via the roots or through the leaves (Sharma and Dubey 2005). The bioavailability of lead is controlled in part by the soil's pH, with absorption increasing with increasing pH between 3.0 to 8.5 (Lee et al. 1998); however, some studies have shown that in soils with a pH between 5.5 and 7.5 the bioavailability of lead is controlled by phosphate or carbonate precipitates and very little soluble lead is available for plant absorption (Sharma and Dubey 2005).

In general, heavy metals become less bioavailable in organic soils, as these metals become bonded to organic compounds within a chelation or humic complex (Shaw 1990). A metal's affinity to create these complexes and their stability differs between the various metals. Shaw (1990) listed the stability of metal-humic substances as: $Pb^{2+} > Cu^{2+} > Ni^{2+} > Co^{2+} > Zn^{2+} > Cd^{2+} > Fe^{2+} > Mn^{2+}$. This indicates that lead typically bonds tightly to organic materials in organic soil, which serves to further reduce its bioavailability, while zinc and cadmium create a weaker complex and can more easily weather into the environment and become bioavailable.

The effect that elevated metal concentrations could have on different species depends on that species' specific phytotoxicity threshold. During Exponent's 2007 DMTS risk assessment, unwashed plant tissue samples, collected at 33-, 330-, 3,300-, and 6,600-foot (10-, 100-, 1000-, and 2,000-meter) intervals from the DMTS, were tested for concentrations of various metals. Sample concentrations were then compared to published phytotoxicity thresholds (McBride 1994; Langmuir et al. 2004; Davis et al. 1978). Published thresholds were developed for agricultural crops, as opposed to arctic species; therefore, it is unknown if thresholds are protective for the plant species found at the site. In addition, tissue samples were unwashed because this more accurately represents the concentrations available to both humans and wildlife (see sections 3.9 and 3.12); however, the concentrations reported within Exponent (2007a, 2007b) represent both metal concentrations within plant tissues (which affect phytotoxicity) as well as metallic dust that settled onto the plant's surface, which may not affect phytotoxicity. Therefore, concentrations in plant tissues likely overestimate the amount of metals actually taken up by vascular plants. This also tends to make the comparison of plant tissue concentrations with literature threshold values a conservative comparison for vascular plants.

Shrubs

For willow and birch species, aluminum and cadmium concentrations above phytotoxicity thresholds were limited to 33 feet (10 meters) from the DMTS and mining facilities (Exponent 2007a); however, willow species have been documented to readily bioaccumulate cadmium and are a concern as a vector for cadmium transfer to wildlife (see Section 3.9) (Gough et al. 2003). Zinc concentrations in shrub tissue samples exceeded the lowest phytotoxicity thresholds at all distances and almost all reference sites tested, indicating that zinc toxicity may be a contributing factor for the observed effects to vascular plants. All other metal concentrations tested were below phytotoxicity thresholds.

Sedges

Concentrations of aluminum and zinc were above phytotoxicity thresholds for sedges at two stations located 33 feet (10 meters) away from the DMTS (Exponent 2007b, Table 6-18). All other metal concentrations tested were below phytotoxicity thresholds.

Mosses (Hylocomium splendens) and Lichens

Metallic concentrations in mosses and lichens were compared to sensitivity thresholds reported in Folkeson and Andersson-Bringmark (1988). Concentrations of zinc were high enough to cause mortality in mosses up to 330 feet (100 meters) away from the DMTS road, and reduction in cover up to 0.62 mile (1,000 meters); zinc concentrations were high enough to cause mortality in mosses up to 0.62 mile (1,000 meters) from the port facility and 1.25 miles (2,000 meters) away from the intersection of the DMTS with the mine's ambient air/solid waste permit boundary [transect TT6] (Exponent 2007a). Zinc concentrations were below lichen toxicity levels by 0.62 miles (1,000 meters) of the DMTS and by 0.9 miles (1,430 meters) of the port (Exponent 2007a). Discrete concentrate spillage may contribute to effects on vegetation in the vicinity of the spill. However, metal concentrations in moss samples collected at spill sites are similar to the levels observed in samples collected at other points near the haul road (Exponent 2001). These overall results suggest that zinc may be a contributing factor to the lower moss and lichen cover observed along the DMTS; however, more research is needed to determine the exact relationship between elevated zinc and its effects near the Red Dog Mine.

Forms of sulfur, such as sulfides and sulfates, may also contribute to the adverse effects observed around the DMTS and mining facilities. Sulfates have been shown to reduce the concentrations of essential minerals, such as calcium, potassium, magnesium, and manganese, in plant shoots (McLaughlin et al. 1998). Sulfides, in the form of zinc sulfide and lead sulfide, are present in the project area, and although these forms of sulfur have a low bioavailability, they could contribute to the adverse effects to the vegetative communities. Sulfur dioxide, which is primarily up-taken in gaseous form through the stomata, can produce acute symptoms in the form of foliar necrosis, while long-term exposure can result in reduced growth and yield, and accelerated aging (WHO 2000). Non-vascular plants lack a protective cuticle or stomata, and are therefore more sensitive to pollution toxicity. Because of this, the toxic effects of sulfur dioxide occur at much lower concentrations than those of vascular plants (Exponent 2007a). Some of the common effects of sulfur dioxide toxicity in non-vascular plants are declining nitrogen fixation, increased membrane leakiness, reduction in photosynthesis and respiration, and loss of photosynthetic pigments (WHO 2000). While the weathering products of lead and zinc sulfides at the site are not thoroughly documented, it is unlikely that they would generate sulfuric acid. Therefore, more research is needed to determine the exact relationship between the types of sulfur present and the potential effects that they might have on the vegetative communities.

DeLong Mountain Regional Transportation System Risk Assessment Findings

The DMTS risk assessment (Exponent 2007a) evaluated the risk related to subsistence. A discussion of the results of ecological sampling of vegetation is included in Section 3.12.2.6.

Draft Fugitive Dust Risk Management Plan

The extent of contamination by fugitive dust is most effectively monitored using vegetation. The draft fugitive dust risk management plan indentifies a number of additional monitoring programs that could be conducted to better describe the behavior of contaminants already in the environment and track future contaminant deposition, including the following:

- Monitor changes in the vertical distribution of metals in surface tundra and underlying soils;
- Monitor tissue concentrations in shrubs, herbaceous plants, mosses, and lichens to track the rate of changes; and,
- Monitor plant community composition including moss and lichen to evaluate plant and bryophyte community health.

3.7.3 Vegetation – Environmental Consequences

Direct effects to vegetation would include both long-term and short-term impacts. Long-term impacts are defined as those that would last at least as long as the project's lifetime. Short-term impacts are defined as those not expected to last as long as the project's lifetime. An example of a short-term impact would be a vegetative community disturbed during construction activities. It would be considered a short-term impact because the area would be allowed to regenerate after construction was completed. The indirect effects of fugitive dust would be considered a long-term adverse impact for all analyses, as it is expected to occur for the life of the project to at least some degree.

3.7.3.1 Effects Common to All Alternatives

By 2011, an additional 18.5 acres of land would be disturbed while mining activities within the Main Deposit are completed. To the extent that these acres are currently vegetated, this would be considered a long-term adverse impact. Dust deposition resulting from mining activities within the Main Pit would continue at the current rate. However, a draft fugitive dust risk management plan currently under development may identify additional measures that would be implemented by the Applicant to reduce the extent of fugitive dust from various project components. The presence of calcium chloride would continue to affect vegetation along the DMTS road for the duration of operations. The extent to which calcium chloride, a dust suppressant, enters the roadside ecosystem is related to the extent of traffic and the frequency with which the solution must be reapplied to the road surface.

A revegetation plan is in preparation as part of the closure and reclamation plan required for an ADEC Waste Management Permit, in accordance with 18 AAC 60 governing solid waste regulations. ADNR is also involved in approving the revegetation plan as part of the draft closure plan. The revegetation plan will satisfy the reclamation guidelines outlined in Article 9 of the NANA-Cominco Agreement. The objectives of the revegetation plan would be: (1) establish plant communities (where appropriate) that are self-sustaining; (2) assist in protecting water quality by controlling erosion and preventing acid rock drainage; and (3) contribute to the proposed land use(s) of the mine after closure (ABR 2007b).

Areas considered for revegetation include waste piles (waste rock dump, oxide ore stockpile, low grade ore stockpile, Main Pit stockpile), overburden area, material borrow areas, water diversion systems, camp pads and roads. Upon closure of the mine, the waste piles would contain most of the mineralized waste rock generated by the mine. As this material would be dominated by components that oxidize to release metals, salinity and acidity, it is unsuitable for revegetation and would require a covering of other material prior to revegetation (ABR 2007b). Portions of the overburden stockpile, Siksikpuk and Ikalukrok shale, quarry material, or unconsolidated materials from hillsides and floodplains, are potential sources for cover material. Areas such as the airstrip, access roads, and storage pads would require recontouring and scarification to break up compacted soils and promote revegetation. Other areas contaminated by mining activities would have the contaminated material removed and then would be backfilled with clean material.

The use of native grass cultivars during revegetation is necessary, as they are the only species native to northern Alaska for which seed is consistently available in bulk from commercial growers (ABR 2007b). Table 3.7-3 lists the native grass cultivars proposed for use. Efforts would be made to improve site conditions for sustaining revegetative growth over the long term, including fertilization and planting of companion legumes that contain nitrogen-fixing bacteria. Planting of willow cuttings would only be considered for the diversion channel system or in other areas where there would be sufficient soil moisture to support plant establishment and growth. The willow cuttings would be collected in late spring and stored (frozen) onsite until planting.

Table 3.7-3 List of Plant Species that May Be Used to Revegetate Areas at the Red Dog Mine, Alaska

Plant Species	Planting Specifications	Disturbance Type
Primary List: Nortran hairgrass (*Deschampsia caespitosa*) Tundra bluegrass (*Poa glauca*) Alpine bluegrass (*Poa alpina*) Spike trisetum (*Trisetum spicatum*) Thickspike wheatgrass (*Elymus lanceolatus*) Polargrass (*Arctagrostis latifolia*) Bluejoint (*Calamagrostis canadensis*) **Secondary List:** Bering hairgrass (*Deschampsia beringensis*) Arctared fescue (*Festuca rubra*)	Seeding Rate 20 pounds/acre (final mixture) Ratio of species would depend on availability, but mix may include predominantly tundra bluegrass and alpine bluegrass for drier areas and Nortran hairgrass, polargrass, and bluejoint for mesic sites.	Thick gravel or mineral fill stockpiles of waste rock, overburden, and marginal and oxide ore; airstrip, roads and gravel pads.
Native forbs: Tilesy sage (*Artemisia tilesii*) Alpine milkvetch (*Astragalus alpinus*) Alpine sweetvetch (*Hedysarum alpinum*) Boreal sweetvetch (*Hedysarum boreale*) Field Oxytrope (*Oxytropis campestris*) Boreal yarrow (*Achillea millefolium* var. *borealis*) **Other potential species*:** Tall fireweed (*Epilobium angustifolium*) Siberian aster (*Aster sibiricus*) Arctic bladderpod (*Lesquerella arctica*)	50 seeds/m^2 for each species. Ratio of species would depend on availability, but mix may include alpine milkvetch, field oxytrope, arctic bladderpod, and Siberian aster for dry areas; and tilesy sage, boreal sweetvetch, alpine sweetvetch, tall fireweed for mesic areas.	Thick gravel or mineral fill stockpiles of waste rock, overburden, and marginal and oxide ore; diversion channel system.
Shrub cuttings and seedlings: Diamondleaf willow (*Salix planifolia*) Feltleaf willow (*Salix alaxensis*) Richardson willow (*Salix richardsonii*) Dwarf arctic birch (*Betula nana*)	For willows, one cutting on one-foot centers For birch seed, 100 seeds/m^2	Diversion channel system, moist depressions at other locations.

Source: ABR 2007b
*No data on germination success.

Continued monitoring of revegetation success and the effects of fugitive dust would be performed at the Red Dog Mine. Long-term monitoring plots were established along nine 2.5-mile (4-kilometer) long transects radiating out from the mine facilities (ABR 2007b, Figure 2). These plots would be monitored semi-annually over the next 10 years to provide information on changes in the plant community, both within and outside the dust shadow. This long-term study would aid in determining whether recovery of vegetation within the affected area is occurring in response to remedial efforts taken and ongoing efforts to reduce fugitive dust emissions. In addition, the Applicant would develop a reclamation registry to track revegetation efforts and success. The registry would likely include variables such as location, site characteristics, treatments applied, plant species, cover values, soil properties, and wildlife use. The registry would be updated every one to two years as new sites were added and additional monitoring data were collected (ABR 2007b).

Under ADNR Mining Laws and Regulations, land reclamation performance standards include leaving an area in a "condition that can reasonably be expected to return waterborne soil erosion to pre-mining levels within one year after the reclamation is completed, and that can reasonably be expected to achieve revegetation, where feasible, within five years after the reclamation is completed, without the need for fertilization or reseeding" (p.35, AS 27.19.100, 11 AAC 97.200). The statute goes on to say, however, that this standard is not required if it is incompatible with the post-mining land use approved for the mine (e.g., commercial). Most of the mine site is on land that is privately owned, and the post-mining land use would be determined by NANA (ABR 2007b).

Teck is working with ADNR to develop site-specific performance standards for revegetation at the Red Dog Mine site. Since the Red Dog Mine is still in the active mining phase, with few areas ready to be reclaimed, only selected areas have been revegetated. Consequently, little data are yet available on the success of revegetation efforts at the mine site. Thus, it is difficult to develop performance standards that are meaningful (and achievable) at this time. As more data become available from revegetation efforts (and rates of natural recovery) at the mine, Teck will develop, in consultation with ADNR, a list of goals and objectives for revegetation efforts that can serve as the basis for evaluating performance. This approach would help ensure that the performance standards developed are achievable within a reasonable time frame (both in terms of bond release and regulatory oversight) and are sustainable over the long term.

3.7.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A, development of the Aqqaluk Deposit would not occur and mining activities at the Main Pit would end by 2011. Dust deposition at the mine, port, and along the DMTS road would continue at current rates unless modified by measures established in the draft fugitive dust risk management plan currently in preparation.

3.7.3.3 Effects of Alternative B – Applicant's Proposed Action

Under Alternative B, mining activities would be extended to the Aqqaluk Deposit and would continue until 2031. The development of the Aqqaluk Deposit would have a long-term adverse impact on approximately 152.3 acres of wetland vegetation (see Section 3.8). In addition, approximately 27.3 acres of vegetation would be lost with the increase in tailings and water levels in the tailings impoundment. Vegetation surrounding the tailings impoundment consists primarily of an open low mesic birch-willow shrub community along the eastern shoreline and an open low mesic birch/willow-ericaceous shrub community along the western shoreline (SRK 2007). Most of this area has been previously disturbed by mining activities including a surface water diversion upslope. The vegetation along the southern shoreline has been completely removed to build the overburden storage area. The eastern shoreline has been impacted by mining facilities and their associated roads. Undisturbed vegetation near the tailings impoundment includes a portion of the eastern shoreline, extending from the southern edge of the waste rock dump storage area to the northern edge of the overburden storage area, and a portion of the western shore adjacent to the tailings dam.

Portions of the Aqqaluk Pit lie within the prevailing upwind direction of the mill site and the existing mining operation; therefore, a large portion of the fugitive dust which would be generated by the development of the Aqqaluk Deposit would fall within areas already adversely affected by dust deposition (SRK 2007). The primary difference between alternatives A and B, in terms of fugitive dust, is the extended period of time during which mining activities would occur, resulting in a longer period of dust deposition to the surrounding area. Effects similar to those occurring now would continue, including more rapid aging, changes in species composition, and reduced vigor for some plant species immediately downwind of the Aqqaluk Pit. Vehicular traffic along the DMTS road is discussed in Section 3.15 and traffic levels would be similar to levels expected under Alternative A, although traffic would continue through 2031.

3.7.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Under Alternative C, mining activities would be extended to the Aqqaluk Deposit and would continue until 2031. Concentrates would be transported from the mine to the port through a pipeline. Construction of the pipeline would result in long-term adverse impact on approximately 145 acres of vegetation. Additionally, vegetation would experience short-term adverse impacts from dust, due to proximity to construction activities. Materials used to construct the bench and to bury the pipeline would be collected from the active borrow sites located along the DMTS road. The borrow areas would not have to be enlarged beyond the sizes initially permitted; therefore, impacts to vegetation from the borrow areas have already been accounted for in the disturbed acreage for existing facilities. Construction of infrastructure to support the concentrate pipeline (e.g., filter presses and generators) would be done within the existing disturbance footprint and would not result in an additional impact on vegetation.

Dust deposition resulting from activities at the Main and Aqqaluk pits would be similar to alternatives B and D; however, dust deposition along the DMTS road would be reduced because of the reduction in vehicular traffic along the DMTS road. Traffic along the DMTS road would be limited to supply trucks and light vehicles only, and the rate of fugitive dust deposition would be reduced in two ways. First, the pipeline would eliminate the possibility of deposition resulting from ore concentrate escaping from the concentrate trucks during loading and unloading and while traversing the DMTS road. Second, the number and frequency of large heavy vehicles traveling along the DMTS road would be drastically reduced; therefore, the amount of fugitive dust (including gravel) deposited into the adjacent environment by these large vehicles would be similarly reduced. See Section 3.15, Transportation, for a discussion of differences between each alternative in regards to vehicular traffic. Similar to effects documented for the Dalton Highway (discussed above) fugitive dust could continue to affect vegetation close to the DMTS road.

Impacts to vegetation resulting from the extended mining efforts within the Aqqaluk Deposit and increased water levels in the tailings impoundment would be similar to those described under Alternative B. Under Alternative C, the Aqqaluk Pit would be partially backfilled and the tailings impoundment would be drained and covered with dry materials after the mine closes in 2031. These areas would be revegetated in a similar manner as those described above in Section 3.7.3.1.

3.7.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Under Alternative D, mining activities would be extended to the Aqqaluk Deposit and would continue until 2031. New construction under Alternative D would include two truck wash stations, and a new pipeline bench incorporated into the DMTS road. The truck wash station would be located within the existing disturbance footprint and would not result in any additional impact on vegetation. Construction of the pipeline bench would result in adverse impacts on approximately 145 acres of vegetation associated with placement of the fill material. Materials used to build the pipeline bench would be collected from existing borrow sites located adjacent to the DMTS road. Disturbances associated with borrow sites were addressed in the 1984 EIS. Since the size of these permitted facilities was addressed in the previous impact assessment, they are not counted again here. Impacts to vegetation resulting from expanded mining efforts within the Aqqaluk Deposit and increased water levels at the tailings impoundment would be similar to those experienced under Alternative B.

Under Alternative D, dust deposition resulting from activities at the Main and Aqqaluk pits would be similar to alternatives B and C; however, the truck washes would reduce the concentrate component of the fugitive dust deposited along the DMTS road. Studies conducted along gravel roads within the State of Alaska have shown that dust deposition resulting from the crushing and dispersal of road gravel to the adjacent environment can have detrimental effects to local vegetation (Walker and Everett 1987; Auerbach et al. 1997). These effects would continue to occur to vegetation already showing impacts from fugitive dust. Unlike Alternative C, which results in a reduction of vehicular traffic, traffic patterns would remain unchanged under Alternative D.

3.7.4 Vegetation – Summary

By 2011, an additional 18.5 acres of vegetation would be disturbed at the mine while mining of the Main Pit is completed. Alternatives B, C, and D add additional vegetative impacts associated with the 406 acres of disturbance at the mine site from development of the Aqqaluk Deposit. Under these alternatives, mining in the Aqqaluk Pit could produce a long-term adverse impact on surrounding vegetation from fugitive dust, which would be produced for the duration of operations.

Under alternatives A and B, fugitive dust emissions from road traffic would continue at the current rate, although fugitive dust control measures identified in the draft fugitive dust risk management plan may result in some reduction of dust levels. Vegetation in close proximity to the road would continue to be affected. This would occur through 2011 under Alternative A and 2031 under Alternative B. Alternatives C and D include 145 acres of disturbance associated with construction of the pipeline bench, although the bench would be reclaimed after closure under Alternative C. Alternative C would, however, reduce vegetation impacts along the road by eliminating fugitive emissions from concentrate trucks. Under Alternative D, fugitive emissions would be reduced to a lesser extent by installation of year-round truck wash facilities at the mine and port.

3.8 Wetlands

Wetlands are transitional areas existing between uplands and open water, commonly considered bogs, swamps, and muskegs. Wetlands provide benefits within the landscape, ranging from providing fish and wildlife habitat to improving water quality. The *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979) provides a basis for characterizing wetlands that can be applied across the United States. This system has been adopted by USFWS for use in its National Wetland Inventory (NWI) mapping program and is the standard approach used to identify and characterize wetlands. Under the Cowardin/NWI approach, two “systems” of wetlands occur within the project area: riverine (e.g., streams and rivers), and palustrine (e.g., tundra). The majority of wetlands occurring within the project area are palustrine wetlands, which have two subclasses: scrub-shrub and emergent. Scrub-shrub wetlands are dominated by shrubs less than 20 feet (6 meters) tall. Emergent wetlands are dominated by herbaceous (non-woody) vegetation, including grasses and sedges. Additional detail on project area wetlands is provided below in Section 3.8.1.

Wetlands are protected under Executive Order 11990, the “no net loss” policy in effect since 1988, and the CWA. Executive Order 11990 calls on agencies to minimize the “destruction, loss, or degradation” of wetlands in carrying out their responsibilities. The order also directs agencies to avoid undertaking or funding new construction in wetlands unless there are no practicable alternatives and all practical measures to minimize impacts to wetlands have been included in the proposal. The no net loss policy reinforces the ideas set forth in the executive order, calling for avoidance, minimization of impacts, and mitigation for unavoidable impacts. Section 404 of the CWA, administered by the Corps, establishes requirements for dredge and fill activities within waters of the U.S., including wetlands. Among other requirements, Section 404 requires compliance with Section 404(b)(1) guidelines. Subpart B of the guidelines requires an analysis to determine whether impacts may be avoided or, if unavoidable, minimized to the extent practicable. Ultimately, the guidelines require selection of the “least damaging practicable alternative” identified through the permitting process.

The Corps defines wetlands as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (Corps 1987). The Corps’ 1987 Manual and the State of Alaska regional supplement along with regulations at 33 CFR § 328 are the tools by which jurisdictional wetlands are identified in the State of Alaska. Jurisdictional wetlands are subject to Section 404 and are defined using soils, vegetation, and hydrologic characteristics. Areas displaying hydric soils with hydrophytic (water loving) vegetation that are saturated or inundated for a defined portion of the growing season and are not isolated from navigable waters of the U.S. are considered jurisdictional wetlands (Corps 1987).

The connectivity of wetlands to navigable waters is a component of jurisdictional wetland determination that has come under closer review in recent years as a result of legal rulings. Red Dog Creek and its tributaries drain to the Wulik River and ultimately to the Chukchi Sea, a navigable water. Most wetlands within the project area are adjacent (connected) to Red Dog Creek and tributaries and are, therefore, considered jurisdictional. Likewise, wetlands occurring along the DMTS road occur adjacent to creeks and streams draining to the Chukchi Sea and are also considered jurisdictional.

3.8.1 Wetlands – Pre-mining Environment

The 1984 EIS describes wetlands based on the vegetative communities that still occur in the undisturbed landscape. Wetland habitat types mapped as part of the 1984 EIS include sedge-grass marsh, sedge-grass wet meadow, sedge-grass bog meadow, wetland herbaceous, sedge-grass tundra, tussock tundra, and open low shrub communities. Wetland types also include riparian tall and riparian low shrubs that occur along the low river terraces and river bars.

Wetland functions are the biological, chemical, and physical processes that occur within wetland systems in the landscape. The degree to which wetlands perform particular functions depends on numerous factors, such as their classification (see below), size, species present, proximity to other habitat types (or disturbances), and location within the landscape. The 1984 EIS described sedge-grass marsh, wet meadow, and bog wetland communities in the project area as providing functions, including wildlife habitat, filtration, erosion control, and runoff retention with moderate to high wetland values. Wetlands occurring along the DMTS corridor (tussock tundra, open low shrub, and wetland complexes) were generally assigned low to moderate values with higher values applying to communities in lowland basins and drainage areas (EPA 1984). Coastal wetlands were also identified for providing nutrient and detrital movement and flood control. The methodology employed to assess wetland function was not provided. Overall, wetland losses were considered to be localized with insignificant effects when considered on a regional basis (EPA 1984).

The 1984 EIS predated the release of the Corps’ 1987 Manual; therefore, wetlands were not identified at the time using the same criteria as “jurisdictional” wetlands are currently delineated. Vegetation community mapping (including wetlands) completed as part of the original baseline (Dames & Moore 1983a) is also inconsistent with more recent vegetation mapping (ABR 2007c; DOWL 2009), which employ a classification system described by Viereck et al. (1992). The discussions that follow are based on the most applicable data set.

3.8.2 Wetlands – Baseline Conditions

Baseline conditions at the project site reflect the current status of wetlands in the vicinity of the mining operations and along the DMTS road. The following discussion relies on data collected in support of the 1984 EIS to the extent necessary, and more heavily on the results of more recent wetland mapping that has been conducted in the vicinity of the mine site and along the DMTS road. The approach to characterizing the baseline condition is to provide a description of wetland/community types that occur within the area, followed by a discussion of the impacts that have occurred to date. Figure 3.15 presents the existing wetlands in the vicinity of the mine area.

3.8.2.1 National Wetland Inventory Classification Descriptions

As noted in the introduction to Section 3.8, the Cowardin/NWI mapping system is used consistently to describe wetland habitats. The following section reflects the descriptions provided by ABR (2007c) and DOWL (2009) for wetland communities occurring in the vicinity of the mine site and along the DMTS road. The overlap with vegetation/wetland communities identified in the 1984 EIS is included to the extent it can be determined. NWI identifiers used by wetland scientists are presented in parentheses below following the names of the wetland communities.

Sedge-Shrub Meadow (PEM/SS1B, PSS/EM1B). Sedge-shrub meadow is the most common vegetation type within the vicinity of the mine site and is dominated either by shrubs or grass-like plants. Dominant species within these communities include cottongrass (*Eriophorum vaginatum*), along with low diamondleaf willow (*Salix planifolia*), dwarf birch (*Betula nana*), and bog blueberry (*Vaccinium uliginosum*). This community type includes the open low shrub and sedge-grass tundra communities described in the 1984 EIS.

Tussock Tundra (PSS/EM1A, PSS/EM1C). This is the most common community occurring along the DMTS road. Dominant species occurring within tussock tundra are similar to other vegetation communities and include cottongrass, sedges (*Carex bigelowii and C. microchaeta*), narrow-leaf Labrador tea (*Ledum decumbens*), and dwarf birch. Associated species include bog blueberry, cranberry (*V. vitis-idaea*), crowberry (*Empetrum nigrum*), and cloudberry (*Rubus chamaemorus*). This community type generally corresponds to the tussock tundra community discussed in the 1984 EIS.

Polygonal Tundra (PSS/EM1C). Polygonal tundra is also a common community occurring along the DMTS road. Dominant shrub species are similar to those that occur within tussock tundra. However, this community occupies sites that are generally wetter than the tussock tundra community and, therefore, include cottongrass, sedges, and other understory species better adapted to wetter conditions. This community generally corresponds to the low shrub communities combined with the sedge grass meadow and tundra communities described in the 1984 EIS.

Mixed Shrub (PSS1B). These communities are dominated by low to tall (less than 5-foot [1.5-meter]) shrubs consisting of either birch or willow. Creek drainages are dominated by willow with understory vegetation consisting of bluejoint grass (*Calamagrostis canadensis*), arctic sweet coltsfoot (*Petasites frigidus*), horsetail (*Equisetum* spp.), and other forbs. On hillsides and in swales, mixed shrub communities are uncommon but where they occur, understory species often consist of Labrador tea and blueberry. This community generally corresponds to open and closed tall shrub communities described in the 1984 EIS based on its distribution in the landscape.

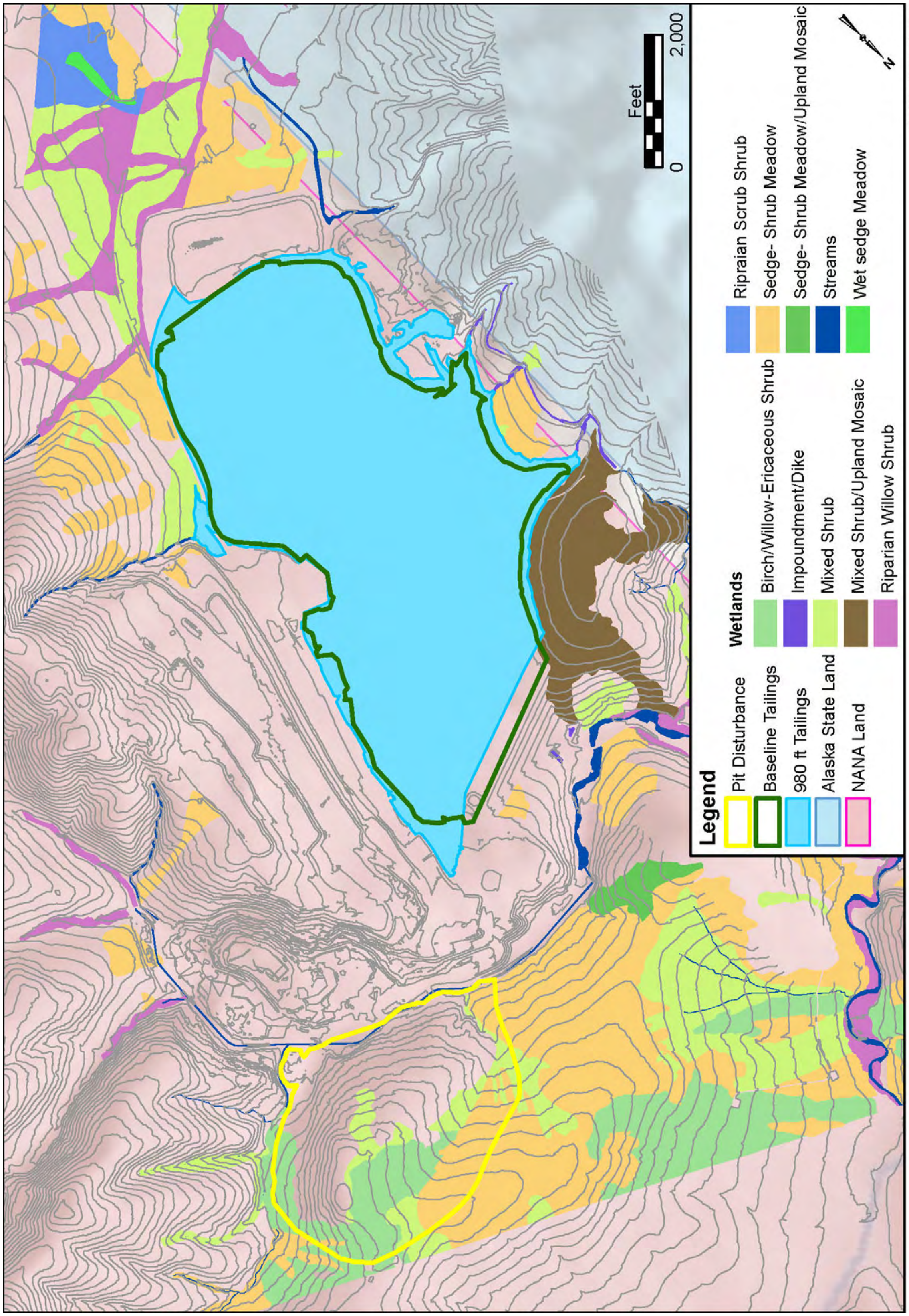


FIGURE 3.15

WETLANDS WITHIN THE MINE AREA

Birch/Willow-Ericaceous Shrub (PSS1/3B). This type occurs in all physiographic positions, from lowland to alpine areas. Shrubs are mostly low (less than 5 feet [1.5 meters] tall) or dwarf (under 0.6 feet [20 centimeters] tall) in size. Canopy cover varies from 25 to over 100 percent. Common species consist of dwarf birch, willow, blueberry and Labrador tea, often with an understory shrub layer of cranberry and crowberry. This community corresponds most closely to the open low shrub communities presented in the 1984 EIS.

Willow Shrub (PSS1C). Most of the tall willow communities are restricted to active floodplain areas along Red Dog Creek and some of the larger creeks along the DMTS road. These communities remain in early successional stages with low species diversity. The most common species is feltleaf willow (*S. alaxensis*). These areas are subject to inundation during peak runoff in spring, and to flooding throughout the growing season. The site also includes low willow communities that are distributed outside the riparian areas and into the hillsides. The riparian willow shrub community, like the mixed shrub community, occupies habitats similar to the tall shrub communities described in the 1984 EIS. The low willow communities occupy areas similar to the open and closed low shrub communities identified in the 1984 EIS.

Sedge-Shrub Meadow/Upland Mosaic (PEM/SS1B//U). This vegetation type consists of a mosaic of Sedge-Shrub Meadow, with inclusions of upland plant communities occurring on gentle slopes (1–3 percent grade). Frost features, such as hummocks and boils, are common. Upland inclusions are composed primarily of arctic willow (*S. arctica*), bearberry (*Arctostaphylos rubra*), altai fescue (*Festuca altaica*), and arctic bentgrass (*Agrostis aequivalvis*). The 1984 EIS described the mixture of wetland and upland communities as complexes rather than mosaics. The sedge-shrub meadow/upland mosaic correspond to the low shrub complexes.

Mixed-Shrub/Upland Mosaic (PSS1B//U). This community occurs in the vicinity of the tailings impoundment and, although the upland plots within the mosaic did not meet the soils or hydrological parameters to be a wetland, hydrophytic vegetation was present (ABR 2007c). Similar to the sedge-shrub meadow/upland mosaic, this mosaic occurs on gentle sloping hillsides, where small variations in topography result in islands of upland areas within a predominantly wetland matrix. Also occurring within this type are small (less than 0.5 acres in size) inclusions of birch/willow-ericaceous shrub. Common species are diamondleaf willow, dwarf birch, Labrador tea, Bigelow’s sedge, cottongrass, and arctic bentgrass. This mosaic corresponds to the tall shrub and complexes identified in the 1984 EIS.

Streams (R3UBH/R2UB1/R2UB2). Streams are a wetland class rather than a community and in this case consist of unvegetated, upper and lower perennial riverine wetlands that include Red Dog Creek and its tributaries, and the creeks and rivers traversed by the DMTS road. The bottom (beds) of streams within the area are unconsolidated and consist of a range of materials from sand to gravel and cobbles.

Impoundment/Dike (PUBHh). This category encompasses impoundments and water diversion structures that are not naturally occurring and were built as part of the water management system. The tailings impoundment itself is considered a waste treatment facility and is not identified under any wetland class. The impoundment/dike category includes the Bons Creek Reservoir as well as a series of diversions and small impoundments above the tailings impoundment that are designed to keep uncontaminated water from entering the tailings facility. With the exception of the Bons Creek Reservoir, these diversions and impoundments have been built in uplands and are not jurisdictional. None of these wetlands were described in the 1984 EIS.

Upland (U). Uplands occur throughout the study area, particularly on hilltops and upper slopes of the Aqqaluk Deposit, as well as on steep slopes and well-drained benches throughout the study area. Common species vary depending on physiographic position, although dwarf birch, diamondleaf willow, blueberry, and Labrador tea are frequently present. On hillsides, bearberry, arctic willow, crowberry, altai fescue, arctic bentgrass, shortstalk sedge (*C. podocarpa*), and grayleaf willow (*S. glauca*) are common. Shrub height varies, but is mostly under 5 feet [1.5 meters] tall. In lowland areas, uplands occur on stabilized terraces along Red Dog Creek, supporting well-drained, coarse textured soils. Common species include feltleaf and diamondleaf willows.

Disturbed Upland (Us). These land cover types apply to gravel fill and spoil associated with roads, trails, pads and other disturbed areas.

3.8.2.2 Wetland Impacts from Existing Operations

The number of wetlands actually disturbed by construction of the Red Dog Mine and associated facilities cannot be accurately measured because of the lack of detail in pre-mining surveys. Wetland delineations, Section 404 permit applications, and spatial data collected since the release of the 1984 EIS are information sources that can be used to estimate the extent of existing wetland impacts, but only for some facilities. As presented in Table 3.8-1, the 1984 EIS predicted that development of the mine facilities and the DMTS would impact approximately 1,356 acres of wetlands (738.0 acres for the mine facilities and 658.0 acres for the port, road, and material borrow sites). The 1984 EIS noted that developing the mine site, including the Main Pit and tailings impoundment, would disturb sedge-grass tundra and low shrub tundra wetland types. Port and road construction were expected to affect more types of wetland communities including open low shrub complexes, sedge-grass tundra, tussock tundra, tussock tundra-low shrub complexes, sedge-grass marsh, sedge-grass wet meadow, sedge-grass bog meadow, and wetland herbaceous (EPA 1984).

Table 3.8-1 Existing Wetlands Impacts as Predicted in the 1984 EIS Versus Observed Impacts

National Wetland Inventory Class	Existing Wetlands w/in Study Area[a] (acres)	Wetlands Disturbed to Date at Mine Site (acres)		Wetlands Disturbed to Date by Port and DMTS Road[b] (acres)	
		Predicted[c]	Actual	Predicted[c]	Actual[d]
Upland (U)	1,875.8	618.0	N/A	96.0	104.2
Scrub-Shrub (PSS) [e]	3,231.2	399.0	N/A	218.0	482.8
Emergent (PEM) [f]	623.4	339.0	N/A	440.0	32.5
Unvegetated Waters (PUS, PAB)	41.9	–	N/A	–	1.0
Riverine (R)	34.4	–	N/A	–	1.3
Total Wetlands	3,930.9	738.0	885.0[g]	658.0	517.6
TOTAL	**5,806.7**	**1,356.0**	**1,475.0[h]**	**754.0**	**621.8**

[a] The Study Area encompasses the area around the mine and around the DMTS. Mine Site Study Area includes the general vicinity around the mine facilities. The DMTS Study Area covers 300 feet on either side of the DMTS and 300 feet from existing disturbance boundaries around the port facilities.
[b] DMTS disturbances include the material borrow sites used for construction
[c] EPA 1984
[d] DOWL Engineers in preparation
[e] PSS includes PSS-dominated PSS/EM complexes, including wetland/upland complexes
[f] PEM includes PEM-dominated PEM/SS complexes, including wetland/upland complexes
[g] Estimated based on a 60:40 wetlands to uplands ratio observed by ABR (2007c)
[h] SRK 2007
N/A = Not Available. Information to make a more accurate estimate of impacts than presented in the 1984 EIS is not available.
— = no disturbance predicted

Based on post-1984 data, the DMTS port and road, and material borrow sites have affected 517.6 acres of wetlands (see Table 3.8-1) (DOWL 2009). DOWL's data show wetlands form approximately 75 percent of the landscape adjacent to the DMTS road. This percentage is higher than the percentage of wetlands surrounding the mine site (discussed below) because the more gentle topography generally transected by the DMTS road better supports wetland hydrology. The 517.6 acres of existing impacts represents a relatively small impact when considered in context with the wetlands in the surrounding area. For example, the drainage area for Ikalukrok Creek includes approximately 67,200 acres (105 square miles) and represents a relatively small portion of the drainage area traversed by the DMTS road. If 75 percent of the drainage area for the Ikalukrok Creek was considered wetlands, then wetlands would account for 50,400 acres. The 517.7 acres of impacted wetlands represents slightly more than 1 percent of wetlands within the Ikalukrok Creek drainage. While this approach is a gross approximation, it puts the impacts into context within the landscape.

The post-1984 data is insufficient to provide an accurate measure of the wetlands impacted by construction of the mine site facilities, including the Main Pit, tailings impoundment, mill site, and waste rock dump. However, based on an observed ratio of 60 percent wetlands to 40 percent uplands (observed by ABR [2007c] and discussed below), a gross estimate for wetlands impacted by existing operations is 885 acres. To put that number into perspective, the drainage area for South and Middle Fork Red Dog Creek encompasses nearly 5,570 acres. Based on the 60 percent of estimated wetlands in the vicinity, roughly 3,342 acres would have been wetlands. Using these numbers as a very rough estimate, existing operations have disturbed approximately 26 percent of the wetlands within the South and Middle Fork Red Dog Creek drainages.

Exploration activities, mainly focused on the Aqqaluk Deposit, were not considered in the scope of the 1984 EIS. Exploration of the Aqqaluk Deposit has been conducted under the Corps' Nationwide Permit No. 6, which limits the extent of impacts to bore holes and temporary pads. These impacts have been minimal. Minor impacts have also occurred during the construction of access roads (also under permit) to the exploration sites. Activities in upland areas within the Aqqaluk exploration area could also have allowed sediment to be carried into wetland areas from adjacent unvegetated areas. Wetlands in the area may have also experienced a reduction in the value of wildlife habitat with the displacement of wildlife as a result of exploration activities. Since activity on the site has been intermittent, effects on habitat would primarily have occurred while exploration activities were going on; however, even intermittent activity could have negatively affected long-term wildlife use, such as nesting birds.

Fugitive dust emissions have occurred along the DMTS road and in the vicinity of the mine and port. The 1984 EIS noted that fugitive dust was likely to have an effect on vegetation along the DMTS road, although the full nature of the effects may not have been predicted. As discussed in detail in Section 3.7.2, the presence of lead and zinc concentrates in the fugitive dust has caused an effect on vegetation and, subsequently, an effect on wetland communities. In general, these effects would result in a shift in species composition. The degree of effect resulting from changes in species composition would depend on changes to the habitat values. The presence of the DMTS road provides an increased opportunity for emergent and scrub shrub wetlands to provide a sediment/toxicant capture and reduction function as runoff from the DMTS road would be filtered by wetlands prior to entering surface water.

3.8.2.3 Baseline Conditions

Mine Area

As noted previously, post-1984 mapping of undisturbed wetlands has been conducted in the vicinity of the mine site, including areas around the tailings impoundment and the Aqqaluk Deposit and along the DMTS road. Table 3.8-2 presents the results of ABR's wetland delineation of the mine area (ABR 2007c). It indicates that sedge-shrub meadow communities cover the greatest area (428.9 acres) within the mine area, followed by birch/willow-ericaceous shrub wetlands (212.1 acres) and mixed shrub/upland mosaics (113.3 acres). Mosaic areas include mixtures of wetland and upland types occurring across areas too small to map distinctly. ABR estimated that the wetland:upland ratio in these areas is approximately 60:40 (ABR 2007c). ABR did not describe the methodology used to determine the wetland:upland ratio but noted that it varied depending on location and that the 60:40 ratio was an average (ABR 2007c). Riparian and open water (unvegetated) wetlands account for 51.1 acres including the Bons Creek Reservoir and Red Dog Creek, diversion dikes, and upper perennial streams, (the tailings impoundment is a waste treatment facility and not considered wetland). Figure 3.15 illustrates existing wetlands in the mine area.

Table 3.8-2 Existing Wetlands Mapped within the General Mine Area (ABR 2007c)

Type	NWI Class	Description	Mine Site Acres	Percent of Area
Wetland	PEM/SS1B, PSS/EMIB	Ericaceous Shrub-Sedge Meadow	428.9	24.9
	PSS1B	Mixed Shrub	169.9	9.9
	PSS1/3B	Birch/Willow-Ericaceous Shrub	212.1	12.3
	PSS1C	Willow Shrub	31.9	1.9
Wetland/Upland Mosaic	PEM/SS1B//U	Sedge-Shrub Meadow/Upland Mosaic (wetland component)	15.9 (9.5)	0.9 (0.5)
	PSS1B//U	Mixed Shrub/Upland Mosaic	113.3 (68.0)	6.8 (3.9)
Unvegetated Waters	R3UBH	Streams	26.7	1.6
	PUBHh	Impoundment/ Dike (unvegetated)	51.1[b]	3.0
Total Waters of the U.S. (including wetland component of mosaics) [a]			**982.7**	**57.1**

Source: ABR 2007c

[a] These numbers include the acres of the wetland and upland components, respectively, of the wetland/upland complexes based on the estimated 60:40 ratio of wetlands:uplands. The methodology to determine the ratio of wetlands:uplands was not provided.

[b] While the impoundment/dike types are non-jurisdictional and not considered Waters of the U.S. in and of themselves, any wetland areas inundated by these man-made structures would remain jurisdictional. For purposes of this analysis these wetland areas are not considered jurisdictional. The impoundment created for the Bons Creek Reservoir (35.7 acres) is connected to a relatively permanent water (Bons Creek); it is considered jurisdictional.

Port and DMTS Road Area

The character of the wetlands adjacent to the port and DMTS road reflects the differences in elevation, substrate, and hydrology from the coastal plains adjacent to the port and to the hills surrounding the Red Dog Mine. As presented in Table 3.8-3, the study conducted by DOWL (2009), which surveyed wetlands within 300 feet of existing disturbance boundaries, identified that tussock tundra, polygonal tundra, and birch/willow-ericaceous shrub communities dominate the landscape adjacent to the DMTS road. Willow communities occur along the small drainages. These observations confirm those presented in the 1984 EIS corresponding to the tussock tundra and various shrub communities. Some of the areas identified as unvegetated water may have developed as a result of the presence of the DMTS road where water may be impounded on the upstream side of the road. Insufficient detail exists on the pre-mining conditions to confirm that these areas have formed as a result of the DMTS road construction. The existing road surfaces and disturbances in the vicinity of the port account for over 600 acres or 15 percent of the study area.

3.8.3 Wetlands – Environmental Consequences

3.8.3.1 Effects Common to All Alternatives

Effects common to all alternatives are simply those that result in a loss of wetlands through filling and inundation. All alternatives would include continued use of the tailings impoundment where tailings

Table 3.8-3 Existing Wetlands Mapped along the DMTS Facilities (DOWL in prep)

Type	NWI Class	Description	DMTS Acres	Percent of Area
Wetland	PSS/EM1B	Tussock Tundra	1,302.2	31.3
	PSS/EM1C	Polygon Tundra	598.9	14.4
	PSS/EM1A	Birch/Willow-Ericaceous Shrub	685.7	16.5
	PEM1, PEM/SS1	Sedge-Shrub meadow	185.0	4.4
	PSS/EM1A, PSS/EM1B	Willow Shrub	118.5	2.9
	PSS/EM1B, PSS/EM1C	Mixed Shrub	44	1.1
Unvegetated Waters	PAB3H, PUS1, PUS5	Open Water	6.2	0.1
	R2UB1, R2UB2, R3UB2	Streams	7.7	0.2
Total Waters of the U.S.			**2,948.2**	**74.9**

would bury additional wetlands as the levels rise. The deposition of fugitive dust would continue under any of the alternatives. Since fugitive dust would affect the vegetation component of wetlands, the impacts are discussed in Section 3.7, Vegetation.

3.8.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A, no additional impacts to wetland resources would occur beyond those that have already occurred. Tailings disposal would continue through 2011, resulting in a small increase in the level of tailings and water in the impoundment. However, wetlands that would be affected by this increase have already been accounted for under existing Section 404 permits. The existing permits do not include the replacement of wetlands on site or off site as part of mitigation.

While the tailings impoundment and Main Pit would contain water over the long term, these areas would provide few of the functions typically associated with lacustrine (or palustrine) wetlands and therefore would only minimally offset any of the functions and values lost with wetlands impacted by the project. Wetland impacts would be permanent.

3.8.3.3 Effects of Alternative B – Applicant's Proposed Action

Under Alternative B, Section 404 permits would be required to raise the tailings impoundment and to develop the Aqqaluk Deposit. Teck has submitted an application to the Corps for a Section 404 permit to develop the Aqqaluk Deposit; the public notice for this application is concurrent with the release of this final SEIS. Teck plans to submit another Section 404 permit application at some point in the future to address wetlands that would be affected by the increases in the height of the tailings impoundment, as well as the levels of water and tailings within the impoundment itself. The current analysis includes the effects of each of these activities regardless of the status of permit applications. The analysis considers Teck's proposed mitigation plan, including steps taken to avoid or minimize impacts to wetlands. In the future, when a permit application is submitted to the Corps (see Appendix A for the Corps' review procedure) for raising the level of the tailings impoundment, the Corps would consider this existing analysis and would conduct additional review to evaluate all described activities, including mitigation proposals.

Wetlands within the Aqqaluk Pit disturbance area consist primarily of sedge-shrub meadow, willow, and mixed shrub communities. Many of these wetlands would be physically removed in the process of developing the pit, which in addition to excavation would include the construction of access roads, diversion ditches and other supporting facilities.

Some wetlands within the footprint of the tailings impoundment would be covered by tailings and inundated by the overlying water cover while others would be filled by the relocation of the access road, diversion structures, and raising the dam itself. No additional wetland impacts would occur along the DMTS road. Table 3.8-4 summarizes the extent of wetland disturbance within each area as a result of developing the Aqqaluk Deposit.

Teck would avoid wetland impacts to the area surrounding the existing waste rock dump by disposing of waste rock in the mined-out Main Pit. Impacts would be minimized by designing the pit as small as possible while still being able remove the ore; wetlands impacts on the periphery would be minimized by keeping the pit walls as steep as possible while maintaining appropriate worker safety and pit stability. The increment of unavoidable wetland loss as a result of the Aqqaluk Project would be relatively small compared to the impact from the initial operation assessed in the 1984 EIS (145.1 acres lost in developing Aqqaluk versus 1,475.0 lost developing the existing operation). Within the South and Middle Fork Red Dog Creek drainages, the losses would be more substantial, with 145.1 acres of impacts to the estimated 2,457 acres of wetlands remaining within the drainage. The incremental loss in wetland function would be smaller when compared to the effects of existing impacts. For example, the value of the wildlife habitat function in many wetlands surrounding the mining area had already been reduced as a result of mining activity prior to being filled by tailings or being removed in the process of developing Aqqaluk Pit.

Table 3.8-4 Wetland Types and Proposed Disturbance Under Alternative B (Acres)

Wetland Classification	Community Type	Aqqaluk Deposit	Tailings Impoundment[a]		Total
		Disturbance Area	Filled	Inundated	
PSS1/3B	Birch/Willow-Ericaceous Shrub	51.0	0	0	51.0
PSS1B	Mixed Shrub	28.9	1.1	0.4	30.4
PEM/SS1B, PEM/EM1B	Sedge-Shrub Meadow	38.6	5.5	2.7	46.8
PEM/SS1B//U	Sedge-Shrub Meadow/Upland Mosaic	0 0	13.4 (8.1)	0	13.4 (8.1)
PSS1B//U	Mixed Shrub/Upland Mosaic (wetland component)	0 0	8.1 (4.9)	5.3 (3.2)	13.4 (8.1)
PUBHh	Impoundment/Dike[b]	0 0	1.3	0.2	1.5
R3UBH	Streams	0.5	0	0	0.5
Total Waters of the U.S. (including wetland component of mosaics)[c]		**119.0**	**19.6**	**6.5**	**145.1**

[a] These numbers reflect effects that would result with a tailings dam height of 986 feet in elevation.

[b] Non-jurisdictional wetlands and not counted toward total waters.

[c] Except as noted, the analysis assumes all wetlands identified are jurisdictional based on the Corps review of the jurisdictional delineation submitted as part of ABR 2007c.

Closure under Alternative B would include open water over the tailings in the impoundment and the development of a pit lake in the mined-out Aqqaluk Pit. Similar to closure under Alternative A, these facilities would provide little of the wetland function that existed on the site before development. The loss in the value of fish habit was already limited by pre-mining water quality within the Middle Fork Red Dog Creek and its tributaries (see Section 3.10.1). The wildlife habitat function provided by wetlands within the Aqqaluk Pit disturbance area would be lost permanently.

The development of wetlands on reclaimed portions of the backfilled Main Pit and waste rock dump would be discouraged because of the potential to enhance infiltration into these facilities (infiltration could produce acid rock drainage). Overall, the loss of wetland wildlife habitat throughout the site may, to some extent, be offset by the uplands formed in reclamation; however, habitat value would ultimately depend on the plant communities that would become established.

Mitigation of wetland impacts generally means avoiding impacts to the greatest extent possible. If impacts are unavoidable, the goal is to minimize their extent. The final aspect of mitigation is to provide compensation for unavoidable losses. The Corps recently finalized a new rule regarding mitigation for wetland impacts and now requires applicants to submit a mitigation plan along with their Section 404 permit applications. The new rule emphasizes mitigation banks and in-lieu fee programs over permittee-responsible mitigation. Teck has proposed to use the “in lieu fee” approach for compensatory mitigation where they would purchase credits at a 1.5:1 to 2:1 ratio of compensation. The in lieu fee program would not likely create or protect wetlands in the Red Dog Creek watershed, meaning that wetland losses in the vicinity would be permanent as discussed above. As part of its review process, the Corps will evaluate whether Teck’s proposal under the in lieu fee program satisfies Section 404 regulatory requirements. The Corps will require that the future Section 404 permit application to raise the level of the tailings impoundment also include a mitigation plan.

3.8.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Under Alternative C, the Section 404 permits identified under Alternative B would be required, as would Section 404 permit authorization to fill wetlands associated with the pipeline bench. Impacts to wetlands resulting from mining activities would be the same under Alternative C as Alternative B, since mining operations would be similar under both alternatives. Closure would be different and would involve open water only in the Aqqaluk Pit; however, water in the Aqqaluk Pit would not provide suitable value and function to be considered wetland habitat in the post-mining landscape. The dry cover over the tailings impoundment would be intended to reduce the amount of infiltration moving through the reclaimed tailings impoundment. Therefore, the establishment of wetlands as part of reclamation within the impoundment would be counter to the long-term objective of minimizing the water that would need to be collected and treated. The presence of wetlands in the reclaimed impoundment could result in increased water leaching through the facility and producing acid mine drainage along with high metals concentrations. For comparative purposes, wetlands impacts from the tailings impoundment and Aqqaluk Pit development under Alternative C would be the same as under Alternative B.

The pipeline bench would be incorporated into the DMTS road, which currently includes nine bridges, three large culvert crossings, and 445 small culverts. The bridges and large culvert crossings address stream crossings, while the small culverts address surface flow. Each culvert would need to be extended underneath the pipeline bench. The pipelines would be cantilevered off the bridges. Construction of the pipeline bench would require the filling of approximately 125.5 acres of wetlands (see Table 3.8-5). The value of some of these wetlands had already been reduced (e.g., wildlife habitat) as a result of the presence of the DMTS road. Many of the wetlands immediately adjacent to the DMTS road have also been affected from both fugitive dust and sediment carried from the road surface. Impacts to wetlands adjacent to the newly constructed bench would be similar to those already being experienced adjacent to the DMTS road, and would include a reduction in value in terms of wildlife habitat. Wetlands immediately adjacent to the road are likely to have undergone sediment deposition from the road. Sediment would be controlled during construction using best management practices, including the installation and maintenance of silt fencing. The fill constituting the pipeline bench would be removed at the end of mining operations from the approximately 125.5 acres of wetlands filled during its construction. Since no mitigation plan for wetlands is available for review, the analysis assumes that wetlands would be allowed to recover naturally. As such, the extent to which wetlands become re-established is uncertain and ultimately, some or all wetland losses could be permanent.

Any ancillary facilities constructed at the port under Alternative C are assumed to be built either within the existing disturbance footprint or in uplands. Therefore, no additional wetland impacts are considered at the port site.

Table 3.8-5 Wetland Types and Proposed Disturbance Under Alternative C

Wetland Classification	Community Type	Pipeline Bench	Aqqaluk Area[a]	Tailings Impoundment[a]	Total
PSS1/3B	Birch/Willow-Ericaceous Shrub	27.7	51.0	0	78.7
PSS1B	Mixed Shrub	0	28.9	1.5	30.4
PSS/EM1B	Tussock Tundra	84.0	0	0	84.0
PSS1C	Willow Shrub	5.0	0	0	5.0
PSS1B//U	Mixed Shrub/Upland Mosaic	0	0	13.4 (8.1)	13.4 (8.1)
PEM/SS1B, PSS/EM1B	Sedge-Shrub Meadow	8.3	38.6	8.2	55.1
PEM/SS1B//U	Sedge-Shrub Meadow/Upland Mosaic (wetland component)	0	0	13.4 (8.1)	13.4 (8.1)
PUS	Unconsolidated Shoreline	<0.1	0	0	<0.1
PUBHh	Impoundment/Dike[b]	0	0	1.5	1.5
R3UBH	Streams	0.5	0.5	0	1.0
Total Waters of the U.S. (including wetland component of mosaics)		**125.5**	**119.0**	**27.4**	**271.9**

[a] The impacted acres include the Aqqaluk Pit disturbance area and the filled and inundated areas in the tailings impoundment.
[b] Non-jurisdictional wetlands and not counted toward total waters.

3.8.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

The effects of Alternative D would be the same as Alternative C in terms of the acres of wetlands filled during operations. While only a single pipeline would be necessary under this alternative, the 24-foot wide pipeline bench (containing a 20-foot wide working surface) is standard engineering practice. Per Alternative C, a Section 404 permit would be needed to authorize wetlands fill associated with construction of the pipeline bench. A wetlands mitigation plan would also be required. The approximately 125.5 acres of wetland impacts resulting from the construction of the pipeline bench would be permanent under Alternative D, unlike Alternative C where the bench would be removed following closure. The pipeline would remain in perpetuity to maintain the wastewater discharge from the water treatment plant at the mine site to the Chukchi Sea. The closure plan for Alternative D would be similar to Alternative B in that the tailings impoundment would remain open water and water would be allowed to accumulate in the Aqqaluk Pit.

3.8.4 Wetlands – Summary

Wetlands would be affected under any of the alternatives selected. Under Alternative A, the extent of wetland impacts would be limited, resulting from the increase in the elevation of the tailings dam to 970 feet, which has already been permitted. Approximately 145 acres of wetland impacts would occur under alternatives B, C, and D as a result of increasing the height of the tailing dam and inundating the area around the impoundment, along with development of the Aqqaluk Pit. Alternatives C and D would generate an additional 125.5 acres of wetlands impacts with construction of the pipeline bench; under Alternative C the fill would be temporary since it would be removed at the end of the operation in 2031, while the fill would be permanent under Alternative D. The greatest loss of wetlands would occur within the South and Middle Fork Red Dog Creek drainages where most of the loss in function would be permanent.

3.9 Wildlife

The geographic remoteness, cold climate, and low level of development in northern Alaska result in the presence of thriving wildlife populations that are uncommon or absent elsewhere in North America. Many of these species are an integral part of the environment and have special cultural and socioeconomic importance, though they are not given a specially designated status. This section discusses wildlife resources in the project area that have been identified as being potentially affected by the proposed project.

Threatened and endangered species are managed under the authority of the ESA (36 USC 1531-1544). The ESA requires federal agencies, including EPA, to make certain that all activities they “authorize, fund, or carry out” will not jeopardize the continued existence of any threatened or endangered species or designated critical habitat. Marine mammals, including the polar bear, are also protected by the Marine Mammal Protection Act. USFWS and NMFS share responsibility for implementing the ESA, with terrestrial species falling under the jurisdiction of USFWS and marine mammals falling under the jurisdiction of NMFS.

Migratory birds are protected by the Migratory Bird Treaty Act (MBTA) of 1918 (16 USC 703-712). The MBTA implements various treaties and conventions between the U.S., Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Taking, killing, or possessing migratory birds is unlawful under the MBTA.

Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds), issued in 2001, provides for the conservation of migratory birds and their habitats and requires the evaluation of the effects of federal actions on migratory birds, with an emphasis on species of concern. Federal agencies are required to support the intent of the migratory bird conventions by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory birds when conducting agency actions.

Although eagles are not considered rare in this part of the State of Alaska, another regulatory mechanism that applies to wildlife in the project area is the Bald and Golden Eagle Protection Act of 1940 (16 USC 668). This act makes it illegal, unless specially permitted, to “take” any bald or golden eagle, alive or dead, or any eagle part, nest, or egg.

This section addresses wildlife resources in the project area. Section 3.9.1 describes the pre-mining environment. Post-mining baseline conditions are described in Section 3.9.2. Section 3.9.3 discusses the effects of the alternatives to wildlife resources.

3.9.1 Wildlife – Pre-mining Environment

3.9.1.1 Wildlife Habitat

Located within the transitional area between the DeLong Mountains and the Chukchi Sea, the Red Dog Mine project area includes inland, coastal, and marine habitats supporting a diversity of wildlife species. The 1984 EIS (EPA 1984) describes the project area as being primarily undeveloped and characterized by moderately sloping hills, broad stream valleys, and coastal lowland lagoon systems. The highest inland areas are sparsely vegetated and support *Dryas* alpine tundra. At lower elevations this habitat becomes a vast expanse of low shrub tussock tundra and sedge-grass tundra interspersed with willow thickets along rivers and small drainages, marshes, and wet meadows (EPA 1984; SRK 2007).

At the coast, tundra transitions into grass-dominated gravel beaches, separating the Chukchi Sea from a series of coastal lagoons (EPA 1984; Corps 2005). Three large lagoons in the immediate vicinity of the port, two of which (Kivalina and Ipiavik lagoons located north of the existing port) are hydrologically connected to the sea and are often brackish. The third large lagoon (Imikruk Lagoon located south of the port) is a freshwater system with no hydraulic connection to the sea except during storm surges; numerous smaller lagoons are located near the port site. Emergent vegetation grows along the shorelines of most lagoons, providing habitat for numerous waterbirds (EPA 1984). A detailed description of plant species associated with these habitat types is provided in Section 3.7.

The near-shore marine environment is characterized by the annual formation and melting of sea ice. The Chukchi Sea is covered in ice from mid-November through May or June. Waters along the coast, within the project area, begin to freeze in early October with a solid cover of ice typically forming in January

(RWJ 1997). Polynyas, or expanses of open water or thin new ice surrounded by sea ice, form within the marine environment when the right combination of environmental conditions (e.g., temperature, tide, current, upwelling, and wind) are present. Polynyas are used by arctic birds and marine mammals for migration, feeding, and reproduction (Stirling 1980). A recurring polynya, important to the migration of marine mammals, forms annually in the Eastern Chukchi Sea south of Point Hope (Dickens 2001 cited in Corps 2005). This polynya sometimes occurs in the form of multiple leads in the ice which are used by migrating marine mammals; in some years these leads bring marine mammals along the coast past Kivalina, Portsite, Sealing Point, and Cape Krusenstern (Corps 2005). Vegetation in the marine environment consists of microscopic algae. The production of plant material in the marine environment by microscopic algae comprises the primary productivity that forms the basis of the marine food chain. Microscopic algae are most abundant and primary productivity levels are at their highest in the Chukchi Sea during the summer (Hillman 1984 cited in Krembs et al. 2003), when there is abundant light and the marine waters are warmer. Kelp and other large multicellular algae found in other oceans and seas of the world are largely absent from the Chukchi Sea.

3.9.1.2 Wildlife Species

Pre-mining wildlife studies were conducted in 1982 and 1983 by Dames & Moore (1983a, b). The project area supports five species of large terrestrial mammal: caribou (*Rangifer tarandus*), moose (*Alces alces*), Dall sheep (*Ovis dalli*), muskox (*Ovibos moschatus*), and brown bear (*Ursus arctos*). Caribou, moose, and Dall sheep have historically been and continue to be important subsistence resources for communities near the project area. Common furbearers in the project area include wolves (*Canis lupus*), wolverine (*Gulo gulo*), red fox (*Vulpes vulpes*), arctic fox (*Alopex lagopus*), lynx (*Felis lynx)*, marten (*Martes americana*), and mink (*Mustela vison*). Snowshoe hares (*Lepus americanus*), muskrat (*Ondatra zibethicus*), and river otters (*Lutra canadensis*) are also present but uncommon. Many of these species are important to hunters and trappers in the region for their pelts, which are used to make traditional Alaska Native crafts and clothing. In addition, the project area supports more than 100 species of birds, most of which are waterfowl and shorebirds (Dames & Moore 1983a). Finally, several species of marine mammals, including beluga whale (*Delphinapterus leucas*), gray whale (*Eschrichtius robustus*), bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*), and polar bear (*Ursus maritimus*), have the potential to occur near the DMTS port site.

3.9.2 Wildlife – Baseline Conditions

This section provides a more detailed description of existing wildlife resources in the project area and impacts that have occurred to date. Information on current baseline conditions was derived from the *Environmental Information Document for the Aqqaluk Extension* (SRK 2007), peer reviewed research, NMFS stock assessments (Angliss and Outlaw 2007), ADF&G annual monitoring reports, the ongoing caribou monitoring program (ABR 2007d), NPS, and various post-construction Wildlife Incident Reports and Wildlife Observation Records prepared by Teck (Red Dog Operations 2005 a, b).

Table 3.9-1 summarizes the status of wildlife species that will be addressed in this SEIS. The 1984 EIS addressed most of the species listed in Table 3.9-1, as noted in the description of the pre-mining environment. One species, the beaver (*Castor canadensis*), did not occur in the project area prior to mine construction but as of 2001 its range has expanded north to include the mine site. Other relevant changes relative to wildlife resources since the inception of mining include the delisting from the ESA of the peregrine falcon and the gray whale, which were federally listed as endangered during the preparation of the 1984 EIS, and the recent listing of the polar bear as threatened. This section expands on the descriptions of these species and species groups, providing relevant life history information and highlighting new information (e.g., recent survey information) that forms the current project baseline.

Table 3.9-1 Status of Species Occurring in the Project Area

Species Common and Scientific Names	Alaska Species of Special Concern[a]	Federal Threatened or Endangered	Federal Candidate	Petitioned for Federal Listing	Other Species of Concern[c]
Mammals					
caribou (*Rangifer tarandus*)					•
moose (*Alces alces*)					•
muskox (*Ovibos moschatus*)					•
Dall sheep (*Ovis dalli*)					•
brown bear (*Ursus arctos*)					•
wolf (*Canis lupus*)					•
wolverine (*Gulo gulo*)					•
arctic fox (*Alopex lagopus*)					•
red fox (*Vulpes vulpes*)					•
beaver (*Castor canadensis*)					•
river otter (*Lutra canadensis*)					•
Marine Mammals					
bearded seal (*Erignathus barbatus*)					•
spotted seal (*Phoca largha*)					•
ringed seal *(Phoca hispida*)					•
harbor porpoise (*Phocoena phocoena*)					•
polar bear (*Ursus maritimus*)		•			
Beaufort beluga whale (*Delphinapterus leucas*)			•		
bowhead whale (*Balaena mysticetus*)	•	•			
gray whale (*Eschrichtius robustus*)					•
Birds					
spectacled eider (*Somateria fischeri*)	•	•			
Steller's eider (*Polysticta stelleri*)	•	•			
arctic peregrine falcon (*Falco peregrinus tundrius*)[b]	•				
American peregrine falcon *(Falco peregrinus anatum*)[b]	•				
olive-sided flycatcher (*Contopus cooperi*)	•		•		
yellow-billed loon (*Gavia adamsii*)[d]				•	

[a] No state listed species occur within the project area.
[b] Downlisted from Alaska Endangered Species List after commencement of mine operations.
[c] Other species of concern include those that have high cultural value, are important subsistence resources, or are important to nonconsumptive users (e.g., photographers or viewers).
[d] USFWS is currently conducting a full status review of the yellow-billed loon to determine if listing is warranted.

Potential effects to wildlife associated with construction and operation of the mine addressed in the 1984 EIS included habitat loss, mortality from mining activities, and attraction of wildlife to project facilities. Contamination from chemicals or metals through the deposition of fugitive dust was not originally anticipated to occur, but has recently been evaluated by the DMTS risk assessment (Exponent 2007). Effects that have occurred under current operations are summarized in the following discussion.

Direct habitat loss has resulted from development of the existing Red Dog Mine and associated processing activities, as well as from exploration activities in areas overlying additional mineral deposits. The impacts related to habitat loss were anticipated in the 1984 EIS although the disturbance footprint of the facilities, including Main Pit, waste rock dumps, tailings impoundment, mill complex, materials sites, and local infrastructure have impacted 2,096 acres while the 1984 EIS anticipated a footprint of 1,823 acres (SRK 2007; EPA 1984).

The deposition of fugitive dust in the vicinity of the mine and along the DMTS corridor resulted in additional habitat loss as well as reductions in habitat quality. Contaminants in fugitive dust decreased the cover of plant communities, including evergreen shrubs, mosses, and lichens, and it reduced the vitality of remaining vegetation adjacent to the road (SRK 2007). Areas receiving the most dust have been located along the DMTS road and near the mine.

Disturbance from noise and human activity in the project area also has likely had an effect on wildlife, causing an indirect adverse effect on habitat. The 1984 EIS noted that this loss is difficult, if not impossible, to quantify because species and even individuals differ in their tolerance to noise and human activity. However, based on the number of wildlife incident reports from mine personnel, it is apparent that many species continue to use the project area associated with the mine, including the mine, DMTS corridor, and port facility. Alternately, mining operations can also result in the creation of artificial habitats or involve human activities that attract wildlife. These scenarios can be detrimental to wildlife and humans, particularly when species or individual animals become habituated and interactions result in death or injury. The risk of exposure to contaminated mine water or chemicals and the proper handling of refuse were two issues identified by the 1984 EIS as being important in relation to the attraction of animals to mine facilities. Hazing is employed when animals need to be deterred from the project area facilities (e.g., the airstrip and tailings dam) because of safety concerns. No animals have been injured during hazing incidents, and all hazing efforts have been successful. Additional information on the occurrence of hazing is provided below under the descriptions of individual species.

Injury and mortality can also occur as a result of mine activities. Traffic along the DMTS road resulted in the deaths of at least 22 animals caused by collisions with vehicles between 1998 and 2007. Species involved in these incidents included caribou, red foxes, a wolf, and a golden plover (SRK 2007). Traffic along the DMTS road in 2003 included approximately 49 vehicle trips per day, 36 of which were concentrate trucks traveling between the mine and the port. Although use of the DMTS road is limited to mine traffic and recreational access is prohibited, there is some level of four-wheeler use along the road by locals to access hunting grounds. This use, as with other vehicle traffic, results in localized disturbance to caribou and other wildlife along the DMTS road.

Another issue identified after operation of the mine began was the potential for exposure to contaminants. There is the potential for spillage of chemicals used for mining and milling processes, including petroleum hydrocarbons, milling reagents, and blasting agents. Spills could occur during transit, storage, and use, and are cleaned up immediately upon detection. Chemical storage areas within buildings are inspected regularly so that any spills or leaks can be contained before wildlife is exposed to the chemicals. Storage tanks outside of buildings include secondary containment systems to prevent release of spilled or leaking chemicals. The mine facility has comprehensive spill response and cleanup procedures in place that make the likelihood of wildlife exposure to chemicals low.

NPS published a study in 2001 that found elevated levels of heavy metals in tundra areas near the mine and along the DMTS road (Ford and Hasselbach 2001). The presence of metals was attributed to fugitive dust deposition resulting from the escape of ore concentrate from concentrate trucks traveling between the mine and the port (dust sources, transport mechanisms, and measures taken to reduce dust emissions by Teck are discussed in Section 3.2, Air Quality). Concern arose about whether the metals within the ore concentrate may have affected subsistence resources and environment. Thus Teck voluntarily initiated a DMTS risk assessment in 2003 to evaluate the potential for adverse ecological effects in habitats within the project area (Exponent 2007a). Results of this DMTS risk assessment are summarized below in Section 3.9.2.1.

The conceptual pathway for potential contamination is that dust emitted from the port, mine, and along the road is transported into the environment by wind carrying dust particles to various habitats (tundra, streams, lagoons, and the Chukchi Sea). These dust particles, present on plants (or metals from the dust metabolized into tissue) may then be eaten by animals, including caribou, ptarmigan, and fish. Some of these animals may then be eaten by other animals or used as subsistence foods. Heavy metals can cause acute or chronic effects on wildlife, including neurotoxic, carcinogenic, or reproductive effects, effects to the immune, and thyroid systems, or liver enzymes (AMAP 2002). Some metals can bioaccumulate (concentration increases within an organism over time as it continues to consume contaminated foods) or biomagnify (concentration increases up through the food chain).

In the spring of 2006, the USGS, in cooperation with NPS researchers, initiated a series of studies designed to address data gaps of the DMTS risk assessment conducted by Exponent (2007) that were of a particular concern for natural resources within Cape Krusenstern National Monument. One component of these studies was to assess metals exposure and potential sub-lethal biological effects (e.g., lesions on internal organs or DNA damage in blood) in small mammals and birds within the monument (Brumbaugh et al. 2008). These animals were selected because they forage on terrestrial organisms and vegetation and are therefore most likely to be exposed to heavy metals contamination through ingestion of fugitive dust.

Blood and liver samples were collected from voles and small ground-nesting birds captured near the DMTS road and at a reference site to assess concentrations of aluminum, barium, cadmium, lead, and zinc. Animals captured near the road had about 20 times greater blood and liver lead concentrations and about three times greater cadmium concentrations when compared to those from the reference site. Barium and zinc concentrations did not differ between the road and reference site and aluminum levels were below reporting limits in nearly all the samples. However, the increased levels were less than tissue concentration thresholds associated with serious biological effects reported from other studies. The study also found no sub-lethal biological effects. The authors concluded that neither voles nor ground-nesting birds inhabiting the areas along the DMTS road appeared to be suffering biological effects due to metals exposure, but recommended continued monitoring (Brumbaugh et al. 2008).

3.9.2.1 DeLong Mountain Regional Transportation System Risk Assessment Findings

The DMTS risk assessment prepared for Teck by Exponent (2007a) estimated the potential for adverse impacts to aquatic and terrestrial organisms (i.e., fish and wildlife) from exposure to metals in environmental media (e.g., soils, surface water) in the project area. The DMTS risk assessment presents risk estimates as hazard quotients (HQs), which are comparisons of the estimated exposure to a toxicity reference value (TRV). A high and low HQ were calculated for each chemical-receptor combination (e.g., barium exposure to caribou) to provide a range of risk estimates. The high HQ is based on the low toxicity reference value, that is the No Observable Adverse Effects Level (NOAEL), and the low HQ is based on the high toxicity reference value, that is the Lowest Observable Adverse Effects Level (LOAEL). The NOAEL represents the highest dose tested that did not show an adverse effect in the test animal. The LOAEL represents the lowest dose tested that showed an adverse effect in the test animal. The “threshold dose” is the dose where adverse effects first appear and it lies somewhere between the NOAEL and LOAEL values. HQs that are greater than 1 indicate a potential for adverse effects. However, if the estimated dose exceeds the NOAEL, but is less than the LOAEL, then there is uncertainty about the risk because it is not known whether the estimated exposure exceeds the threshold dose. Because of this, the LOAEL-based HQ is often given more weight when evaluating the results of the risk calculations. A LOAEL-based HQ that exceeds 1 provides a stronger indication that the estimated dose exceeds the level where an adverse effect could occur.

In interpreting the significance of the HQs it is important to keep in mind a number of other factors such as the uncertainties and conservatism associated with the exposure estimates and the toxicity reference values that are used in the DMTS risk assessment. In addition, HQs within the project area were compared to HQs calculated for reference areas, and it was assumed that any HQs that fall within the range of reference area HQs, indicate no risk of adverse impacts.

Bioavailability. The extent to which a chemical is absorbed by the gastrointestinal tract, and thus is available in the blood stream to cause adverse effects in tissues and organs, is termed bioavailability. The solubility of a chemical influences its bioavailability, with more soluble compounds generally being more bioavailable. For example, some barium compounds, such as barium chloride and barium hydroxide, are quite soluble, have high bioavailabilty, and are toxic. Whereas, barium compounds with low solubility, such as barium sulfate and barium carbonate, have low bioavailability and low toxicity (ATSDR 1992b cited in Exponent 2007a).

According to EPA, aluminum toxicity has been linked to soil pH. Soils at a site with pH greater than 5.5 can generally be considered non-toxic in terms of aluminum (EPA 2008a). Exponent (2007a) found that soil pH decreased with distance from the DMTS and mining facilities, ranging from 6.9 to 7.7 adjacent to the DMTS road, and declining to 5.0 at 0.5 miles (750 meters) from the road.

In the DMTS risk assessment it was conservatively assumed that the metals ingested by wildlife were 100 percent bioavailable (i.e., completely absorbed in the GI tract). In addition, it was conservatively assumed that the bioavailability of the metals in site related exposure media (e.g., tundra soils) was the same as the bioavailability of the metals in the toxicity studies used to develop the TRVs. These conservative assumptions are intended to be protective of ecological receptors in the absence of site-specific data. For aluminum and barium these assumptions may be overly conservative and thus exposures and risks are potentially over estimated. These conservative assumptions are further discussed in the following paragraphs.

In vitro laboratory studies by Shock et al. (2007 cited in Exponent 2007a) that simulate the effect of gastric fluids (i.e., stomach acid) on a chemical’s solubility indicate that the fraction of aluminum and barium that is dissolved (i.e., “bioaccessible”) from tundra soil samples along the DMTS road is much less than 100 percent (0.31 to 4.0 percent and 3.8 to 20 percent, respectively). Bioaccessibility can be used to provide an indication of bioavailability, though it does not provide a definitive determination. The results of the study suggest that the bioavailability of aluminum and barium from site soils could be low and thus, the exposure levels in the DMTS risk assessment could be overestimated. This in turn could result in aluminum and barium HQs that are overestimated. If a bioavailability value of less than 100 percent was used in the DMTS risk assessment exposure calculations, then the HQs would be proportionately less. For example, if a relative bioavailability of 4 percent is used for aluminum then the exposure is 1/25th of the exposure at 100 percent bioavailability (i.e., 4% / 100% = 1/25th). The HQ would be reduced by that same amount. For example, if the aluminum HQ was 25 when 100 percent bioavailability is assumed, then the HQ would be 1.0 when only 4 percent bioavailability is assumed (i.e., 25 x 1/25 = 1.0). Likewise, if the barium HQ was 5.0 when 100 percent bioavailability is assumed then the HQ would be 1.0 when only 20 percent bioavailability is assumed (i.e., 20% / 100% = 1/5th; 5 x 1/5 = 1.0). Note that there is uncertainty regarding the bioavailability of aluminum and barium, and that the study by Shock et al. (2007) suggests that the bioavailability may be less than that assumed in the DMTS risk assessment. Although the available information does not allow for a definitive determination of the bioavailability of these metals, it is strong evidence that the bioavailability assumption used in the DMTS risk assessment was very conservative.

The TRVs for aluminum and barium are based in part on studies where soluble forms of the metals were used and the metals were dissolved in drinking water. Metals dissolved in drinking water are expected to be more readily absorbed in the gastrointestinal tract than metals that are associated with other ingested media, such as soil and wildlife diet items (e.g., plants). Because of the higher degree of absorption of the metals, the toxicity studies with drinking water result in greater toxicity than would occur from ingestion of soil and diet items. The use of these more conservative TRVs also overestimates risk.

In addition, the NOAEL TRV for mammals exposed to barium (5.1 mg/kg per day) may be overly conservative. EPA (2005) performed a comprehensive review of the toxicity literature for barium and derived a NOAEL TRV for mammals of 51.8 mg/kg per day, which is approximately 10 times greater than the TRV used in the DMTS risk assessment. Increasing the barium TRV for mammals by a factor of 10 would reduce the calculated HQs by a factor of 10. If exposures for barium were compared against the TRV of 51.8, all hazard quotients for caribou and muskrat, and most hazard quotients for vole and shrew, would drop below 1.0. Similar to aluminum and barium, a study by Arnold and Middaugh (2001 cited in Exponent 2007) showed the bioavailability of lead in Red Dog ore is much less than 100 percent (approximately 6.8 to 13.5 percent). Therefore, the exposure and risk estimates for lead also are likely overestimated.

Results of the DMTS Risk Assessment. The DMTS risk assessment developed estimates of potential exposure, derived from food-web models, for a variety of different wildlife species that were representative of the trophic levels (e.g., terrestrial herbivore, terrestrial carnivore) that could be potentially exposed to metals in the project area. Risk estimates (i.e., HQs) were developed using the estimated exposures. Effects were considered acceptable, if the HQs were less than 1. Representative species of terrestrial wildlife that were evaluated in the DMTS risk assessment included caribou, moose, arctic fox, tundra vole, tundra shrew, willow ptarmigan, lapland longspur, common snipe, and snowy owl. Representative species of wildlife that are associated with aquatic environments were also evaluated, including moose, muskrat, common snipe, black-bellied plover, brant, and green-winged teal. Note that some species (e.g., moose) were evaluated for both terrestrial and aquatic environments. The following discussion summarizes the results of Exponent’s (2007) DMTS risk assessment.

The term ‘risk’ refers to the potential toxic effects of exposure to contaminants. These would be chemical specific and would include a wide range of effects such as gastrointestinal distress, muscular paralysis, carcinogenic effects, and cardiovascular effects. The level of risk is based on the toxic endpoints exhibited at the NOAEL or LOAEL dose. These are usually based on reproductive effects (e.g., population level effects). For example, for individuals feeding in close proximity to the mine facilities, exposure to lead is possible; however, the risk of lead toxicity to a species’ overall survival would be considered low. Estimated HQs and conclusions from the 2007 DMTS risk assessment are presented in Table 3.9-2 for select species.

It is important to note that there is inherent uncertainty in this type of risk assessment because it is a modeling exercise and true availability of contaminants and true risks are unknown. The DMTS risk assessment was completed as a separate process from the SEIS, and therefore the SEIS incorporates information from the DMTS risk assessment to the extent that it was available and applicable. There may be additional species that would have been good candidates for consideration in the DMTS risk assessment process that were not included. The muskox is one such species that was not addressed directly by the DMTS risk assessment but they consistently occur near the DMTS, and thus have the potential for exposure to fugitive dust contamination. There is some uncertainty in using caribou to represent muskox in the DMTS risk assessment. Caribou serves as an appropriate indicator species for the muskox in terms of diet, since caribou diet is modeled as consisting of 80 percent nonvascular plants. However, muskox have a smaller home range than caribou in the region so risks would not necessarily be equivalent.

Table 3.9-2 Summary of Risks for Wildlife Species Evaluated in the DeLong Mountain Regional Transportation System Risk Assessment (Exponent 2007)

Species	Group Representing	Metal with NOAEL-Based Hazard Quotient (HQ) >1	Maximum NOAEL-Based HQ[a,b]	Maximum LOAEL-Based HQ[b]	Risk Conclusions from DMTS Risk Assessment
caribou	terrestrial mammalian herbivore	aluminum	67	6.7	Risks to population expected to be low given the low estimated risks to individuals, and the relatively low number of caribou that potentially over-winter in the project area.
		barium	7.9	2.0	
moose	terrestrial/fresh water stream/ coastal lagoon mammalian herbivore	aluminum	3.0	All <1.0	Not at risk from exposure to metals at any of the sites evaluated, including the mine site, along the DMTS road, the port, and the freshwater streams and coastal lagoons. No adverse effects anticipated.
arctic fox	terrestrial mammalian carnivore	aluminum	21 (4.4)	2.2	Potential slight risk of adverse effects from exposure to mercury in the vicinity of the DMTS road. Small mammals, the fox's preferred prey, had generally low levels of mercury in the tissues, with elevated levels in only one sample. The highest HQ for aluminum occurred at the port. Overall, the levels are considered low and not sufficient to cause adverse impacts to arctic fox populations.
		mercury	11	2.1	
muskrat	stream/pond/ coastal lagoon mammalian herbivore	aluminum	83 (65)	8.3	May be at risk of adverse effects from exposure to barium and cobalt in the tundra ponds; aluminum, barium, and vanadium at the Omikviorok River site; and barium at the Anxiety Ridge Creek road site. However, aluminum and barium HQs were also greater than 1 for some of the reference locations, with maximum HQs of 65 for aluminum and 1.9 for barium. The HQs for the lagoons were within the range of those at the reference lagoon, therefore, muskrat are not considered at risk from exposure to metals in the lagoons.
		arsenic	1.2 (5.4)	0.54	
		barium	4.4 (1.9)	1.1	
		cobalt	3.5	0.86	
		vanadium	1.9 (3.0)	0.30	
tundra vole	terrestrial mammalian herbivore	aluminum	210 (30)	21	Adverse effects on survival or reproduction could occur in tundra voles near the road or mine site.
		arsenic	1.7	0.17	
		barium	20 (1.6)	5.0	
		lead	2.6	0.32	

Species	Group Representing	Metal with NOAEL-Based Hazard Quotient (HQ) >1	Maximum NOAEL-Based HQ[a,b]	Maximum LOAEL-Based HQ[b]	Risk Conclusions from DMTS Risk Assessment
		molybdenum	1.1	0.11	
		vanadium	1.5	0.15	
tundra shrew	terrestrial mammalian invertivore	aluminum	88 (100)	8.8	Adverse effects on survival or reproduction could occur in tundra shrew near the road or mine site. The maximum site related HQ for aluminum (88) is less than the HQ for aluminum in the reference area (100).
		arsenic	1.5	0.15	
		barium	28 (1.6)	7.2	
		cadmium	4.1	0.43	
		lead	2.4	0.29	
		mercury	2.5	0.49	
		molybdenum	1.2	0.12	
		selenium	1.7 (1.1)	1.0	
		vanadium	1.9 (1.3)	0.19	
		zinc	1.3	0.65	
brant	coastal lagoon avian herbivore	N/A	All HQs <1.0	All <1.0	Not at risk from exposure to metals at the Port Lagoon North and North Lagoon. All HQs are less than 1.
green-winged teal	stream and pond avian herbivore	N/A	All HQs <1.0	All <1.0	Not at risk from exposure to metals at any of the sites evaluated. All HQs are less than 1.
black-bellied plover	coastal lagoon avian insectivore	lead	1.3	All <1.0	The HQ for lead is only slightly greater than 1, and the HQ for lead in the reference area is slightly less than 1 (0.93). There may be a very slight risk of adverse effects from exposure to lead at Port Lagoon North, but no significant risk to populations.
common snipe	terrestrial/ stream avian invertivore	aluminum	1.2 (1.3)	All <1.0	May be at risk of adverse effects from exposure to barium at the mine and lead at the port but the risk is considered low. The HQ for aluminum in the reference area (1.3) is greater than the HQ for the mine (1.2).
		barium	2	All <1.0	
		lead	1.5	All <1.0	
snowy owl	terrestrial avian carnivore	mercury	14	7.2	May be at slight risk of adverse effects from exposure to mercury along the DMTS road. Small mammals, the owl's preferred prey, had generally low levels of mercury in their tissues, with elevated levels in only one sample. Overall, the levels are considered low and not sufficient to cause adverse impacts to snowy owl populations.
Lapland longspur	terrestrial avian invertivore	N/A	All <1.0	All <1.0	Not at risk from exposure to metals at any of the sites evaluated. All HQs are less than 1.

Species	Group Representing	Metal with NOAEL-Based Hazard Quotient (HQ) >1	Maximum NOAEL-Based HQ[a,b]	Maximum LOAEL-Based HQ[b]	Risk Conclusions from DMTS Risk Assessment
willow ptarmigan	terrestrial avian herbivore	barium	4.0	2.0	Barium is unlikely to be a risk due to barium's low biological availability. Risk from lead is possible near the port and mine, potentially resulting in population-level effects in these areas, though the likelihood is low because of the length of the road. The HQs for mercury and zinc only slightly exceed 1 and risks are considered unlikely but cannot be completely ruled out.
		lead	6.2	2.2	
		mercury	1.2	0.62	
		zinc	1.4	0.81	

Source: Exponent (2007) DMTS Risk Assessment for the DeLong Mountain Transportation System.
[a] Reference Area HQs that are greater than 1 are shown in parentheses.
[b] The HQs in the table are based on the 95% UCL exposure concentration and the LOAEL- and NOAEL-based TRVs.

The DMTS risk assessment found that:

- No harmful effects were predicted for the coastal lagoon, freshwater stream, and tundra pond environments, though effects to invertebrates and plants in shallow ponds near the port site could not be ruled out.
- In general, there was a low risk to wildlife receptors. Willow ptarmigan (representative of avian terrestrial herbivores) feeding in areas close to the mine and the port may be at slight risk (i.e., HQ slightly greater than 1.0) from exposure to lead. Tundra shrews and tundra voles near the road or mine site are at potential risk from exposure to metals. (Note that the draft fugitive dust risk management plan proposes to perform further sampling to monitor exposure and risk for these species to address ADEC's concerns.)
- The risks to wildlife from exposure to aluminum and barium are likely overestimated based on the conservative assumptions regarding bioavailability and the derivations of the TRVs (see the discussion above for additional details on these assumptions). The conservative assumptions and uncertainties associated with aluminum and barium should be kept in mind when reviewing the risk estimates for these metals.

3.9.2.2 Terrestrial Mammals

Caribou. The project area is encompassed by the range of the Western Arctic Caribou Herd (WAH), the largest caribou herd in the State of Alaska and one of the largest in the world. In the early 1970s the WAH numbered approximately 242,000 caribou but subsequently underwent a dramatic decline, resulting in a population of 75,000 caribou in 1976 (Dau 2005). The population then began to increase, growing at 13 percent annually, and numbered approximately 190,000 prior to construction of the mine (EPA 1984). The WAH continued to grow steadily until 1990 at which time growth slowed. The most recent photo-census conducted in 2003 produced an estimate of approximately 490,000 caribou which is the largest size documented for this herd (J. Dau, pers. comm. cited in SRK 2007). During the winters of 1994–1995 and 1999–2000 localized mass-mortality events occurred west of the mine near Cape Thompson. These events were attributed to starvation caused by poor overwinter body condition (O'Hara et al. 2003; Dau 2004).

Arctic caribou are in a continual state of movement as they seek new places to forage and gain refuge from the seasonally profuse mosquitoes. Early studies, summarized by Dames & Moore (1983a) and SRK (2007a), documented the WAH's seasonal use and movement patterns. The WAH's traditional calving grounds are located on the Utukok Uplands in the upper drainages of the Utukok, Colvillek, Ketik, and Meade rivers, approximately 100 miles northeast of the project area. This area provides snow-free forage and protection from predators. Calves are typically born from late May to early June, after which time the herd commences a post-calving movement toward the Arctic Slope where it resides during the summer. In July and August, after calving, the herd tends to concentrate when insect harassment is at its worst. From the calving grounds the WAH proceeds in segments in a counterclockwise movement southwest to the west end of the DeLong Mountains where they then turn east and disperse through the Brooks Range. Figure 3.16 shows the movement of satellite-collared WAH caribou through the years 1988 through 2004.

Fall migration begins in mid-August when the WAH begins to move southward through the Brooks Range to its wintering grounds. Winter distributions, in both numbers and location, are highly variable and may be dependent on local weather conditions (EPA 1984). During the mid-1980s through the mid-1990s, most of the WAH wintered in the Nulato Hills as far south as the Unalakleet River drainage (200 to 250 miles south of the mine site), though a small number of caribou use areas farther north including the Singoalik, Asikpak, Kivalina, Wulik, and Omikviorok river drainages (EPA 1984). However, since 1996, the wintering caribou have shifted northwest toward the eastern Seward Peninsula. Periodically, (five winters since 1986–1987) up to 30,000 caribou have wintered within 15 miles of the Chukchi Sea coast between Cape Lisburne and Cape Krusenstern. The two mortality events described above occurred during two of these winters. A few hundred caribou also winter just east of the DMTS road in the Mulgrave Hills.

Movement rates drop once the WAH reaches winter range, where it remains until April, at which time caribou begin their spring migration back to the calving grounds. The spring migration is a more direct and communal movement than the fall migration with the entire herd traveling north together. Caribou wintering in the project area typically move north through the Kivalina and Wulik drainages, though most of the spring migration occurs well to the east of the mine and transportation corridor (Dames & Moore 1983a).

Caribou are most abundant in the project area during the post-calving period (late June-early July) and during the fall migration (August–October), although a small number may occur year-round. While calving does not typically occur in the project area, the presence of snow may delay calving or result in calving occurring unusually far south. In the past, a small amount of calving has occurred in the Mulgrave Hills east of the project area during years with a late spring (EPA 1984).

Tens of thousands of caribou pass through the upper drainages of the Kivalina and Wulik rivers in their post-calving aggregation and again in the fall on their way to wintering areas to the south and east. While most of this activity occurs north of the project area, a large aggregation of caribou traveled across the DMTS road in July 1988 which triggered closure of the road until caribou had passed, in accordance with the Applicant's caribou policy (SRK 2007). Surveys conducted in July 1996 by ADF&G documented up to a quarter of the WAH within 5 miles of the mine, though small groups of 10 to 20 are most common around the mine site and groups of 50 to 200 are regularly seen along the DMTS road.

These groups are typically seen from late summer to mid-winter (SRK 2007). During fall migration large groups numbering upwards of 20,000 caribou may move across the DMTS road as they travel south, though the mine and the DMTS road are located on the western periphery of the area used in the fall.

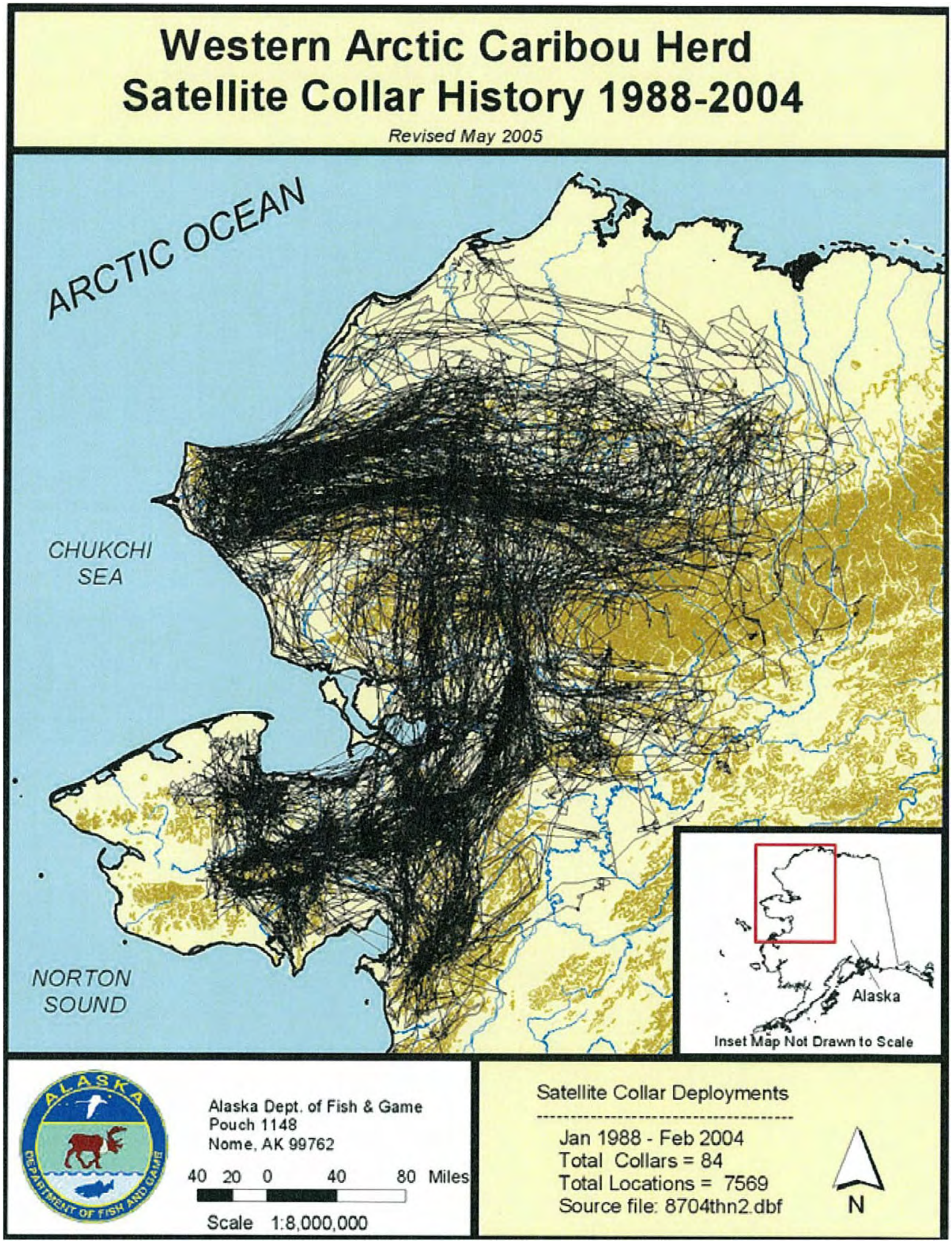


Figure 3.16 WAH Range ADF&G 2005 Figure 1

While some caribou winter range has been lost as a result of mining operations, it is a comparatively small amount of the available winter range for the WAH. The loss would generally not affect the carrying capacity of the area since only a small number of the WAH wintered in the project area prior to or since mine construction.

The development of mining in the range of the WAH has led to recent concern by local residents that heavy metal contamination may be affecting the population and may present a risk to human consumption. In recent years between 15,000 and 17,000 caribou have been harvested annually (Dau 2002b). Several analyses of potential contamination have ensued. Between 1994 and 1996 caribou were collected for radionuclide testing and body condition analysis from five sites in northern Alaska including the location of the previously mentioned mortality events (Point Hope and Cape Thompson, Alaska), two reference sites (Barrow and Teshekpuk Lake, Alaska), and the Red Dog Mine (O'Hara et al. 1999). Heavy metal testing was later conducted on the liver, kidney, muscle, bone, rumen contents, and feces of the same animals (O'Hara et al. 2003). Though results confirmed that the mass-mortality event was caused by malnutrition and not due to elevated radionuclide or heavy metals contamination, differences were noted among locations. O'Hara et al. (1999) found that radionuclide levels were low compared to those reported in studies from Canada and other northern regions (e.g., Sweden), and did not present a human health risk. O'Hara et al. (2003) found levels of lead in feces and liver, copper in the rumen contents, and arsenic in muscle to be higher in caribou harvested near the Red Dog Mine than the other study sites. These differences were attributed to the mineral-rich nature of the area and concentrations were not at levels of concern for toxicoses for caribou or for the humans consuming them. However, the authors recommended further study to properly address the effects of mining activity (O'Hara et al. 2003). Cadmium concentrations in the kidney were considered to be a potential concern for human consumption, with levels being high in caribou harvested near the reference site in Barrow, Alaska, relative to the other sites. However, this was an expected finding given that cadmium concentrations increase with age, that levels were within the reported range for caribou in other regions, and that in other regions there are already existing consumption advisories for caribou kidneys (O'Hara et al. 2003).

Subsequently, as part of the the early stages of the DMTS risk assessment, 10 caribou were harvested in 2002 by ADF&G biologists along the DMTS road, six that were 14 miles from the port and 4 that were approximately a mile from the mine airstrip (Exponent 2005). These caribou were analyzed for lead, zinc, cadmium, and arsenic levels in muscle, liver, and kidney tissues. The results were compared to the data in O'Hara et al. (2003). The mean concentration of lead in caribou livers from the Red Dog Mine (2.7 mg/kg wet weight) was greater than the mean concentrations of lead in caribou livers from the other Alaska locations (0.19 to 1.42 mg/kg wet weight) evaluated in O'Hara et al. (2003). Comparisons of the remaining data indicated that the mean concentrations of metals in the Red Dog Mine samples were in the range of the data presented in O'Hara et al. (2003). The presence of metals in caribou was re-evaluated in the 2007 DMTS risk assessment, which concluded that the risk of exposure to high levels of contaminants by caribou are low, given that caribou are highly mobile and forage over larger spatial areas with varying chemical concentrations in food. See Appendix H of the DMTS risk assessment (Exponent 2007b) for additional details on the evaluation of metals in caribou tissues.

Caribou and other wildlife are discouraged by hazing from using the area near the tailings impoundment to avoid any potential exposure to contaminants. Hazing activities include the use of "poppers" (noise-makers fired from a 12-gauge shotgun), sirens, a snow machine, persons on foot, and "honking and hollering." Hazing is also used to clear caribou from the airstrip prior to the arrival or departure of any aircraft. On-site wildlife incident reports maintain a record of all hazing incidents. Since 1998, 12 incidents have occurred where caribou near the mine have warranted hazing.

Concerns have been raised about the disruption of caribou migration or grazing in the project area as a result of the DMTS road. In response to these concerns, a caribou monitoring plan was developed by the Applicant in consultation with ADF&G to track movement patterns and determine the need for temporary closure of the road during migration (Lawhead 2007). The Red Dog Mine has a policy in place that includes informing drivers about the presence and location of caribou and requiring that drivers stop until caribou have moved through. The policy calls for closure of the DMTS road for short periods during caribou migration (i.e., when caribou are crossing the road). There is no record of any extended road closures to accommodate migrating caribou. On three occasions in late September and early October 2002 herds of caribou were reported to be blocked by or blocking traffic along the DMTS road. During two occasions Teck staff walked the road to encourage caribou to move through, and on one occasion the caribou moved on their own.

Roads also present a risk of vehicle collisions. Since 1998, on-site wildlife incident reports have included 14 incidents of dead caribou, nine that were collision related. The 1984 EIS concluded that given the level of road use along the DMTS road projected during construction and operation (20–25 vehicles per day plus periodic maintenance vehicles), major shifts in caribou movement patterns were unlikely unless the establishment of the road generated a high amount of traffic in the future. The 1984 EIS underestimated the amount of daily traffic using the road (currently reported as approximately 49 vehicles daily, including 36 concentrate truck trips) and the size and weight of trucks using the road. These large and heavy vehicles have the potential to cause additional disturbance due to ground shaking. However, the individual effects of noise, vibrations, or visual cues cannot be differentiated, and therefore are collectively considered traffic related effects. The extent and nature of noise generation at the site is discussed under Section 3.16. The result of the traffic underestimation can not be determined since clear pre-construction caribou distribution patterns are unavailable for comparison to the more recent data, such as radio-collar tracking information. However, tracking data collected between 1988 and 2004 have been used to delineate calving grounds and winter range of caribou, covering a time period that captures both pre- and post-construction conditions. These data confirm the use of the areas to the north, east, and south of the mine and port facilities, and that a small number of caribou cross the DMTS road (Dau 2005). Based on these data, Dau (2005) concluded that the mine and port facilities have only had limited localized effects on caribou movement and distribution.

More recent surveys conducted in 2007 documented that no reports of large spring movements by caribou across the DMTS road were received, suggesting that spring migration was made by relatively small numbers of wintering caribou (typically in the high hundreds to low thousands) moving northward out of the Mulgrave Hills east of the corridor (Lawhead 2008). In July 2007, during the post-calving period, a cluster of radio-collared caribou were located in the DeLong Mountains, suggesting that a potentially large number of caribou could be located north and east of the mine. This prompted a helicopter survey in the vicinity of the mine in July 2007, however a maximum of approximately 900 caribou in four different groups were located between two and nine miles from the mine (Lawhead 2008). The survey did not document any caribou along the Wulik or Kivalina rivers or west of the DMTS road. The fall migration in 2007 was also noteworthy for the scarcity of caribou in the region in which the mine and corridor are located (Lawhead 2008). An unusually late movement of caribou across the corridor occurred in early November with an estimated 1,000 caribou in the area mostly northwest of the DMTS road (Lawhead 2008).

Moose. During winter, moose are found along rivers and streams within the project area where they concentrate within low elevation riparian tall-shrub habitats. As snow subsides during the late spring and summer, moose disperse to higher elevation shrub habitats, which they use through the summer and fall. Project areas with high winter use include the drainages of the Wulik and Kivalina rivers and Rabbit Creek valley, located south of the Mulgrave Hills.

Moose were not found within the project area until their range expanded in the 1950s, during which time they moved from the east (Dau 2002a). The moose population in Game Management Unit (GMU) 23, which encompasses the project area, currently exists at a low density relative to other populations in Alaska. Fall and spring surveys conducted from 1992 to 2001 have documented densities ranging from

0.3 to 1.1 moose per square mile (Dau 2002a). This population supports harvest by both resident and non-resident hunters.

Moose frequently occur in drainages in the vicinity of Red Dog Mine, including North Fork Red Dog Creek, Ikalukrok Creek, and the upper portions of the Wulik River. They have been documented in vegetated areas near the active mining area and have been reported in the vicinity of the tailings impoundment area. The primary impacts to moose from current mining activities are likely associated with human activity (noise from mine operations, vehicle traffic along the DMTS road, and activities at the port). Some moose may be temporarily displaced by mining activities while others will require hazing. Since 1998 there have been six on-site wildlife reports of moose, five of which occurred at the mine site (TCAK unpublished data). Four observations were of moose in the tailings impoundment (two single adult moose, a group of two bull moose, and one cow-calf pair) and one was of a moose on the runway. With the exception of one adult moose that left the tailings impoundment on its own, the other moose were hazed using methods including helicopters, sirens, and poppers; no sickness or injury resulted from these actions (TCAK unpublished data). The DMTS road has not created a barrier for movement of this species. Accordingly, any disturbance or mortality of these species associated with the project would not be expected to have effects on the local population level (e.g., within GMU 23).

Muskox. Historically muskox occurred in western Alaska. However, the species was extirpated in the first half of the 20^{th} century. In 1970, 36 muskox were introduced into the Kukpuk River drainage. Additional transplants occurred in 1977 in the Cape Thompson region and in 1980 in the lower Kukpuk Drainage. The Cape Thompson population, which occurs within the project area, ranges from the Noatak River north to Cape Lisburne and generally remains within 15 miles of the coast.

The muskox population remains fairly small. The population in the northwestern portion of GMU 23 numbers from 290 to 327 muskoxen based on annual surveys conducted between 1997 and 2000 (Dau 2002b). Muskoxen are regularly observed along the DMTS road with approximately 45 animals residing in the Tahinichok Mountains east of the DMTS road in the late 1990s (EVS 1997) and several smaller groups occurring farther east in the Igichuk Hills. As with moose, the primary impacts to muskoxen from current mining activities have likely been associated with human activity (e.g., noise from mine operations, vehicle traffic along the DMTS road, and activities at the port). Some muskoxen may be temporarily displaced from mining activities while others may require hazing. In addition, because muskoxen occur along the road and are relatively sedentary, they may also be at risk of exposure to contaminants. On-site wildlife reports include two sightings of muskoxen since 1998 (one at Tutak Creek along the DMTS corridor in 2001, and one downstream from the tailings dam in 2002), however site environmental staff indicated that sightings of individual muskoxen in the vicinity of the mine area are more common (two or three times per year; SRK 2007). No population level effects have been documented.

Dall Sheep. Dall sheep inhabit meadows in open alpine ridges where steep, rugged slopes provide escape terrain from predators. Habitat in the vicinity of the project area is limited to the Wulik Peaks and the mountains bordering the headwaters of the Wulik River and Ikalukrok Creek (EPA 1984). The project area is on the northwestern margin of the range of the Dall sheep in the State of Alaska.

The Dall sheep population in the vicinity of the project area experienced high natural mortality beginning in 1990, which reduced sheep numbers drastically. To help the population recover, most areas were closed to hunting between 1991 and 1998, with only limited hunting allowed since. By 2001, the population had recovered to pre-crash levels (Dau 2002a). No Dall sheep have been observed at the Red Dog Mine, although they are frequently observed on Anxiety Ridge and Deadlock Mountain, south of the mine (J. Kulas, pers. comm. cited in SRK 2007).

Impacts of current mining activities to Dall sheep have likely been minimal because the only suitable habitat for this species in the project area exists on the high peaks away from the immediate vicinity of the mine. No development has occurred in those areas. Therefore, impacts to individual Dall sheep or the population within GMU 23 are unlikely.

Brown Bear. Brown bears occur in the project area throughout the year, making use of a variety of habitats (Dames & Moore 1983a). During spring, they use alpine slopes, then during summer and fall use shifts to lowland or coastal areas. During fall they also use areas around salmon spawning streams. The mine area also provides important denning habitat during the winter. Surveys conducted in 1982 documented seven dens in the Asipak River drainage in the Siatak Hills region.

There is little information on the brown bear population in the project area. The current ADF&G management goal for brown bears in GMU 23 is to maintain a regional density of one adult bear per 26 square miles in the Noatak River drainage, which is based on the results of a population census conducted in 1987. Since 1987, population information has been based on qualitative evidence from local residents, some long-term commercial operators, and opportunistic observations of agency staff (Dau 2005). These observations suggest that the brown bear population is increasing, which may reflect the increasing muskoxen, caribou, and moose populations, which provide a stable prey base, and the increasing number of salmon reaching salmon streams resulting from the decline of the Kotzebue Sound commercial fisheries (Dau 2005).

Brown bears have been observed in the project area at the confluence of Ikalukrok Creek and the Wulik River, and along the western slope of the mountains from Anxiety Ridge Creek to Tutak Creek. Occasionally brown bears are observed at the mine site, and a radio-telemetry study conducted in 1988 indicated brown bears were using the landfill at the Red Dog Mine; garbage has been incinerated since mine operations began and no subsequent observations of bears using the landfill have been documented (SRK 2007).

A slight reduction in bear habitat is associated with current mining operations but is not expected to affect the population in GMU 23 because of the availability of bear habitat surrounding the project area. The primary impact to brown bears has likely been disturbance. One recorded incident of a den disruption occurred in September 1991 during development of a new materials site for the project (Ayers 1993). The materials site was immediately below a den and the bear subsequently abandoned the site. On-site wildlife reports include eight incidents since January 1998. Two of these records were sightings of a sow and two cubs and the other of two bears required no additional action. The other reports include a truck collision with a bear cub that subsequently ran away, apparently uninjured, and five incidents, four in late September 2004 and one in late June 2007, of a sow and two cubs at the mine site at the overburden stockpile and laydown area. The bears were considered to be a risk for personnel and required hazing by poppers and sirens to move them from these sites. Reports indicate that the hazing methods were becoming ineffective and that bear incidents were requiring considerable amounts of time. No injuries to bears or personnel were recorded.

Wolf. Wolves occur throughout the mine region and are important predators. A radio-telemetry study of 86 wolves in 19 packs during 1987–1992 reported that wolf packs in the region usually did not follow migratory caribou but maintained year-round resident territories, feeding primarily on moose when caribou migrated (Ballard et al. 1997). Studies indicated that between 1987 and 1990 the wolf population grew from densities of seven to 11 wolves per square mile (Ballard et al. 1997). Single animals and packs of up to 12 wolves were reported in the project area prior to construction of the mine (Dames & Moore 1983a).

Wolf sightings have continued throughout mine operations. Wolves are seen once or twice a year along the DMTS road, and less frequently in the vicinity of the mine, although tracks, scat and the occasional wolf kill are more commonly observed. In the winter of 2004/2005, wolves were observed near the Bons Creek Reservoir several times over a period of a few days. A pair of wolves was reported twice in on-site wildlife reports, both in March 2002 near material site MS-13, along the DMTS road. In the second report, one of the wolves was killed by a truck. Three or four caribou carcasses reported in wildlife records since January 1998 (all near the airstrip and Bons Creek Reservoir) were attributed as wolf kills. Wolves primarily prey on caribou during winter and moose throughout the rest of the year; therefore, they would likely respond to changes in the local distribution or abundance of these species. However, impacts to caribou and moose have already occurred during mine operation and wolves appear to have adjusted to mining activity. No population level impacts are anticipated in GMU 23.

Arctic and Red Fox. Both red and arctic foxes occur in the region in a variety of habitats, although arctic foxes are probably more common in coastal tundra areas than they are in the uplands adjacent to the mine site. Both species are omnivorous, primarily feeding on small mammals such as lemmings and voles when they are available, but will also consume birds, berries, eggs, and carrion. In areas where small mammals are the main food source, populations of both species fluctuate in response to the cyclic changes in the populations of their prey.

Arctic foxes have rarely been sighted at the mine. Red foxes are the species most frequently reported by mine personnel, and this species requires the most attention, including the safe collection and disposal of carcasses from road kills and disease, rabies tests, potentially unsafe animal/human encounters, and animals entering mine facilities. Although appropriate garbage handling procedures and employee awareness programs have been implemented, on-site wildlife reports since January 1998 have recorded 35 observations of foxes. Several of these were habituated foxes, including repeated cases of a fox entering or attempting to enter a warehouse (these incidents occurred in 1998 and 2005) or the port kitchen facility (these incidents occurred in 2006 and 2007). Five reports were of foxes at landfills, although this appeared to be unrelated to the availability of food (SRK 2007). It is likely that these interactions will continue in the future.

Wolverine. Wolverines are a wide-ranging species that use a variety of habitats. Optimal habitat is best defined by adequate year-round food supplies in large, sparsely inhabited wilderness areas. Research has shown that when wolverines live sympatrically with other predators (e.g., wolves, brown bears, and lynx), these other species tend to use rugged, lower elevation habitat, whereas wolverines use open rugged terrain at higher elevations (Dalerum 2005 cited in van Dijk 2008). Dens are typically located in tree hollows and holes under tree roots in areas with abundant food sources (Banci 1994). However, in the tundra habitat of northwest Alaska wolverines den under the snow. Magoun (1985 cited in Banci 1994) provided data on natal dens of two females that had entrance tunnels extending less than 6 feet (2 meters) beneath the snow surface accessing den systems of up to 164 feet (50 meters) in length. In northwest Alaska, food levels are particularly low and dispersed because of the absence of overwintering caribou; consequently, home ranges of wolverine are larger than those reported elsewhere (Magoun 1985 cited in Banci 1994). Wolverines have evolved as scavengers, using the remains of other, more efficient predators, such as lynx and wolf, in addition to carcasses of animals that have died from accidents or diseases. Recent research by Dalerum (2005 cited in van Dijk 2008) on wolverines in the tundra ecosystem of Norway suggest that wolverines rarely kill their own prey during the winter season, but rather depend on carrion or sometimes cached food. Since the 1970s a general state-wide decline in the wolverine population has been identified (Golden et al. 1993). NPS is conducting a radio-telemetry study of wolverines in the upper Noatak River drainage, east of the mine; however, no wolverines have been documented in the vicinity of the mine.

Wolverines have most likely been affected by human activity associated with the mine. The literature suggests that they are extremely sensitive to human activity and prefer landscape with minimal development (Banci 1994). While habitat in the vicinity of the mine would have been limited by the lack of adequate food supply, development of the mine may have displaced individuals from use of the area. It is unlikely that existing operations have produced population level effects given the wide-ranging nature of this species.

River Otter and Beaver. River otters may occur in riparian habitats in the project area. Little site specific information exists for this species in the project area prior to mine construction, though according to ADF&G, they are found in the lower and middle Noatak River and the upper Kobuk River (ADF&G 1978 cited in MacDonald and Cook 2002).

Beavers occur in the forested portions of Alaska where they are closely tied to areas with a year-round supply of water. Water provides protection from predators. Beavers construct dens in the banks of rivers and streams, or lodges made of logs, sticks and mud in areas of slower moving water, where they live, cache food, and rear young. Beavers eat bark, aquatic plants of all kinds, roots, and grasses. Beavers did not occur as far north as the Red Dog Mine before 2001 (Dau 2001).

Both the river otter and beaver are associated with freshwater aquatic habitats. Impacts to river otter may have resulted from road and facility (bridge) construction. Operations at the DMTS are not expected to impact either of these species.

3.9.2.3 Small Mammals

Arctic ground squirrels are abundant in the DeLong Mountains and constitute important prey for raptors and carnivores such as rough-legged hawks and grizzly bears. Five species of microtine rodents (tundra vole, northern red-backed vole, singing vole, brown lemming, and collared lemming) and four species of shrews (cinereus [also known as common or masked], montane [dusky], barren ground, and tundra [formerly arctic] shrews) have been documented in the DeLong Mountains and surrounding area (Douglas 1984 cited in SRK 2007). When baseline studies were conducted prior to construction of the mine, small mammal densities in the project area were low, with only one tundra vole trapped along the mine runway site (Dames & Moore 1983a). Red-backed voles, however, have been frequently observed by mine personnel.

Individual small mammals have likely been displaced by mine development. Local impacts to these species may have also resulted from road and facility construction that fragments habitat, potentially disrupting local dispersal patterns.

The tundra vole and tundra shrew were evaluated in the DMTS risk assessment and the findings of that assessment are summarized above.

3.9.2.4 Birds

At least 92 bird species have been recorded in coastal and inland habitats in the region (SRK 2007). Habitats for birds in the vicinity of the mine are dominated by shrub and tussock tundra, with some riparian shrub habitats along drainages; lagoons and other wetland areas provide habitat for waterbirds. In the higher elevations, open waterbodies, other than the tailings dam, are uncommon. Birds observed in the project area include a variety of waterbirds, raptors, ptarmigans, and other migratory and resident species. Wildlife incidents involving birds have been recorded 19 times between January 1998 and December 2007, including seven observations of dead, sick, or injured birds (two of unidentified owls at the port; one road-killed golden plover; two of single injured ptarmigan; one road-killed seagull; and two dead northern pintails found at the mine sump). A flock of ptarmigan was hazed from the runway, and a raven was reported feeding on garbage at the landfill. The remaining incidents were flocks of ducks and geese in the tailings impoundment where birds were hazed in each case.

Waterbirds. Large river deltas along the coast, including those associated with the coastal lagoons of the Singoalik River, Asipak River, Kivalina River, Wulik River, Imikruk Creek, Omikviorok River, and

Tugak Lagoon were identified as important spring migration staging areas for waterbirds. The Kivalina River and Omikviorok River lagoons are areas of concentrated use during fall migration. However concentrations of birds using these areas were lower than other staging areas within Kotzebue Sound (Dames & Moore 1983a). The sedge-grass marshes associated with ponds and the riparian low shrub areas along the Kivalina, Wulik, and Omikviorok river drainages provided suitable inland breeding and molting habitat for species such as the Canada goose because of the presence of open water and emergent vegetation. The near-shore areas and lagoons in the vicinity of the port site are within the migration route of many bird species including waterfowl, seabirds, and terrestrial birds. During the spring migration, thousands of ducks, geese, loons, and other water birds migrate north and sometimes fly very low along the beach or over the near-shore ice (Corps 2005).

Limited waterfowl habitat occurs along the DMTS road primarily in the form of small lakes, ponds, and sedge-grass marshes. The 1984 EIS concluded that direct and indirect habitat loss would be expected to occur in the vicinity of Mud Lake because of dust, noise, and possibly altered drainage patterns, but that the major impact would be caused by human activity. It is likely that activity near the mine, along the access road, and at the port may elicit temporary displacement.

As noted above, ducks and geese have been documented using the tailings dam, prompting hazing by mine personnel. No injuries to wildlife have been reported resulting from exposure to the tailings impoundment. The 2007 DMTS risk assessment indicated that the likelihood of adverse population-level effects to wildlife foraging in streams, including waterbirds, is considered to be very low (Exponent 2007a).

Several species of waterbirds were evaluated in the DMTS risk assessment. These include brant, green-winged teal, black-bellied plover, and common snipe. Risk to all species appears to be low. The DMTS risk assessment results for these species are summarized above.

The yellow-billed loon was petitioned for ESA listing in April 2004. USFWS recently published a 90-day finding on this petition concluding that listing may be warranted (FR 72:31256-31264) and is currently conducting a status review for the species. The near-shore areas and lagoons in the vicinity of the port provide habitat for the yellow-billed loon. Yellow-billed loons forage on fish and invertebrates in the marine environment as well as in freshwater. Yellow-billed loons nest exclusively in coastal and inland low-lying tundra from 62° to 74° N latitude, in association with permanent, fish-bearing lakes. The project area does not have any fish-bearing lakes associated with inland low-lying tundra habitat and is therefore unlikely to support nesting yellow-billed loons. In 2000, surveys conducted for the DMTS navigational improvements draft EIS documented all species of loon found in North America migrating in the vicinity of the port during spring (Corps 2005). Birds were observed flying low over the water along or near the beach.

Raptors. The 1984 EIS indicated that the project area provides suitable habitat for cliff nesting raptors, such as the rough-legged hawk, gyre-falcon, and peregrine falcon (Dames & Moore 1983a, b). Nest surveys confirmed the nesting of all of these species except the peregrine falcon (Dames & Moore 1983b; SRK 2007). Several nests were located in the mine vicinity and along the proposed transportation corridor. In 2005, three rough-legged hawk nests were reported in the mine area near the DD-2 materials site, one near the confluence of the North Fork and Middle Fork Red Dog Creek and another approximately 2 miles downstream from the North Fork and Middle Fork confluence. The nearest recorded peregrine falcon nest is located on the Omikviorok River bridge on the DMTS road (SRK 2007). Two golden eagle nests were also documented in the vicinity of the mine in 1982 (Dames & Moore 1983a). The nests were inactive in 1982, and subsequent surveys over the past 16 years have not documented golden eagles using the area. Other raptor species observed include merlin, northern harriers, and the short-eared owl.

Prior to the construction of the mine, the peregrine falcon was federally listed as endangered under the ESA and was the most notable raptor in the region. However, Dames & Moore (1983a) note that the southern slopes of the Brooks Range were not known for supporting high densities of peregrine falcons despite being 150 miles (241 kilometers) from one of the largest peregrine falcon concentrations in North America. The snowy owl was evaluated in the DMTS risk assessment and the results are summarized above.

Migratory Birds. Neotropical migratory birds are far-ranging species that require a diversity of habitat for foraging, breeding, and wintering. Therefore, patterns of population declines are generally detected at larger observational scales than those traditionally used to manage lands, and by assessing habitat at a larger geographic scale (Finch and Stangel 1993).

More than 100 species of birds migrate from the lower 48 states and Central and South America, to nesting, breeding, and rearing grounds in the State of Alaska. Most birds fly to the interior or northern Alaska and only pass through southeast Alaska on their way to breeding grounds. There are 114 “Important Bird Areas” identified by the Audubon Society, and a Partner for BirdLife International is working to identify a network of sites that provide critical habitat for birds. Of those areas identified, 49 sites have been recognized to date as important habitat for migratory birds in the State of Alaska.

Five species have been identified as species of concern for northern Alaska, including the gyrfalcon, snowy owl, gray-cheeked thrush, Smith’s longspur, and hoary redpoll (BPIF 1999). Within the project area, riparian corridors of willow and alder shrubs contain the highest diversity of land birds. Other than the loss of riparian zones along the South Fork and Middle Fork Red Dog Creek, impacts from existing operations on riparian areas are limited to DMTS road crossings. The extent of existing impacts on this habitat type is small considering the amount of riparian habitat within the project area specifically, and northwest Alaska in general. The Lapland longspur was evaluated in the DMTS risk assessment, and the results are summarized above.

3.9.2.5 Upland Game Birds

Ptarmigan. Willow and rock ptarmigan were identified by the 1984 EIS as important avian species in low shrub and tussock tundra in the mine region. As discussed above, the DMTS risk assessment indicated that the willow ptarmigan may be at slight risk of adverse effects from exposure to lead at the mine site and at the port. The HQs for barium are slightly elevated at the mine and along the DMTS road, but the DMTS risk assessment concludes that barium is unlikely to be a risk to willow ptarmigan because of barium’s low biological availability and the conservative toxicity value that was used in the risk calculation. The HQs based on the 95 percent UCL concentrations and the NOAEL TRVs are slightly elevated for zinc at the port (1.3) and at the mine (1.4), and for mercury at the port (1.2), but the LOAEL HQs are less than 1. In addition, the zinc and mercury HQs based on the mean concentration are less than 1. The DMTS risk assessment concludes that risks are unlikely given that the most conservative HQs are only slightly above 1 and that the HQ for the mean concentration is less than 1, but risks cannot be completely ruled out.

3.9.2.6 Marine Mammals

Historically, 17 species of marine mammals occurred within the Chukchi Sea (Johnson et al. 1966, Table 3.9-3). Literature published after 1966, summarized by Angliss and Outlaw (2007), indicates that many of these species no longer occur in the Chukchi Sea (sei whales, humpback whales, fin whales, northern right whales, and narwhals). Other species were known to be only occasional migrants in the eastern Chukchi Sea and the waters in the vicinity of the DMTS port site (orcas, ribbon seals, and fur seals) at the time of mine construction (Angliss and Outlaw 2007). These species were not addressed extensively in the 1984 EIS (EPA 1984) because they are unlikely to occur within the project area, and thus are not considered further in this document.

Table 3.9-3 Marine Mammals Historically Occurring in the Chukchi Sea*

Pinnipeds (Seals and Walruses)	Cetaceans (whales and porpoises)	Other Marine Mammals
Bearded seal	**sei whale**	polar bear
ringed seal	**minke whale**	
ribbon seal	**humpback whale**	
spotted seal	bowhead whale	
fur seal	gray whale	
Pacific walrus	beluga whale	
	orca whale	
	harbor porpoise	
	Narwhal	

Source: Johnson et al. (1966)
*Based on more recent literature, the species in bold no longer occur in the eastern Chukchi Sea.

Marine mammals that have the potential to occur in the vicinity of the DMTS port site, and thus have the potential to be affected by port operations, include the bearded seal, ringed seal, spotted seal, beluga whale, bowhead whale, gray whale, harbor porpoise, and polar bear. The polar bear, which was listed as threatened in 2008, is discussed under Threatened, Endangered, and Candidate Species in Section 3.9.2.7. The Pacific walrus typically remains 30-40 miles offshore from the port so it is not considered further here. In August and September 2007 a juvenile walrus, apparently abandoned by or otherwise separated from its mother, was reported around the base of the shiploader cells at the port site. However, this occurrence is considered unusual. In September 2007, this walrus was captured and subsequently relocated to the Alaska Sealife Center.

The polar bear is the only marine mammal species federally listed under the ESA that occurs within the project area. However, many marine mammals are particularly important in the diet and traditional use of the Alaska Native communities in the vicinity of the project area who have seasonal camps situated along Kotzebue Bay and the Chukchi Sea (see Section 3.12, Subsistence, for additional discussion).

The primary impacts to marine mammals associated with the mine are noise and disturbance from the construction and ongoing operation of the port and DMTS facilities that could have displaced individual marine mammals using the coastal waters in the vicinity of the project area. The existing loading and shipping operations only generate sounds during the open water season. Sound measurements during the open water period indicated that noise from these operations may be heard up to 16.5 miles offshore of the port (noise from the actual port and tugs transporting ore to carriers moored offshore was estimated to extend 6.5 miles offshore; biweekly arrivals and departures of ships increase this distance by 12 miles) (Corps 2005). Thus marine mammals would have to be present beyond these distances to be outside the range of detectable noise during the summer. Sound measurements during normal winter operations indicated that marine mammals would be exposed to sounds of vehicles and generators within half a mile of the port and up to 3.7 miles if especially noisy maintenance work were to be performed (Corps 2005).

Anecdotal evidence from subsistence hunters and others in the project area suggests that some species (e.g., beluga whale) that swim up the coast during migration appear to avoid the area near the port (Corps 2005). This has been attributed, in part, to noise associated with port operations and vessel traffic, but the effects of noise are confounded for some species by changes in human hunting practices (e.g., the greater use of motorized boats in recent decades and the avoidance of noise sources by hunted species) as well as changes in the climate and marine conditions in the Chukchi Sea. It is likely that displacement due to the port is not more than local, occurring during concentrate loading operations. There is no indication that current operations have resulted in major changes in migration routes or movements of any species (Corps 2005). The presence of individual species in the vicinity of the port and potential effects of ongoing port operations are discussed briefly below. The DMTS navigational improvements draft EIS (Corps 2005) provides an analysis of effects of current mining operations, focusing on the DMTS port facilities, and is incorporated as appropriate.

Bearded Seal. Two subspecies of bearded seals inhabit the circumpolar region. *Erignathus barbatus nauticus* ranges from the Arctic Ocean (85˚ N) south to through the Bering Sea to Hokkaido, Japan (45˚ N). Only this subspecies occurs in the project area. In Alaska, bearded seals are distributed over the continental shelf of the Bering, Chukchi, and Beaufort seas (Angliss and Outlaw 2007). During the 1970s and 1980s the world-wide population of this subspecies was between 250,000 and 300,000. No specific estimates exist for the Chukchi Sea at that time.

Bearded seals are closely tied to the seasonal availability of sea ice and generally inhabit waters less than 660 feet (200 meters) deep. A majority of the population migrates to and from the Bering Sea following the advance and retreat of the polar ice edge although a small number of seals remain year-round, occupying the open water of the Chukchi Sea during the summer. Pups are born on the ice. The bearded seal population in the eastern Chukchi Sea typically occurs south of Kivalina (within the project area) in late fall with the advance of the icepack, and again in the spring as the icepack moves north (Dames & Moore 1983a). Sea-based operations at the port are suspended for the season by the time bearded seals are in the area.

Early studies indicated that bearded seals primarily feed on benthic invertebrates such as crab, shrimp, clams, and snails; fish such as sculpin, flatfish, and cod comprise a minor component of the diet (Johnson et a. 1966; Lowry et al. 1980). Predators of bearded seals include polar bears, orcas, walruses, and humans.

Ringed Seal. Ringed seals also have a circumpolar distribution from the North Pole to 35˚ N. The Alaska stock occurs throughout the Beaufort, Chukchi, and Bering seas as far south as Bristol Bay, where they are closely associated with ice-covered waters. Based on their distribution, they are thought to be the most abundant marine mammal on the northwest Alaska coast. Reliable population estimates for the Alaska stock of ringed seal are not available. However aerial surveys conducted between 1985 and 1987 in the Chukchi and Beaufort seas from Kotzebue Sound north and east to the U.S.–Canadian Border resulted in a partial estimate of over 44,000 hauled-out animals (Frost and Lowry 1988). Surveys conducted between 1976 and 1987 between Cape Thomas (north of the project area) and Cape Krusenstern (south of the project area) by ADF&G documented densities ranging from 1.9 to 3.3 seals per square mile, with densities being greater closer to shore (Frost and Lowry 1988).

Like bearded seals, ringed seals migrate with the advance and retreat of the ice edge. Most spend the winter dispersed on the southern edge of the ice pack, but some disperse to near-shore wintering areas that provide suitable ice and feeding conditions. In the spring the ringed seals move north and eventually into the northern Chukchi Sea where they remain dispersed along the edge of the ice pack for the summer. Therefore, they are most likely to occur in the vicinity of the project area in late fall through early summer when ice cover is present.

Ringed seals were the most common marine mammal observed during studies conducted prior to mine construction (Dames & Moore 1983a). Large numbers of ringed seals continue to be present near the port during winter within 4,000 feet of the barge loader (Corps 2005). The effects of ongoing port operations to ringed seals include noise from spring maintenance, generators, and vehicles at the port. Based on aerial counts of ringed seals on the ice in the vicinity of the port and other comparable areas, ongoing operations do not appear to have affected the distribution or abundance or this species (Corps 2005).

Ringed seals primarily forage on arctic cod, saffron cod, and other fish but they will forage on shrimps and other crustaceans when available. In addition to humans, predators of ringed seals include polar bears, arctic and red foxes, walruses, dogs, wolves, wolverines, and ravens (ADF&G 1994).

Spotted Seal. Spotted seals occur along the continental shelf of the Beaufort, Chukchi, Bering, and Okhotsk seas south to the Yellow and Western seas of Japan (Shaughnessy and Fay 1977 cited in Abar 2002). Within the eastern Chukchi Sea/Kotzebue Sound region, spotted seals replace ringed seals during the ice-free summer and early fall months. Estimates of the world population of spotted seals range from 335,000 to 450,000 animals, with approximately 200,000 to 250,000 seals in the Bering Sea population (Burns 1994).

The spotted seal is strongly associated with sea ice from late fall to late spring-early summer and bears its young on the drifting pack ice. Once ice has retreated, spotted seals move to coastal habitats where they remain during the summer and early fall. Coastal haulouts are found as far north as the Chukchi and Beaufort seas. Spotted seals form large aggregations on both ice and land. Recent satellite tagging studies have shown that some seals make extensive feeding trips of several hundred miles from the Chukchi Sea coast to the western Chukchi Sea and back. In autumn-early winter they move southward and away from the coast just before and during freeze-up. Some seals move down the Chukotka Peninsula coast and then into the central Bering Sea. Thus, spotted seals occasionally occur in the vicinity of the port during summer, near the mouths of rivers and lagoons.

Beaufort Sea Beluga Whale. Beluga whales occupy the arctic and subarctic regions in five distinct stocks (O’Corry-Crowe 2001). The Beaufort Sea stock has the potential to occur near the project area migrating north through the Chukchi Sea in April and May to summer areas near the Mackenzie River Delta. This stock follows offshore leads that are typically more than three miles from the port. The Eastern Chukchi Sea stock winters in the Bering Sea, then migrates in the spring to the Kotzebue Sound/Eschscholtz Bay area to calve and molt. This stock then migrates north along the coastline past the port in early July. Beluga whales from this stock swim close to shore following the breakup of the ice. When the Beaufort Sea and Eastern Chukchi Sea stocks migrate south in the fall they both are usually farther offshore than in the spring.

Surveys conducted for the DMTS navigational improvements draft EIS observed several belugas migrating between the port site and Kivalina, approximately three miles offshore, and two belugas passing near the shiploader platform (Corps 2005). Scoping comments from Alaska Native subsistence hunters indicated that beluga whales traversing near shore have been observed heading into deep water in an apparent effort to avoid activity at the port. There has been a decline in subsistence take of the species over the past several decades, which corroborate their observations (see Section 3.12 for additional information). These trends coincide with the increased use over the last several decades of motorboats for hunting (Corps 2005). Based on a summary of traditional ecological knowledge of beluga whales derived from interviews with Alaska Native hunters in the region, avoidance and habituation responses of these whales to anthropogenic noise appears to depend in part on association with hunting activities (Mymrin et al. 1998). That is, there is some evidence that beluga whales may become more habituated to human-caused noise in the absence of hunting, and conversely may avoid such noise if they associate it with hunting. Additionally, as mentioned above, global warming also has the potential to alter whale habitat use patterns through changes in ice coverage and productivity, particularly whales that are closely associated with ice habitats (Tynan and DeMaster 1997). The International Whaling Committee noted the vulnerability of beluga whales to changing ice conditions (IWC 1997). Thus the extent to which noise generated from the terminal has, or has not, caused a local shift in use of the waters surrounding the port by beluga whales must be considered in the context of all of these factors.

Gray Whale. Gray whales migrate along the Pacific coast between arctic seas and wintering areas in more temperate waters. The Eastern North Pacific stock is the largest surviving population. Gray whales make long migratory movements of up to 14,000 miles. In October they leave their feeding grounds in the Bering and Chukchi seas and head south for their mating and calving areas in Baja California, Mexico. Gray whales seasonally inhabit the near-shore waters of Kotzebue Sound and the coastal waters of the Chukchi Sea during their northern migration; their southern migration follows the western coast of the Chukchi Sea. This species typically does not feed near the port, but does pass through the area during summer on their way to feeding grounds in the Point Lay/Wainwright area.

Harbor Porpoise. Three stocks of harbor porpoise occur in Alaskan waters, including the Bering Sea, Southeast, and Gulf of Alaska stocks. The Bering Sea stock has the potential to occur in the waters near the port. In June and July of 1999, an aerial survey covering the waters of Bristol Bay resulted in an uncorrected abundance estimate for the Bering Sea harbor porpoise stock of 16,271 (Angliss and Outlaw 2007). Harbor porpoises typically occur in waters less than 330 feet (100 meters) deep and use shallow areas along the eastern Chukchi Sea coast during summer (Hobbs and Waite in review cited in Angliss and Outlaw 2007). Harbor porpoises may occur near or may migrate past the port after the icepack recedes in the later spring and summer, and may remain in the vicinity of the port during the open-water season.

3.9.2.7 Threatened, Endangered and Candidate Species

Polar Bear (Threatened). The polar bear is the largest terrestrial carnivore and top predator inhabiting the arctic. Polar bears have a circumpolar distribution and are found in areas where sea ice remains for a substantial part of the year. Throughout their range they spend most, if not all, of their time on the ice from which they stalk their primary prey, the ringed seal, which is also dependent on year-round sea ice. Typically polar bears wait for ringed seals to emerge from the water to breathe or climb onto the ice to rest. Polar bears also prey on bearded and harp seals, juvenile walrus, beluga whales, narwhal, fish, and seabirds and their eggs (Buck 2007).

There are 19 known polar bear populations in the circumpolar region; two occur in the United States. The range of the Chukchi/Bering Seas population overlaps the project area, extending from western Alaska to Wrangel Island and eastern Siberia. Polar bears may inhabit the coast within the project area during winter, in association with ice flows. The occurrence of bears along the coast varies considerably and is related to the timing and direction of ice movements. Typically, few polar bears are found between Point Hope and Kivalina except when northwest winds drive ice southeast along the coast, bringing polar bears with it (EPA 1984). During the summer, bears occur near the edge of the pack ice in the Chukchi Sea and Arctic Ocean, mostly between 70° and 72° north latitude, well north of the project area. The polar bear has been listed as threatened under the ESA by USFWS.

Polar bears would likely occur in the project area along the coast only during winter when no on-water activities occur. The only activity occurring at that time is the delivery of ore concentrate from the mine to the port for storage. Polar bears occasionally have been observed passing by the loader, but have not been reported to remain near the port facilities (Corps 2005).

Olive-sided Flycatcher (Candidate and Species of Concern). The olive-sided flycatcher is a long distance migrant. They are typically found in the coniferous forest biome throughout North America, though they occasionally use deciduous/coniferous forests. They are associated with openings, including muskegs, meadows, burns, and logged areas, and water, including streams, beaver ponds, bogs, and lakes.

Olive-sided flycatchers breed in central Alaska between mid-May and early-June, remaining until mid-August. They are aerial hawkers that hunt for insects from perches. Therefore, they require openings for hunting and forested habitats for nesting.

The project area occurs on the periphery of the breeding range of this species. Current mining activities have likely had no effect on this species because of the absence of suitable coniferous habitat.

Spectacled Eider and Steller's Eider (Threatened and Species of Concern). Neither species of eider is likely to occur at the mine site as both species nest in coastal wet tundra and migrate along the Bering Sea coast. Previous studies have not documented either species within 10 miles of the mine or DMTS road (EVS 1997); however, the project area does occur in the migratory route for both species. Thus, occasionally a migrating bird could stop over in marine waters near the port site or adjacent lagoons. A few small flocks were seen during the wildlife surveys at the port in 2000 (Corps 2005). The closest breeding habitat is located several hundred miles south. No critical habitat for these species has been documented in the project area. These species generally migrate along offshore leads and typically occur far from land; therefore, existing operations are unlikely to have an effect on these species.

Bowhead Whale (Endangered and Species of Concern). The bowhead whales inhabiting the western arctic consist of two stocks including those that summer in the Bering and Chukchi seas, and those that summer in the eastern Beaufort Sea. The Bering Sea/Chukchi Sea stock numbers approximately 7,700 whales (Angliss and Outlaw 2007). During spring migration, pods of bowhead whales follow fractures and leads in the ice and the zone between shore-fast ice and pack ice round the coast of Alaska to summer feeding grounds in the Beaufort Sea. Typically, bowhead whales do not migrate close to the shoreline of the project area, but follow leads in the ice that are three miles or farther offshore from the port. Surveys conducted in the spring of 2000 did not detect any bowhead whales; the last bowhead harvested by a whaling crew in Kivalina was in 1995.

3.9.3 Wildlife – Environmental Consequences

3.9.3.1 Effects Common to All Alternatives

Under all alternatives, effects of fugitive dust produced by mine related activities would continue to some extent. A draft fugitive dust risk management plan intended to minimize risk to the environment is currently being developed that would be implemented under all the alternatives. This plan builds upon ongoing efforts taken by the Applicant to reduce dust emissions, which include the use of newer trucks, installation of a truck wash, and upgrades to storage, loading, and transfer facilities. Elements of this plan include programmatic and engineering controls, monitoring, and remediation and restoration activities. However, since the fugitive dust risk management plan and its implementing plans have not been finalized, it is uncertain which action items will be implemented.

A revegetation plan would also be implemented under all of the alternatives (ABR 2007d). This plan, which is also under development, would re-establish vegetation types on disturbed areas that are ecologically compatible with the local climate. Native vegetation (primarily grasses) would be used to seed disturbed areas in most cases. In some cases (discussed in more detail in Section 3.7) native vegetation may not be desirable in supporting long-term site stability, in which case, the stability function (i.e., not encourage roots to penetrate a cover) would be favored over a land use function (e.g., native species supporting subsistence uses). Thus, non-native species may be desirable where (1) the priority is to stabilize the soil surface; or (2) influence the community composition in the reclaimed landscape. Once established, the presence of vegetation would improve wildlife habitat in the area, although it would not necessarily match the habitat types that existed in the area before mining began. See Chapter 2 for additional information.

Under all alternatives some activity along the DMTS road would continue during operations and for maintenance of the wastewater treatment system after closure. Thus, the potential for direct mortality of wildlife and disturbance associated with vehicles along the road would continue, proportional to the level of traffic required.

3.9.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A, mining of the Main Pit would continue until 2011. Impacts to wildlife, similar to those experienced from current mine operations, would continue until mining ceases; disturbed sites would be reclaimed; and human activities in the area would be reduced. Some effects, such as those resulting from altered habitats and low levels of human activity, would continue over the long term.

Terrestrial Mammals

Continued mining of the Main Pit, installation of additional facilities, and activities associated with the DMTS would result in minor (less than one acre) additional direct habitat loss. Deposition of fugitive dust would continue at the current rate, given that mining operations would continue at existing levels. Thus, under Alternative A, no additional indirect loss of habitat along the DMTS road caused by fugitive dust deposition would occur. Levels of human activity would also remain the same under Alternative A: therefore, no additional displacement of terrestrial mammals from the project area or alterations in movement patterns would be anticipated. Additionally, the risk of collision with vehicles using the DMTS road would continue at current levels, which over the last 10 years has resulted in an average of two collisions per year.

Terrestrial mammals would continue to have the potential to be exposed to contaminants either through the consumption of contaminated plants or through exposure to water in the tailings impoundment. However, as indicated in the 2007 DMTS risk assessment, risk to terrestrial mammals from these sources is low, and would remain low under Alternative A.

Some terrestrial mammals may continue to be attracted to artificial habitats created within the project area (e.g., the tailings impoundment) or become habituated to human activity (e.g., red foxes), and would require hazing. To date, hazing has been successful in deterring animals from project facilities without resulting in injury or death. Under Alternative A, hazing practices would be expected to be implemented as needed with similar results.

Birds

Because only minimal changes in the project footprint and no changes in human activity would occur under Alternative A, no additional habitat loss or displacement of birds would be expected. Waterbirds would be expected to periodically use the tailings impoundment and therefore would continue to be exposed to contaminants, though the level of risk to these species would remain low as determined by the 2007 DMTS risk assessment. Hazing practices would be used to deter birds from using this area.

No new impacts to riparian habitats, which support a diversity of bird species, or other habitats used by birds (e.g., lagoons, wetlands, tundra) would occur under Alternative A because of the minimal change in the project footprint (less than one acre for the new water treatment facility).

Marine Mammals

Under Alternative A, exposure of marine mammals to noise and disturbance associated with port operations would be unchanged from current conditions under normal operations. Therefore, the level of effects to marine mammals in the vicinity of the project area would remain the same under the no action alternative for the duration of operations. As noted above, under the description of baseline conditions, recent local observations suggest that some marine mammals may be avoiding the port; however, these potential effects are confounded by concurrent changes in human hunting practices. Furthermore, any displacement that might occur as a result of continued operation of the port under Alternative A would be expected to be temporary and localized.

Threatened and Endangered Species

As under current operations, no effects to threatened and endangered species would result from continued operation of the project under Alternative A because of the lack of suitable habitat within the project area capable of supporting them (olive-sided flycatcher) or their general absence from the project area (spectacled eider, Steller's eider, bowhead whale, and polar bear). The polar bear's use of the port area would be limited to winter and spring, outside the period of the facility's operation.

3.9.3.3 Effects of Alternative B – Applicant's Proposed Action

Under Alternative B, mining activities would be extended to the Aqqaluk Deposit and would continue until 2031. The development of the Aqqaluk Deposit would increase the disturbance footprint from 2,147 acres to 2,553 acres, with approximately 246 acres associated with the open pit, and approximately 142 acres associated with increasing the level of water in the tailings impoundment. Alternative B would have a long-term adverse impact on approximately 2,553 acres of habitat until reclamation was completed. Section 3.7 summarizes impacts on individual habitat types.

As in Alternative A, impacts to wildlife under Alternative B would continue until mining ceases, disturbed sites are reclaimed, and human activities decrease, though these actions would continue to occur for an additional 20 years. The Aqqaluk Deposit has already been heavily disturbed by exploration, although much of the area was composed of sparsely vegetated, low quality upland barrens and alpine low shrub/tundra prior to exploration. Exploration activities have included road and drill pad construction, exploration drilling, bulk sampling, and the use of helicopters for moving drilling equipment, delivering supplies to rigs, and the transportation of drill crews. The location and extent of the Aqqaluk Deposit is shown in Figure 1.2. Small areas of lowland wetlands occur in the pit disturbance area and along the edges of the tailings impoundment. Since some of this area has already been physically disturbed, and undisturbed areas are adjacent to ongoing activity, development of these areas would result in minimal new habitat loss for wildlife on a regional scale; however exploration activities alone would have fewer long-term consequences than the actual mining of the deposit (Alternative B), which would involve a conventional blast-shovel-truck operation similar to that in the Main Pit. Thus, Alternative B would have greater noise and disturbance effects, and more extensive habitat loss than Alternative A.

Tailings from the Aqqaluk Deposit would be stored in the existing tailings impoundment, raising water levels and inundating shoreline. Although this area has attracted species (e.g., waterfowl) the Applicant discourages them to prevent possible exposure to contaminants. Hazing would continue at current levels. A water cover would be maintained over the tailings following closure. At closure, a pond would form in the Aqqaluk Pit and be used to store the site's contaminated water, including seepage from the waste rock dump and pit walls. Hazing activities would be used to deter wildlife from using open water at the site for as long as water treatment operations are necessary.

Development of the Aqqaluk Deposit would result in an increase in the size of the tailings impoundment and longer exposure to fugitive dust from mine facilities and the DMTS road. Although this change would result in a potential for increased exposure to contaminants, the 2007 DMTS risk assessment food-web model analysis indicates that incremental exposure would be negligible (Exponent 2007a).

Land Mammals

Alternative B would result in a minor amount of direct habitat removal for large terrestrial mammals. Small mammals inhabiting the area of the deposit would likely have already been displaced from the Aqqaluk Deposit area during exploration activities. These effects would be localized and displacement from the project area, or alterations in movement patterns, would only be anticipated for small mammals with limited movement capabilities in the immediate vicinity of the Aqqaluk Pit.

Some terrestrial mammals would continue to be attracted to the tailings impoundment and Aqqaluk Pit lake. To minimize exposure of terrestrial mammals to contaminated water, hazing practices would continue to deter animals from using these areas. Because the mine site is considered to have a low value in terms of wildlife habitat (i.e., due to the extent of disturbance and activity), direct habitat loss resulting from the increase in size of the tailings impoundment would be limited. Furthermore, although Alternative B may increase the opportunity for accidental exposure of terrestrial mammals to contaminants, the 2007 DMTS risk assessment indicated that incremental exposure would be negligible (Exponent 2007a).

Alternative B would increase the duration of indirect habitat loss (e.g., activity along the DMTS road) for 20 years, but activity levels at the mine are not expected to change appreciably relative to current levels. This effect is localized, and therefore is anticipated to be restricted primarily to small mammals such as ground squirrels, voles, and shrews, rather than wider-ranging species that forage over large areas, such as caribou and muskox. However, it should be noted that although muskox are capable of moving large distances, they are frequently sedentary and at least one herd is semi-resident along the DMTS road and the Tahinichok Mountains. Improvements in dust control have been ongoing and additional improvements planned under the draft fugitive dust risk management plan may further reduce these effects.

Exposure to fugitive dust would occur for a longer time under Alternative B than Alternative A, and could possibly result in higher metals exposure concentrations for terrestrial mammals in the project area. However, the effects on wildlife from the longer duration of exposure under Alternative B is not expected to differ greatly from the predicted effects for Alternative A. As with indirect habitat loss due to fugitive dust deposition, exposure to heavy metals would be greatest for less mobile animals (e.g., shrew, vole), than for wider-ranging species (e.g., caribou, fox) that forage over larger areas.

The increased duration of project operations would also extend the period during which terrestrial mammals could be exposed to chemicals, such as petroleum hydrocarbons, milling reagents, and blasting agents. As a result, transportation, storage, and handling of chemicals will take place over a longer time period, thus increasing the potential number of spills that might occur. However, as described in Section 3.8.2, there is a low likelihood of terrestrial mammals being exposed to chemicals either spilled or stored and used in mine facility areas.

Access to the mine site would continue to be restricted during mining of the Aqqaluk Deposit. Therefore, current traffic levels and effects related to human activities (e.g., traffic related incidents) would remain the same as Alternative A although they would carry forward for the additional 20 years of operations.

Birds

Initial clearing activities at the Aqqaluk Deposit would have the potential to destroy nests of any birds that may be present when such work is undertaken. To reduce the potential impacts to nesting birds and to prevent destruction of nests and loss of eggs or chicks, a mitigation measure would be to conduct ground-breaking activities at the deposit and any associated material sites outside the nesting season in the region (late May through early July).

Nesting raptors would most likely be affected by noise and human activity in the vicinity of the Aqqaluk Deposit. Surveys conducted in 2005 documented three rough-legged hawk nests. The nearest nest was approximately 1.5 miles from the Aqqaluk Pit. The nests have remained active through ongoing mining operations. Therefore, it is unlikely that these nests would be further affected by activities associated with the Aqqaluk Deposit.

At closure of the mine, mitigation measures (e.g., hazing) would need to be implemented to prevent the use of the contaminated water in the tailings impoundment and Aqqaluk Pit lake by wildlife, including birds. Similar measures currently employed to keep wildlife from using the tailings impoundment have been successful; therefore, such a program would be expected to be effective in preventing adverse effects. Over the long term, the gradual improvement in water quality in the tailings impoundment may create new habitat for waterbirds and other wildlife. The improvement in water quality would also reduce the extent of potential exposure of waterbirds and other wildlife to contaminants from the mine. Impacts to birds using the near-shore environment and lagoons in the vicinity of the port (e.g., yellow-billed loons) would be the same as Alternative A, although continuing until 2031.

Marine Mammals

Effects to marine mammals would be the same as Alternative A although they would continue through 2031.

Threatened and Endangered Species

No direct or indirect effects would occur from the development of the Aqqaluk Deposit to the spectacled eider or Steller’s eider because these species do not occur in the project area. The 2007 DMTS risk assessment indicated that levels of contaminants in the marine environment near the port were not elevated and any exposure to highly mobile marine mammals, such as ESA-listed whales, would be of minimal duration and unlikely to have any measurable effect. Individual polar bears in the vicinity of the port could be exposed to noise, though operations would remain unchanged from current conditions.

3.9.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Alternative C would install a pipeline between the mine area and the port for transport of concentrate. The pipeline would be installed in a bench adjacent to and at the same level as the road. The bench would be revegetated, resulting in the permanent removal of 145 acres of tundra habitat vegetation. The habitat disturbed by the pipeline bench would exist for the duration of mining activities.

Installation of the pipeline would substantially reduce the truck traffic between the mine and the port. This would reduce fugitive dust emissions and would decrease the potential for direct mortality associated with vehicle collisions and disturbance from human activity along the DMTS road. Emissions of fugitive dust elsewhere in the project area would remain the same as Alternative B.

Alternative C would also have a wastewater discharge pipeline and fuel pipeline to further reduce truck traffic. These pipelines would not create additional impacts to wildlife as they would be buried within the same bench as the concentrate pipeline. All other activities at the mine, including mining of the Aqqaluk Deposit, and at the port would have the same impacts as Alternative B. Closure under Alternative C assumes dry closure of the tailings impoundment, which would eliminate the tailings impoundment as a source of potential exposure to toxics and as new water habitat when water quality improves.

One 100 kW-wind turbine has been proposed near the port facilities and would be located in an area that would need to be determined based on additional study. The proposed unit would be approximately 115 feet (35 meters) in height from the ground to the hub and would have a rotor sweep of approximately 70 feet (21 meters). Temporary or permanent habitat loss and displacement of birds from habitats near the turbine would not occur to a measurable level as placement would occur in an area already affected by port activities. A bird mortality monitoring plan should be developed.

Land Mammals

Effects to terrestrial mammals from mining operations would be the same as Alternative B. The reduction of heavy truck traffic along the DMTS road would drastically reduce transportation related effects. Traffic and impacts from fugitive dust have already reduced the habitat value of this area although it has not been eliminated entirely; the value of habitat lost in building the pipeline bench would be much less than occurred before construction of the DMTS road. A reduction in the number of concentrate truck trips along the DMTS road would reduce the amount of fugitive dust, leakage of concentrate, and chance of chemical spills that could contaminate vegetation along the road and in the vicinity of the mine and port. However, trucks carrying various chemicals and explosives would still transit the DMTS road, so the chance of spills would not be entirely eliminated. Reducing traffic would result in lower heavy metal exposure for terrestrial mammals in the surrounding environment. While the transfer of contaminants through the food web has already been determined to be a low risk for terrestrial mammals under current operating conditions, the overall reduction in contamination resulting from Alternative C would further reduce this risk.

The initial construction of the pipeline bench would create additional disturbance to wildlife using the area. Species such as caribou and muskoxen that actively use the project area and have been documented along the DMTS road may be temporarily displaced during construction. This would not be expected to alter migration patterns or preclude long-term use of the area because of the lower levels of traffic following construction. To ensure that caribou migration was not affected by construction activities, the timing for building the pipeline bench should avoid major migratory movements of terrestrial mammals through the project area. The construction plan should also identify procedures for facilitating caribou crossing of the DMTS road to reduce any potential temporary shifts in local movement patterns through the project area. The likelihood of this mitigation measure being implemented is good since it could be included as part of the Corps' Section 404 permit for the pipeline construction. Following construction, the reduction in traffic should also reduce the extent of localized changes in caribou movement that had occurred from concentrate truck traffic.

The three individual pipelines carrying concentrate slurry, diesel fuel, and wastewater prior to discharge have the potential to result in a spill of these materials should one of the pipelines fail. Potential effects of a spill include exposure of terrestrial mammals to contaminants and increased disturbance associated with repair activities. The spill response procedures in place would minimize effects of spills on terrestrial mammals and any other disturbance related effects would be short term in nature, maintaining an overall reduction in activity level along the DMTS road.

The impacts at closure would also be similar to those described under Alternative B although the pipeline bench and pipelines would be removed and the disturbed area revegetated. Although temporary effects would be the same as those described for construction, this sequence of events may actually improve habitat values on the side of the DMTS road since any contaminants deposited in the form of fugitive dust may be buried or remediated as part of the reclamation process.

Mine water would be collected in the Aqqaluk Pit lake prior to treatment. Wildlife could be attracted to this water source. A hazing program, similar to that currently employed at the tailings impoundment, would need to be put in place to discourage use of the contaminated water.

Effects to terrestrial mammals from the construction and operation of a wind turbine near the port facilities may include avoidance caused by increased noise and the visual presence of the turbine; however, wildlife likely will avoid the vicinity of the port because of existing structures and ongoing activities.

Birds

The pipeline would parallel existing bridges to span riparian areas and therefore would maintain riparian habitat potentially important to avian species using the project area. All other effects to birds, such as from the operation of the tailings impoundment, would be the same as Alternative B. At closure, the tailings impoundment would be drained and covered, eliminating it as a source for potential contaminants. However, hazing practices would need to be applied to the Aqqaluk Pit lake to discourage its use as long as treatment was required.

Construction and operation of a turbine at the port site has the potential to adversely affect avian species through direct mortality and injury caused by collisions with the wind turbine and/or its guy wires. The exact level of risks to the avian species that either use the port area, or migrate through it, would depend on their mean use of the area and the heights at which each species flies. Avian species that fly at heights similar to the rotor-swept area would have a higher risk of turbine related mortality than those that fly below or above the turbines. Specifically, raptors and migrant passerines (i.e., perching birds, including songbirds) are found more often in post-construction turbine mortality monitoring compared to other groups of birds, such as waterfowl, because of their flight heights and behaviors (Erickson et al. 2001, 2005; Drewitt and Langston 2006; Johnson et al. 2007; Strickland and Morrison 2008). However, to date, limited numbers of raptors or migratory passerines have been documented near the port site. As the proposed turbine would be located within an area already disturbed by the port's activities, temporary or permanent habitat loss and displacement of birds from habitats near the turbine would not occur on a measurable level. To quantify the level of impact to avian species resulting from the port's turbine, a detailed post-construction mortality monitoring plan would be developed and implemented.

Marine Mammals

Impacts to marine mammals would be the same as Alternative B with the additional impact of temporary in-water disturbance during the installation of the outfall and its subsequent removal for mine closure. Temporary reductions in water quality would result from dredging the bottom for pipeline construction, which would increase levels of suspended sediment and turbidity. These effects would dissipate quickly due to wind and wave action. Turbidity plumes could temporarily displace any marine mammals in the vicinity of the outfall site. Construction noise could also cause marine mammals to temporarily avoid the construction areas. However, these effects would be localized and would not be expected to alter the distribution or movement patterns of marine mammals in the project area. Any impacts could be further minimized by avoiding construction during whale migration periods. This measure could be accomplished by incorporating a requirement into the Corps' Section 10 or Section 404 permits for installation of the outfall.

During mine operation, the discharge into the marine environment would meet Alaska State WQS with a small (approximately a cube 10 feet on a side) mixing zone and therefore would have no effect on marine mammals (i.e., they would be at levels below those determined to be harmful for these species). See Section 3.5.3.4 for discussion of mixing zones. At closure, discharge effects to the marine environment would cease because treated water would then be discharged to Red Dog Creek. No impacts to marine mammals would occur from the construction and operation of a land-based wind turbine near the Port facilities.

Threatened, Endangered, and Sensitive Species

Impacts to threatened, endangered, and sensitive species would be the same as Alternative B. The marine outfall would have a minor effect on water quality in its immediate vicinity, but as noted for marine mammals, the effects would be temporary during the installation and removal of the pipe and the discharge would meet Alaska WQS outside of the limited mixing zone.

Impacts to migratory birds, including the olive-sided flycatcher, are possible from the construction and operation of a wind turbine near the port facility. A detailed post-construction mortality monitoring plan would be developed and implemented to assist in developing long-term measures to reduce or eliminate mortalities, if they are reported. To date, polar bears have occasionally been reported offshore of the port facilities in winter. However, the presence of a wind turbine is not anticipated to have any effect on polar bears or their prey.

3.9.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Alternative D would include installing two truck washes and a discharge pipeline adjacent to the road and bench. The bench would be similar to that proposed under Alternative C. Alternative D includes delayed opening of the port site until after beluga migration and closure of the DMTS road during the fall caribou migration. At closure of the mine, the pipeline and wastewater discharge to the Chukchi Sea would remain. Other closure components of Alternative D are the same as Alternative B. Alternative D would be similar to Alternative B in terms of level of traffic, human activity, and mining activity.

Land Mammals

Effects to terrestrial mammals under Alternative D may be greater than under Alternative B as a result of a change in traffic patterns. While the DMTS road would be closed during caribou migration, additional truck traffic would be necessary during other parts of the year to transport the volume of concentrate that would need to be stored at the mine site CSB during the closure. The additional traffic could result in higher mortality and more frequent interactions with vehicles.

Birds

Effects to birds would be similar to those described under Alternative C, except the additional habitat loss would be permanent.

Marine Mammals

Effects to marine mammals would be similar to Alternative C although the marine discharge would continue following mine closure and over the long term. Closure of the port during the spring beluga migration may result in fewer disturbances; however, the physical presence of the port itself, and ongoing activities associated with it, may cause some localized displacement. Teck reports that the Subsistence Committee must give Teck approval to commence shipping activities after the annual spring beluga hunt has ceased, which may limit the value of the port closure over existing conditions.

Threatened, Endangered, and Sensitive Species

Impacts to threatened, endangered, and sensitive, species would be the same as Alternative C.

3.9.4 Wildlife – Summary

Under all alternatives, effects of fugitive dust produced by mine related activities would continue to some extent. A draft fugitive dust risk management plan intended to minimize risk to the environment is currently being developed that would be implemented under all the alternatives. A revegetation plan would also be implemented under all alternatives. Some activity along the DMTS road would continue under all alternatives during operations and for maintenance of the wastewater treatment system after closure. Thus, the potential for direct mortality of wildlife and disturbance associated with vehicles along the road would continue, proportional to the level of traffic required.

None of the alternatives involve significant impacts to wildlife since the bulk of the impacts to habitat have already occurred with construction of the Main Pit, mine facilities, DMTS road, and port facilities.

Although it is sparsely vegetated, development of the Aqqaluk Pit under alternatives B, C, and D would result in additional habitat loss. Alternatives C and D include additional habitat disturbance associated with construction of the pipeline bench. This habitat is already affected by fugitive dust and DMTS road traffic. Alternative C and, to a lesser extent, Alternative D would provide for a slightly lower risk to small mammals and ptarmigan because of reduced fugitive emissions of concentrate. The elimination of most concentrate truck traffic under Alternative C would reduce mortality associated with traffic as well as some of the localized effects of traffic on caribou movement.

Under all alternatives except Alternative D, localized effects of port activities on beluga whale movement would continue for the duration of operations. Impacts would be avoided under Alternative D by the delayed port opening schedule. Because of the small size of the marine mixing zones under alternatives C and D, there would be no impact on marine mammals from the discharge.

3.10 Aquatic Resources

Aquatic resources (primarily fish and benthic invertebrates) were monitored and described prior to current mining activity in several documents (EVS and Ott Water Engineers 1983; EPA 1984; Dames & Moore 1983a). Many ADF&G studies have documented aquatic conditions since mining operations began (Ott and Morris 2005, 2006, 2007, 2008; Scannell and Ott 1998, 2001, 2002; Scannell, Ott, and Morris 2000; Scannell and Anderson 1999; Scannell 1996; Ott and Scannell 1994, 1996, 2003; Ott, Scannell, and Robus 1992; McLean 2005; Ott 2004). The characteristics of the marine aquatic environment are summarized in detail relative to the port by the Corps (2005), and EPA (1984).

3.10.1 Aquatic Resources – Pre-mining Environment

3.10.1.1 Pre-mining Aquatic Resources – Freshwater

Original baseline conditions of many regional streams were characterized as typical cold water, fast flowing streams with abundant organisms. However, naturally occurring metals concentrations and other dissolved constituents in many of the streams (refer to Table 3.5-7 in Section 3.5) have adversely affected the aquatic environment (Dames & Moore 1983a; EPA 1984). North and South Fork Red Dog Creek were generally unaffected by metals. Water quality in Ikalukrok Creek upstream of Main Stem Red Dog Creek was adversely affected by several seeps, including Cub and Moil creeks. Middle Fork Red Dog Creek upstream of the mine facilities was impacted by seeps in Rachel and Connie creeks. Ikalukrok Creek upstream of Red Dog Creek is occasionally affected by natural metal deposit leaching.

Periphyton

While not actually measured at the time of pre-mine baseline surveys, periphyton growth in Red Dog Creek downstream of the ore body, at least to Ikalukrok Creek, was visibly low to absent (Dames & Moore 1983a; Scannell 2005). One of the original authors of the baseline surveys noted in a 2005 report that periphyton growth was obvious where it had been absent 20 years earlier, especially in the lower two thirds (from Station 151 downstream, see Figure 3.17) of Main Stem Red Dog Creek below the North Fork, and on the Red Dog Creek side of Ikalukrok Creek for some distance downstream (several hundred meters) (Houghton 2005).

Benthic Macroinvertebrates

Invertebrate fauna abundance in Ikalukrok Creek upstream of the confluence of Red Dog Creek (Station 9) and some distance downstream of the confluence (Station 8), the North Fork Red Dog Creek, the South Fork Red Dog Creek and the upper Middle Fork Red Dog Creek above the ore body (Figure 3.17) were considered typical of cold fast streams (EPA 1984). However, invertebrate fauna was scarce in Middle Fork

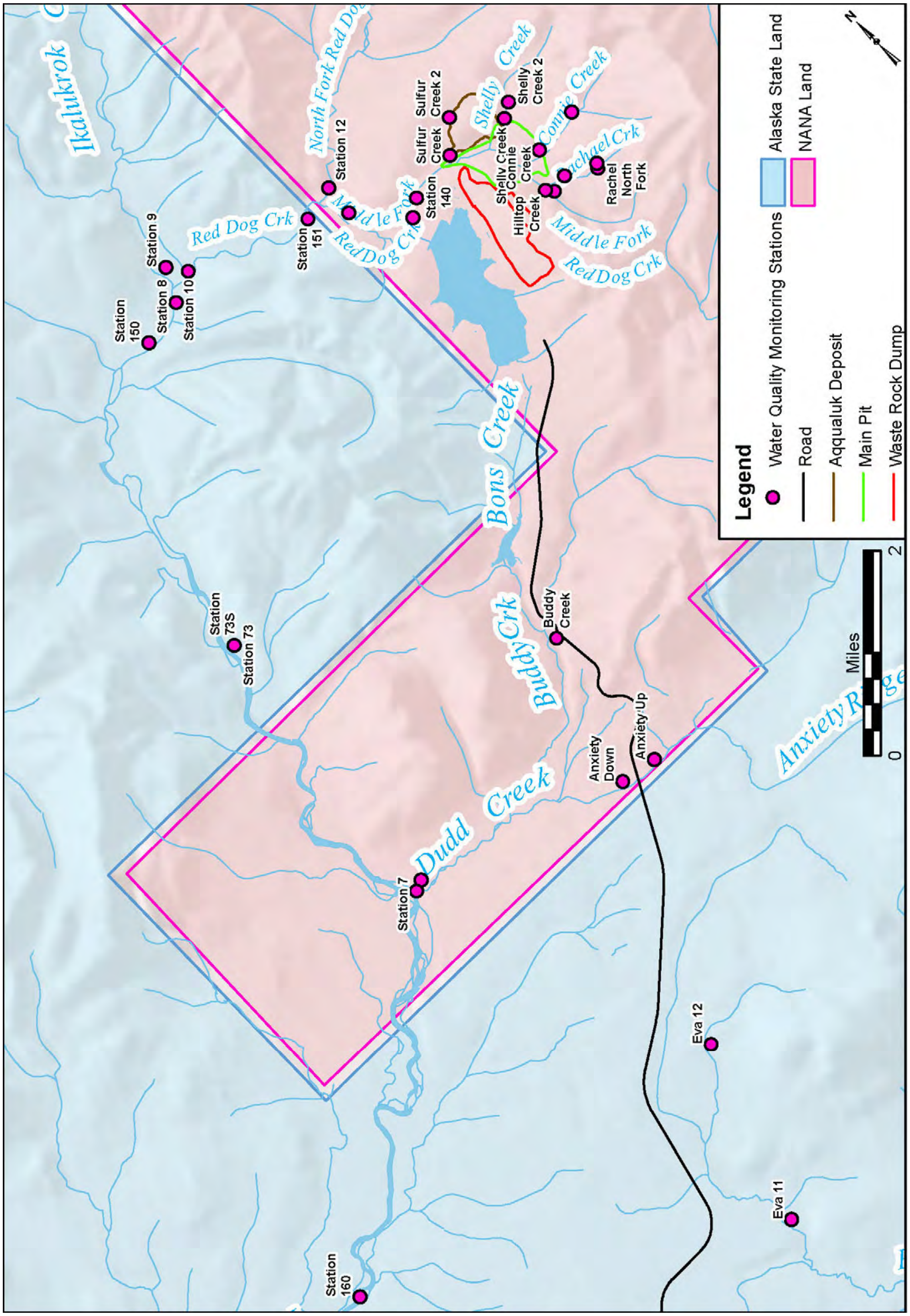


FIGURE 3.17
WATER QUALITY MAP

Red Dog Creek below the ore body and remained low downstream. Benthic macroinvertebrate abundance was at least an order of magnitude higher in Ikalukrok Creek (July and August 1982 densities were 245 and 285 organisms / 0.1 m^2, respectively) just upstream of the confluence with Red Dog Creek, than in Red Dog Creek itself (July and August 1982 densities were 3 and 26 organisms/ 0.1 m^2, respectively) (Dames & Moore 1983a). The reduced abundance trend, although not as severe as in Red Dog Creek, continued in Ikalukrok Creek downstream from the confluence with Red Dog Creek for at least 1,640 feet (500 meters) primarily on the east bank where Red Dog Creek flows were more concentrated, with density ranging from 31 (east bank) to 122 (west bank) organisms/ 0.1 m^2 in July 1982 (EPA 1984; Dames & Moore 1983a). Lowest abundance was generally associated in reaches with the highest metals concentrations (EPA 1984).

Within the project study area non-biting midge fly larvae (Chironomidae) were the most abundant benthic macroinvertebrates, followed by stonefly nymphs (Plecoptera), segmented worms (Oligochaeta), mayfly nymphs (Ephemeroptera), and caddisfly larvae (Trichoptera) in the samples collected prior to mining,. Other benthic macroinvertebrates collected included blackflies (Simuliidae), dancefly larvae (Empididae), biting midges (Ceratopogonidae), water mites (Hydracarina), seed shrimp (Ostracoda), and roundworms (Nematoda) (EPA 1984).

Fish

Portions of Red Dog Creek were inhospitable to native fish species prior to mine development. Arctic grayling (*Thymallus arcticus*) were rarely observed during the pre-mining studies (Dames & Moore 1983a). The only Dolly Varden char (*Salvelinus malma Walbaum*) reported from Red Dog Creek were dead fish found in the main stem (Ward and Olson cited in Scannell 2005; Dames & Moore 1983a). Main Stem Red Dog Creek served only as a migration corridor allowing arctic grayling to enter the North Fork Red Dog Creek during high flow periods when metals concentrations were relatively low. When spawning in North Fork Red Dog Creek was successful, larval and fry grayling could safely pass from the North Fork downstream to the Ikalukrok during high flows in the summer and fall. Prior to mine development, field reports indicated frequent fish mortality of arctic grayling in Red Dog Creek, reducing numbers of many of these juvenile fish produced in the North Fork (Dames & Moore 1983a; Ward and Olson, EVS Consultants, and Ott Water Engineers 1983 cited in Scannell 2005). No fish were observed in the Middle Fork Red Dog Creek upstream of the North Fork confluence even though these areas were searched extensively. Frequent fish kills in Red Dog Creek were noted including mostly arctic grayling and lesser numbers of arctic char (*Salvelinus alpinus*) (Scannell 2005). Ward and Olson and EVS Consultants and Ott Water Engineers 1983 (cited in Scannell 2005) noted that the original baseline study analysis, done by Dames & Moore (1983a), considered the lower 3.1-mile (5-kilometer) reach of Red Dog Creek acutely toxic to fish and most other aquatic organisms. This reach extends from the mouth through Middle Fork Red Dog Creek, which crosses and drains the ore body. South Fork Red Dog Creek appeared unaffected by metals but was essentially isolated from all fish access as a result of the toxic conditions downstream in Main Stem and lower Middle Fork Red Dog Creek.

Sampling in Ikalukrok Creek found a few dead fish in the immediate area downstream of the confluence with Red Dog Creek (Dames & Moore 1983a). Early electrofishing in the 1.8-mile (3-kilometer) reach of Ikalukrok Creek downstream of Red Dog Creek found only one juvenile Dolly Varden char. Aerial surveys of the Ikalukrok Creek reach from Dudd Creek to Red Dog Creek (12 miles) only observed 0 to 6 adult Dolly Varden char compared to 2 to 1,200 in the lower 26 miles of Ikalukrok Creek during the same period in 1982 (Dames & Moore 1983a), suggesting limited use of this region by adult Dolly Varden char. Pre-mine sampling of fish in the DMTS streams was limited to identifying species present and characterizing habitat.

3.10.1.2 Pre-mining Aquatic Resources – Marine Waters

The shoreline conditions at and near the DMTS port site prior to construction consisted of a mix of gently sloping beaches transitioning to low coastal plain. Shallow lagoons lie east of the shoreline beaches. Immediately adjacent to the port facility are two lagoons, North Port Lagoon and South Port Lagoon, north and south of the DMTS road and dock, respectively. The shoreline bathymetry is fairly shallow being less than 50 feet (15 meters) 4 to 5 miles (6.5 to 8 kilometers) offshore (EPA 1984). The bottom consists of a mixture of sands, muds, and occasional gravel, with sand occurring at depths less than 16 feet (5 meters).

Marine sampling methods vary depending on the habitat being sampled. Beach seines and fyke nets are used to sample fish in shallow shoreline areas, while otter trawls are used to sample bottom fish in moderately shallow to deep waters. Beach seines are active sample net gear and have floats on the top and weights on the bottom. They are used to surround and capture fish along a shallow shore area. The nets are typically less than 200 feet in length. Fyke nets are passive gear and have a wing net leading to shore and a bag with fykes (trapping openings). Fyke nets are set along shallow shore waters and rely on fish being directed into the trapping portion of the net. Otter trawls consist of a large funnel-shaped bag net towed by a boat to actively capture fish within a few feet of the bottom of the water.

Invertebrates

Benthic invertebrates near the shore line described before mine construction included a variety of segmented worms, crustaceans, tunicates, bivalves, and brittle stars (*Leptasterias* sp. and *Crossaster* sp.). Cumaceans, nematodes and tunicates occurred primarily in shallow water, with brittle star and bivalves primarily in deeper water. Amphipods were common in both depths (EPA 1984). Epibenthic invertebrates, based on benthic tows, were primarily gammarid amphipods, mysid shrimp, and crangonid shrimp (EPA 1984). Gammarid amphipods were abundant at all near-shore depths (0 to 50 feet [0-15 meters]), while crangonid and pandalid shrimp were most abundant in the deeper areas (33 to 50 feet [10-15 meters]). Diversity was generally high, with highest values at deeper depths. Sea stars were most abundant in otter trawl samples. Similar to benthic tows, both crangonid and pandalid shrimp were also common in otter trawls. Only one crab species (helmet crab [*Telmessus cheiragonus*]) was collected. Commercially important king crabs were not collected during the baseline surveys for the port site area (EPA 1984). Samples collected farther from shore showed greater diversity and a greater number of organisms, including golden king crab (*Lithodes aequispina*), than near-shore sampling (Corps 2005). The port site region is in the outer geographic range of the king crab.

Fish

Fish species were fairly limited in number based on sampling with beach seines, fyke nets and otter trawls in baseline surveys conducted near the port (EPA 1984).

Twenty different species were captured with the otter trawl capturing the greatest number and diversity. The most common species was saffron cod (*Eleginus gracilis*) which was abundant in all gear types. Other fish captured in all gear were starry flounder (*Platichthys stellatus*), arctic flounder (*Liopsetta glacialis*), and rainbow smelt (*Osmerus mordax dentex*). Beach seine samples were dominated by starry flounder, Pacific herring (*Clupea harengus pallasi*), arctic flounder, rainbow smelt, and surf smelt (*Hypomesus pretiosus*). Fyke net catches were dominated by saffron cod, with lesser amounts of five other species. The most dominant fish in otter trawls were saffron cod, yellow fin sole (*Limanda aspera*), and Alaskan plaice (*Pleuronectes quadrituberculatus*). Depth increased catch for otter trawl. In general, abundance and diversity were lowest in the near-shore areas based on the gear catches. The greatest number of anadromous species captured were pink salmon (*Oncorhynchus gorbuscha*) and Bering cisco (*Coregonus laurettae*), but occasional humpback whitefish (*Coregonus oidschian*), chum salmon (*Oncorhynchus keta*), arctic char, and arctic grayling (EPA 1984). While not directly found in sample catches, it has been reported that sheefish (*Stenodus leucichthys),* a large (60 pound) whitefish, also may be present in the marine shoreline waters. In Alaska, sheefish are primarily found in fresh water, but some stocks are considered estuarine anadromous and may be present in brackish coastal waters. Locally they have been reported to follow salmon fry along the coast as far north as Point Hope (Corps 2005).

Only ninespine sticklebacks (*Pungitius pungitius*) were found in lagoons adjacent to the DMTS port site.

3.10.2 Aquatic Resources – Baseline Conditions

3.10.2.1 Baseline Aquatic Resources – Freshwater

Construction of the tailings impoundment buried approximately 3.3 miles (5.3 kilometers) of clear water, gravel bottomed stream habitat in South Fork Red Dog Creek (EPA 1984). Although fish were not present in the reach prior to construction, some productivity from macroinvertebrates was observed in the pre-mining environment (Dames & Moore 1983a; EPA 1984). Burial of the reach represents a permanent loss of that stream segment for any future use regardless of changes in water quality in Main Stem or Middle Fork Red Dog Creek. However, the overall abundance and diversity of periphyton, invertebrate, and fish communities located in various reaches downstream of the mine have increased since the mine opened, likely resulting from improvements in water quality from wastewater treatment at the mine (see Section 3.5) (Ott and Morris 2005, 2007; Ott 2004; Scannell 2005; Houghton 2005).

DeLong Mountain Regional Transportation System Risk Assessment Findings

The DMTS risk assessment (Exponent 2007a) evaluated the risk to aquatic and terrestrial organisms from elevated metals concentrations from fugitive dust within the environment surrounding the Red Dog Mine and DMTS. The highest levels of cadmium (0.308 mg/kg), lead (0.612 mg/kg), and selenium (2.01 mg/kg) in Dolly Varden char in Anxiety Ridge Creek were found near or downstream of the DMTS. The Anxiety Ridge Creek drainage basin contains more mineralized areas than other creeks that cross the DMTS road and fish may be accumulating metals from local lead and zinc mineralization. The levels of cadmium, lead, and selenium in Dolly Varden char were compared to no-effect and lowest adverse-effect tissue concentrations that are associated with adverse effects in various freshwater fish (Jarvinen and Ankley 1999 cited in Exponent 2007a). The results from this comparison were mixed, with the concentrations of cadmium, lead, and selenium in Anxiety Ridge Creek being greater than the lowest reported effects thresholds, but also within the ranges of no-effects thresholds reported in Jarvinen and Ankley (1999 in Exponent 2007a). In addition, fish collected upstream of the road had cadmium and selenium levels above the lowest ends of the effects threshold range. Zinc levels were below the lowest ends of the effects range for all samples. Based on these comparisons, adverse effects to fish in Anxiety Ridge Creek cannot be ruled out. However, fish that have been sampled have appeared healthy over multiple years, and tissue concentrations in most of the areas sampled are in the range of the concentrations in other similar Alaska systems (Ott and Morris 2004). Also, prey concentrations were within the concentration ranges in invertebrate composites at the two reference stations. The overall conclusion by Exponent (2007a) was that exposure to metals at stream crossings was unlikely to cause adverse effects on abundance of fish.

Periphyton

Periphyton densities are highest in the main stem (Station 10) and North Fork Red Dog Creek (Station 12), and lowest in Station 20 in the lower Middle Fork Red Dog Creek (Ott and Morris 2007). Middle Fork Red Dog Creek is not classified for aquatic life because of the documented absence of aquatic life under pre-mining conditions. Between 2000 and 2006, a general increasing trend in chlorophyll biomass has been identified by ADNR at Station 10, and Ikalukrok Creek stations 9 and 8,upstream and downstream of the confluence with Red Dog Creek, respectively (Ott and Morris 2007).

Invertebrates

The majority of invertebrates present in the project area are Diptera, primarily Chironomidae and Simulidae, with a few Tipulidae. Common Plecoptera genera found in this study were *Allocapnia* and *Alloperla*. Ephemeroptera were more commonly found in Ikalukrok Creek upstream of Red Dog Creek (Station 9). Table 3.10-1 lists the invertebrates that have been collected within the Wulik River drainage from 1995 to 1996 (Scannell and Ott 1998).

Table 3.10-1 Taxonomic List of Invertebrates Collected in the Wulik River Drainage 1995 and 1996 (Scannell and Ott 1998)

Taxonomic Group	Common Names	Family/Subfamily	Genus
Ephemeroptera	Mayflies	Baetidae	*Baetis*
		Heptagenidae	*Cinygmula*
Plectoptera	stonefly nymphs	Perlodidae	*Alloperla*
		Nemouridae	*Nemoura*
		Capniidae	*Capnia*
Diptera	midgefly larvae	Chironomidae L	
		Chironomidae P	
	Craneflies	Tipulidae	*Tipula*
		Tipulidae	*Limonia*
	Blackflies	Simulidae	*Simula*
Coleoptera	Beetles	Staphylinidae L	*Stenus*
		Hydrophilidae L	*Hydrochus*
Miscellaneous	Roundworms	Nemotoda	
	Springtails	Collembola	*Podura*

Source: SRK (2007a)

Annual reports on monitoring conducted within the area have presented data on abundance (as measured by number of insects per net), density (number of insects per m^3 of water), richness (as measured by the number of taxa represented), and the percentage of Ephemeroptera, Plectoptera, and Tricoptera (EPT) versus Chironomidae within the project area (Ott and Morris 2007; SRK 2007). EPT are considered more sensitive to environmental conditions than Chironomidae; therefore, a higher percentage of EPT could indicate a lesser degree of adverse impact. The results indicate that the highest invertebrate abundances and densities are in North Fork Red Dog Creek (Station 12) and in Ikalukrok Creek upstream of Station 9 in Red Dog Creek (SRK 2007). The richness was similar in all stations, with more year-to-year variability than between station variability. The percent EPT was typically highest in Ikalukrok Creek upstream of Red Dog Creek (Station 9); however, the results showed wide variations from year to year, and the percent EPT results for North Fork Red Dog Creek and the stations downstream of the mine showed similar ranges of values (SRK 2007). Lower Middle Fork Red Dog Creek (Station 20) had similar abundance as Main Stem Red Dog Creek (Station 10) but lower than the North Fork's Station 12 (Ott and Morris 2007). Although quantitative comparisons are not possible because of differences in sampling methods, the area downstream of the mine has shown increased productivity compared to pre-mining conditions.

Fish

Table 3.10-2 summarizes fish presence by life-history stage in the major stream segments. As noted previously, fish have not been observed in Middle Fork Red Dog Creek at any time, including the pre-mining period (Scannell 2005; EPA 2006a). Because of the unsuitable conditions in Middle Fork Red Dog Creek, an impassible fish weir was placed at the mouth of lower Middle Fork Red Dog Creek to prevent fish from entering this segment. Based on the data available, the winter distribution of all fish species is primarily limited to Ikalukrok Creek downstream of the confluence with Dudd Creek and in the Wulik River (EPA 2006a), although a few species may overwinter in the Dudd Creek tributaries, Anxiety Ridge and Buddy creeks (Ott and Morris 2007, 2008).

Table 3.10-2 Fish Use Within the Project Area

Creek Segment	Spawning	Rearing	Out-migration
North Fork Red Dog Creek	AG	AG, DV, SS	AG, DV, SS
Middle Fork Red Dog Creek	none reported	none reported	none reported
Main Stem Red Dog Creek	AG	AG, DV, SS	AG, DV, SS
Ikalukrok Creek upstream of Red Dog Creek [a]	AG[c]	AG, DV, SS	AG
Ikalukrok Creek between Red Dog Creek and Dudd Creek	none reported	AG, DV, SS	AG, DV, SS
Ikalukrok Creek downstream of Dudd Creek [b]	DV, Chum Chin, SK [c]	AG, DV, SS, Chin	DV

Taken from EPA 2006
AG = Arctic grayling, DV = Dolly Varden char, SS = Slimy sculpin, Chum = Chum salmon, Chin = Chinook salmon, SK = Sockeye salmon
[a] Incomplete surveys
[b] Arctic grayling and slimy sculpin survey data not available
[c] Species present but spawning activity not confirmed

Arctic Grayling (*Thymallus arcticus*). Spawning and rearing of arctic grayling have been documented in both Main Stem Red Dog Creek and North Fork Red Dog Creek (Ott and Morris 2007; SRK 2007). Water temperature appears to be the most important factor determining spawning time, emergence of age zero fish, and potential first year growth. Spawning is usually complete five to nine days after temperatures reach 39 °F (4 °C) (Ott and Morris 2007; SRK 2007).

Fry hatch in late June and rear in Main Stem Red Dog Creek and North Fork Red Dog Creek until fall. Grayling feed on benthic invertebrates and terrestrial insects. In late August or September, young-of-the-year and adults migrate downstream to overwintering areas in Ikalukrok Creek or the Wulik River. ADF&G and ADNR observed large numbers of grayling young-of-the-year in Main Stem Red Dog Creek in 1995, 1996, 1997, 1999, 2003 and 2004 (Ott and Morris 2005), suggesting that arctic grayling spawn in lower Main Stem Red Dog Creek (Ott 2002; Ott and Morris 2007). Use of Main Stem Red Dog Creek by arctic grayling adults and young-of-the-year in the past few years appears to be increasing (Scannell 2005; Scannell and Ott 1998). Increased use is likely related to overall improvements in water quality, increased primary production and increased numbers and diversity of benthic invertebrates (Scannell 2005).

Chinook and Sockeye Salmon (*Oncorhynchus tshawytscha and O. nerka*). Both Chinook and sockeye salmon are rare within the project area. Prior to construction of the Red Dog Mine, Chinook salmon used Ikalukrok and Dudd creeks for spawning (Dames & Moore 1983a). In 2001, two Chinook salmon were observed in lower Ikalukrok Creek (EPA 2006a). No juvenile Chinook salmon were caught in sampling nets between 1990 and 2003 (EPA 2006a), however juveniles were found in Ikalukrok Creek and Anxiety Ridge Creek for the first time in 2004 (Ott and Morris 2007). Townsend and Conley (2004) observed 56 adult Chinook salmon in a side channel slough in lower Ikalukrok Creek in August 2004, the highest number ever observed, while in 2006 none were seen in this same region (Ott and Morris 2007). Water temperature measurements indicate that the slough containing the Chinook salmon is dominated by groundwater with little influence from Ikalukrok Creek water or the Red Dog Mine effluent (Ott and Townsend 2005). In 2005, minnow traps were fished in lower Ikalukrok Creek for the first time since 1990. Six juvenile Chinook salmon were captured within these minnow traps (Ott and Townsend 2005). ADEC reports that the Chinook salmon in Ikalukrok Creek do not represent a significant breeding population (ADEC 2003b).

In field surveys conducted in 1997, eight sockeye salmon were observed in lower Ikalukrok Creek (Ott 2002); however, sockeye salmon use and abundance in the Ikalukrok Creek drainage is probably limited (EPA 2006a).

Chum Salmon (*O. keta*). Recent chum salmon spawning numbers are now comparable with those found during baseline studies, except for 1981, when the number of spawners was substantially higher (Ott and Morris 2007; SRK 2007). Chum salmon are found in Ikalukrok Creek. They spawn in the lower 9.5-mile reach of Ikalukrok Creek below Dudd Creek from late July through August (Scannell and Ott 2002). The population in this reach increased after low numbers in the 1990s (Ott and Morris 2007). Higher numbers occurred in 2001 and 2002, and recently peaked at 4,185 fish in 2006, the highest number since peak counts in 1981 (Ott and Morris 2007). ADNR reported that the large number of chum salmon in recent years are good indications that the population has recovered from the low numbers reported in the 1990s (Ott and Morris 2007).

Dolly Varden Char (*Salvelinus malma Walbaum*). Within the Wulik River drainage, more than 90 percent of overwintering Dolly Varden char are found downstream of the mouth of Ikalukrok Creek (Ott and Morris 2007; Scannell and Ott 1998). Dolly Varden char spawn in the fall and juveniles emerge in the spring. Spawning has been documented in Ikalukrok Creek below Station 160, near the confluence of Ikalukrok Creek and Dudd Creek, and within Dudd Creek itself (EPA 2006). Numbers of fish estimated within the Wulik River are variable, but are comparable with pre-mining surveys, with 60,000 to 140,000 typically observed (Ott and Morris 2007; SRK 2007). During their time in the marine environment, Dolly Varden char move past or through the DMTS port area (Corps 2005).

Juvenile distribution is broader than that of adult spawners. Juvenile Dolly Varden char captures continue to be highest in Buddy Creek and Anxiety Ridge Creek. Elsewhere, juvenile Dolly Varden char migrate upstream in Ikalukrok Creek, through Main Stem Red Dog Creek, and into North Fork Red Dog Creek in early summer and return to the Wulik River in fall to overwinter. The number of Dolly Varden char in Main Stem Red Dog Creek has decreased from highs observed in 1998 and 1999. Ott and Morris (2007) believe the lower number may be the result of improving water quality conditions in recent years in Ikalukrok Creek upstream of Red Dog Creek, allowing Dolly Varden char to more easily use those segments. The improvement in water quality conditions could be the result of changes in the character of a natural mineral seep on Cub Creek, a tributary to Ikalukrok Creek upstream of Red Dog Creek, which was first observed in 1997. The seep produced elevated cadmium and zinc levels at upstream Station 9 in Ikalukrok Creek from 1999 through 2001 but metals concentrations have since decreased (Ott and Morris 2006, 2007). The numbers of individuals captured during the survey years vary considerably, due, in part, to natural variables such as the timing of migration, length of breakup (spring melt), patterns/magnitude of rainfall events, and the rate of temperature change. Years with high numbers of fish in reference sites also tend to have higher numbers in stations downstream of the mine. The highest numbers of juvenile Dolly Varden char are observed from late July to mid-August.

Metal concentrations in Dolly Varden char: Concentrations of aluminum, cadmium, calcium, copper, lead, mercury, selenium, and zinc in fish tissue (gills, kidney, liver, muscle, and reproductive tissue) were measured as part of the biomonitoring programs (Ott and Morris 2007). The Maniilaq Association also commissioned a study on fish tissue concentrations (SRK 2007). The results indicate that metal concentrations in adult Dolly Varden char tissue are not noticeably elevated compared to fish populations elsewhere (also see Section 3.12, Subsistence). However, because of Dolly Varden chars' anadromous life cycle, interpretation of adult tissue samples is questionable. Dolly Varden char out-migrate from overwintering in fresh water rivers to feed in the Bering and Chukchi seas during the summer months. Feeding grounds include coastal areas along Siberia, where fish can be exposed to elevated levels of numerous pollutants (SRK 2007). Further, Dolly Varden char is not obligate to specific rivers for overwintering (i.e., they may spend each winter in a different stream).

In 2002, Ott and Morris sampled juvenile Dolly Varden char tissues from watercourses that cross the DMTS road and from Main Stem Red Dog Creek (Ott and Morris 2004). The results of this study are better suited to determining what contributions local sources have had on the metal concentrations in fish than those that sampled adult Dolly Varden char. Because juveniles leave freshwater after smolting, metals concentrations in juveniles are representative of the watercourses in which they were sampled. The results of this study do not aid in determining whether the metals concentrations found could have a direct impact on fish, only the relative differences between the various watercourses. Ott and Morris (2004) found that the highest concentrations of cadmium, lead, selenium, and zinc in juvenile Dolly Varden char tissues occurred in Main Stem Red Dog Creek. The next highest concentrations for cadmium and lead were found in Anxiety Ridge Creek downstream of the DMTS road. Levels of cadmium and lead were lowest at Aufeis Creek and the Omikviorok River at the southern end of the DMTS road. The next highest concentrations of selenium were in South Fork Aufeis Creek and Aufeis Creek, downstream of the DMTS road. Zinc concentrations were lowest in Aufeis Creek. Samples from Buddy Creek were statistically similar to those from Main Stem Red Dog Creek. Table 3.10-3 lists the relative differences (low, medium, and high) between the various watercourses sampled. The designated level is only in relation to values measured locally and in fish from other Alaskan regions and is not an indicator of effects to the fish (Ott and Morris 2004).

Slimy sculpin (*Cottus cognatus*). Slimy sculpin have been documented in Main Stem and North Fork Red Dog Creek, but are most commonly observed in Ikalukrok Creek immediately upstream and downstream of Dudd Creek. Prior to mine operations no slimy sculpins were found in the Red Dog Creek drainage. Since 1996, the total number captured in the monitoring programs has increased (Ott and Morris 2007; SRK 2007). Prior to 2002, the number of slimy sculpins detected on average in Ikalukrok, Red Dog, Buddy, and Anxiety Ridge creeks was less than 20 fish per year. Since 2003 the number of fish detected per year was typically greater than 20 fish, and values above 60 fish were detected in 2004 and 2005 (Ott and Morris 2007).

Table 3.10-3 Relative Comparisons (Low, Medium, and High) for the Concentration of Cadmium, Lead, Selenium, and Zinc in Juvenile Dolly Varden Char

These values do not refer to toxicity levels, only relative concentrations

Red Dog Area	Cadmium[a]	Lead[b]	Selenium[c]	Zinc[d]
South Fork Aufeis Creek	Low	Low	Medium	Low
North Fork Aufeis Creek	Low	Low	Medium	Low
Aufeis Creek	Low	Low	Medium	Low
South Fork Omikviorok River	Low	Low	Medium	Medium
North Fork Omikviorok River	Low	Low	Medium	Medium
Omikviorok River Downstream	Low	Low	Medium	Medium
Anxiety Ridge Creek Upstream	Low	Low	Medium	Medium
Anxiety Ridge Creek Downstream	Medium	Medium	Medium	Medium
Buddy Creek	Medium	Medium	Medium	Medium
Main Stem Red Dog Creek	High	High	High	High
North Fork Red Dog Creek	Medium	Medium	Medium	Medium
Grayling Junior Creek	High	Medium	Medium	High
Ferric Creek	Low	Low	Medium	N/D

Adapted from Ott and Morris (2004)
N/D = no data
[a] Cadmium (mg/kg): Low = 0.03 to 0.21; Medium = 0.44 to 0.47; High = 0.80 to 3.13
[b] Lead (mg/kg): Low = 0.02 to 0.18; Medium = 0.25 to 0.73; High = 8.4
[c] Selenium (mg/kg): Low = 1; Medium = 2.2 to 7.2; High = 12.7
[d] Zinc (mg/kg): Low = 78.6 to 90.4; Medium = 111 to 124: High = 170 to 286

3.10.2.2 Baseline Aquatic Resources – Marine

This section discusses the presence and abundance of algae, marine invertebrates and marine fish near the port under current conditions. Marine mammals are discussed in Section 3.9, Wildlife. Development of the port facility, including the dock approach and fill pylons, has resulted in the disturbance of less than one acre of near-shore bottom-area habitat.

Much of the following description of the existing conditions section was developed from the DMTS navigational improvements draft EIS (Corps 2005). This document supplies extensive summaries of relevant marine biological resource studies done to date that characterize important marine resources in the vicinity of the DMTS port. The most relevant information is provided below, but more detailed information, such as density and location of specific organisms captured by the various studies in the project area, can be found in that document.

DMTS Risk Assessment Findings. Earlier marine sediment samples of eight metals collected near the loading facility were compared against ecological screening criteria for sediment samples in marine environments. Some of these exceeded their criteria before changes were made in loading operations. However recent samples (in 2004) for these same metals found no exceedance of the screening criteria for any of the metals (Exponent 2007). Therefore, metals in marine sediments are not considered to be at levels that result in risks to marine organisms. While loading operations may continue to contribute to these concentrations, the improved methods will likely reduce future input of lead and other metals.

The DMTS risk assessment also evaluated the potential increase of metals in sediment in the small lagoons adjacent to the loading dock (just north of dock) by testing amphipods in the sediment. The analysis found no measurable adverse toxic effects to the amphipods that were tested. These results suggest that invertebrate communities in these isolated (no direct marine or freshwater stream connections) areas have not been adversely affected by current operations, including deposition of fugitive dust (Exponent 2007).

Algae. Algae within the near-shore marine environment adjacent to the port consist of microscopic algae that inhabit both the water column (phytoplankton) and bottom sediments (benthic). The abundance and productivity of algae communities within the Chukchi Sea depend, in part, on the season. Productivity levels are lowest during winter and spring, when thin mats of microscopic algae form on the underside of ice (Corps 2005). The dominant species comprising these mats are pinnate diatoms (*Nitzschia, Amphiprora, Fragilariopsis*) and dinoflagellates (*Peridinium*). The abundance of these algae ice mats peaks in late May and then declines rapidly as ice breaks up and melts in June (Horner 1985). Algae abundance and production levels are highest during the summer, when light levels are elevated and water temperatures are warmer (Corps 2005). During summer months, benthic algae make up the greatest percentage of the algae community, while planktonic algae become dominant in deeper, more turbid waters. During these warmer months, *Amphiprora ratilans, Gyrosigma, Licmophora,* and *Navicula*, form a thin mat over the bottom sediments (Corps 2005).

Algae within the shadow of the dock facilities likely have experienced reduced production and some loss of bottom producing area, although surface areas of the facilities themselves may add new surfaces that could support primary producers. Overall the affect to primary productivity has been unnoticeable locally or regionally.

Marine Invertebrates. Listed in descending order, the marine invertebrates detected near the port during the survey were sea stars (*Evasterias echinosoma, Asterias amurensis, Leptasterias polaris acervata,* and *L. nanimensis*), helmet crab, king crab, lyre crab (*Hyas spp*.), shrimp (Crangonidae, Caridea, and *Sclerocrangon boreas*), jellyfish (various species), and brittle star (*Gorgonocephalus caryi*) (Corps 2005). King crab, lyre crab, helmet crab, and shrimp are of particular importance because they are a potential source of food for subsistence hunters (also see Section 3.12, Subsistence), and could be present in the vicinity of the port. The dock facilities do not appear to have adversely affected benthic or epibenthic invertebrates. The area (less than one acre) lost to production is small and the surface area of the marine facilities themselves provide attachment area for some invertebrates. The facility produces some disruption of coastal processes and some local scour from propeller activity possibly reduces abundance in a very small region of sea floor.

Helmet Crab. Helmet crabs were the most abundant species of crab detected at the port (Corps 2005). They were detected in both spring and summer months, suggesting that they are present near shore during both iced and ice-free seasons.

King Crab. Abundance of king crabs within the project area was historically low; however, surveys have indicated that they are present in the area at least occasionally throughout the year. Populations may be more abundant near the mouth of Rabbit Creek, about 9 miles (14.5 kilometers) south of the port (Corps 2005). Multiple factors could contribute to the limited abundance of king crabs at the port: their recruitment is dependent on larvae drifting north from the Bering Sea, suitable hard substrates are absent at the port site, and king crabs may move away from areas where rivers flow into the sea, because of unfavorable water temperatures and salinity (Corps 2005).

Lyre Crabs. Surveys of the area found lyre crabs during spring but not during summer months (Corps 2005). The Corps suggested that the lack of lyre crabs detected near the port during summer could result from an offshore migration to deeper waters during these months (Corps 2005).

Shrimp. Species of the family Crangonidae that inhabit the waters of the southeastern Chukchi Sea include, *Argis dentata*, *A. lar*, *Crangon communis*, *C. dalli*, *C. septemspinosa*, and *Sclerocrangon boreas* (Kessler 1985). Crangonidea seasonally migrate between inshore and offshore. They typically range in depths of 18 to 600 feet (3 to 180 meters), while summer trawling surveys near the port found crangonidea shrimp predominantly in water ranging from 30 to 70 feet (10 to 20 meters) in depth (Corps 2005). Crangonidea shrimp are sparsely distributed in waters directly offshore of the port; however, the largest abundance of shrimp found within the project area can be found offshore from Rabbit Creek (Corps 2005).

Pandalid shrimp near the port include *Pandalus goniurus*, and to a lesser extent, *P. borealis*, and *Pandalopsis aleutica* (Corps 2005). Adult pandalids are typically found in waters at a depth of 150 to 1,500 feet (45 to 450 meters) and were more abundant south of the port (near the mouth of Rabbit Creek) than they were adjacent to the port (Corps 2005).

Shrimp from the family Hippolytidae were also found near the port but in very low numbers (Corps 2005). These include *Lebbeus groenlandicus*, *L. polaris*, and several shrimps in the genus *Eualus*.

Marine Fish. In this section, marine fish will be defined as those species that spawn, hatch, and spend their entire life span in the marine environment. Freshwater fish and anadromous fish that typically spawn in the streams of the project area (Dolly Varden char and Chinook, sockeye and chum salmon) are noted below and discussed further in Section 3.10.2.1. Anadromous fish present in the marine environment adjacent to the port that do not typically spawn in the freshwater streams of the project area are discussed within this section.

A trawl survey was conducted at the port in 2000 to identify marine fish resources within the area. Diversity and abundance was low near the port; the most common marine fish detected during the survey were yellowfin sole, northern sculpin, saffron cod, snake prickleback, sturgeon poacher, arctic staghorn sculpin, and longhead dab (RWJ 2001).

Surveys conducted at the port site have documented six species of anadromous fish including, pink salmon, chum salmon, arctic char, arctic cisco (*Coregonus autumnalis*), Dolly Varden char, and whitefish (various species) (Dames & Moore 1983a; Corps 2005). Overall abundance of fish was low; pink salmon and arctic cisco were the most abundant species detected, with other species detected only infrequently during beach seine surveys (Corps 2005).

Small runs of arctic char, pink salmon, and chum salmon can be found in the Omikviorok River, Ipiavik Lagoon, Agarak Creek, and Rabbit Creek near the port; while larger runs of Dolly Varden char and variable runs of Pacific salmon can be found in the Wulik, Kivalina, and Noatak rivers (Corps 2005). Whitefish found at the port include least cisco (*Coregonus sardinella*), Bering cisco, round whitefish (*Prosopium cylindraceum*), broad whitefish (*Coregonus nasus*), and humpback whitefish, and are relatively common in Kivalina Lagoon and the lower Wulik River (Corps 2005; Morrow 1980).

The local structure effects, both adverse and beneficial, are likely slight because of the small size of total area affected and from fish behavior. Fish are often attracted to in-water structures as areas of food sources and rest or cover from currents. These areas may also serve as hiding places for predators. Dolly Varden char have been noted around the sheet pilings in marine near-shore structures. Juvenile outmigrants from the Wulik River may remain in near-shore areas for over a week and could be subject to potential predation around the structures should large fish be present. Again, the magnitude of these effects would be slight because of the limited size of the facility.

Transfer activities at the port occur on a continuous basis throughout the summer and noise occurring while loading may cause some local movement of fish (e.g., startle response) from the area during the start up of individual loading operations. However, any effects are likely to be very narrow in extent and duration.

A scoping comment noted the occurrence of dead fish on the beach near the port facility during operations. This event was investigated by Teck when it was first reported in July 2006 (Eckert 2006). At that time large numbers (thousands) of capelin (*Mallotus villosus*), a shoreline spawning smelt species, were found washed upon the shore near the DMTS dock. These fish naturally occur in very shallow water only during spawning, as they deposit their eggs in the high intertidal zone. The occurrence of these fish on the beach corresponded to a two-foot tidal surge, which may have beached the fish during spawning. ADF&G has documented this cause of death along other Alaskan beaches for this species (Eckert 2006). Samples of the fish (about 40 fish) examined after the incident found they were in spawning condition, which supports the suggestion that the fish were spawning when they were beached. The fish lacked obvious signs of injury or disease that could have contributed to a beaching. Teck discussed the details of the fish condition with the ADF&G fish pathology lab in Anchorage. The laboratory biologist concluded that sending samples to the lab for pathology examination would not be useful, and agreed that the incident was likely a natural event. The details of the incident and findings were reported to the Subsistence Committee, local communities, and the State.

3.10.3 Aquatic Resources – Environmental Consequences

3.10.3.1 Effects Common to All Alternatives

Freshwater

Under all alternatives, the Bons Creek Reservoir would be used as a water source during operations and would remain as fish habitat following closure and reclamation.

Marine Waters

As noted above under baseline conditions, studies supporting the DMTS risk assessment found metals concentrations in recent sediment samples collected in the vicinity of the port did not exceeded screening criteria for marine sediment (Exponent 2007a). While continued loading operations have the potential to contribute contaminants and sediments to the water column, elevated concentrations have not been observed since improvements in loading procedures (e.g., enclosing the conveyor belt) have been made. The Applicant’s continued improvements to transfer methods are likely to minimize future releases of lead and other contaminants during the transfer process.

A large fuel spill could adversely impact local aquatic populations in the short term. Over the 16 year period of operation of the port site, spills have been extremely rare. The largest reported spill was a 40 gallon hydraulic fluid spill from a vessel at the loading platform. The largest reported diesel spill into marine waters was less than a gallon. To put the impact of spills to date in context, over 200 million gallons of fuel oil have been offloaded at the site since operations began (Corps 2005). While the record suggests that spills are highly unlikely, there is potential for an occurrence. The effect of any spill would be dependent on size, location, weather conditions, and the speed and effectiveness of the spill response.

Diesel fuel rapidly breaks down in the environment and the dynamic nature of the region would spread hydrocarbon spills rapidly and reduce concentrations, thus reducing potential adverse impacts from spills. Small spills could have a locally significant impact, but would probably not be significant on a greater than local basis. Larger spills could have greater than local impacts on fish and invertebrate populations. Fuel transfer best management practices, spill control plans, and rapid response to spills would continue to be the primary mitigation measures to avoid or minimize the effects of spills.

The Corps assessed the potential impacts related to expansion of the port facility by considering the effect of what they classified as the Maximum Most Probable Discharge of 4,000 gallons of fuel product (Corps 2005). The analysis determined that most of the fuel could be recovered if weather conditions were moderate, but would rapidly dissipate if waves were severe. A 4,000-gallon spill in open water would rapidly disperse. Some ingestion by marine invertebrates may occur, which, if not at toxic levels, would be mostly excreted within a few weeks. If the spill reached beaches, some intertidal communities would be adversely affected, but these communities are sparse. Most fish would be unlikely to be affected by a spill of this magnitude as they would move away from the toxic areas and petroleum products would rapidly evaporate, dissipate, and break down (Corps 2005).

3.10.3.2 Effects of Alternative A – No Action Alternative

Freshwater

No marked effects to aquatic resources (periphyton, macroinvertebrates, and fish), beyond those currently experienced would occur under this alternative. Maintaining the 1998 NPDES permit limitations would supply limited benefits to aquatic resources within reaches designated for aquatic life, including Main Stem Red Dog Creek and may provide some benefit to periphyton and benthic fauna within Middle Fork Red Dog Creek.

The reduction of TDS levels in the existing mixing zone in Middle Fork Red Dog Creek may benefit benthic organisms in this reach as TDS levels in the existing discharge may exceed levels known to be harmful to some aquatic macroinvertebrates (Scannell and Jacobs 2001). It is important to note that no fish are present in this reach since they are excluded by the weir upstream of the confluence with the North Fork. The reach is not designated by the State as suitable for aquatic life and fish production as a result of historic, naturally poor water quality conditions.

The reduction in TDS levels may improve conditions for some benthic invertebrates in Main Stem Red Dog Creek. Scannell and Jacobs (2001), who conducted an extensive literature review of the effects of TDS on aquatic organisms, including their effect on Alaskan systems, found adverse effects to some invertebrates at TDS concentrations below 1,500 mg/L. However, they concluded that “aquatic invertebrate growth and survival is affected by concentrations of TDS greater than 1,500 mg/L.” Therefore, while reductions in TDS levels may benefit specific individuals, they are likely to have limited benefit on the overall health and vigor of benthic resources over current conditions.

Some potential improvement for spawning arctic grayling in Main Stem Red Dog Creek may also occur from the reduction in TDS compared to current conditions. Again, these benefits may be slight, if at all, based on recent bioassay results (Brix and Grosell 2005). Based on this study, the maximum concentration to protect arctic grayling is 1,387 mg/L (see Section 3.10.3.3, for further discussion of the Brix and Grosell [2005] study). Discharge limits on metals in treated wastewater and TDS concentrations below mixing zones would continue to protect aquatic resources in Main Stem Red Dog Creek, Ikalukrok Creek, and the Wulik River downstream in segments that are protected for aquatic life under Alaska WQS.

The concentrations of metals have been reduced compared to pre-mining conditions, resulting in improved aquatic habitat in Main Stem Red Dog Creek and reaches immediately downstream of the confluence in Ikalukrok Creek. These conditions would remain the same under Alternative A since TDS concentrations are not considered to be limiting habitat conditions in Ikalukrok Creek or further downstream.

Elevated metal concentrations in fish tissue (juvenile Dolly Varden char) found within some of the tributaries along the DMTS road may continue (Ott and Morris 2004). Road runoff and dust entering stream segments near road crossings may have had some influence on these levels. Some tissue metal concentrations have been in ranges that overlap literature values ranging from no adverse effects to some adverse effects to salmonids. Corresponding increases in metals concentrations have not been observed in water quality monitoring. Based on observations over a period of years, adult and juvenile fish observed through regular sampling in regions with high concentrations of metals appear healthy (Ott and Morris 2004, 2007). Therefore, adverse effects to fish populations from road dust appear unlikely. However, additional monitoring should be continued using resident fish species to ensure that metals levels do not show an increasing trend and that effects to the health of these species do not occur in the future. The draft fugitive dust risk management plan identifies this monitoring need, and the agencies are evaluating how to require this monitoring in their permits and/or decisions.

Finally, fish habitat would be maintained in Bons Creek Reservoir to support introduced fish populations. Post-mining reclamation includes covering waste material dumps with soil, interception of runoff and diversion to storage areas, covering of the exposed tailings with water to prevent acid rock drainage, continued treatment of water before discharge to Red Dog Creek to ensure it meets NPDES permit limits, and flow management. These measures would ensure that current conditions are maintained and potential effects on fish and other aquatic resources would be minimized.

Marine Waters

Marine resource would be unchanged from current conditions under normal operations for the duration of mining and shipping activities.

3.10.3.3 Effects of Alternative B – Applicant's Proposed Action

Freshwater

The main difference between Alternative A and Alternative B in terms of aquatic resources is modification of the TDS limits in the NPDES permit from 170 mg/L as a monthly average (196 mg/L daily maximum) at end of pipe to 1,500 mg/L in stream, based on the approved site-specific criteria and the subsequent TDS concentration in the discharge to Middle Fork Red Dog Creek.

The proposed TDS limit of 1,500 mg/L would be protective of major benthic macroinvertebrates. Scannell and Jacobs (2001), based on a literature survey of effects of TDS on aquatic organisms, concluded that invertebrate growth and survival were not effected until TDS exceeded at least 1,500 mg/L. Therefore, the benthic organisms that serve as major food sources for fish would not be affected by a TDS concentration of 1,500 mg/L in the Red Dog Creek drainage.

Early data indicated that the 1,500 mg/L was protective of all fish life stages in the study area except for the salmonid fertilization stage. Based on published literature, a TDS level of 500 mg/L was set during the spawning period of arctic grayling (the only fish species to spawn in Red Dog Creek) (see Figure 3.18). Because data was preliminary, EPA issued a CWA Section 308 information request to the Applicant to determine effects of TDS on arctic grayling fertilization and also Dolly Varden char, as this species spawns in Ikalukrok and Dudd creeks (Figure 3.18).

Tests were conducted on arctic grayling and Dolly Varden egg fertilization over a two-year period using methods approved by EPA (Brix and Grosell 2005; EPA 1999). Tests were conducted on egg fertilization as this life stage has been found to be the most sensitive to TDS concentrations for these species. That is, egg incubation, fry, juveniles, adults are not adversely affected by TDS concentrations as low as affect the egg fertilization stage. The intent was to test effects of TDS concentrations at 125, 250, 500, 750, 1,000, and 2,000 mg/L on egg fertilization success, although actual concentrations tested varied and, in some cases, the maximum target concentration (2,000 mg/L) was not achieved.

The effects of TDS were observed at various levels for both arctic grayling and Dolly Varden char. The data was reported at no observable effects concentration (NOEC), the lowest observable effects concentrations (LOEC), the chronic value (geometric mean of the NOEC and LOEC) and the concentrations causing 20 percent and 50 percent effects (EC20 and EC 50). These effects levels are standard methods used by EPA to set water quality criteria for the lowest category of effects. The effect was determined relative to a control egg sample and was measured as relative percent of eggs that were fertilized under each of the test TDS concentrations. For example the test concentration of TDS that was first observed to have a statistically lower fertilization rate than the control would be termed LOEC, while the next lower TDS test concentration would be termed the NOEC or no effects concentration.

The results of each of the tests are shown in Table 3.10-4 for arctic grayling. Based on representative methods literature (see Brix and Grosell 2005), the geometric mean of the EC20 was considered the most appropriate use to estimate the species mean value (SMV) of the data to set TDS limits in Main Stem Red Dog Creek. Using the results of all eight tests reported, the ecogeometric geometric mean/estimated SMV is 1,357 mg/L.

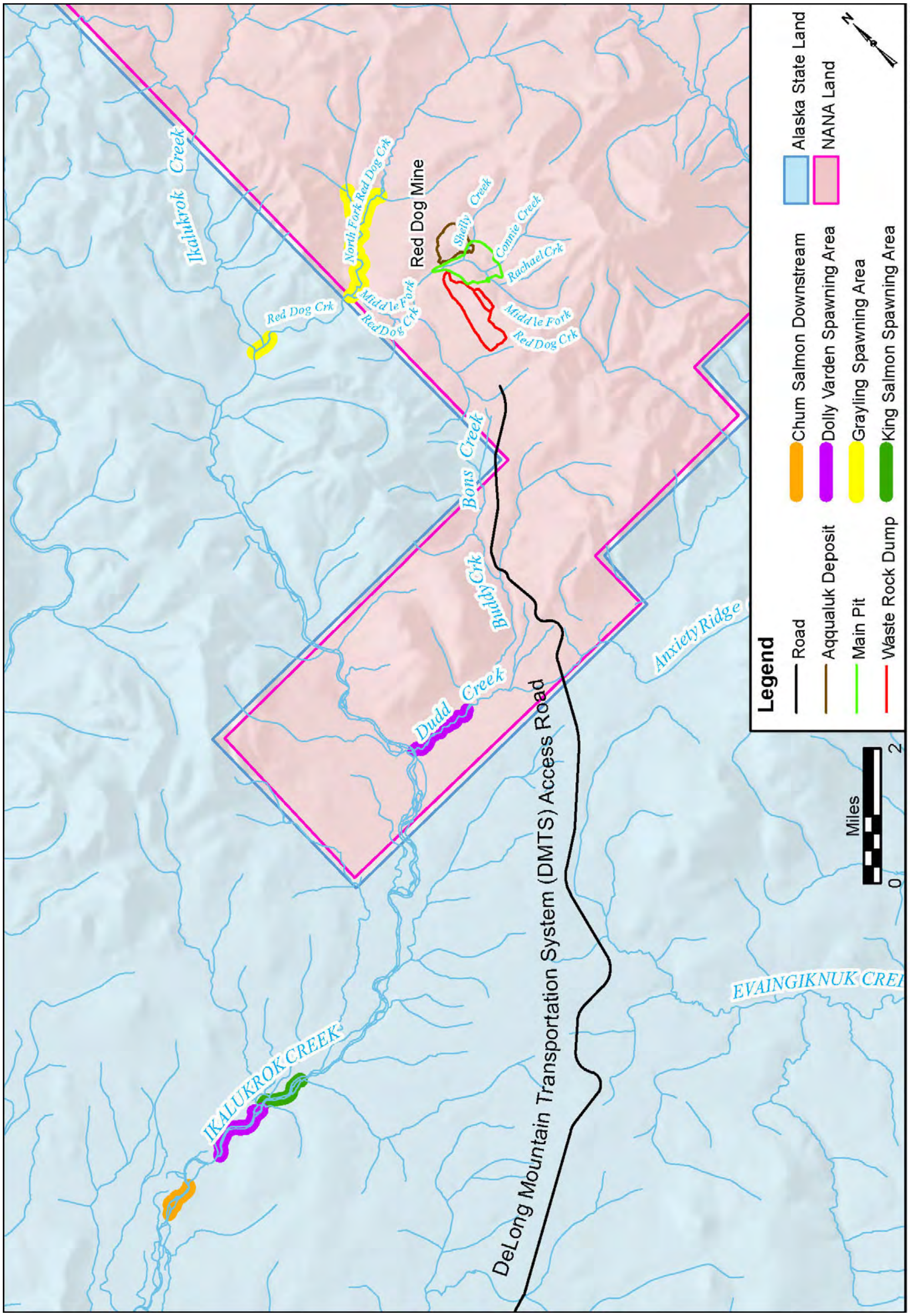


FIGURE 3.18

FISH SPAWNING STREAM SEGMENTS

Table 3.10-4 Toxicity Testing Results with Arctic Grayling (mg/L TDS)

Test*	NOEC	LOEC	Chronic Value	EC20	EC50
1	921	>921	>921	>921	>921
2	1,381	>1,381	>1,381	>1,381	>1,381
3	254	503	357	748	>1,381
4	132	254	183	202	>1,381
8	2,782	>2,782	>2,782	>2,782	>2,782
9	2,782	>2,782	>2,782	>2,782	>2,782
10	2,782	>2,782	>2,782	>2,782	>2,782
11	2,782	>2,782	>2,782	>2,782	>2,782

Source: Brix and Grosell 2005
*Tests 1-4 were performed in 2004 and tests 8-11 were performed in 2005.

All eight arctic grayling tests were considered to meet the criteria of valid tests (Brix and Grosell 2005). However some factors outside of the control test parameters may have influenced the results. A total of six of the eight tests showed no significant effects of TDS at any of the tested concentrations. Tests 1 and 2 (both 2004 tests) were conducted with 921 and 1,381 mg/L, respectively as the highest concentrations in the experiments. While no effects were observed at these levels, these levels became the EC20 value by default since higher concentrations were not tested. This situation had the effect of lowering the mean EC20 (SMV) across all the tests. The other four tests (2005 tests), with no detectable TDS effects, all included higher concentrations (to 2,782 mg/L). Tests 3 and 4 (done in 2004) showed measured effects at much lower concentrations. While each of these tests was considered valid, there was concern that the holding time of the milt that was used in the tests may have affected the viability of the sperm, reducing survival. The investigators found in Dolly Varden char egg tests that egg mortality increased with milt holding time, especially after milt was held beyond about 5 or 6 hours. Control mortality increased from less than 5 percent when held less than about 4 hours, to over 30 percent when held for more than 7 hours. While exact holding times were not recorded for the 2004 tests, holding times were reported greater than 4 hours and exceeding 8 hours in at least one test for arctic grayling. In 2005, the test holding time was less than 3 hours in all cases. With the exception of the holding times, the 2004 and 2005 tests were conducted in exactly the same manner.

Brix and Grosell (2005), in their evaluation of the results, noted that it is reasonable to consider that milt holding times may have influenced results of the 2004 tests. This is especially relevant when considering how divergent some 2004 results were from the 2005 test results. If the one potential outlier test (202 mg/L TDS) had been removed from the analysis, the SMV value, based on the other 7 remaining tests, would have been 1,782 mg/L, which is similar to the Dolly Varden tests results (see below). However, in the absence of proof that specific problems occurred with these tests, the value of 1,387 mg/L is the concentration that can be conclusively identified as being protective based on the analytical test protocol.

Similar studies testing the effects of TDS on egg fertilization were done for Dolly Varden char. Brix and Grosell (2005) conducted seven successful tests during 2004 and 2005 at the project site. They found that none of the TDS levels, including the highest concentrations tested, had measurable adverse effects on Dolly Varden egg fertilization. The highest TDS concentrations included in the seven tests ranged from 1,704 to 1,817 mg/L

The Dolly Varden char test results and other data indicate that spawning fish in lower Ikalukrok Creek would be protected with the 1,500 mg/L limit in Main Stem Red Dog Creek. Dolly Varden char, chum salmon, and rarely Chinook salmon spawn in the lower regions of Ikalukrok Creek (see Figure 3.18). With a discharge of 1,500 mg/L TDS at the end of the mixing zone in Red Dog Creek, the TDS in spawning areas in Ikalukrok Creek would be constantly below the 500 mg/L during the spawning season, so no adverse effects would occur to Dolly Varden char from this alternative.

Stekoll et al. (2003) indicated that the chronic value (i.e., lowest calculated concentration to have adverse effects) for chum salmon fertilization is over 600 mg/L TDS. Chum salmon spawning is considered one of the most sensitive of salmonid species to TDS (Weber-Scannell and Duffy 2007). Chinook salmon spawning, which rarely occurs in the Wulik River, would likewise be protected by these limits.

Based on the results of the TDS testing and a targeted literature review, EPA approved the State's site specific criteria of 1,500 mg/L of TDS as being protective of aquatic resources at their current level of protection within the stream systems potentially affected by the project discharge. As discussed above, the bioassay tests are not fully conclusive that the TDS limit of 1,500 mg/L below the mixing zone in Main Stem Red Dog Creek is fully protective of arctic grayling spawning; however, the evidence is strong that the limit will be protective.

Other differences between this alternative and Alternative A that have minor potential for adverse effects to aquatic organisms include increases in allowable cadmium concentrations in the discharge, and inclusion of a mixing zone for pH, cyanide and ammonia. However as discussed below, for a variety of reasons these changes would not have adverse effects to local aquatic resources.

The inclusion of the mixing zones would not change the composition of the discharge or instream concentrations, since the Applicant will maintain the same level of water treatment and use enhanced treatment as needed for TDS reduction. The limits for cyanide and ammonia would ensure no exceedances of the aquatic chronic WQS outside of the mixing zone. The mixing zone would result in a dilution of 1.5:1. Based on mine effluent analysis, the median values of both cyanide and ammonia at the point of discharge are below chronic concentration levels (refer to Table 3.5-12 in Section 3.5, Water Resources – Surface Water). Because of dilution from Middle Fork and North Fork Red Dog Creek, chronic levels in the mixing zone would rarely occur. Chronic levels that could occur in the mixing zone would not impede organisms passing through the region, because the duration of exposure would be less than the time necessary to cause chronic effects. This would include not inhibiting passage of fish between Main Stem Red Dog Creek and the North Fork as documented in ADEC's CWA Section 401 Certification of the 2007 NPDES permit (ADEC 2007). Additionally, no spawning occurs within the mixing zone (EPA 2006a) so no spawning fish would be affected.

The permitted level of cadmium (2 μg/L) differs from the Alternative A level of 0.48 μg/L. However, the background levels in Red Dog and Ikalukrok creeks are naturally much higher than 2 μg/L (refer to Table 3.5-7 in Section 3.5, Water Resources – Surface Water); therefore, increasing permissible concentrations within the discharge would not cause an increase in levels in Red Dog Creek. Under most operations, discharge from the outfall would reduce background levels because of dilution (EPA 2006a). The increase would likely have no adverse effects on aquatic organisms within the Red Dog or Ikalukrok Creek systems as the organisms regularly encounter levels much higher than 2 μg/L.

Discharge pH levels would be considered adverse in the basic range (about 9.5 to 10.5). The aquatic life protection range is a pH of 6.5 to 9.0. However, the outfall discharges into Middle Fork Red Dog Creek water, which has a pH in the range of 5.8 to 6.7. When the discharge mixes with this water, which occurs in the Middle Fork before reaching the confluence with the North Fork Red Dog Creek, the pH is within the aquatic life protection range. So no adverse effects would occur from pH in Main Stem Red Dog Creek or further downstream (EPA 2006).

An increase in the TDS levels being discharged into Middle Fork Red Dog Creek, and some of the other parameters noted above, may reduce the population of algae and benthic organisms in that reach compared to Alternative A. However, as noted under Alternative A, this creek segment is not designated as suitable for aquatic life in the WQS, has no fish populations present, and is blocked from fish entry by the presence of a weir near its confluence with North Fork Red Dog Creek. Also current benthic indicators (taxa diversity, benthic drift) are similar to some of the other local stream reaches even with higher TDS levels discharged in recent years (Ott and Morris 2007). Other factors, such as naturally elevated metals (e.g., zinc and lead) concentrations from the undisturbed portion of Middle Fork Red Dog Creek entering upstream of the mine discharge may be limiting overall benthic insect and periphyton production within this reach, independent of TDS or other discharge parameters. For example, the Middle Fork above the mine discharge (Station 140) had a median zinc concentration of 2.6 mg/L from 1998–2004 (SRK 2007), which is much higher than acute WQS for freshwater aquatic life (EPA 2006a). The resulting concentration in the Middle Fork downstream of the mine discharge (Station 20) had a median zinc value of 1.22 mg/L which would remain unchanged regardless of TDS concentrations. Natural background lead concentrations are also above chronic WQS in the undisturbed Middle Fork reach. So any decrease in periphyton benthic production from increased TDS levels may be slight and would likely not have adverse effects on fish populations downstream.

In Ikalukrok Creek, the only mixing zone authorized is for TDS. Above Station 150, TDS levels will be below 1,500 mg/L and, therefore, not adversely impacting aquatic life. As shown in Figure 3.18, spawning only occurs in Ikalukrok Creek below Station 160. The draft NPDES permit requires TDS levels to be less than 500 md/L below Station 160 from July 25 through the end of the discharge season. This further ensures no impacts on spawning habitat.

The potential effects of dust and runoff containing metals being deposited into streams along the DMTS road would be similar to Alternative A except for the duration of inputs. Since the mine would continue to operate over a longer period, truck traffic along the DMTS road would be present for a longer period of time, extending the potential input of contaminants and sediment to streams from transportation related activity. Whole body tissue metal concentrations have been collected from juvenile Dolly Varden char in local streams, including Red Dog Creek, Anxiety Ridge Creek, and other streams crossed by the DMTS road (Ott and Morris 2004). Compared to literature values, observed concentrations have ranged from levels that may produce no adverse effects to those that could produce some adverse effects in salmonids (Jarvinen and Ankley 1999; Exponent 2007a). However, based on regular sampling of fish and observations of adult and juvenile populations in these reaches over a period of years, adverse effects have not been documented (Ott and Morris 2004). The continued exposure of water with fluctuating metals levels is not anticipated to cause adverse effects to fish or other aquatic organisms in the future although the continued exposure represents a potential risk to these populations. Therefore, continued monitoring of the DMTS streams is warranted. In addition, resident species have not been studied, and should be monitored to further evaluate the relationship between metals levels in the streams and in fish.

During the development of the Aqqaluk Pit, part of Sulfur Creek would need to be diverted around the mine area. Sulfur Creek does not support any fish because of relatively small flows, the steep gradient of the creek, and the high historical metals concentrations downstream preventing any upstream passage of fish. Currently, the fish weir on lower Middle Fork Red Dog Creek prevents fish from entering the Middle Fork and its tributaries, including Sulfur Creek. The diversion could cause loss of macroinvertebrate habitat in the creek. Because of the distance between Sulfur Creek and currently occupied fish habitat downstream, its small size and relatively low total aquatic production, any exported autochthonous production (e.g., macroinvertebrate drift) is likely to have little to no contribution to system production of fish downstream. The diversion may produce some improvement in water quality by eliminating some of the exposure to some currently undisturbed mineralized areas. The impacts on the creek would be permanent, but the effect to downstream habitat would be minor.

Post mining reclamation is designed to minimize adverse effects on aquatic resources. This includes covering waste dumps with soil, intercepting runoff and diversion to storage areas, covering the exposed tailings with water to prevent acid rock drainage, continuing treatment of water before discharge to Red

Dog Creek to ensure it meets NPDES permit limits, and managing flow. If the closure plan is effectively implemented, including long-term water treatment, there would be no adverse effect to aquatic resources.

Marine Waters

The effects would be the same as Alternative A except that the duration of the effects would be longer.

Since operations would occur for a longer period, the chance for fugitive dust in marine waters, spills in the marine system from oil, and other types of spills would increase proportionally for the duration of operations. However, the port operations have not been found to be causing adverse effects currently and therefore are not anticipated to cause adverse effects in the future despite the longer operating period.

3.10.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Freshwater

The initial construction of the pipeline bench would disturb soils near streams increasing the potential for sediments to enter stream channels. The increased amount of fine material that could be carried to streams could have the potential to reduce spawning success of native salmonids and could reduce production in benthic organisms. Sediments could increase turbidity, which in turn could reduce feeding success of resident fish. Some of these effects would only occur over the short term during elevated runoff events. However, proper construction techniques, including sediment control and timing of construction, would eliminate or minimize the potential for discharges of sediment to streams. Sediment as a pollutant source would be a short-term concern, lasting only during construction and until the disturbed areas were revegetated or slopes otherwise stabilized. During project decommissioning, removal of the pipeline bench would have similar effects as construction, while best management practices would reduce the potential for contamination of aquatic habitat from sediments.

The presence of three individual pipelines crossing nine bridges means a potential for spills of concentrate slurry, diesel fuel, and treated water prior to discharge in the event of a pipeline failure. While contingencies for spills would be designed into the pipelines to minimize the volume associated with a spill, a pipeline leak or failure at or near a stream crossing would result in the release of contaminants to the stream. The concentrate slurry would consist of finely ground material with high metals concentrations that would be readily carried downstream. Depending on the volume lost, a concentrate spill to a stream channel could cause adverse effects downstream for a distance proportional to the size of the spill. The slurry would be toxic for large areas of the streams, should a spill occur directly to a stream, because of the high concentrations of metals. The fines in the concentrate could also smother eggs and adversely affect spawning gravels until flushed or otherwise removed from the system.

A break in the diesel pipeline could send diesel fuel downstream, where again, the distance affected would depend on the volume of fuel leaked. Effects would range from direct mortality to reduced feeding and growth, reduced reproductive success, avoidance of the stream segments, and disruption of migration. Since diesel is a volatile hydrocarbon, effects would be relatively short-lived (less than a year).

Although the wastewater in the discharge pipeline would have been treated, a spill from the pipeline could result in some adverse effects to downstream aquatic resources since the water would not necessarily meet WQS for the surface water receiving the spill. The impacts would depend upon the quantity, receiving water conditions, and effectiveness of response actions.

All three pipelines would be designed to minimize the likelihood of a leak or failure. Management practices, including regular integrity monitoring, would minimize the amount of slurry or water that would be lost including that which could enter a stream. Overall, spills would result in adverse effects to aquatic organisms downstream of the spill. The effects of any spill would generally be short-lived since cleanup measures would be required by EPA and ADEC. In these fast-moving stream systems new individuals would be expected to repopulate affected stream segments relatively quickly with most organisms fully recovered within a year. However, some species, especially fish, may take several years to recolonize, depending on the persistence of the pollution following a spill (Yount and Neimi 1990).

The reduction of concentrate truck activity would reduce the chance of metals entering the aquatic food chain from truck-generated road dust, leakage of ore concentrate from transport trucks, and the chance of a concentrate spill into streams from truck accidents. Based on the average daily trips in 17 years more than 200,000 concentrate and 10,000 fuel truck trips have occurred (see Section 3.15, Transportation). In that 34 documented spills have resulted in over 1,000 tons of concentrate being spilled. From 2000 through 2007 one fuel truck spill of 7,000 gallons occurred. In recent years the truck spill frequency has been reduced to 0 to 2 per year. Because of the low frequency of spills, the chance of a spill of either concentrate or diesel actually entering a stream is low. However some metals in the past have apparently entered streams. While some fish in streams crossed by the road have had higher than typical levels of some metals, adverse effects to fish are not apparent and current risk to fish and other aquatic resources appears to be low (see Alternative A). The elimination of concentrate and fuel truck traffic would reduce the risk of metals or diesel entering streams from fugitive dust or a vehicle accident.

Moving the mine's discharge from Middle Fork Red Dog Creek to the Chukchi Sea would result in lower TDS concentrations in the Middle Fork and downstream (refer to Table 3.5-14 in Section 3.5). However, any benefit from the decrease in TDS levels would likely be offset by an increase in metals concentrations experienced by aquatic life downstream (see Section 3.5.3.4). The change would result from the loss of the dilution currently provided by Outfall 001, which equals about 18 to 38 percent of flow in Main Stem Red Dog Creek, depending on stream flow conditions (refer to Table 3.5-14 in Section 3.5, Water Resources – Surface Water). Above the existing outfall (Station 140), the Middle Fork contains runoff from mineralized areas outside the existing mining disturbance. While concentrations in Middle Fork Red Dog Creek would be lower than in the pre-mining condition (when the stream also contained mineralization from the ore body), they would still exceed WQS for a number of parameters (e.g., zinc and lead, which already are well over chronic and in some cases acute criteria for aquatic life). The increased metals concentrations (20 to 50 percent based on the loss in flow and existing metal concentrations) would be noticeable in Main Stem Red Dog Creek, again because of the lack of dilution provided by the existing outfall. Metals concentrations in the main stem would be less than those observed in the Middle Fork but would still exceed WQS for, at least, lead, cadmium, and zinc. For example, dissolved zinc and cadmium would increase by about 26 to 53 percent (see Table 3.5-14 in Section 3.5, Water Resources – Surface Water). Eliminating the existing outfall would also lower hardness levels in Middle Fork Red Dog Creek (refer to Table 3.5-14 in Section 3.5, Water Resources – Surface Water). The lower hardness levels may contribute to adverse effects related to metals exposure since higher hardness levels tend to reduce the bioavailability of some metals to aquatic organisms (Scannell 2005).

Effects to aquatic organisms in Main Stem Red Dog Creek would result from this loss of dilution (flow) from the outfall. The result of the increase in metals concentration would be slightly negative and could reduce production of periphyton, benthic insects, and fish growth or survival in this reach. Specifically, arctic grayling and Dolly Varden rearing and spawning in Red Dog Creek could be reduced and grayling migration to North Fork Red Dog Creek could also be affected. Since current TDS levels in this reach are at or near levels considered to be protective of aquatic resources, the net effect to aquatic resources through discharge diversion would be negative. Effects to organisms from naturally high metals concentrations in Red Dog Creek likely already occur and moderate increases are not likely to substantially change the condition of this aquatic system. No overall adverse or positive effects to the aquatic resources in Ikalukrok Creek or the Wulik River are likely to occur.

The transfer of the current mine discharge to ocean discharge would substantially reduce the average flow in Main Stem Red Dog Creek. Currently the outfall discharge is, on average, about 20 percent of the flow in Red Dog Creek (mean Outfall 001 discharge is 14 cfs, and Red Dog Creek flow near the mouth is 70 cfs during June to September). The reduction in flow could reduce overall aquatic habitat in Main Stem Red Dog Creek during the flowing water period (often May to October). However, the main stem reach undergoes a wide range of flows during the open water period (1 to 766 cfs; EPA 2006b) so aquatic resources in this reach are tolerant of wide ranges in flow. Therefore, flow reduction is likely to have little, if any, adverse effect to aquatic organisms in this reach.

The monitoring program associated with ADEC's waste management permit would track changes to the distribution and population of fish species and could identify whether changes are different than predicted in the SEIS. If changes in fish distribution or populations are above acceptable levels, ADEC (and ADF&G) would work with the Applicant to develop adaptive management measures that could offset observed effects.

Because of the increased metals concentrations and reduced flow, the overall effects of moving the discharge to the Chukchi Sea may be more negative than positive to aquatic resources of Red Dog Creek system during the life of operations. At closure, under this alternative the discharge would return to Red Dog Creek and conditions in the streams would return to those comparable to Alternative B. The effects associated with the Sulfur Creek diversion would be the same as Alternative B.

Marine Waters

Actions related to concentrate loading and the related pier effects would be the same as Alternative B. Construction of the outfall pipe to the Chukchi Sea would take less than one week, during which time it would cause short-term adverse effects to benthic resources, including algae, invertebrates and fish. The dredging the bottom for the pipeline would cause locally increased suspended sediment and turbidity. Winds and waves would, however, rapidly dissipate the turbidity, reducing local effects. Sessile or semi-mobile benthic and epibenthic organisms (e.g., polychaete worms, amphipods, and basket starfish) would be buried in high sediment areas. More mobile species like crabs and shrimp would be temporarily displaced as they moved from the disturbed area. The noise from construction activities may cause fish to avoid the local area of construction, but this would likely only be within a few hundred feet and the fish would likely avoid high suspended sediment areas already. Since the bottom area has greater abundance and density farther offshore, the outer area of dredging may have greater loss of invertebrates and temporary movement of mobile invertebrates and fish.

Effects on anadromous fish species (e.g., Dolly Varden char, pink salmon) should be slight. Fish moving along the shore, from the shore edge out to the discharge diffuser, may be temporarily displaced when encountering turbidity plumes and construction noise. Construction should occur in July and early August to reduce interference with fish migration near the local port site facility; the time frame could be governed by a stipulation in the Corps' Section 10 or Section 404 permit. Following construction, the dredged area would recolonize rapidly (Corps 2005). Overall there would be some local loss of sessile organisms and displacement of mobile species on a local basis but the adverse effects would not extend beyond the specific local area and recovery would be rapid. The construction activity also adds the risk of minor fuel and oil spills from equipment used during construction.

The discharge of treated wastewater would meet permit limits based on Alaska WQS protective of marine life. Some parameters would require a small mixing zone (a cube approximately 10 feet on a site) based on the current effluent quality. Therefore, the discharge would have no adverse effect to the marine system beyond the mixing zone. Local benthic organisms near the point of discharge could be adversely affected by the discharge. Transient organism (e.g., crabs and fish) passing through the discharge would not be adversely affected because of short exposure time. TDS concentrations would be less than natural levels in the marine environment and would therefore have no adverse effects. Organisms may exhibit some avoidance of the point of discharge because of the lower salinity level of the discharge. That is, marine organisms are not adapted to low salinity fresh water so the immediate discharge point may have slight reduction in organism abundance until the water mixes adequately with the surrounding marine waters. Because discharge water is less saline it would affect little bottom area as it would rise in the water column since it would have lower density than the surrounding salt water. Discharge effects to the marine environment would cease at the closure of the mine as the treated water discharge would return to Red Dog Creek.

3.10.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Freshwater

Alternative D includes a permanent wastewater discharge pipeline, therefore effects would be the same as Alternative C except the following.

The truck washes would reduce the levels of fugitive dust that could potentially be carried to the surface water along the DMTS road. The potential reduction for metals to enter streams would be better than under alternatives A or B, but not as high as Alternative C because concentrate transport by road would still occur as would the risk for concentrate spills. Discharge would continue to the Chukchi Sea after closure, so the operational impacts on the marine environment and Red Dog Creek would continue over the long term. The ground disturbance from reclamation of the pipeline would not occur.

Marine

Effects to marine resources would be the same as described under Alternative C; that is, no adverse impacts due to the marine wastewater discharge are expected. At closure, the discharge would continue to the Chukchi Sea and the discharge would still be required to meet NPDES permit limits protective of water quality in the Chukchi Sea.

3.10.4 Aquatic Resources – Summary

Aquatic life conditions have changed in Main Stem Red Dog Creek compared to pre-mining conditions. This includes improved arctic grayling spawning, arctic grayling fry rearing, slimy sculpin rearing, and juvenile Dolly Varden char rearing. Under alternatives A and B, the current conditions in Red Dog Creek would be maintained during operations and after closure. With the construction of the discharge pipeline, under alternatives C and D, water quality would worsen and stream flow would be reduced in Main Stem Red Dog Creek. It is difficult to predict the exact impact on aquatic life from alternatives C and D because of the variability of water quality and flow in the Red Dog Creek system. While aquatic life conditions would likely be worse than current conditions, they would remain improved compared to pre-mining conditions. Specifically, spawning and rearing that now occurs in Red Dog Creek could be reduced and grayling migration to North Fork Red Dog Creek could be affected. Impacts on aquatic life in Ikalukrok Creek and further downstream are not expected to occur under any of the alternatives. Under alternatives C and D monitoring and adaptive management would be necessary to respond to changes in Red Dog Creek.

While some fish tissue monitoring has identified elevated levels of metals in fish collected from streams crossed by the DMTS road, there is a high level of variability in the results and additional sampling is needed. At the port site, the marine discharge under alternatives C and D would not have an adverse affect on aquatic life because the discharge would meet WQS either at the point of discharge, or for some parameters, at the edge of a small mixing zone. The actual mixing zone size would need to be authorized by ADEC during the NPDES permitting process and would be subject to public notice along with the draft NPDES permit.

3.11 Land Use and Recreation

3.11.1 Land Use and Recreation – Pre-mining Environment

3.11.1.1 Land Ownership and Management

The study area for the land use and recreation analysis consists of the northwestern portion of GMU 23, extending from the western boundary of Kobuk Valley National Park to the Chukchi Sea coastline and south from the DeLong Mountains to the southern boundary of Cape Krusenstern National Monument (Figure 3.19).

Land ownership patterns surrounding the Red Dog Mine site have remained relatively constant since mine construction (Figure 3.20). The mine is located on approximately 4,000 acres within a 120-square-mile property privately owned by NANA. State lands extend to the east and south from the NANA property. South of the State land, on the Chukchi Sea coastline, lies Cape Krusenstern National Monument, managed by NPS. Established in the early 1980s, primarily to preserve its extensive archeological resources, the national monument is visited by large numbers of migratory birds. Numerous private allotments and inholdings lie within the national monument, mostly along the coastline, north and south of Rabbit Creek. The DMTS road crosses the northwestern corner of the national monument, terminating at NANA-owned lands at the coast. NANA also owns land parcels surrounding the communities of Kivalina and Noatak.

The Noatak National Preserve and Wilderness, established in 1980 and also managed by NPS, lies to the east of the mine. The portion of the Noatak River within the preserve was designated a Wild and Scenic River in 1980. Private inholdings within the preserve boundary are located along the banks of the Noatak River. The Alaska Maritime National Wildlife Refuge, managed by USFWS, occupies the northwestern corner of the study area. Other federal land within the study area consists of two large parcels managed by the Bureau of Land Management, one southwest of the mine in the Baird Mountains, and one east of the mine between the coast and the state lands.

Although much of the land within the study area is occupied by national parks or preserves, NPS has no roads, campgrounds, trails, or other developed recreational facilities within these parklands. The NPS Visitors Center and NPS headquarters in Kotzebue are the only facilities providing visitor information and services for these areas. There are informal trails throughout the study area used primarily for access to subsistence resources, most notably the winter trail along the coastline between Kivalina and Kotzebue, as well as trails connecting Noatak to Cape Krusenstern National Monument and Noatak National Preserve. The Alaska Department of Transportation provides funding for marking the winter coastal trail (NPS 1986).

3.11.1.2 Pre-mining Land Uses

Subsistence. Before development of the Red Dog Mine and associated facilities, the predominant land use in the study area was subsistence activities. The extent and nature of pre-mining subsistence activities are discussed in Section 3.12.

Mining. Mineral exploration activities in the vicinity of the mine began in the 1970s with passage of the Alaska Native Claim Settlement Act (ANCSA), which started an evaluation of the area's mineral resources. In 1975, the Bureau of Mines issued a press release regarding the mineral potential of the DeLong Mountain area. GCO Minerals Company and Cominco subsequently began exploration, resulting in 18,000 claims filed in the area west and southwest of the Red Dog Mine. In 1980, the Red Dog Deposit was first drilled, and NANA obtained selection rights to the Red Dog area with passage of the ANILCA.

FIGURE 3.19

Alaska Department of Fish & Game - Game Management Unit 23

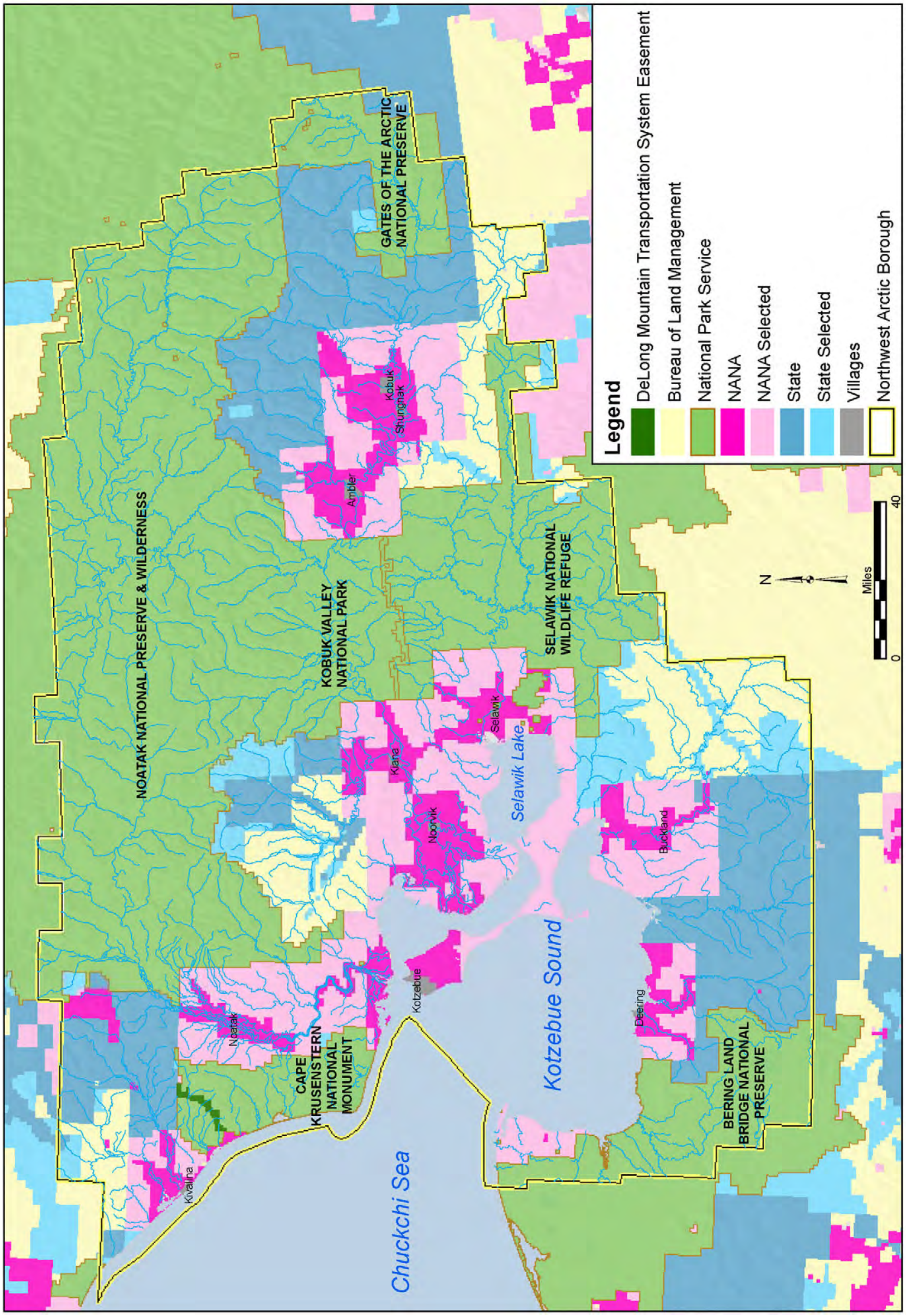


FIGURE 3.20

NORTHWEST ARCTIC BOROUGH LAND OWNERSHIP

In 1982, NANA signed a letter of agreement with Cominco (now Teck) allowing them to permit, construct, and operate the mine on NANA property. Initial development and construction of the mine began in 1986. Other mineral exploration not associated with the Red Dog Deposit was conducted throughout the region.

Recreation. Non-subsistence recreation occurred throughout the study area before mining, although to a much lesser extent than subsistence activities. The primary recreational activities occurring in the study area before mining included hunting, fishing, boating, hiking, birdwatching, and sightseeing. For the purposes of this document, non-subsistence recreation for all activities except fishing is defined as recreational activities of people living outside GMU 23. This is based on the assumption that most of the hunting by residents of GMU 23 is for subsistence purposes. Non-subsistence fishing is defined as fishing by anyone with an Alaska fishing license, because subsistence users are not required to obtain fishing licenses. Non-subsistence recreational activity by local residents has also occurred in the study area, such as all-terrain vehicle or snowmachine use, but these activities are difficult to distinguish from subsistence uses and thus are not quantified in this section.

Recreational activities have historically taken place throughout the study area’s federal and state lands, although the lack of access has limited the extent of recreation. Aircraft provide the only access to the area for non-residents, typically through air charter services or professional guides. Cape Krusenstern National Monument had very minimal non-local recreational use in the years before the mine was built, estimated at 50 persons per year. Visitors to the monument were typically there to see the archeological features, as well as for camping, hiking, and photography (NPS 1986). In addition, local residents frequently cross through the national monument to access inholdings, or subsistence resources, or to travel to Kotzebue (Jeschki 2008; Stevenson 2007). Noatak National Preserve, which is considerably larger than Cape Krusenstern National Monument, was more heavily used, with an estimated 4,170 visits throughout the preserve in 1982 (NPS 2008c). Since approximately one-third of the preserve lies within the study area, it is estimated that there were approximately 1,390 visits to the portion of the preserve within the study area.

Although sport fishing in the study area has historically been lighter than other parts of Alaska because of the difficult access, the area’s trophy-size Dolly Varden char have attracted anglers from the lower 48 states and international locations. The heaviest use has occurred on the Noatak and upper Wulik rivers. Other sport fisheries in the study area include arctic grayling, whitefish, northern pike, ninespine stickleback, lake trout, arctic char, pacific salmon, and burbot (ADF&G 2007). There were an estimated 2,141 recreational angler days on the Noatak River in 1986 (Scanlon 2008a). Sport fishing within the mine site area was unlikely before mining due to the lack of access, the adverse natural conditions for fish (Section 3.10), and the availability of better fishing in the Wulik River (Scanlon 2008b), but some limited sport fishing did occur on Ikalukrok Creek, about 8 to 10 miles downstream of its confluence with Red Dog Creek (Driver 2008b). Sport fishing near the DMTS road was not prevalent, but has occurred along Rabbit Creek within Cape Krusenstern National Monument.

Recreational hunting also occurred in the study area before mining. Hunters frequented the Cape Krusenstern area until 1980 when the national monument was formed and hunting was limited to subsistence users. Before mine construction, local guides took sport hunters to the mine site and immediate vicinity, particularly the Wrench and Kelly creek drainages (Driver 2008a; Jacobson 2008). The 1984 harvest reports for moose show a total of 146 sport hunters from Alaska and 72 out-of-state hunters. Sheep harvest data shows 24 Alaska resident sport hunters in 1984 and 10 non-resident hunters (ADF&G 2008a).

Before mine development, much of the boating was associated with hunting and fishing. Guides flew hunters and anglers into the area then accessed the remote river systems with inflatable boats. Float trips were also associated with birdwatching and sightseeing. In the early 1980s, an estimated 200 non-residents floated the Noatak River, most of who would disembark within Noatak National Preserve boundaries (EPA 1984).

3.11.2 Land Use and Recreation – Baseline Conditions

3.11.2.1 Land Ownership and Management

The current ownership and management of lands within the study area are similar to those in the 1980s, with much of the study area managed by NPS. Since construction of the mine, NWAB has established its current zoning code, which regulates uses of all lands within NWAB (Figure 3.21). According to the NWAB Municipal Code, the mine and port are located within the Resource Development (RD) Zone District. The purpose of the RD Zone District is to accommodate large-scale resource extraction and similar activities that do not seriously impair subsistence resources and that operate under a master plan approved by the NWAB (NWAB 1993). Once resource extraction activities are completed, the mine site would revert to the original zone district, which in the case of the Red Dog Mine, would be the General Conservation (GC) Zone District. The purpose of the GC Zone District is to conserve the natural ecosystem for species used for subsistence (Oleasik 2008).

The DMTS is within the Transportation Corridor (TC) Zone District. The intent of the TC Zone District is to accommodate industrial development and enhance economic opportunities for residents, while minimizing negative effects, such as increased access and fish and wildlife impacts. As with the RD Zone District, removal and reclamation of transportation facilities would result in the area reverting to the GC Zone District.

The lands north of the mine site are zoned Subsistence Conservation (SC). The SC zone also extends southeast of the DMTS road. The SC Zone District is intended to conserve subsistence resources and to promote access to those resources for subsistence purposes. The lands extending south from the mine site along the DMTS road are zoned GC. The Bureau of Land Management and state lands west of Kobuk Valley National Park are zoned Commercial Recreation, which emphasizes commercial recreation consistent with the conservation of wildlife habitat and other resources (NWAB 1993).

ADNR’s Northwest Area Plan provides land use and management direction for state lands. The plan has recently been updated and has been adopted by ADNR (ADNR 2008). The state lands immediately to the west of the mine, within the upper Wulik drainage, are designated as Mineral Lands. Mining permits in this area are to consider impacts upon caribou habitat and migration. Most state lands along the lower Wulik and Noatak rivers are to be managed as wildlife habitat. A portion of the DMTS road traverses this land management unit. North of Cape Krusenstern National Monument lie several parcels designated as General Use, which are to be managed for multiple uses. Any long-term uses in the General Use management unit must consider impacts on the caribou herd (ADNR 2008).

Recreational hunting and fishing is allowed on state and federal lands throughout the study area, except for Cape Krusenstern National Monument, where hunting is limited to subsistence uses. Sport fishing is allowed within the national monument. All recreational and subsistence hunters must obtain a state hunting license. Large game hunting requires a permit or ticket for the specific hunt or species. State fishing licenses are required for any type of sport fishing. Subsistence anglers are not required to get a fishing license. Sport hunters and anglers are only allowed access to NPS lands by fixed-wing airplanes, motorboats, and non-motorized surface transportation. The use of off-road vehicles for recreational hunting and fishing is not allowed in the national monument or Noatak National Preserve. Hunting and fishing use of NANA lands is limited primarily to shareholders. Non-shareholders who have lived in the area for at least five years may apply for a permit to hunt on NANA lands but are not allowed to use aircraft.

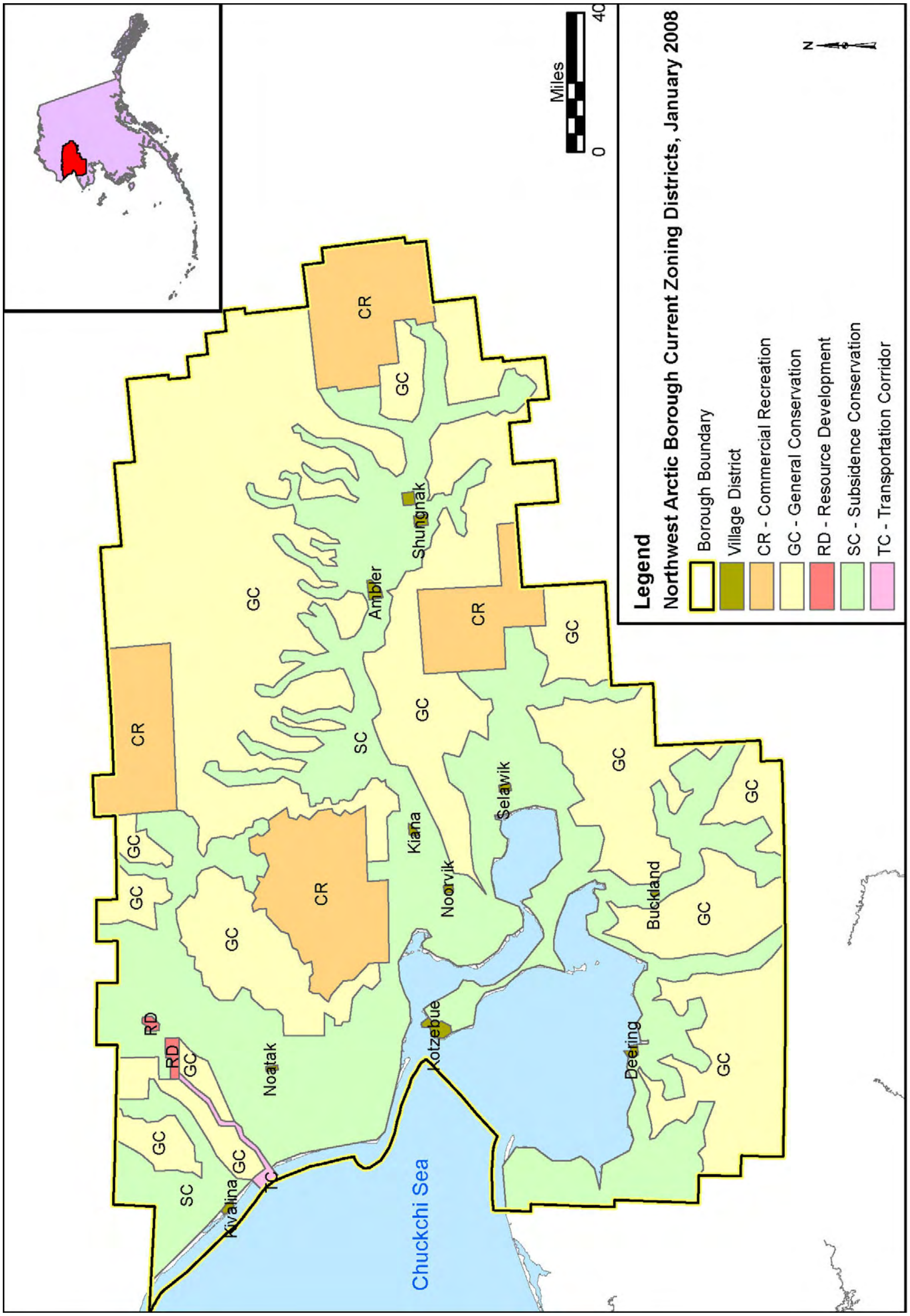


FIGURE 3.21
NORTHWEST ARCTIC BOROUGH LAND USE ZONE DISTRICTS

3.11.2.2 Current Land Uses

Mine Site and DMTS. Since construction of the mine, land uses of the immediate area of mine and DMTS have changed from primarily subsistence activities to mining and related transportation uses. Public access for subsistence or recreational use is not allowed within the mine boundaries. Recreational hunting or fishing by project personnel is also prohibited within the mine site.

Mine facilities include the open pit mine, waste rock and low grade ore stockpiles, mill, tailings impoundment, water management facilities, and ancillary facilities. The ancillary facilities include the personnel camp, airstrip, roads, powerhouse, and fuel storage. A total of 2,147 acres were disturbed as of 2006 to accommodate these facilities, with an additional 18.5 acres to be disturbed between 2006 and 2011.

Study Area. Land uses occurring outside mine boundaries are similar to pre-mining conditions, consisting primarily of subsistence uses, mining, and recreational activities. Residential and commercial land uses occur primarily within the communities of Kivalina and Noatak. Rural residential land uses also occur outside the villages, primarily on land inholdings and allotments. Current subsistence activities occurring in the study area are discussed in Section 3.12.

Recreational use of the study area has remained relatively constant for all activities except hunting, which has increased since construction of the mine. The area continues to be relatively remote, with little access and no developed recreational facilities or public roads. Cape Krusenstern National Monument sees very little recreational use by nonresidents, estimated at 20 to 30 people per year. Non-resident recreational activity is focused on the beaches and lagoons within the southwest side of the monument and along Rabbit Creek, with some hiking in the mountains (Rice 2008). There is also some recreational all-terrain vehicle and snowmachine use by local residents within the monument. Although visitation data published by NPS show 2,569 recreational visits to the national monument in 2006, most of these reflect visitors to NPS Visitors Center in Kotzebue and not people that enter the monument (Jeschki 2008; Stevenson 2007).

Noatak National Preserve sees considerably more recreational use than Cape Krusenstern National Monument, with an estimated 7,010 recreational visits in 2005 and 3,272 visits in 2006 (NPS 2008c). Since approximately one-third of the preserve lies within the study area, it is estimated that there were approximately 2,337 and 1,090 visits to the portion of the preserve within the study area in 2005 and 2006 respectively. People visit the preserve primarily to hunt, fish, hike, or float the rivers.

The DMTS road is the only road built in the rural portion of the study area since mine construction, but use of the road is restricted to mine traffic and thus it does not provide recreational access. Most of the recreational hunters and anglers access the study area by aircraft, some of whom are accompanied by commercial guides. Some of the guides take inflatable boats, providing access along navigable drainages.

Three air charter services currently hold permits to fly into Cape Krusenstern National Monument and nine hold permits for the Noatak National Preserve (NPS 2008a, b). An example of someone with a charter service permit is Mr. Eric Seih, a bush pilot who has been transporting recreationists into the study area for the past 16 years. He flies primarily hikers, floaters, and anglers into the Wulik and Noatak river drainages. He reports that he does not regularly fly over the mine site, but does cross the DMTS road. One client expressed concerns about seeing the mine facilities and helicopters during his trip, and consequently was taken to a different part of the area (Seih 2008). Most of the commercial hunting and fishing clients are from outside Alaska or from other countries (Stevenson 2007).

Noatak National Preserve currently has eight guide services with permits to operate in the preserve. Cape Krusenstern National Monument only has one permitted guide service, Mr. and Mrs. Phil and Carol Driver of Midnight Sun Lodge (NPS 2008a, b). The Drivers operate a hunting/fishing lodge, located approximately 25 miles southwest of the project site on the Wulik River, downstream of Ikalukrok Creek. They have about 35 clients per year, whom Mr. Driver flies to hunting and fishing camps for day or overnight trips. He generally takes about six of his clients into Cape Krusenstern National Monument each year for fishing, sightseeing, and wildlife viewing. Most of his trips occur within a 50-mile radius of the mine and require flying over the mine site and DMTS. The closest place to the mine that Mr. Driver currently takes his clients to hunt is the Wulik River/Sheep Creek confluence (Driver 2007). He also takes people to fish for grayling on Ikalukrok and Tutak creeks.

Mr. J.P. Jacobson of Arctic Rivers Guide Services has been guiding hunters and anglers in the study area for 41 years. He operates out of his lodge, located about 25 miles east of the mine on the Kugururok River. He is permitted to guide 12 hunters per year in the preserve, but usually takes fewer. His trips are 10 to 12 days long, between August 8 and September 25. About 95 percent of his clients are from the lower 48 states or Europe. He currently hunts for caribou, bear, wolves, and sheep. He has hunted moose, but moose hunting has been limited in recent years. Although he used to hunt near the mine site before mining, particularly Wrench Creek and Kelly River, he was able to move to other areas and does not feel the mine has adversely affected his business (Jacobson 2008).

In spite of the lack of access, hunting has increased over the past 20 years to the extent that conflicts with subsistence hunters have become common (see Section 3.12.2). In response to these conflicts, ADF&G has published “Unit 23 Nonlocal Hunter Orientation” on their website in an effort to educate sport hunters and reduce conflicts with local residents (ADF&G 2008b). The rise in hunter numbers is attributed to the increasing difficulty of hunting in other parts of Alaska, combined with the relatively large caribou herd in GMU 23. The increase was relatively steady until it leveled off in recent years because of stricter regulations (Dau 2008). Conflicts have arisen from non-local hunters occupying camps historically used by local families, hunting too close to the camps, or scaring off game species with aircraft noise.

Sport hunting occurs on state and federal lands throughout the study area, particularly the Noatak and Wulik rivers and other drainages. The area within a 10-mile radius of the mine is not heavily used for sport hunting (Dau 2007), although some hunting occurs along Wrench Creek and the Kelly River. Hunter data from the 2006 ADF&G Harvest Reports (Table 3.11-1) show there were 259 recreational moose hunters and 12 sheep hunters in GMU 23, the majority of whom were from Alaska. During the same year there were 818 caribou hunters and 36 brown bear hunters, with the majority from outside Alaska.

Table 3.11-1 Recreational Hunters in Game Management Unit 23, 2006

Species	Alaskan Residents		Non Residents		Total	
	Hunters	Harvest	Hunters	Harvest	Hunters	Harvest
Moose	183	64	76	34	259	98
Caribou	321	218	497	386	818	604
Sheep	10	4	2	2	12	6
Brown Bear	0	0	36	16	36	16

Source: ADF&G 2008a

Fishing pressure in the study area is still lighter than the more accessible parts of Alaska and has remained relatively constant since mine development. There were 2,538 angler days on the Noatak River in 2006, compared to an average of 2,208 for the 1986 to 2006 period. Most of the area’s sport fishing occurs on the Noatak, Wulik, and Kelly rivers. Sport fishing on the Kivalina River is rare, except when associated with hunting (Scanlon 2008a). The area’s trophy-size Dolly Varden char continue to attract visitors from out-of-state and other countries. The Wulik River has over 100,000 anadromous Dolly Varden char overwintering annually, making it likely the most important Dolly Varden char stream in northwestern

Alaska. The Noatak River is also an important Dolly Varden char fishery. Over the past 40 years, 66 percent of the Dolly Varden char qualifying for the ADF&G trophy fish program have come from northwestern Alaska, including the current state record of 27 pounds, 4 ounces taken from the Wulik River. ADF&G expects the study area’s Dolly Varden char fishery to grow in popularity as more anglers experience its high-quality fishing opportunities (Scanlon 2008a). The number of angler days on the Wulik River in 2006 was more than twice the 10-year average, indicating a possible increase in awareness of the resource.

Sport fishing for arctic grayling in the study area is generally associated with float trips or while fishing for other species (Scanlon 2008a). Most of the grayling are harvested from the Noatak River, with the remainder harvested primarily from the Kelly and Wulik rivers. Fishing for northern pike also occurs in the Noatak, Squirrel, and Kelly rivers, but considerably less than for Dolly Varden char and arctic grayling. Chum salmon are also harvested, primarily from the lower reaches of the Noatak. Fishing in the immediate vicinity of the mine is not prevalent because of the lack of access and the availability of better fishing on other rivers (Scanlon 2008b).

Floating the area’s scenic rivers and waterways also occurs in the study area. Commercial guides have recently started offering float trips within Cape Krusenstern National Monument. The floaters are flown into Cape Krusenstern Lagoon and then float down the Turkrock River in inflatable kayaks to the coast. Approximately 20 to 30 people per year participate in these trips, which focus on birdwatching (Stevenson 2007).

Approximately 300 to 400 people float the Noatak River each year in kayaks, canoes, and rafts. Most of these boaters are from the lower 48 states or other countries and about one-half are on guided trips (Stevenson 2007). People who float the river usually put in on the Kugururok, Nimiuktuk, or Kelly rivers and float to Noatak Village or occasionally to Kotzebue (Scanlon 2008b). Mr. Seih also flies approximately 20 to 40 people to the Wulik for float trips (Seih 2008). Motor boating also occurs on the Noatak River and in the lagoons in Cape Krusenstern National Monument, but is generally associated with subsistence activities (Stevenson 2007).

A limited amount of hiking occurs in the study area. Mr.Seih flies approximately 30 to 40 hikers each year into the Lik Camp, located 4 miles northwest of the mine site. He reports that hiking has been increasing in recent years as the area becomes better known (Seih 2008).

3.11.3 Land Use and Recreation – Environmental Consequences

3.11.3.1 Effects Common to All Alternatives

All of the alternatives will result in continued disturbance of the mine site. Subsistence uses at the mine site will continue to be displaced to other parts of the study area. Effects on subsistence uses are discussed in Section 3.12.3.

Sport hunting is the only recreational activity that has historically occurred at the mine site and thus would continue to be displaced to other portions of the study area by mining activities. It is important to note that NANA limits access to their lands by non-shareholders, and thus as long as NANA owns this property and their regulations remain in place, sport hunting would be displaced to other areas with or without mining. Since the waterways within the mine site have not been historically used for sport fishing, continued mining would not displace fishing activities. Mine employees are prohibited from hunting or fishing while on site and thus do not affect hunting and fishing pressure in the area.

Recreational activities outside the mine site would continue to experience minor effects under all of the alternatives. Use of the study area by hunters has increased in recent years and may continue to increase depending on ADF&G hunting regulations. Fishing in the study area is likely to increase in the future as anglers become more aware of the high-quality Dolly Varden char fishery. This may be indicated by the sharp increase in Dolly Varden char harvest from the Wulik River in 2006. Hiking and floating the area's rivers may also increase as the area becomes better known.

The presence of the mine would have relatively little direct impact on these activities. The mine could potentially be visible to the few people who hike the surrounding mountains. It would be visible to more people from the air, mostly to visitors flying toward Wrench Creek or the upper Wulik or Kelly rivers. According to local guides, some visitors are disappointed to see industrial activity on their trip to the area, whereas others do not seem to mind it (Driver 2007; Seih 2008). The mine pit, tailings impoundment, and waste rock dumps would be the primary features visible from the air. Recreational boaters on the Noatak River or in Cape Krusenstern National Monument are not likely to fly near the mine site to access their starting points. Mine lighting would also be visible from aircraft, but much of the recreational activities occur during the summer and early fall when days are longer. There is a small possibility that reflected lighting from the mine would occasionally be visible from the western edge of Noatak National Preserve or surrounding peaks.

It is unlikely that mine-generated noise would have substantial effects on recreation. Table 3.16-1 indicates that the helicopter and mine equipment noise decays to background levels within 11 kilometers, assuming no interference (see Section 3.16). People hiking or hunting in the upper Wulik River or Wrench Creek / Kelly River drainage would thus be unlikely to hear these mine noises because of distance and intervening topography. The exception is the noise generated by blasting. Table 3.16-1 indicates blasting noise decays to background levels at 95 miles without intervening topography (see Section 3.16). The owner of the Midnight Sun Lodge, however, which is located 25 air miles from the mine, states that he may have heard blasting noise on rare occasions, but not routinely (Driver 2008b). The steep walls of the mine pit and the surrounding mountains likely buffer most blasting noise. Blasting in more exposed areas, such as in borrow areas, may be more audible. See Section 3.16 for a detailed discussion of noise effects.

Continued use of the DMTS would also have minor direct effects on recreation. Sport hunters and anglers would be able to see the port, road, and associated traffic from surrounding peaks or the air, which may affect their perception of the study area. Effects of fugitive dust on vegetation along the road corridor would also be visible from the air (Section 3.15). Vehicle noise from the DMTS road likely would not be audible over the aircraft noise. Floaters visiting Cape Krusenstern National Monument do not generally fly over the road or port, since floating occurs south of the road in Cape Krusenstern Lagoon. Local residents traveling along the coastline for recreation or subsistence activities would cross the road near the port, but the presence of the road would not restrict recreational activities.

Effects on the number or distribution of sport fisheries or game species in the study area would be considered indirect effects on recreation. Section 3.9.3 describes the expected effects of the alternatives on game species. The study area's caribou population has increased substantially since mine construction, with a consequent increase in hunting days. Although continuation of the mine and use of the DMTS may result in additional direct mortality and disturbance of caribou and other game species, population-level effects are not expected, and thus adverse effects on sport hunting would not occur.

The abundance of sport fisheries in the study area is not expected to be affected by any of the alternatives. Although there may be some risk of metals contamination, particularly in the vicinity of the DMTS, it is considered unlikely to have adverse effects on the abundance of fish. See Section 3.10.3 for discussion of the effects of alternatives on fish populations and metal levels.

After completion of mining, NANA may elect to prohibit access to the mine site for recreational or subsistence uses, in which case these activities would continue to be displaced to other areas. If not, access to the area would become available for subsistence uses. If NANA's access policies remain the same, recreational access by non-shareholders would continue to be restricted. If NANA opens the mine site to non-shareholders, the area could potentially be used for sport hunting again, but would not be an attractive location for sport fishing due to the ongoing wastewater treatment and lack of high quality habitat.

After completion of mining, the site would be reclaimed, reducing visual impacts from the air. Revegetation would reduce the site's visual contrast with the surrounding landscape in terms of color and texture to the extent that vegetation in the reclaimed areas blended with adjacent native vegetation. Regrading the major project features, such as the waste rock piles, would be directed primarily at establishing stable slopes rather than creating natural landforms. This would reduce but not eliminate the contrast of these facilities with the surrounding landforms. The alternatives differ in terms of the nature of the facilities remaining in place and thus expected visual impacts from the air vary by alternative.

3.11.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A the existing conditions would continue to occur through 2011. After completion of mining in 2011, the mine site would be reclaimed. Displacement of subsistence and recreational uses may continue beyond 2011 if NANA chooses to restrict access to the site. After closure, the mine site would be visible to recreationists flying over the site. The lake in the mine pit would be visible, as would the tailings impoundment and wet tailings cover. The waste rock dump and other facilities would be revegetated and regraded as discussed above. The DMTS road would remain in place for continued access to the site and thus it would continue to be visible, although there would be relatively little traffic compared to mine operations.

3.11.3.3 Effects of Alternative B – Applicant's Proposed Action

Under Alternative B the existing conditions would continue to occur through 2031. The area of disturbance visible from aircraft would be larger than Alternative A, with an additional 406.5 acres disturbed. During mine operation, the benched walls of the Aqqaluk Pit would be visible from the air, as well as the tailings impoundment and the waste rock dumps. The benched walls of the Main Pit would initially be exposed to view, but would be gradually covered over the life of the mine by the waste rock from the Aqqaluk Pit. Interim reclamation of the existing oxide and waste rock dumps would occur during mining and they would be fully reclaimed by 2020.

Final reclamation of the mine would begin in 2031. Once the site was reclaimed, the lake in the Aqqaluk Pit, the tailings impoundment, and the wet cover over the tailings would be visible from the air. It may be possible, depending on the depth of the wet cover, to see the tailings, and thus the impoundment would contrast to some extent with the natural surroundings. Water would only partially fill the Aqqaluk Pit, and thus some of the pit walls and benches would remain visible. The Main Pit would be filled with waste rock and would be revegetated. Other facilities would also be revegetated and regraded. The DMTS road would remain in place, but there would be relatively little traffic compared to mine operations.

3.11.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

The effects of Alternative C on land use would differ from those under Alternative B because of the partial backfilling of the Aqqaluk Pit and the dry cover on the tailings impoundment instead of the wet cover proposed under Alternative B.

Views of the DMTS road from the air would differ under Alternative C because of the construction of a 24-foot wide bench along the road to house the concentrate pipeline. Traffic would be greatly reduced under this alternative, which would reduce fugitive dust. This alternative would also require enlargement of borrow areas for pipeline construction, which may be visible from aircraft and may generate additional noise effects from blasting. Alternative C would result in an additional 631.5 acres being disturbed over

Alternative A, much of which would result from the pipeline bench. After mine closure in 2031 the road would remain in place, but the bench would be removed and reclaimed.

3.11.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

The effects of Alternative D on land use would be similar to Alternative B in terms of disturbances at the mine site. The benched walls of the Aqqaluk Pit, the tailings impoundment, and waste rock dumps would be visible from the air. As under Alternative C, a 24-foot wide bench would be required along the road to house the wastewater pipeline. Other dust control measures would be implemented as described in Section 3.15.2.2. The bench and road would be more visible from the air than the road corridor under Alternative B. After mine closure the road and bench would remain in perpetuity. Also under Alternative D, the port would remain closed until July 1 and the DMTS road would be closed during fall caribou migration. The road closure would not substantially benefit recreational hunting, since sport hunters are generally flown into the study area and thus can fly to wherever the caribou herds are located at any given time.

3.11.4 Land Use and Recreation – Summary

None of the alternatives would be expected to have a direct impact on recreation in the study area. NANA limits access to their lands by non-shareholders, and thus as long as NANA owns the property and their rules remain in place, recreation would be displaced to other areas with or without mining.

Visual impacts may be experienced by the limited number of recreationists flying over the site en route to their destinations and, potentially, by hikers in the surrounding mountains. Under Alternative A, site reclamation would begin in 2011. Some concurrent reclamation of the waste rock dump would occur during operations under alternatives B and D and mining would cease in 2031 under alternatives B, C, and D. Alternatives C and D create additional land disturbance and associated visual effects due to the presence of the pipeline bench. Dry closure of the tailings impoundment under Alternative C could have less visual impacts if the cover is vegetated.

3.12 Subsistence

This section describes pre-mining and current subsistence uses in the study area and analyzes the potential direct and indirect effects of the proposed Red Dog Mine Aqqaluk Extension on subsistence uses of residents in the study area. For the subsistence analysis, the study area includes the communities of Kivalina, Kotzebue, and Noatak. Residents from these communities use the project area, which includes the road, mine, port site, and surrounding drainages, for subsistence activities, and they harvest resources that travel through or reside in the project area.

The study area is composed of state, federal, and private lands. In Alaska, subsistence hunting and fishing are regulated under a dual management system by the State of Alaska and the federal government. Much of the private land in the region is owned by the regional Native Corporation (NANA) and the Kotzebue village corporation (Kikiktagruk Iñupiat Corporation [KIC]). Subsistence uses on NANA lands are limited primarily to shareholders, although some non-local recreational uses are allowed by permit. Hunting guides are not permitted to operate on NANA lands (NANA 2003). Subsistence activities on all lands in Alaska, including private lands, are subject to State and federal subsistence regulations.

State law is based on Title 16 of Alaska Statute and Title 5 of the Alaska Administrative Code, Chapter 99, and regulates State subsistence uses. Under State law, "'subsistence uses' means the noncommercial, customary and traditional uses of wild, renewable resources by a resident domiciled in a rural [sic] area for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation, for the making and selling of handicraft articles out of non-edible by-products of the fish and wildlife resources taken for personal or family consumption, and for customary trade, barter, or sharing for personal or family consumption" (Alaska Statute 16.05.094[33]).

Federal subsistence law is based on Title VIII of ANILCA and regulations found in 36 CFR § 242.1 and 50 CFR § 100.1. Under federal law, "subsistence uses means the customary and traditional uses by rural Alaska residents of wild renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of non-edible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (ANILCA Title VIII Section 803).

The Alaska Federation of Natives describes subsistence as:

> The hunting, fishing, and gathering activities, which traditionally constituted the economic base of life for Alaska's Native peoples and which continue to flourish in many areas of the state today. Subsistence is a way of life in rural Alaska that is vital to the preservation of communities, Tribal cultures, and economies. Subsistence resources have great nutritional, economical, cultural, and spiritual importance in the lives of rural Alaskans… Subsistence, being integral to our worldview and among the strongest remaining ties to our ancient cultures, is as much spiritual and cultural, as it is physical (Alaska Federation of Natives 2005).

The majority of public State and federal lands in the study area are open to subsistence hunting and fishing activities for residents in the study communities. Title VIII of ANILCA specifies that "rural residents engaged in subsistence uses shall have reasonable access to subsistence resources on the public lands" (ANILCA Title VIII Section 811). NANA shareholders, spouses and descendants of shareholders, and Natives who live outside the region but who "traditionally hunt in the region" may hunt and fish on NANA lands without a permit. Additionally, non-shareholders who have been permanent residents in the region for at least five years and who "have traditional and customary use of fish and game" may engage in hunting and fishing activities on NANA lands by permit (NANA 2003).

Subsistence uses are central to the customs and traditions of many cultural groups in Alaska, including people living in the NWAB. Native Alaskans have relied on wild resources for food, clothing, and shelter for thousands of years. Today, residents participate in a “mixed, subsistence-market” economy, where families invest money into small-scale technologies to assist in harvesting wild foods (ADF&G 2000). Cash from commercial fishing, trapping, and/or wages from public and private sector employment provides the means to purchase supplies (gas, transportation, and equipment) used in subsistence activities (see Section 3.17.2). Subsistence activities include hunting, fishing, trapping, gathering wood, and picking berries.

Participation in subsistence activities promotes transmission of traditional knowledge from generation to generation and serves to maintain people’s connection to the physical and biological environment. The subsistence lifestyle encompasses Iñupiaq cultural values, such as sharing, respect for elders, respect for the environment, hard work, and humility. In addition to being culturally important, subsistence is a source of nutrition for residents in an area of Alaska where food prices are high. While some people earn income from employment, these and other residents rely on subsistence to supplement their diets throughout the year. Furthermore, subsistence activities support a healthy diet and contribute to residents’ overall well being.

3.12.1 Subsistence – Pre-mining Environment

3.12.1.1 Subsistence Harvests

Several subsistence harvest studies in the three study communities of Kivalina, Kotzebue, and Noatak, documented residents’ use of subsistence resources prior to the Red Dog Mine development. Initiated by the U.S. Atomic Energy Commission’s environmental studies of the Cape Thompson area, Saario and Kessel (1966) documented Kivalina residents’ subsistence uses from 1959–1961 (two study years of harvest data), and Foote and Williamson (1966) reported on the subsistence uses of Noatak from 1960–61 (one study year). As part of an effort to document subsistence harvests in five Native regions for the Joint Federal-State Land Use Planning Commission, Patterson (1974) compiled harvest estimates for these three study communities during the early 1970s. Burch (1985) conducted two Kivalina subsistence studies in 1964–1966 (two study years) and again in 1982–1984 (two study years). Braund and Burnham (1983) also documented Kivalina Dolly Varden char harvest amounts in 1982. A study in 1986 by Georgette and Loon (1993) documented pre-mine subsistence harvest in Kotzebue. The results of these studies are provided in detail in Appendix D.

Kivalina

Four separate studies, beginning in 1959 and representing seven harvest years, reported on the subsistence harvests of Kivalina residents prior to the development of the Red Dog Mine. In each of five study years (1964–65, 1965–66, 1971–72, 1982–83, and 1983–84), caribou, Dolly Varden char (referred to as “trout” by local residents), bearded seal, ringed seal, and beluga comprised the bulk of residents’ harvests. When harvested, as in 1983–84, bowhead also contributed to a large portion (15.6 percent) of the subsistence harvest. Resource availability was an important factor in the composition of resource harvests from year to year. In 1964–65 the ratio of caribou harvests to all harvests was the lowest of all study years, whereas in the following year, caribou comprised over 50 percent of the total harvested subsistence resources.

Residents compensated for low harvests of one resource by increasing their harvest efforts on other more available resources. Burch (1985:77) explained that in 1965–66, residents experienced the worst recorded fall harvest of Dolly Varden char (contributing 7.3 percent), a major subsistence resource for both human and dog consumption. With the arrival of caribou shortly after the end of the fall fishery, Kivalina residents compensated for the low harvests of Dolly Varden char by increasing their harvest of caribou (53.6 percent).

Per capita harvest levels decreased from 1,838 pounds in 1959–60 to less than 1,000 pounds in 1982–83 and 1983–84. In general, per capita harvest levels for resources contributing the most to the overall harvest amounts, including caribou, bearded seal, other seals, and arctic char, declined between the 1960s and 1980s. Only beluga harvests showed an increasing trend in harvest amounts. Burch (1985:111) noted that the decreased use of sled-dogs, major consumers of fish and other subsistence resources, must be taken into account as part of an explanation for the decrease in per capita harvest. When the total number of consumers (persons plus dogs) is analyzed in relationship to the total harvest, the pounds per consumer actually increased between the 1960s and 1980s (Burch 1985: Table 27).

Kotzebue

At 1,068,208 pounds, Patterson's (1974) estimate of the total pounds harvested from 1971–72 is nearly identical to the 1,067,280 total pounds estimated by ADF&G for the 1986 study year. However, the contributions of certain resources, notably caribou and salmon, varied greatly from year to year. Comparing harvest data from 1971–72 and 1986, caribou represented 63.7 percent of the total harvest in 197–72 and 24.4 percent in 1986, while salmon accounted for 0.1 and 18.4 percent, respectively. The 1971–72 information was derived in part from a literature review (see Patterson 1974), whereas the ADF&G 1986 study was based on a survey among Kotzebue households. In 1986, caribou, salmon, bearded seal, and sheefish constituted the majority of Kotzebue residents' subsistence harvests. Moose was the next highest contributor at 3.3 percent of the overall harvest. Caribou, at a harvest of 260,645 pounds, comprised nearly one-quarter of the community's total harvest that year, the most for a single resource. Georgette & Loon (1993:183) noted that Kotzebue harvest levels (per capita of 398 pounds) in 1986 were greater compared to harvest levels from Alaska communities (e.g., Barrow, Dillingham, Cordova) with similar populations. Georgette & Loon (1993) estimated that there were 1,889 dogs in Kotzebue in 1986, an average of 2.5 dogs per household.

Noatak

The earliest comprehensive pre-mine subsistence harvest study for Noatak (Foote and Williamson 1966), conducted in 1960–61, shows over 80 percent of the harvest coming from caribou and salmon. Much of the remainder of the harvest included beluga, bearded seal, and non-salmon fish. Waterfowl and berries contributed approximately 2,000 pounds each to the total harvest. An estimated 75,000 individual salmon were harvested that year for approximately 57 percent of the total harvest. However, Foote & Williamson (1966) estimated Noatak residents caught 60,000 (360,000 pounds) of these salmon for consumption by 500 sled-dogs, and another 12,000 were saved to feed to dogs left in the community over the summer. The number of winter-time residents in the community of Noatak at that time was estimated to be 235 persons, thus residents owned approximately two dogs per capita.

Overall harvest level estimates for 1971–72 are substantially lower than 1960–61, mostly due to decreased salmon harvests. Both studies reported similar harvest numbers for caribou, furbearers and small land mammals, waterfowl, and upland birds. Non-salmon fish harvests had higher reported total pound amounts in 1971–72, while marine mammal harvest pounds decreased. In 1971–72, caribou, Dolly Varden char, and chum salmon comprised over 85 percent of the community's total harvest. Moose and beluga were the fourth and fifth highest contributors to Noatak's subsistence harvest during that time period.

In terms of per capita pounds, the two most important marine resources in 1960–61, beluga and bearded seal, provided over 300 pounds combined. Most of the marine mammal harvests occurred and were consumed while residents were at summer camps in Sheshalik (Foote & Williamson 1966:1102). Caribou per capita harvest estimates equaled approximately 762 pounds per person. Foote & Williamson (1966:1106) estimated that caribou contributed to 84 percent of Noatak's winter diet in 1960–61.

3.12.1.2 Subsistence Use Areas

In addition to documenting Kivalina and Noatak's pre-mine subsistence harvest amounts, these same studies and others also recorded these communities' pre-mine subsistence use areas. Studies documenting Kivalina and Noatak pre-mine subsistence use areas include Saario and Kessel (1966), Foote and Williamson (1966), Braund and Burnham (1983), and Schroeder, Anderson, and Hildreth (1987). No mapped data exist for pre-mine Kotzebue subsistence use areas.

Kivalina

Studies conducted by Saario and Kessel (1966), Foote and Williamson (1966), Braund and Burnham (1983), and Schroeder, Anderson, and Hildreth (1987) documented Kivalina's pre-mine subsistence use areas for varying time periods (Figure 3.22). Of all the studies, Schroeder, Anderson, and Hildreth (1987; time period ca. 1925–1986) recorded the broadest extent of Kivalina's use areas. They documented a continuous use area extending north to south from the Brooks Range to Kotzebue Sound, and west to east from the Chukchi Sea to the drainages surrounding the upper portion of the Noatak River. The study also reported subsistence use areas as far as Selawik Lake and in Shishmaref Inlet. Foote & Williamson (1966) recorded Kivalina's all resource use areas from 1950 to 1960, as well as spring, summer, fall, and winter use areas for a variety of subsistence resources including caribou, furbearers, marine mammals, waterfowl, fish, and berries. Kivalina residents' subsistence activities during this time period ranged from as far north as Point Hope in the spring to as far south as Rabbit Creek during the summer (Figure 3.22). Winter, fall, and spring use areas were located as far inland as the foothills of the DeLong Mountains (Foote and Williamson 1966).

Pre-mine Kivalina subsistence use area maps by individual resource are provided in Appendix D. Land mammal use areas, including those for caribou, bear, and furbearers, occur over an expansive inland area from Cape Thompson in the north to Cape Krusenstern in the south, and inland into the Noatak National Preserve and DeLong Mountains. Moose hunting was generally focused along the coast and nearby rivers and sheep hunting was reported around several inland mountains. Marine mammal hunting by Kivalina residents extended between Cape Thompson and Sheshalik. Seal and walrus use areas extended farther out into the Chukchi Sea, while beluga and polar bear use areas were located closer along the coastline. Kivalina residents' lifetime fishing use areas occurred along the Kivalina and Wulik rivers, in lagoons south of the community, in the waters near Sheshalik, and in Selawik Lake. Bird hunting and egg gathering activities occurred along the coast and along the Wulik and Kivalina rivers. Residents' harvests of vegetation, including berries, plants, and wood, were located along the Kivalina and Wulik rivers and on the coast from south of Chariot to Sheshalik.

Noatak

Foote and Williamson (1966), Braund and Burnham (1983), and Schroeder, Anderson, and Hildreth (1987) recorded Noatak's pre-mine subsistence use areas (Figure 3.23). Braund and Burnham (1983) documented partial Noatak subsistence use areas for 1977–1982, focusing on use areas west of the community potentially affected by the development of the proposed Red Dog Mine. As shown on Figure 3.23, the range of Noatak's all resources lifetime (ca. 1925–1986) subsistence use areas stretched from the Selawik River and Kotzebue Sound to the north beyond the Amatusuk Hills in the Brooks Range (Schroeder, Anderson, and Hildreth 1987). Noatak residents reported lifetime use areas as far as Point Hope to the west and as far east as the upper drainages of the Noatak River. Foote & Williamson (1966) mapped Noatak's 1950–1960 all resources use areas (Figure 3.23). Their study described unmapped use areas extending to the east and north beyond the locations shown on Figure 3.23. Foote and Williamson documented spring and summer use areas as far south as Sheshalik and Kotzebue. In the summer the majority of harvest activity occurred along the Noatak River or around the Sheshalik area. Autumn use

Figure 3.22: Pre-Mine Subsistence Use Areas Kivalina, All Resources

Lifetime (circa 1925-1986) Subsistence Use Areas
16 Kivalina hunters, All Resources

1950-1960 Subsistence Use Areas
Unspecified number of hunters, All Resources

1977-1982 Subsistence Use Areas
19 Kivalina hunters, 8 Noatak hunters, 4 Kotzebue hunters, All Resources

Previous to 1962 Subsistence Use Areas
Unspecified number of hunters, All Resources (partial)

For all data sets, other areas may have been used for resource harvesting.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

Sources:
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.
1977-1982: Braund, S.R. and D.C. Burnham 1983.
1950-1960: Foote, D.C. and H.A. Williamson 1966.
Previous to 1962: Saario, D.J. and B. Kessel 1966.

Figure 3.23: Pre-Mine Subsistence Use Areas Noatak, All Resources

Lifetime (circa 1925-1986) Subsistence Use Areas
25 Noatak hunters All Resources

1977-1982 Subsistence Use Areas
19 Kivalina hunters, 8 Noatak hunters, 4 Kotzebue hunters All Resources (partial)

1950-1960 Subsistence Use Areas
Unspecified number of hunters, All Resources

For all data sets, other areas may have been used for resource harvesting.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

Sources:
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.
1977-1982: Braund, S.R. and D.C. Burnham 1983.
1950-1960: Foote, D.C. and H.A. Williamson 1966.

areas expanded to the west and east of Noatak River. Residents traveled to the northernmost use areas in the DeLong Mountains during the winter and spring months.

Appendix D shows pre-mine Noatak use area maps by individual resource. Land mammal hunting for caribou and furbearers extended along a vast expanse of the Noatak River, overland to the east and west of the river, and north beyond the Brooks Range. Moose and bear use areas were located primarily along the Noatak River drainage, although bear hunting occurred over a larger overland area west of the river. Sheep hunting occurred in the hills and mountains east of the Noatak River and in the DeLong Mountains north of the community. Marine mammal hunting by Noatak residents, including hunting of bowhead, beluga, seal, walrus, and polar bear, occurred in Kotzebue Sound and in the Chukchi Sea from Cape Krusenstern to Point Hope. Bird use areas were documented in a large area from the hills east of the Noatak River to the Chukchi Sea coast, while egg gathering locations were concentrated along the Noatak River and in various coastal areas from Sheshalik to Cape Krusenstern. Partial Noatak fishing areas (Dolly Varden char) were documented along the Wulik River near Mount Jarvis and along a small stretch of Rabbit Creek several miles inland from the coast. Residents gathered vegetation, including berries, plants, and wood, primarily along the Noatak River and along the coastline to Cape Krusenstern from Sheshalik.

3.12.2 Subsistence – Baseline Conditions

3.12.2.1 All Resources

This section provides a description of current subsistence uses by residents of the study communities and impacts on subsistence uses through 2007. Current subsistence harvest data are available for Kivalina (ADF&G 2008c; Magdanz, Braem et al. 2008), Noatak (ADF&G 2008c; Magdanz et al. 2008) and Kotzebue (ADF&G 2008c; Whiting 2006). SRB&A conducted subsistence mapping and traditional knowledge interviews in Kivalina and Noatak in 2008. Subsistence use area maps for Kivalina and Noatak are derived from SRB&A's resulting supplemental report (SRB&A 2009) and ADF&G use area data for 2007 (Magdanz et al. 2008). Partial subsistence use areas are available for the three study communities based on fieldwork conducted by SRB&A in 1998 and 2004 (SRB&A 2000 and 2005). During SRB&A's 2008 interviews in Kivalina and Noatak, respondents provided observations about changes in subsistence uses and resources over the last 20 years (i.e., since the mine started operations). For each resource, residents were asked whether they had noticed a change in use, abundance, quality, migration/distribution, and habitat. Respondents discussed both positive and negative changes and often identified more than one change per resource. Each observation was entered as a separate record into an Access database.

The residents' responses are incorporated into this section to describe changes in subsistence uses and resources since the mine began. Table 3.12-1 shows the overall number of changes, observations, and the number of observers reporting at least one change by resource category. Other data on mine-related impacts to subsistence uses and current subsistence uses are from SRB&A (2000 and 2005) and the Corps (2005).

Harvest Trends

Tables 3.12-2 through 3.12-4 provide usable pounds per capita by resource for each of the study communities during each available study year. Current subsistence harvest data are available for all resources for Kivalina (1992 and 2007), Kotzebue (1991, 2002, 2003, and 2004) and Noatak (1994 and 2007). Additional harvest data are available in more detail in Appendix D. Given the high percentage of non-Native households in Kotzebue compared to Kivalina and Noatak (see Section 3.17, Socioeconomics), comparisons of per capita harvest data between the three communities is somewhat problematic. Kotzebue harvest data from 2002, 2003, and 2004 are from surveys with Native households

Table 3.12-1 Number of Resource Change Observations and Observers by Resource Category

Resource Category	Observations about Resource Changes			Number of Observers (Percent of Respondents)		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Caribou	108	131	239	37 (84%)	35 (83%)	72 (84%)
Moose	14	10	24	11 (25%)	9 (21%)	20 (23%)
Other Large Land Mammals	12	35	47	11 (25%)	20 (48%)	31 (36%)
Bowhead	44	16	60	29 (66%)	7 (17%)	36 (42%)
Beluga	66	35	101	34 (77%)	21 (50%)	55 (64%)
Bearded Seal	27	22	49	20 (45%)	11 (26%)	31 (36%)
Other Seal	1	4	5	1 (2%)	3 (7%)	4 (5%)
Walrus	14	3	17	10 (23%)	3 (7%)	13 (15%)
Polar Bear	7	0	7	4 (9%)	0	4 (5%)
Furbearers/Small Land Mammals	26	75	101	17 (39%)	31 (74%)	48 (56%)
Waterfowl	12	16	28	10 (23%)	12 (29%)	22 (26%)
Eggs	0	1	1	0	1 (2%)	1 (1%)
Upland Birds	2	26	28	2 (5%)	18 (43%)	20 (23%)
Dolly Varden Char	51	35	86	28 (64%)	13 (31%)	41 (48%)
Other Non-Salmon Fish	12	4	16	7 (16%)	3 (7%)	10 (12%)
Salmon	17	23	40	11 (25%)	17 (40%)	28 (33%)
Berries	31	19	50	22 (50%)	11 (26%)	33 (38%)
Plants and Wood	2	4	6	2 (5%)	4 (10%)	6 (7%)
Totals	446	459	905	N/A	N/A	N/A

SRB&A 2008

N/A = not applicable

Table 3.12-2 Kivalina Per Capita Harvests by Resource Category, All Study Years

	Pounds Usable Weight Per Capita									
	1959–60	1960–61	1964–65	1965–66	1971–72	1982–83	1983–84	1992	1996	2007
All Resources	1,838	1,671	1,341	1,549	1,541	778	940	761	–	594
Caribou	382	581	209	830	371	179	284	138	–	85
Moose	–	–	0	12	0	11	11	26	–	5
Other Large Land Mammals	–	–	1	3	0	1	2	1	–	0
Bowhead	–	–	0	0	0	0	147	39	–	0
Beluga	96	48	53	107	53	159	166	29	–	51
Bearded Seal	339	107	295	236	279	169	74	157	–	224
Other Seal	244	78	380	204	213	49	26	30	–	14
Walrus	5	–	0	19	12	14	13	62	–	3
Polar Bear	3	–	0	3	2	0	3	3	–	
Furbearers/Small Land Mammals	0	0	0	0	0	0	0	0	–	0
Waterfowl	–	–	–	0	4	3	4	7	3	8
Eggs	–	–	3	0	3	0	0	2	1	2
Upland Birds	–	–	–	0	0	0	1	1	0	1
Dolly Varden char	–	–	378	113	510	179	178	203	–	158
Other Non-Salmon Fish	–	–	10	28	77	1	18	35	–	18
Salmon	–	–	6	0	3	1	5	15	–	8
Berries	10	–	–	3	8	10	4	13	–	17
Plants and Wood	5	–	–	1	6	0	0	1	–	2

Source: Magdanz et al. 2008; ADF&G 2008a; Burch 1985; Saario & Kessel 1966
— = data not available
SRB&A 2008

Table 3.12-3 Kotzebue Per Capita Harvests by Resource Category, All Study Years

	Pounds Usable Weight Per Capita			
	1971–72	1986	1991	1997
All Resources	630	398	593	–
Caribou	401	97	141	–
Moose	19	13	35	–
Other Large Land Mammals	1	2	1	–
Bowhead	0	0	0	–
Beluga	29	8	3	–
Bearded Seal	64	75	126	–
Other Seal	4	20	25	–
Walrus	1	4	3	–
Polar Bear	0	2	0	–
Furbearers/Small Land Mammals	1	1	1	–
Waterfowl	0	5	2	7
Eggs	0	0	0	1
Upland Birds	1	1	2	2
Dolly Varden char	6	9	18	–
Other Non-Salmon Fish	90	79	144	–
Salmon	1	73	75	–
Berries	9	7	15	–
Plants and Wood	1	1	1	–

Source: ADF&G 2008a; Whiting 2006; Patterson 1974
— = data not available
SRB&A 2008

Table 3.12-4 Noatak Per Capita Harvests by Resource Category, All Study Years

	Pounds Usable Weight Per Capita						
	1960–61	1971–72	1994	1997	1999	2002	2007
All Resources	2984	1149	461	–	–	–	361
Caribou	762	564	221	–	224	120	114
Moose	–	37	4	–	6	4	11
Other Large Land Mammals	–	2	0	–	1	0	3
Bowhead	–	–	0	–	–	–	0
Beluga	195	34	8	–	–	–	11
Bearded Seal	156	17	37	–	–	–	47
Other Seal	23	3	0	–	–	–	2
Walrus	–	8	3	–	–	–	0
Polar Bear	–	–	0	–	–	–	–
Furbearers/Small Land Mammals	3	10	0	–	0	0	1
Waterfowl	8	3	4	4	–	–	5
Eggs	–	–	0	0	–	–	0
Upland Birds	1	1	1	1	–	–	0
Dolly Varden char	–	250	40	–	–	–	64
Other Non-Salmon Fish	138	27	19	–	–	–	34
Salmon	1692	180	120	–	–	–	51
Berries	8	13	4	–	–	–	16
Plants and Wood	–	2	0	–	–	–	–

Source: Magdanz et al. 2008; ADF&G 2008a; Patterson 1974; Foote & Williamson 1966.
— = data not available
SRB&A 2008

only and may be more representative of subsistence uses when compared to Kivalina and Noatak. Residents of the study communities harvested between 364 and 761 pounds of wild resources per capita (based on available data) since the earliest current harvest study (1991 in Kotzebue, 1992 in Kivalina, and 1994 in Noatak). These numbers illustrate the continuing importance of subsistence foods in local residents' diets. Section 3.17, Socioeconomics, provides descriptions of demographic and economic changes in NWAB communities over time. Changes in population, demographics, income, and employment are all relevant to subsistence uses. While the region has experienced a slow growth in population since the 1990s, it has also experienced net out migration since 1970. In other words, more people have moved out of the region than have moved to the region. With the available data, it is not possible to link population changes directly to changes in subsistence. However, it is possible that out migration has had an effect on subsistence harvests in the study communities, especially if those leaving the communities are major subsistence providers.

Kivalina. Recent subsistence harvest data for Kivalina, from 1992 and 2007, show 100 percent of households using subsistence resources during each year and total harvests equaling 261,765 and 255,344 pounds of wild food, respectively (Appendix D). Kivalina residents harvested an estimated 761 per capita pounds of subsistence resources in 1992, and 594 per capita pounds in 2007 (Table 3.12-2). Dolly Varden char, bearded seal, and caribou were the top species harvested during both recent and pre-mine study years.

Kivalina's recent harvests, compared to pre-mine harvest levels, on initial review appear to have steadily decreased from 1,838 usable pounds per person in 1959–60 to 594 pounds in 2007 (Table 3.12-2). However, the per capita amounts do not take into account the pounds of subsistence resources fed to dogs (Section 3.12.1.1 Subsistence Harvests). One major factor in the decrease in subsistence harvests has been the shift from sled-dogs to snowmachines as the primary mode of transportation. This shift was already evident by 1983–84 when Burch (1985: Table 27) counted only 34 dogs in the village compared to 207 in 1965–66. Using Burch's adjustments for dog consumption, per capita subsistence harvests in Kivalina were 710 (1965), 675 (1982), and 829 (1983). The 1992 harvest of 761 pounds per capita is within this range, although unadjusted for dog consumption. Also important to note is that the 1992 harvest estimate is based on a sample of households rather than a census as it was in the 1960s and in 1983. There is a 95 percent probability that the 1992 per capita harvest is between 678 and 845 pounds. The 2007 range figure of 458–730 (594 +/- 136) pounds per capita overlaps the 1992 confidence interval. Thus it cannot be concluded that 2007 Kivalina harvests of all resources were significantly lower than 1992 harvests.

As Table 3.12-2 shows, per capita caribou harvests, equaling 138 and 85 pounds during recent study years (1992 and 2007), are substantially less than earlier per capita harvest amounts of 179 (in 1982–83) and 284 (in 1983–84) pounds, even when taking into account the fact that both the 1992 and 2007 estimates are subject to sampling error (1992: 126–151; 2007: 60–110). Based on the SRB&A 2008 subsistence change interviews, residents of Kivalina most often attribute this decrease in caribou harvests to the disruption of the caribou migration caused by the DMTS road and traffic (see "Caribou Resource Change," below).

Beluga harvests have decreased from pre-mine study levels. The 1982–83 and 1983–84 beluga harvest levels are most representative of Kivalina pre-mine beluga harvests, because before resumption of bowhead whaling in 1966 Kivalina only harvested beluga in July. After 1966 Kivalina also harvested beluga in the spring. In 1982–83 and 1983–84, Kivalina residents harvested 159 and 166 usable pounds per capita compared with only 29 and 51 pounds per capita in 1992 and 2007 respectively (Table 3.12-2). Based on the 2007 SRB&A subsistence change interviews, Kivalina residents attribute this decrease in harvests to the port site and port site noise diverting the summer beluga from their normal migratory route along the Kivalina coastline. They also reported that the 2007 harvests of 51 pounds per capita of beluga was an anomaly in that harvests during previous years were much lower. See "Marine Mammals" below for additional information regarding residents' beluga harvests and related changes.

Kotzebue. Table 3.12-3 shows per capita harvest data for Kotzebue for all study years (1991, 1997, 2002, 2003, and 2004) by resource category. Total yearly harvests in recent years ranged from 892,782 pounds in 2003 to 2,163,033 pounds in 1991 (Appendix D: Table 10). Mean household pounds ranged from 2,674 in 1991 to 5,032 in 2002. Caribou, sheefish, and bearded seal comprised the top three harvested species, by percent of total harvest, during each study year. Other major harvested species include chum salmon, moose, spotted seal, and Dolly Varden char.

In 1991, 99 percent of Kotzebue households reported using at least one resource, and at least 90 percent used caribou, berries, and salmon (Appendix D). Compared to earlier harvest data for Kotzebue, harvest amounts have not changed noticeably. The total estimated pounds harvested in 1991 (after mine operations began) were higher than in any other study year (Appendix D: Table 10). Compared to the 1986 harvest data, the pounds of usable weight per capita were higher in 1991 for most resource categories (Table 3.12-3). In 1986 the mean household pounds of harvested wild foods (1,395) was less than in any recent study year (Appendix D). Whiting (2006) notes that Fall and Utermohle's 1991 survey used a 10-year-old sample that had been used for a previous survey, biasing the sample towards "long-term households;" this may be one explanation for the higher harvest estimates seen in 1991. Furthermore, 2002, 2003, and 2004 data, funded by the Native Village of Kotzebue, includes only Native households; given that Native households in Kotzebue harvest substantially more wild foods than non-Native households (Georgette 1986 in Whiting 2006), the noticeably higher household harvest amounts for those study years are not surprising. The composition of subsistence harvests in Kotzebue has remained relatively steady, with caribou, bearded seal, and sheefish among the top harvested species during each post- and pre-mine study year. However, the harvests of some species have declined. Beluga provided 29 and eight usable pounds per capita in 1971–72 and 1986, whereas in 1991, residents harvested only three pounds per capita. Residents' observations regarding the decline in beluga availability are discussed in more detail in Section 3.12.2.3.

Noatak. Current Noatak harvest data from 1994 and 2007 show that residents harvested 174,851 and 191,553 total pounds of subsistence foods during those years (Appendix D). The decline in per capita amounts from 1994 to 2007 (from 461 to 364) are evident almost entirely in their harvests of caribou, which dropped from 221 pounds per capita in 1994 to 114 pounds per capita in 2007 (Table 3.12-4). During the SRB&A 2008 interviews, residents of Noatak reported that declining harvests of caribou in recent years are due primarily to an increase in sport hunting activities along the Noatak River and changing migration routes (see "Caribou Resource Change," below). A comparison to earlier harvest data (Table 3.12-4) indicates that residents' subsistence harvests have declined over time, the most extreme case being the 2,984 per capita pounds of wild foods harvested in 1960–61 compared to the 361 per capita pounds harvested in 2007. However, Foote and Williamson (1966) reported that of 75,000 salmon harvested at Noatak from 1960–61, 72,000 were fed to dog teams. An undetermined number of salmon were harvested at Sheshalik for consumption by both humans and dogs. As snowmachines have replaced dogs as the primary mode of winter travel, it can be assumed that the majority of currently harvested foods are consumed by humans. Caribou harvests in 1960–61 were more than twice current yearly caribou harvests, and again, this can be attributed partly to declining caribou availability as reported by local residents. Foote and Williamson (1966) reported that 1960–61 was an especially successful year for caribou as their range had recently expanded to nearby lowlands. Also contributing to the 1960–61 numbers were the harvest of 52 beluga whales providing 195 pounds of meat per capita (Table 3.12-4). Residents of Noatak reported that beluga availability at Sheshalik has declined over the last 20 or more years (see discussion below, under "Marine Mammal Resource Changes"). Despite changes in overall harvest numbers, uses of subsistence resources remain high. In 2007, 100 percent of households reported using at least one subsistence resource, and 97 percent reported harvesting at least one resource (Appendix D).

Subsistence Use Areas

Current (1998–2007) subsistence use areas for Kivalina and Noatak for all resources are shown on Figures 3.24 and 3.25. The pre-mine use areas shown on Figures 3.22 through 3.23 represent a much longer time frame than the more recent use areas depicted on Figures 3.24 and 3.25. Some of the pre-mine data collected by Schroeder, Andersen & Hildreth represents uses from as early as 1925; however, use areas from Schroeder, Anderson, and Hildreth (1987) and Braund and Burnham (1983) were for shorter time periods and show somewhat less extensive use of the land. Because resource availability fluctuates and changes over time, lifetime use areas are likely to be much larger than those recorded for a 10-year span. Future fluctuations in the availability of local resources may once again require a return to traditional areas not currently in use. Changes in settlement patterns and travel methods may also lead to changes in subsistence use areas. During studies conducted in Kivalina and Noatak in the 1950s and 1960s, the main modes of transportation were dog teams, wooden boats (some with outboard motors), and skin boats (*umiaqs*) (Saario and Kessel 1966; Foote and Williamson 1966). Jobs in the communities were rare (the men often took summer employment in other areas of the state), and so residents dedicated much of their time while in the village to harvesting subsistence resources. Hunting trips often lasted days or even weeks. By the 1980s, jobs in or near local communities were more available and dog teams had been replaced by snowmachines as the primary method of winter travel (Burch 1985). These trends have continued to the present day and allow residents to stay in their communities for employment while taking shorter trips from the community for subsistence pursuits. Thus, some residents may have less time for subsistence because of work and other responsibilities, but they continue to travel substantial distances within shorter periods of time.

Partial use area data depicting Kotzebue onshore and offshore subsistence uses between Kotlik Lagoon and Cape Thompson were collected by SRB&A for the 1995–2004 time period and are represented on Figure 3.26. This study focused on the potential port site expansion, so it addressed a limited geographic area. Kotzebue residents reported traveling as far as Cape Thompson for subsistence uses, although the majority of overlapping use areas reported by Kotzebue residents occurs along Rabbit Creek, Kotlik Lagoon, and along the shore to the port site. Because the SRB&A 2000 and 2005 reports provide only partial use area data, these use areas are not discussed below under individual resource headings unless relevant.

Kivalina. Figure 3.24 depicts Kivalina subsistence use areas from 1998–2007 for all resources, with 2007 use area data collected by ADF&G also shown. Respondents reported subsistence uses over a continuous offshore area from Cape Krusenstern to Cape Thompson with use extending to Point Hope, and inland to the DeLong Mountains and Noatak River. Fewer use areas also appear near Kotzebue, Cape Lisburne, Point Lay and Selawik.

Earlier studies documenting Kivalina’s all resources use areas appear on Figure 3.22, and the extent of lifetime use areas are also depicted on Figure 3.24. Figure 3.22 depicts the documented extent of Kivalina’s all resources subsistence use prior to the development of the Red Dog Mine. Some of these studies (e.g., Saario & Kessel 1966) did not map use areas for all subsistence resources. Comparison of Figures 3.24 and 3.22 show that the majority of Kivalina’s pre-mine subsistence uses documented by Saario and Kessel (1966), Foote and Williamson (1966), and Braund and Burnham (1983) occur in the same general areas as the locations shown with the highest number of overlapping subsistence use areas on Figure 3.24. Schroeder, Anderson, and Hildreth’s (1987) documentation of Kivalina lifetime (ca. 1926–1986) subsistence use areas are similar to residents 1998–2007 use areas although their lifetime areas extended further to the east and do not show uses as extensively near Point Hope. For further comparison of subsistence use areas see the individual “Subsistence Use Areas, Seasonal Round, and Harvest Patterns” discussions under each resource category heading below.

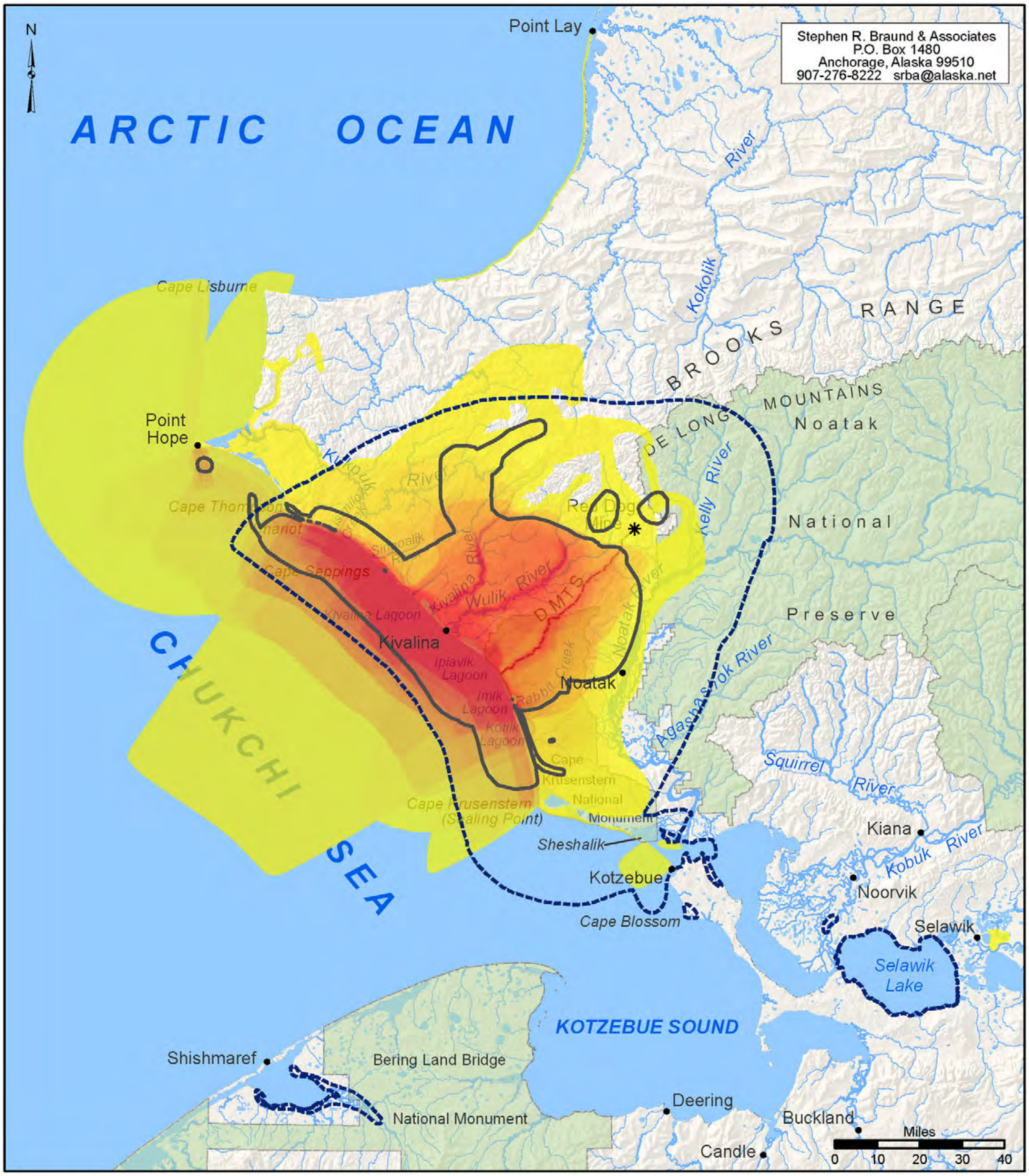


Figure 3.24: 1998-2007 and Lifetime Subsistence Use Areas Kivalina, All Resources

1998-2007 Overlapping Subsistence Use Areas
High
Low
1194 Use Areas
43 Respondents
All Resources

2007 Subsistence Use Areas
301 Use Areas
35 Households
All Resources

Lifetime (circa 1925-1986) Subsistence Use Areas
16 Kivalina hunters
All Resources

For all data sets, other areas may have been used for resource harvesting.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.

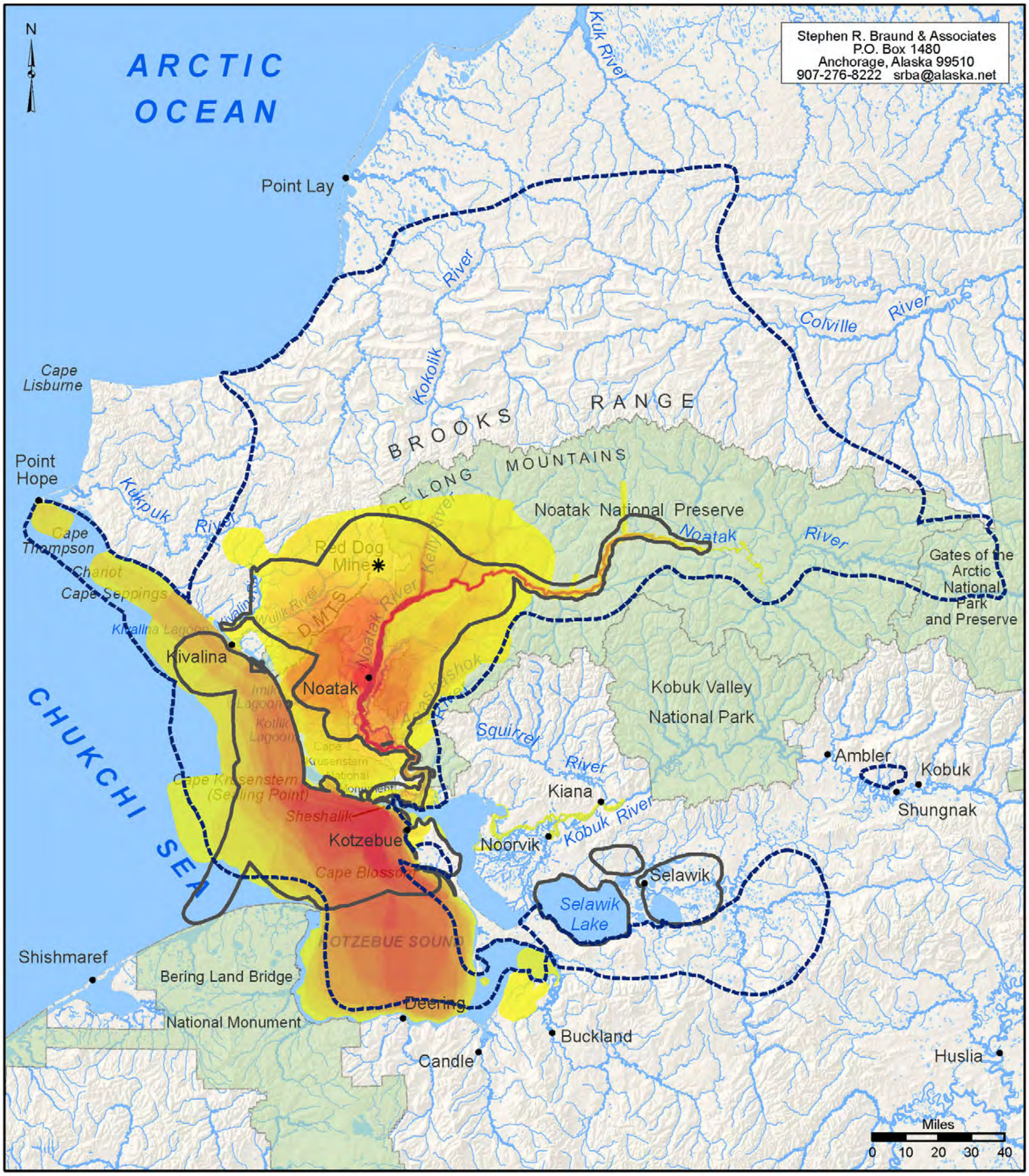


Figure 3.25: 1998-2007 and Lifetime Subsistence Use Areas Noatak, All Resources

1998-2007 Overlapping Subsistence Use Areas
High
Low
948 Use Areas
41 Respondents
All Resources

2007 Subsistence Use Areas
378 Use Areas
82 Households
All Resources

Lifetime (circa 1925-1986) Subsistence Use Areas
25 Noatak hunters
All Resources

For all data sets, other areas may have been used for resource harvesting.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.

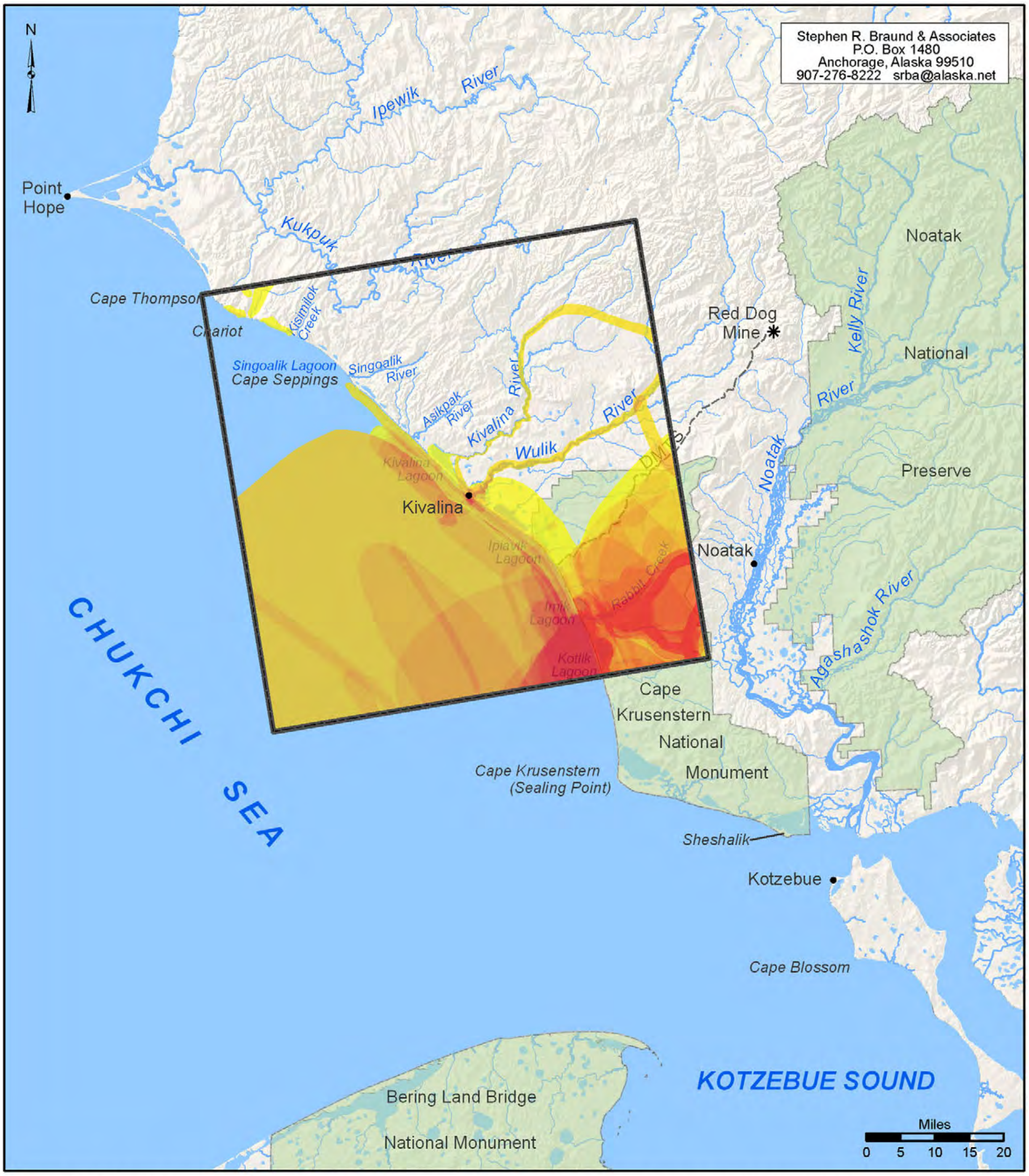
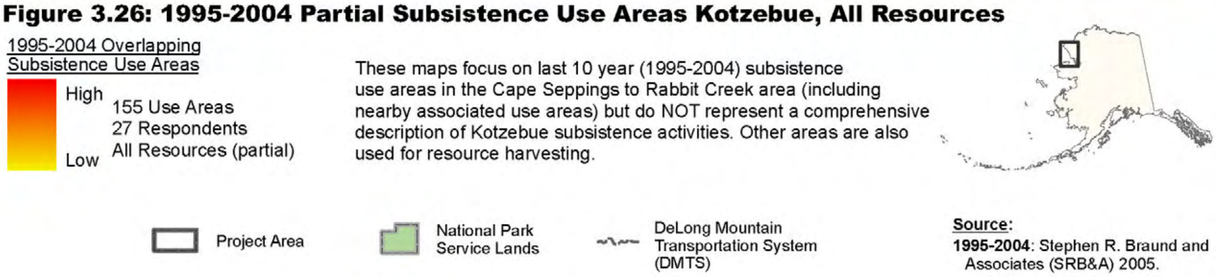


Figure 3.26: 1995-2004 Partial Subsistence Use Areas Kotzebue, All Resources



Noatak. Current Noatak use areas are depicted on Figure 3.25, which shows the last 10 year (1998–2007) use areas as reported by Noatak respondents in 2008 for all resources, as well as 2007 use areas gathered by ADF&G. The extent of Noatak lifetime use areas provided on Figure 3.23 is also shown on Figure 3.25 for comparison. Residents reported using an extensive area to pursue subsistence resources in the last 10 years, spanning north beyond the Red Dog Mine site and south to the southernmost waters of Kotzebue Sound. The use of two major hunting bases, one from Noatak and one from the seasonal camp at Sheshalik, is evident. In addition, residents travel to other communities, including Kivalina, Kotzebue, Point Hope, Noorvik, and Kiana, to participate in subsistence activities. The highest frequencies of overlapping use areas occur along the Noatak River; inland from the Noatak River, west to the DMTS road, and east to the hills that border the "Noatak Flats;" and in Kotzebue Sound, especially in the waters surrounding Sheshalik to Cape Krusenstern (Sealing Point). Uses in 2007 were similar to those reported for the 1998–2007 time period, although no use areas were reported for the southern portion of Kotzebue Sound or along the coast beyond Kivalina, and several use areas were reported in the Selawik vicinity that were not captured for the 1998–2007 time period (Figure 3.25). Compared to earlier subsistence use area data for Noatak (Figure 3.23), current use areas do not extend as far north as those lifetime use areas collected by Schroeder, Andersen & Hildreth (1987) prior to mine operations.

During SRB&A interviews in Noatak in 2008, elders and other subsistence users indicated that residents once traveled much farther north to trap furbearers and hunt caribou (SRB&A 2009). Residents stopped traveling as far north because the caribou herd began migrating closer to the community and such extensive travel was no longer necessary. Participation in trapping has also declined, and many of the historic traplines that ran north of the Noatak River are no longer in use. Despite this, a number of individuals continue to trap furbearers in areas closer to Noatak. Other factors that may affect residents' ability to travel farther for subsistence include increasingly high gas prices and other living expenses (such as heating oil), and less time for subsistence pursuits because of community-based employment responsibilities. A number of residents interviewed in 2008 indicated that gas prices have affected the frequency and duration of their subsistence activities.

Resource Change

The 1984 EIS (EPA 1984) addressed potential effects of the mine on subsistence uses, including increased harvest pressure and competition in the mine area and along the road from local and non-local mine employees, changes in resource distribution due to mining activities, a decline in or displacement of subsistence resource populations because of interference with fish and wildlife cycles (i.e., disturbance of winter caribou grazing at South Fork Red Dog Creek), displacement of caribou related to disturbance from the DMTS road, fewer opportunities to hunt and fish due to incompatible work schedules, and a decline in subsistence participation due to an increase in wage employment.

The 1984 EIS also discussed potential changes to subsistence resources resulting from mine operations. Potential effects to terrestrial mammals included habitat loss, mortality from mining activities, and attraction to mining facilities (see Section 3.9.2); effects to vegetation included loss of vegetation due to construction of facilities, traffic, and contamination related to dust and spills; and effects to fish included increased exposure to heavy metals (although the likelihood of this occurring was predicted to be low), increased sediment levels resulting from construction activities, and increased harvest pressure from mine employees (EPA 1984).

Direct and indirect effects on wildlife, vegetation, and aquatic resources resulting from mine operations to date are addressed in Sections 3.7.2, 3.9.2, and 3.10.2. Effects include direct habitat loss associated with construction of the Red Dog Mine, mine facilities, mine-related activities, and contamination from fugitive dust; wildlife disturbance due to mine-related noise and human activity; habituation of wildlife to mine facilities; wildlife mortality due to DMTS road traffic (resulting in 22 animal deaths between 1998 and 2007); and an increased presence of metals in tundra near the mine and along the DMTS road.

3.12.2.2 Land Mammals

Harvest Trends

Land mammals harvested by residents of the study communities include caribou, moose, bear, Dall sheep, muskox, and a variety of furbearers and small land mammals including wolf, wolverine, fox, and muskrat. Of these land mammals, caribou is harvested in the largest quantities by residents in each of the three study communities. Annual caribou harvests are subject to large variations in caribou distribution and hunting conditions, and therefore are themselves highly variable. As shown in Table 3.12-2, for example, per capita harvests of caribou by Kivalina harvesters were 209 pounds per capita in 1964–65 and 830 pounds per capita the next year, 1965–66. With just nine harvest observation years in the last 50 years it is difficult to conclusively discern a trend within this large interannual variation.

Caribou. ADF&G household studies documented Kivalina's 1992 and 2007 caribou subsistence harvests. Detailed harvest data for Kivalina are available in Tables 8 and 9 of Appendix D. Of the top 20 species harvested, caribou was the third greatest contributor to Kivalina's total harvest during both years (Appendix D: Table 9). Compared to earlier caribou harvest data, per capita caribou amounts have decreased from over 300 pounds per person in all but one study year in the 1960s, to 284 in 1983–84, to a low of 85 pounds in 2007 (Table 3.12-2). As noted above, harvest estimates based on samples of households are also subject to sampling error. The 95 percent confidence interval for 2007 caribou harvests in Kivalina is 60–100 pounds per capita. During household surveys in 2008, 29 percent of Kivalina households reported that they harvested fewer land animals in 2007 than in previous years, and 26 percent reported that they did not harvest enough land animals to meet their needs (Magdanz et al. 2008). Caribou availability may vary widely from year to year because of factors such as population and weather. Braund and Burnham's 1983 report on Kivalina and Noatak subsistence use patterns notes that caribou were not always available in the Kivalina area but, "As their numbers increased, local residents' use of caribou grew until it has now become firmly entrenched in the subsistence cycle of Kivalina and Noatak residents" (Braund and Burham 1983). Furthermore, the report states, "For at least the past five years, 1977–1982, a fair number of caribou have migrated through, and/or overwintered in, the Kivalina and Noatak hunting areas." Citing Peter Lent's *The Caribou of Northwestern Alaska* (Lent 1966), Braund and Burnham's report notes that the availability of caribou in the Kivalina area is related to the size of the caribou herd; when the caribou population is high, caribou are more available near Kivalina. Presently, the caribou population is healthy and in 2003, the size of the herd was the largest ever documented (see Section 3.9). Despite this, residents' observations, as well as steadily declining harvests of caribou since the 1980s, indicate a trend of decreasing availability. As discussed below under Caribou Resource Change, the observed value of 85 pounds per capita (lower than any pre-mine study year) of caribou harvested in 2007, coupled with local observations of displacement of caribou by DMTS road activity and reports of a healthy caribou herd with no overall migratory changes (see Section 3.9.2) support the conclusion that there has been a decrease in caribou harvest not explained by natural variations in caribou distribution and hunting conditions.

Kotzebue harvests of caribou have remained high, with residents harvesting between 636 and 1,046 mean household pounds during the study years of 1991, 2002, 2003, and 2004 (Appendix D: Table 10). Caribou constitute a large percentage of residents' yearly resource harvests, accounting for between 23 and 26.2 percent of the total harvest during each study year. Comparison of recent caribou harvest data to harvest data collected before mine operations began show little change in harvests or participation over time, although the per capita harvests in 1971–72 were much higher (Table 3.12-3). Per capita harvest amounts for caribou in 1986 are slightly lower than in recent years. The percentage of households attempting to harvest caribou rose from 50 percent in 1986 to 70 percent in 1991.

Caribou continues to be an important subsistence resource in Noatak, although harvests of caribou have declined since the 1990s. In 1994 and 1999, residents harvested 221 and 224 pounds of caribou per capita, respectively (Table 3.12-4). More recent studies in 2002 and 2007 show caribou providing approximately half the per capita amount observed in the 1990s, at 120 pounds in 2002 and 114 pounds in 2007. Older harvest data from 1960–61 show that caribou provided 762 pounds of caribou meat per capita that year (Table 3.12-4). During household surveys for the 2007 study year, 59 percent of Noatak residents reported that they harvested fewer land animals in 2007 than in previous years, and 43 percent of households reported that they did not harvest enough land animals that year. Of those responses, 83 percent pertained to caribou. In 39 percent of cases, residents attributed not getting enough land animals to a change in their abundance (Magdanz et al. 2008). Foote and Williamson's (1966) description of caribou hunting patterns from 1960 to 1961 suggest that caribou were widely available that year and in closer proximity to the village than in the past. Possible reasons for the recent decline in caribou harvests are discussed below (Land Mammal Resource Changes).

Moose. As discussed in Section 3.9.2, moose expanded to the project area in the 1950s and is thus a relatively new subsistence resource available to local hunters. Although not harvested in quantities comparable to caribou, residents of the three study communities harvest moose at varying degrees to support their subsistence diet throughout the year. Of the three communities, Kotzebue residents harvest the most moose per capita (see Tables 3.12-2 to 3.12-4). Although Kivalina's 2007 moose harvest amount decreased from 1992 harvest levels, moose has not historically been a major contributor to Kivalina's overall harvests, comprising between zero to 1.5 percent of the total harvest between 1964 and 1984 (Appendix D: Table 15). During interviews with local Noatak hunters, residents indicated that they prefer caribou and often only hunt moose when they are low on caribou meat. However, one individual reported that because of the scarcity of caribou in recent years, moose had become more important as a supplement to her family's diet (SRB&A 2009). Noatak per capita harvests of moose were higher in 2007 than in any other recent study year (1994, 1999, and 2002) (Table 3.12-4).

Other Large Land Mammals. Although local residents do not rely heavily on the harvests of other large land mammals (muskox, sheep, or bear) for subsistence, limited harvests of these resources continue and for a number of people these animals provide a desired and valued meat. In 2007, Kivalina households harvested two other large land mammals for a total contribution of less than one pound per person and 0.1 percent of the total harvest (Appendix D: Table 8). Residents of Kotzebue harvested other large land mammals during each recent study year, with harvests varying from four animals harvested in 2003 to 48 animals harvested in 1991 (Appendix D: Table 10). Noatak harvests of other large land mammals were higher in 2007 than during any other study year and provided three pounds per capita (Table 3.12-4). Residents harvested both black and brown bear, muskox, and Dall sheep (Magdanz et al. 2008).

Furbearers and Small Land Mammals. Participation in furbearer hunting and trapping declined since the 1960s and 1970s, when residents of Noatak, for example, harvested 1,354 and 1,329 animals, respectively (Appendix D: Table 5). Foote and Williamson (1966) reports that furbearer prices declined starting in the 1940s and, although locals were discouraged from participating in large scale trapping operations, Noatak residents still harvested 1,115 muskrat, 200 of which were eaten, and various other species of furbearing animals. Despite the decline in trapping activities, the use and harvest of furbearers and small land mammals remains important to many local residents. Thirty-one percent of Kivalina households reported using furbearer and small land mammal species in 2007, and 44 percent of households in 1992 (Appendix D: Table 8). Current Noatak harvests of furbearers and small land mammals are relatively low; however the most recent 2007 harvest data indicates an increase in residents' harvests of these resources. In 1994, 1999, and 2002, the number of furbearers and small land mammals harvested in Noatak ranged from 16 in 2002 to 41 in 1994 (Appendix D: Table 12). However, in 2007, 21 percent of households tried to harvest furbearers and small land mammals and successful harvests amounted to 91 animals. Comparing earlier Kotzebue furbearers/small land mammal data to current harvest data indicates that harvests of these resources have remained relatively stable over time (Table 3.12-3).

Subsistence Use Areas, Seasonal Round, and Harvest Patterns

Caribou. Figure 3.27 shows Kivalina's last 10-year (1998–2007) and 2007 caribou subsistence use areas, with the extent of lifetime use areas also shown. Residents reported an extensive use area from Cape Krusenstern to north of Point Hope, nearly as far as Cape Lisburne. Respondents search inland for caribou as far east as the Noatak River, and north into the DeLong Mountains. The highest number of overlapping use areas occur along the Kivalina and Wulik rivers, DMTS, and coastline from Rabbit Creek to Kisimilok Creek. During interviews in 2008, Kivalina harvesters identified only 21 percent of their caribou use areas as always successful, compared to 55 percent of always successful all resources use areas (SRB&A 2009). Conversely, only 16 percent of all resources use areas were described as unpredictable compared to 39 percent of caribou use areas. In the last 10 years (1998–2007) residents most often hunt for caribou during August and September, although hunting activities were reported year-round. Residents reported taking multiple trips to over 70 percent of their caribou use areas, and day trips (as opposed to overnight trips) to nearly 90 percent of their caribou use areas (SRB&A 2009). Thus, although harvests of caribou have declined, residents continue to put a notable amount of effort into hunting the resource. Not only do subsistence activities take time and effort, but they also require money for gasoline, supplies, and equipment repair. Residents note that hunting caribou has become increasingly difficult as the resource becomes less available and gas prices rise.

Direct comparisons of pre-mine Kivalina use areas with more recent use areas are difficult because of the difference in study time periods (i.e., lifetime versus 1998–2007), and thus only general observations are discussed. Subsistence use area studies for caribou show that many of the caribou use areas documented by Saario and Kessel (1966) and Braund and Burnham (1983) occur in the areas of highest overlap reported by Kivalina residents during SRB&A 2008 interviews. Kivalina residents' lifetime (ca. 1925–1986) caribou use areas extended farther to the north and east across the Noatak River than current (1998–2007) use areas. A few respondents reported last 10-year caribou use areas towards Point Hope that were previously undocumented in earlier pre-mine subsistence use area studies.

Current (1998–2007 and 2007) Noatak use areas for caribou are depicted on Figure 3.28. Caribou hunting in Noatak generally occurs from August until April, with residents' efforts intensifying in August and September, when they travel by boat along the local river system to harvest migrating caribou, and from January until March, when snowmachine conditions allow for more extensive overland hunting (SRB&A 2009). Last 10-year (1998–2007) caribou use areas extend from the mouth of the Noatak River to beyond Nimiuktuk River, although the highest number of river-based use areas occur between Nimiuktuk and Agashashok rivers. Winter use areas extend overland both west and east of the Noatak River, with the highest numbers of overlapping subsistence use areas reported between the DMTS road and Noatak River. Residents also reported hunting caribou in the last 10 years near Kotzebue, Buckland, and along the Kobuk River. When asked to describe their caribou hunting success over the last 10 years (1998–2007), residents' responses indicated that success has declined in recent years. While more than half of their hunting areas were described as always or usually successful, more than one-third were described as either unpredictable, seldom, or unsuccessful. In comparison, residents described only 20 percent of their all resources use areas as unpredictable, seldom, or unsuccessful (SRB&A 2009).

Pre-mine lifetime caribou use areas for Noatak, shown on Figure 3.28, are similar to current use areas but extend farther north. As discussed above (Section 3.12.2.1), residents of Noatak indicate that caribou have not always migrated through the Noatak area; several elders remembered a time when local hunters traveled beyond the Brooks Range to the north to harvest caribou (SRB&A 2009). Foote and Williamson documented this shift in use areas in their report on the Cape Thompson region, noting that caribou had recently returned to nearby lowlands and "few men therefore bothered to travel north of the Brooks Range (*Seeyaleenik*) for furs or meat" (Foote and Williamson 1966). It is possible that future changes in caribou distribution could result in local residents once again traveling farther north to harvest the resource.

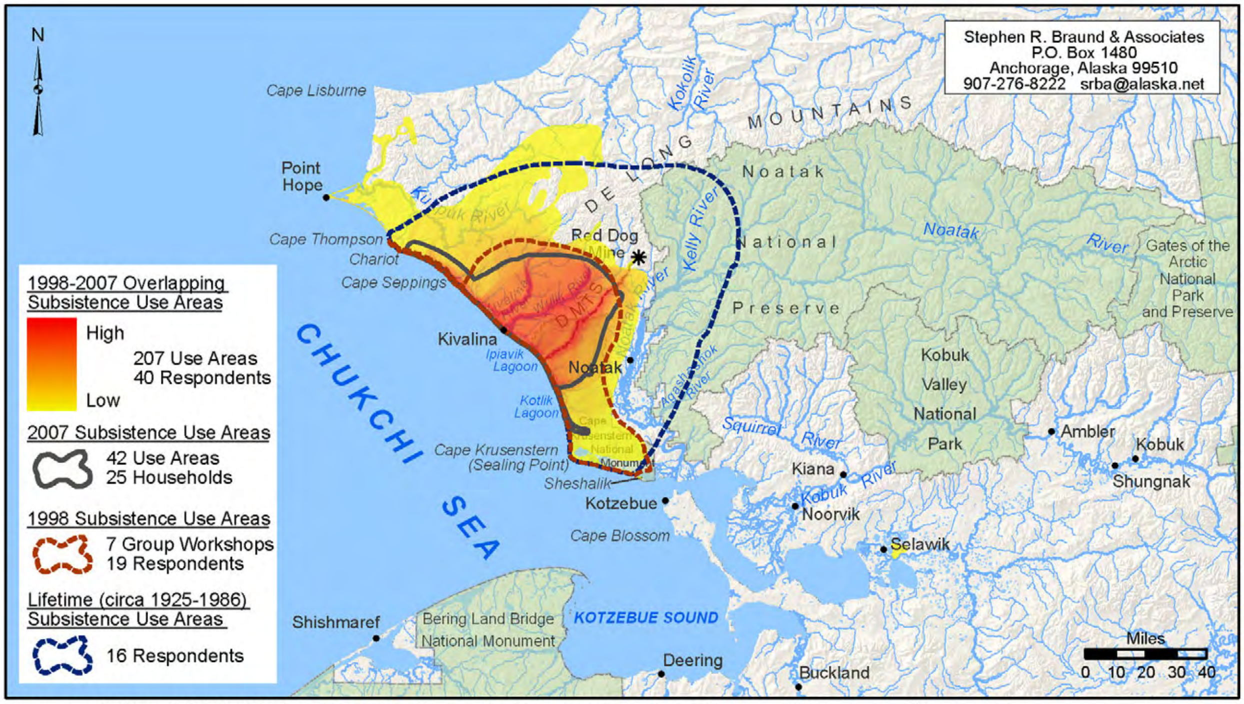


Figure 3.27: 1998-2007 and Lifetime Subsistence Use Areas Kivalina, Caribou

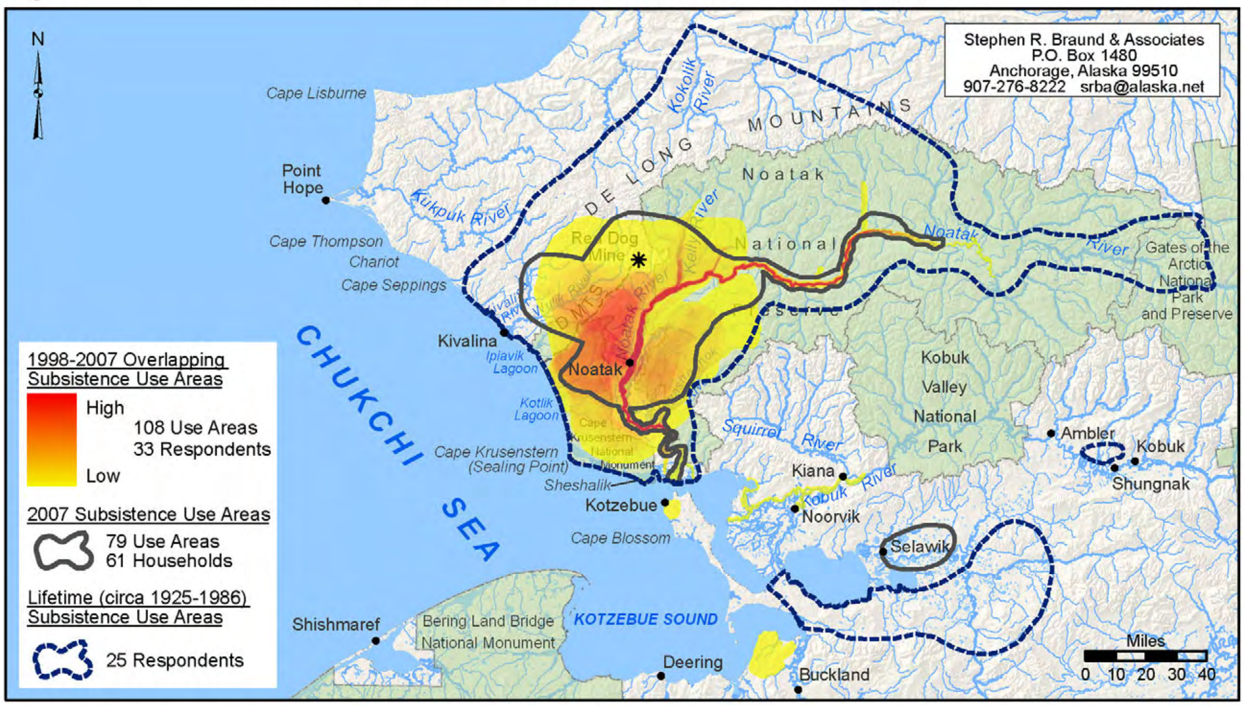


Figure 3.28: 1998-2007 and Lifetime Subsistence Use Areas Noatak, Caribou

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.
1998: SRB&A 2000.
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

For all data sets, other areas may have been used for resource harvesting.

Other Large Land Mammals. Maps for other land mammal resources (moose, bear, muskox, and sheep) are in Appendix D. The majority of Kivalina residents' moose hunting areas are located along the Kivalina and Wulik rivers, although a few use areas also occur along the coast, north and south of the community. Current last 10-year (1998–2007) moose hunting by Noatak residents occurs primarily along the Noatak River by boat. Noatak and Kivalina moose hunting areas have not changed much since mine operations began. Kivalina residents reported other land mammal subsistence use areas along the Kivalina and Wulik rivers, presumably for bear, and for Dall sheep farther inland near the DeLong Mountain foothills. Current (1998–2007) Noatak use areas for muskox, sheep, and bear have been reported both west and east of the Noatak River, with the highest number of overlapping use areas reported in the hills northeast of the community, between the Noatak and Eli rivers, where a number of respondents reported harvesting Dall sheep. Pre-mine lifetime Kivalina and Noatak use areas for bear and Dall sheep are more extensive than current use areas, although use areas for more limited time periods, such as Braund and Burnham's 1977–1982 study, show land mammal hunting in similar or smaller areas.

Furbearers and Small Land Mammals. Current Kivalina furbearer and small land mammal use areas extend from Point Hope to Cape Krusenstern, as far east as the Noatak River and northeast beyond the DeLong Mountains into the Brooks Range. Earlier use area data indicate that Kivalina furbearer and small land mammal use areas have changed minimally; while lifetime use areas are not located as far north or northwest as current use areas, they do extend farther east, to locations east of the Noatak River. Current (1998–2007) Noatak furbearer and small land mammal use areas, including hunting and trapping areas, extend over a large area from Kivalina inland beyond the Red Dog Mine site, in the mountains east and west of the Noatak River, and south to the mouth of Noatak River. Compared to lifetime pre-mine use areas, current Noatak furbearer use areas are similar but substantially smaller, in that residents do not travel as far north or east as they once did. As discussed in Section 3.12.2.1, trapping is no longer as prevalent in Noatak as it once was because of a decline in fur prices beginning in the 1940s and 1950s (Foote and Williamson 1966), and although residents continue to trap and hunt furbearers, it is no longer economically viable to travel such extensive distances in pursuit of this resource. It is possible that residents may return to these traditional areas if there is a rise in fur prices or resurgence in trapping by local residents.

Land Mammal Resource Changes

Of the land mammals discussed in this section, residents' harvests and uses of caribou are most likely to be affected by Red Dog Mine activities. However, some isolated effects have also occurred related to other land mammals. Moose are found in the vicinity of the Red Dog Mine, including near Red Dog Creek, Ikalukrok Creek, and the Wulik River. Impacts to moose to date include displacement due to mine related noise and activity. However, no impacts on the overall population have occurred or are expected to occur in relation to the Red Dog Mine (see Section 3.9.2). A limited number of Kivalina and Noatak residents discussed changes in moose over the last 20 years, and these are discussed in further detail in Appendix D. Research to date has not identified any major changes to other large land mammals resulting from Red Dog Mine activities. Muskoxen and Dall sheep do not regularly occur in the mine area, although sightings of muskoxen have been reported near the mine. The brown bear population experienced a minor loss of winter denning habitat due to construction of the mine, and one den disturbance has been reported. Bears are sometimes found at the mine site, and mine personnel have used hazing to encourage bears to leave the area. No injuries were reported to occur because of these activities. No substantial impact to bears resulting from the Red Dog Mine has occurred or is expected to occur (see Section 3.9.2). Residents' observations regarding changes in other large land mammals were related primarily to an increase in bear over the last 20 years; their observations are discussed in Appendix D.

Section 3.9.2 provides descriptions of baseline conditions for various species of furbearers and small land mammals, including wolf, wolverine, fox, river otter, beaver, and ground squirrels. Many of these species occur near mine, road, and port site facilities. Effects on furbearers and small land mammals include changes in prey availability, mortality due to collisions on the DMTS road, attraction to mine facilities (in the case of red foxes), and disturbance due to mine related activities. The species most likely to be affected by mine activities is the wolverine, because of its sensitivity to human and development related activities. However, overall population impacts to any individual species are unlikely because of the broad range of habitat (see Section 3.9.2). The 1984 EIS addressed potential impacts to small mammals and predicted that habitat loss resulting from construction activities would be minimal and localized, and small mammals would likely adapt to the presence of mine related facilities (EPA 1984). Noatak and Kivalina residents interviewed in 2008 reported various changes in furbearers and small land mammals over the previous 20 years. Residents' observations regarding the causes of these changes did not pertain to the Red Dog Mine and are discussed in further detail in Appendix D.

Caribou Resource Change. Studies on the WAH have addressed effects related to the Red Dog Mine since operations began (see Section 3.9.2). Caribou have experienced a small loss of winter habitat resulting from the construction of the mine, although this has not had an effect on the resource because of the broad expanse of wintering grounds available to the herd. Traffic along the DMTS road was found to cause "limited, localized" effects on caribou movement and distribution, and nine caribou fatalities have occurred as a result of traffic collisions. Given the currently healthy population of the WAH, these fatalities have had no effect on overall population numbers. The conclusions presented in Section 3.9.2.2 include the following statement: "Based on these data, Dau (2005) concluded that the mine and port facilities have only had limited localized effects on caribou movement and distribution." Based on the experiences of Kivalina active hunters, localized effects of truck traffic on caribou movements near the DMTS have affected caribou hunting success.

According to the experiences of subsistence users in northwest Alaska and the North Slope, while the overall patterns or abundance of a resource may not be affected by development activities, localized changes in resource movement can affect their availability and predictability to subsistence users who hunt in only a portion of the entire range of the resource. Therefore, although changes in caribou related to the Red Dog Mine from a biological standpoint may be viewed as minimal, resulting effects of localized changes in resources on subsistence uses are more obvious. Because residents rely on only a portion of the expansive WAH range to harvest caribou, small changes in caribou availability can have large effects on subsistence uses. Subsistence users in the study communities have observed various changes in caribou since mine operations began, citing both mine related and other causes.

During SRB&A fieldwork in 2008, respondents from Kivalina and Noatak were asked to share their observations regarding changes in subsistence resources. Residents' observations regarding changes in caribou are compiled in Table 3.12-5. Eighty-four percent of the 44 harvesters interviewed in Kivalina and 83 percent of the 42 harvesters interviewed in Noatak made observations of changes in caribou (see Table 3.12-1). The principal caribou resource changes observed are (1) migration changed or diverted; (2) harvest less; (3) resource smaller/skinnier; (4) disease/infection; and (5) resource in smaller groups. These changes are discussed in further detail in the following pages.

Twenty-seven percent of Kivalina caribou change observations and 23 percent of Noatak caribou change observations concerned a change in migration or distribution of caribou (Table 3.12-5). Table 3.12-6 shows the reported causes of changes in migration/distribution. Forty-six percent of Kivalina observations related to caribou migration/distribution cite that the DMTS or road traffic have caused the change compared with only 12 percent of Noatak observations (Table 3.12-6).

Table 3.12-5 Observations of Caribou Resource Changes

Observation	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Migration Changed or Diverted	29	30	59	27%	23%	25%
Harvest Less	10	11	21	9%	8%	9%
Resource Smaller/Skinnier	8	9	17	7%	7%	7%
Disease/Infection	6	8	14	6%	6%	6%
Resource in Smaller Groups	6	5	11	6%	4%	5%
More Difficult	1	8	9	1%	6%	4%
Worse Success	1	8	9	1%	6%	4%
Abnormal Resource Death	9	0	9	8%	0%	4%
Increase in Species Number	6	1	7	6%	1%	3%
Decrease in Species Number	2	4	6	2%	3%	3%
Further from Village	3	3	6	3%	2%	3%
Move to Different Areas	1	5	6	1%	4%	3%
Habitat Disturbed/Destroyed	1	4	5	1%	3%	2%
Declining/Damaged Feeding Habitat	4	1	5	4%	1%	2%
Change in Texture of Meat	5	0	5	5%	0%	2%
Closer to Village	0	5	5	0%	4%	2%
Later Migration/Arrival	0	5	5	0%	4%	2%
Harvest Resource Closer to Community	0	4	4	0%	3%	2%
Use Area Changed	0	4	4	0%	3%	2%
Sharing Less	3	0	3	3%	0%	1%
Change in Habitat Location	1	2	3	1%	2%	1%
Take Fewer Trips	2	0	2	2%	0%	1%
Take Shorter Trips	1	1	2	1%	1%	1%
Harvest Season Changed	0	2	2	0%	2%	1%
Habitat Changed	2	0	2	2%	0%	1%
Change in Resource Behavior	0	2	2	0%	2%	1%
Contamination	1	1	2	1%	1%	1%
Farther from Riversides/Farther Inland	0	2	2	0%	2%	1%
Take Longer Trips	0	1	1	0%	1%	0%
Use Less	0	1	1	0%	1%	0%
Travel Farther to Harvest Resource	1	0	1	1%	0%	0%
Less Difficult	1	0	1	1%	0%	0%
Dust on Vegetation	0	1	1	0%	1%	0%
Increase in Resource Size	0	1	1	0%	1%	0%
Resource Injury	0	1	1	0%	1%	0%
Resource Appears Unhealthy	1	0	1	1%	0%	0%
Earlier Migration/Arrival	0	1	1	0%	1%	0%
Abnormal Migratory Event	1	0	1	1%	0%	0%
Timing of Migration	1	0	1	1%	0%	0%
Taste	1	0	1	1%	0%	0%
Total Observations	108	131	239	100%	100%	100%
Total Number of Caribou Change Observers	37	35	72	N/A	N/A	N/A
Total Number of Community Respondents	44	42	86	N/A	N/A	N/A

SRB&A 2008

N/A = not applicable

Table 3.12-6 Reasons for Change in Caribou – Migration Changed or Diverted

Cause	Number of Causes Mentioned			Percent of Causes Mentioned		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Sport Hunting Methods Disturbing Migration Routes	4	13	17	9%	30%	20%
Traffic along DMTS Road	13	2	15	30%	5%	17%
DMTS	7	3	10	16%	7%	11%
Change in Food Availability	3	5	8	7%	11%	9%
I Do Not Know	6	1	7	14%	2%	8%
Airplane Traffic Disturbance	0	6	6	0%	14%	7%
Boat Traffic Disturbance	0	5	5	0%	11%	6%
Disturbance	2	2	4	5%	5%	5%
Predators	3	1	4	7%	2%	5%
Mining Activities	2	1	3	5%	2%	3%
Traffic Disturbance	0	2	2	0%	5%	2%
Wildfires	0	1	1	0%	2%	1%
Habitat Disturbed/Destroyed	0	1	1	0%	2%	1%
Declining/Damaged Feeding	1	0	1	2%	0%	1%
Contact/Merging with Other Herds	1	0	1	2%	0%	1%
Noise Related to Mining Activities	1	0	1	2%	0%	1%
Dust from Mining Activities	0	1	1	0%	2%	1%
Total	43	44	87	100%	100%	100%
All Mine Related Causes	23	7	30	53%	16%	34%

SRB&A 2008

Forty-four percent of Noatak observations related to a change in caribou migration/distribution indicate that sport hunting methods, including disturbance by airplanes, are responsible while only 9 percent of Kivalina caribou change observations cite these reasons for the change in migration or distribution of caribou. In addition, 11 percent of Noatak and 7 percent of Kivalina caribou change observations cite a change in caribou food availability as a cause of the change in caribou migration/distribution.

The 1984 EIS did not predict an overall change in caribou movement due to the DMTS road, but it substantially underestimated levels of traffic (see Section 3.9.2). Furthermore, the National Research Council's (NRC) study on the cumulative effects of North Slope oil and gas activities reported that caribou have been found to avoid roads and other structures, and noted, "The presence of a road or pipeline alone, without vehicular or human activity, can elicit avoidance" (NRC 2003). Hunters from Kivalina, Noatak, and Kotzebue have reported changes in caribou movement during multiple studies, indicating that the caribou sometimes follow the road rather than cross it directly (SRB&A 2005), or that traffic along the DMTS road, including all-terrain vehicle traffic from young local hunters, disrupts caribou movements and diverts them farther from local hunting grounds (SRB&A 2000 and 2005; Corps 2005). Long-term monitoring of satellite-collared caribou from the WAH illustrate the migratory movement patterns of the WAH and indicate that caribou periodically cross the DMTS, though these movements are both seasonally and annually variable (Dau 2005; Lawhead 2008). According to Jim Dau, an ADF&G biologist, to date the operation of the mine, road, and port site have had a limited, localized effect on caribou movement and distribution (Dau 2005). As described in SRB&A (2000), residents indicated that caribou traditionally cross the Noatak River from the east near Noatak in the fall; once they have been informed of their crossing, residents in Kivalina expect the arrival of caribou within a couple of weeks. In more recent years, however, hunters observe that once caribou reach the road, they are diverted inland toward the mountains and only a few stragglers cross the road and reach the flats east of Kivalina where hunters have traditionally harvested them. One Kivalina hunter described changes in caribou related to the DMTS road as follows:

> Our caribou are not migrating through as much as when they first built that road. There used to be thousands and thousands of caribou that come through here and to Kivalina, and I notice the caribou are always coming up through this side [south of road], and going up toward Atqasuk and Nuiqsut and Kaktovik. A few would cross, but most go up behind the mine and head up that way. The first year they built this road, that is when everything changed...Even right now. I would say it's all because of this road and trucks coming up and down too much (SRB&A Kivalina Interview January 2008).

Residents from Noatak and Kotzebue have made similar observations regarding changes due to the DMTS road (SRB&A 2005, 2009), while others believe the mine road has had little effect, or that the caribou have now acclimated to the presence of the road (SRB&A 2005). SRB&A 2008 interviews in Noatak indicate that a major current concern to residents is related to the effect of sport hunting activities on caribou distribution and migration:

> Usually, the [caribou hunting] success is further up. The areas where we usually wait for [the caribou,] they're not as heavy as before. Further up it seems like they're always on the mountainsides, up on the hills. We harvested just a real small amount this fall, and then they sent a guy to find where the big herd was, and they were way up there in their calving area still, way far away. And then later we heard that they were crossing the road, but they went further down, to Kotzebue area. We see a lot of planes up there, a lot of planes flying really low. We have an agreement that the planes are not supposed to fly a certain distance from the river and have to stay higher, but they don't listen (SRB&A Noatak Interview January 2008).

Other factors described by residents of the study communities as affecting caribou migration and distribution include the availability of lichen, increased recreational activity, changes in hunting methods, and pressure from wolves (SRB&A 2000, 2005, 2009; COE 2005).

Nine percent of Kivalina caribou change observations and 8 percent of Noatak caribou change observations cite harvesting less caribou (Table 3.12-5). An additional 12 percent of Noatak observations regarding changes in caribou cite increased difficulty hunting and worse success. Seventy-three percent of Kivalina caribou observations and 33 percent of Noatak observations citing decreased harvests attribute the decline in harvest amounts to a change in caribou migration (Table 3.12-7) (see discussion above, under "Migration/Distribution").

Table 3.12-7 Reasons for Change in Caribou – Harvest Less

Causes	Number of Causes Mentioned			Percent of Causes Mentioned		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Migration Changed or Diverted	8	6	14	73%	33%	48%
Employment/Lack of Time	1	2	3	9%	11%	10%
Decrease in Species Abundance	1	2	3	9%	11%	10%
Later Migration/Arrival	0	3	3	0%	17%	10%
Personal Reasons	1	1	2	9%	6%	7%
Change in Subsistence Dependents	0	2	2	0%	11%	7%
Change in Resource Availability	0	1	1	0%	6%	3%
Farther from Riversides/Farther Inland	0	1	1	0%	6%	3%
Total	11	18	29	100%	100%	100%

SRB&A 2008

Residents generally indicated that the amount of caribou harvested had changed because caribou are less available and harder to find, primarily because of changes in their migratory patterns. A hunter from Kivalina summarized this view saying:

> [The] success rate has gone down significantly. Before, it was always, especially those times of year, especially in this area, Wulik River, you always got some. Especially October. Quite a few times up in here [Wulik] five miles...In the beginning [right after the road was built] our success was less, but to put food on the table we had to go further. The road has quite a bit to do with it. The patterns have changed considerably (SRB&A Kivalina Interview January 2008).

In Noatak, six of the 11 individuals who reported harvesting fewer caribou indicated that the change started in 2004 or later, and six reported the change in migration/distribution to be a main cause of the decline (SRB&A 2009). In Kivalina, seven of 10 individuals who reported harvesting fewer caribou said that the change started in 2005, and eight individuals indicated that a change in migration/distribution was the main reason for the decreased harvests. SRB&A's 2000 and 2005 reports include few observations of changes in use, indicating that decreased harvests in Kivalina and Noatak may be a relatively new phenomenon. However, Tables 3.12-2 and 3.12-4 indicate that caribou harvests have been declining since the 1990s. The 1984 EIS addressed the potential that there would be a decline in subsistence participation due to an increase in wage employment, or that incompatible work schedules would affect subsistence activities. Three individuals in Noatak and Kivalina reported harvesting fewer caribou resulting from employment responsibilities or lack of time, two respondents cited personal reasons for a decreased harvest, and two indicated that they harvested fewer caribou because of fewer household dependents. The remaining causes cited by Noatak and Kivalina respondents were related to outside factors, such as changes in the migration, distribution, and abundance of caribou. Thus, based on the SRB&A 2008 interviews, mine employment has not had a substantial impact on residents' participation in subsistence activities, although some individuals reported having less time to hunt because of employment associated with the Red Dog Mine. As discussed in Section 3.17, Socioeconomics, employment at the Red Dog Mine may have resulted in residents relocating from NWAB communities to Anchorage. Data show that 20 Kotzebue residents, three Kivalina residents, and two Noatak residents, who were employees of Red Dog Mine, moved outside of the NWAB (presumably to Anchorage) (see Table 3.17-21). It is possible that emigration of local residents, if they are subsistence providers, could have an effect on overall community harvests.

Eight (of 44) Kivalina respondents and nine (of 42) Noatak respondents observed that caribou are smaller or skinnier (Table 3.12-5). Thirty-three percent of those residents citing a decrease in size of caribou did not know why the change has occurred (Table 3.12-8). Residents mentioned climate change, various types of disturbance, changes in feed, and contamination as reasons for the decrease in size. No single cause was cited more than twice. Noatak residents made similar comments regarding the decreasing size of caribou during interviews in 2005 (SRB&A 2005).

Six percent of Kivalina observations of caribou change and 6 percent of Noatak observations of caribou change cited increased disease or infection among caribou (Table 3.12-5). Furthermore, 4 percent of caribou change observations were related to abnormal resource deaths. Fifty percent of the Kivalina observations and 75 percent of the Noatak observations of increased disease/infection among caribou did not know the cause of the change (Table 3.12-9). Four observations cited contamination related to Red Dog Mine. During interviews in 2008, one Noatak hunter described his observations regarding changes in the health of caribou:

> You start noticing these big growths on them, big water sacs, like they're sick. We went up to this one caribou. Nice looking, in the water, got him out and big blotches on him. [It started happening] within the past 10 years. Not only down there, but further up the river, where people shoot them and just cut the guts out. They shot that caribou and it was not good. One thing I

> really noticed, whenever we skin the caribou and cut the joints off, it's always yellow. Not like before. The following year, we started seeing some pus in them. When you cut the joints, water comes off and now it's yellow. It started with the yellow, then they started getting the pussy stuff, and nowadays you see growths all over. Not all caribou are like that. Maybe one in 100 are like that. Every herd, there's one like that. [There were] three reported this year (SRB&A Noatak Interview January 2008).

Table 3.12-8 Reasons for Change in Caribou – Resource Smaller/Skinnier

Causes	Number of Causes Mentioned			Percent of Causes Mentioned		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
I Do Not Know	4	3	7	40%	27%	33%
Climate	0	2	2	0%	18%	10%
Disturbance	2	0	2	20%	0%	10%
Airplane Traffic Disturbance	0	2	2	0%	18%	10%
Declining/Damaged Feeding Habitat	2	0	2	20%	0%	10%
Predators	0	2	2	0%	18%	10%
Traffic along DMTS Road	2	0	2	20%	0%	10%
Change in Feeding	0	1	1	0%	9%	5%
Contaminated by Ore Dust from Trucks	0	1	1	0%	9%	5%
Total	10	11	21	100%	100%	100%
All Mine Related Causes	2	1	3	20%	9%	14%

SRB&A 2008

Table 3.12-9 Reasons for Change in Caribou – Increased Disease/Infection

Causes	Number of Causes Mentioned			Percent of Causes Mentioned		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
I Do Not Know	3	6	9	50%	75%	64%
Contaminated by Ore Dust from Trucks	2	1	3	33%	13%	21%
Contamination Due to Mining Activities	1	0	1	17%	0%	7%
Increase in Species Number	0	1	1	0%	13%	7%
Total	6	8	14	100%	100%	100%
All Mine Related Causes	3	1	4	50%	13%	29%

SRB&A 2008

Five of the nine observations noting abnormal deaths did not give a reason; two observations cited ice blocking access to food and two cited contamination as possible reasons (SRB&A 2009). Residents of all study communities have cited concerns about the possible contamination of caribou due to mine activities, particularly when they see caribou feeding near the road where dust has contaminated the tundra. Several studies have been conducted to determine the effects of mine activities on caribou health (see Section 3.9.2). Tissue sampling of caribou in the mine area determined that the mine did not affect caribou health and a 2007 DMTS risk assessment reported that there was a low risk of contamination from consumption of caribou (Section 3.9.2). However, a number of residents have reported that they no longer hunt in certain areas, such as along the DMTS road, resulting from concerns of contamination. In some cases, hearing someone talk about potential contamination led to that respondent avoiding a certain area. Thus, fear of contamination or perceived contamination due to mine activities has affected subsistence for some local hunters.

Six percent of Kivalina observations of caribou change and 4 percent of Noatak observations of caribou change were that caribou tend to be in smaller groups (Table 3.12-5). Eighty-four percent of observations cited in Kivalina and 43 percent of observations in Noatak attribute it to the DMTS, traffic on the DMTS road, or mining activities (Table 3.12-10). Residents reported that the diversion of caribou from the DMTS road and noise related to mining activities causes the caribou to scatter, resulting in smaller groups of caribou rather than large herds. Noatak residents also attributed the change to caribou being chased by predators as well as disturbance from traffic not related to the mine (i.e., boats and airplanes).

Table 3.12-10 Reasons for Change in Caribou – Resource in Smaller Groups

Causes	Number of Causes Mentioned			Percent of Causes Mentioned		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
DMTS	5	2	7	42%	29%	37%
Traffic along DMTS Road	3	1	4	25%	14%	21%
Disturbance	2	0	2	17%	0%	11%
Traffic Disturbance	0	2	2	0%	29%	11%
Mining Activities	2	0	2	17%	0%	11%
Predators	0	1	1	0%	14%	5%
Change in Food Availability	0	1	1	0%	14%	5%
Total	12	7	19	100%	100%	100%
All Mine Related Causes	10	3	13	83%	43%	68%

SRB&A 2008

3.12.2.3 Marine Mammals

Harvest Trends

Residents of the three study communities harvest various species of marine mammals, including bowhead whales, beluga whales, bearded seal, ringed seal, spotted seal, walrus, and polar bear. Of the three study communities, Kivalina is the only one recognized by the Alaska Eskimo Whaling Commission as a bowhead whaling community. However, some residents of Noatak and Kotzebue travel to other communities, such as Kivalina and Point Hope, to participate on whaling crews, bringing the meat and *maktak* back to share with local households. Beluga whales and bearded seal are the most commonly harvested marine mammal resources among the study communities, although harvests of beluga whales have declined over time.

Beluga. Beluga hunting is common among residents of Kivalina, Kotzebue, and Noatak; however the timing, location, and methods associated with these hunts are different. Residents of Kivalina hunt beluga during two separate seasons. Two distinct stocks of beluga migrate past Kivalina; the Beaufort Sea stock migrates north during April and May, while the Eastern Chukchi Sea stock migrates north past the community during July (see Section 3.9.2). Kivalina whaling crews first harvest the beluga in open leads during their spring migration in April and May. Later in July, community members harvest Eastern Chukchi Sea beluga stock in open water as they follow the coastline on their migration north. Kotzebue and Noatak residents hunt beluga in Kotzebue Sound and along the Chukchi Sea coast in the late spring (June) and summer in open water as the beluga migrate north.

As shown in Table 3.12-2, Kivalina beluga harvests expressed as usable pounds per capita vary widely by year: 96 (1959–60), 48 (1960–61), 53 (1964–65), 107 (1965–66), 53 (1971–72), 159 (1982–83), 166 (1983–84), 29 (1992), and 51 (2007). Burch (1985:54) explains that the increase in beluga harvests in 1982–83 and 1983–84 compared to earlier study years was in large part due to the addition of a second beluga hunting season in conjunction with resumption of spring bowhead whale hunting after 1966 and the corresponding greater number of Beaufort Sea beluga harvested during the spring migration. During those two years, 50 of the 58 beluga taken were harvested during the spring migration. Prior to 1966, residents harvested beluga primarily in July (Burch 1985:53). In 1971–72, however, the harvest of 53 pounds per capita was similar to that of the two 1960 observation years, indicating the importance of interannual variability in hunting conditions.

Of the 22 belugas harvested by Kivalina residents in 2007, 18 were harvested during the summer (Table 3.12-11). Ten beluga were harvested in 1992, all during the spring (Table 3.12-11). Summer beluga harvests during the 1960s and in 1982–83 and 1983–84 ranged from six beluga in 1964–65 to 14 in 1959–60. Compared to the 2007 summer catch these numbers show little change. However, many Kivalina residents explained that the 2007 summer harvest of beluga was unusually high compared to recent years, and that prior to 2007, residents had experienced difficulty harvesting belugas during the summer. They also explained that the 2007 beluga that were harvested in the summer came from the north, and respondents continued to maintain that the port site was an ongoing cause for the displacement of beluga from Kivalina. As shown in Table 3.12-11, zero summer belugas were harvested between 2003 and 2006. Aside from the 18 summer belugas harvested in 2007 and a harvest of three summer belugas in 2002, Kivalina residents have not harvested more than one beluga during any summer since 1982–83. Figure 3.29 shows Kivalina spring and summer beluga harvests since 1955. Data are not available for every year. This figure suggests that residents began focusing on the spring beluga hunt after its resumption in 1966. However, an overall decline in spring beluga harvests beginning in 1987 did not result in residents harvesting more during the summer, despite reported efforts to do so. Thus, summer beluga harvests have declined and remained low regardless of their success during the spring hunt. As indicated by the harvest of 18 belugas in the summer of 2007, residents will harvest substantial numbers of beluga during the summer months when they are available, and the decline in harvests is not due to a lessened desire for this resource. Further explanation of residents' observations regarding the displacement of beluga and other changes are discussed below ("Marine Mammal Resource Changes").

Current beluga harvest data for Kotzebue indicate that beluga harvests have remained relatively the same since the first baseline study in 1991 when residents harvested 11 belugas, contributing to 0.5 percent of the community's total harvest that year. Compared to pre-mine studies, harvests of beluga have declined. Changes in beluga availability for Noatak residents (who generally hunt the resource from Sheshalik) are discussed below ("Beluga Resource Changes").

Noatak harvests and uses of beluga in 2007 were high compared to previous recent harvest data from 1994 (Table 3.12-12). It was an unusual year, according to residents interviewed in 2008. Whereas beluga harvests have declined in Kotzebue Sound due to changes in beluga distribution and availability (see discussion under "Marine Mammal Resource Changes"), residents of Kotzebue and Noatak were surprised when a large pod of beluga whales appeared near Kotzebue in the spring of 2007. Residents of Noatak who were staying at Sheshalik and residents of Kotzebue were able to harvest belugas from this pod of whales. Four percent of Noatak households harvested six whales in 2007, and beluga products were distributed among 81 percent of households (Appendix D: Table 12). In 1994, three belugas were harvested by six percent of Noatak households and only 18 percent of households used the resource that year. Table 3.12-4 shows combined beluga harvest data for Kotzebue and Noatak residents from 1987 to 2007. Only harvests from the Chukchi Sea (summer stock) are shown. Over time, harvests of beluga by residents of Kotzebue and Noatak have varied widely. However, the data indicate a decline in beluga harvests over the last 10 years. Noatak beluga harvest data from the 1960s and 1970s show Noatak residents harvesting substantially more belugas during those times (Table 3.12-4). From 1960–61, residents harvested 195 pounds of usable beluga products per capita, and in 1971–72, residents harvested 34 pounds per capita. Figure 3.30 indicates that, despite two peak harvest years in 1996 and 2007, harvests of beluga by residents of Kotzebue and Noatak have been somewhat lower since 1990. Noatak residents hunt belugas both in Kotzebue Sound and with Kivalina residents during the spring and summer hunts. Explanations of changes in beluga migration, distribution, and availability in both the Kotzebue Sound and Kivalina areas are discussed below ("Beluga Whale Resource Changes").

Table 3.12-11 Kivalina Beluga Harvest Amounts

Subsistence Year	Spring (Beaufort Sea) Stock	Mixed Stock	Summer (Eastern Chukchi) Stock
1955	—	—	6 [a]
1956	—	—	6 [a]
1958	—	—	16 [a]
1959	—	—	14 [a]
1960	—	—	7 [a]
1964–65	—	—	6 [a]
1965–66	7	—	5
1971–72	—	10 [b]	—
1982–83	23	—	4
1983–84	27	—	1
1987	4	—	0
1988	5	—	1
1989	0	—	0
1990	0	—	1
1991	0	—	1
1992	10	—	0
1993	3	—	0
1994	3	—	0
1995	3	—	0
1996	7	—	0
1997	0	—	1
1998	0	—	0
1999	1	—	0
2000	43	—	1
2001	0	—	0
2002	0	—	3
2003	0	—	0
2004	1	—	0
2005	2	—	0
2006	0	—	0
2007	4	—	18

[a] Kivalina residents harvested only summer stock beluga whales until 1966
[b] The majority of these whales were harvested from the spring stock

— = data not available
Sources: ABWC 2008; Burch 1985; Frost and Suydam (In prep); Patterson 1974; Saario and Kessel 1966

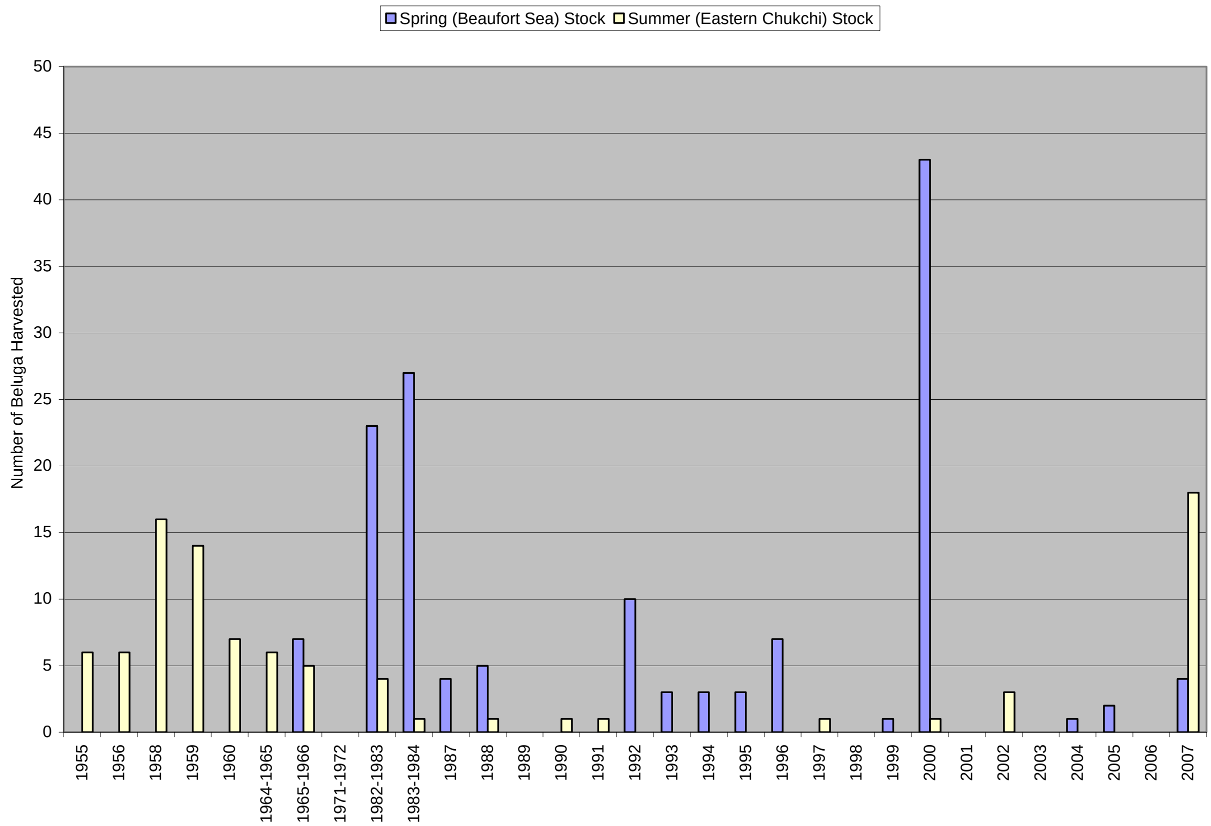


Figure 3.29 Kivalina Beluga Harvests by Stock

Table 3.12-12 Kotzebue and Noatak Beluga Harvests, 1987—2007, Chukchi Sea Stock

Year	# of Beluga Harvested
~1960	50
1977	3
1978	5
1979	2
1980	13
1981	4
1982	25
1983	19
1984	31
1985	2
1986	6
1987	22
1988	8
1989	37
1990	6
1991	11

Year	# of Beluga Harvested
1992	5
1993	6
1994	7
1995	4
1996	68
1997	7
1998	4
1999	2
2000	0
2001	9
2002	4
2003	0
2004	1
2005	1
2006	2
2007	69

Sources: ABWC 2008; Frost and Suydam (In prep) SRB&A 2008

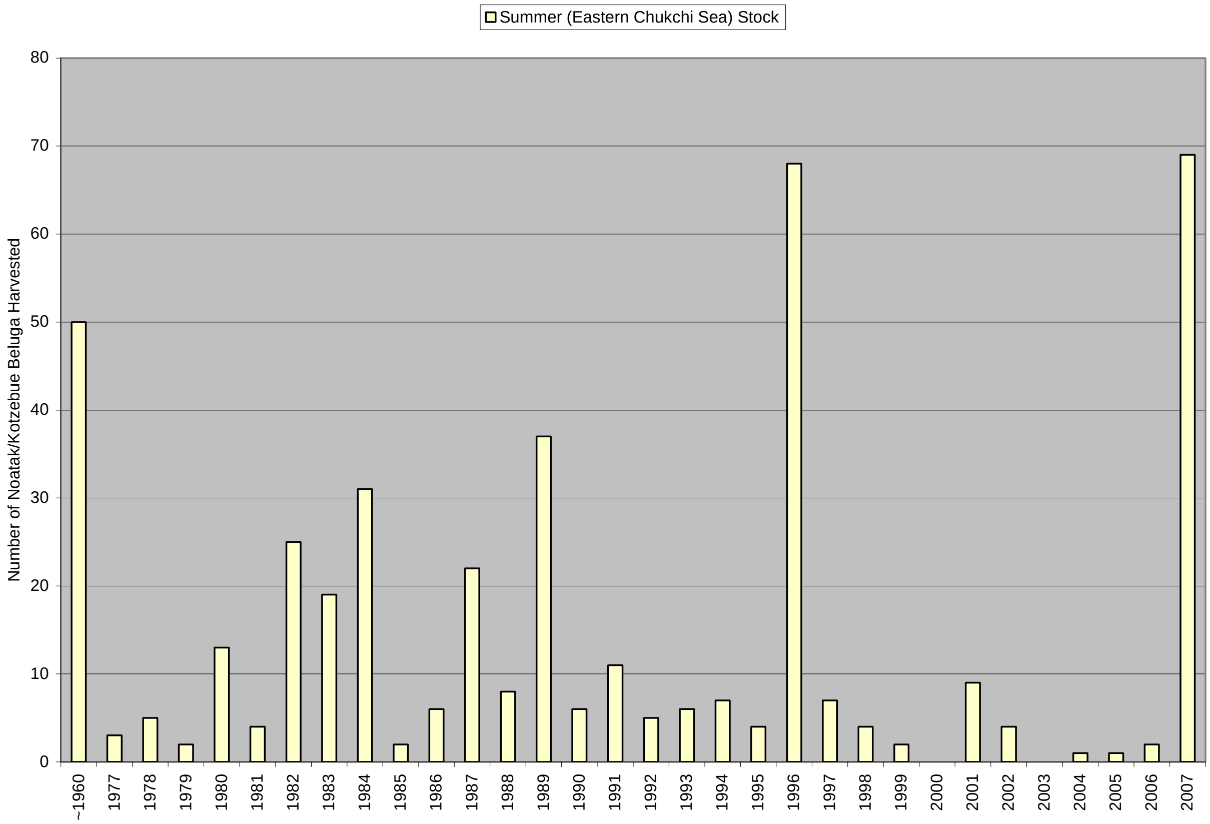


Figure 3.30 Kotzebue and Noatak Beluga Harvests

Bearded Seal. Another key marine mammal resource for residents in the study communities is bearded seal (*ugruk*). Kivalina households' estimated 2007 harvest of bearded seal contributed 224 pounds per capita toward their total per capita harvest of 594 pounds (Table 3.12-2). Current bearded seal harvests, at 224 and 157 pounds per person in 2007 and 1992, fall within the range of bearded seal per capita harvests (74 to 339 pounds) reported for previous study years. Bearded seal is one of the three most harvested resources, in terms of the percent of total harvest, by Kotzebue residents (Appendix D: Table 11). Kotzebue bearded seal harvests have not changed considerably from earlier harvest data. However, mean household pounds of bearded seal in 1986 were lower than in more recent study years. In Noatak, harvests of bearded seal contributed 47 pounds per capita in 2007 and 37 pounds per capita in 1994 (Table 3.12-4). Reported harvests of bearded seal for 1970–1971 are substantially lower than in current study years; however, the 1960–61 data show Noatak residents harvesting 195 pounds of bearded seals per capita, higher than in 1994 (37 pounds) and 2007 (47 pounds) (Table 3.12-4). Foote and Williamson (1966) report that edible products derived from whales and seals harvested at Sheshalik provided food for both humans and dogs, and the decline in harvests may in part reflect the lower number of dogs in the community.

Bowhead Whale. During April and May of each year, Kivalina whaling crews actively participate in the spring whale hunt, when they harvest bowhead and beluga whales. Kivalina last harvested a bowhead whale in 1995. Bowhead whales' regular migration route in the spring occurs in open leads several miles out from shore (see Section 3.9.2), and therefore residents' bowhead hunting success is often dependent on the stability of the ice conditions and which lead the bowhead whales are in. Even though the community has not harvested a whale in 13 years, a high percentage of households continue to try to harvest this resource. In 2007, 48 percent of households reported attempting to harvest bowhead whale (Appendix D: Table 8). Sixty-four percent used and received bowhead whale from friends and relatives in other whaling communities such as Point Hope and Barrow. During years when the community successfully harvested a bowhead whale (see 1983, 1992), this resource contributed a substantial amount to the overall harvest. While few residents of Kotzebue harvest bowhead whales, use of bowhead whale in 1991 was high, with 61 percent of households using the resource and only 2 percent trying to harvest the resource (Appendix D: Table 10). During interviews with Noatak residents in 2008, hunters reported traveling either to Point Hope or Kivalina to participate in bowhead whale hunting (SRB&A 2009). Uses of bowhead whales declined between 1994 and 2007.

Other Marine Mammals. Other marine mammals harvested to a lesser extent by Kivalina, Kotzebue, and Noatak households include ringed and spotted seal, walrus, and polar bear. Harvests of “other seal” have declined in Kivalina and Noatak compared to pre-mine harvest data, but they have remained relatively stable in Kotzebue. In 1985, Burch (1985:49) postulated that the decreased seal harvests (primarily ringed seal) may be due to an ever decreasing reliance on seal as an important source of dog food and heating fuel. During SRB&A 2008 interviews, Kivalina respondents did not report any changes in other seal that might explain the decrease in harvest amount. Thus, it is likely that Burch’s assumptions in 1985 are correct and that the change in harvest levels is a result of a long term trend in lower demand, and that current harvest levels meet residents’ needs. Residents of the study communities indicate that walrus and polar bear hunting depend primarily on ice conditions and thus harvest success varies from year to year. No overall changes in walrus or polar bear harvest trends are evident. For further discussion of marine mammal harvest trends, see Appendix D.

Subsistence Use Areas, Seasonal Round, and Harvest Patterns

Current (1998–2007) marine mammal use areas for Kivalina and Noatak are shown on Figures 3.31 and 3.32. The extent of pre-mine lifetime use areas for marine mammals is also shown on these figures. Current Kivalina marine mammal use areas (Figure 3.31) extend as far north as Point Lay and as far south as Kotzebue. Residents travel long distances from shore to harvest marine mammals; compared to pre-mine lifetime marine mammal use areas, current use areas have expanded farther from shore. This expansion of use areas may reflect residents’ need to travel farther because of changing ice conditions.

While some Noatak hunters travel to Kivalina and Point Hope to hunt beluga or bowhead whales in the spring with whaling crews in those communities, the majority of marine mammal hunting by Noatak residents takes place while they are staying in seasonal camps at Sheshalik. Residents usually reported taking one yearly trip to Sheshalik and staying there for at least one week, harvesting various subsistence resources, including beluga, bearded seal, and other marine mammals, during their stay (SRB&A 2009). The 1998–2007 marine mammal use areas for Noatak shown on Figure 3.32 extend as far as Point Hope to the north, occur along the Chukchi Sea coast to Cape Krusenstern, and cover the entirety of Kotzebue Sound. The highest number of overlapping use areas occur in Kotzebue Sound. Comparison of 1998–2007 use areas to pre-mine lifetime marine mammal use areas indicates that the extent of residents’ marine mammal harvests has not changed dramatically.

Beluga. Current (1998–2007) Kivalina and Noatak beluga use areas are shown on Figures 3.33 and 3.34. Kivalina residents reported the majority of their current (1998–2007) beluga subsistence use areas in the Chukchi Sea from Kotlik Lagoon to Cape Thompson, and additional areas near Point Hope and Point Lay (Figure 3.33). The highest number of overlapping use areas occur from the port site area north towards the Singoalik River and several miles offshore. Residents only described 39 percent of beluga use areas as always or usually successful, compared to three-quarters of use areas for all resources (SRB&A 2009). Over one-quarter of beluga use areas were characterized as seldom successful compared to only 5 percent of all resources use areas. Pre-mine beluga subsistence use areas were documented along the coast from Cape Thompson all the way to Sheshalik (Figure 3.33). Kivalina residents have reported that prior to the mine, summer beluga regularly migrated along the coast directly by Kivalina, but now are deflected out to sea or back south because of noise and activity related to the port site.

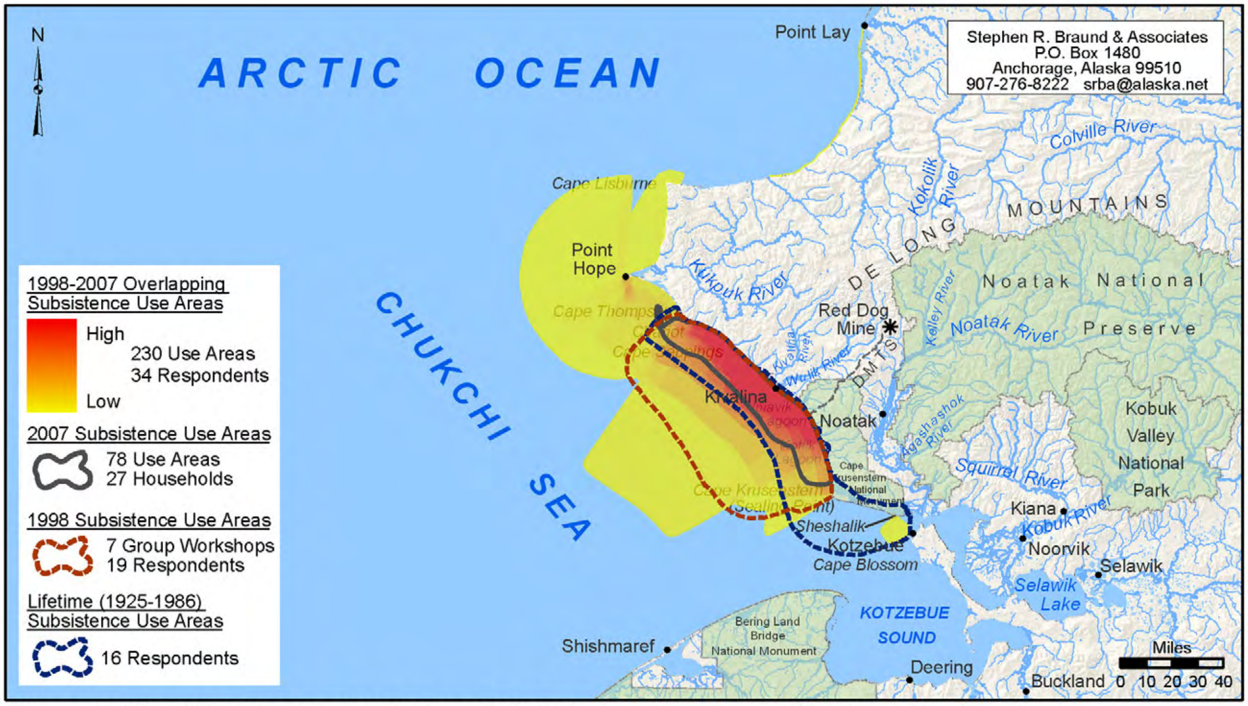


Figure 3.31: 1998-2007 and Lifetime Subsistence Use Areas Kivalina, Marine Mammals

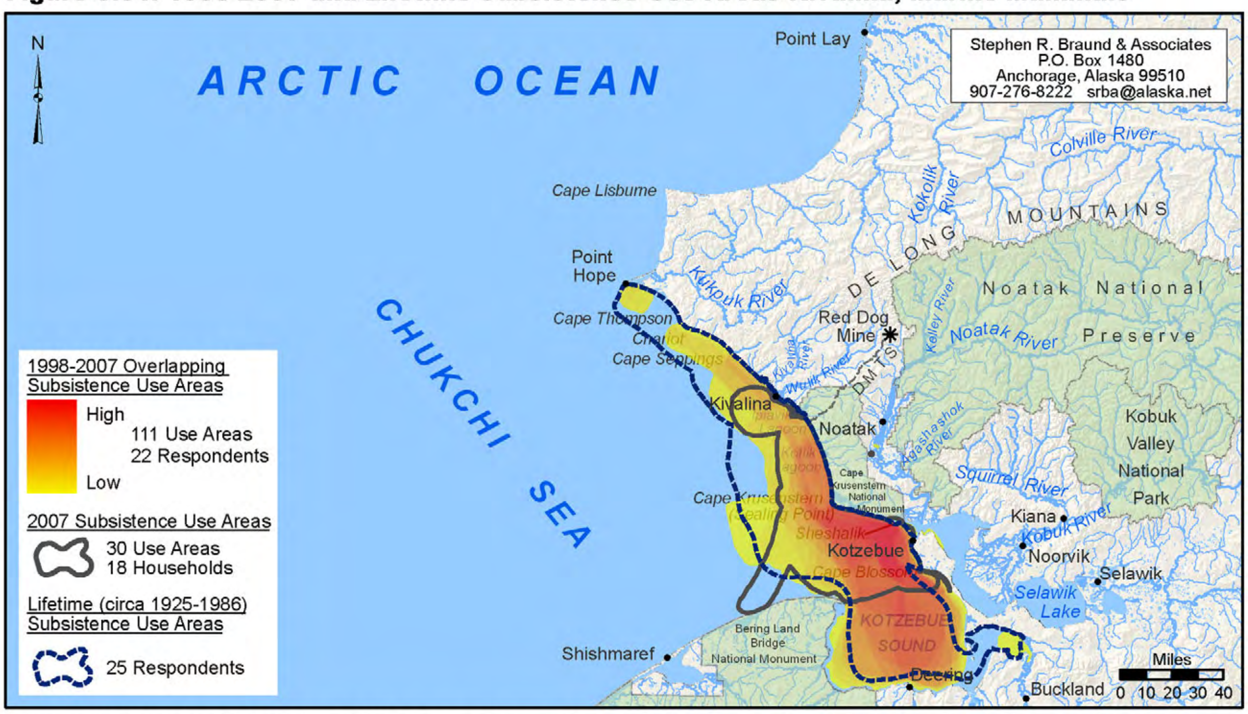


Figure 3.32: 1998-2007 and Lifetime Subsistence Use Areas Noatak, Marine Mammals

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.
1998: SRB&A 2000.
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

For all data sets, other areas may have been used for resource harvesting.

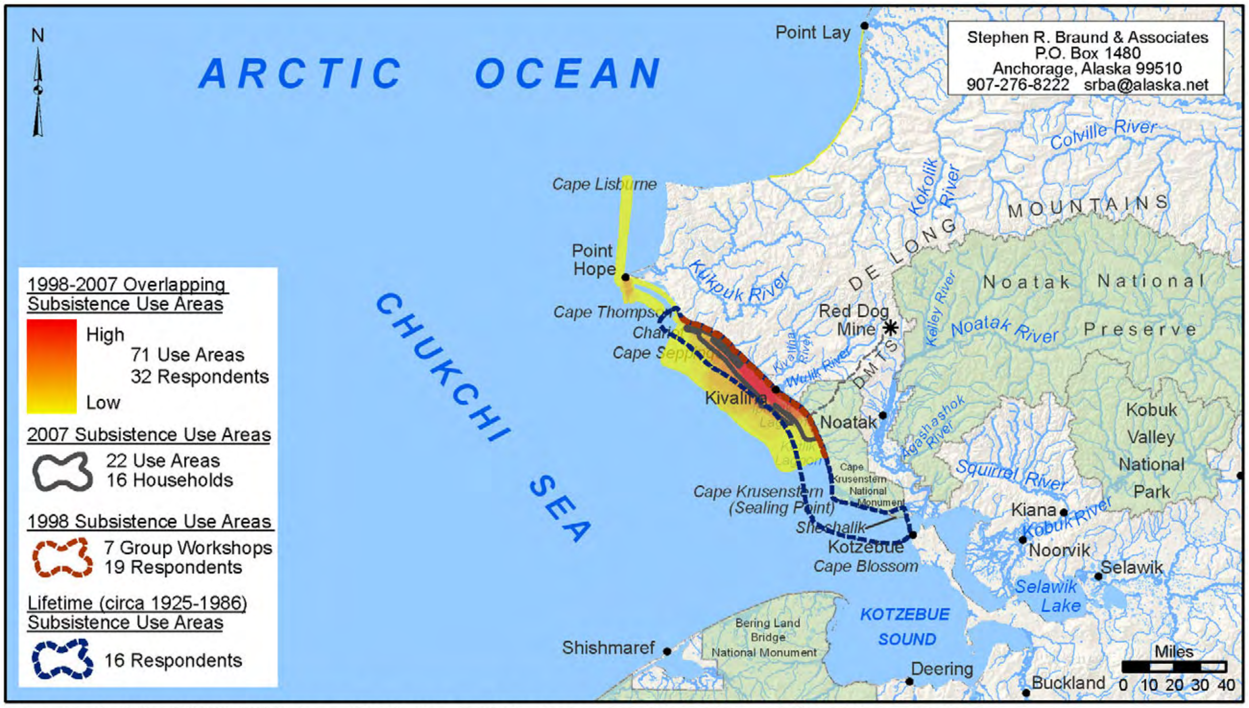


Figure 3.33: 1998-2007 and Lifetime Subsistence Use Areas Kivalina, Beluga

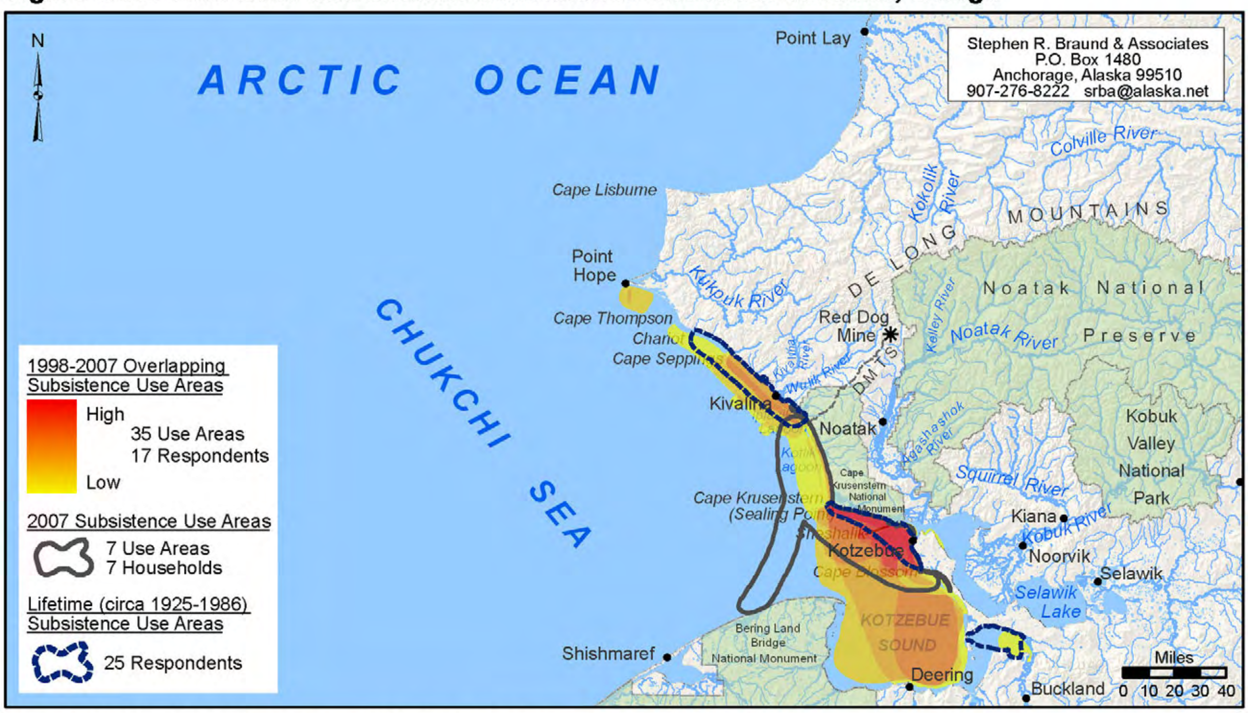


Figure 3.34: 1998-2007 and Lifetime Subsistence Use Areas Noatak, Beluga

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.
1998: SRB&A 2000.
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.

National Park Service Lands

DeLong Mountain Transportation System (DMTS)

For all data sets, other areas may have been used for resource harvesting.

According to many Kivalina residents, compared to the ease with which the beluga were harvested near the community prior to the port site development, the option of hunting beluga south of the port during the summer would require a substantial investment of time and money that many residents do not have (SRB&A 2000:35, 2005:33). For further discussion of beluga changes see “Beluga Whale Resource Changes” below.

The majority of beluga hunting at Sheshalik occurs in June and July. Last 10-year (1998–2007) Noatak beluga use areas are located throughout much of Kotzebue Sound and along the coast from Cape Krusenstern (Sealing Point) to Chariot and at Point Hope (Figure 3.34). The highest number of overlapping beluga use areas reported by Noatak respondents occurs in the waters between Cape Krusenstern, Sheshalik, and Kotzebue. Pre-mine use area data are available in the form of lifetime beluga hunting areas, and partial “sea mammal” (seal, bearded seal, walrus, and beluga) use areas; a comparison of pre-mine and current use area data indicate that beluga hunting areas have expanded over time. As discussed below under “Beluga Whale Resource Changes,” residents of Noatak have noted that beluga are less available than in the past, and the expansion of their search area for this resource is perhaps a reflection of that change.

Other Marine Mammals. Maps and discussions of current use areas for other marine mammal resources are in Appendix D. For the most part, comparison of these maps to pre-mine maps for marine mammal resources shows little change where residents hunt these resources. Noatak bowhead whale use areas currently do not occur south of the port site, whereas pre-mine use areas show hunting as far south as Sealing Point. During interviews in 1998, individuals discussed previous bowhead hunting areas south of the port that are no longer used because of noise and unstable ice conditions created by the port (SRB&A 2000:30).

Marine Mammal Resource Changes

Changes in marine mammals associated with the Red Dog Mine are primarily related to beluga whales and, to a lesser extent, bowhead whales. The 1984 EIS addressed the potential effects of the port site on marine mammals and predicted that marine mammals would generally avoid the area (EPA 1984). However, the extent of effects was predicted to vary depending on each species’ usual proximity to shore. For example, as bowhead whales generally travel farther from shore, the effects would be minimal except for the small number of whales traveling closer to shore.

No changes to bearded seals resulting from mine related operations have been recorded. Bearded seals follow the ice pack north past Kivalina in the spring, before sea-based port site operations have begun, and south past Kivalina in the late fall, after sea-based port site operations have ceased (Corps 2005). Bearded seals may occur in the port site area in small numbers year-round, but most follow the ice pack to other destinations. Studies have concluded that bearded seals are equally abundant offshore from the port site and at similar distances than elsewhere, and subsistence harvests of bearded seal have not changed because of port site activity (Corps 2005). Local residents’ observations about changes in bearded seal are generally related to changes in ice conditions. For further discussion of these observations, see Appendix D.

There is no evidence suggesting that port site activities have affected ringed, spotted, or other species of seals, despite ringed seals being present in large numbers in the port site vicinity throughout the winter months. Spotted seals occur periodically along the coast near the port site during the summer months, and both seal species migrate with the pack ice in the spring and fall. Studies suggest that ringed seals have acclimated to port site noises and do not indicate any changes to ringed seal distribution in the port site area (see Section 3.9.2) (Corps 2005). The Draft EIS for navigational improvements for the port (Corps 2005) did not predict any considerable effects on subsistence uses of ringed, spotted or other seal resulting from port site operations.

Because walrus typically do not visit the port site area, instead migrating past the port site between 30 and 40 miles from shore, existing or potential effects to subsistence uses of walrus resulting from mine related activities are considered unlikely and there is no evidence that effects on walrus have occurred (Corps 2005). Observations made by local residents regarding walrus indicate that walrus distribution and availability vary widely depending on ice and wind conditions (SRB&A 2000, 2005, 2009). See Appendix D for further discussion of their observations.

Polar bears occur periodically in the port site area; however, their appearance in that area usually ceases before sea-based operations begin (Corps 2005). No port-site related effects on polar bears have been recorded. However, impacts related to climate change are of current concern, and polar bears were recently listed as threatened under the ESA.

Bowhead Whale Resource Change. Harvests of bowhead whales by Kivalina hunters in recent years have not decreased enough to determine that an impact or change has occurred, and port site operations such as loading, shipping, and barge activity do not occur until the water is open after the spring whale hunt (Corps 2005). Bowhead whales generally do not migrate close to the port site, traveling in leads in the spring that are usually at least three miles from shore (see Section 3.9.2). Local hunters observe that, in the presence of multiple leads in the ice, bowhead whales will travel in the lead farthest from shore (SRB&A 2000). Winter operations reportedly produce sounds detectable within a half a mile of the port and within 3.7 miles during maintenance work. In the fall, bowhead whales are even farther from shore as they migrate south. Studies have concluded that noise associated with open water port site operations is detectable up to 16.5 miles from shore (see Section 3.9.2).

Kivalina residents in particular have noted local changes in bowhead whales. As stated above (under “Caribou Resource Changes”), small local changes in resources may have minimal effects on the health and abundance of that resource as a whole, but can have much larger consequences for local hunters. Sixty-six percent of the harvesters interviewed in Kivalina and 17 percent of the harvesters interviewed in Noatak made observations about changes related to bowhead whales (Table 3.12-1). The principal bowhead resource change observations are: (1) harvest less; (2) migration changed or diverted; and (3) farther from shore (Table 3.12-13).

As noted above, previous studies have concluded that no major changes to bowhead whale hunting have occurred resulting from Red Dog Mine activities. The average harvest of bowhead whales by Kivalina hunters previous to port site construction was one every four years; the average after construction was one every five years (Corps 2005). However, 30 percent of Kivalina respondents reported harvesting fewer bowhead whales over the last 20 years (Table 3.12-13). One explanation for the view that harvests have gone down (despite numbers showing little change at the time of Corps 2005 EIS) may be that the circumstances surrounding unsuccessful harvests have changed. Six individuals cited less ice cover and more open leads as the reason for the decreased harvest (Table 3.12-14). Four individuals attributed the change to a migration change, and three indicated that the whales were farther from shore.

During multiple studies, residents indicated that the ice has been thinner and more dangerous and that there have been more open leads (SRB&A 2000 and 2005). This has resulted in fewer opportunities to safely hunt bowhead whales. Several community members explained that multiple open leads cause bowhead whales to travel farther from the Kivalina coastline as they migrate north towards Point Hope and beyond. Because of these factors, Kivalina whaling crews are unable to establish trails to the leads where the bowheads are migrating and thus experience diminished chances for harvesting a whale. Residents commonly attributed these events to climate change. One hunter observed:

Table 3.12-13 Observations of Bowhead Whale Resource Changes

Observation	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Harvest Less	13	1	14	30%	6%	23%
Migration Changed or Diverted	12	0	12	27%	0%	20%
Farther from Shore	9	3	12	20%	19%	20%
Worse Success	0	4	4	0%	25%	7%
More Difficult	0	3	3	0%	19%	5%
Use Area Changed	3	0	3	7%	0%	5%
Disease/Infection	3	0	3	7%	0%	5%
Harvest Season Changed	0	2	2	0%	13%	3%
Decrease in Species Number	0	2	2	0%	13%	3%
More Aggressive/Bold	2	0	2	5%	0%	3%
Take Fewer Trips	0	1	1	0%	6%	2%
Habitat Disturbed/Destroyed	1	0	1	2%	0%	2%
Increase in Species Number	1	0	1	2%	0%	2%
Total Observations	44	16	60	100%	100%	100%
Total Number of Bowhead Whale Change Observers	29	17	46	N/A	N/A	N/A

SRB&A 2008

N/A = not applicable

Table 3.12-14 Reasons for Change in Bowhead Whales – Harvest Less

Causes	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Less Ice Cover/More Open Leads	6	0	6	46%	0%	43%
Migration Changed or Diverted	4	0	4	31%	0%	29%
Farther from Shore	3	1	4	23%	100%	29%
Total Observations	13	1	14	100%	100%	100%

SRB&A 2008

> We never get any [bowhead whales] for so many years because the ice conditions are bad. Because I believe that global warming is causing all the ice to be thin. Now we can't go far out because when it piles up there is no trail. I am always looking for a way to go out in the past few years. You can go out for one day, but there is no trail. That is why we didn't get belugas in winter time. No trail. It is not that they are not there, but the ice conditions, when it is thin for so many years, when it piles, it piles way high. When it is thick it just bumps up against [the shorefast ice] and when it is thin it breaks up and piles up. Just like piling up Styrofoam...Past few years now. Last time we had a whale was 1994. Since that time the ice condition was too thin (SRB&A Kivalina Interview 2008).

All individuals who blamed less ice cover and more open leads for the decline in harvests cited this as a main cause of the change. Residents reported that the change started anywhere from 1988 to 1998, and generally indicated that the change was ongoing (SRB&A 2009).

During SRB&A's 2008 interviews, 27 percent of Kivalina bowhead observations were related to a change or diversion of bowhead whale migration (Table 3.12-13). Noatak respondents did not report such a change. Sixty-seven percent of Kivalina observations identify noise or port site noise as the reason for the migration change or diversion, and the remaining third of observations attributed the change to the port site or related activities (Table 3.12-15). Local traditional knowledge is that bowhead whales are extremely sensitive to noise and changes in their environment and some local hunters believe that the bowhead whales migrate farther from shore to avoid noise. Those residents citing a change in bowhead migration have attributed the change both to noise generated by the port site and to noise from onshore and offshore traffic and motors (SRB&A 2000, 2005, 2009). Those individuals citing noise and port site noise as a cause of the migration change all identified this as a main cause. Residents generally associated the start date of the migration change with the construction of the port site in 1989, although five individuals reported the start of the change occurred in 1995, 1996, or 1998 (SRB&A 2009). All Kivalina residents who reported a change in migration/distribution indicated that the change was ongoing.

Table 3.12-15 Reasons for Change in Bowhead – Migration Changed or Diverted

Causes	Number of Observations			Percentage of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Port Site Noise	6	0	6	50%	0	50%
Port Site and Related Activities (e.g., Barges)	4	0	4	33%	0	33%
Noise	2	0	2	17%	0	17%
Total Observations	12	0	12	100%	0	100%
All Mine Related Causes	10	0	10	83%	0	83%

SRB&A 2008

Twenty percent of Kivalina bowhead observations and 19 percent of Noatak bowhead observations are that bowhead whales are farther from shore (Table 3.12-13). Residents attributed the majority of these observations (78 percent in Kivalina and 100 percent in Noatak) to less ice cover and more open leads (Table 3.12-16). As discussed above, hunters in both communities have noted that ice conditions have deteriorated in recent years causing unsafe travel and hunting circumstances. In addition, hunters observed that more open leads in the spring are resulting in bowhead whales traveling in the farthest leads and thus farther from shore. Less ice cover/more open leads was identified as the main cause of the change by six of seven Kivalina respondents and all three Noatak respondents who reported the change (SRB&A 2009). Residents reported the start date of the change to have occurred between 1988 and 2002, with 1998 being the most commonly cited start date. Residents reported observing the change in Kivalina and Point Hope whaling grounds, and the majority of respondents believed that the change was ongoing (SRB&A 2009).

Table 3.12-16 Reasons for Change in Bowhead – Farther from Shore

Cause	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Less Ice Cover/More Open Leads	7	3	10	78%	100%	83%
I Do Not Know	2	0	2	22%	0%	17%
Total Observations	9	3	12	100%	100%	100%

SRB&A 2008

Beluga Whale Resource Change. Effects on beluga whales related to port site operations include displacement and disturbance due to associated noise. Studies have been conducted to determine the extent of effects on beluga migration and distribution, and no overall changes to marine mammal species have been observed (Corps 2005). Any effects on beluga whales are reported to be localized near the port site (see Section 3.9.2). As discussed above (Section 3.12.2.5), the 1984 EIS addressed the potential effects of noise and activities associated with the port site on marine mammals, and predicted that marine mammals would avoid the area. The extent of this effect was largely dependent on the species' proximity to shore, and the 1984 EIS did not directly address beluga whales.

It is common knowledge among local hunters that beluga whales are sensitive to noise and, as such, avoid sources of noise. Observations of beluga whales avoiding outboard motors have been reported as early as the 1950s and 1960s, and residents observe that belugas associate outboard noise with danger (Corps 2005). Studies show that while belugas may become habituated to certain noises and no longer react to them, noises that have repeated negative consequences for beluga may cause beluga to respond more defensively through avoidance (Corps 2005). Furthermore, changes in ice conditions are known to affect beluga whales (Section 3.9.2).

Subsistence users in Kivalina have reported changes to their subsistence uses of beluga due to local changes in their migratory patterns and abundance (Corps 2005, SRB&A 2000 and 2005). Although changes to migratory patterns are reportedly localized, and overall changes in migration patterns have not occurred (Section 3.9.2), the changes have had considerable effects on residents' ability to hunt and harvest this traditional and important subsistence resource. During SRB&A's 2008 interviews, 34 Kivalina respondents (77 percent of those interviewed) and 21 Noatak respondents (50 percent of those interviewed) provided observations about changes in beluga (Table 3.12-1). The principal beluga resource change observations are: (1) migration changed or diverted; and (2) harvest less (Table 3.12-17).

Table 3.12-17 Observations of Beluga Resource Changes

Observation	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Migration Changed or Diverted	28	14	42	42%	40%	42%
Harvest Less	16	2	18	24%	6%	18%
Decrease in Species Number	1	6	7	2%	17%	7%
Closer to Shore	6	0	6	9%	0%	6%
Worse Success	0	4	4	0%	11%	4%
Abnormal Migratory Event	4	0	4	6%	0%	4%
Harvest More	3	0	3	5%	0%	3%
Use Area Changed	0	3	3	0%	9%	3%
Increase in Species Number	3	0	3	5%	0%	3%
Move to Different Areas	0	3	3	0%	9%	3%
Farther from Shore	2	1	3	3%	3%	3%
Take Fewer Trips	1	1	2	2%	3%	2%
Habitat Disturbed/Destroyed	1	0	1	2%	0%	1%
Skittish Behavior in Species	0	1	1	0%	3%	1%
Change in Resource Behavior	1	0	1	2%	0%	1%
Total Observations	66	35	101	100%	100%	100%
Total Number of Beluga Whale Change Observers	34	21	55	N/A	N/A	N/A

SRB&A 2008

N/A = not applicable

Forty-two percent of Kivalina beluga observations and 40 percent of Noatak beluga observations cited beluga migration changes (Table 3.12-17). Ninety-six percent of Kivalina beluga observations attributed the change to port site activities or port site noise (Table 3.12-18). Seven of the Noatak observations (55 percent) cited disturbance from traffic (boat, plane, or other) or noise (Table 3.12-18). Kivalina residents generally referred to beluga migration changes occurring near the port site, whereas Noatak residents discussed changes to beluga migration occurring in Kotzebue Sound, where Noatak residents have traditionally hunted the resource.

Table 3.12-18 Reasons for Change in Beluga - Migration/Diversion

Causes	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Port Site and Related Activities (e.g., Barges)	16	0	16	57%	0%	39%
Port Site Noise	11	0	11	39%	0%	27%
Boat Traffic Disturbance	1	4	5	4%	31%	12%
Not Using Traditional Hunting Methods	0	2	2	0%	15%	5%
Predators	0	2	2	0%	15%	5%
I Do Not Know	0	2	2	0%	15%	5%
Traffic Disturbance	0	1	1	0%	8%	2%
Airplane Traffic Disturbance	0	1	1	0%	8%	2%
Noise	0	1	1	0%	8%	2%
Total Observations	28	13	41	100%	100%	100%
All Mine Related Causes	27	0	27	96%	0%	66%

SRB&A 2008

Kivalina residents have reported changes in beluga migration patterns near the port and have blamed both noise from port site activities and other sources (e.g., boat and all-terrain vehicle traffic) for the change (SRB&A 2000, 2005). According to hunters, belugas no longer migrate directly past Kivalina in the summer as they once did, but instead turn and migrate away from shore once they reach the area near the port site. Kivalina residents traditionally waited until the belugas reached the Kivalina area and hunted them as they passed by. However, residents report that they now must either go south of the port site or farther north to hunt belugas (SRB&A 2000). One individual reported that the change began after the port construction occurred:

> [The change] is basically through the port site with the expansion. It drives them a lot farther out. It is usually how they work, with the barges and stuff [affecting the beluga]. It changed their migration. I was pretty young when they did that expansion. They are further out. They are both the main cause [barges and port site]. It is still going on. When they started building that port site [is when it started]. They started going more out, from there they are to watch them go through that channel and pass by before that expansion. After that expansion we haven't seen them. We used to see them on the other side of that channel, real close. They go along the beach and head out.

In Kivalina 31 of 34 observations of why beluga migration/distribution changed cite port site noise or activities as main causes of the change (SRB&A 2009). Twenty-three respondents reported 1989 as the start date for this change, and those individuals who provided a location for the change indicated that the change occurred at the port site. Residents believe the change is ongoing (SRB&A 2009).

Noatak residents' observations regarding changes in beluga migration are vastly different from those of Kivalina residents. Hunters in Noatak have traditionally harvested beluga while staying in seasonal camps or cabins located at Sheshalik Spit. Beluga hunting usually occurs in Kotzebue Sound or along the coast past Cape Krusenstern ("Sealing Point") toward Kivalina, often while residents target bearded seal. Thus, while Noatak residents hunt beluga during their summer migration before they reach the port site where Kivalina hunters report changes, they have also observed local changes in beluga migratory patterns in Kotzebue Sound. The change observed is generally that beluga no longer migrate into Kotzebue Sound as they once did, rather bypassing the sound altogether and continuing north toward Kivalina. Residents cited disturbance from boats, airplanes, and noise (related to increasing activity in Kotzebue Sound), as well as a declining use of traditional hunting methods (Table 3.12-18). As one hunter described it:

> Last 10 years there was hardly any beluga in [Kotzebue Sound]. The boats would rush, so they would turn around and go back out…. They don't hunt the traditional way anymore. When there was a pod, they'd start circling on the outside here, they'd come through the outside and drive [the beluga] into the shallows. That's the traditional way [to hunt]. But now, in the open water, they want to shoot, want to get them right now [instead of waiting] (SRB&A Noatak Interview January 2008).

Four residents cited boat traffic disturbance as a main cause of the change (SRB&A 2009). Hunters reported varying start dates for the change, with the earliest start date cited as 1970 and the latest, 2007. The 2007 start dates reflects a more recent change reported by Noatak residents; a pod of beluga whales migrated into Kotzebue Sound for the first time in many years, and local residents were able to harvest a substantial number of belugas during this event (SRB&A 2009).

Residents of Kivalina reported harvesting fewer beluga over the last 20 years. Twenty-four percent of Kivalina observations of beluga change cite harvesting fewer beluga (Table 3.12-17). Eighty-eight percent of these observations attributed the declining harvests to a change in beluga migration (see discussion above) (Table 3.12-19). One Kivalina hunter observed,

> We are not getting the beluga we used to. We are not getting half of the beluga during the summer time. They started telling us the one who works in the towers started telling us they would see beluga coming up along the shore and as soon as they hit the port they head straight out to ocean. That is why we don't see beluga in the summertime (SRB&A Kivalina Interview February 2008).

Table 3.12-19 Reasons for Change in Beluga – Harvest Less

Cause	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Migration Changed or Diverted	14	1	15	88%	50%	83%
Farther from Shore	1	1	2	6%	50%	11%
Less Ice Cover/More Open Leads	1	0	1	6%	0%	6%
Total Observations	16	2	18	100%	100%	100%

SRB&A 2008

Although it can be inferred from beluga harvest data and local observations that residents of Noatak have also experienced a decline in harvests of beluga, this change either started more than 20 years ago or residents did not feel that the change had occurred in recent memory and did not report it. Only two Noatak respondents reported a decline in their harvests of beluga (Table 3.12-17). These individuals attributed the change to a change in or diversion of beluga migration, and to belugas being farther from shore.

In Kivalina all 14 observations citing migration changed or diverted as a cause for harvesting fewer beluga cite this as a main cause for the change. Fourteen individuals reported the start date of the change to be 1989 or 1990 (SRB&A 2009). The majority of individuals who reported harvesting fewer beluga indicated that this change was ongoing.

Although harvests of beluga have declined, 2007 was a relatively high harvest year in Kivalina. While the belugas following the coast toward Kivalina in the summer migrated away from the coast upon reaching the port site, residents explained that a group of belugas arrived from the north and hunters were able to harvest 18 animals from this group. Residents provided two main explanations for this event. Some believed that orca (killer) whales had chased the belugas toward shore, while others thought that the belugas were a different stock that had arrived from Siberia.

Noatak residents experienced a similarly abnormal harvest year for belugas. As described above ("Migration Changed or Diverted"), in 2007 a large number beluga whales migrated into Kotzebue Sound for the first time in a number of years, providing an opportunity for Noatak and Kotzebue hunters to harvest the resource.

3.12.2.4 Birds

Harvest Trends

Residents of Kivalina, Kotzebue, and Noatak harvest migratory birds, including ducks and geese; upland birds, including ptarmigan and spruce grouse; and bird eggs, including murre, gull, geese, and duck eggs. Although migratory birds only accounted for 0.9 to 1.3 percent of Kivalina's total subsistence harvest in 1992 and 2007, over 80 percent of households reported use of this resource (Appendix D: Table 8). In 1992, 1996, and 2007, residents harvested seven, three, and eight per capita pounds respectively (Table 3.12-2). Compared to pre-mine harvest data, there is a slight trend of increasing per capita waterfowl harvests from 1971–72 to 2007 (see Table 3.12-2). In Kotzebue, waterfowl harvests have provided two and seven pounds of usable weight per capita during the 1991 and 2007 harvest studies respectively (Table 3.12-3). Earlier waterfowl harvest data for the 1986 study year are similar to current harvest data, with waterfowl harvests amounting to five pounds per capita (Table 3.12-3). Although harvest numbers dropped in 1991, more recent waterfowl studies in 1997, 2002, 2003, and 2004 show a gradual increase in harvest levels (Appendix D: Table 10). Noatak harvests of waterfowl have remained relatively steady over recent years, with four pounds per capita harvested in 1994 and 1997 and five pounds per capita harvested in 2007 (Table 3.12-4). Older waterfowl harvest data from the 1960s and 1970s indicate that waterfowl hunting has not changed substantially over time (Table 3.12-4).

Egg harvest data for the three study communities indicate little change in residents' harvests of eggs over time (see Tables 3.12-3 to 3.12-5). However, data for Noatak indicate a possible increase in residents' participation in egg harvesting. In 2007, 28 percent of households harvested eggs, as opposed to 24 percent in 1997 and 7 percent in 1994 (Appendix D: Table 12).

Harvests of upland birds in the study communities are relatively low, contributing a small amount to the total yearly subsistence harvest. Comparison of current harvest data to earlier harvest data does not indicate any overall changes in Kivalina residents' harvests of upland birds (Table 3.12-2). Current Kotzebue upland bird harvest data are available for the study years of 1991 and 1997 (Table 3.12-3). A comparison of current and pre-mine Kotzebue harvest data show an increase in the total pounds of upland birds harvested (from 2,147 pounds in 1986 to 5,584 in 1991 and 5,530 in 1997) (Appendix D: Table 10), as well as twice the per capita pounds (Table 3.12-3). Noatak harvests of upland birds (ptarmigan) are similar to those of Kotzebue, and amounted to an average of three pounds per household in 1994 and two pounds per household in 2007 (Table 3.12-4). Harvests from the 1960s and 1970s were slightly lower (Table 3.12-4).

Subsistence Use Areas, Seasonal Round, and Harvest Patterns

Kivalina and Noatak subsistence use areas for waterfowl, eggs, and upland birds are provided in Appendix D. Kivalina waterfowl subsistence use areas are located along the coast and lagoons from Cape Krusenstern to Chariot, with additional areas extending farther inland around the Kivalina and Wulik rivers. Pre-mine lifetime Kivalina waterfowl subsistence areas are located along the coast and lagoons from Sheshalik to Cape Thompson and the entire lengths of the Wulik and Kivalina rivers. Noatak waterfowl subsistence areas for the time period of 1977–1982 are nearly identical to the 1998–2007 use areas. Noatak residents reported a high number of overlapping waterfowl use areas along the Noatak River between the mouths of the Kelly and Agashashok rivers (including Sevisok Slough), in the flats east of Noatak, and around lakes west of the community. Pre-mine lifetime use areas for waterfowl as reported by Noatak residents generally depict the same extent of waterfowl hunting areas but are more continuous, spanning from the Kelly River to the mouth of the Noatak River and west of Noatak, encompassing the entire Cape Krusenstern National Monument.

Kivalina respondents reported two primary locations from which they harvest their subsistence supply of eggs. Residents travel by boat at the end of June and early July to harvest murre eggs from the cliffs at Cape Thompson (SRB&A 2009), and also harvest primarily gull eggs near the mouths of the Kivalina and Wulik rivers. Kivalina's 1925–1986 egg use areas occur farther along the Kivalina and Wulik rivers than current egg use areas. Noatak egg harvesting areas for the 1998–2007 time period occur along the Noatak River and several surrounding tributaries, near Sheshalik, and on Chamisso Island in Kotzebue Sound. Comparing current use areas to pre-mine use areas, egg use areas remain very similar with the exception of pre-mine use areas reported along the coast from Sheshalik to Cape Krusenstern (Sealing Point) and around lakes east of the mouth of Noatak River.

Kivalina's upland bird use areas, all identified for ptarmigan, are located along various creek and river drainages in the Kivalina area, including Kisimilok Creek, Singoalik River, Asikpak River, Kivalina River, Wulik River, Imikruk Creek, and Omikviorok River. The highest frequency of overlapping ptarmigan use areas occurs along the lower portion of the Wulik River. Current (1998–2007) upland bird use areas reported by Noatak residents are located on either side of the Noatak River, at the mouth of the river, and near Kotzebue. The highest numbers of overlapping ptarmigan hunting areas are located close to Noatak on either side of the river. No pre-mine upland bird use area data are available.

Bird Resource Changes

Baseline conditions of birds are described in Section 3.9.2. Effects on waterfowl resulting from mine related facilities and activities include habitat loss and changes in migratory routes (Corps 2005). Both local residents and biologists have observed localized changes in migration routes near the port site barge loading facilities, where birds either divert around the port site and then return to shore north of the port site, or fly at higher altitudes once they reach the port site (Corps 2005, SRB&A 2000 and 2005). The birds generally return to shore before reaching Kivalina residents' spring waterfowl hunting areas to the north of the port site (Corps 2005). Few residents have reported effects on their harvests of waterfowl resulting from local change in migration (SRB&A 2000, 2005). Other documented effects on waterfowl include loss of habitat at the port site, along the DMTS road, and at the Red Dog Mine; isolated mortalities along the road or at the mine site; and use of the tailings impoundment by migratory waterfowl (see Section 3.9.2). Mine employees implement hazing when waterfowl are seen in the tailings impoundment, and no injuries or fatalities have been reported as a result. Section 3.9.2.1 also notes that the 2007 DMTS risk assessment found willow ptarmigan feeding in the mine and port areas may be slightly more at risk for exposure to lead than other species. Otherwise, no effects on ptarmigan due to mine related facilities or activities have been reported (Corps 2005). Willow ptarmigan inhabit the area near the port site (Corps 2005).

The 1984 EIS addressed impacts to waterfowl related to the mine and reported potential loss of habitat and disturbance due to mine related activities. Effects on subsistence harvests of birds are reported to be minor (Corps 2005).

Kivalina and Noatak residents made few observations about changes in waterfowl or eggs, although 43 percent of harvesters interviewed in Noatak reported changes in upland birds (Table 3.12-1). The principal observation of change in upland birds was that residents harvest less. In Noatak, nine of 12 individuals reporting that they harvest fewer ptarmigan cite personal and family reasons as the main causes for this decline (see Appendix D, Upland Birds Resource Change). Further discussion of changes in waterfowl and upland birds is available in Appendix D.

3.12.2.5 Fish

Harvest Trends

Subsistence users in the three study communities rely heavily on their yearly harvests of various species of fish, including Dolly Varden char (referred to locally as “trout”), chum salmon, whitefish, and sheefish. The primary species harvested vary by community.

Dolly Varden Char. In Kivalina, Dolly Varden char, along with caribou and bearded seal, constitute the majority of the yearly subsistence harvest. In both 1992 and 2007, Dolly Varden char accounted for 26 percent of the overall harvest and was the No. 1 and No. 2 single species harvested for those years (Appendix D: Tables 8 and 9). Aside from an unusually low harvest of 113 pounds per capita in 1965–66, Dolly Varden char harvests have provided between 158 and 510 usable pounds per capita during study years between 1964 and 2007 (Table 3.12-2). Dolly Varden char was among the top three harvested species in Noatak during two recent harvest surveys (1994 and 2007) (Appendix D: Table 13). Harvests of Dolly Varden char by Noatak residents accounted for 40 per capita pounds in 1994 and 64 per capita pounds in 2007. Harvests of Dolly Varden char in 1971–1972 were substantially higher than in more recent years, with residents harvesting an estimated 250 pounds per capita (Table 3.12-4). Reasons for this may be related to declining harvests of fish for dog food, or variations in resource availability. During interviews in Noatak, seven residents reported decreased harvests in 2007 (SRB&A 2009).

Harvests of Dolly Varden char by Kotzebue residents are not as substantial as in the other study communities, but still are an important contributor to residents’ yearly harvests. Dolly Varden char accounted for 3.1 percent of Kotzebue’s total harvest in 1991 and between 0.9 and 2.1 percent from 2002 to 2004 (Appendix D: Table 17). Similarly, harvest data from 1971–1972 and 1986 show Dolly Varden char accounting for between 0.9 and 2.3 percent of residents’ total harvest for those years (Appendix D: Table 17).

Other Non-Salmon Fish. Species of other non-salmon fish harvested by study community residents include whitefish, sheefish, saffron cod (“tomcod”), and pike. Kivalina households’ 2007 harvests of other non-salmon fish represented 3 percent of the total harvest for a total of 18 pounds per person (Appendix D: Table 8). In 1992, humpback whitefish, saffron cod, and arctic cod were the top species of other non-salmon fish harvested for that year, and in 2007, saffron cod, whitefish, and grayling were the top three other non-salmon fish harvested by Kivalina residents (Appendix D: Table 9). Other non-salmon fish harvests in 1992 were higher compared to all previous study years except the 1971–1972 study (Table 3.12-2). As sheefish are a major subsistence resource for residents of Kotzebue, other non-salmon fish contribute substantially more to Kotzebue subsistence harvests than in the other study communities.

Top other harvested non-salmon fish for Kotzebue in 1991 included sheefish (which was the top harvested species in 2002, providing more household pounds than caribou), tom cod, herring, pike, whitefish, and cisco (Appendix D: Table 11). Residents in 1986 harvested fewer pounds of other non-salmon fish per capita (79 pounds) than in 1991 (144) (Table 3.12-3). The harvest data indicate a possible increase in sheefish harvests in the early 1990s, which have stayed relatively consistent over the years. Harvests of other non-salmon fish by Noatak residents provided 34 pounds per capita in 2007 (Table 3.12-4). Top harvested species of other non-salmon fish included whitefish, burbot, sheefish, grayling, Bering cisco, and northern pike (Appendix D: Table 13).

Salmon. The primary species of salmon harvested in the study area is chum salmon, although residents have reported harvests of other species as well. Salmon is an important subsistence resource in Noatak, comprising 26.1 and 14.1 percent of the total harvest during the 1994 and 2007 study years respectively (Appendix D: Table 12). Per capita pounds of harvested salmon were considerably lower for Noatak residents in 2007 than in 1994; while some Noatak residents interviewed in 2008 reported harvesting fewer salmon over the last 10 years, their explanations for the decline varied (SRB&A 2009). Noatak's 1971–1972 harvest of salmon was similar to more recent harvests; however, 1960–61 harvest data show Noatak residents harvesting 1,692 pounds of salmon per capita compared to 180 pounds in 1971–1972, 120 pounds in 1994, and 51 pounds in 2007 (Table 3.12-4). Foote and Williamson (1966) explained that the majority of the salmon harvested in 1960–61 were fed to dogs (see discussion above, Section 3.12.2.1). During recent (1991, 2002, 2003, and 2004) harvest studies in Kotzebue, chum salmon was the second most harvested species of fish in terms of its contribution toward total yearly harvests, and the fourth most harvested resource (Appendix D: Table 11). During four harvest studies (1991, 2002, 2003, and 2004), chum salmon provided between 330 and 863 mean household pounds of wild foods (Appendix D: Table 11). The mean household pounds of salmon harvested in 1986, at 256, was somewhat lower than in recent years. Unlike Noatak and Kotzebue, salmon does not account for a large portion of the subsistence harvest of Kivalina. Per capita harvests of salmon vary from year to year, although 1992 and 2007 per capita harvests were higher than any previous study year (Table 3.12-2).

Subsistence Use Areas, Seasonal Round, and Harvest Patterns

Residents harvest fish along rivers and in coastal waters and lagoons. Figures 3.35 and 3.36 show Kivalina and Noatak current (1998–2007) and lifetime use areas for Dolly Varden char. Kivalina residents' harvests of Dolly Varden char primarily occur along the Wulik River in the fall and throughout the winter months, and at the mouth of the Kivalina Lagoon in June (Figure 3.35). The Wulik River has the greatest concentration of overlapping use areas for Dolly Varden char. Current (1998–2007) Noatak use areas for Dolly Varden char (locally called "trout") are located along a long expanse of the Noatak River, at Sheshalik, and along the Wulik River (Figure 3.36).

Current subsistence use area maps for other non-salmon fish and salmon are located in Appendix D. Kivalina residents reported other non-salmon fish use areas along the Kivalina and Wulik rivers, in Kivalina Lagoon, at the mouth of New Heart Creek, and in Kotzebue Sound south of Sheshalik. Kivalina salmon use areas for 1998–2007 are located in similar areas. Kivalina respondents identified the bulk of their fish use areas along the Wulik River. Last 10-year (1998–2007) Noatak use areas for other non-salmon fish include use areas for whitefish, arctic grayling, northern pike, and sheefish. Of these species, whitefish is the most commonly harvested. Current use areas for other non-salmon fish are located along the Noatak River from the mouth to beyond Nimiuktuk River, at Sheshalik, and based out of several other communities including Kivalina (Wulik River), Kotzebue, and Noorvik.

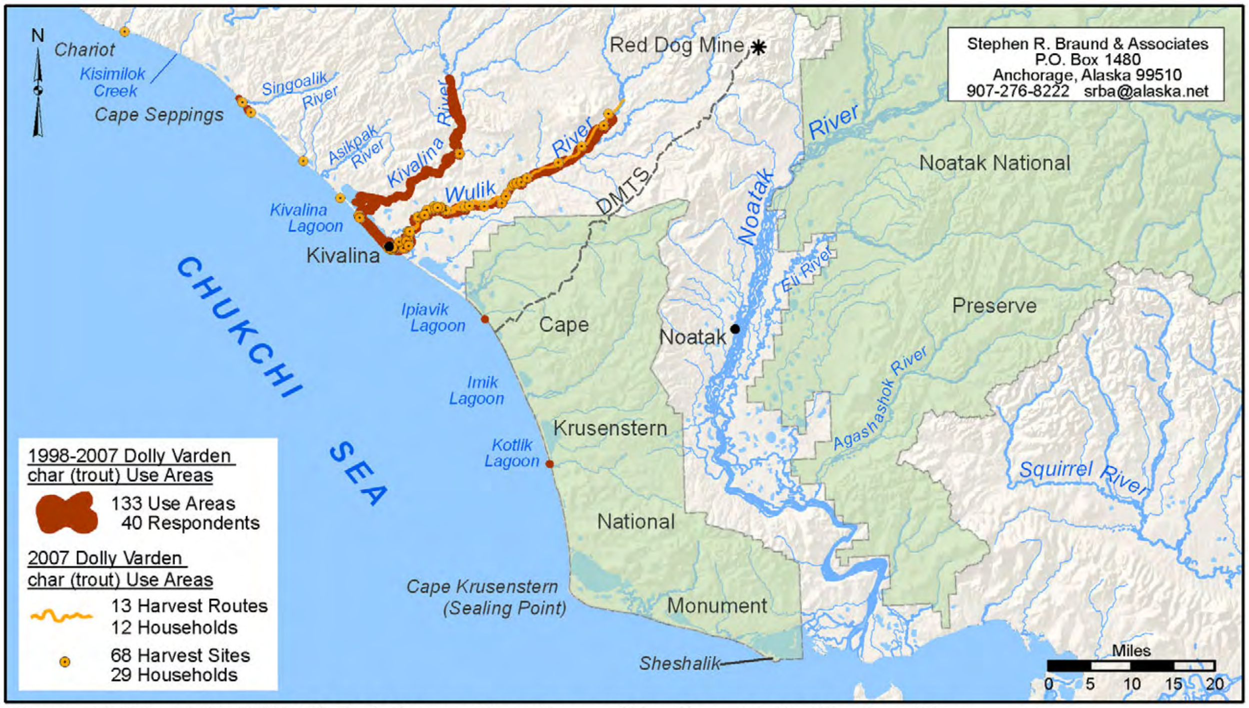


Figure 3.35: 1998-2007 Subsistence Use Areas Kivalina, Dolly Varden Char

Figure 3.36: 1998-2007 Subsistence Use Areas Noatak, Dolly Varden Char

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.

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For all data sets, other areas may have been used for resource harvesting.

Saario & Kessel (1966) documented Kivalina fishing sites, all located along the Wulik River, and presumably used to catch Dolly Varden char, the primary contributor to Kivalina's fish harvests (see "Harvest Trends," above). Similarly, Braund and Burnham (1983) show all but one of Kivalina's 1977–1982 Dolly Varden char seining use areas located along the Wulik River. Pre-mine lifetime Dolly Varden char use areas for Kivalina residents appear on Figure 3.35. This figure shows fishing use areas along the Kivalina and Wulik rivers, along the coast from Ipiavik Lagoon to the Asikpak River, and south of the community near Sheshalik and in Selawik Lake. The only pre-mine data on Noatak Dolly Varden char use areas are partial and limited to uses west of the Noatak River. Uses for the 1977–1982 time period occurred along the Wulik River and Rabbit Creek. Residents have reported fishing for Dolly Varden char at both of these locations since mining operations began. No pre-mine use area data are available for any species of fish other than Dolly Varden char.

Fish Resource Changes

The 1984 EIS addressed potential effects to fish resulting from construction and operation of the Red Dog Mine (EPA 1984). Potential effects raised included metal accumulation due to increased uses of Red Dog and Ikalukrok Creek by grayling, char, and salmon (although any potential for effects on humans were considered low). Other potential effects were discussed in relation to possible contamination due to construction and use of the road where it crossed fish bearing streams or rivers, as well as increased fishing pressure from local residents and mine employees at stream crossings.

Section 3.10.2.1 provides a baseline description of freshwater aquatic resources. Actual effects to fish resulting from the Red Dog Mine include loss of potential stream habitat at Red Dog Creek (although fish did not occur in that area of Red Dog Creek during pre-mining conditions), and higher overall numbers of fish downstream from the mine possibly due to improvements in water quality caused by wastewater treatment. Studies regarding the effects of the Red Dog Mine on freshwater fish have been somewhat inconclusive. The Draft EIS for navigational improvements at the port site reported no evidence that changes to habitat or small spills related to the Red Dog Mine and DMTS, have resulted in effects on the population or harvests of local fish species (Corps 2005). Arctic grayling have become increasingly present in Red Dog Creek, an occurrence attributed to improved water quality and other factors (see Section 3.10.2.1). Recent years have seen a decline in Dolly Varden char in the lower portion of Red Dog Creek because of improved water quality and resulting accessibility farther upstream from the mine site (see Section 3.10.2.1). Somewhat higher levels of metals were found in Dolly Varden char downstream from the DMTS road; however, a DMTS risk assessment conducted in 2007 concluded that the potential for overall effects on fish due to exposure to metals at stream crossings was low (Exponent 2007a). Another study sponsored by Maniilaq Association concluded that metal concentrations in Dolly Varden char were not substantially different than for fish populations outside the mine area, and a 2002 study found that juvenile Dolly Varden char sampled in Red Dog Creek had higher levels of metals than in other local drainages (see Section 3.10.2.1 for further discussion). Studies of effects of the mine on Dolly Varden char have generally been inconclusive because of the wide-ranging life-cycle of the resource.

Dolly Varden Char Resource Changes. Fish are a major source of subsistence for residents of Kivalina, Noatak, and Kotzebue. Subsistence users in Kivalina have expressed concerns about potential contamination of fish, especially Dolly Varden char, through contamination of the watershed. While residents generally discuss concerns related to contamination of fish in the context of Dolly Varden char, the source of most of their yearly fish harvests, effects on salmon and other fish are also a concern. Incidents such as residents being urged not to harvest the resource because of discharges from the mine (this reportedly occurred once in the 1980s) (SRB&A 2000), and observations of "fish kills" (SRB&A 2005) have made some residents even more concerned about the health of the resource and the health of local residents who use these resources. During interviews with subsistence users in 2008, 65 percent of Kivalina harvesters and 32 percent of Noatak harvesters made observations about changes in Dolly Varden char (Table 3.12-20). Principal changes observed were: (1) physical abnormalities; (2) harvest less; (3) decrease in species number; (4) abnormal resource death; (5) change in texture of meat; and (6) move to different areas (Table 3.12-20). Although some observations were made about changes in salmon and other non-salmon fish, the reported causes of these changes did not pertain to the Red Dog Mine or were closely related to the changes in Dolly Varden char discussed in further detail below. For more information on observations of change in salmon and other non-salmon fish, see Appendix D.

Table 3.12-20 Observations of Dolly Varden Char Resource Changes

Observation	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Physical Abnormalities	11	0	11	22%	0%	13%
Harvest Less	2	7	9	4%	20%	10%
Decrease in Species Number	2	7	9	4%	20%	10%
Abnormal Resource Death	7	1	8	14%	3%	9%
Change in Texture of Meat	8	0	8	16%	0%	9%
Move to Different Areas	2	3	5	4%	9%	6%
Climate Affecting Travel	3	0	3	6%	0%	3%
Habitat Disturbed/Destroyed	2	1	3	4%	3%	3%
Disease/Infection	0	3	3	0%	9%	3%
Later Migration/Arrival	0	3	3	0%	9%	3%
Shorter Migration	3	0	3	6%	0%	3%
Take More Trips	0	2	2	0%	6%	2%
Take Shorter Trips	2	0	2	4%	0%	2%
Worse Success	0	2	2	0%	6%	2%
Habitat Obstructed	0	2	2	0%	6%	2%
Increase in Species Number	2	0	2	4%	0%	2%
Decrease in Resource Size	2	0	2	4%	0%	2%
Take Fewer Trips	0	1	1	0%	3%	1%
More Difficult	0	1	1	0%	3%	1%
Travel Farther to Harvest Resource	1	0	1	2%	0%	1%
Use Area Changed	0	1	1	0%	3%	1%
Harvest Season Changed	0	1	1	0%	3%	1%
Increase in Resource Size	1	0	1	2%	0%	1%
Change in Resource Behavior	1	0	1	2%	0%	1%
Resource Injury	1	0	1	2%	0%	1%
Abnormal Migratory Event	1	0	1	2%	0%	1%
Total Observations	51	35	86	100%	100%	100%
Total Number of Dolly Varden Char Change Observers	28	13	41	N/A	N/A	N/A

SRB&A 2008

N/A = not applicable

Eleven Kivalina observations cited physical abnormalities in Dolly Varden char (Table 3.12-20), including physical deformities, open sores, patchy or peeling skin, and cysts with pus (SRB&A 2009). Nine of the 11 did not know the reason for the change (Table 3.12-21). No more than two cited any single reason. Related to the 11 observations of physical abnormalities in Dolly Varden char is eight observations of a change in the texture of Dolly Varden char meat made by Kivalina residents (Table 3.12-20). These residents observed that the fish are not as firm as they were in the past. As one individual said: “I saw some char like they are elders or something. They don’t really cut very well. It looked good, but when you touch it, it is real soft and when you try and cut it, it is real soft" (SRB&A Kivalina Interview January 2008). In contrast to Kivalina subsistence users, Noatak residents did not note any changes in the texture or physical appearance of the resource, although three observations were made regarding diseases or infection of Dolly Varden char (Table 3.12-20).

Table 3.12-21 Reasons for Change in Dolly Varden Char – Physical Abnormalities

	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Water Contaminated by Mine	2	0	2	18%	0	18%
I Do Not Know	9	0	9	82%	0	82%
Total	11	0	11	100%	0	100%
All Mine Related Causes	2	0	2	18%	0	18%

SRB&A 2008

3.12.2.6 Vegetation

Harvest Trends

Residents of the study communities have indicated that harvests of berries vary from year to year based on the amount of rain and snow the area receives. During years of abundant berry growth, berry harvests are substantial. Local residents generally try to harvest enough berries to last until the next berry picking season. Plants are harvested in smaller quantities than berries, but are still a valuable resource to residents.

Kivalina. In recent harvest surveys (1992 and 2007) berry harvests provided 13 to 17 pounds per person during these two years (Table 3.12-2). In 2007, berries were the fourth most harvested resource after bearded seal, Dolly Varden char, and caribou (Appendix D: Table 9). Comparison of current and pre-mine per capita amounts show an increasing trend in Kivalina households' use of berries from 1959 to 2007 (Table 3.12-2) Harvests of plants and wood by Kivalina residents provided one and two pounds per capita in 1992 and 2007 respectively. According to Table 3.12-3, Kivalina residents' use of plants and wood has changed little since the 1959–60 study, with a high amount of interannual variability over time.

Kotzebue. The most recent Kotzebue harvest data for berries are for the year 1991 and show a high percentage of households using (92 percent) and harvesting (83 percent) berries (Appendix D: Table 10). During that year, berries provided 15 pounds of subsistence foods per capita. In 1986 the berry harvest provided approximately seven pounds per capita (Table 3.12-3). Compared to earlier harvest data years, per capita harvests in 1991 were high. Given the available data, Kotzebue residents' harvests of plants have remained relatively stable, with each harvest year showing a per capita harvest of approximately one pound (Table 3.12-3).

Noatak. Noatak berry harvests rose dramatically between 1994 and 2007, with residents picking over four times as many berries in 2007 (Appendix D: Table 12). In 1994, harvests of berries provided four pounds per person, while in 2007 households harvested approximately 16 pounds of berries per person. Comparison to earlier harvest data from the 1960s and 1970s indicates a possible increase in residents' harvest of the resource (Table 3.12-4). Foote and Williamson (1966), who collected the 1960–61 harvest data, noted that the summer of 1960 was especially dry and produced few berries. Uses of plants by Noatak residents rose in 2007 from 1994, with 51 percent of households using the resource in 2007 as opposed to only 22 percent in 1994 (Appendix D: Table 12). The total amount of plants harvested, however, did not change much. Compared to earlier plant harvest data from the 1970s (1960–61 plant harvest data is not available) (Table 3.12-4), plant and wood harvests have declined somewhat; however, this may be a result of fewer residents harvesting wood for fuel in recent years.

Subsistence Use Areas, Seasonal Round, and Harvest Patterns

Kivalina. For the 1998–2007 time period, Kivalina berry harvesters reported picking berries primarily during August and September by boat and four-wheeler along the coast and lagoons from Cape Krusenstern to Cape Seppings as well as by boat along the Kivalina and Wulik rivers (Figure 3.37). The greatest concentration of overlapping berry use areas is found along the perimeters of Kivalina and Imikruk lagoons, and several miles along the Wulik River from the mouth. During 2008 SRB&A interviews, a number of respondents said they no longer harvest berries near the port site as they once had because of concern over ore dust contaminants resulting from trucking and port site activities. These same concerns were also expressed during 2004 interviews in Kivalina (SRB&A 2005:44). For additional discussion of berry use area changes see “Berries Resource Changes” below. Kivalina 1998–2007 plants and wood subsistence use areas are provided in Appendix D. These areas are primarily located at the north end of Kivalina Lagoon and along the Kivalina and Wulik rivers, with a few additional areas along the beach north of Kivalina, and near Rabbit Creek, Kotlik Lagoon and Noatak.

Pre-mine berry and plant subsistence use areas documented by Saario and Kessel (1966) and Braund and Burnham (1983) are located along the Kivalina and Wulik rivers, and along Kivalina and Imikruk lagoons. Kivalina’s lifetime berry and plant use areas are depicted on Figure 3.37 and cover a much more expansive area than more recent use areas, including the coastline and inland areas from Sheshalik to Cape Seppings, entire lengths of the Kivalina and Wulik rivers, and other areas near Kotzebue, Noorvik, and Shishmaref.

Noatak. Noatak subsistence users described berry use areas for the 1998–2007 time period along the Noatak River, around the community, and at various other coastal locations between the mouth of the Noatak River and Cape Krusenstern, at Rabbit Creek, and near the communities of Kivalina and Kotzebue (Figure 3.38). The highest frequencies of overlapping use areas shown on Figure 3.38 are located around the community of Noatak, along the Noatak River between the Kelly and Agashasok rivers, along Paul Slough, at Sheshalik, and near Krusenstern Lagoon. Compared to pre-mine berry use areas (also shown on Figure 3.38), current use areas for berries occur along a substantially larger segment of the Noatak River (although pre-mine berry use areas are located in a slightly larger overland area east of the river), as well as in locations near other communities, indicating that Noatak berry use areas have not changed over the last 20 years.

Noatak residents reported harvesting plants, including sourdock (wild spinach), wild potato (*masu*), Hudson’s Bay tea, stinkweed, and wild onion; and wood from 1998–2007 at various locations along the Noatak River, along the coast from Sheshalik to Cape Krusenstern (Sealing Point), and near Kotzebue (Appendix D). Pre-mine lifetime use areas for wood are along the Noatak River from the Kelly River to the mouth. Several Noatak residents indicated that fewer residents currently harvest wood resulting from the increasing use of stove oil for heat (SRB&A 2009).

Vegetation Resource Changes

Vegetation (including berries) surrounding the DMTS has been affected directly and indirectly by operations related to the Red Dog Mine. Local uses of vegetation have also been affected. The main direct effect on vegetation is the construction of the port site, road, and mine site, and the accompanying loss of vegetation in those areas. Another effect is contamination of vegetation from fugitive dust related to mine operations. Vegetation near the port site, road, and mine facilities has higher levels of metal and dust concentrations; the highest concentrations of dust are located along the DMTS road near the port site, and on the north side of the road (see Section 3.7.2). Residents once harvested berries at the port site, but many now avoid that area because of concerns of contamination (SRB&A 2005). Others choose to continue picking berries in the port site vicinity. Subsistence users in Kivalina have noticed changes in the color and health of vegetation along the road and near the port and have blamed the changes on increased

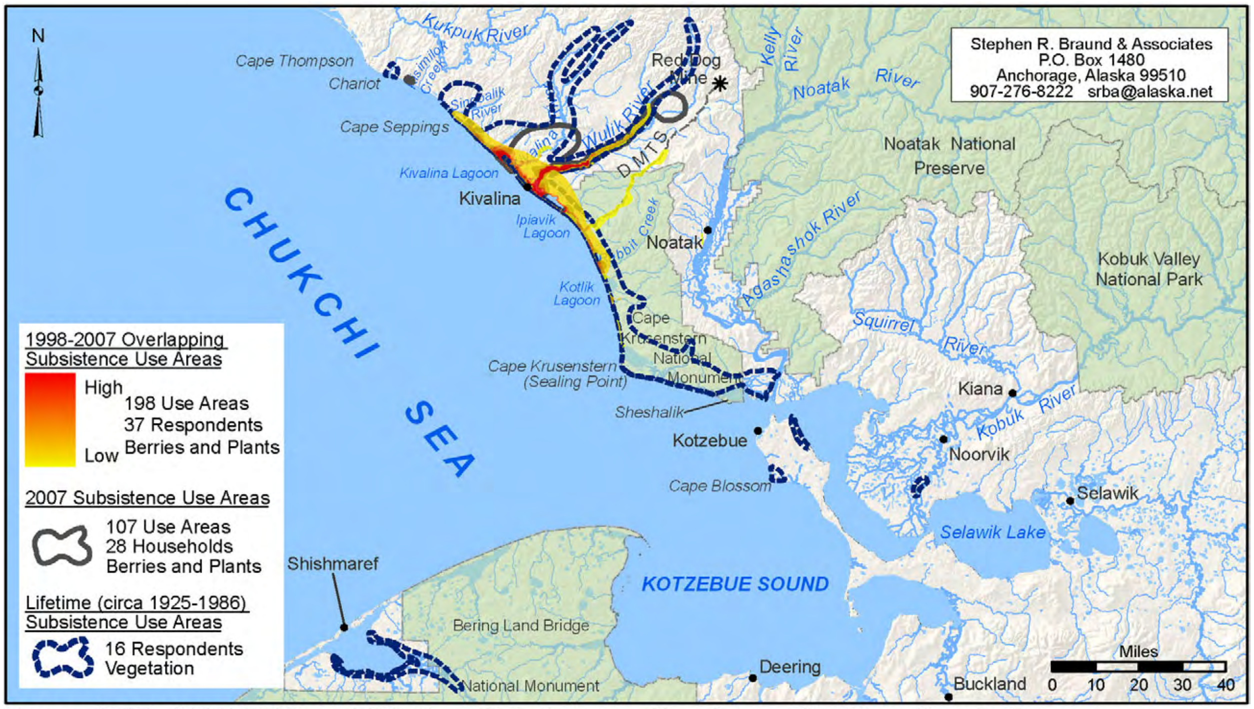

Figure 3.37: 1998-2007 and Lifetime Subsistence Use Areas Kivalina, Vegetation

Figure 3.38: 1998-2007 and Lifetime Subsistence Use Areas Noatak, Vegetation

Sources:
1998-2007: Stephen R. Braund and Associates (SRB&A) Forthcoming.
2007: Magdanz et al. 2008.
Lifetime: Schroeder, R., D. B. Anderson (ADF&G) and G. Hildreth (Maniilaq Association) 1987.

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For all data sets, other areas may have been used for resource harvesting.

amounts of dust and metals. One person described flying over the port site and seeing a "perfect circle around it of brown and orange" (SRB&A 2005). Residents have primarily voiced concerns about effects of the Red Dog Mine on berries, although it can be assumed that concerns about effects on harvested plants are similar.

Samples of salmonberry were collected by E&E in 2001 (cited in Exponent) and by Exponent in 2001 and 2004. Samples of sourdock were collected by E&E in 2001 and by Exponent in 2004. Six metals were detected in the samples: antimony, barium, cadmium, lead, thallium, and zinc. Washed and unwashed samples were analyzed, but there was no significant difference between the concentrations in washed and unwashed samples. However, to be conservative, only the data for unwashed samples were used in the 2007 DMTS risk assessment. The exposure point concentrations (EPCs) used in the DMTS risk assessment for berries and sourdock were based on the lower of the 95 percent UCL or the maximum measured concentration (as per EPA risk assessment guidance). The EPCs (as mg/kg wet weight) for berries were: barium 0.078, cadmium 0.052, and zinc 4.7. The EPCs for sourdock were: antimony 0.012, barium 10.6, cadmium 0.013, thallium 0.00049, and zinc 5.4. The EPCs for lead were based on the mean concentration and were 0.15 mg/kg for berries and 0.21 mg/kg for sourdock. A summary of the data used to calculate the EPCs for berries and sourdock is located in Table 5-2 of Exponent (2007).

The potential risks to subsistence users consuming berries and sourdock were calculated in the DMTS risk assessment for adults and children, as well as for adult DMTS workers. The metals in berries and sourdock are not carcinogenic via oral ingestion, so it was necessary to only calculate non-cancer risks (based on Hazard Indices [HIs]). All of the calculated HIs were well below 1.0, thus indicating no potential risk of non-cancer health effects from consumption of berries or sourdock. The HIs for consumption of berries were 0.0007 for adults, 0.002 for children, and 0.0004 for adult DMTS workers. The HIs for consumption of sourdock were 0.0002 for adults, 0.0005 for children, and 0.0001 for adult DTMS workers. Blood lead levels were not calculated separately for consumption of berries or sourdock, but rather were calculated for all sources of lead exposure including consumption of berries and sourdock. The modeled blood lead levels were all less than the level of concern of 10 ug/dL.

Berries Resource Changes. Contamination of berries is still a concern to residents and was raised during scoping meetings. During interviews in 2008, 50 percent of Kivalina harvesters interviewed and 22 percent of Noatak harvesters interviewed made observations about changes in berries (Table 3.12-1). The principal changes observed in berries were: (1) use area changed; (2) habitat disturbed/destroyed; (3) decrease in species number; and (4) increase in species number (Table 3.12-22). Residents also pointed out various changes related to the health or quality of berries, including dust on vegetation, decrease in resource size, change in texture or color, change in taste, increase in resource size, contamination, physical abnormalities, resource appears unhealthy, and resource no longer edible.

Nine Kivalina harvesters reported a berry use area change. All nine attributed the change to dust from mine related activities (Table 3.12-23). Residents indicated that there are areas where they used to harvest berries that they no longer use because of observed or perceived contamination resulting from port site/barge activities, mine activities and traffic along the DMTS road. One person described the area affected as "a two mile radius around the port and the road, the sides of the road, and the mine" (SRB&A Kivalina Interview January 2008).

3.12.2.7 Subsistence and Employment

SRB&A interviews included a brief questionnaire regarding residents' employment history related to the Red Dog Mine, including Teck and their subcontractors, and those companies' subsistence leave policies. Researchers asked Kivalina and Noatak respondents if they had worked for any company associated with the Red Dog Mine, whether that company had a subsistence leave policy, and if the policy worked for the respondent. Table 3.12-24 summarizes both communities' responses. A total of 58 respondents provided

Table 3.12-22 Observations of Berries Resource Changes

Observation	Number of Observations			Percent of Observations		
	Kivalina	Noatak	Total	Kivalina	Noatak	Total
Use Area Changed	9	0	9	29%	0%	18%
Habitat Disturbed/Destroyed	6	1	7	19%	5%	14%
Decrease in Species Number	2	4	6	6%	21%	12%
Increase in Species Number	2	3	5	6%	16%	10%
Dust on Vegetation	3	0	3	10%	0%	6%
Decrease in Resource Size	0	3	3	0%	16%	6%
Change in Texture/Color of Berries/Plants	3	0	3	10%	0%	6%
More Difficult	0	2	2	0%	11%	4%
Worse Success	0	2	2	0%	11%	4%
Taste	2	0	2	6%	0%	4%
Harvest More	0	1	1	0%	5%	2%
Harvest Less	1	0	1	3%	0%	2%
Resource Distributed over Larger Area	0	1	1	0%	5%	2%
Increase in Resource Size	0	1	1	0%	5%	2%
Contamination	1	0	1	3%	0%	2%
Physical Abnormalities	0	1	1	0%	5%	2%
Resource Appears Unhealthy	1	0	1	3%	0%	2%
Resource No Longer Edible	1	0	1	3%	0%	2%
Total Observations	31	19	50	100%	100%	100%
Total Number of Berries Change Observers	22	11	33	N/A	N/A	N/A

SRB&A 2008

N/A = not applicable

Table 3.12-23 Reasons for Change in Berries – Use Area Changed

Cause	Number of Observations		
	Kivalina	Noatak	Total
Contaminated by Ore Dust from Trucks	6	0	6
Contamination due to Mining Activities	1	0	1
Contaminated by Ore Dust from Barges and Port	2	0	2
Total	9	0	9
All Mine Related Causes	9	0	9

SRB&A 2008

98 employment experiences related to the Red Dog Mine. Of the 98 experiences, 24 percent had a subsistence leave policy, 46 did not have a subsistence leave policy, and 30 percent were unknown. Of the 26 records citing that a subsistence leave policy existed, respondents reported that 42 percent said the policy worked, 12 percent said the policy did not work, and 46 percent did not know if the policy worked. A number of individuals who did not know whether a policy existed reported working temporary/seasonal jobs and were unaware of a subsistence leave policy or did not ask about one, because their goal was to work as much as possible for the duration of their temporary/seasonal job. Several individuals reported the company they worked for did not have a subsistence leave policy and that they would carry out their subsistence activities during their off weeks or during their paid time off. One person describing their employment experience with Teck said:

> We had PTO – paid time off. It was only two weeks on, one week off. That one week we would do our subsistence. If we needed time off, we took PTO. It builds up, depending on how much you work. I wouldn't say much for [employer]: it was kind of like a contract. And Cominco is different, they're long term and they have a human resources office. Teck Cominco, they have

> everything there, human resources, people you can go talk to (SRB&A Noatak Interview January 2008).

Table 3.12-24 Subsistence Leave Policy Responses, Kivalina and Noatak

Company Name/Type	Did Company Have a Subsistence Leave Policy?					Did Policy Work?				
	# of Employment Experiences	Yes	No	Do not know	Total	Number of records citing policy existed	Policy worked	Policy did not work	Do not know if policy worked	Total
Teck	40	34%	37%	29%	100%	16	44%	6%	50%	100%
NANA	15	33%	33%	33%	100%	5	20%	20%	60%	100%
Current Contractors	12	0%	82%	18%	100%	0	N/A	N/A	N/A	N/A
Construction Contractors	22	10%	55%	35%	100%	2	100%	0%	0%	100%
Other Companies	9	25%	38%	38%	100%	3	33%	33%	33%	100%
Total	98	24%	46%	30%	100%	26	42%	12%	46%	100%
Number of Respondents = 58										

SRB&A 2008

N/A = not applicable

Researchers also asked respondents if the subsistence leave policies could be improved. Individuals recommended that companies without subsistence leave policies should incorporate one into their company. Others provided general recommendations that the companies should be more lenient towards employees needing time off for subsistence purposes, or should allow employees to accrue subsistence leave hours, and others provided specific suggestions regarding subsistence leave including the following:

> Just in regards to Kivalina side, whaling is usually the best time of the year like March, April, and May and they could grant the Kivalina guys more paid leave for hunting and whaling. Whaling season (SRB&A Kivalina Interview January 2008).

> Yeah, [employees should get] at least two days off. Two to three days off to hunt caribou. I was a hopper crew operator and mill operator (SRB&A Kivalina Interview January 2008).

In general, respondents were unsure if a subsistence leave policy even existed or stated that the companies they worked for never had such a policy. Lack of communication between the companies and their employees regarding subsistence leave appears to be the primary reason for respondents' uncertainty. Employees may be better able to plan their subsistence activities if company policies were more clearly articulated.

3.12.3 Subsistence – Environmental Consequences

3.12.3.1 Effects Common to All Alternatives

As stated under the baseline conditions analysis, which includes an assessment of the effects of mining activities to date, traffic along the DMTS road, without additional mitigation actions, has likely resulted in a lower harvest of caribou by Kivalina harvesters than would otherwise be the case. This assessment is based on interviews with active harvesters from Kivalina, in addition to harvest data and the conclusions in Section 3.9, Wildlife. Continued traffic along the DMTS road under the same mitigation practices is likely to continue to affect Kivalina caribou harvests from what harvests would be without DMTS road activity. However, based on SRB&A 2008 resource change interviews, some residents felt that a change in mitigation practices would be to stop traffic when caribou are present, which could reduce the effect of DMTS road activity on the displacement of caribou. One suggestion (discussed in more detail below) was to use an independent observer to determine when to close the road to traffic rather than relying on the truck drivers. The policies for closing the road are established in an agreement between NANA and Teck and are beyond the authority of the agencies involved in developing this SEIS.

The magnitude and duration of the effect of mining activities on the Kivalina caribou harvest differs by alternative and the choice of mitigation practices. These differences are discussed below.

Again, as stated under the baseline conditions analysis, port activities have likely resulted in a lower harvest of beluga by Kivalina harvesters than would otherwise be the case. This effect would likely continue as long as port activities continue, and is therefore an effect common to all alternatives. The magnitude and duration of the mining activities on Kivalina's beluga harvest differs by alternative and the choice of mitigation practices. These differences are discussed below.

Fugitive dust caused by mine activities would also continue to some extent under all alternatives. Residents would likely continue to avoid certain berry picking areas due to concerns about contamination, and concerns about contamination of caribou, fish, and other subsistence resources would continue among local subsistence users. These impacts would be most prevalent among subsistence users in Kivalina; however, residents of Noatak have also expressed similar concerns (see relevant discussions in Section 3.12.2).

Clearly, concerns have been identified about the effects of DMTS port activity, traffic, and fugitive dust on subsistence resources since operations began. NANA and Teck have noted that the Subsistence Committee determines when shipping activities can commence after hunting activities have ceased. While the function of the Subsistence Committee is also outside the scope of the SEIS, the SEIS recommends that Teck, NANA, and the Subsistence Committee review its policies and procedures, and, potentially, the way the committee interacts with the citizens of Kivalina and Noatak. The goal of the review should be to find ways to more effectively respond to locals' concerns about mine related effects on subsistence in the future.

3.12.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A, current mining operations would continue until 2011. Impacts to subsistence uses resulting from these activities would continue to occur until mining operations cease. Some impacts would continue after mining operations cease. These impacts include those related to continued use of the DMTS road for maintenance and loss of berry picking areas. Residents would likely continue to avoid certain areas, such as those near the port site and along the DMTS road, due to concerns about contamination. In addition, loss of employment related to the Red Dog Mine could have long-term impacts on subsistence for local communities. Subsistence generally requires income to purchase gasoline, equipment, and supplies. Many households, especially those in Kivalina and Noatak where jobs related to the Red Dog Mine account for between 30 and 50 percent of employment (Figure 3.49), will experience reduced income with closure of the Red Dog Mine. These households may have increased difficulty participating in subsistence activities unless other sources of income are found.

Land Mammals

Mine and port site facilities, including the DMTS road, have not been shown to alter the overall migratory patterns of the WAH; however, localized effects from mine operations have affected caribou movement and distribution (Section 3.9.2, Wildlife). Local observations of change regarding harvesting fewer caribou and caribou migration/distribution, as well as lower per capita caribou harvest levels since the development of the mine indicate that these localized effects, resulting from mine and port site operations, may affect local caribou harvests of Kivalina residents. These effects would continue to occur under

Alternative A. The combined effects of localized impacts on caribou movement from mine operations, in addition to effects on caribou migration/distribution resulting from changes in food availability, increased recreational activity, changes in hunting methods, and predator pressures are substantial, decreasing the total harvest of subsistence resources by Kivalina residents. Further declines in caribou harvests may lead to residents expanding their hunting grounds, causing increased competition for subsistence users who currently hunt in those areas.

The effects of continued mining operations until 2011 on caribou harvests could be reduced through a change in mitigation actions. During interviews in 2008, local subsistence users discussed possible mitigation strategies related to the displacement of caribou. Residents' suggestions included increased enforcement of existing regulations, appointment of an independent observer who would ensure that concentrate trucks stop during caribou migrations, and closure of the DMTS road during caribou migrations. Residents' comments include the following:

> They need someone who is not connected to Teck Cominco, who is independent, who can say when these concentrate trucks can continue, end of July, August, September, October. And it would have to be more than one person, because there are several areas the caribou cross the road (SRB&A Kivalina Interview January 2008).
>
> They can stop running their trucks when it is time for the caribou. Can't they stock up what they have to bring down and let the caribou pass? Just for a short period of time. Because usually when they pass they are on the other side, it doesn't take them long. At least give them a week (SRB&A Kivalina Interview January 2008).
>
> They always tell us let the first bunch pass, don't hunt or disturb them. You can hunt all you want after the first bunch go through. When they built the road we told them that if you want the caribou to migrate through, crossing the road, you are going to have to stop the traffic. The first bunch is coming, you will have to let them cross... They were told [to stop trucks]. Some up there are trying but the drivers don't want to sit for one hour or two hours (SRB&A Kivalina Interview January 2008).
>
> If I had control, the traffic would stop as soon as the migration started. They have to migrate through. You need a guy on site who knows what they are doing. You need a guy at the port who has authority to say when the caribou are migrating. They need to be connected to the Subsistence Committee. He would not be a Teck Cominco employee with fear of losing his job; he would be a NANA employee. He would be neutral, preferably a local (SRB&A Kivalina Interview January 2008).

The DMTS risk assessment (Exponent 2007a) concerning ecological and human health risks associated with contamination from metal deposition at the mine, DMTS road, and port site found higher concentrations of metals near the mine and DMTS port as well as north and west of the DMTS road. Exponent concluded in the DMTS risk assessment that these concentrations did not pose a human health risk and that harvests of subsistence resources could continue in all areas. EPA's interpretation of the DMTS risk assessment was that some uncertainty existed in how the caribou data were analyzed. EPA recommends that additional caribou data be collected as part of the fugitive dust risk management plan (see Section 3.13.2.1). However, EPA is not advising people to avoid caribou consumption. See Sections 3.9.2 (Wildlife), and 3.10.2 (Aquatic Resources) for further discussion of DMTS risk assessment results. Despite these assurances, local residents, the majority of whom live in Kivalina, have expressed concern over contamination to certain subsistence resources, including caribou. A number of individuals avoid harvesting caribou near the DMTS because of these contamination concerns (see Section 3.12.2.17). Residents' concerns would continue over the life of the mine, and possibly after mine closure due to the presence and use of the road for maintenance purposes.

Marine Mammals

While the overall migratory movements of marine mammals have not changed, local displacement of beluga near the port site due to concentrate loading operations does occur (Section 3.9.2). Local observations regarding changes to beluga migration/distribution due to the port site combined with a decrease in the number of summer beluga harvests may indicate that the local displacement of beluga resulting from concentrate loading operations contributes to Kivalina residents' decline in summer beluga harvests. Port site operations are not the only possible cause for the decrease in Kivalina's beluga harvests; other factors include noise from outboard motors, particularly when used to hunt belugas. Changes to the marine environment, including ice conditions, affect beluga migration/distribution (Corps 2005). Use of outboard motors to hunt beluga as well as changing ice conditions have occurred in other beluga harvesting communities, such as Kotzebue, Noatak, and Point Lay, yet among those communities, Kivalina has the lowest recorded total beluga harvests from the Chukchi Sea stock since 1986 (Table 3.12-25).

Table 3.12-25 Beluga Harvest Amounts, Chukchi Sea Stock

	Kivalina	Kotzebue, Noatak	Point Lay
1987	0	2	22
1988	1	8	40
1989	0	37	16
1990	1	6	62
1991	1	11	35
1992	0	5	24
1993	0	6	77
1994	0	7	56
1995	0	4	31
1996	0	68	41
1997	1	7	3
1998	0	4	48
1999	0	2	47
2000	1	0	0
2001	0	9	34
2002	3	4	47
2003	0	0	36
2004	0	1	53
2005	0	1	41
2006	0	2	29
Total	8	184	742

SRB&A 2008

Under Alternative A, localized displacement of beluga near the port site will continue to occur through the closure of the mine in 2011 and Kivalina residents will likely continue to experience reduced summer harvests. Several Kivalina residents also expressed their concern that port site operations and noise may be affecting bowhead spring migration. Noise produced at the port site during the spring migration usually does not extend beyond a few hundred yards from shore, with noise from occasional maintenance work detectable up to approximately 3.7 miles offshore (Corps 2005). Bowhead whales do not typically migrate along the coast near Kivalina in the spring, but rather follow open leads three miles or farther from shore (Section 3.9). Unlike beluga, Kivalina bowhead harvest numbers do not appear to have changed considerably since mine operations began. Given the low activity level at the port site during spring migration and the distance that bowheads usually migrate from the shoreline, it is unlikely that port site operations and noise affect bowhead migration. Residents provided several suggestions for mitigating the impacts on beluga and bowhead whales. These included delaying open water activities until after the summer beluga migration, and completing port site preparations before the spring migration:

> When they start up there and start getting ready to ship the ore out they could start getting their belts ready early in the winter instead of getting them ready during the spring when the animals are coming up. I know they have to test them with the ship loading before they load the ships (SRB&A Kivalina Interview January 2008).

> If they normally delayed their ships until after the ice goes away…. It can be done. They normally start in June and July, but they should start in August (SRB&A Kivalina Interview January 2008).

Birds

No additional impacts to local residents' subsistence use of birds would occur under Alternative A. Diversion of migratory birds over the port site, as observed by locals and non-locals, may continue to some extent after mine closure as the port site would physically remain in place. However, overall harvests of birds by residents of the study communities have not been affected by local changes in distribution to date, and therefore would not be affected under Alternative A.

Fish

Residents' concerns regarding contamination of Dolly Varden char and other fish would continue under Alternative A until closure of the mine in 2011. Residents expressed concern about the long-term health effects of eating resources potentially contaminated near the mine and DMTS that are later harvested in other subsistence use areas. Residents' suggestions for mitigation of these concerns include paving the DMTS road, improved covering of concentrate trucks, and increased studies on contamination in fish, especially Dolly Varden char. A thorough dissemination of the DMTS risk assessment findings in condensed form to local residents may better inform individuals regarding their concerns of contaminated subsistence resources in the project area.

Vegetation

Under the Alternative A, residents' concerns over the contamination of vegetation will likely continue, as well as avoidance of certain berry use areas. No additional loss of berry picking areas would occur under Alternative A because there would be no changes in the project footprint under this Alternative. Residents expressed concern about the long-term health effects of eating resources potentially contaminated near the mine and DMTS. Residents' suggestions for mitigation of these concerns include paving the DMTS road and improved covering of concentrate trucks. A thorough dissemination of the DMTS risk assessment findings in condensed form to local residents may better inform individuals regarding their concerns of contaminated subsistence resources in the project area.

3.12.3.3 Effects of Alternative B – Applicant's Proposed Action

Under Alternative B current mining activities would continue until 2031, extending to the Aqqaluk Deposit. Activities at the port site and along the DMTS road would continue as under Alternative A, but for a longer duration of time.

Resource contamination impacts would be the same as Alternative A except extending in duration until mine closure in 2031. Extending the duration of the project would increase the potential for extended and increased exposure to metal contaminants.

Some additional habitat loss would occur under Alternative B due to clearing for the Aqqaluk Deposit; however, it is unlikely that this would result in long-range effects on subsistence resources in the area (see Section 3.9.3.3).

Land Mammals

Impacts to caribou distribution and availability would be the same as Alternative A except extending in duration until mine closure in 2031. As in the case of Alternative A, a change in mitigation actions along the DMTS road could reduce the effect of mining operations on Kivalina caribou harvests.

Residents' concerns about contamination of caribou would continue and possibly worsen over the length of mine operations, and continued avoidance of caribou seen near the DMTS road could result in decreased harvests over time. The effects of decreased subsistence harvests resulting from user avoidance and resource displacement include fewer opportunities to participate in traditional and culturally important activities and decreased access to a nutritionally important food source.

Marine Mammals

Effects of port site operations on beluga harvests would be the same as Alternative A except the duration would be through 2031 rather than 2011, and the impacts related to port site operations may worsen over the duration of mine operations.

Birds

Impacts to subsistence uses of birds would be the same as Alternative A, except the duration would be through 2031 rather than 2011.

Vegetation

Contamination of vegetation due to fugitive dust would be the same as Alternative A, except extending until 2031. Residents' concerns about contamination of berry and plant resources would continue and possibly worsen over the length of mine operations, and continued avoidance of berry use areas could result in decreased harvests of berries and plants over time, particularly for Kivalina residents. The effects of decreased harvests resulting from user avoidance from fear of contamination include fewer opportunities to participate in traditional and culturally important activities, and decreased access to a nutritionally important food source.

3.12.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Alternative C would be the same as Alternative B except that buried pipelines would be installed parallel to the DMTS road between the mine and port sites for transport of concentrate, wastewater discharge, and diesel fuel. In addition, wastewater discharge would be redirected to occur in the Chukchi Sea rather than in Red Dog Creek. Construction of the pipeline would require removal of vegetation and incorporation of a 24-foot-wide bench into the DMTS road. The pipeline would be removed upon closure of the mine, causing further disturbance of vegetation. Use of the pipeline to transport concentrate would substantially reduce the amount of traffic along the DMTS road. Activities at the mine and port site would otherwise remain the same as Alternative B.

Land Mammals

Current mine and port site operations, which include vehicle traffic along the DMTS road, cause limited localized effects on caribou movement and distribution (see Section 3.9). Multiple observations by Kivalina and Noatak residents attribute displacement of caribou and the subsequent decrease in resource harvests to DMTS road traffic. Under Alternative C a slurry pipeline for lead and zinc concentrate as well as a diesel fuel pipeline would reduce vehicle traffic along the DMTS road by eliminating the use of fuel trucks and concentrate trucks that currently generate an average of 36 trips per day between the mine and the port. Decreasing the overall number of daily trips along the DMTS road would reduce the localized effects on caribou movement caused by mine and port site operations, in turn reducing the potential impact on caribou availability to local subsistence users. Depending on the time of the year, the construction of the pipeline may temporarily displace caribou, making their movements less predictable for local subsistence users. The Section 404 permit could limit construction to periods outside the migration season.

Marine Mammals

Impacts to marine mammal distribution and availability would be the same as Alternative B. Construction and installation of the wastewater outfall in marine waters near the port site may temporarily displace marine mammals from the port site area resulting from noise and temporary changes in water quality from dredging (see Section 3.9.3.3). Local residents, particularly Kivalina residents, have reported harvesting marine mammals, particularly bearded seal, near the port site area primarily during the month of June. Installing the wastewater pipeline following marine mammal migrations through the port site area would minimize the impact on residents' marine mammal subsistence activities. This restriction could be accomplished through the Corps Section 10 permit.

In addition to reducing the dispersal of fugitive dust along the DMTS road, Alternative C proposes disposing of wastewater via pipeline into the Chukchi Sea. Discharging wastewater into the Chukchi Sea rather than Red Dog Creek would likely alleviate residents' concerns regarding contamination of fish resources in the Wulik River; however, new concerns would likely be raised about discharging wastewater into the port site area and potential contamination of marine mammal resources. As discussed in Section 3.5, the size of the mixing zone would be very small (less than 10 feet in any direction) under all sea conditions and pollutant concentrations in the mixing zone would only be harmful through extended exposure by aquatic organisms. As a result, marine mammals which would only briefly pass through the mixing zone would not be affected. Residents, however, could perceive that the mammals are affected. This may result in avoidance of marine waters surrounding the port site area for marine mammal resource harvesting.

Birds

Impacts to subsistence uses of birds would be the same as Alternative B.

Fish

In addition to reducing the dispersal of fugitive dust along the DMTS road, Alternative C proposes disposing of wastewater via pipeline into the Chukchi Sea. In effect, this Alternative would reduce the amount of TDS concentrations in Red Dog Creek, but the removal of Outfall 001 would reduce flow in Red Dog Creek, thereby reducing the dilution of naturally occurring metal concentrations. As discussed in Section 3.10.3.5, findings by Exponent (2007a) and Ott and Morris (2004) concluded that fish within the project area appear healthy, have tissue concentrations within the range of concentrations in other similar Alaska systems, and that the exposure to metals at stream crossings was unlikely to have negative effects on fish abundance. This section further explains that changing the discharge of wastewater from Red Dog Creek to the Chukchi Sea would have neither positive nor adverse effects on fish resources in the Wulik or Ikalukrok rivers. However, subsistence users, particularly residents of Kivalina, have concerns that discharge of wastewater into Red Dog Creek is contaminating their fish resources, particularly in the Wulik River, and that abnormal fish deaths ("fish kills") may be caused by the contamination (see "Fish Resource Changes"). Discharging wastewater into the Chukchi Sea rather than Red Dog Creek would likely alleviate residents' concerns regarding contamination of fish resources in the Wulik River;

however, new concerns may be raised about discharging wastewater into the port site area and potential contamination of marine fish. Returning water discharges to Red Dog Creek after the closure of the mine, as proposed under this Alternative, may reintroduce residents' concerns regarding contamination of fish resources in the Wulik River.

The potential for pipeline spills of slurry, diesel fuel, or discharge water near stream crossings may also create new contamination concerns for local users. Although Kivalina residents do not harvest fish in waters along the DMTS road, any spill of contaminants from the pipeline resulting in a direct fish kill could negatively affect Kivalina or Noatak residents' downstream harvests of fish or pose a health risk to local residents.

Vegetation

The slurry pipeline proposed under Alternative C would result in reduced dispersal of fugitive dust along the DMTS road. The haul trucks carrying lead and zinc concentrates would no longer be used and traffic along the DMTS road would be reduced to supply trucks and light vehicles. As a result, the escape of dust from the concentrate trucks traveling along the DMTS road would no longer occur and less overall traffic on the DMTS road would reduce the amount of fugitive dust contaminating surrounding vegetation. While the escape of fugitive dust resulting from mine and port site operations would continue to occur, Alternative C would, to some extent, address subsistence users' concerns related to the contamination of vegetation from concentrate dust escaping the truck containers.

3.12.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Alternative D would be the same as Alternative B, except that measures would be taken to enhance dust control through truck cleaning in two enclosed washing facilities on both ends of the DMTS road, and Alternative D includes two subsistence provisions (road and port closure). As under Alternative C, wastewater discharge would occur in the Chukchi Sea rather than Red Dog Creek; however, unlike Alternative C, discharge would continue to occur in the Chukchi Sea after mine closure. As in Alternative C, wastewater would be transported to the Chukchi Sea via a pipeline buried in a bench incorporated into the DMTS road.

Land Mammals

Alternative D includes measures to reduce fugitive dust and the effects of mining activities on caribou harvests. The DMTS road would be closed for one month during the fall caribou migration to reduce displacement of caribou from hunting areas. This road closure provision would incorporate mitigation proposed by local residents recommending closure of the DMTS road during caribou migrations through the area (see Section 3.12.3.2). Because the timing of the caribou migration and associated harvests vary from year to year, it would be impractical to limit the closure of the DMTS road to an assigned month. Caribou can be found near the mine and DMTS road as early as July and migrate in the fall through the project area from August to October (see Section 3.9). Residents reported that caribou migrate from the Noatak area past the mine and DMTS area towards Kivalina in the fall (late August and September), dispersing towards the south by October or November (SRB&A 2009; SRB&A 2000). During interviews in 2008, Kivalina residents reported over 200 caribou subsistence use areas accessed in August and September during the time period 1998 to 2007 and less than 20 use areas accessed in October (Figure 3.39). In addition, Kivalina residents harvested an estimated 90 caribou in 2007 during August and September and only six in October (Figure 3.40; Magdanz et al. 2008).

Comparing these data to harvest by month data from the 1960s and 1980s indicate that there has been a shift in the timing of Kivalina residents' caribou harvesting activities (Figure 3.41). Whereas in the 1960s and 1980s residents generally harvested the majority of their caribou in October, residents in 2007

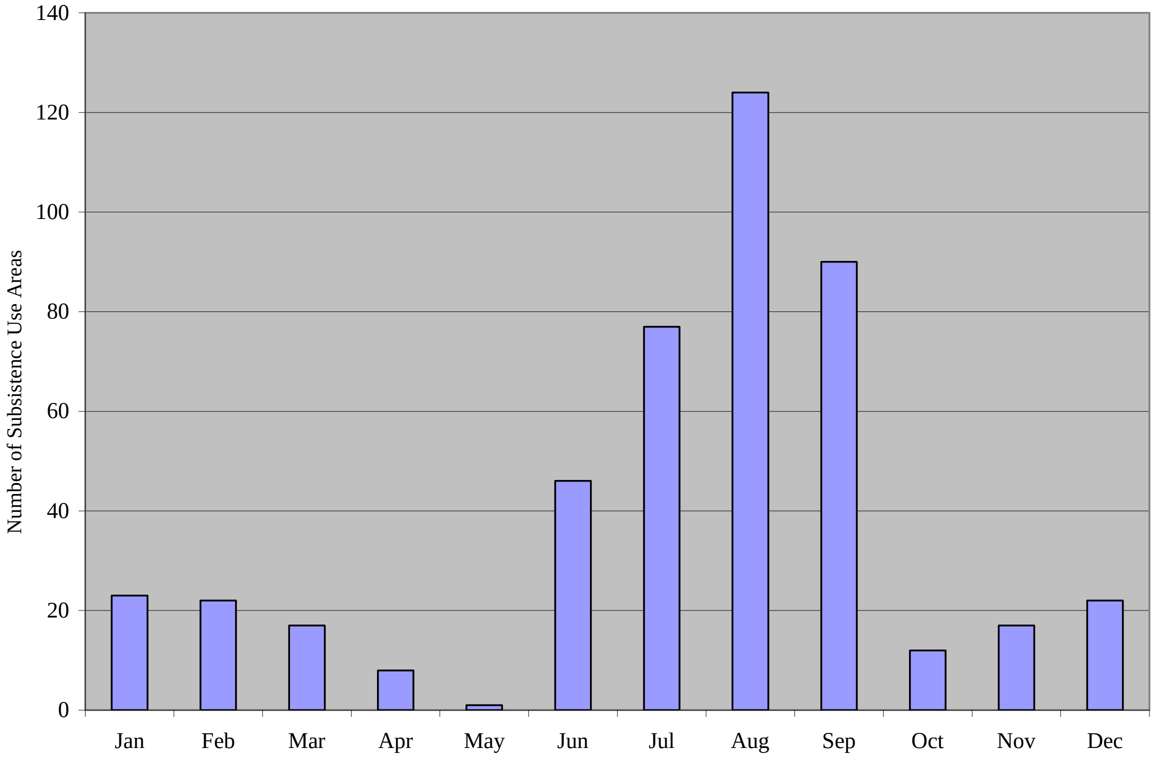


Figure 3.39 Kivalina 1998–2007 Caribou Use Areas by Month

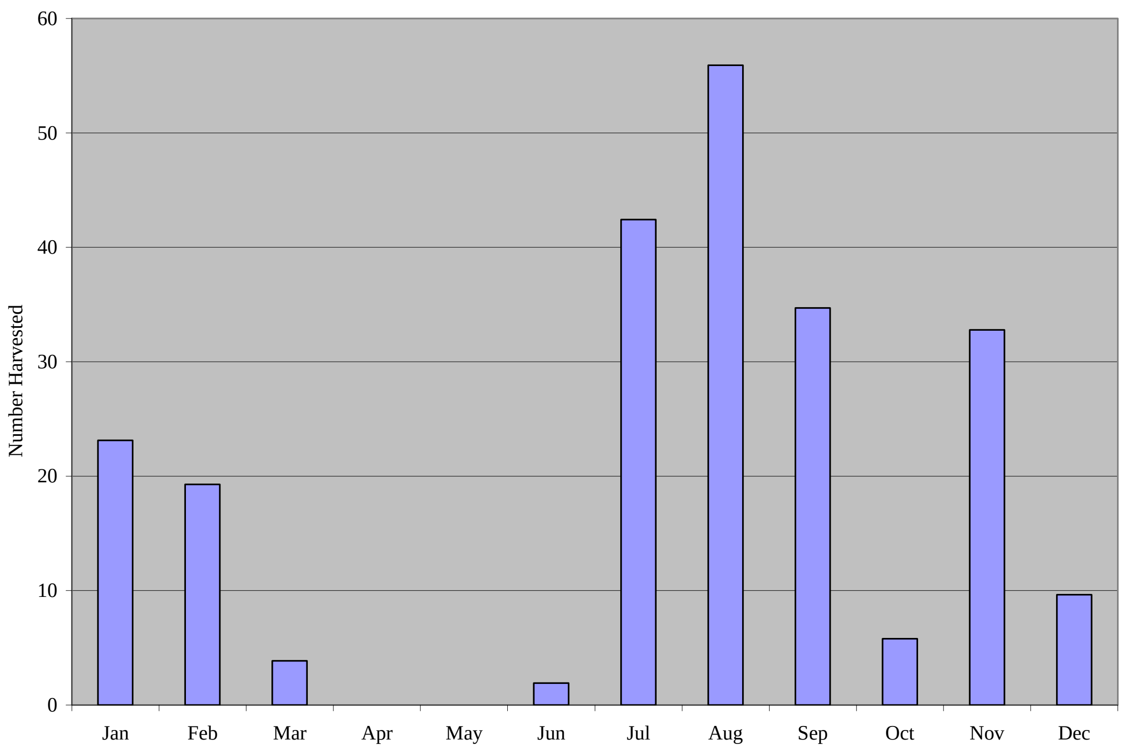


Figure 3.40 Kivalina 2007 Caribou Harvest Amounts by Month

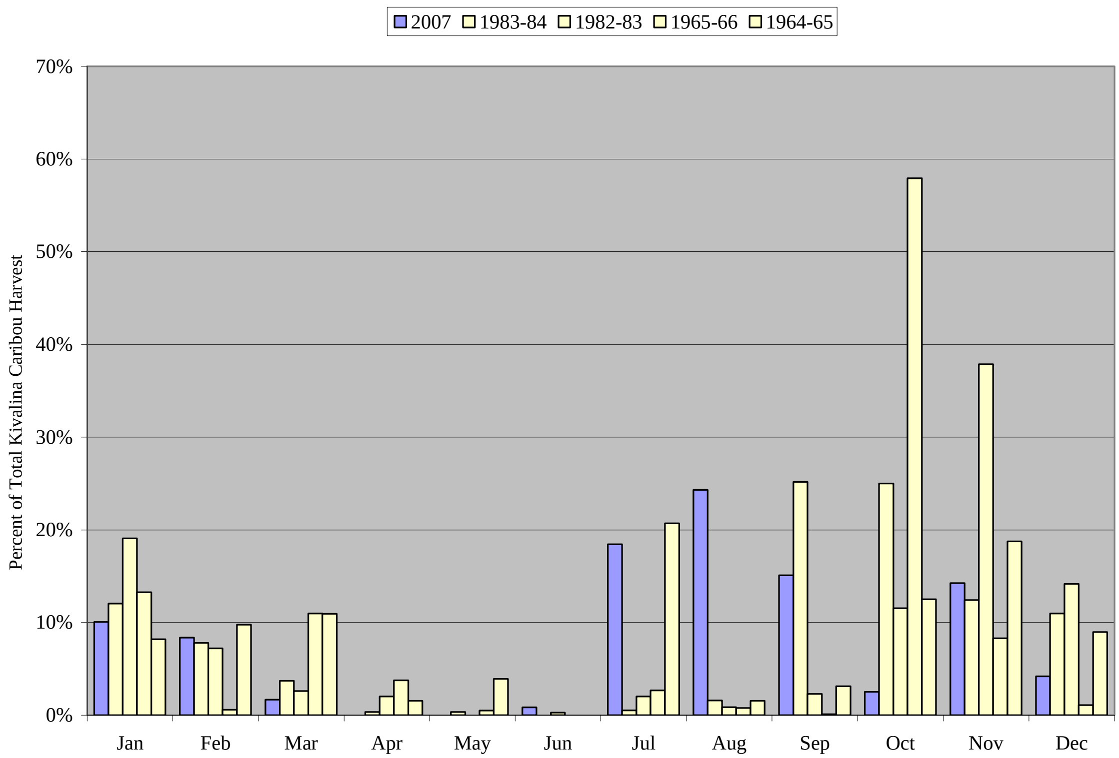


Figure 3.41 Caribou Harvest Percentages by Month, All Study Years

harvested few caribou in October, with the majority of harvests occurring from July through September (Figure 3.41). Although it is unclear why this shift has occurred, it is possible that the change in the timing of their harvests is related to the DMTS road as hunters have suggested. Other possible reasons for the shift in the timing of residents' caribou harvests include an overall change in the timing of the caribou migration, and changes in residents' harvest patterns associated with faster travel methods and technologies facilitating transportation and storage of meat (e.g., freezers).

Marine Mammals

A second subsistence provision under Alternative D would allow for the closure of the port during the Eastern Chukchi beluga migration along the coast during June. This provision could have a beneficial effect on Kivalina's summer beluga harvests by reducing the effect of port site ore loading operations on beluga movements along the coast, reported by some Kivalina residents to be the primary cause of their decreased summer beluga harvests. This provision would incorporate several local residents' mitigation suggestions that the port close during the beluga summer migration to lessen the localized effects of port site operations on beluga movements and availability (see Section 3.12.3.2).

As under Alternative C, wastewater discharge would occur in the Chukchi Sea. Impacts related to subsistence resource contamination associated with the wastewater outfall location would be the same as Alternative C except wastewater generated after the closure of the mine would continue to be discharged into the Chukchi Sea. Impacts from construction and installation of the wastewater pipeline in marine waters near the port site on marine mammals would be the same as Alternative C.

Birds

Impacts to subsistence uses of birds would be the same as Alternative B.

Fish

Impacts to subsistence uses of fish would be the same as Alternative C, except that wastewater discharge would not be returned to Red Dog Creek after mine closure, instead remaining in the Chukchi Sea. Any concerns about contamination of marine fish from discharge near the port site, particularly among Kivalina residents, would continue as long as discharge occurs. Reducing the amount of fugitive dust through enclosed truck washing facilities may reduce local residents' concerns about dust contaminating aquatic resources.

Vegetation

Impacts related to contamination of vegetation resulting from concentrate transport would be the same under Alternative D as under Alternative B except that trucks would be cleaned in two enclosed washing facilities. This may help to reduce local residents' concerns regarding contamination of vegetation resulting from the dispersal of fugitive dust along the DMTS road.

3.12.4 Subsistence – Summary

As discussed in Section 3.12.2.1, the 1984 EIS discussed potential effects of the Red Dog Mine on subsistence uses and on local wildlife used for subsistence purposes. The predicted changes included increased harvest pressure and competition related to an influx of mine employees, changes in resource distribution, wildlife disturbance, declines in wildlife populations, including loss of vegetation, contamination related to dust and spills, and changes in subsistence due to employment. The primary subsistence related changes that have occurred as a result of the Red Dog Mine are related to wildlife disturbances and declines. Contamination continues to be a major concern for local residents but the DMTS risk assessment concluded that the concentrations of metals in subsistence areas did not pose a human health risk, and that harvests of subsistence resources could continue in all areas. To date, subsistence impacts have included effects on: (1) marine mammal movement and associated harvest around the port site; (2) caribou movement and associated harvest along the DMTS road; and (3) vegetation surrounding the port and DMTS road and associated berry picking. Under Alternative A, these effects would lessen after closure in 2011. Under Alternative B, the effects would continue through closure in 2031. The pipeline under Alternative C would lessen impacts on caribou and, potentially, berry picking because of reduced dust emissions. Alternative D would reduce the concentrate component of dust emissions but road dust emissions would be similar to current conditions. Closure of the road during WAH migration and delayed port opening may reduce impacts on caribou and marine mammal subsistence activities.

3.13 Health

This section describes the effects of operations at the Red Dog Mine on health, in terms of public health of area residents (including local workers' families) and industrial health (which includes safety of employees and contractors working at the mine and port facilities). These two separate aspects of health are presented independently, below, based on standard approaches for describing public and industrial health, respectively. Maniilaq Association, representing the cooperating agency interests of nine tribal governments, contributed an analysis of public health issues based on the approach of a health impact assessment with procedures that are discussed in Appendix E.

Appendix F provides descriptions of Kivalina and Noatak, the two villages closest to the Red Dog Mine. Appendix G provides a description of the social conditions within the NWAB. Both of these appendices, along with the discussions of Subsistence (Section 3.12) and Socioeconomics (Section 3.17) provide supplemental information relevant to the discussion of public health.

3.13.1 Health – Pre-mining Environment

3.13.1.1 Public Health

The last 60 years have witnessed a profound improvement in overall health for Alaska Natives throughout the state. In 1950, life expectancy at birth was 46.6 years. By 1960 it had climbed to 61 years, and by 1990, 68.8 years (Goldsmith et al. 2004). These health improvements can, in large part, be attributed to decreases in mortality from infectious disease. In 1954, infectious disease was responsible for over 45 percent of Alaska Native deaths. By 1989 the proportion of deaths caused by infectious diseases had fallen to 1.3 percent (Bjerregaard, Young et al. 2004).

In the NWAB, trends in major causes of illness and mortality in the pre-mining environment follow:

- Age-adjusted cancer mortality rates were 255/100,000 (1979–1983), and increased to 348/100,000 (1984–1989).
- Heart disease mortality increased over this period, from roughly 310/100,000 to 370/100,000.
- Alcohol use and social and psychological problems were disparately common across rural Alaska Native communities in the pre-mining period. While data in the NWAB are limited, these are generally acknowledged locally as long-standing issues.
- Suicide was extremely rare in Iñuit communities prior to 1960, and tended to be confined mainly to elders, according to historical reports (Krauss and Buffler 1976; Hicks and Bjerregaard 2006). From the early 1960s to 1989 the number of suicides increased 500 percent (Alaskan Natives Commission 1992). Suicide not only increased in frequency, but showed a complete demographic shift, and is now a phenomenon confined primarily to youth. Suicide and injury rates tend to parallel psychological and social problems and alcohol use.
- Deaths from unintentional injury between 1979 and 1988 remained fairly constant at roughly 180/100,000 (ANTHC 2008a).
- Diabetes and related metabolic problems are increasing substantially across rural Alaska. Regional prevalence data for the 1980s are not available, but data indicate that the prevalence of these problems likely began increasing rapidly in the 1970s. The following subsections will review more recent trends in health status in the NWAB in greater depth.

3.13.1.2 Industrial Health and Safety

Health and safety conditions at the mine site in the pre-mining environment are not applicable.

3.13.2 Health – Baseline Conditions

3.13.2.1 Public Health

The following subsections describe public health across the following range of categories: general health; subsistence, nutrition, and diet related diseases; social and psychological health; injury; cancer; pulmonary disease; and environmental contaminants. These subsections show that there is overlap among the categories.

General Health Status

As gauged by overall mortality, Alaska Native health status since 1989 has generally continued to improve (Lanier, Ehrsam and Sandidge 2002). Much of the overall improvement in life expectancy correlates to decreasing injury rates in the 1990s. However, the decline in overall mortality rates should not be construed as an indicator of across-the-board health improvement. Indeed, as mortality rates from injury and infectious disease dropped, new health problems emerged, including dramatic increases in the rate of cancer (+120 percent), chronic obstructive pulmonary disease (+191 percent), and diabetes (+262 percent). Today the top six leading causes of mortality for Alaska Natives are: (1) cancer; (2) heart disease; (3) injury; (4) chronic obstructive pulmonary disease; (5) cerebrovascular disease; and (6) suicide. Mortality rates for Alaska Natives exceed “U.S. All Races” for all causes, except heart disease. In the Kotzebue Service Unit, the top six leading causes of mortality are (1) cancer; (2) heart disease; (3) injury; (4) suicide; (5) cerebrovascular disease; and (6) chronic obstructive pulmonary disease. Mortality rates for the Kotzebue Service Unit exceed rates for Alaska Natives for all causes except heart disease. The rate of suicide in the Kotzebue Service Unit is second only to Norton Sound.

A more detailed analysis of mortality rates in the Kotzebue Service Unit is provided below. This includes a review of trend data (where available) and a comparison with statistical data representing “All Alaska Natives”. Where possible, health indicator comparisons are also made with two adjacent and analogous regions, the North Slope Borough to the north, and Norton Sound to the south (see Table 3.13-1). All three are coastal Iñupiat regions with similar village demographics and one major hub community. All three regions are also characterized by their dependence upon two primary economies, traditional (subsistence-based) and cash-based, driven largely by natural resource extraction.

Table 3.13-1 Northwestern Alaska Regional Comparisons

Region	North Slope Borough	NWAB	Norton Sound
Population	6,807	7,334	9,380
Number of Villages	9	11	16
Hub Village (Population)	Barrow (4,065)	Kotzebue (3,104)	Nome (3,540)
Average Village Population (excluding hub village population)	343	423	389
Unemployment Rate	5.9 percent	10.8 percent	12.6 percent
Homes with Water/Sewer (2006)	91 percent	82 percent	70 percent
Infant Mortality (1980–2003)/1000	1.6	1.7	1.9
Greatest Mortality Disparity	Cancer	Suicide	Injury

Source: ADCCED Community Profiles online search, 2008 (Community Data) and ANTHC health data

A number of factors can be identified that have driven health changes over time. Cultural change, or acculturation, can influence both psychosocial health and health behaviors, such as diet composition, exercise, and smoking (Shepard and Rode 1996; Bjerregaard 2001; Curtis et al. 2005). Socioeconomic conditions (discussed in detail in Section 3.17) exert a profound influence on the physical, mental, and social health of individuals and communities. Increased income for individuals, and economically favorable conditions for communities, is associated with powerful improvements in most health outcomes (Brenner 1987; Grandados 2005; Brenner and Mooney 1983; Brenner 2005). The observed health improvements are attributed to the increased per capita resources available for health related spending; improved infrastructure, such as safe roads; water and sanitation; community improvements, including education, health care, public safety and emergency services; lower stress levels; and greater social integration and opportunity (Brenner 1987; Marmot and Wilkinson 2004).

The effects associated with economic development in arctic indigenous communities are complex. Aside from the obvious benefits, the evolution toward a cash economy can also be a source of social strain within subsistence-based indigenous communities. Rapid economic growth in indigenous communities has been associated with alcohol and drug abuse, tobacco use, a decrease in the subsistence diet and an increase in market food diet (Shepard and Rode 1996; Curtis et al. 2005). Less time for hunting, a loss of hunting skills, and an increasing cost of hunting supplies have been cited as reasons for increased consumption of store-bought foods, high in saturated fats and refined sugar. Physical inactivity is also due to an increase in per capita disposable income (Chan et al. 2006). These effects have, in some cases, contributed to an increase in the risk for chronic illnesses, such as diabetes, high blood pressure, obesity, and heart disease.

As discussed in Socioeconomics (Section 3.17), mining has become the dominant economic force in the NWAB. However, the broad economic benefits received by NANA and the NWAB have not necessarily translated into improvements in the public health infrastructure at the local level. A major health concern is lack of adequate water and sewer infrastructure in some villages, and inadequate revenue to operate and maintain water and sewer infrastructure in almost all villages. Inadequate water and sanitation service is not only a cause for health disparities, but also may adversely impact the retention of residents in the villages.

Despite the overall improvement in health indicators, health disparities remain between Alaska Natives and the non-Native population in all regions, including the NWAB. These disparities are discussed in greater detail in subsequent sections. Figure 3.42 illustrates mortality rates in Maniilaq Service Area, North Slope Borough, Norton Sound, all Alaska Natives, and U.S., All Races.

Subsistence and Health

Subsistence is discussed in detail in Section 3.12. This discussion focuses on the relationship between subsistence, diet, and human health. This section reviews the contribution of subsistence diet to nutritional health and chronic diet related diseases, such as diabetes, high blood pressure, obesity, and heart disease; changes in the nutritional system in rural Alaska including the NWAB; and what is known about the causes of observed changes.

Subsistence plays a fundamental and defining role in Iñupiat culture, social structure, and economy, and provides a wide range of well-documented protective health benefits. The continued strength and importance of subsistence in rural Alaska Native communities provides the cornerstone of cultural integrity, psychological health and overall wellness. Subsistence activities also provide an important source of physical activity.

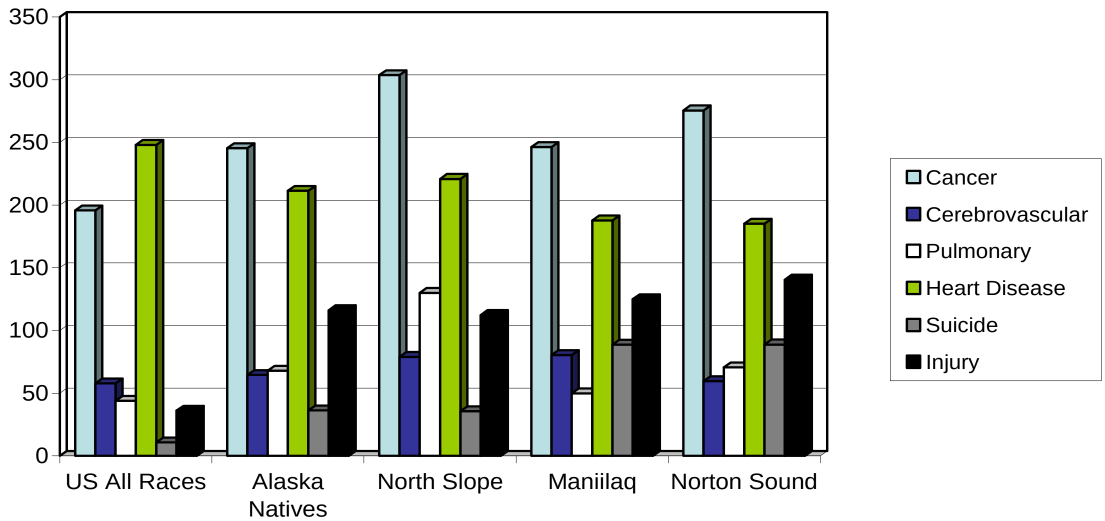


Figure 3.42 Age-Adjusted Alaska Native Mortality Rates By Service Region and U.S. 1999–2003, Genders Combined (per 100,000)

Relationship between subsistence-based diet and health. Subsistence foods used in rural Alaska have demonstrated health benefits, including the following:

Consumption of subsistence foods results in a lower cumulative risk of nutritionally mediated health problems, including diabetes, obesity, high blood pressure, and heart disease (Chan et al. 2006; Dewailly et al. 2001; Dewailly et al. 2002; Din, Newby, and Flapan 2004; AKDHSS 2005; Murphy et al. 1995; Ebbesson et al. 2007).

Traditional foods provide a range of micronutrients essential to health (Bersamin et al. 2007); iron (Nobmann et. al 2005); and very high levels of omega-3 fatty acids, anti-inflammatory substances found in oily cold-water fish such as salmon (Murphy et al. 1995; Ebbesson et al. 2007).

Subsistence foods make up a substantial, although incompletely quantified, proportion of the diet in the NWAB. Evidence for this comes indirectly from serial subsistence harvest surveys, and from a few nutritional surveys that have addressed the consumption of subsistence foods in the region (Ballew et al. 2004). Dietary transition away from subsistence foods in rural Alaska carries a high risk of excess consumption of processed simple carbohydrates and saturated fats similar to urban communities that have low availability and high cost of fresh produce, fruits, and whole grains (Bersamin and Luick 2006; Kuhnlein and Receveur 2002).

The rate of adult obesity in the Maniilaq region is 25.4 percent, lower than the All Alaska Natives rate of 36.4 percent. In the Maniilaq region, 25.2 percent of children are overweight, compared with 27.6 percent of Alaska Native children statewide (ANTHC 2008a). Current type II diabetes prevalence for Alaska Natives in the NWAB is 39/1,000, compared with 40/1,000 for Alaska Natives in general. Of the three northern regions, NWAB has the highest type II diabetes rate, with Norton Sound next at 32/1,000, and North Slope Borough the lowest (28/1,000). Between 1990 and 2006, type II diabetes rates increased 126 percent in the NWAB, compared with 114 percent statewide in the Alaska Native population (ANMC Diabetes Program 2008). Type II diabetes is also a growing concern among Alaska Native youths; rates have doubled between 1998 and 2003, from 151 to 299 per 100,000 (ADHSS-PH 2005). High blood pressure has been shown to relate to decreasing consumption of subsistence foods in Alaska Natives. The prevalence of high blood pressure in the NWAB has not been determined.

Between 1989 and 2003 heart disease rates in the Maniilaq Service Area have gradually declined. Over a similar period, heart disease deaths among Alaskans under the age of 65 increased from 184/100,000 to 277/100,000, accounting for 20 percent of all deaths of those Alaskans under the age of 65. Of all deaths from diseases of the heart, the highest mortality rate was seen in Alaska Native men (326/100,000). This is a substantial change from 50 years earlier, when non-Native males suffered heart disease at twice the rates of Native men (Eberhart et al. 2004).

Effects of Existing Operations on Subsistence, Nutrition, and Diet Related Diseases. The subsistence discussion in Section 3.12.2 indicates that caribou harvests in Kivalina and Noatak have likely declined for mine and non-mine related reasons, other than natural variation in caribou abundance and distribution. Other information sources, including the scoping process, have identified other potential sources of effects or concerns related to the Red Dog Mine. The following discussion provides additional detail.

Studies in other arctic subsistence communities have demonstrated that increases in employment and higher incomes in subsistence communities enable and promote market food purchases (Chan et al. 2006). As noted previously, the consumption of store-bought food over a traditional subsistence diet has had an effect on nutrition and health.

As described in Section 3.12.2 (Subsistence), total per capita harvest of subsistence resources is declining in each of the three study areas (Noatak, Kotzebue, and Kivalina). The subsistence analysis found, in particular, that mine related activities have contributed to decreasing harvest of caribou and beluga in Kivalina. The effect of the decreased harvests on diet is unknown and the SEIS recommends that a dietary survey be developed and implemented for residents of Kivalina. The survey should be conducted in collaboration with community stakeholders, according to accepted principals of nutritional epidemiology, with the purpose of quantifying the contribution of subsistence resources to the diet. While it would not be possible to determine the precise contribution of caribou and other resources to diet in the past, an understanding of how subsistence correlates with consumption in the present would allow a reasonably accurate extrapolation to understand how harvest-level changes may impact the diet. Based on the results of the study, a decision could be made whether to develop support measures to diminish any adverse nutritional effects of reduced harvest. The agencies have not found ways to require this survey in their permits and/or decisions.

Approximately 100 residents from 10 villages work at the Red Dog facility on two-week shift schedules. No subsistence activities are allowed while on shift, although employees are allowed to bring, store and prepare their own subsistence food. While employment schedules at the mine can create conflicts with subsistence activities, Teck allows employees some flexibility in planning work schedules around subsistence activities (R. Sheldon, pers. comm.). The subsistence survey noted only three respondents (one from Kivalina, two from Noatak) indicated that employment/lack of time was responsible for decreased caribou harvest (Table 3.12-7) although the number of employees surveyed was limited.

Scoping comments by village residents of Kivalina and Noatak indicated concerns about the safety and potential contamination of subsistence resources, including the statement that people no longer picked sourdock (*quagaq*) or berries near the port for fear of contamination, although they continue to use other harvest areas for these resources (see Section 3.12.2.6). Residents of Kivalina are concerned about potential contamination of the Wulik River, which is used both for subsistence and as the drinking water source for the village. A 2001 study by the Alaska Department of Health and Social Services found that heavy metals concentrations in drinking water were low and did not pose a risk (ADHSS 2001). Teck's human health DMTS risk assessment (discussed in more detail below in the environmental contaminants subsection) included data for contaminants in some subsistence foods, but did not show contaminant levels warranting concern in the Wulik River or in subsistence resources in the immediate vicinity of the DMTS road and port (Exponent 2007a). It should be noted that the DMTS risk assessment procedure uses a set of assumptions, and the results of the DMTS risk assessment have not been validated through direct studies. The draft fugitive dust risk management plan (Exponent 2008), developed in response to the DMTS risk assessment, includes a monitoring program that will be put in place to address some of the concerns related to contaminants in subsistence resources (including berries and *quagaq*).

Social and Psychological Health

Alaska Native communities throughout the state, including the NWAB, suffer from high rates of social and psychological health problems, including anxiety, depression, suicide, drug and alcohol abuse, and domestic violence. These problems clearly predate mining in the NWAB. They are discussed in the SEIS because socioeconomic and demographic changes in general have well-recognized effects – both positive and adverse – on rates of these problems in other arctic indigenous populations that have been studied. A large body of literature has documented that these problems relate to cultural change and modernization, a term which encompasses the rapid social, cultural, and economic transitions being experienced by many arctic communities even today (Curtis et al. 2005; Bjerregaard 2001; Shepard and Rode 1996; Travis 1984).

Alcohol and Drug Use. Per capita, alcohol consumption in Alaska is the 4^{th} highest in the U.S. Alcohol related hospitalizations among Alaska Natives are 2.5 times higher than for the U.S. population (CDC 1992) and alcohol related death rates are almost 9 times the national average, accounting for 7 percent of Alaska Native deaths (Indian Health Services 2001). Fetal Alcohol Syndrome among Alaska Natives is twice as common as the U.S. average (ADHSS 2002) and four times higher than the rest of Alaskans.

Villages in the NWAB, with the exception of Kotzebue, are “dry” villages, in which the sale and importation of alcohol have been banned; Kotzebue is a “damp” community, in which the sale of alcohol is prohibited, but a controlled amount of alcohol importation is allowed. The prevalence of binge drinking among Alaska Natives in “wet” villages, where alcohol is readily available, is twice as high (24.7 percent) as in dry villages (12.9 percent; Alaska BRFSS, unpublished data, 1996). One recent study conducted in the NWAB documented binge drinking, at least monthly, in 47 percent of men, while 24 percent of women in the study population met criteria for problem drinking (Seale et al. 2006). A survey conducted between 2000 and 2004 found that 16 percent of NWAB residents had reported an alcohol binge within the last 30 days; the study noted that this percentage had decreased from 21 percent reported for the 1993 to 1995 time period.

Effects of Existing Operations on Social and Psychological Health. The influence of the Red Dog Mine on social and psychological health problems has not been investigated. Nevertheless, pathways through which the mine may influence these health issues both positively and adversely are discussed below.

Mining related socioeconomic and demographic changes in the NWAB may contribute to acculturation by imposing different cultural values, social behavior, and economic patterns. The sudden increased availability of discretionary income among mine workers and their families has been implicated in social and psychological health problems in studies of analogous populations. This problem has been documented, for example, in Canada, where indigenous communities have noted that mine wages are often spent on tobacco, alcohol, and illicit drugs (Gibson and Klinck 2005; Hipwell et al. 2002; Brubacher and Associates 2002). Economic disparity within a village can also be exacerbated by mine related employment and dividends, and may alter the values underlying sharing networks fundamental to the subsistence socio-cultural system. These problems have been reported in indigenous communities involved with local mining and other natural resource extraction projects (Tatz et al. 2006; Gibson and Klinck 2005; North Slave Metis Association 2002; M. Galginaitis, pers. comm. 2007).

Corporate policies on drug and alcohol use can have a positive or negative influence. Alcohol was permitted in the "company town" of Nanisivik Mine in Canada, and residents reported that alcohol contributed to domestic violence, sexual abuse, and the break-up of families (Brubacher and Associates 2002). Teck strictly prohibits the use or possession of alcohol by employees on site (Teck Cominco 2003). Employees are screened for drug use and those that break policy are put on leave and required to attend counseling.

Rotating shifts at the mine also involve long periods away from home which have been blamed for marital discord and family dysfunction in analogous populations (Coumans 2002; Gibson and Klinck 2005). Children of mine workers have less interaction with the employed parent. Social service personnel at Maniilaq Association have commented that the prolonged absence of men who work at the mine creates a deficit of role models for male children, and furthermore, that the stress associated with re-integrating families when mine employees return home may, in individual cases, exacerbate problems such as domestic violence and alcohol use. These types of problems would not be limited to Alaska Natives or residents of the NWAB. To address these types of issues, Teck's health insurance includes an employee assistance program that provides counseling to employees (or family members) who may have these types of problems.

Injury

Injury encompasses both intentional injuries (suicide, homicide, violence), and unintentional injuries. Suicide rates are disparately high for Alaska Natives, and as noted in Section 3.13.1.1, the problem appears to be changing from an elder issue to one confined primarily to youth. The rate of suicide among young Iñupiat men has been documented as high as 185/100,000, nearly 16 times the national rate, a trend that mirrors that seen in Canadian Iñuit communities (Wexler 2006; Bjerregaard and Hicks 2006). Alcohol is frequently involved in suicides; in 1989, 79 percent of those who committed suicide had detectable levels of blood alcohol.

Trend data for NWAB indicate that prior to 1989–1993, suicide rates were gradually declining, and yet remained substantially higher than in the North Slope Borough. Despite economic improvements in the NWAB, suicide rates gradually increased from 1993 to 2003. From 2000 to 2005, the Maniilaq Service Area had the highest suicide-attempt rate of all service areas in Alaska, and as of 2005, NWAB was second only to Norton Sound in suicide death rates statewide (ANTHC 2008c). The reasons for elevated NWAB and Norton Sound suicide rates are not completely understood. Most studies have suggested rapid cultural change, multi-generational cultural strain, and economic depression as explanations for the high rates of suicide in Iñuit communities (Bjerregaard and Hicks 2006; Travis 1984; Wexler 2006). A recent comparison data from North Slope Borough, NWAB and Norton Sound support the economics influence argument. North Slope Borough had the lowest 2007 unemployment rates (5.9 percent), followed by NWAB (10.8 percent), and Norton Sound (12.6 percent). Between 1999 and 2005, North Slope Borough had a suicide death rate of 61.3/100,000, compared with NWAB 81.0/100,000, and Norton Sound 92.9/100,000 (ANTHC 2008a).

Unintentional injury rates are also high in rural Alaska Native communities, due in part to high rates of alcohol abuse. In 1992, the age-adjusted injury mortality rate in Alaska was 87.8/100,000, the highest rate in the U.S. The rate was even higher in rural Alaska at 189.8/100,000 (Alaska Division of Public Health 1997). Between 1999 and 2003, unintentional injury was the second leading cause of death in the NWAB; suicide was the third leading cause, and combined, they surpassed even cancer. The non-fatal injury hospitalization rate was 115/10,000, compared with 99.6/10,000 for all Alaska Natives. The top five non-fatal injuries in the Maniilaq Region were suicide attempt by poisoning, unintentional falls, unintentional other transport, assault, and unintentional natural/environment (Hill et al. 2004).

Compared with the two neighboring Iñupiat regions, unintentional injury mortality rates in the NWAB (132/100,000 for 1999 – 2005) were higher than the North Slope Borough (106/100,000), and lower than Norton Sound (152/100,000) – the same pattern was observed for suicide (ANTHC 2008b). As with suicide, injury rates correlate closely with alcohol use and social strain. Alcohol has been estimated to be involved in up to 40 percent of injuries and traumatic deaths in Alaska Natives (ANTHC 2006). The high injury rates are also due to the realities of the subsistence way of life in a harsh environment. One study found, for example, that snow machine accidents were more common than auto accidents, and more commonly resulted in serious injury or death (Landen et al. 1999).

Some reduction in unintentional injury mortality rates has been achieved, largely because of injury prevention programs and the efficacy of alcohol control and local prohibition ordinances (ANTHC 2008a; Lanier et al. 2002; Goldsmith et al. 2004). Prohibition ordinances are also highly effective in preventing alcohol related injury, resulting in injury rates up to 2.7 times lower in dry villages compared with wet villages (Landen et al. 1997; Berman et al. 2000; Chiu et al. 1997; Wood and Gruenewald 2004).

Effects of Existing Operations on Injury Rates. The relationship between the Red Dog Mine and injury rates in the villages has not been investigated directly. As described above, injury rates correlate strongly with social and psychological problems; hence, potential effects of mining on social and psychological health could exert an indirect positive or negative influence on injury patterns in the region. Localized impacts on accident rates could be postulated if residents in Kivalina and Noatak travel farther to hunt resources that have been displaced by mine activities. One scoping comment noted that crossing the port area on all-terrain vehicles could expose residents to traffic related hazards, depending on conditions and activities at the port. However, no site reports were reviewed to characterize the extent of this situation for this analysis.

Cancer

Public health personnel in the region note that there have been frequent concerns raised by the public regarding the potential link between high cancer rates in the region and mine related contaminants. This section briefly reviews the baseline rates of cancer in the NWAB compared to cancer rates in other regions of the state.

Between 1969 and 2003 the overall incidence of cancer in Alaska Native men has increased 23 percent, and among Alaska Native women it has increased 30 percent. Nine types of cancer are statistically more frequent than in the U.S. white population: nasopharynx, gallbladder, stomach, liver, colon/rectum, esophagus, kidney, lung, and pancreas. Cancer is now the leading cause of mortality in the Kotzebue Service Unit. The leading cause of cancer among men is colon, for women, breast cancer, and combined is colon. Cancer mortality rates are lower than in either the Barrow Service Unit (North Slope Borough) or Norton Sound.

The cancers listed above have all increased markedly in Alaska Natives, with the exception of stomach and pancreatic cancer, which have rates that have remained essentially unchanged between 1969 and 2003. Average annual age-adjusted cancer incidence from 1989–2003 for the Kotzebue subregion (Maniilaq service area) and other service units is available from the Alaska Native Tumor Registry. The highest cancer rates are seen for the Anchorage and Barrow Service Units and the lowest is the Yukon-Kuskokwim Service Unit. The rate for the Kotzebue subregion is 425.5/100,000 as shown in Table 3.13-2 below. Incidence data for the most common malignancies over the 1989–2003 period are available for each region's Alaska Native population. The frequency of the most common malignancies in the NWAB compared to other populations is given in Table 3.13-2.

Table 3.13-2 Average Annual Age-Adjusted Cancer Incidence Rates per 100,000 among Alaska Natives 1989-2003 by Service Unit Men and Women Combined, compared to all Alaska Natives, and U.S. Whites

Site	Anchorage	Barrow	Kotzebue	Norton Sound	Yukon/ Kuskokwim	Alaska Natives	U.S. Whites
All Sites	554.2	579.5	425.5	479.8	407.6	478	490.5
Stomach	28.0	36.2	24.9	43.5	21.2	22	7.4
Colon and Rectum	104.0	125.1	90.8	129.6	107.3	98.2	55.9
Pancreas	14.0	30.1	13.1	13.5	16.1	14.8	10.9
Lung and Bronchus	118.2	162.2	82.7	99.3	91.3	92.5	66.7
Breast	83.9	N/A	60.5	43.0	26.8	63.9	75.8
Prostate	38.7	30.5	11.8	11.8	10.8	34.2	76.2

N/A – not available

Historically, there has been concern among residents in the NWAB that environmental causes of cancer have not been fully evaluated. However, tobacco use and diet represent significant risk factors for cancer and act as confounders in the evaluation of other environmental risk factors.

Effects of Existing Operations on Cancer Rates. Available data do not suggest an association between local cancer rates and activities at the Red Dog Mine. There is no evidence of an unusual environment related cancer for mine workers, nor is there any evidence of a cancer trend that differs substantially from trends observed in other regions.

Pulmonary Disease

Chronic lung disease is disproportionately common in Alaska Native communities, and has increased substantially in the last 30 years. Pulmonary disease is discussed in the NWAB because of the possibility that air quality emissions related to mining could influence rates of pulmonary disease.

In the NWAB, chronic lung disease is the seventh leading cause of death, and pneumonia and influenza were the sixth leading cause of death. Age-adjusted mortality from these problems was 49.8/100,000 for chronic lung disease, and 77.9/100,000 for pneumonia and influenza; these numbers can be compared with the rates in the U.S. white population of 46.8/100,000 for chronic lung disease, and 22.6/100,000 for pneumonia and influenza. The rate of death from chronic lung diseases in the NWAB region ranked lowest among Alaskan sub regions, and the rate of death from pneumonia and influenza ranked highest (Day et al. 2006). Pneumonia is the leading cause of hospitalization in the Maniilaq subregion, and chronic lung disease is the seventh most common cause. Maniilaq has lower levels of mortality from pulmonary disease than either the North Slope Borough or Norton Sound.

The causes of pulmonary problems in rural Alaska Natives are not completely understood, but a number of contributing factors have been identified. Smoking tobacco is known to be a major risk factor, and 77 percent of residents in the Maniilaq subregion smoke, compared with 47 percent of Alaska Natives statewide, and 20.4 percent of U.S. whites. Smoking is important as a cause of pulmonary disease in infants and young children as well, because of the contribution of second-hand smoke to poor indoor air quality. Another factor that has been shown to contribute to high rates of serious pulmonary infections in infants is the lack of running water, which makes hand washing and personal hygiene more difficult in some (or portions of some) villages (Hennessey et al. 2008). Air pollution is also known to contribute to pulmonary disease. In villages in the NWAB, major contributors to outdoor air pollution include vehicular traffic emissions, combustion of diesel and heating oil for power generation and heat, and dust from traffic and wind on the predominantly dirt roads in villages. A study of serious respiratory infections in Canadian Iñuit infants revealed that poor ventilation in village housing was a powerful contributing factor (Kovesi et al. 2007).

Effects of Existing Operations on Pulmonary Disease. According to the air quality analysis (Section 3.1.2), based on monitoring at the site and modeling of dispersion, air quality at and near the mine is generally well within attainment with NAAQS/AAAQS, and is therefore unlikely to contribute substantially to rates of pulmonary disease. Air monitoring around the mine site demonstrated that at the ambient air boundaries, levels of air-borne contaminants were below national ambient air standards. The ambient air boundaries extend out 300 feet on either side of the road and between 0.5 and 4 miles from the mine. It is possible that individuals traveling within the ambient air boundaries may be exposed; however, limited on-site air monitoring within the ambient air boundaries did not demonstrate substantially elevated levels of air-borne contaminants.

Environmental Contaminants

Environmental contaminants exist within the NWAB and throughout the arctic from naturally occurring and man-made sources. For example, elevated metals levels in Red Dog Creek before mining began were high enough to negatively affect aquatic habitat (see Section 3.10.1). The Red Dog Mine's wastewater discharge and fugitive dust are anthropogenic sources of environmental contaminants associated with the mine, although others unrelated to Red Dog also exist. Exposure to environmental contaminants can occur through air (inhalation), or direct consumption of contaminated soils, vegetation, water, fish, or animals. This subsection discusses the exposure of NWAB residents to environmental contaminants.

Several sources of information are available to evaluate the risks to human health posed by environmental contaminants. The most direct measure of contamination is human testing (biomonitoring) discussed below.

Biological Monitoring of Community Members for Cadmium. In a 2004 study by the ADHSS (Middaugh and Arnold 2005), blood cadmium levels were evaluated in residents of Kivalina and Noatak. Out of eight adults tested in Kivalina, seven had levels below the detection limit (1 µg/L), while one person (14.3 percent) had a level above the detection limit, at 1.2 µg/L. In Noatak, 46 persons over 18 years of age were tested. Seven (15.2 percent) had detectable results over 1.0 µg/L, with a maximum reported level of 7 µg/L. Too few persons under 18 years old participated in the study to report data on that age group.

These data are somewhat difficult to interpret because so many persons had levels below the detection limit, and the data do not directly compare with national data. However, data from the National Health and Nutrition Examination Survey (NHANES) (CDC 2005) from 1999-2002 showed that approximately 10 percent of U.S. residents, 20 years and older, had blood cadmium levels of over 1.0 µg/L. This is a smaller percentage of people with levels over 1.0 µg/L than seen in Kivalina and Noatak (~15 percent).

The percent of persons with blood cadmium levels over 1.0 µg/L in Kivalina and Noatak is somewhat higher than the percentage in the general U.S. population. Small sample sizes, particularly as seen in Kivalina, make it very difficult to determine if the data accurately reflect levels in the entire population. Additionally, the higher percentage of persons with detectable blood cadmium levels may reflect high smoking rates among Alaska Natives, since tobacco is a common source of cadmium exposure (CDC 2005). In studies from the mid-1980s, concentrations of cadmium in blood in normal populations range from about 0.4 to 1.0 µg/L for non-smokers and 1.4 to 4.0 µg/L for smokers (ATSDR 1999).

Biological Monitoring of Community Members for Lead. Blood lead levels (BLLs) were collected by the ADHSS from residents of Kivalina and Noatak in 1990 and 2004 (Middaugh 1991; Middaugh and Arnold 2005). In 2006, the Alaska Community Action on Toxics also tested BLLs in Kivalina residents

(Rosen 2007). These data showed a decrease over time in the geometric mean BLL in adults and children in Kivalina (Table 3.13-3). In Noatak, data from 1990 and 2004 also showed a decrease in BLL in adults. However, there were too few persons less than 18 years old tested to report those data or draw any conclusions about trends. Nationally, BLLs have also declined substantially since the phase-out of leaded gasoline in the 1970s.

Compared to the national data from 2001–2002, adults, youth, and older children in Kivalina had lower average BLLs in 2006 (Table 3.13-3). Children 1 to 5 years old had BLLs similar to the national average. In Noatak in 2004, the average adult BLL was slightly higher than the national average. These human biomonitoring data suggest that BLLs in Kivalina and Noatak are consistent with national averages. No BLLs from Kivalina or Noatak were collected prior to the mine opening that could be compared with the above data.

Table 3.13-3 Blood Lead Levels in Residents of Kivalina and Noatak

Population	Arithmetic Mean Blood Lead Level								
	1990			2004			2006		
	Number of Samples	Concentration (µg/dL)	Max.	Number of Samples	Concentration (µg/dL)	Max.	Number of Samples	Concentration µg/dL	Max.
Kivalina									
Adults >18 years	94	6.09	35	8	1.3	3	24	0.77	2.0
Children 7-18 years	none	N/A	N/A	none	N/A	N/A	86	0.77	3.0
Children <7 years	none	N/A	N/A	none	N/A	N/A	135	1.68	12.0
Children 6-18	86	2.66	12	<5	—	—	none	N/A	N/A
Children 0-5 years	39	2.87	5	<5	—	—	none	N/A	N/A
Noatak									
Adults >18 years	158	7.81	34	46	2.1	7	none	N/A	N/A
Children 6-18	83	5.34	21	<5	—	—	none	N/A	N/A
Children 0-5 years	45	4.20	11	<5	—	—	none	N/A	N/A
National Average Concentration (µg/dL) (2001–2002)									
Adults > 19 years	1.56								
Youth 12–19 years	0.94								
Children 6–11 years	1.25								
Children 1–5 years	1.70								

N/A = not applicable
— = not reported due to an insufficient number of samples

Effects of Existing Operations on Environmental Contaminants. Wastewater discharges and fugitive and point source air emissions are the primary sources for environmental contaminants from the Red Dog Mine. The DMTS risk assessment included a human health component (HHRA) to address concerns from the mining operation, particularly as they relate to fugitive dust (Exponent 2007a). The HHRA is the primary source of information to describe the relationship between the existing operation and environmental contaminants.

HHRA Findings

The HHRA estimated the potential for adverse health effects to children and adults from exposure to metals in environmental media (e.g., soil, surface water) in the project area (Exponent 2007a). Potential routes of exposure and potential receptors were identified using a Conceptual Site Model (CSM). The results of the CSM were used to determine what pathways warranted further evaluation in the DMTS risk assessment. Based on the results of the CSM, the HHRA focused on people involved in subsistence uses within the project area, including fishing, hunting, and gathering plants and berries, and consumption of foods obtained through these activities; this exposure scenario was termed the “Subsistence Use Scenario” and considered for adults and children. In addition, the HHRA focused on people who were involved in subsistence use and who also worked at the mine; this scenario was termed the “Combined Worker/Subsistence Use Scenario.”

The HHRA included an analysis of the available sampling data to determine what metals warranted evaluation in the DMTS risk assessment. The analysis compared the concentrations of metals in soil and other media to health-based screening levels to provide a preliminary indication of which metals may be of concern. Based on this analysis, antimony, barium, cadmium, lead, thallium, and zinc were identified as chemicals of potential concern in the terrestrial environment, and lead and thallium were identified as chemicals of potential concerns for the freshwater environment. Potential exposures were evaluated and doses to metals were calculated for both the Subsistence Use Scenario and the Combined Worker/Subsistence Use Scenario.

The potential risks from lead are treated differently than the potential risks from the other chemicals of potential concerns. The risks from potential exposure to lead were evaluated by estimating BLLs using EPA exposure models for lead. The estimated BLLs are compared to EPA’s current target level of 10 μg/dL. That target may be revised downward in the future since CDC, ATSDR, and EPA have stated that there is no safe BLL, and no level has yet been found that does not correlate with adverse health outcomes (Brown 2007; ATSDR 2007; EPA 2000; EPA 2006).

The potential risks for metals other than lead were calculated by comparing the estimated exposures to Reference Doses, EPA’s standard toxicity values for evaluating chronic health effects of chemicals. A HQ is the ratio of the estimated dose to the reference dose. A unique HQ is calculated for each metal and each exposure pathway. The total risk for a given pathway is the Hazard Index and it is the sum of the HQs for that pathway. An HQ of less than 1 indicates that the estimated exposure is less than the level of concern and adverse health effects would not be expected. The same applies to Hazard Indices that are less than 1. An HQ greater than 1 does not definitively indicate that there is a risk but indicates that there is a potential for adverse health effects. The same applies to Hazard Indices that are greater than 1. In interpreting the significance of the HQs and Hazard Indices, it is important to keep in mind the uncertainties and conservatism associated with the exposure estimates and the toxicity values that are used in the HHRA process. The results of the DMTS risk assessment are discussed in the following paragraphs.

Subsistence Use Scenario – Children. Potential risks to children from exposure to lead were evaluated with EPA’s IEUBK model, which estimates the BLL. The model evaluated two estimates of the biologically availability (i.e., bioavailability) of lead. The higher the bioavailability of the lead, the more it is absorbed into the body, and the more likely it could cause harm. The modeled BLLs for children were below EPA’s target level of 10 μg/dL; the highest geometric mean BLL modeled was 1.9 μg/dL. The HHRA concluded that lead does not pose an unacceptable risk to children in the study area.

Risks from other metals, such as cadmium and zinc, were also evaluated. The results showed that the risks (i.e., Hazard Indices) did not exceed the level of concern (1.0). The authors concluded that the other metals do not pose an unacceptable risk to children in the study area.

Subsistence Use Scenario – Adults. Potential risks from lead exposure were not evaluated for the Adult Subsistence user, because children are more sensitive to lead and thus the lead analysis for children is expected to cover potential risks to adults (Exponent 2007). The HHRA results showed that the risks from exposure to the other metals do not exceed the level of concern (1.0). The HHRA concluded that the other metals do not pose an unacceptable risk to adults involved in subsistence use.

Combined Worker/Subsistence Use Scenario. Risks from lead exposure were evaluated using EPA's adult lead model. The model focuses on the most sensitive endpoint for adults and that is the BLL in the fetus of a pregnant woman. The modeled BLLs for the fetus were below EPA's target level of 10 μg/dL; the highest geometric mean BLL modeled was 2.7 μg/dL. Thus, the HHRA concluded that lead does not pose an unacceptable risk to worker/subsistence users, even if they are pregnant. Risks from the other metals were also evaluated with the results showing that the other metals do not pose an unacceptable risk to the Worker/Subsistence user.

EPA HHRA Findings

The previous subsection reviewed the HHRA findings as prepared by Exponent. In its review of the HHRA, EPA generally agreed with the findings with one notable exception. EPA's assessment of the data concluded that health risks from caribou consumption were underestimated by an order of magnitude. The HHRA calculated risks based on estimates of metals attributable to the DMTS (estimated at 9 percent of the total measured values), but the sources of the metals in caribou tissue have not been determined. EPA's approach uses the measured concentrations of metals in caribou (rather than the estimated concentrations) to represent the best estimate of exposure to people who consume caribou, regardless of the sources of the metals. EPA recognizes the nutritional and cultural value of caribou consumption, as well as the potential for substituting less healthful replacements, and is not recommending avoiding caribou consumption as a result of this analysis.

To reduce uncertainty in the risk associated with caribou, EPA believes additional sampling of caribou tissue for metals should be undertaken. The sampling and analysis should be done at a sufficient level of detail that the amount of various tissues consumed can be determined and assessed. Recommended safe levels of consumption could be based on the results of the caribou studies. Stakeholder engagement and participation in protocol development, data collection, and analysis could potentially enhance community acceptance of the results. As possible actions, the draft fugitive dust risk management plan includes: (1) development of a monitoring plan for foods and water; and (2) determination of safe consumption levels in subsistence foods and water. In addition to the draft fugitive dust risk management plan, the agencies are evaluating ways to require this monitoring in their permits and/or decisions.

3.13.2.2 Industrial Health and Safety

Health and Safety Programs. Historically, mining has been a dangerous occupation. Regulations and technological improvements have dramatically improved mine related health problems. Mining injuries are a long-standing concern, and prompted the creation of the Mine Safety and Health Administration (MSHA) in 1978. Lost work time and fatalities have decreased in the U.S. mining industry (NIOSH 2008). Mine employees may also be exposed to airborne dusts containing crystalline silica (quartz) and heavy metals such as lead, cadmium, and zinc during ore mining, crushing, milling, and transportation operations. The inhalation of airborne dust is a primary route of entry for the toxic metals and crystalline silica into the human body. Additionally, the metals may enter the body through ingestion, either as a result of hand-to-mouth contact such as consumption of contaminated food and drink, smoking in contaminated areas, or from swallowing inhaled dust that deposits in the upper respiratory tract.

Teck has developed and implemented a corporate health and safety program for its Red Dog Mine operations to address worker protection against chemical and physical hazards at its mine, milling, and port facilities. Health and safety policies and procedures are documented in the *Employee and Contractor Safety Handbook* and the *Employee Safety and Lockout Procedures Manual* (revised June 2007), which address all mine operations including drilling and blasting, conveyors, cutting and welding, transportation, and heavy equipment.

Teck's health and safety program elements include employee health and safety standards for lead and cadmium exposures and respiratory protection. The lead and cadmium exposure programs address a wide range of topics including routes of exposure (i.e., inhalation, ingestion), adverse health effects, medical treatment, air monitoring, biological monitoring (i.e., blood lead, blood and urinary cadmium, etc.), medical removal protection, MSHA/Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits and Action Levels, employee training and counseling, employee access to records, employer and employee responsibilities, respiratory protection, personal hygiene, change rooms, work clothing, safe work practices, housekeeping, equipment ventilation, and prohibited activities.

MSHA regulates operations at the Red Dog Mine; however, Teck has adopted several OSHA requirements that are more detailed and, in some cases, more stringent than MSHA. For example, Teck has adopted the OSHA Permissible Exposure Limit for lead of 50 micrograms per cubic meter of air (µg/m^3), expressed as an eight-hour time-weighted average. The corresponding MSHA value is 150 µg/m^3. Additionally, Teck has imposed stricter requirements for some program elements including its Action Level for cadmium in air which is stated to be 1.5 µg/m^3 compared to the OSHA Action Level of 2.5 µg/m^3. Teck adjusts the OSHA Permissible Exposure Limits and Action Levels downward to reflect the 12-hour employee workshifts, as required by OSHA/MSHA. Thus, the corrected Permissible Exposure Limit for lead is 33 µg/m^3.

Teck has identified and characterized the mine areas and operations where exposure to contaminated dust from rock and soil and other chemical hazards is likely to occur. Teck contracted an industrial hygiene consulting firm to conduct employee exposure and general area air monitoring on a quarterly basis for lead, cadmium, crystalline silica, and total dust. The October 2007 quarterly sampling report summarizes air sampling results for numerous job descriptions from 2001 to 2007 (Northwest Industrial Hygiene, Inc. 2007). The worker exposure concentrations to lead and other airborne contaminants represent what is present in the worker breathing zone (generally defined as within a one-foot radius of the nose and mouth) without regard to the use of respirators. Worker exposure monitoring data show that lead particulate is the predominant air contaminant at all monitored tasks. Job tasks with the highest lead exposure include dewatering (maximum 480 µg/m^3), flotation (maximum 439 µg/m^3), and grinding operators (maximum 434 µg/m^3) at the mill operations; electricians (maximum 92.5 µg/m^3) and other mill maintenance staff (maximum 509.6 µg/m^3); crusher operators (maximum 380 µg/m^3) at the mine; loader, dozer and truck discharge operators (maximum 2,197 µg/m^3) at the port site CSBs; and laborers and sample buckers (maximum 398 µg/m^3). Approximately 62 percent of all air monitoring measurements exceeded the corrected Permissible Exposure Limit for lead of 33 µg/m^3. On a few occasions, the CSB loader operator (maximum 1,810 µg/m^3) and the line haul driver (maximum 1,123 µg/m^3) at the mine have shown lead exposure concentrations two orders of magnitude above the Permissible Exposure Limit.

Approximately 72 percent of measured worker exposure concentrations to cadmium have been below the corrected OSHA Permissible Exposure Limit of 3.3 µg/m^3. Workers who perform some tasks, such as the dewatering operator, crusher operator, sample bucker, and truck discharge operator, have shown repeated cadmium concentrations above 3.3 µg/m^3 but below 5 µg/m^3. However, a maintenance laborer showed a one-time maximum detected concentration of 93.6 ug/m^3.

Approximately 57 percent of employee breathing zone concentrations of respirable crystalline silica exceeded the calculated Permissible Exposure Limit of 50 ug/m^3, which is based on the cristobalite content of the dust. The range of respirable crystalline silica concentrations varied from none detected to 416 ug/m^3, with all but four measurements at or below 150 ug/m^3.

The data show that worker exposure concentrations to airborne lead, cadmium, and respirable crystalline silica concentrations vary greatly within job tasks and among the various monitored mine operations. To address the potential for exposures, Teck requires the use of respiratory protection (i.e., full-face air purifying respirator) in all work areas where the mineral ore and concentrates are handled and processed, such as the mill, crushing operation areas, reagent building, and CSBs. These regulated areas are posted with signage noting the required use of respiratory protection against dust hazards.

General area air samples collected from 2001 to 2007 show the highest airborne lead and cadmium concentrations were found at the lead stock tank (top), filter press maintenance workbench, zinc stock tank / met lab sample bench, lead cleaners discharge well, and at the port truck hopper discharge areas. The mill control room, north corridor to the PAC, south corridor to administration, and mill lunch room showed lead concentrations well below the OSHA/MSHA Permissible Exposure Limit and cadmium was not detected.

The MSHA Data Retrieval System website shows personal health sampling results for various air contaminants (respirable quartz, metal dusts, and metal oxide fumes) and noise for 2004 through April 2008. MSHA did not issue any citations or orders for this time period, with the sole exception of a citation for excessive noise exposure of a truck driver in June 2005. The citation was subsequently terminated in December 2006.

Teck has made major improvements to the mine dust collection systems over a six-year period, which include new baghouse systems at the crushing operations, truck dump, new CSB, conveyors, surge silos between conveyors, and at the barge loader conveyor at the port. New exhaust ventilation equipment has been installed in the heavy equipment mobile shop. These improvements should reduce fugitive dust emissions in work and surrounding areas. Reductions in worker exposure concentrations to lead have been demonstrated for the crusher operator since 2005 and the port truck discharge operator since 2004. The October 2007 study shows employee breathing zone lead concentrations of 4.2 $\mu g/m^3$ and 2.0 $\mu g/m^3$, respectively compared to historical maximum airborne lead concentrations of 393 $\mu g/m^3$ and 2,197 $\mu g/m^3$, respectively (Northwest Industrial Hygiene, Inc. 2007).

Teck's surface miner training program includes initial and annual eight-hour minimum refresher training on site-specific health and safety hazards in accordance with the MSHA training plan (Part 48 Subpart B). MSHA-approved instructors provide training to new and experienced miners on hazard recognition, emergency evacuation plans, communications, electrical hazards, first aid, explosives, ground control, and other applicable health and safety topics. Additionally, new task training for surface miners addresses safe operating procedures for assigned work tasks, equipment and machinery, and includes supervised practice during non-production. Teck's *Qualified Operators and Competent Persons* provides specialized training on equipment ranging from fork trucks, cranes, graders, and dozers to 20-ton trucks.

Teck maintains a chemical inventory and material safety data sheets (MSDS) of process reagents, fuels, and other chemical products used in the mine operations. Updated MSDS are provided through a third-party service. The significant materials inventory, which is part of the mine pollution prevention plan, also includes all mined rock and other miscellaneous materials. Blasted rock from the mine is known to contain "sub-economic" levels of zinc, lead, and silver.

Teck has not incurred any environmental spills or releases that have adversely impacted worker health and safety during its years of operation. Historically, there have been truck spills of lead and zinc ore concentrates along the DMTS road as well as spills of petroleum hydrocarbons, such as diesel fuel, engine oil, hydraulic oil, and other materials. These spills have been remediated by specially trained and equipped emergency response personnel.

Mine Site / Port Site Biological Monitoring for Lead and Cadmium. Teck has adopted OSHA guidelines for biological monitoring for lead and cadmium as internal policy and programs, although it is not required under MSHA. All Teck employees are monitored for blood lead at hire and least annually, regardless of the area in which they work. Employees that work in areas that meet or exceed OSHA/MSHA action levels are monitored biannually. Employees with BLLs greater than 25 µg/dl of whole blood are monitored quarterly and are counseled in personal hygiene, personal protective equipment usage, etc. Persons with BLLs greater than 35 µg/dl are monitored monthly. Teck supervisory and Loss Control personnel meet with the employee to reinforce the importance of respiratory protection and good personal hygiene. Employees with BLL greater than 40 µg/dl are scheduled to report to Loss Control with their supervisor where additional counseling is provided. The employee must read, acknowledge, and sign the Counseling Form that requires adherence to company policies and guidelines for worker protection. Employees whose BLL exceeds 50 µg/dl are placed in the medical removal program until the BLL is at or below 40 µg/dl.

Blood lead sample data from approximately 2,000 Teck employees from 1995 to 2007 show that 434 of 8,706 BLLs were above 25 µg/dl and 31 were at or above 40 µg/dl. Of 1,627 blood lead measurements of approximately 750 Teck contractor employees and visitors, 91 were above 25 µg/dl and 11 of these were at or above 40 µg/dl. Over the operating history, there have been two cases of medical removal for elevated BLLs. Both employees (a driller and a welder) were temporarily relocated within the plant to different jobs until their BLLs were below the 40 µg/dl criteria. Further investigation revealed the elevated BLLs were likely due to poor personal hygiene, failure to wear the required protective equipment and personal hobbies (loading lead shot).

According to a recent report by the ADHSS, 308 of 2,710 Alaskan workers whose blood lead was tested between 1995 and 2006 exceeded the CDC adult health criteria for lead of 25 µg/dl. More than 90 percent of these workers were employed in the mining industry. Thirty-nine workers had BLLs above 40 µg/dl, while the median blood lead concentration was 9 µg/dl. The state epidemiologist who prepared the report noted that most of the blood test results were from Red Dog Mine workers (ADHSS 2008). The fact that most test results came from Red Dog Mine workers reflects the fact that Red Dog is the state’s largest lead producer and therefore has more employees who would be tested.

Several published industrial hygiene studies review lead sulfide mine and mill workers’ exposure concentrations to lead and BLLs. One study showed that exposures to elevated airborne lead concentrations do not result in increased lead absorption as indicated by blood lead measurements. Among 15 lead sulfide workers, there was poor correlation between total air lead and blood leads for the total group and the subgroups (smokers and non-smokers) (Bernard 1977).

OSHA recognizes that although the BLL is a good index of current or recent lead absorption into the human body, it does not necessarily indicate the total body burden of lead and is not an adequate measure of past exposure. This is because lead has a high affinity for bone, and up to 90 percent of the body’s total lead is deposited there. The BLL also does not fully reflect the biologically active lead deposited in soft tissues such as the liver, kidney, and brain. Therefore, a low BLL does not exclude an elevated total body burden of lead. Consequently, OSHA requires that lead-exposed workers receive a blood test for the zinc protoporphyrin enzyme along with the BLL. Blood zinc protoporphyrin is a better indicator of lead toxicity than the level of blood lead itself. An elevation in the level of circulating zinc protoporphyrin may occur at BLLs as low as 20-30 µg/100 g in some workers. OSHA maintains the enzyme disturbances measured by the zinc protoporphyrin test are early stages of a disease process that may eventually result in the clinical symptoms of lead poisoning and are, in themselves, considered to be a material impairment of health. Teck's blood lead monitoring program includes testing for zinc protoporphyrin.

Teck employees who are assigned to areas that have been identified as being above the cadmium action level at the mill, mine, or port are monitored for cadmium when they are hired and at least annually thereafter. The frequency of biological monitoring depends on the most recent blood and urinary test results. The program has specific criteria for annual, semiannual, and quarterly monitoring. Since the inhalation of cadmium is classified as a probable human carcinogen by EPA, Teck provides medical examinations on a biennial, annual, or semiannual basis according to the same criteria for biological monitoring. Employee counseling is required as part of semiannual and quarterly monitoring and employees must read, acknowledge, and sign a counseling form.

Mine and Port Site Accident Statistics. The calculated non-fatal injury days lost (lost time) incidence rates for the Red Dog Mine operations for the calendar years 1995 to 2007 vary from 0.74 to 5.93 as shown on the MSHA data retrieval system. These incidence rates are generally similar to or slightly higher than the national non-fatal lost time incidence rate for surface mines.

Teck records for 2000 to 2007 show that the calculated total injury incidence rates for the mine and port operations vary from 2.0 to 9.1 and 0 to 5.6, respectively. The total number of lost-time injuries per year varied from 4 to 16 for the mine operations and from 0 to 2 for the port operations over this time period. The total annual number of other MSHA-reportable injuries ranged from 8 to 38 for the mine operations and from 0 to 1 for the port operations for the same time period. Injuries were largely caused by physical hazards and were classified as material handling, use of hand tools or machinery, and slips and trips. The DMTS operations have not resulted in an injury or lost-time incident in the eight-year period from 2000 to 2007.

The Red Dog Mine incurred one employee fatality between 1995 and 2007 (the accident occurred in December 2006). Teck conducted an incident investigation, provided the report to MSHA, and modified procedures within the pit to ensure a similar accident would not occur in the future. The national operator fatal injury rates for surface mines vary from 0.0039 to 0.0135 for this time period (note that fatal injury rates are standardized to a 100-worker operation working 2000 hours/year). Teck had a zero (0) operator fatal injury rate for all years except 2006, when the rate was 0.26.

Safety performance at the mine has been varied with no obvious trend over the past eight years in terms of the number of MSHA reportable injuries. Teck experienced its worst corporate safety performance in 2007, and as a result assigned an experienced operations superintendent to serve as the on-site Loss Control superintendent. Consequently, safety performance for 2008 year-to-date had reportedly greatly improved (T. Zigarlick, pers.comm.). Teck employs four other full-time site-safety personnel plus 40 emergency response-trained personnel and 17 emergency medical technicians.

Teck has implemented incident investigation procedures that include root cause analysis and development of action plans to correct site conditions or employee behaviors that have resulted in an incident. The incident facts and follow-through are documented on the electronic "SiteLine" tracking system.

According to the MSHA Data Retrieval System, Teck has not received any MSHA citations for violations of the health and safety standards for air quality (30 CFR § 56.5001) from 1995 to April 2008. As shown in Table 3.13-4 below, Teck received the highest number of MSHA citations (95) in 2005 and the highest penalties (fines) in 2006 and 2007. The largest penalties were assessed for violations of MSHA requirements for training new miners, other hazard training, warning signs, safe access, trimming stockpile and muckpile faces, and equipment blocking in a raised position. Other notable safety violations cited by MSHA from 2004 through 2008 included work on power circuits, combustible waste, personal protective clothing for welding, cutting and working with molten metal, safety belts and lines, and operating speeds and control of equipment. As reported by MSHA, reductions in the number of citations and fines had occurred in 2008 (first quarter). Teck has promptly corrected (same day or within two days) all of these major safety violations, with the exception of procedures development, which was accomplished in less than two months.

Table 3.13-4 Summary of MSHA Inspections, Citations and Major Violations Red Dog Mine, Alaska 2004–April 2008

	2004	2005	2006	2007	2008
# MSHA Inspections	3	6	7	2	2
# Citations Issued	19	95	23	24	11
Penalties Assessed ($)	$1,574	$9,508	$31,989	$24,684	$6,263
Significant Safety Violations	Correction of dangerous conditions Safety belts and lines Operating speeds and control of equipment	Personal protective clothing for welding, etc. Firefighting, evacuation and rescue procedures	Blocking equipment in a raised position Inspection and cover plates Combustible waste Warning signs Container labeling Safe access Taglines, hitches and slings Hazard training/new miner training Snow and ice on walkways and travelways	Trimming stockpile and muckpile faces	Work on power circuits Insulation and fittings for power wires and cables

3.13.3 Health – Environmental Consequences

The public health effects analysis draws on the process of health impact assessment (Quigley et al. 2006); see Appendix E for a description of the methodology. The scope of health effects described below were determined by considering the proposed action and alternatives in the context of general health; subsistence nutrition, and diet related health problems; social and psychological health; injury; and environmental contaminants and health. (Neither cancer rates nor pulmonary disease have any bearing in assessing the differences among alternatives.) Within these selected categories, the analysis considered: (1) prevalent illnesses, health disparities and vulnerabilities in the NWAB population; (2) projected impacts on other resource areas that might affect health (including socioeconomics, subsistence, air quality, and water quality); (3) public testimony; and (4) mechanisms of health and illness that are well-substantiated by public health data from other populations.

Effects from the different alternatives on industrial health and safety vary little since the nature of most operations would remain the same under all alternatives. The impact analysis for industrial health and safety therefore focuses on BLLs and accident rates.

3.13.3.1 Effects Common to All Alternatives

Public Health

General Health. Under all alternatives, mine closure would result in the abrupt loss of income and employment, and could be associated with substantial adverse health effects. The sudden loss of these revenues at the end of operations could affect the availability and quality of educational services and schools, and less revenue would be available to maintain, renovate, and design water and sewer systems. The loss of revenue would affect the NWAB in its ability to provide services and community infrastructure, with adverse effects on community health and well-being. Job loss and economic depression are strongly associated with elevated mortality from heart disease, increased social problems, and higher injury rates (e.g., Brenner 1997; Brenner 1987). These effects would occur across the entire NWAB, and could be most severe for families that depend directly on mine related income and employment. The delay in mine closure under alternatives B, C, and D would provide a window of opportunity to allow a long-range planning process by the NWAB, NANA and individuals that could lessen the severity of impacts from an economic downturn at the conclusion of mining activities. However, even with adequate preparation, these effects are likely to occur in some degree.

Subsistence, Nutrition, and Diet-Related Health Problems. As discussed in section 3.13.2.1, subsistence is directly tied to health in the NWAB. Mine activities have likely contributed to a localized effect on diet, reflected in the reduction of the amount of caribou and beluga harvested, and concerns about the effects of dust contamination on other resources used primarily by Kivalina residents. Furthermore, residents' concerns about contamination of caribou and other subsistence resources would continue and possibly worsen over the length of mine operations. Displacement of caribou could continue to decrease the success of subsistence hunts by Kivalina residents and alteration of the migration of caribou near the DMTS road could result in decreased harvests over time. The reduction in harvest could contribute to effects on the nutritional system and increase the risks of diabetes and metabolic disorders. A dietary survey was recommended under the description of the baseline conditions (Section 3.13.2) to provide additional information on the relationship between subsistence resource changes and diet.

Closure would result in the cessation of mining activities and the drastic reduction in DMTS traffic could contribute to an improved harvest in areas currently affected by traffic on the DMTS road. An improvement in subsistence harvests could produce a corresponding improvement in nutrition. Since mine closure would likely translate into a loss of income in the form of NANA dividends or subsidies, families throughout the NWAB would have less income to support household expenses, including subsistence activities.

Social and Psychological Health. Under all alternatives, prolonged absences of family members employed at the mine would continue to affect family dynamics through the duration of operations. Children of mine workers would have less interaction with the employed parent. Social service personnel at Maniilaq Association have commented that the prolonged absence of men who work at the mine creates a deficit of role models for male children. The stress associated with reintegrating families when mine employees return home may, in individual cases, exacerbate problems such as domestic violence and alcohol use (although villages in the NWAB outside Kotzebue are dry).

Since income and employment play a generally positive role in social and psychological health, the loss of many mine related jobs in the region at closure may have negative effects in these aspects. Further, income from mining would be dramatically reduced, including revenues to the NWAB, NANA dividends, and other indirect economic inputs related to the mine that currently play a role in maintaining economic stability and providing regionally for services and infrastructure.

The risk of social/psychological problems would likely increase with an abrupt loss of income and the decline in infrastructure that supports community well-being and safety. Injury rates generally parallel social and psychological health rates, and could be exacerbated by deterioration of equipment and infrastructure secondary to an economic recession.

Injury. Injury rates in the NWAB parallel social and psychological health, and also reflect the inherent dangers of subsistence activities. No subsistence changes would be expected regionally although local changes in Kivalina have been documented and are likely to continue. The relatively small number of hunters that report needing to travel farther from home to successfully harvest caribou (Section 3.12.2.2) could face an increased risk of injury as long as traffic continues on the DMTS road at current levels. As noted previously, social and psychological problems, and injury rates related to these problems, correlate strongly with economic depression and sudden job loss; the cessation of mining at the conclusion of the project, again, represents the greatest risk of increased injury. Many of these problems could be avoided or minimized with adequate planning.

Environmental Contaminants and Health. No evidence exists to indicate any of the alternatives would affect cancer rates within the NWAB. Exposure to carcinogens from mining appears to be low, based on the findings of the HHRA (Exponent 2007a).

Air quality in the region currently meets or exceeds CAA standards. Although adverse health effects can occur at levels of criteria pollutants lower than NAAQS for vulnerable populations such as elders, people with chronic lung and cardiovascular disease, and infants, the mine is remote from centers of population and is not likely to contribute to deterioration in air quality in local villages.

Following closure, emissions of fugitive dust would decrease in proportion to the reduction in traffic on the DMTS road. Post-closure traffic reductions could result in less exposure to harmful components of fugitive dust such as lead and cadmium for people subsisting near the mine, road, and port site. Contamination from fugitive dust at the mine, road, and port site would, however, persist in the environment for many decades. The HHRA found that at present, the risk of health problems as a result of exposure to environmental contaminants is low (Exponent 2007a). EPA has identified the need for additional caribou monitoring to verify the results. Exposures to environmental contaminants related to the permitted air emissions and the treated wastewater discharge are not expected to increase health risks.

Recommendation. The potential effects of large-scale mining operations on general health are complex and, for the Red Dog Mine, have not been directly investigated. The health analysis has suggested that positive and negative impacts have occurred since the mine began operations. These changes have occurred as a result of a number of factors including the Red Dog Mine and other development; improvements in technology, transportation and communication; and social changes. To address these and future changes, a Stakeholder Participatory Monitoring and Review Committee could be formed to coordinate and collaborate ongoing health efforts and initiatives in the area, including those related to mining. The committee would be voluntary and a would consist of a collaborative multi-stakeholder group comprising members from public health agencies such as ADHSS and Maniilaq Association, NANA, Teck, and the NWAB. Specific activities could include oversight and advisory functions for monitoring identified in this section; planning for future anticipated changes such as mine closure; and addressing new health issues and questions related to mining as they arise in future permitting, operations, and management decisions. The committee could ensure adequate consultation among public health agencies and stakeholders (health agencies, regulatory agencies, local, regional, and tribal governments, and industry) on any issues related to regional health, including mining.

Industrial Health and Safety

Mine Site / Port Site BLLs. Worker exposures (reflected in BLLs) from mining and milling operations are expected to be similar under all alternatives, with the only difference being the duration of operations (shorter duration under Alternative A). The minor differences among alternatives are discussed below.

Mine Site / Port Site Accident Rates. Accident rates associated with mining and milling operations are expected to be similar under all alternatives, with the only difference being the duration of operations (shorter duration under Alternative A). Differences in transportation and concentrate handling among alternatives are discussed separately below.

3.13.3.2 Effects of Alternative A – No Action

Public Health

General Health. Under Alternative A, current mining operations would continue until 2011. The abrupt loss of jobs and the revenue streams associated with mine closure (the dominant economic force in the region) could be associated with significant adverse effects on general health and well-being for residents of the region as a whole, and particularly for those families whose finances largely depend on mine related income. The change in the water treatment system to reduce TDS levels could improve perceptions about the discharge. If perceptions about the discharge changed, it could help address some village concerns about the safety of drinking water and subsistence fishing.

Subsistence, Nutrition, and Diet Related Health Problems. The effects related to mine (and transportation) on local subsistence resources would be reduced under Alternative A compared to the other alternatives (particularly alternatives B and D) because of the reduction in DMTS traffic following closure in 2011. As discussed in section 3.13.2, subsistence is directly tied to health in the NWAB. With the loss of income in the form of direct employment, NANA dividends, or subsidies, families throughout the NWAB would have less income to support household expenses, including subsistence activities. Closure of the mine in 2011 under Alternative A would provide substantially less time for planning to overcome the negative effects of the revenue loss compared to the other alternatives.

Social and Psychological Health. Under Alternative A, problems associated with employees being away from their families would occur for a much shorter duration than under the other alternatives, assuming the individual planned to remain employed at the mine over the long term. The end of employment at the mine in 2011 would allow more time for personal pursuits, including family, assuming employment was not obtained elsewhere.

As noted above in Section 3.13.3.1, the important role income and employment play in social and psychological health would be likely to result in negative effects on these aspects beginning in 2011. The relatively short time frame until mine closure under Alternative A would limit the opportunity for individuals to plan and save to counter the economic instability that would occur with the loss of jobs, NANA dividends, and other indirect economic inputs related to the mine and the services they support. Increased counseling for workers as part of mine closure may be necessary to avoid the types of social and psychological effects described previously.

Environmental Contaminants and Health. While the potential exposure to carcinogens and environmental contaminants are unlikely to produce effects under any alternative, the duration during which local residents are exposed to mine related fugitive dust would be much shorter under Alternative A than under the other alternatives.

Industrial Health and Safety

Mine Site / Port Site BLLs. The continuation of the current open pit mining operations of the Main Pit until completion in 2011 would not be expected to present any significant changes in worker exposure concentrations to airborne contaminants and BLLs as described above.

Upon completion of the mining activities, site reclamation and closure plan operations would be initiated. Closure tasks would involve regrading the slope of the waste rock dump and covering the waste rock with a two-layer soil cover. The regrading task is anticipated to present similar hazards as the current waste hauling and dumping tasks, although contaminant concentrations in cover material should be lower than currently in the ore and waste material. The same worker protective measures would be in place to ensure minimal risk of inhalation and ingestion of contaminated dusts and soils.

Mine Site / Port Site Accident Rates. The mine non-fatal injury lost time incidence rates and fatal injury rates would be expected to be similar to 2008 rates based on the enhanced Loss Control department supervision, employee training, and other health and safety program implementation up to the time of closure. Closure activities would be expected to show a decrease in both fatal and non-fatal injury incidence rates since many hazardous mining and milling operations would be terminated.

3.13.3.3 Effects of Alternative B – Applicant's Proposed Action

Public Health

General Health. Under Alternative B current mining activities would continue until 2031, extending to the Aqqaluk Deposit. Activities at the port site and along the DMTS road would continue as under Alternative A, but for a longer duration of time.

The delay in mine closure under this alternative compared with Alternative A would provide time for stakeholders in the region to develop and institute measures that would help diversify and stabilize the local economic base. For example, NANA's long-term plan is to position the corporation and its shareholders for economic stability following the closure of the mine.

Subsistence and Nutrition. As outlined in Section 3.13.3.1, the effects of operations along the DMTS road on subsistence, and subsequently nutrition, would continue through 2031.

Social and Psychological Health. Positive and negative effects on social and psychological health would continue to occur through 2031 as described in Section 3.13.3.1. For those families experiencing effects from the prolonged absences of family members employed at the mine, the effects would continue through the duration of employment but could be mitigated through counseling or other means. The beneficial role of income from the Red Dog Mine on social and psychological health would continue for an additional 20 years including revenues to the NWAB, NANA dividends, and other indirect economic inputs discussed in more detail in Section 3.17.3. At the conclusion of the project in 2031, a major change in the economic conditions across the NWAB would be anticipated, presenting an important and potentially difficult period of transition for which careful planning would be required to avoid predictable social and psychological problems.

Environmental Contaminants and Health. According to the HHRA (Exponent 2007a), lead and cadmium levels in the vicinity of the DMTS at present are unlikely to be associated with any increase in health risk. No other carcinogens have been identified in association with local mining, and therefore no substantial change in cancer rates related to Alternative B are anticipated. The air quality analysis indicates that effects on air quality from Alternative B are expected to be similar to Alternative A. The discharge to Red Dog Creek under operations and following closure would meet water quality standards and limits established in the NPDES permit, and would not be a substantial source of environmental contaminants that could affect human health.

Industrial Health and Safety

Mine Site / Port Site BLLs. Teck expects that lead and zinc ore concentrations in the Aqqaluk Pit area to be similar to those found in the existing Main Pit. As such, it is expected that Teck would extend and continue to refine its health and safety program for the mining operations extending into the Aqqaluk Deposit to prevent employee exposure to toxic dusts and other health and safety hazards. Therefore, the development of the Aqqaluk Deposit, along with ongoing disposal of waste rock, ore storage, milling, water treatment, and tailings disposal operations would not be expected to present any significant changes in worker exposure to airborne contaminants and BLLs as described in Section 3.13.2 above.

The closure plan would be initiated upon completion of Aqqaluk mining activities in 2031. Closure would involve regrading the slope of the waste rock dump and covering the waste rock with a two-layer soil cover. The site reclamation and regrading tasks are anticipated to present similar hazards as the current waste hauling and dumping tasks. The same worker protective measures would be in place to ensure minimal risk of inhalation and ingestion of contaminated dusts and soils.

Mine Site / Port Site Accident Rates. The mine non-fatal injury lost time incidence rates and fatal injury rates would be expected to be similar to 2008 rates based on the enhanced Loss Control department supervision, employee training and other health and safety program implementation up to the time of closure (2031). Site reclamation and closure activities would be expected to show a reduction in both fatal and non-fatal injury incidence rates since many hazardous mining and milling operations would be terminated.

3.13.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Public Health

Alternative C would result in similar overall health effects as described above under Alternative B with some limited exceptions associated with the use of the pipelines for the transport of concentrate, wastewater, and diesel fuel. The wastewater discharge point would be relocated to the Chukchi Sea rather than Red Dog Creek.

General Health. Effects would be the same as Alternative B, except that the elimination of the discharge into Red Dog Creek may help address some village concerns about drinking water and subsistence food safety, particularly for fish. The discharge would be returned to Red Dog Creek after closure.

Subsistence and Nutrition. Through the life of operations under Alternative C, reduced traffic (and accompanying traffic related fugitive dust) on the DMTS road could reduce impacts on subsistence harvest of caribou by Kivalina residents. Reducing effects on subsistence harvest could have a positive effect on nutrition and related metabolic disorders. Continued economic benefits from the mine would support subsistence by providing funds for equipment, supplies, and fuel.

Social and Psychological Health. As noted previously, subsistence is vital to social and psychological well-being in Iñupiat communities. Improvement in the availability of caribou and other subsistence resources could make a positive contribution to social and psychological health and well-being in the affected communities, including a slight decrease in injury rates.

Environmental Contaminants and Health. While the HHRA (Exponent 2007a) found little health risk likely based on available data regarding contaminants, the elimination of the concentrate trucks would reduce the major source of fugitive dust along the DMTS road and would reduce risks that could result from exposure to the dust. Although fugitive dust emissions under this alternative are expected to be lower, any change in health risk would be limited. Concerns about waterborne contaminants in Red Dog Creek would be eliminated but could simply be transferred to concerns about water quality contaminants in the Chukchi Sea. However, the permit limits for the Chukchi Sea discharge would be based on water quality standards although a small mixing zone could potentially be included.

Industrial Health and Safety

Mine Site / Port Site BLLs. Lead and zinc concentrates would be transported to the port via a slurry pipeline in lieu of concentrate trucks. Therefore, it is anticipated that further reductions in airborne toxic dust exposure and associated employee BLLs would be achieved for mine-site loader operators and other impacted personnel.

Port activities would increase, however, with the addition of filtration of lead and zinc concentrates and continued storage of filtered concentrates in the CSB. Additional worker exposure to lead, cadmium, and zinc could occur at the filter presses, thereby requiring the continued use of approved respiratory protection, protective work clothing, and good personal hygiene practices. Again, the small number of issues with employee exposure over the years of operation indicates that the increased risk of exposure would be adequately addressed by Teck's policies and procedures.

Mine Site / Port Site Accident Rates. Accident rates for transportation activities would be reduced or eliminated with replacement of concentrate trucks with a slurry pipeline. Projected accident rates for mining and milling operations and closure activities are the same as described previously.

3.13.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Public Health

The effects of Alternative D would be similar to Alternative B, except that measures would be taken to enhance dust control through truck washing, and two subsistence provisions (road and port closure) would be included. As under Alternative C, wastewater discharge would be to the Chukchi Sea but under Alternative D the marine discharge would be in perpetuity.

General Health. Similar to Alternative C, the elimination of the discharge into Red Dog Creek may help address some village concerns about drinking water and subsistence food safety, particularly for fish. The subsistence measures in this alternative could increase access to caribou and beluga.

Subsistence and Nutrition. Reduced traffic on the DMTS road during caribou migration could reduce impacts on the subsistence harvest of caribou, thereby reducing the contribution that operation of the DMTS road may have on the risk to nutrition and related metabolic disorders. Likewise, a positive effect on subsistence harvests of beluga whales would have a positive effect on nutrition. As with the other alternatives, continued economic benefits from the mine would support subsistence by providing funds for equipment, supplies, and fuel.

Social and Psychological Health. Any improvement in the availability of caribou or beluga whales would also make a positive contribution to social and psychological health and well-being in the affected communities, particularly Kivalina.

Environmental Contaminants and Health. The truck washes would reduce the contribution from lead and zinc concentrates to fugitive dust, although road dust would continue to be generated by truck traffic. The exposure risk from airborne contaminants, while minimal, would be less than under Alternative B but greater than under Alternative C. Concerns about waterborne contaminants in Red Dog Creek would be eliminated but could simply be transferred to concerns about water quality contaminants in the Chukchi Sea, regardless of the need for the discharge to meet water quality standards.

Industrial Health and Safety

Mine Site / Port Site BLLs. The concentrate component of fugitive dust emissions would be dramatically reduced by using truck washes at either end of the DMTS road. While already well-controlled, these dust control measures could potentially reduce worker exposures to contaminated dust during transportation activities and vehicle maintenance and fueling tasks.

Mine Site / Port Site Accident Rates. Accident rates would be similar as discussed for Alternative B.

3.13.4 Health – Summary

Public Health

Tables 3.13-5 through 3.13-8 summarize the effects of each alternative. A positive sign (+) indicates a benefit compared to other alternatives for that particular effect while a minus sign (-) indicates a negative effect compared to the other alternatives.

Table 3.13-5 Summary of the Potential Public Health Effects of Alternative A

HEALTH FOCUS	PUBLIC HEALTH EFFECTS
Subsistence and Nutrition	(+) decreased traffic on haul road (+) decreased fugitive dust emissions (+) improved subsistence hunting locally (-) loss of income leading to: a) difficulty purchasing subsistence fuel and equipment b) purchase of low-quality, inexpensive foods in village stores
Social and Psychological Health	(+) less impact to subsistence resources from traffic on haul road (-) sudden loss of income leading to poverty, stress, social dysfunction (-) loss of income leading to: a) difficulty purchasing subsistence fuel and equipment b) purchase of low-quality, inexpensive foods in village stores (-) social unrest related to financial stress/unemployment (-) deteriorating infrastructure
Environmental Contaminants and Health	no effect anticipated on cancer rates, respiratory illness, or cardiovascular disease (+) lower emissions of fugitive dust, TDS, and metals from mine

Table 3.13-6 Summary of the Potential Public Health Effects of Alternative B

HEALTH FOCUS	PUBLIC HEALTH EFFECTS
Subsistence and Nutrition	(+) continued income from mining supporting purchase of subsistence fuel and equipment (-) continued traffic on haul road which may disrupt caribou (-) continued fugitive dust emissions
Social and Psychological Health	(+) continued employment and income, stabilizing socioeconomics across region (-) mine workers absent from families, creating potential stressors for family functioning; continued impacts on subsistence resources (+) stabilization of current socioeconomic conditions through mine closure (+) continued funding for NWAB, supporting infrastructure development (-) continued subsistence impacts leading to more challenging hunting conditions
Environmental Contaminants and Health	cancer - no effects predicted (-) continued emissions of fugitive dust from mine

Table 3.13-7 Summary of the Potential Public Health Effects of Alternative C

HEALTH FOCUS	PUBLIC HEALTH EFFECTS
Subsistence and Nutrition	(+) continued income from mining supporting the purchase of subsistence fuel and equipment (+) decreased traffic on haul road, reducing impact on caribou harvest (+) decreased fugitive dust emissions, resulting in less impact on subsistence resources in the vicinity of the mine over time
Social and Psychological Health	(+) continued employment and income, stabilizing socioeconomics across region (+) improved access to subsistence resources (less than Alternative D) (-) mine workers absent from families, creating potential stressors for family functioning (+) stabilization of current socioeconomic conditions (+) continued funding for NWAB
Environmental Contaminants and Health	cancer - no effects predicted (+) reduced emissions of fugitive dust from mine

Table 3.13-8 Summary of the Potential Public Health Effects of Alternative D

HEALTH FOCUS	PUBLIC HEALTH EFFECTS
Subsistence and Nutrition	(+) continued income from mining supporting purchase of subsistence fuel and equipment (+) reduced traffic on haul road during caribou migration (+) reduced effects on beluga whale migration (-) continued fugitive dust emissions affecting community subsistence practices (less effect than Alternative B)
Social and Psychological Health	(+) continued employment and income, stabilizing socioeconomics across region (-) mine workers absent from families, creating potential stressors for family functioning (+) improved access to subsistence resources (+) stabilization of current socioeconomic conditions (+) continued funding for infrastructure
Environmental Contaminants and Health	cancer - no effects predicted (-) continued emissions of fugitive dust (less than Alternative B)

Industrial Health and Safety

Worker exposure and accident rates for the mine and milling operations would be similar for all alternatives because the nature of the operations would not vary by alternative. However, the duration of activity under Alternative A would result in less exposure and less risk of accident than the other alternatives. Port operations would also result in similar exposure and accident risks under alternatives A, B and D because again, operations would be similar in each case although of shorter duration for Alternative A. Alternative C would essentially eliminate the accident risks associated with trucking and would reduce lead and zinc exposures to some equipment operators. To some extent, risks for exposure (and accidents) would be shifted from the mine to the port and would be associated with the filter presses.

3.14 Cultural Resources

The purpose of this section is to describe cultural resources in the area of the Red Dog Mine, DMTS road, and port site; describe impacts on cultural resources resulting from mine activities to date; and assess potential impacts to cultural resources related to the proposed expansion of the Red Dog Mine and continued use of the road and port facilities. This discussion identifies known cultural resources in the study area and the potential for unknown or undocumented cultural resources that may be affected by the proposed undertaking.

Section 3.14 includes a discussion of cultural resources that have been or could be found in the vicinity of the Aqqaluk pit area as well as the Red Dog Mine, DMTS road, and port site. Cultural resources include sites and materials of prehistoric Native American (e.g., stone quarries, game lookouts, tool manufacturing sites, house and cache pits, campsites, villages, and stone tent rings), historic European and Euro-American, and historic Iñupiat origin (e.g., traditional cabin sites, camp sites, burial grounds, traditional subsistence harvest sites, reindeer corrals and other traditional land use areas, landscapes, symbols, and place names). A key assumption for the cultural resources analysis is that cultural resources are assumed to be eligible, or potentially eligible, for the National Register of Historic Places (NRHP) unless stated otherwise. The NRHP is an inventory of historic properties within the United States and the national repository of documentation on different types of historic properties, significance, abundance, condition, ownership, needs, and other information (NPS 1997). The NRHP was created with the passage of the National Historic Preservation Act (NHPA) of 1966 (16 USC 470 Sec. 101). Congress passed the act to preserve and protect the nation's historic properties in response to the country's rapid expansion and development.

The cultural resources analysis relies on:

- Alaska Heritage Resource Survey (AHRS) files located at ADNR, Office of History and Archaeology;
- An assessment of available literature regarding cultural resources in the proposed project area; and
- The application of existing laws and regulations regarding the assessment of effects on cultural resources caused by an undertaking.

The study area includes the Aqqaluk Deposit, existing ore deposit, tailings impoundment, ore processing and associated facilities, the DMTS road corridor, and the port area. The Aqqaluk Deposit is located adjacent to and north of the existing mine pit and facilities area. The 50-mile DMTS road connects the existing Red Dog Mine site to the port site, traversing through several drainages originating in the DeLong Mountains en route. The road corridor crosses land owned by NANA, as well as state, federal, and Cape Krusenstern National Monument lands.

The relevant regulations for the evaluation of effects to cultural resources are NEPA and Section 106 of NHPA and its implementing regulations, 36 CFR § 800. NEPA requires a review of project and program impacts on the cultural environment, which includes historic properties, other culturally valued places, cultural use of a biophysical environment (e.g., religious, subsistence), and sociocultural attributes (e.g., social cohesion, social institutions, lifeways, religious practices, and/or other cultural institutions).

The NHPA requires federal agencies to consider the effects of their undertakings on cultural resources that are eligible for the NRHP. Section 106 applies when a project has been determined to be an undertaking, which includes a project, activity, or program funded in whole or part under the direct or indirect jurisdiction of a federal agency, including those carried out by or on the behalf of a federal agency; those carried out with federal financial assistance; those requiring a federal permit, license, or approval; and those subject to state or local regulation administered pursuant to a delegation or approval by a federal agency (36 CFR § 800.16[y]). If the undertaking will have an adverse effect on historic properties, the agency must continue to consult to resolve the adverse effects. Federal agencies follow the Section 106 process in reviewing project activities and prescribing appropriate actions to meet the requirements for compliance.

The NHPA defines historic properties as prehistoric and historic districts, sites, buildings, structures, and objects listed on, or eligible for inclusion on, the NRHP including artifacts, records, and material remains related to the property (NHPA, 16 USC 470w, Sec. 301.5). Consideration is given to both the criteria of significance and integrity of the property's historic qualities. For a cultural resource (e.g., districts, sites, buildings, structures, and objects) to be eligible for the NRHP, it must possess integrity of location, design, setting, materials, workmanship, feeling, and/or association (36 CFR § 60.4).

Other relevant legislation that applies to cultural resources includes the Alaska Historic Preservation Act (AS 41.35.010-41.35.240), Antiquities Act of 1906 (16 USC 431 et seq.); the Archaeological Resources Protection Act of 1979 (16 USC 470 et seq.); the Abandoned Shipwreck Act of 1987 (P.L. 100-298); the American Indian Religious Freedom Act; Section 4(f) of the Department of Transportation Act (49 USC 303); the Archaeological and Historic Preservation Act of 1974 ("Moss-Bennett" Act); Executive Order 13007 ("Indian Sacred Sites"); and the Native American Graves Protection and Repatriation Act (25 USC 3001–3013).

Knowledge of northern human inhabitants has been recorded for approximately 150 years, and attempts at understanding the cultural history of the area began in earnest at the beginning of the 20th century (Lobdell 2000:8). There have been more than 40 surveys in the region since the 1930s; however, many of these were conducted adjacent to the Red Dog area within Cape Krusenstern National Monument and Noatak National Preserve (e.g., Ford 1959; Solecki 1950; Anderson 1972, 1977; Giddings and Anderson 1986; McClenahan and Gibson 1990; McClenahan 1993; Rasic 2000). The earliest surveys in the area connected with the Red Dog Mine were conducted by the Bureau of Land Management (BLM) beginning in 1979, and these surveys identified 37 sites that documented prehistoric and historic Native use of the area (Smith 1982, 1983). Most of these sites consisted of surface lithic scatters on bedrock terraces or other prominent topographic features. Most of the sites could not be dated because of lack of organic material and diagnostic artifacts. Diagnostic artifacts collected during these surveys reflected use of the area for at least the last 6,000 years (e.g., Northern Archaic and Arctic Small Tool traditions).

Later studies were conducted by Edwin S. Hall and Associates (e.g., Gal 1990, 1991; Gerlach and Hall 1984, 1986; Hall 1982, 1983a, 1983b, 1983c, 1983d, 1986, 1987, 1989; Hall and Bowers 1987; Mason 1990; Ream 1988) and Northern Land Use Research, Inc. (e.g., Bowers, Higgs, and Gerlach 1998a; Gerlach, Higgs, and Mason 1996, 1997; Potter 1999; Potter et al. 2000a; Potter, Bowers, and Gerlach 2000b; Potter 2001). Edwin S. Hall and Associates identified 124 cultural resource sites between 1982 and 1985. Surveys conducted by Edwin S. Hall and Associates after 1986 identified an additional 22 cultural resource sites. Northern Land Use Research, Inc. identified 10 additional sites between 1996 and 2001. Similar to the BLM surveys, most sites identified during surveys conducted by Edwin S. Hall and Associates and Northern Land Use Research, Inc. were surface lithic scatters and lacked organic material and diagnostic artifacts that would allow dating of the sites. Diagnostic artifacts collected during these surveys reflected use of the area for at least the last 10,000 years (e.g., Paleoarctic, Northern Archaic and Arctic Small Tool traditions, historic Iñupiat). A summary of cultural resource surveys and sites identified during surveys conducted in the Red Dog Mine area is included in the *Integrated Plan for the Management of Cultural Resources in the Red Dog Project Area* (Potter et al. 2006: Table 5.1).

3.14.1 Cultural Resources – Pre-mining Environment

3.14.1.1 Prehistoric Environment (Before 11,500 years ago to A.D. 1778)

Human prehistory in northwest Alaska begins with the Paleoindian and Paleoarctic traditions dating to approximately 11,500 years ago and continuing into the historic period that begins in AD 1778 when English explorer James Cook sighted land near Kivalina. The following sections describe prehistoric traditions in the region that, based on locations of their documented remains, have potential for occurring in the Red Dog Mine project area. The cultural history and human development sequences of northern Alaska are incomplete. Table 3.14-1 depicts a provisional cultural sequence for northwest Alaska.

Table 3.14-1 Provisional Cultural Sequence for Northwest Alaska

Tradition	Date	Finds	Representative Sites in the Red Dog Area
Paleoindian	11,200-8,800 BP	Large lanceolate points, bifaces, scrapers, gravers	Tuluaq (DEL-00360)
Paleoarctic	10,000-7,000 BP	Distinctive cores and blades, microcores, microtools, bifaces, burins	DEL-00163, DEL-00166, DEL-00168, DEL-00185
Northern Archaic	6,000-2,000 BP	Side-notched projectile points, microblades, bone tools, scrapers	DEL-00342
Arctic Small Tool (Choris, Norton, Ipiutak)	4,500 BP-AD 1000	Diminutive lithic microtools, cores, burins, blades	DEL-00185, DEL-00337, NOA-00035
Northern Maritime (Birnirk, Western Thule, Late Prehistoric Iñupiat)	AD 400-AD 1778	Stone and bone tools, evidence of dog traction, harpooning whales from skin boats	DEL-00340
Historic Iñupiat	AD 1826	Stone, metal, trade goods, organic artifacts plus historic, ethnographic, and informant accounts	Onalik Reindeer Corral (NOA-00074)

Sources: Anderson 1984; Giddings and Anderson 1986; McClenahan 1993; Potter et al. 2006

Paleoindian Tradition (11,200 to 8,800 years ago)

The earliest sites in northern Alaska date to the end of the Pleistocene and beginning of the Holocene, approximately 11,000 years ago. The Paleoindian Tradition is primarily defined by a lithic toolkit that includes fluted and unfluted, lanceolate projectile points, hide scrapers, and spurred gravers. There is a lack of archaeological evidence, such as faunal remains, that indicates diet in Paleoindian sites; however, it has been hypothesized that Paleoindians hunted mammoth, bison, and caribou based on faunal evidence collected in Paleoindian sites elsewhere. Paleoindian sites in the Red Dog vicinity include Tuluaq (DEL-00360) and DEL-00185 (Potter et al. 2006; Rasic 2000).

American Paleoarctic Tradition (10,000 to 7,000 years ago)

The American Paleoarctic Tradition may have appeared after, or possibly contemporaneous with, the Paleoindian Tradition. Much like the Paleoindian tradition, the American Paleoarctic Tradition is primarily defined by the lithic toolkit. Because certain tool types associated with this tradition, such as distinctive cores, blades, and burins, are similar to stone technologies from Northeast Eurasia, connections across the Bering Land Bridge have been hypothesized. This stone technology is hypothesized to have been oriented toward the production of composite antler and stone projectiles used to dispatch late Pleistocene-Early Holocene fauna based on intact composite tools and faunal remains found in Paleoarctic sites elsewhere. American Paleoarctic sites in the Red Dog vicinity likely include DEL-00163, DEL-00166, DEL-00168, and DEL-00185 (Gerlach and Hall 1986; Potter et al. 2006).

Northern Archaic Tradition (6,000 to 2,000 years ago)

The Northern Archaic Tradition appeared between 5,000 and 6,000 years ago in the form of distinctive side-notched projectile points (Anderson 1968; Potter et al. 2006). This point type, as well as other distinctive stone tools, is found throughout interior and northern Alaska and the Yukon Territory. Northern Archaic groups are hypothesized to have been primarily hunters of large terrestrial animals, such as caribou. Northern Archaic Tradition sites in the Red Dog area include DEL-00342 (Bowers et al. 1998a; Potter et al. 2006).

Arctic Small Tool Tradition (4,500 years ago to AD 1000)

The Arctic Small Tool Tradition initially appeared in Alaska approximately 4,500 years ago. Arctic Small Tool tradition is identified by small, finely flaked stone tools and may represent the beginning of bow and arrow use in northwest Alaska. The Arctic Small Tool Tradition is believed by some researchers to be the earliest archaeological tradition associated with modern Iñupiat people. Cultures associated with the Arctic Small Tool Tradition include Choris, Norton, and Ipiutak.

Choris appeared in coastal areas of northwest Alaska from 3,700 to 500 years ago. Choris cultural remains have been documented on the North Slope of the Brooks Range dating from 2,700 to 2,500 years in age. Elements of the Choris culture, named after the type site in eastern Kotzebue Sound, have been documented as far inland as Anaktuvuk Pass and Galbraith Lake (Anderson 1984). Assigning Choris origins to the northern interior Alaskan occurrences is less certain than is desirable (Anderson 1984). The Norton culture was first defined at the Iyatayet site on Norton Sound, and spans a period from approximately 2,500 to 2,000 years ago. Cultural remains documented at Norton sites suggest that the Norton culture has its origins in the Choris culture (Giddings 1964). The Ipiutak culture is hypothesized to have contributed to the development of Thule culture. Ipiutak lacked pottery, ground slate tools and stone lamps, which are associated with the earlier Norton culture and later Iñupiat cultures. Ipiutak sites have been documented both at coastal and inland sites. The presence of Ipiutak sites in the Brooks Range and its temporal position, immediately preceding Thule, indicates that Ipiutak culture played a major role in the prehistory of the area. Inland Ipiutak persisted substantially longer than the presence of the culture in coastal areas. Coastal age ranges fall within the period from 2,000 to approximately 1,100 years ago, while those of the interior fall within the period from 1,350 to 550 years ago (Gerlach and Hall 1988; Giddings and Anderson 1986). Arctic Small Tool Tradition artifacts were identified in sites in the Red Dog area including at DEL-00185 and DEL-00337 (Gerlach et al. 1997; Bowers, Simon, Williams, and Gerlach 1998b; Potter et al. 2000a; Potter et al. 2006).

Northern Maritime Tradition (AD 400 to AD 1778)

Beginning approximately 2,000 years ago, ancestral forms of the historic Native cultures emerged, and underwent the final stages of development leading up to the cultural forms that were encountered by European explorers in the 19th century. Archaeological excavations suggest that marine mammal hunting from strategic promontories may have become a preferred subsistence strategy, while land mammal hunting, especially of caribou, remained important in the foothills regions (Giddings and Anderson 1986; Gerlach and Hall 1986). An example of a site in the Red Dog area that dates from this period is DEL-00340 (Bowers et al. 1998a). The Northern Maritime Tradition includes the Birnirk, Western Thule and Kotzebue periods.

The Birnirk period, a direct precursor of the historic Thule culture, appears in the Bering Strait by 1,600 years ago. Birnirk peoples lived in semisubterranean winter houses and engaged in the harvest of marine and land mammals, birds, and fish. The Birnirk type-site is located near Barrow at the base of the Barrow spit (Piġniq). Other sites that contain Birnirk cultural remains include Walakpa, Point Hope and Cape Krusenstern. Birnirk style artifacts have been found from northeastern Siberia to northwestern Canada, indicating a large trade network reminiscent of the extensive Iñupiat trade network in place in the 19th century.

Western Thule is part of the widespread Thule culture, which is the immediate prehistoric predecessor of the various historic Iñupiat groups. Approximately 1,000 years ago, a favorable climate coupled with technological innovations, such as the *umiaq* (a large skin boat), the *qataq* (cold trap door for winter houses), and the *umiat* (dog sled), resulted in the rapid expansion of Thule populations from the Bering Strait along the shores of the Beaufort Sea to Greenland, and southeast around the shores of the Bering Sea, ultimately to Kodiak Island and Prince William Sound. Developed Thule appeared 1,000 years ago and persisted in the North American Arctic to historic contact (Giddings and Anderson 1986). It ultimately spread from the Bering Strait along the shores of the Beaufort Sea to Greenland, and southeast around the shores of the Bering Sea to Kodiak Island and Prince William Sound. When the early explorers and whalers arrived on the Beaufort Sea coast in 1826, they encountered the Thule people. Thule people hunted sea mammals, including whales, as well as terrestrial game, such as caribou. In many Thule areas, salmon were also an important subsistence resource.

3.14.1.2 Historic Environment (After A.D. 1778)

The historical period for the area starts in 1778 when Captain James Cook sighted land near the present-day village of Kivalina. Because of shallow water along the coast in this area, few early European or American explorers made observations about the people living in this area. Members of the Vasil'ev and Shishmerev expedition noted a large settlement on the Kivalina coast in 1926. Kashevarov documented a Kivalliñigmiut camp in 1838. Healy encountered Kivalliñigmiut along the Kivalina coast in 1880 (Burch 1998).

The Red Dog Mine area was traditionally occupied by the Kivalliñigmiut, whose territory was centered around the Kivalina and Wulik river drainages. A discussion of the Kivalliñigmiut is included in *The Iñupiaq Eskimo Nations of Northwest Alaska* (Burch 1998:23–57) and is summarized briefly here. The Kivalliñigmiut seasonal round consisted of seal hunting in spring; caribou hunting in summer; freshwater fishing, berry picking, and small and large game hunting in early fall; caribou hunting in fall; and fishing and hunting in winter. Caribou were the focus of subsistence activities, with summer and fall caribou hunting using water drives, large and elaborate systems of drive lines, and complex social arrangements. Spring settlements were located mainly on the coast, fall settlements were located primarily along river valleys, and winter settlements were located in both areas. Winter structures were typically willow-framed, caribou hide covered tents, and summer structures were typically tents built using locally available stones to secure the dwelling from wind. The Kivalliñigmiut participated in trade fairs, festivals (e.g., Sheshalik and at the mouth of the Wulik River), and feasts with their neighbors. In the 19th century, Kivalliñigmiut population estimates ranged from 280 to 448 people in 20 settlements.

The advent of commercial whaling in the 1850s brought rapid changes to Iñupiat society as the economy became increasingly cash based. Subsistence continued to be an important part of Iñupiat society regardless of the increasing reliance of cash in the economy. The commercial fur trade became an important part of the economy across the Brooks Range and the North Slope in the early 20th century until fur prices collapsed in the 1930s. Cultural resources associated with the fur trade include sod house ruins, ice cellars, trading posts, and graves. An example of such a site in the Red Dog area is a transitional historic tent ring site with firearm shells and stone tools (DEL-00182). Reindeer herding was also important during the early part of the 20th century. An example of a site from this period is the Onalik Reindeer Corral (NOA-074) located near the port site that was part of the Kivalina reindeer herd management established in 1905.

3.14.2 Cultural Resources – Baseline Conditions

A review of available information regarding cultural resources in the Red Dog area identifies 425 documented cultural resource sites in an area bounded by the Chukchi Sea to the west, the DeLong Mountains to the north, and the Noatak River to the south (ADNR-OHA n.d.; Potter et al. 2006). Information regarding cultural resources in this area has been compiled during 40 surveys since 1979 (ADNR-OHA n.d.; Potter et al. 2006). Documented cultural resources are mostly prehistoric lithic sites that have not been assessed for eligibility for the NRHP. Cultural deposits are generally located on the ground surface or in shallow deposits, and few can be dated because of a lack of organic materials and diagnostic artifacts. The few sites that can be dated include historic Iñupiat, late prehistoric, Arctic Small Tool Tradition, Northern Archaic Tradition, American Paleoarctic Tradition, and Paleoindian. Site types in the area range from prehistoric stone quarry sites, game lookout and tool manufacturing sites, house and cache pits, campsites, villages, stone tent rings, historic reindeer corrals, cabins, and burials. Sites in the area are often situated on promontories overlooking the creek and river valleys, on elevated bedrock outcrops situated in tussock tundra, and in low-lying areas where streams intersect.

Currently, 116 documented cultural resource sites are located within two miles of existing or proposed components. When limited to within 1,000 feet of existing or proposed components, the number of documented cultural resource sites is reduced to 42. When limited to the footprint of existing or proposed components, the number of documented cultural resource sites is further reduced to 17, some of which have already been destroyed by construction activities. These cultural resources are discussed below.

Several cultural resource sites are located in the proposed Aqqaluk Deposit and immediate vicinity. Four known sites are located within 1,000 feet of the proposed Aqqaluk Deposit: DEL-00163, DEL-00185, DEL-00294, DEL-00295, DEL-00296, DEL-00337, and DEL-00338. DEL-00294, DEL-00295, and DEL-00296, lithic scatter sites with no diagnostic artifacts, were assessed for eligibility for the NRHP in 1996 and were not recommended to be eligible (Gerlach et al. 1997). Site DEL-00294 was disturbed as a result of operations; sites DEL-00295 and DEL-00296 were excavated as mitigation for the disturbance of site DEL-00294. DEL-00185 was assessed and recommended as eligible in 1996 (Gerlach et al. 1997). DEL-00185 was a lithic site with Arctic Small Tool Tradition artifacts located on the boundary of the Aqqaluk Deposit that contained debitage, biface fragments, microblades, microblade cores, and large lanceolate projectile points. This site was recommended eligible for the NRHP. DEL-00185 was excavated in 1998 as a mitigation strategy and more than 14,000 artifacts were recovered (Bowers et al. 1998b; Potter et al. 2000a; Potter et al. 2006).

Five lithic sites are located within the Main Pit: DEL-00297, DEL-00298, DEL-00299, DEL-00300, and DEL-00301. One site, DEL-00298, was found not eligible for the NRHP, and the other sites were destroyed in construction of the pit (Potter et al. 2006).

There are seven sites in the vicinity of the tailings impoundment that have already been disturbed or will be disturbed by the time mining of the main deposit is complete: DEL-00168, DEL00169, DEL-00281, DEL-00282, DEL-00283, DEL-00284, and DEL-00285. DEL-00281 through DEL-00285 were mitigated in 1987 (Ream 1988). The eligibility status of DEL-00168 and DEL-00169 has not been determined. Two small lithic scatter sites (DEL-00158 and DEL-00159) were destroyed by construction activity in the tailings impoundment area. DEL-00343 is a NRHP eligible site that is currently submerged in the tailings impoundment.

Three cultural resource sites are located within the mill and camp area: DEL-00171 (lithic debitage site), DEL-00172 (isolated flake), and DEL-00240 (lithic site). No determinations of eligibility have been conducted for the sites; however, DEL-00240 was excavated in 1985 (Gerlach and Hall 1986).

While no cultural resources have previously been identified in the DMTS road corridor, several sites have been identified in material sites (e.g., NOA-00071, NOA-00137, and DEL-00241). NOA-00071 is a small flake scatter; NOA-00137 is a lithic site with diagnostic artifacts (e.g., stemmed spear point, end scraper, microblade) associated with Arctic Small Tool Tradition, as well as flakes and biface fragments; and DEL-00241 is an isolated lithic (wedge-shaped microblade core). None of the sites have been assessed for eligibility for the NRHP. Several sites are located within 1,000 feet of the road corridor, including, in order from the mine site to the port: DEL-00160, DEL-00161 (small lithic scatters located near the airstrip), DEL-00170 (lithic site), DEL-00167 (lithic site), NOA-00305 (isolated lithic artifact), NOA-00135 (lithic site, Arctic Small Tool Tradition), NOA-00136 (small lithic site), NOA-00118 (lithic site), NOA-00081 (lithic site), and NOA-00082 (lithic site, Northern Maritime Tradition). DEL-00160 and DEL-00161 have not been assessed for eligibility for the NRHP and have been destroyed. DEL-00167 has been found not eligible for the NRHP. DEL-00170, NOA-00081, NOA-00082, and NOA-00305 have not been assessed for eligibility for the NRHP. NOA-00118, NOA-00135 and NOA-00136 have been completely excavated and/or collected.

3.14.3 Cultural Resources – Environmental Consequences

3.14.3.1 Effects Common to All Alternatives

An adverse effect to a cultural resource occurs when an undertaking may alter, directly or indirectly, any of the characteristics of a cultural resource that could qualify the property for inclusion in the NRHP by diminishing the property's integrity (location, design, setting, materials, workmanship, feeling), and/or association (i.e., association with an important event or person [Criteria A and B], style of architecture [Criterion C], or information potential [Criterion D]), thus rendering it ineligible for the NRHP. Indirect effects to cultural resources include those impacts that result from the action later in time or further removed in distance. These effects are reasonably foreseeable and result from increased access to cultural sites in the vicinity of the project area and the potential for encroachment of project components into culturally sensitive areas. This could result in a greater vulnerability of cultural resources to damage caused by project personnel and equipment during construction and operation of facilities and infrastructure. For the purposes of this assessment of effects, all cultural resources are assumed to be eligible, or potentially eligible, for the NRHP unless stated otherwise.

Examples of direct effects to cultural resources from ongoing or proposed activities could include physical destruction of or damage to all or part of the resource, removal of the resource from its original location, change of the character of the resource's use or of physical features within the resource's setting that contribute to its historic significance, change in access to traditional use sites by traditional users, or loss of cultural identity with a resource. Indirect effects to cultural resources from the proposed project could include impacts caused by increased access to and close proximity of project components to cultural resources. This could result in a greater vulnerability of cultural resources to damage caused by project personnel and equipment construction and operation.

Potential indirect effects associated with human access to cultural resources along the DMTS road and near the port and mine sites will continue until closure of the mine. These effects could include removal, trampling, or dislocation of cultural resources by personnel or visitors. Access related effects could be mitigated through implementation of the existing Cultural Resources Management Procedure, which includes annual training for employees/contractors; posting of cultural resource information, including company policy regarding cultural resources; and maintaining confidential records for all sites with access limited to designated employees.

Most of the area that could be affected by continued operation of the Red Dog Mine has been surveyed during cultural resource investigations associated with the Red Dog Mine Project. As part of this effort, the *Integrated Plan for the Management of Cultural Resources in the Red Dog Project Area* (Potter et al. 2006) was drafted to identify cultural resources in the Red Dog area, recommend methods to identify cultural resources as the project expands, and address effects from current and future Red Dog activities on known and previously undocumented cultural resources in the Red Dog area. As part of this Integrated Plan, a standard operating procedure has been implemented to address known and previously undocumented cultural resources in the Red Dog area. The methods recommended in these documents meet state and federal standards for the identification and treatment of cultural resources and should be followed as this project continues and expands.

3.14.3.2 Effects of Alternative A – No Action Alternative

Under Alternative A, current mine operations would continue until 2011 and the Aqqaluk extension would not occur. Because no additional footprint is associated with this Alternative, there would be no further direct impacts to cultural resources resulting from construction activities. However, continued use of the DMTS road, port site, and mine site until 2011 may result in direct and indirect effects on cultural resources.

Continued operation of the mine, tailings disposal, and mill and camp areas could affect cultural resources, although appropriate mitigation has already been carried out at the most important sites, and it is likely that no additional sites will be found in this area. As discussed under Section 3.14.2, some sites have already been affected by construction of the Main Pit and tailings impoundment. There are seven sites in the vicinity of the tailings impoundment that have already been disturbed or will be disturbed by the time mining operations at the Main Pit cease in 2011. DEL-00343, a NRHP eligible site that is currently submerged in the tailings impoundment, will be directly affected by continued operation of the Red Dog Mine. Appropriate measures should be carried out to mitigate these effects, such as excavation of the site, or excavation of a similar site in the vicinity.

The potential for contamination or disturbance of cultural resources associated with spills along the DMTS road, cleanup activities related to spills, maintenance of mine and port facilities, and use of material and disposal sites, will continue under Alternative A. Cultural resource surveys in the area of the Main Pit and associated mitigation are complete, and therefore no additional effects on cultural resources in that area are expected to occur. Continued enforcement of procedures related to cultural resources, such as halting operations when cultural resources are found, and documenting the site will help mitigate any potential effects in the unlikely event that previously unidentified cultural resources are located in the Main Pit during operational activities.

Although no effects to cultural resources resulting from spills or disturbances along the DMTS road have been documented to date, the potential for spills will exist as long as mine operations and use of the road continue. Spills of hydrocarbons or toxic materials could cause a physical disturbance or contamination of surface or shallow cultural resource sites. Sites could be adversely affected during cleanup activities through direct effects, such as damage or disturbance, or indirect effects, such as increased access that could result in looting or inadvertent damage. The current operational plans, such as the spill response plan, could help mitigate effects to cultural resources from spills and cleanup.

Accelerated erosion associated with mining activities that could result in exposure of cultural resources from shallow sites will also continue to occur under Alternative A. Erosion in tundra areas through natural aeolian (wind), colluvial (water-gravity), and alluvial (water) processes could result in effects such as exposure of artifacts and features from shallow sites. Continued operation of the port site could affect a grave and ice cellar site (NOA-00307) that is currently fenced to restrict access. This site is associated with the Onalik Reindeer Corral (NOA-00074) that was excavated in 1986 and has since mostly eroded into the Chukchi Sea (Hall and Gerlach n.d.; Potter et al. 2006). Teck's Integrated Plan notes that NOA-00307 will continue to be protected with fencing and monitored for possible direct or indirect effects from continued operation of the Red Dog Mine.

Activities associated with reclamation of the mine after closure in 2011, including construction of water management facilities, placement of covers over the tailings impoundment and waste rock dumps, and revegetation would occur within the existing footprint. If material to create covers for mine components is obtained from areas outside of the existing footprint or from areas not previously surveyed, undocumented cultural resources could be affected. Areas favored for material sites are often the same areas that were favored by prehistoric peoples and often contain cultural resources. These areas should be surveyed carefully prior to ground disturbing activity. If a cultural resource is found, it should be assessed for eligibility for the NRHP and avoided or mitigated in an appropriate manner.

3.14.3.3 Effects of Alternative B – Applicant’s Proposed Action

Under Alternative B mining activities would extend to the Aqqaluk Deposit and continue until 2031. Activities at the port site and along the DMTS road would continue as under current conditions, but would extend in duration until 2031. Thus, the direct and indirect effects discussed under Alternative A would continue, but for a longer duration of time. The chance for a spill at the mine site or along the DMTS road that could contaminate or disturb cultural resource sites would increase over the length of mine operations. Furthermore, indirect effects related to human access to cultural resource sites along the DMTS road and at the mine site would also increase over time with continued access and personnel changes.

As discussed in Section 3.14.2, several cultural resource sites are located within the immediate vicinity of the Aqqaluk Deposit and could be directly or indirectly impacted by construction and operation of the Aqqaluk Deposit. Two lithic sites, DEL-00295 and DEL-00296, were located within the Aqqaluk Deposit area and have not been assessed for eligibility for the NRHP. These sites have been destroyed by exploration activities. DEL-00185 was excavated in 1998 for mitigation and more than 14,000 artifacts were recovered (Bowers et al. 1998b; Potter et al. 2000a; Potter et al. 2006). Because effects to this site have already been mitigated through excavation, the site is no longer extant. Therefore, there will be no impacts to this site from construction and/or operation of the Aqqaluk Deposit. DEL-00338 is a small lithic scatter with flakes and a core fragment that was recommended not eligible for the NRHP (Gerlach et al. 1997).

DEL-00337 is a small chert quarry site with an estimated 500 flakes and several bifacially worked flakes, possibly associated with the Arctic Small Tool Tradition that was recommended as eligible for the NRHP (Gerlach et al. 1997). DEL-00163 is a lithic site with numerous formal tools the design of which suggests occupation dating to the late Pleistocene or early Holocene. As a result, the site was recommended as eligible for the NRHP. Because DEL-00163 and DEL-00337 could be eligible for the NRHP, they should be avoided by construction and operation activities if possible, and monitored for direct and indirect effects.

Effects related to reclamation of the Main Pit and tailings impoundment would be the same as Alternative A, except that borrow material could come from the Aqqaluk Pit, and therefore no additional borrow sites would be needed. Thus, fewer impacts related to reclamation would occur under Alternative B than under Alternative A.

3.14.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Similar to Alternative B, mining activities under Alternative C would continue until 2031, extending to the Aqqaluk Pit. However, under Alternative C, buried pipelines would be installed along the DMTS road to transport concentrate slurry, treated tailings wastewater, and diesel fuel. Wastewater discharge would occur in the Chukchi Sea rather than in Red Dog Creek.

Continued operations at the mine site (including the Aqqaluk Pit) and port site, would result in similar impacts to cultural resources as Alternative B. However, the footprint of the DMTS road would expand with installation of the pipelines, which would require construction of a 24-foot-wide bench and removal of vegetation. Identified and unidentified cultural resources along the DMTS road could be affected because of construction of these components and associated activity. Furthermore, cultural resources near the pipeline could be contaminated or disturbed if pipeline spills of concentrate, diesel fuel, or discharge water occur, and could also occur during cleanup operations. Sites documented within the proposed right–of-way for the proposed pipeline should be reinvestigated, documented, and assessed for NRHP eligibility prior to disturbance so appropriate mitigation measures can be conducted. If the pipelines are placed outside of the previously surveyed road right-of-way, then a survey should be conducted, and sites found within the corridor should be documented, assessed for eligibility for the NRHP, and mitigated as appropriate, prior to construction.

3.14.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Alternative D would be the same as Alternative B, except that two enclosed truck washing facilities would be built at either end of the DMTS road, a buried pipeline bench would be incorporated into the DMTS road to transport wastewater to its discharge location in the Chukchi Sea, and two subsistence provisions would go into effect.

If the enclosed truck washing facilities are in areas not previously surveyed, then undocumented cultural resource sites could be disturbed or destroyed during construction. Surveys should be conducted in the areas proposed for construction of the truck washing facilities, and mitigation should be carried out as appropriate. The effects of fugitive dust on cultural resources are likely minimal; however, the enhanced dust control under this alternative may further minimize these effects. Similar to Alternative C, pipeline spills could affect cultural resources along the DMTS road. Under Alternative D, however, potential spills would consist of wastewater discharge only, rather than concentrate, wastewater discharge, and diesel fuel.

The two subsistence provisions proposed under Alternative D are, 1) closure of the DMTS road for one month during the fall caribou migration and, 2) closure of the port site during the July beluga migration. These closures may result in a minor decrease in potential impacts to cultural resources associated with spills along the DMTS road and human access to cultural resource sites during those closure periods. It is unclear where material would be stockpiled during these closures. Should stockpiles occur in areas that have not been previously surveyed, cultural resource surveys should be conducted and any cultural resources within the footprint should be documented, assessed for NRHP eligibility, and mitigated as appropriate.

3.14.4 Cultural Resources – Summary

The number of documented cultural resource sites within the footprint of existing or proposed components is 17, some of which were impacted by earlier construction activities. Alternative A will not impact known cultural resources in the vicinity of the Main Pit, beyond those already impacted by historic construction and mining activity. Alternatives B, C, and D have the potential to adversely impact two known sites within the Aqqaluk Pit and four additional sites located within 1,000 feet of the Aqqaluk Pit. Under Section 106 of the NHPA, EPA and the Corps are consulting with SHPO on the two sites (DEL-00163 and DEL-00337) that have been recommended for inclusion in the NRHP. EPA sent a letter to SHPO with a determination that there would be no adverse effect to these sites with implementation of Teck’s Cultural Resource Protection Plan. SHPO’s response will be documented in EPA’s NEPA Record of Decision.

Direct and indirect impacts to cultural resources, under alternatives B, C, and D, have the potential to occur for 19 years beyond the cessation of mining under Alternative A.

No cultural resources have been identified along the DMTS road, although the pipeline bench construction under alternatives C and D could destroy unknown or unidentified resources. Teck’s cultural resource policy would be in place in the event that previously unidentified cultural resources were identified during construction.

Only alternatives C (wind turbine) and D (truck wash) would involve expanding the footprint of the port facility beyond already disturbed areas. In these cases, the disturbance footprint would be minimal and designed to avoid known resources in the vicinity. Indirect impacts to potential cultural resources located adjacent to the port facility would last through 2011 under Alternative A or 2031 under alternatives B, C, and D.

3.15 Transportation

This section discusses baseline conditions and analyzes potential direct and indirect transportation related impacts of the proposed Aqqaluk Project and the alternatives to the Applicant's proposed action. Three alternatives for the project plus a no action alternative are evaluated. Mitigation measures are identified, where appropriate.

The DMTS consists of a road corridor and a port on the Chukchi Sea. The DMTS supports mining operations at the Red Dog Mine by transporting and shipping the lead and zinc concentrates produced at the mine. Portions of the DMTS corridor pass through NANA lands, Cape Krusenstern National Monument lands administered by NPS, Alaska state lands administered by ADNR, and the Cape Krusenstern National Historic Landmark Archeological District, which encompasses the entire port, the national monument, and much of the DMTS corridor (Operating and Maintenance Plan 2004). NANA was granted a 100-year right–of-way through the Cape Krusenstern National Monument through a land exchange agreement with NPS, which was authorized and ratified by the United States Congress. Teck operates and maintains the DMTS for AIDEA, which financed and retains ownership of the DMTS. Operation of the DMTS is subject to several agreements between AIDEA, NANA, Teck, and NPS. Teck has priority, non-exclusive use of the DMTS, and contracts NANA/Lynden to transport material between the mine and the port. The corridor road is a State road, and as such, NANA/Lynden trucks and truck drivers must comply with State regulations.

3.15.1 Transportation – Pre-mining Environment

The existing environment, prior to the start of mining operations, was composed of an area characterized by moderately sloping hills, broad stream valleys, and coastal lowland lagoon systems, underlain by a layer of permafrost (EPA 1984). Nearly all of the project area was undeveloped and roadless. For transportation, villagers from nearby Kivalina and Noatak use all-terrain vehicles and snowmachines in the winter to traverse the ice and snow for subsistence or to visit neighboring communities, and boats to navigate rivers in the summer, after the ice break (Alaska Department of Transportation and Public Facilities 2004). NWAB communities were and remain accessible year-round by air.

3.15.2 Transportation – Baseline Conditions

3.15.2.1 DeLong Mountain Regional Transportation System Haul Road

Traffic

The original evaluation of options in placement of the DMTS was described in the 1984 EIS. The DMTS road is used year-round to transport lead and zinc concentrate from the mine to the port facility for shipment to market, and less frequently, to transport supplies and fuel from the port to the mine (TCAK 2004a). The 52-mile road is constructed of crushed rock and gravel. The road was originally built on a geotextile liner, covered with approximately five feet of fill and one foot of one-inch or less surface course material. The road is approximately 30 feet wide. The road includes nine bridges, three major culvert crossings, and 445 minor culvert crossings. A number of material sites that are mined for surface course material or for water withdrawal are located along the road.

Concentrate transport is achieved by a fleet of eleven 120-ton trucks operated by NANA/Lynden. Bulk fuel is transported from the port by 24,900-gallon single tanker trucks. A back-up hauler for fuel consists of a flatbed truck carrying two 5,000-gallon International Organization for Standardization (ISO) tanks and pulling one 5,000-gallon trailer-mounted ISO tank. Supplies are transported to the mine using a fleet of four flatbed trucks, each capable of carrying one to four Conex shipping containers. The transport of supplies increases in the summer months when the supply barges arrive. Light vehicle traffic on the DMTS road includes the road surface crew, who may travel the road twice per day, other department members as required to support operations, and persons from regulatory agencies who infrequently travel the DMTS road. Once per week, port employees are transported between the port and the airport using passenger vans. Typical traffic on the DMTS road on average is summarized in the Table 3.15-1.

Table 3.15-1 Summary of Traffic on DeLong Mountain Regional Transportation System Road

Traffic Type	Number of Units in Use Per Day	Average Round Trips Per Unit Per Day	Maximum Round Trips Per Unit Per Day	Total Average Round Trips Per Day
Concentrate Trucks	7 – 8	5	6	36
Fuel Trucks	1 – 2	1.7	4	1.7
Supply Trucks	1 – 2	1.2	4	1.2
Maintenance Vehicles*	1 – 5	N/A	N/A	N/A
Light Vehicles	3 – 10	1	2	10

Source: TCAK 2004a
*Maintenance vehicles do not make trips, but use the road to get to the working area.
N/A = not applicable

The majority of traffic on the DMTS road is the round-trip transport of concentrate from the mine to the CSBs at the port facility. Typically seven or eight concentrate trucks are in use on a daily basis, allowing for continuous maintenance of the fleet. Typically each truck makes three round trips per 12-hour shift, with an average of 36 total concentrate truck round trips made per day. Until the fall of 2001, the tractors towed side-dump A-Train trailers with rolling tarp covers. At that point the fleet was changed to specially designed tractor units that tow tandem trailers with B-Train assemblies. The B-Train assembly design provides a more stable attachment between the truck and trailer, improving performance and handling. The new trailers have hydraulically operated steel covers that seal in concentrate during transport. Each truck transports approximately 109 tons of concentrate per trip. A schematic of the current concentrate truck fleet is shown in Figure 2.14 in Chapter 2.

Health and Safety Record

Incidents of concentrate truck spills reported from 1990 through 2007 are summarized in Table 3.15-2. As noted above, the train assemblies and the tandem trailers were updated in the fall of 2001. The number of spills and the corresponding amount of concentrate that spilled markedly decreased after that point. No reportable injuries occurred from accidents on the DMTS road from 2000 through 2007.

Wildlife Incidents

An indication of the direct impacts of the concentrate hauling system on wildlife can be measured through traffic–wildlife collision statistics. Procedures are implemented for reducing activity on the DMTS road when caribou are in the vicinity (Operating and Maintenance Plan 2004). According to the plan, when migrating caribou are in the vicinity, truck traffic ceases until the caribou have crossed the road, and are at least 300 feet from the road. Observations regarding the effectiveness of the procedures for traffic and caribou are discussed in Section 3.12.2.2. Incidents of traffic-wildlife collisions on the DMTS road from 2004 through 2007 are summarized in Table 3.15-3. Indirect effects of traffic on wildlife are discussed in detail in Section 3.9.

Table 3.15-2 Health and Safety Record Summary

Year	Number of Spills	Tons of Concentrate Spilled	Volume of Fuel Spilled (gallons)
1990	5	194	N/A
1991	1	30	N/A
1992	3	124	N/A
1993	2	63	N/A
1994	1	36	N/A
1995	0	0	N/A
1996	2	72	N/A
1997	3	42	N/A
1998	7	199.4	N/A
1999	3	176.5	N/A
2000	2	70	0
2001	2	24	0
2002	0	0	0
2003	0	0	0
2004	0	0	7,048
2005	1	120	0
2006	2	1.45	0
2007	0	0	0

N/A = Not available

Table 3.15-3 Traffic–Wildlife Collisions 2004–2007

Date	Incident Description
January 23, 2004	Concentrate truck struck two caribou; unknown if injury or death resulted.
May 13, 2005	Concentrate truck struck brown bear cub, however no injury was apparent.
August 14, 2005	Light pick-up struck and killed a golden plover.
August 5, 2006	Concentrate truck struck and killed a fox.
October 6, 2006	Light pick-up struck and killed a fox.
November 14, 2006	Plow truck struck a caribou, which later died as a result of injuries.
December 1, 2006	Ptarmigan in flight struck the windshield of a grader; unknown if injury or death resulted.
December 2, 2006	Concentrate truck struck and killed a caribou.
December 13, 2006	Concentrate truck struck and killed a wolf.
April 2, 2007	Ptarmigan in flight struck the windshield of a grader and was killed.
April 12, 2007	Concentrate truck struck and killed a fox.
July 21, 2007	Passenger SUV struck a seagull; injuries were most likely fatal.
October 13, 2007	Concentrate truck struck and killed a fox.
November 18, 2007	A dead fox was reported on the side of the road; it had been struck but the incident was not reported.

Source: TCAK, Siteline Wildlife Incidents, 2004-2007, memo dated 2/18/08

3.15.2.2 Road Maintenance

Existing Dust Control Measures

Traffic on unpaved roads generates fugitive dust. The generation of dust results in a loss of fine particulates in the road that act as road surface binders (Sanders and Addo 1993). The dust itself pollutes the environment, and the loss of fine particulates contributes to road instability. Therefore, the control of dust is important for ameliorating both of these problems. In addition to the dust generated by traveling the DMTS road, concentrate dust that may cling to the exterior of concentrate trucks during the loading and unloading process is a concern. Measures taken to decrease the traffic-generated dust include the application of a palliative and of water (Operating and Maintenance Plan 2004). The palliative is calcium chloride, and is applied to the entire road approximately three to four times per year. It may either be applied dry and then watered, or applied as a water solution. Water is withdrawn from permitted material sites from May through September.

A test paving of the road occurred during 2002 (Exponent 2007b). Approximately 2.5 miles were paved from the fuel island to the New Heart Creek Bridge, including the road around the port facility CSBs and truck unloading building. The "high float" road surface quickly developed potholes and was removed shortly after it was installed.

Efforts have been taken to reduce fugitive concentrate dust that collects on the exterior of concentrate trucks during loading and unloading, or that is tracked out by the concentrate trucks from the CSBs at the mine and the port. The loading area at the mine site CSB isolates the trucks from the loader and stored concentrate. The loading area includes a dust control system composed of a stilling shed and curtains to contain any entrained dust during loading operations; fans have been designed to draw airborne dust back into the mine CSB and reduce the amount of dust reaching the concentrate trucks and trailers. The system was upgraded in 2008 to include a baghouse that keeps the mine site CSB under negative air pressure. A truck wash installed at the mine is used in the summer to remove concentrate from the outside of trucks prior to exiting the mine site. The truck wash is not used during the winter months because of the possibility of creating driving hazards, such as freezing brakes or hydraulic lines. At the port, an "air wash" dust control system was installed at the truck unloading building, which uses a 55,000 cubic feet per minute (cfm) baghouse to draw dust laden air from the truck unloading hopper, and uses positive airflow to minimize the potential of dust adhering to the concentrate trucks.

Snow Removal

The DMTS road is monitored daily, weather permitting, to identify areas of wear, snow drifts, or areas requiring dust control. The road was designed to be "self-cleaning," so that by design, snowfall would be blown off the road by wind because of the dryness of the snow, the frequent winds typical of the area, and the road's elevation above the surrounding ground. When snowfall or snow drifts accumulate, a grader or plow truck is used to move snow to the side of the road and to push snow across bridge crossings. A front-end loader equipped with a snow blower or a large-capacity snow blower may be used to disperse snow pushed to the side of the road, away from the roadbed to the surrounding tundra.

Surface Replacement

Yearly, the road is assessed to determine where surface course material needs replacement. On average, approximately 15,000 yards of surface course materials are prepared and applied to around five miles of road each year. Surface course material is generated at material sites in the DMTS corridor. The borrow site locations and approximate volume to be excavated were originally characterized in the 1984 EIS (EPA 1984). Currently, two material sites (MS-2 and MS-9) are actively mined for surface course material. Material sites within the national monument are currently inactive, but are retained for potential future use. Several other material sites are permitted for water withdrawal of up to 200,000 gallons per day per site each year by ADNR Temporary Water Use Permit F2002-10. The material sites on ADNR land are permitted by ADNR State Land Use Permit ADL415967, which limits material to 25,000 cubic yards per year. The current material sites and associated uses are summarized in Table 3.15-4.

Table 3.15-4 DeLong Mountain Regional Transportation System Material Sites

Material Site	Mile Post	Land Owner/Rights	Material Use	Other Authorized Use	Status	Notes
1-1E	N/A	NANA	Embankment fill, surface course	none	Closed	Port construction
2A	0.75	NANA	Offshore cell fill, surface course	none	Closed	Road construction
2	1.9	NANA	Embankment fill, surface course, riprap, sand	Water withdrawal/ sanitary landfill	Active	
3	8.1	Easement/ National Monument	Embankment fill, surface course, riprap	none	Inactive / future potential	
4	11.7	Easement/ National Monument	Embankment fill	none	Inactive / future potential	
5	17.0	Easement/ National Monument	Embankment fill, surface course, riprap, sand	Water withdrawal	Inactive / future potential	
6	18.3	Easement/ National Monument	Embankment fill, surface course, riprap, sand	Water withdrawal	Active / closing 2008	
7	25.5	Easement/ ADNR Land	Embankment fill	none	Inactive	
8	29.3	Easement/ ADNR Land	Embankment fill	none	Inactive	
8A	30.6	Easement/ ADNR Land	Embankment fill, riprap	none	Inactive	
9	33.5	Easement/ ADNR Land	Embankment fill, “high-float” test material, surface course	Water withdrawal	Active	
10	38.3	Easement/ ADNR Land	Embankment fill, surface course, riprap	Water withdrawal	Inactive / future potential	
11	40.5	Easement/ ADNR Land	Embankment fill, surface course	Water withdrawal	Inactive / future potential	
12	42.8	Easement/ ADNR Land	Embankment fill, surface course, riprap	none	Inactive / future potential	
13	46.2	NANA	Embankment fill, surface course, riprap	none	Inactive	Rock cut used in road design
14	47.5	NANA	Embankment fill, riprap	none	Inactive	Rock cut used in road design

N/A = not applicable

3.15.2.3 Airport

The airstrip for the mine facility is located approximately three miles southwest of the mill (SRK 2007). The airstrip is 6,350 feet long and is capable of accommodating commercial jet aircraft. It is used year-round to transport personnel, equipment, supplies, and perishables to and from the mine site. The plane schedule is shown in Table 3.15-5.

Helicopter use is highly variable (TCAK, memo, 2008). Helicopters are used both by the environmental group and by the exploration group. The environmental group uses a Robinson R-44 or similar helicopter for field sampling and station maintenance approximately 100 field days per year, for approximately one hour each day. The flight path is highly variable.

Table 3.15-5 Weekly Fixed Wing Schedule

Day	Service	Time
Sunday	No Scheduled Service	
Monday	1 Flight Between Red Dog and Kotzebue	Arrival – 12:45 pm Departure – 1:00 pm
Tuesday	NAC Freight Flight	
Wednesday	Crew Rotation 1 Flight Between Red Dog and Anchorage 4–6 Flights from Red Dog to Region	 Arrival – 4:30 pm Departure – 5:15 pm
Thursday	No Scheduled Service	
Friday	1 Flight Between Red Dog and Kotzebue	Arrival – 12:45 pm Departure – 1:00 pm
Saturday	1 Flight Between Red Dog and Anchorage	Arrival – 4:30 pm Departure – 5:15 pm

Source: TCAK 2008

The exploration group uses an A-Star or similar helicopter for moving drill rigs to exploration sites. The flight time is usually one to three hours per day and is divided among drilling equipment, delivering supplies to the rigs, and transporting drill crews. The exploration field season is highly variable, and may range from 0 to 130 days in the field.

3.15.2.4 Port

At the port facility, the open water season extends for approximately 100 days, from June until October (Corps 2005). Lead and zinc concentrate is distributed to market by bulk ore carriers during this period. Freight and fuel are also delivered to the port at this time. On average each year, 27 ore carriers anchor in deep waters offshore from the port facility. The ore carriers are loaded from two lightering barges, the *Kivalina* and the *Noatak.* The barges are loaded at the barge loading dock by conveyors that transfer the concentrate from the CSBs. Each barge is transported from the shallow water dock to the ore carrier with the assistance of two tugs. A fifth tug is used to pull the stern of the ore carrier to maintain proper orientation. The average time to load each barge is four hours, and the average time to load an ore carrier is three days. On average, that requires 323 round trips of the barges and the 4 tugs per year. In addition, about 12 barges per year travel to the port to provide shipments of freight and fuel.

3.15.3 Transportation – Environmental Consequences

The important issues associated with transportation include direct and indirect effects on wildlife, accidents that cause the release of contaminants into the environment or cause injuries or fatalities to employees or local residents, and the generation of fugitive dust, some of which may contain lead and zinc concentrate. The direct effects on wildlife are indicated by traffic–wildlife collisions statistics, whereas indirect effects resulting from the noise generated by concentrate trucks or the continued presence of concentrate trucks may be indicated by changes in animal behavior. The primary discussion of these effects is found in Section 3.9. Traffic statistics using accident and spill data will be used to assess the effects of changes in transportation among the alternatives. Finally effects of fugitive dust generation are discussed and the impacts associated with changes in transportation among the alternatives are assessed.

3.15.3.1 Effects Common to All Alternatives

The common element of transportation among alternatives A, B and D is the continued use of concentrate trucks and fuel trucks. These vehicles are sources of greenhouse gas emissions. The baseline, or existing, use of the DMTS road in transporting fuel and concentrate is discussed above. Mitigation measures common to all alternatives would be, at a minimum, the continuation of current standard operating procedures and the implementation of a fugitive dust risk management plan that is currently under development for dust control. Since the fugitive dust risk management plan and its implementing plans are not yet final, at this time it is not clear what mitigation measures will be implemented.

3.15.3.2 Effects of Alternative A – No Action Alternative

The existing conditions would continue to occur through 2011, when mining of the Main Pit is expected to be complete. Based on the record since using the B-Train tractor trailer units, less than one spill a year (0.6) would be expected for the duration of operations through 2011. Spill volume could range from less than 1 ton to 109 tons, which would represent the entire contents of the truck. As has been done in the past, spills would be cleaned up and contaminated soils would be removed and hauled to the mine site. Wildlife collisions would be expected to continue at similar rates as experienced during previous operations, representing a threat to small numbers of mammals and birds. After mine closure, ownership of the DMTS would be retained by AIDEA. MS-5 would possibly become an active material site to generate material for site reclamation.

3.15.3.3 Effects of Alternative B – Applicant's Proposed Action

Similar to Alternative A, under Alternative B the concentrate would continue to be transported along the DMTS road to the port for shipment through 2031. The effects currently associated with transportation would continue through the life of the mine. Dust control and accident and spill prevention would be accomplished through the use of existing standard operating practices and the draft fugitive dust risk management plan in development. No expansion of material sites is expected, and current uses of material sites would be expected to continue through the life of the mine.

3.15.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Alternative C would involve construction of three pipelines. One pipeline would transport concentrate as a slurry from the mine to the port, which would eliminate fugitive dust emissions associated with the transport of concentrate. Fuel would also be pumped to the mine from the port, largely eliminating the need for fuel transport trucks. Traffic along the DMTS road would be greatly reduced, with fugitive dust sources and greenhouse gas emissions being limited to light vehicles and supply trucks. Incidents of concentrate truck accidents with wildlife, or concentrate truck accidents that may cause injury or harm to employees or local residents, would be eliminated. The noise that concentrate truck and fuel truck traffic generates would also be eliminated under this alternative.

Under Alternative C, treated wastewater would be piped from the mine to an outfall at the Chukchi Sea through another pipeline. A marine outfall would greatly reduce the current use of a helicopter for environmental sampling.

Construction of the pipeline bench under this alternative would require the expansion of current material sites. MS-3 is not currently active, but could be used to generate material for construction of the pipeline bench from the mine to the port.

3.15.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

The effects of Alternative D would be the same as Alternative B, except there would be more stringent dust control procedures in place, reducing the generation of fugitive dust. Two truck washes would be installed for cleaning the concentrate trucks. The first would replace the existing outdoor wash with an enclosed system. The concentrate trucks would be washed before leaving the mine site and again after leaving the truck unloading building at the port to prevent tracking of concentrate dust that collects on the exterior of the trucks during loading and unloading. The truck wash system would be an automatic drive-through system equipped with a water-recycle system and dryers upon exit to prevent freezing of the truck brakes and hydraulics. The mine site truck wash system could be installed near the contractor PAC for trucks to pass through before entering the DMTS road. Each truck wash would require a disturbance area of approximately 60 feet by 120 feet.

Material site usage for road maintenance would be expected to be similar to Alternative B. Under Alternative D, the DMTS road and the port would be closed for approximately 30 days each fall to reduce impacts on subsistence. The DMTS road would be closed in the fall, when caribou herds are migrating. Closure of the DMTS road in the fall would require a modification to the travel schedule since the same number of annual trips would be necessary over 11 months instead of 12 under current operations. The primary discussion of how this would reduce impacts on subsistence is found in Section 3.12.3. The port would open later in the shipping season to reduce impacts on spring hunts for marine mammals. Refer to Section 3.12.3 for a more detailed discussion of the effects of this alternative on subsistence.

Under Alternative D, treated wastewater would be discharged by pipeline to the Chukchi Sea. The need for a helicopter to conduct environmental sampling, as in Alternative C, may be eliminated. Expansion of current material sites would be expected to provide the material for construction of the bench for the discharge pipeline.

3.15.4 Transportation – Summary

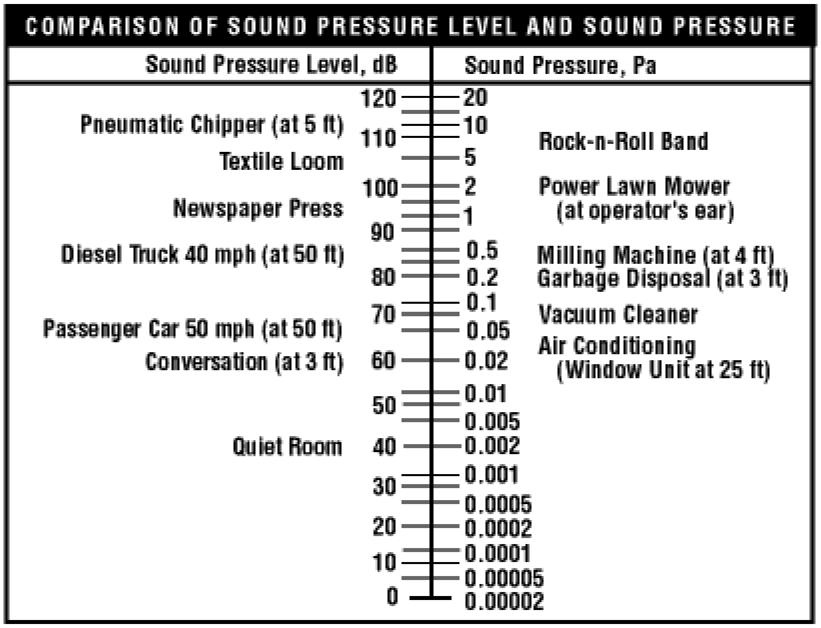
Transportation along the DMTS road and seaward from the port facility would continue to occur under all alternatives. Potential impacts, under all alternatives, result from fugitive dust emissions, collisions with wildlife, and spills. Transportation along the DMTS road under Alternative A would largely cease following closure in 2011, although some light vehicle traffic would continue for ongoing maintenance of the water treatment plant and other facilities. Transportation under alternatives B, C, and D would continue through 2031, light vehicle use is expected to continue past 2031 for ongoing maintenance, similar to post-closure levels under Alternative A. Potential impacts under Alternative B are similar to but longer in duration than Alternative A. Alternative C eliminates concentrate truck traffic and diesel truck traffic, with only supply trucks and light vehicle traffic remaining. Alternative D is similar to Alternative B, but with enhanced mitigation measures (truck washes) to reduce the concentrate component of fugitive dust emissions. Potential impacts from marine transportation are not expected to vary across the alternatives, with the exception of Alternative A’s shorter duration.

3.16 Noise

This section discusses baseline conditions and analyzes potential direct and indirect noise related impacts of the Applicant’s proposed action and alternatives. Noise is unwanted sound that adversely impacts people and the environment (NPC 2008). Sound is essentially vibration in the air induced by a source. The vibration produces alternating bands of dense and sparse air particles that ripple outward from the source. The result of the movement of the air particles is a fluctuation in normal atmospheric pressure, or sound waves. These sound waves can be described in terms of three variables: amplitude, frequency, and time pattern.

The amplitude of a sound wave is also described as the sound pressure, which is perceived by the human ear as loudness. Sound pressure is usually expressed in pressure units of Pascals (Pa). The range of pressure that can be heard by the human ear is from 0.00002 Pa to 20 Pa. To overcome the difficulty of working with such a great range, the decibel (dB) scale is used, which is a logarithmic scale. When sound pressure is converted to decibels, it is described as the sound pressure level. The zero of the decibel scale is equivalent to 0.00002 Pa, which is the threshold of human hearing. All other sounds are compared to this value in the decibel scale. For example, the sound pressure of a sharp, painful sound is about

10 million times greater than the least audible sound in terms of sound pressure. Comparison of sound pressure level units and sound pressure units, as well as the sound pressure levels of common sound sources is shown in Figure 3.43.



Source: Canadian Centre for Occupational Health and Safety, http://www.ccohs.ca/oshanswers/phys_agents/noise_basic.html, February 25, 2008.

Figure 3.43 Sound Pressure

The sound pressure levels of two separate sounds are not directly additive. For example, if a sound of 70 dB is added to another sound of 70 dB, the total sound pressure level is 73 dB, not 140 dB. A summary of noise level addition is provided in Table 3.16-1. If the difference between two sounds is greater than 10 dB, then the sound level of the louder noise predominates.

The rate at which the sound source causes the air to vibrate is the frequency of the sound. The unit of frequency is usually Hertz (Hz), which is essentially the cycles of sound waves per second. The human ear perceives frequency as pitch, and can identify sounds with frequencies from 16 Hz to 20,000 Hz, but hears sounds most readily with frequencies between 1,000 Hz and 6,000 Hz.

The time pattern is the duration of the sound. It can be described as continuous, intermittent, or impulsive, and can indicate if the noise fluctuates in intensity.

Measurement of sound approximating the way sound is heard by the human ear gives more weight to the frequencies that people hear more easily. EPA recommends the A-weighted scale for measurement of sound, measured in dB(A). EPA has suggested protective noise levels for public health and well being for outdoor areas of 55 dB(A) averaged over a 24-hour period (NPC 2008). MSHA noise standards for protection of mine workers were updated September 13, 2000 (U.S. Department of Labor 2008). The rule requires mine operators to use all feasible engineering controls to reduce miners' noise exposure to a permissible exposure level. The permissible exposure level is an eight-hour time weighted average (TWA_8) of 90 dB(A). An action level at which miners need to be enrolled in a hearing conservation program is 50 percent of the permissible exposure level or 85 dB(A). The rule also requires that no miner is exposed at any time to sound levels exceeding 115 dB(A).

Table 3.16-1 Addition of Noise Levels (in Decibels)

Numerical difference between two noise levels [dB(A)]	Amount to be added to the higher of the two noise levels [dB or dB(A)]
0	3.0
0.1 - 0.9	2.5
1.0 - 2.4	2.0
2.4 - 4.0	1.5
4.1 - 6.0	1.0
6.1 - 10	0.5
10	0.0
Step 1: Determine the difference between the two levels and find the corresponding row in the left hand column. **Step 2**: Find the number [dB or dB(A)] corresponding to this difference in the right hand column. **Step 3**: Add this number to the higher of the two decibel levels.	

Source: Canadian Centre for Occupational Health and Safety, http://www.ccohs.ca/oshanswers/phys_agents/noise_basic.html, February 25, 2008.

3.16.1 Noise – Pre-mining Environment

The background noise level of the project site was characterized in the 1984 EIS (EPA 1984). The project area is located in a remote region of northwest Alaska. Using data from similar remote locations, typical natural noise levels were reported within 15 to 45 dB(A). Natural noise associated with storms was approximated at 65 dB(A). Noise attributed to the Alaska Native communities was associated with subsistence activities using snowmachines, outboard motors, and float planes, which may typically generate noise levels up to 85 dB(A) at 50 feet (15 meters).

3.16.2 Noise – Baseline Conditions

Currently, noise is generated at the project site by mining, mining related activities such as transportation of the concentrate on the DMTS road, and port activities. A summary of noise generating activities is shown in Table 3.16-2. The distance required for the noise generated by each activity to decay to a sound level equivalent to background noise is also given in the table. Note that the distances provided in the table represent the maximum distance each sound would be audible. The values provided assume no attenuation (e.g., a subsurface blast deep within the pit) and in reality, sounds would only be audible over shorter distances. For example, Section 3.11.2 notes that the owner of a lodge located approximately 25 miles from the site may have heard noise from blasting only rarely (Driver 2008b).

Blasting occurs at the mine approximately once every other day, and occurs at two of the borrow sites on the DMTS road approximately four times per year. The noise generated by the blasting process is more commonly measured using an unweighted scale called the peak instantaneous noise level (dB_{peak}), which cannot be compared directly to the A-weighted noise levels of other sources of noise at and around the mine site. This is because blasting occurs infrequently, and is of a short duration. Noise from blasting is often perceived as much quieter than its peak noise level might imply, because the frequency of its noise is very low, below the frequency of human hearing. Peak unweighted noise levels for blasting can be determined from the airblast pressure, which is estimated using the following empirical formula (Fidell et al. 1983).

Table 3.16-2 Baseline Noise Sources

Sound Source	Sound Pressure Level [dB(A)]	Frequency/ Duration	Maximum Combined Noise [dB(A)]	Distance to Background [45 dB(A)]
Mine				
Bulldozers	97 @ 50 ft (15 m)	Continuous	102 @ 50 ft (15 m)	6.8 mi (11 km)
Front-End Loaders	90 @ 150 ft (15 m)	Continuous		
Ore Trucks	90 @ 50 ft (15 m)	Continuous		
Primary/Secondary Crushers/ Grinding Mill	95 @ 50 ft (15 m)	Continuous		
Diesel-Powered Generators	100 @ 50 ft (15 m)	Continuous		
Worker Accommodations	60 @ 50 ft (15 m)	Continuous		
Airstrip				
Aircraft Operations (Jets)	95 @ 50 ft (15 m)	~ 2/week	102 @ 50 ft (15 m)	6.8 mi (11 km)
Helicopter	102 @ 50 ft (15 m)	~ 1/week		
Helicopter	82 @ 500 ft (152 m)	~ 1/week		
Helicopter	76 @ 1,000 ft (305 m)	~ 1/week		
Helicopter	70 @ 2,000 ft (610 m)	~ 1/week		
Haul Road				
Concentrate Truck Units	90 @ 50 ft (15 m)	~ 1/ every 45 minutes	93 @ 50 ft (15 m)	2.3 mi (3.8 km)
Tanker/Supply Trucks	90 @ 50 ft (15 m)	~ 1/day		
Utility/ Passenger Vehicle	80 @ 50 ft (15 m)	~1/day		
Portable Crusher MS-2 and MS-9	100 @ 50 ft (15 m)	Periodic	100 @ 50 ft (15 m)	5.2 mi (8.4 km)
Port (air propagated)				
Concentrate Trucks	90 @ 50 ft (15 m)	~ 1/every 45 minutes	93 @ 50 ft (15 m)	2.3 mi (3.8 km)
Tanker Trucks	90 @ 50 ft (15 m)	~ 1/day		
Diesel Powered Generators	85 @ 50 ft (15 m)	Continuous		
Crane Loader	70 –85 @ 50 ft (15 m)	~12/year		

Source: EPA 1984

$$AB = 0.162(D/W^{-1/3})^{-0.794}$$

Where: AB is the airblast pressure in pounds per square inch;
D is the distance in feet; and
W is the maximum charge per delay

The peak sound pressure level is determined through the following calculation.

$$\text{Sound Pressure Level} = 20 \log (AB) + 171$$

The peak sound level for blasting with a maximum charge weight of 400 pounds, and at a distance of 229 feet (61 meters) is estimated to be 130 dB_{peak}.

The noise generated by ship loading and shipping offshore of the port facility is described in the DMTS navigational improvements draft EIS (Corps 2005). Sound pressure levels were not provided for air-propagated noise generated by ship loading operations; however, it was stated that noise from the on-shore operations could not be detected beyond 1,300 feet offshore on a calm day. Ship noise was characterized as being heard as far as 10 to 10.5 miles away for ore carriers and tugs, respectively.

Table 3.16-1 shows the extent that noise generated at the mine, the haul road, and the port facility perpetuates until reaching natural background levels of 45 dB(A). In effect, the sound generated by a point source decays by 6 dB as the distance from the source doubles. The equation for calculating the change in sound pressure levels as distance increases is given by:

$$\Delta dB = (a * 10) * \log (D_1/D_2)$$

Where: ΔdB is the change in sound pressure levels in units of decibels;
a is a drop off rate coefficient; here, a = 2.0 for a source with no ground or atmospheric absorption;
D_1 is the distance at which the sound pressure level is measured; and
D_2 is the distance at which a new sound pressure level is to be determined.

The analysis assumes that there is no attenuation or interference from other sources or obstructions between the sound source and the receptor. The analysis also assumes that the sound is propagated through air over land. The rate of decay of sound over a water body is less than what would occur over land. As noted previously, the assumptions provided a conservative analysis in which noise generated by mining activities is not attenuated by natural factors, such wind, rain, topography, and natural background noise, which in reality would dampen noise (Figure 3.44).

3.16.3 Noise – Environmental Consequences

The issues associated with noise are the impacts on wildlife resulting from mining and DMTS activities, and the impact on users of the Cape Krusenstern National Monument and Noatak National Preserve (also see sections 3.9.3 and 3.11.3). Impacts can be approximated by using noise measurements and determining the distance the noise propagates.

3.16.3.1 Effects Common to All Alternatives

Noise would continue to occur under all alternatives, generated by activities at the mine site and shipping activities at the port facility. Under Alternative A, mining and the associated generation of noise would cease in approximately 2011. Under the remaining alternatives, mining would continue through approximately 2031. Under all alternatives, blasting noise would impact the largest area, although infrequently. Blasting noise may affect recreation activities such as fishing the Wulik River by detracting from the secluded environment, or subsistence hunting activities by startling wildlife. Under all alternatives, safety procedures for blasting would ensure compliance with MSHA noise standards for mine workers.

3.16.3.2 Effects of Alternative A – No Action Alternative

The existing conditions, consisting of noise generated by mining activities, transport activities on the DMTS road, and activities at the port for shipping, would continue to occur through 2011. After mining ceases in 2011, the site would be reclaimed and noise levels would generally return to pre-mining conditions. Ongoing wastewater treatment at the mine would require the use of generators and some activity by heavy equipment would be required to handle sludge generated in the wastewater treatment process. The level of activity would be minimal compared to existing operations.

3.16.3.3 Effects of Alternative B – Applicant's Proposed Action

The existing conditions would continue to occur through 2031 as a result of the continued mining activities at the Aqqaluk Deposit. Mining Aqqaluk would be expected to start in 2010. To accommodate mining of both the Main Pit and the Aqqaluk Deposit, new equipment may be added. However, the noise level of each individual piece of new equipment would be similar to existing equipment, and would not contribute to an increase in the combined total noise level coming from the mine. The effects of noise generated under Alternative B would be similar to the impacts of Alternative A, except it would continue for a longer period of time.

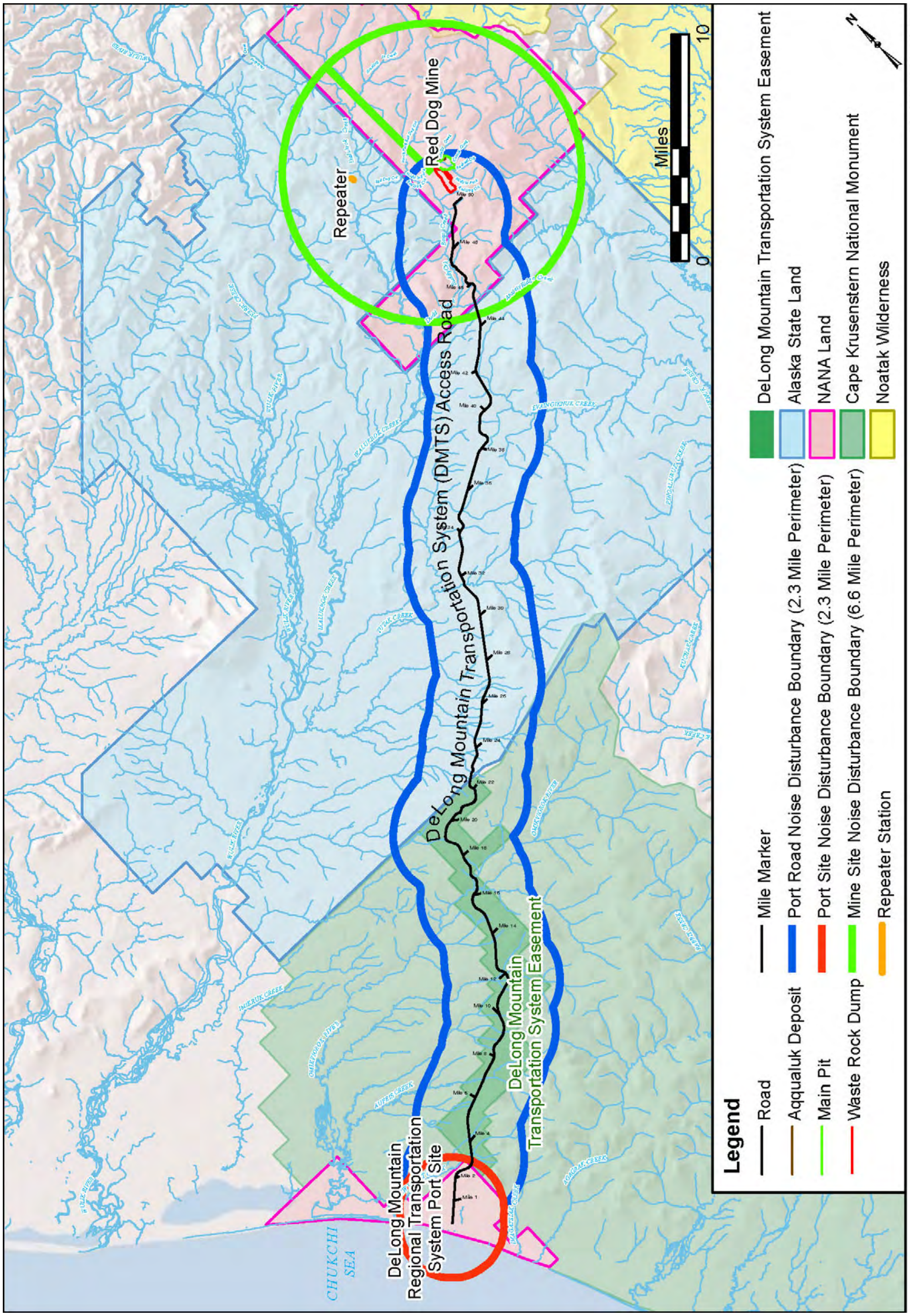


FIGURE 3.44
NOISE DISTURBANCE BOUNDARY

3.16.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Under Alternative C, pipelines would be used to transport concentrate from the mine to the port, and fuel from the port to the mine. The use of pipelines would eliminate concentrate trucks and fuel trucks, eliminating much of the DMTS road noise. A daily supply truck and light vehicle traffic would continue but noise levels on the DMTS road would be much lower than operations involving the concentrate trucks. A minimal amount of additional noise would be created at the port with the addition of new generators. The filter press operations necessary to dewater the concentrate prior to storage would be conducted indoors and therefore would not contribute to external noise at the port. The use of the pipeline would reduce the extent of environmental monitoring within the Wulik River drainage. The reduction in monitoring would reduce helicopter traffic in the area and the attendant noise. The reduction would occur until the relocation of the outfall back to Red Dog Creek after closure in 2031. However, the post closure monitoring program might be conducted on a smaller scale requiring less helicopter sampling than the current program.

3.16.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Under Alternative D, the DMTS road would be closed for the month of October. The noise associated with the concentrate trucks would be eliminated for this time period to lessen transportation related effects on the fall caribou migration pattern. Also, the shipping season at the port facility would open later, so port activities would not interfere with any subsistence activities related to marine wildlife conducted through the middle of July. The reduction in noise from helicopter-based sampling would be the same as Alternative C, except the reduction would be permanent.

3.16.4 Noise – Summary

Noise would continue to occur under all alternatives, generated by activities at the mine site, vehicles traveling the DMTS road, and shipping activities at the port facility. Under all alternatives, blasting noise would impact the largest area, although infrequently. Under Alternative A, mining and the associated generation of noise would cease in approximately 2011. Under the remaining alternatives, mining would continue through approximately 2031. Under Alternative C, the use of pipelines would eliminate concentrate trucks and fuel trucks, eliminating much of the DMTS road noise. Under Alterative C, there would be a minimal amount of additional noise associated with generators at the port. Under Alternative D, the DMTS road would be closed for the caribou migration during month of October and the shipping season at the port facility would open later to accommodate subsistence activity. Both closures would provide positive noise benefits to subsistence resources. Additionally, the use of pipelines under alternatives C and D would reduce helicopter traffic related to environmental sampling.

3.17 Socioeconomics

The Northwest Arctic Region is composed of approximately 39,000 square miles along the Kotzebue Sound, and the Wulik, Noatak, Kobuk, Selawik, Buckland and Kugruk rivers. It is governed by the NWAB and is the second-largest borough in Alaska after the North Slope Borough. The region contains 11 communities, 10 of which are incorporated cities with municipal governments. The population of the region is predominately Iñupiat Alaskan and the tribal IRA Councils in each village also play a role in governance in the communities. According to the NANA Lands Department, about 76 percent of the land in the region is federally owned and protected as parks, preserves and wildlife refuges. Other major landowners include the State of Alaska, NANA, and the Kikiktagruk Iñupiat Corporation. As a major landowner, NANA, also plays a key leadership role in the region.

The NWAB is a home-rule borough, incorporated in 1986. According to the Alaska Constitution, a home-rule borough can exercise any power not specifically prohibited by state law or by the borough's charter, which defines its powers and duties and is adopted by voter approval. The borough is governed by a mayor, who is elected to a three-year term, and an 11-member Assembly whose members are also each elected to a three-year term. The Assembly holds meetings once a month in Kotzebue. The borough is responsible for holding yearly elections in October, during which the residents also vote on members of the School Board and the Planning Commission.

The NWAB provides a variety of services to the region including public safety, planning and zoning, the public library in Kotzebue, the regional Department of Motor Vehicles, and regional economic development. One of the key functions of the borough is to support education through the NWAB School District. The borough also participates in both the Higher Education Consortium and the Northwest Arctic Leadership Team with the Maniilaq Association, the NWAB School District, and NANA.

Note that Appendix F provides descriptions of Kivalina and Noatak, the two villages closest to the Red Dog Mine. The community descriptions include details on local economic data. Appendix G provides a description of the social conditions within the NWAB and offers supplemental material relevant to socioeconomics.

3.17.1 Socioeconomics – Pre-mining Environment

3.17.1.1 Northwest Arctic Borough Population and Demographics

Throughout the 1960s, 1970s, and early 1980s, the population of the NWAB area (known then as the Kobuk Census Area) grew slowly. The area’s population increased at an annual rate of 1.3 percent in the 1960s and 1.8 percent during the 1970s. Data indicate that population growth accelerated early in the 1980s, increasing at about 3 percent annually between 1980 and 1983, though differing methodologies for estimating population may have accounted for some of the change. Most of the individual communities in the area were also growing throughout this period. Table 3.17-1 presents the population of each village in the NWAB between 1960 and 1983.

In 1980, 85.1 percent of the NWAB population was Alaska Native. In 2000, 82.5 percent of the population was Alaska Native, according to U.S. Census data.

Table 3.17-1 Northwest Arctic Borough Area Pre-Red Dog Population, 1960, 1970, 1980, 1983

Community	1960	1970	1980	1983
Ambler	70	169	192	275
Buckland	87	104	177	218
Deering	95	85	150	165
Kiana	253	278	345	364
Kivalina	142	188	241	269
Kobuk	54	N/A	62	85
Kotzebue	1,290	1,696	2,054	2,237
Noatak	275	293	273	365
Noorvik	384	462	492	522
Selawik	348	429	535	599
Shungnak	135	165	202	241
Northwest Arctic Borough	3,560	4,048	4,831	5,340

Source: U.S. Census Bureau, 1960, 1970, 1980 and Alaska Department of Labor, 1983, as reported in the 1984 Red Dog EIS, and Alaska Department of Labor, 1983

N/A = not available

Northwest Arctic Borough Migration Patterns

While the population of the northwest Arctic region has grown since the 1960s, the area has experienced a net out migration since 1970. Separating the differences in migration patterns based on the time frame before and after construction of the Red Dog Mine is complicated. To simplify the discussion and provide for more continuity, migration patterns beginning with the pre-mining time period are discussed under Section 3.17.2.1, Northwest Arctic Borough Migration Patterns.

3.17.1.2 Northwest Arctic Borough Employment and Income

The Alaska Department of Labor reported a total of 1,438 jobs in the NWAB area in 1980, more than twice the number reported in 1970. Government was by far the largest source of employment in the area, particularly the federal government. The decline in federal employment between 1970 and 1980 was largely the result of the Indian Self-Determination Act of 1975, which allowed ANCSA non-profits to apply for grants or contract with the Bureau of Indian Affairs to administer their own health and social service programs. By 1980, state and local government had become the largest source of employment, accounting for almost half of all wage and salary jobs. The dramatic increase in state revenues as oil production in Prudhoe Bay came on line in 1977 fueled a six-fold increase in state budgets and a 13-fold increase in local revenue sharing, which drove the corresponding increase in state and local employment in the NWAB between 1970 and 1980. Overall, government accounted for 63 percent of all jobs in 1970 and 1980 (Table 3.17-2).

Table 3.17-2 Northwest Arctic Borough Area Employment by Industry, 1970 and 1980

Industry	1970		1980	
	Number	Percent	Number	Percent
Mining	—	—	—	—
Construction	—	—	81	5.6
Manufacturing	—	—	—	—
Transportation, Communication and Utilities	106	16.6	125	8.7
Trade	100	15.6	133	9.2
Finance, Insurance and Real Estate	—	—	18	1.3
Services	17	2.7	168	11.7
Federal Government	300	46.7	218	15.2
State and Local Government	104	16.3	692	48.1
Miscellaneous	—	—	—	—
Total	641	100.0%	1,438	100.0%

Source: Alaska Department of Labor, as reported in the 1984 Red Dog EIS

— = not reported

Similarly, government was the most important source of personal income in the NWAB area in 1970 and 1980. In 1970, government directly accounted for $4.8 million of the area’s total personal income of $7.3 million (in 1970 dollars). In 1980, government generated $17.1 million in personal income for residents of the NWAB area, $12.1 million of which was from state and local government (values in 1980 dollars).

Total personal income in the NWAB area in 1980 was $35 million, while per capita income was $7,225 (1980 dollars). Transfer payments (payments from governments to individuals) accounted for 21.5 percent of all personal income in 1980 (Table 3.17-3). Per capita personal income in the NWAB was $15,286 in 2000, according to census data.

Table 3.17-3 Northwest Arctic Borough Area Total and Per Capita Income by Source, 1970 and 1980

Source	1970		1980	
	Income	Percent	Income	Percent
Net Earned Income (in thousands)	$6,761	77.8%	$26,261	74.8%
Dividends (in thousands)	216	2.5	1,178	3.4
Transfer Payments (in thousands)	1,708	19.7	7,544	21.5
Total Personal Income (in thousands)	8,685	100.0	34,983	100.0
Per Capita Personal Income	$2,141	N/A	$7,225	N/A

Source: U.S. Department of Commerce, 1982, as reported in the 1984 Red Dog EIS

N/A – not applicable

3.17.2 Socioeconomics – Baseline Conditions

3.17.2.1 Northwest Arctic Borough Population and Demographics

Since 1990, the population of the NWAB has increased 21 percent. In 2007, the NWAB population totaled 7,396 residents, 2.6 percent above the 2000 population. Population growth was slow and generally steady from 2000 to 2007, with slight declines between 2000 and 2001 and between 2004 and 2005 (Table 3.17-4). Overall, the NWAB's population increased by 188 residents between 2000 and 2007.

The NWAB's 7,396 residents live in the regional center of Kotzebue and 10 smaller communities: Ambler, Buckland, Deering, Kiana, Kivalina, Kobuk, Noatak, Noorvik, Selawik, and Shungnak. These communities are situated along the NWAB's four major rivers, all of which flow into Kotzebue Sound. Kotzebue continues to serve as the hub of the region, and is the transfer point for goods shipped to the outlying communities. As Table 3.17-5 shows, Kotzebue has not only a larger population than the other communities in the region, but also a more diverse population, higher employment rates, higher median age, higher median income, and smaller household size. Kotzebue is also distinctive in that it is the only northwest Alaska community that chose to incorporate its own ANCSA village corporation—KIC—and not to merge its assets with NANA as did the other 10 communities for the purposes of simplifying land ownership and reducing administrative costs.

Table 3.17-4 Northwest Arctic Borough Population, 1990, 2000–2007

Communities	1990	2000	2001	2002	2003	2004	2005	2006	2007
Ambler	–	309	282	295	291	276	282	277	277
Buckland	–	406	404	426	409	438	434	418	461
Deering	–	136	137	129	131	145	139	138	133
Kiana	–	388	404	400	408	396	381	399	391
Kivalina	–	377	385	383	387	390	385	392	398
Kobuk	–	109	94	106	125	126	131	135	119
Kotzebue	–	3,082	3,059	3,074	3,068	3,141	3,122	3,102	3,133
Noatak	–	428	438	455	468	450	474	470	489
Noorvik	–	634	643	676	648	612	627	636	636
Selawik	–	772	777	778	819	833	831	842	828
Shungnak	–	256	245	249	263	266	259	260	269
Remainder NWAB	–	279	227	227	234	229	229	230	229
NWAB Total	6,113	7,176	7,095	7,198	7,251	7,302	7,294	7,299	7,363

Source: U.S. Census Bureau 2000 and Alaska Department of Labor and Workforce Development 2008

— = data for individual villages not available

Table 3.17-5 Profile of NWAB Village Demographics, 2000

Community	Population (2000)	Percent Native	Percent Employed (age 16 +)	Median Age	Median Household Income	Avg Household Size
Ambler	309	87	74	21.8	$43,500	3.9
Buckland	406	97	65	17.8	$38,333	4.8
Deering	136	94	58	27.0	$33,333	3.2
Kiana	388	93	55	22.4	$39,688	4.0
Kivalina	377	97	47	20.8	$30,833	4.8
Kobuk	109	94	45	17.4	$30,750	4.2
Kotzebue	3,082	77	70	25.9	$57,163	3.4
Noatak	424	96	55	22.7	$30,833	4.3
Noorvik	634	95	52	21.2	$51,964	4.7
Selawik	772	95	44	18.9	$25,625	4.5
Shungnak	256	95	66	18.8	$44,375	4.6

Source: U.S. Census Bureau 2000

Northwest Arctic Borough Migration Patterns

While the overall population of the NWAB has increased, the northwest arctic region has experienced net out-migration since 1970 (Table 3.17-6). In each decade since 1970, more people moved from the region than moved to the region (ADLWD 2008). The number of out-migrants increased in each period. Out-migrants also increased as a percent of the total population, rising from 3 to 10 percent of the population.

Table 3.17-6 Components of Population Change

	Natural Increase	Net Migration	End of Period Population
1970-1980	931	-148	4,831
1980-1990	1,591	-309	6,113
1990-2000	1,451	-349	7,215
2000-2007	929	-748	7,396

Source: ADLWD 2008

Population in the region grew throughout the period in spite of the negative effects of migration on population change. Throughout the period, population grew because natural increases exceeded the level of net out-migration. Natural increase equals the number of births minus the number of deaths. Rates of natural increase were relatively high throughout the period. However, both the rate of natural increase and the actual natural increase fell during the 1990s and through 2007. In the post 2000 period, net out-migration increased to almost 81 percent of the natural increase.

The patterns of migration and levels of natural population increases are related. Young people are more likely to migrate. Historic high birth rates mean more candidates for migration. As the young migrate, rates of birth fall and death rates rise, resulting in a decline in natural population increase. High regional rates of natural increases in the 1970s and 1980s might be expected to result in the pattern of both out-migration and natural increase seen in the region since 1990. Out-migration is likely to be more pronounced when employment opportunities do not keep pace with a growing labor force.

Migration is more complex than described by net migration (Huskey and Howe, forthcoming). People not only leave the region, they also return. According to the U.S. Census, between 1995 and 2000, approximately 71 percent of out-migrants from the NWAB were replaced by in-migrants. This means population change is more fluid than described by net changes. There is also a great deal of migration within the region. According to the 2000 census almost 50 percent of the in-migrants to villages in the NWAB were from other villages.

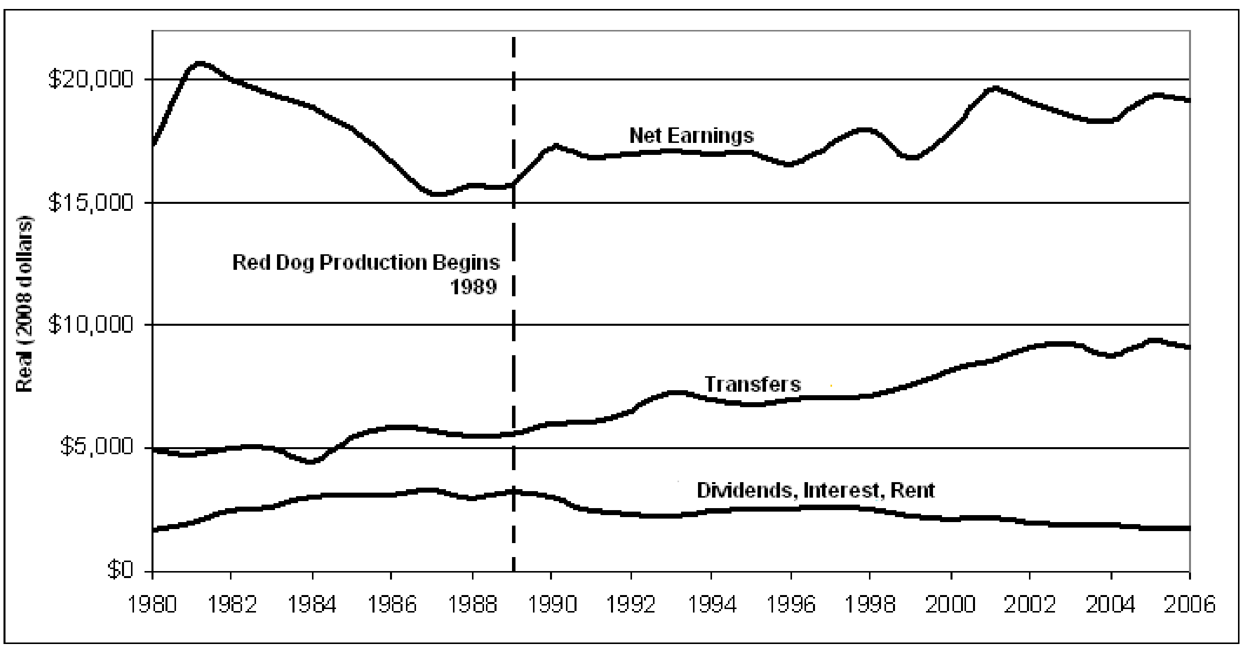
In 2000, 60 percent of NWAB residents were living in the same residence as they were in 1995. Of the residents who were not in the same residence, about one-quarter (25.8 percent) had moved from one location to another within in the NWAB. All others had moved to the NWAB from elsewhere in Alaska (7.7 percent), from another state (5.9 percent), or had moved from another country (0.4 percent) (U.S. Census Bureau, 2000 Census).

Kotzebue had the most active migration activity in the NWAB. Less than half (46.4 percent) of the residents in the community in 2000 were in the same residence as they were in 1995. Of the residents that were not in the same residence, just under 30 percent (29.8 percent) had moved from within the NWAB and almost one-quarter (23.9 percent) of the population had moved to the community from outside the NWAB since 1995 (U.S. Census Bureau, 2000 Census).

3.17.2.2 Northwest Arctic Borough Economy

Personal Income

Figure 3.45 displays the per capita income of the NWAB by type of income, from 1980 to 2006, in 2008 dollars. Table 3.17-7 shows the percent increase for each type of income. Over this time span, total real per capita income increased by almost 50 percent.



Source: Bureau of Economic Analysis and ISER calculations

Figure 3.45 Northwest Arctic Borough's Real Per Capita Income by Component

Table 3.17-7 Northwest Arctic Borough's Real Increase in Per Capita Income, 1980 to 2006

Parameter	Percent
Per Capita Income	48
Per Capita Net Earnings	31
Per Capita Transfers	119
Per Capita Dividents, Interest, Rent	22

Source: Bureau of Economic Analysis

Per capita net earnings decreased in the years leading up to Red Dog production, but rose fairly steadily since 1989. Dividends[1], interest and rent rose in the years prior to Red Dog start up and decreased slightly thereafter. Per capita transfer payments rose steadily throughout the period. As a percentage increase, transfer payments grew the most at 119 percent growth between 1980 and 2006, compared to 31 percent growth in net earnings (Table 3.17-7). This is primarily due to rising health care costs, and the fact that Medicaid and Medicare fall into this category. Medical benefits make up the largest component of transfer payments and have increased the most. The Alaska Permanent Fund Dividend (PFD) program began in 1982. From 1983 to 2006, the real-dollar increase in medical transfer income was 480 percent, while miscellaneous (primarily PFD) transfers increased by only 6 percent As a share of total transfer income, medical transfers increased from 20 percent in 1983 to 56 percent in 2006, while miscellaneous transfers (consisting primarily of PFDs) decreased from 32 percent to 16 percent.

Table 3.17-8 shows per capita household income[2] by source from the 2000 U.S. Census, in 2008 dollars and as a percentage of total income. The table is sorted by total per capita household income. Total income in the NWAB was well below the Alaska average, and just over half of Anchorage's total income. Kivalina and Noatak are near the bottom of the list with almost the lowest income in the borough.

Wage and salary income made up about three-quarters of total income in most places, while self employment income made up the lowest portion in most places – in the NWAB, only Kotzebue, Noorvik and Kiana had a contribution from self employment above 1 percent.

Second after wage and salary income is the category including interest, dividends, rent, and other sources. In Alaska, the share was 10 percent, and most NWAB communities had a higher share, from 8.2 percent (Kotzebue) to almost 20 percent (Kivalina and Selawik). Note that the two communities with the lowest total income had the highest percentage from this category. One factor contributing to the size of this category is the PFD, which was $1,769.84 in 1999. On the U.S. Census long form questionnaire, this would have been reported in the "other" category, or (incorrectly) in the "interest, dividends, and rent" category. NANA dividends would also be included in this category.

Ranking third is social security, supplemental security, and retirement income at about 6 percent in the NWAB overall. Ranking last in the borough is public assistance, at less than 2 percent, although this is mostly due to the weight of Kotzebue; in most NWAB communities, income from public assistance was higher than income from self employment.

[1] The Alaska Permanent Fund Dividend is included in the "Transfers" category, not the "Dividends, Interest and Rent" category.
[2] Household income is used because households are the level at which income by source is reported in detail by the Census.

Table 3.17-8 Per Capita Household Income by Source in 1999

	Total	Wage and Salary	Self Employment	Interest, Dividends, Rent and Other Sources	Social Security, Supplemental Security, and Retirement	Public Assistance
	2008 Dollars					
Anchorage	$31,375	$24,100	$2,000	$2,996	$2,128	$150
Alaska	**$27,957**	**$20,935**	**$1,972**	**$2,782**	**$2,096**	**$172**
Kotzebue	$22,920	$18,770	$1,022	$1,883	$1,109	$135
Ambler	$18,291	$14,429	$134	$2,486	$601	$641
NWAB	**$16,756**	**$13,197**	**$527**	**$1,838**	**$932**	**$262**
Noorvik	$14,824	$10,990	$260	$2,079	$1,142	$353
Kiana	$14,654	$11,154	$704	$1,435	$752	$609
Deering	$14,022	$11,039	$73	$1,993	$826	$91
Shungnak	$13,808	$10,478	$3	$2,172	$952	$203
Buckland	$12,792	$9,999	$12	$1,577	$961	$243
Kobuk	$12,102	$9,749	$0	$1,543	$680	$129
Noatak	**$12,084**	**$9,043**	**$87**	**$1,851**	**$820**	**$283**
Kivalina	**$10,368**	**$7,523**	**$0**	**$2,001**	**$520**	**$325**
Selawik	$10,355	$6,930	$46	$2,013	$806	$560
	Percentage of Total					
Anchorage	100.00%	76.8%	6.4%	9.5%	6.8%	0.5%
Alaska	**100.00%**	**74.9%**	**7.1%**	**10.0%**	**7.5%**	**0.6%**
Kotzebue	100.00%	81.9%	4.5%	8.2%	4.8%	0.6%
Ambler	100.00%	78.9%	0.7%	13.6%	3.3%	3.5%
NWAB	**100.00%**	**78.8%**	**3.1%**	**11.0%**	**5.6%**	**1.6%**
Noorvik	100.00%	74.1%	1.8%	14.0%	7.7%	2.4%
Kiana	100.00%	76.1%	4.8%	9.8%	5.1%	4.2%
Deering	100.00%	78.7%	0.5%	14.2%	5.9%	0.6%
Shungnak	100.00%	75.9%	0.0%	15.7%	6.9%	1.5%
Buckland	100.00%	78.2%	0.1%	12.3%	7.5%	1.9%
Kobuk	100.00%	80.6%	0.0%	12.7%	5.6%	1.1%
Noatak	**100.00%**	**74.8%**	**0.7%**	**15.3%**	**6.8%**	**2.3%**
Kivalina	**100.00%**	**72.6%**	**0.0%**	**19.3%**	**5.0%**	**3.1%**
Selawik	100.00%	66.9%	0.4%	19.4%	7.8%	5.4%

Source: U.S. Census Bureau 2000

Table 3.17-9 shows aggregate wages reported to the Alaska Department of Labor and Workforce Development (ADLWD) and aggregate wages paid to Red Dog employees living in the NWAB from 1989 to 2007. These are in nominal dollars. The community with the highest percentage of wages from Red Dog is Noatak, with more than one-third of total wages over this time period coming from Red Dog employment. Kivalina is near the middle with 17 percent of wages coming from Red Dog.

Both the U.S. Census and Bureau of Economic Analysis data indicate that personal income in the NWAB increased at a greater rate than Alaska as a whole. U.S. Census data indicate that from 1979 to 1999, real personal income increased 28.8 percent in the NWAB and decreased 3.2 percent in Alaska. Bureau of Economic Analysis data indicate growth rates of 18.8 percent and -7.4 percent for the NWAB and Alaska, respectively. Real earnings declined in Alaska from 1983 to 1996 reflecting the shift in employment from higher wage jobs in government and industry into lower wage jobs in the service sector. By contrast, real earnings in the NWAB grew from 1989 to 2001. U.S. Census data indicate that the NWAB had the greatest increase in personal income of any region in Alaska. Bureau of Economic Analysis data indicate the NWAB ranked third in personal income growth over the period.

Table 3.17-9 Aggregate Total Wages and Red Dog Wages, 1989-2007

Community	Total Wages	Red Dog Wages	Red Dog Percentage
Noatak	**$62,739,520**	**$21,734,608**	**34.6%**
Ambler	$43,393,105	$9,436,340	21.7%
Buckland	$48,470,287	$9,721,001	20.1%
Noorvik	$83,590,661	$15,382,736	18.4%
Kivalina	**$41,435,093**	**$7,203,088**	**17.4%**
Kiana	$61,843,237	$9,795,259	15.8%
Shungnak	$29,002,230	$4,521,484	15.6%
Deering	$19,627,439	$2,517,295	12.8%
Kotzebue	$789,697,723	$28,276,920	3.6%
Kobuk	$9,759,167	$304,812	3.1%
Selawik	$68,788,664	$960,061	1.4%
Total	**$1,258,347,125**	**$109,853,604**	**8.7%**

Source: Alaska Department of Labor and Workforce Development 2008
Note: Total wages may be slightly underreported, due to data suppression.

Table 3.17-10 shows the rank ordered real per capita income changes in NWAB communities in 1979, 1989 and 1999 (in 2008 dollars). Kobuk, the smallest community of the borough, had the fastest income growth: 96.6 percent between 1979 and 1999. Kivalina, the community with the second-highest proportion of employment at Red Dog, came in third at 81.4 percent real income growth. (The change in Noatak, the community with the highest proportion employed at Red Dog, is not measurable because there is no income figure available from the 1980 Census.) Kotzebue, the city with the largest population but smallest percentage of Red Dog employees, had the lowest rate of growth in real income but remained the borough’s leader in per capita income. This means that income inequality between communities is shrinking in the borough.

Table 3.17-10 Rank Ordered Changes in Real Per Capita Income, NWAB Communities, 2008 dollars

	1979	Percent Change 1979-1989	1989	Percent Change 1989-1999	1999	Percent Change 1979-1999
Kobuk	$6,983.39	36.8	$9,551.98	43.7	$13,729.98	96.6
Buckland	$7,119.02	11.0	$7,903.81	69.8	$13,421.77	88.5
Kivalina	$6,425.81	36.4	$8,766.72	33.0	$11,658.98	81.4
Noorvik	$9,521.17	35.7	$12,924.20	29.7	$16,763.27	76.1
Selawik	$6,594.59	62.4	$10,709.58	6.4	$11,394.00	72.8
Deering	$9,057.01	41.7	$12,832.44	19.5	$15,340.76	69.4
Ambler	$14,726.31	-13.9	$12,685.98	50.7	$19,122.95	29.9
Shugnak	$12,043.87	29.3	$15,567.63	-7.0	$14,471.91	20.2
Kiana	$13,963.77	9.1	$15,232.35	5.6	$16,085.48	15.2
Kotzebue	$22,384.83	9.6	$24,539.04	3.9	$25,506.10	13.9
Noatak	N/A	N/A	$12,509.51	7.7	$13,470.58	N/A

N/A = not available
Source: U.S. Census Borough Bureau, 1980,1990 and 2000

Employment and Payroll

NWAB employment (as measured by the Bureau of Economic Analysis), which includes self-employed proprietors) totaled 3,474 jobs in 2005 (Table 3.17-11). Employment in the NWAB has been reasonably steady, between 3,300 and 3,400 jobs. The increase of 156 jobs in 2005 represents a 4.7 percent increase.

In 2005, 64 percent of all NWAB employment was in the private sector, strictly defined as non-government. The remaining 36 percent was government employment, including federal, state, and local governments. It is important to note that many private organizations receive some public funds, either through government contracts or grants. For example, Maniilaq, one of the largest employers in the borough, is classified as a private organization although it is supported by public funds.

Table 3.17-11 Northwest Arctic Borough Employment by Industry, 2001–2005

	2001	2002	2003	2004	2005
Total employment	**3,351**	**3,411**	**3,323**	**3,318**	**3,474**
Wage and salary employment	3,024	3,049	2,978	2,945	3,087
Proprietors employment	327	362	345	373	387
Nonfarm proprietors employment	327	362	345	373	387
Nonfarm employment	3,351	3,411	3,323	3,318	3,474
Private employment	2,213	2,107	2,077	2,083	2,210
Forestry, fishing, related activities, and other	58	46	35	43	42
Mining	D	D	D	D	D
Utilities	D	D	D	D	D
Construction	D	64	48	31	57
Manufacturing	L	D	D	10	D
Wholesale trade	D	L	L	L	L
Retail trade	208	D	215	223	182
Transportation and warehousing	151	155	D	D	D
Information	59	55	58	65	68
Finance and insurance	D	D	D	D	D
Real estate and rental and leasing	D	D	D	D	D
Professional and technical services	D	D	D	D	D
Administrative and waste services	18	D	D	D	D
Educational services	15	19	20	18	20
Health care and social assistance	D	D	D	D	D
Arts, entertainment, and recreation	52	D	94	165	246
Accommodation and food services	80	D	116	111	109
Other services, except public administration	96	107	103	99	89
Government and government enterprises	1,138	1,304	1,246	1,235	1,264
Federal, civilian	57	55	56	55	57
Military	47	54	54	54	54
State and local	1,034	1,195	1,136	1,126	1,153
State government	54	59	64	71	68
Local government	980	1,136	1,072	1,055	1,085

Source: Bureau of Economic Analysis 2008
D = Not shown due to disclosure of confidential data
L = Lower than $50,000

NWAB employment as measured by the ADLWD, which excludes proprietors and uniformed military personnel, averaged 2,911 jobs in 2006. These jobs accounted for $126.7 million in payroll, with an average monthly wage of $3,628. A total of 153 "units," or employers, reported 2006 employment in the NWAB (Table 3.17-12).

Table 3.17-12 Northwest Arctic Borough Employment and Earnings, 2006

	Units	Average Employment	Total Wages	Average Monthly Wages
Total Industries	153	2,911	$126,757,967	$3,628
Total Government	75	1,244	36,945,083	2,474
Federal Government	10	54	2,426,573	3,768
State Government	20	67	3,560,519	4,412
Local Government	45	1,123	30,957,991	2,296
Private Ownership	78	1,667	89,812,884	4,490
Goods-Producing	10	465	—	—
Natural Resource and Mining	5	438	—	—
Construction	5	26	2,508,386	7,938
Trade, Trans. and Utilities	25	265	9,061,261	2,849
Information	5	55	2,783,439	4,243
Financial Activities	3	114	5,228,234	3,825
Professional and Business Services	1	3	—	—
Educational and Health Services	12	543	—	—
Leisure and Hospitality	10	167	4,494,737	2,249
Other Services	12	56	771,611	1,145

Source: ADLWD 2008

— = no data

Red Dog Mine employment is captured in the "Natural Resource and Mining" sector, which averaged 438 jobs in 2006 (this does not include employment with NANA/Lynden, which is included in the "Trade, Transportation, and Utilities" sector). Wages are not published by the ADLWD because of confidentiality restrictions.

The single largest employers in the NWAB include the school district, with reported employment of 648, and Maniilaq Association, with an average of 542 jobs in 2006. Red Dog Mine related employers include Teck and NANA Management Services. NANA/Lynden employment at the Red Dog Mine is not reported, most likely because it is grouped with other Lynden employment and reported in Anchorage. NANA/Lynden employs approximately 50 workers at the Red Dog Mine.

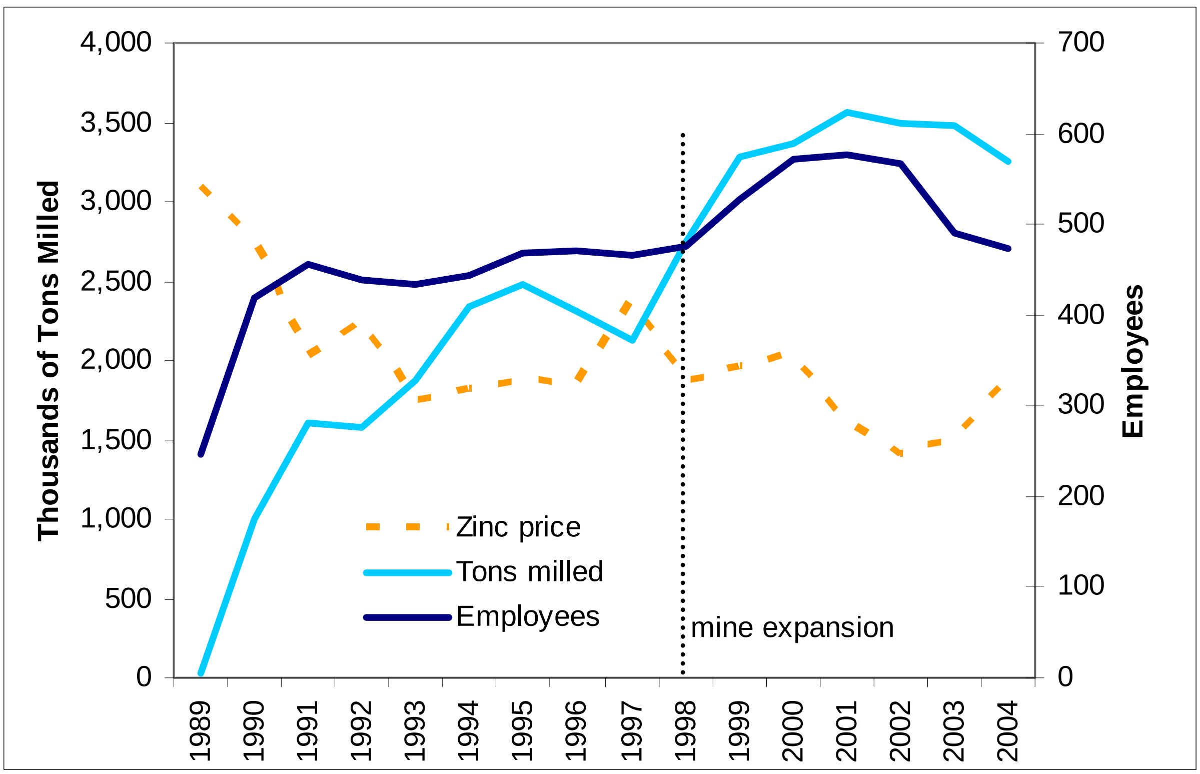
Reported employment for the top employers in the NWAB includes residents and non-residents of the NWAB (Table 3.17-13).

Employment at Red Dog Mine rises and falls with mine production. Production rates have been affected by world zinc prices. Figure 3.46 shows Red Dog production, employees, and world zinc prices from 1989, the first year of Red Dog's production, to 2004. Tons of ore milled is used here as the measure of production, rather than tons of concentrate produced because the milled volume reflects the mine's labor output. Increases in production generally mean increases in employment: they are 87 percent correlated. In particular, the large-scale mine expansion, which began in April 1996 and ended in September 1998, increased production by 35 percent and increased employment by 22 percent.

Table 3.17-13 Northwest Arctic Borough Top 20 Employers, 2006

	Low Monthly Employment	High Monthly Employment	Annual Average
NWAB School District	625	668	648
Maniilaq Association	514	569	542
Teck Cominco Alaska, Inc.	329	434	384
City of Kotzebue	66	79	75
NANA Management Services, LLC	55	73	64
AK Commercial Co.	60	71	62
Kikiktagruk Iñupiat Corp	30	84	54
NW Iñupiat Housing Authority	33	76	51
Veco Alaska, Inc.	28	70	45
OTZ Telephone Cooperative, Inc.	32	43	36
Northwest Arctic Borough	20	58	31
Bering Air Incorporated	26	34	30
Kotzebue IRA Council	24	35	29
City of Noorvik	23	39	28
Selawik City Council	19	40	27
Department of The Interior	21	33	25
U.S. Postal Service	22	28	25
Noatak Village Council	17	32	24
Selawik IRA Council	13	40	24
Kivalina City Council	15	32	23

Source: ADLWD Firm list 2008



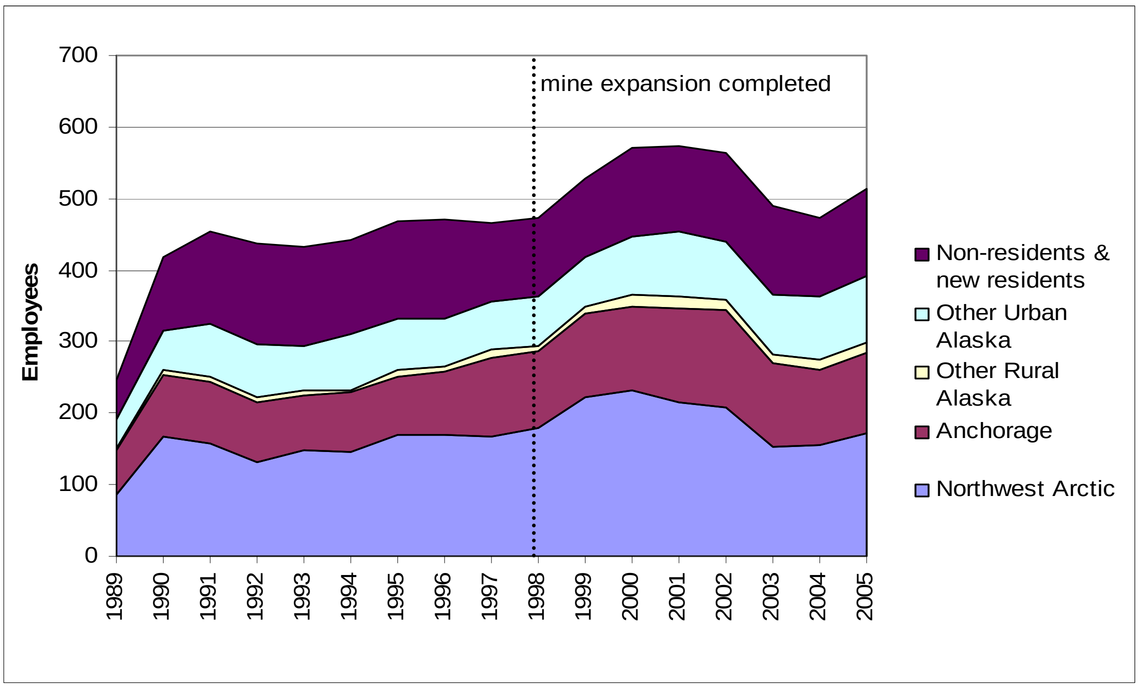
Employment is head count, including seasonal and temporary workers during the calendar year.
Source: Alaska Department of Community and Economic Development and the London Metal Exchange.

Figure 3.46 Red Dog Production, Employment and Zinc Price

Figure 3.47 displays Red Dog employment by region. The Alaska Department of Labor identified the residency of Red Dog employees using PFD data. Employees with no corresponding PFD match are either non-residents or new residents who are not yet eligible for a PFD. Statewide, the Department of Labor estimates about 15 percent of the employees with no PFD match are new residents, and the rest are non-residents. This figure shows that that although employment in the NWAB is variable, the variation in employment from other Alaska regions is largely parallel.

Figure 3.48 illustrates Red Dog employment as a percent of total employment in northwest arctic communities in 2000. Noatak and Kivalina, the communities geographically closest to the mine and which enjoy preferential hire, have the highest percentage of employment: 44 percent and 37 percent, respectively. Four of the top five communities in percent employment at Red Dog are also in the top five in proximity to the mine.

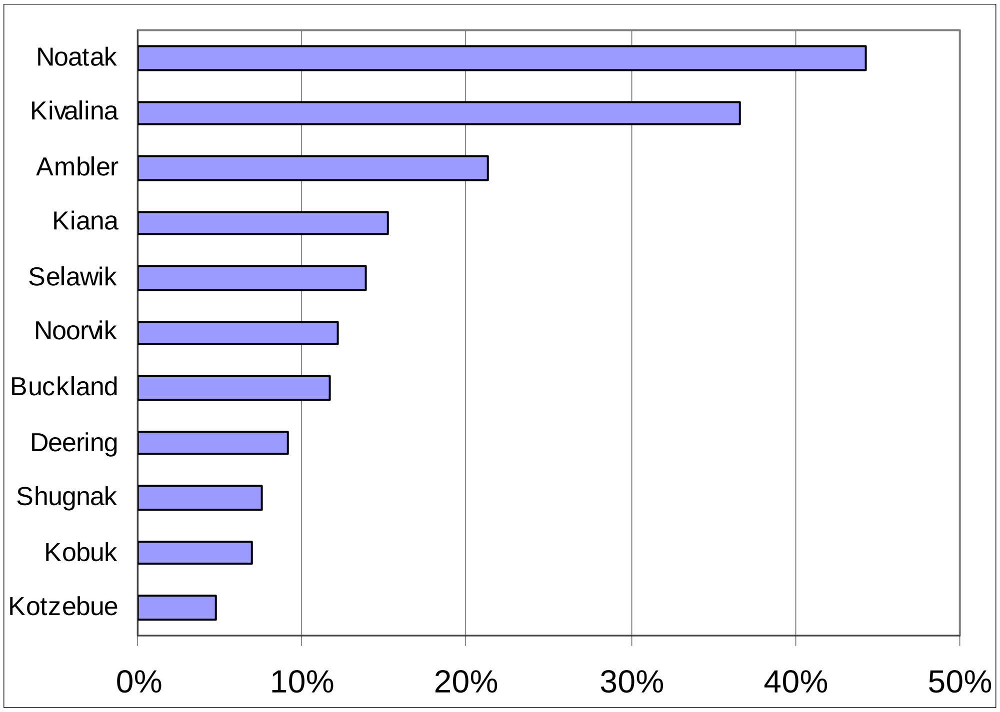
Figure 3.49 shows NWAB employment by sector from 1985 to 2004. State government employment shrank during this time period while "other private" showed the largest growth. In 1985, government (federal, state, and local) provided the largest share of jobs in the NWAB; by 2004 the private sector (Red Dog and other private entities) provided the largest share of jobs. This is in spite of an increase in local government employment in 2001 due to changes in ADLWD counting methods[3] in which tribal entities switched from "private ownership" to "local government."



Source: ADLWD, Research and Analysis Section, 2007

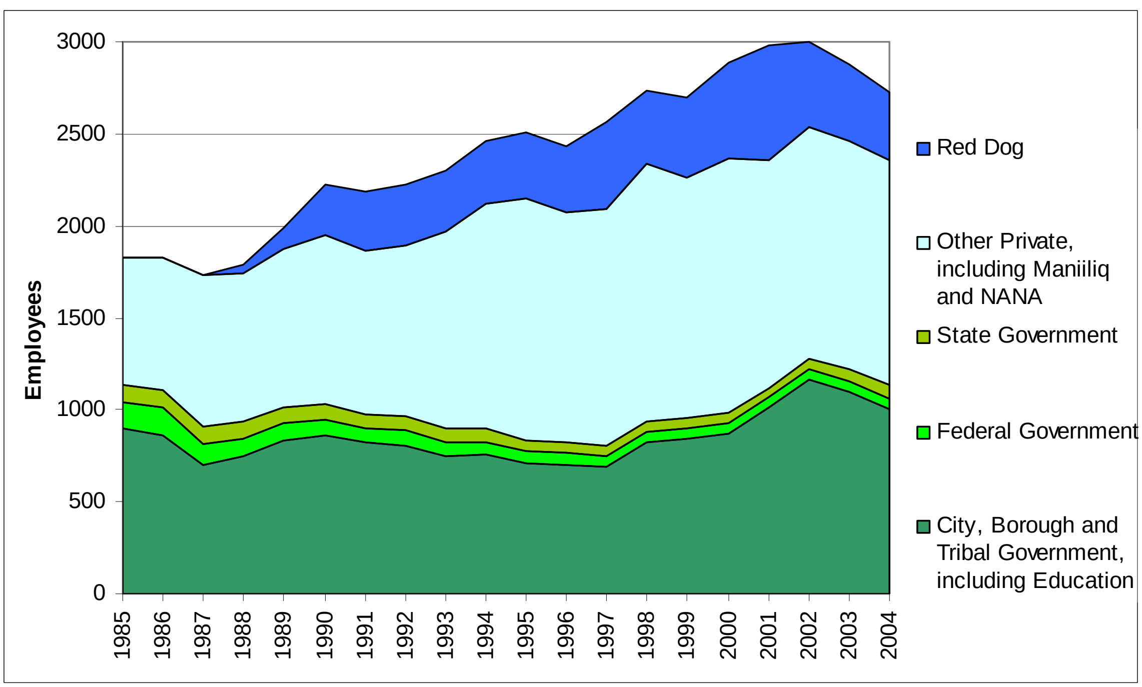
Figure 3.47 Red Dog Employment by Region, 1989–2005

[3] The counting method changed from the Standard Industrial Classification (SIC) system to the North American Industrial Classification System (NAICS). This should not affect the comparability of the numbers except in the aforementioned instance of tribal entities.



Source: ADLWD 2007 (Red Dog Employee Figures) and U.S. Census Bureau 2000 (Employment Numbers and Age Numbers).

Figure 3.48 Red Dog as Percent of Total Employment in NWAB Communities, 2000



Source: ADLWD, Research and Analysis Section, 2007

Figure 3.49 Employment by Sector in the NWAB

The shift in employment from the public to the private sector also occurred in other areas of remote rural Alaska, due to declines in state spending and employment, declines in federal employment, and increases in ANCSA nonprofit employment. Table 3.17-14 shows the percentage of jobs in the private sector over time for remote rural boroughs and census areas, based on the average number of jobs in each given year. While most of remote rural Alaska increased their proportion of private sector jobs over the last two decades, the NWAB had one of the highest rates of increase and gained in rank order from 11 out of 13 remote rural areas in 1985, to 8 out of 13 in 2005. Red Dog employment largely accounted for this relative gain.

Table 3.17-14 Percent of Jobs in Private Industry, Remote Rural Boroughs and Census Areas

	1985	1995	2005	Percentage Change
Aleutians (East Borough + West Census Area)*	57.9	83.5	85.0	27.1
Yukon-Koyukuk Census Area + Denali Borough*	37.9	51.7	59.8	21.8
Northwest Arctic Borough	**38.0**	**66.6**	**58.8**	**20.8**
Bristol Bay Borough	63.6	66.6	79.1	15.6
Bethel Census Area	45.3	61.0	54.3	9.0
Nome Census Area	48.2	58.7	54.4	6.2
Wade Hampton Census Area	30.8	39.4	32.8	2.0
Prince of Wales-Outer Ketchikan Census Area	56.2	64.4	57.9	1.7
Kodiak Island Borough	74.9	82.1	75.1	0.2
Skagway-Hoonah-Angoon Census Area + Yakutat Borough*	63.0	74.0	63.0	0.0
North Slope Borough	83.3	70.0	81.6	-1.7
Wrangell-Petersburg Census Area	67.6	67.7	64.0	-3.7
Dillingham Census Area + Lake and Penninsula Borough*	65.6	72.7	56.3	-9.3

* Weighted averages for comparability across years
Source: ADLWD, Research and Analysis Section, 2007

Key Industry Overview

Government. As is the case in most of Alaska, and particularly in rural Alaska, government employment and spending is a key component of the economic base of NWAB. Employment with government and government enterprises accounted for 1,264 jobs in 2005, 36 percent of all employment in the NWAB (Table 3.17-15). Local government, including NWAB government, city governments, tribal governments/councils, and the school district, accounts for 86 percent of all government employment in the NWAB.

Table 3.17-15 Northwest Arctic Borough Total Employment and Government Employment, 2001–2005

	2001	2002	2003	2004	2005
Total Employment	3,351	3,411	3,323	3,318	3,474
Government and government enterprises	1,138	1,304	1,246	1,235	1,264
Federal, civilian	57	55	56	55	57
Military	47	54	54	54	54
State and local	1,034	1,195	1,136	1,126	1,153
State government	54	59	64	71	68
Local government	980	1,136	1,072	1,055	1,085

Source: Bureau of Economic Analysis 2008

Employment data actually understates the importance of government in the economy. Other employers in the region are dependent on government funding, including Maniilaq, one of the NWAB's largest employers. Government money also flows into the region's economy for construction projects, other government procurement, and transfer payments to individuals.

Some of the single largest sources of federal money flowing to the NWAB include Indian Health Services Health Management Development Program funds ($33 million in 2005), Impact Aid ($7 million), Indian Housing Block Grants ($6 million), Social Security payments to individuals ($5 million), Tribal self-governance funds ($4 million), and food stamps ($3 million).

The amount of federal money flowing into the NWAB increased in 2005 to $88.5 million (including only direct expenditures), from $84.9 million in 2004 (tables 3.17-16 and 3.17-17). The increase was largely the result of an increase in payments to individuals, along with an increase in procurement contracts.

Visitor Industry. While the visitor industry is an important part of Alaska's economy, with 1.6 million visitors (summer, 2006) who spent $1.5 billion while in Alaska, the industry plays a small role in the NWAB economy. Many recreational visits to the region are centered around sport hunting, which remains a controversial activity in a region reliant on subsistence hunting and fishing.

Commercial Fishing. Commercial fishing plays a limited role in the NWAB economy, but does generate income for a number of residents. In 2005, 45 NWAB residents fished under 47 permits, harvesting 734,041 pounds of fish and earning $213,505 in gross (ex-vessel) income (CFEC 2008). The Kotzebue salmon gillnet fishery accounts for most of this activity (41 of the 47 permits fished in 2005), but NWAB residents also fish elsewhere in the state and draw money back into the regional economy.

Mining Industry (Unrelated to the Red Dog Mine). The NWAB is richly endowed with mineral resources and has a long history of exploration and production. Historically, placer mining produced over 600,000 ounces of gold, including mining in the Kiana, Noatak, and Shungnak areas, as well as the Fairhaven-Inmachuk District (ADCCED 2008). Exploration activity has identified numerous base metals (copper, lead, and zinc), precious metals (gold and silver), chromium, other metals, and coal deposits.

Today, mining is the single most important private sector economic activity in the NWAB. While there is substantial exploration activity in the region, the Red Dog Mine accounts for nearly all of the local economic impact related to mining. The following analysis provides an overview of some of the mining industry activity in the NWAB that is not related to the Red Dog Mine. A detailed assessment of the economic impact of Red Dog Mine in the region and in the state overall is provided in the next section.

Minerals Exploration Activity in the NWAB. In addition to the Red Dog Mine, numerous mineral occurrences have been identified in northwest Alaska. Notable among these occurrences is the Lik Deposit, located 12 miles north of Red Dog Mine. Historic exploration work identified resources of 24 million tons of 9 percent zinc, 3.1 percent lead, and 1.4 ounces per ton gold. Zazu Metals, in a 50/50 partnership with Teck, has initiated a drilling program to evaluate the property's economic potential. This deposit is noteworthy because its development and operation could use much of the infrastructure now in place for the Red Dog Mine.

The Anarraaq Deposit, located about 6 miles north of the Red Dog Mine, is located on State land and patented by Teck. Drilling has identified a resource of about 17 million tons containing 17 percent zinc, plus high concentrations of lead and silver. The nearby Aktiguruk Deposit also contains high concentrations of zinc. These deposits are being actively explored by Teck.

Table 3.17-16 Northwest Arctic Borough Consolidated Federal Funds Summary, 2003–2005

	2003	2004	2005
Total Direct Expenditures or Obligations	$84,019,855	$84,891,521	$88,477,328
Retirement/Disability Payments for Individuals	6,498,738	6,822,446	6,893,477
Other Direct Payments for Individuals	4,278,383	4,372,771	5,379,271
Direct Payments other than for Individuals	1,172,892	4,954,620	6,657,227
Grants (Block, Formula, Project, and Cooperative Agreements)	65,438,483	61,519,988	60,379,023
Procurement Contracts	2,680,314	3,250,586	5,198,915
Salaries and Wages	3,951,045	3,971,110	3,969,415
Other Federal Assistance			
Direct Loans	484,200	Not available	80,700
Guaranteed/Insured Loans	150,000	4,034,000	2,500,000
Insurance	3,334,840	3,393,686	4,462,303

Source: U.S. Census Bureau 2000

Table 3.17-17 Northwest Arctic Borough, Consolidated Federal Funds 2005

	2005
Total Direct Expenditures or Obligations	**$88,477,328**
Retirement/Disability Payments for Individuals	***6,893,477***
Social Security	5,354,395
Federal Retirement and Disability Payments	1,147,103
All Other	391,979
Other Direct Payments for Individuals	***5,379,271***
Food Stamps	3,240,403
Medicare- Hospital Insurance	1,181,473
Medicare- Supplementary Medical Insurance	665,761
All Other	1,393,169
Direct Payments other than for Individuals	***6,657,227***
Aid to Tribal Governments	1,025,696
Consolidated Tribal Government Program	557,414
Tribal Self-Governance	4,004,739
Indian Self-Determination Contract Support	275,327
All Other	794,051
Grants (Block, Formula, Project, and Cooperative Agreements)	***60,379,023***
National School Lunch Program	953,883
Indian Housing Block Grants	6,211,952
Highway Planning and Construction	2,091,678
Indian Environmental General Assistance Program	907,855
Impact Aid	7,114,010
Alaska Native Educational Programs	1,714,835
Community Health Centers	1,027,309
Indian Health Services Health Management Development Program	33,344,281
Temporary Assistance for Needy Families	770,252
Low-Income Home Energy Assistance	789,061
All Other	4,546,052
Procurement Contracts	***5,198,915***
Procurement Contracts – Department of Defense	1,806,639
Procurement Contracts – All Federal Agencies other than Defense and U.S. Postal Service	2,739,923
Procurement Contracts – U.S. Postal Service	652,353

	2005
Salaries and Wages	***3,969,415***
Salaries and Wages – All Government Civilian Employment Except Defense and U.S. Postal Service	1,518,000
Salaries and Wages – U.S. Postal Service	2,451,415
Other Federal Assistance	
Guaranteed/Insured Loans and Direct Loans	2,580,700
Insurance	4,462,303

Source: U.S. Census Bureau 2000

Well to the southeast of the Red Dog Mine, the Kobuk River area is also the target of extensive exploration activity. Mantra Mining, Inc., is examining the Arctic Deposit, part of the Ambler District, located approximately 180 miles southeast of the Red Dog Mine. The Ambler property includes 35,000 acres of patented and State of Alaska mining claims. The Arctic Deposit includes 40 million tons with an average grade of 4 percent copper, 5.5 percent zinc, 0.8 percent lead, 1.6 ounces per ton silver, and 0.2 ounces per ton gold (Szumigala and Hughes 2007).

Another Ambler District Deposit, the SUN, is owned by Andover Ventures. The SUN property consists of 11,000 acres of State of Alaska mining claims. The deposit includes high concentrations of copper, lead, zinc, silver, and gold. In 2007, Andover conducted 14,750 feet (4,500 meters) of drilling and constructed a 1,500-foot airstrip.

Coal resources have also been identified in the NWAB. Coal was actually mined at the Chicago Creek Deposit in the early 1900s and burned to support gold placer mining operations in the area. The Chicago Creek coal resource includes 15 million tons of sub-bituminous coal. The Kobuk coal resource includes 10 million tons of high-volatile bituminous coal (ADCCED 2008).

3.17.2.3 Government and Public Services in the NWAB

Overview

The NWAB is a home rule borough, incorporated in 1986. According to the Alaska Constitution, a home rule borough can exercise any power not specifically prohibited by state law or the NWAB's charter, which defines its powers and duties, and is adopted by voter approval. The NWAB does not levy any taxes on its residents, although communities within the NWAB do (Division of Community and Regional Affairs, ADCCED).

All of the communities in the NWAB are second-class cities, with the exception of Noatak, which is an unincorporated community. Both first- and second-class cities provide a range of municipal services, such as police protection and sewer and water utilities. The difference between the two classes of city includes taxing authority, responsibility for schools, and the powers and duties of the mayor. For example, with regard to education, a first-class city must exercise education powers while a second-class city may not. Additionally, a community must have at least 400 permanent residents to form a first-class city (ADCCED 2008).

None of the communities in the NWAB impose a property tax. Eight of the 11 communities have a sales tax, ranging from 2 percent to 6 percent, and Kotzebue levies two special taxes, a 6 percent bed tax and a 6 percent alcohol tax.

Northwest Arctic Borough

The NWAB was incorporated two years before the Red Dog Mine began operations to provide services to the region's residents using revenue generated from the mine. Over the past 20 years, the expansion of both NWAB staff and services has paralleled the increasing amounts of Teck PILT to the regional governing body. In recent years, the PILT have grown substantially, making Teck the largest single revenue source for NWAB (Table 3.17-18). Revenue increases have allowed the NWAB to increase its staff from nine employees to 15, and increase funding for its four main departments—public services, planning, economic development, and education.

Table 3.17-18 Northwest Arctic Borough Revenues, Fiscal Year 2007

Revenue Sources	General Funds	Bulk Fuel	Kivalina Bulk Fuel Shoreline Protection Grant	Debt Service	Non-major Funds	Total Revenue Funds
Local Sources						
Teck	$8,721,473	N/A	N/A	N/A	N/A	$8,721,473
NWAB Usage Fee	2,126,016	N/A	N/A	N/A	N/A	2,126,016
Investment Income	353,095	N/A	N/A	276,214	N/A	629,309
Fuel Revenue	N/A	1,048,408		N/A	N/A	1,048,408
Contribution from School District	50,000	N/A	N/A	N/A	N/A	50,000
Other	72,406	N/A	N/A	N/A	582,219	654,625
Total Local Income	11,322,990	1,048,408	0	276,214	582,219	13,229,831
Intergovernmental						
Federal Sources	636,441	N/A	1,063,742	N/A	265,977	1,966,160
State Sources*	633,267	N/A	1,326,690	4,329,382	770,062	7,059,401
Total Revenue	$12,592,698	$1,048,408	$2,390,432	$4,605,596	$1,618,258	$22,255,392

Source: NWAB, Basic Financial Statements and Supplementary Information, FY 2007
*This includes federal funds passed through the State of Alaska

N/A = not applicable

In fiscal year (FY) 2007, the NWAB's expenditures totaled $25.7 million. Nearly 29 percent of expenditures were directed toward school renovation projects in Deering and Shungnak, and another 14 percent went directly to the school district. Other NWAB expenditures include $2.2 million for general government costs, $5 million for public services, and $6.3 million for debt service.

Without PILT funds from the Red Dog Mine, the NWAB would be much more reliant on state and federal funds. For example, as noted by a NWAB official, the ongoing efforts to relocate Kivalina (because of severe erosion on its shores) would be completely dependent on state or federal aid if the NWAB did not have significant revenue from the Red Dog Mine. These funds are not only important logistically, but give the region a sense of self-reliance and self-determination.

The NWAB is working to develop short- and long-term plans to address the possibility of revenue that would be forgone due to an unplanned closure of the Red Dog Mine. A savings account was established for short-term use if mining operations cease. Long-term revenue prospects are much less certain.

Municipal/Tribal Services and Finances

Ten of the 11 communities in the NWAB have both a municipal government and a tribal council. Neither the municipal governments nor tribal councils have direct links to the mine. The division of services provided by each entity is generally clear, with separate funding sources and administrative bodies. Kiana is somewhat distinctive because a single individual serves as the executive director of both the municipality and the tribal council, although each governing entity still has distinct revenue sources and the tribal council has a directive board. Noatak is an unincorporated community, and thus does not have any form of municipal government; the NWAB provides services not accounted for by the tribal council.

Seven of the remaining communities (Ambler, Buckland, Deering, Kivalina, Kobuk, Noorvik, and Shungnak) have formed contractual agreements with the Maniilaq Association, the regional health and social services provider, to provide services to community residents. Maniilaq receives per-community funding from the Bureau of Indian Affairs based on tribal enrollment in each community. Funding generally ranges from $70,000 to $150,000 per community. These funds are pooled by Maniilaq, and combined with funds from other sources, to pay for and implement community service programs, such as food preservation, housing improvement, realty, rights protection, subsistence hunting, traditional foods, tribal environment protection, and the newly reinstated Village Public Safety Officer program. Additionally, these communities receive monthly payments or a lump sum amount from Maniilaq under the Aide-to-Tribal Governments program. These payments cover tribal administration salaries and costs.

Typically, municipal governments in the NWAB receive their primary revenues from local sources. State and federal revenue often comes in the form of capital project funding. Services provided by municipalities commonly include water and sewer utilities, landfill operation, and cable television services, in addition to capital improvement projects. Table 3.17-19 provides an overview of regional community municipal revenues and expenditures for FY 2005.

Table 3.17-19 Municipal Revenues and Expenditures, Fiscal Year 2005

	Local Revenues	Outside Operating Revenues	Outside Capital Revenues	Total Revenues	Operating Expend.	Capital Expend.	Total Expend.
Ambler	$208,767	$10,940	$28,790	$248,497	$251,444	$42,683	$294,197
Buckland	702,416	0	0	702,416	668,226	707	668,933
Deering	367,613	44,698	100,022	512,333	476,322	0	476,322
Kiana	681,182	6,166	44,792	732,140	657,404	0	657,404
Kivalina	214,808	10,249	0	225,057	290,833	0	290,833
Kobuk	201,052	1,241	25,000	227,293	226,380	0	226,380
Kotzebue	6,386,286	153,487	343,624	6,883,397	6,505,656	512,094	7,017,750
Noorvik	485,751	0	0	485,751	579,930	0	579,930
Selawik	547,801	35,503	23,397	606,701	601,457	3,635	605,092
Shungnak	141,970	35,288	70,135	247,393	220,566	17,744	238,310

Source: Alaska Department of Commerce, Community and Economic Development, Community Database
Note: Noatak is an unincorporated community and thus has no municipal finances. Water and sewer utilities, as well as landfill operation are handled by the local village council.

Health and Social Services in the Northwest Arctic Borough

Most health and social services programs offered in the NWAB are managed by Maniilaq Association, a non-profit corporation. Maniilaq Association represents 12 federally recognized tribes located in northwest Alaska and manages social and health services for about 6,500 people within the NWAB and the village of Point Hope. Maniilaq also coordinates tribal and traditional assistance programs, as well as environmental and subsistence protection services.

Maniilaq Association is one of the largest employers in the region with approximately 550 workers and is therefore a key component of the regional economy.

Maniilaq health service facilities and programs include a health center, dental clinic, eye clinic, laboratory, Social Services Department, pharmacy, physical therapy, radiology, and 11 remote village clinics.

There are no apparent direct economic linkages between Maniilaq operations and the Red Dog Mine. Maniilaq provides health and social services to mine employees and their families that reside in the region. However, there is no indication that the presence of the mine related population has any positive or negative impact on Maniilaq services in terms of cost or availability of services. In 2007, Teck made a $106,500 contribution to Maniilaq Association in support of its cancer treatment program.

Northwest Arctic Borough School District

School enrollment in the NWAB has been steady at around 2,000 students over the past several years. The NWAB School District administers schools in 11 different communities, with local enrollments ranging from 35 students in Kobuk to 720 students in Kotzebue.

The NWAB School District's FY 2008 budget reports annual operating revenues of $45.8 million. Contributions from the NWAB's general fund total $3.8 million. In FY 2007, roughly 70 percent of general fund revenues were Teck PILT. The school district's estimated 2008 expenditures are $45.3 million. Roughly 65 percent of these funds are directed toward instructional expenditures.

Approximately one-fifth of NWAB School District students have parents employed directly at the Red Dog Mine or at one of the mine contractors, according to a school district official. The number of former district students employed at the mine is unknown.

The most notable concrete effect that the Red Dog Mine has had on the NWAB School District, according to the NWAB School District Superintendent, is Teck's financial backing of a $100 million bond initiative passed by the NWAB in 1998. (PILT revenues flowing from the mine to the NWAB were essential for securing and repaying the bond.) Bond funds, in conjunction with State government grants, were used to renovate, and in some cases completely rebuild, severely dilapidated village schools throughout the NWAB. The superintendent underscored that without Teck backing, the bond initiative would not have been possible.

The Red Dog Mine supports and facilitates the Career Awareness and Job Shadow programs for students throughout the NWAB. Under the Job Shadow Program, high school students spend three days paired with a Red Dog Mine employee at the mine site, learning first-hand what it is like to work in the mining industry. The Red Dog Mine finances the logistics of these programs.

The Alaska Technical Center (ATC), governed by the NWAB School District Board of Directors, is an adult vocational/technical training school constructed in 1981 to help local residents meet the construction and operational employment demands of the Red Dog Mine and regional support services. Funded primarily by the ADLWD, ATC currently offers four nine-month courses, employer-designed short programs, and adult basic education/general educational development. In 2007, 90 percent of ATC's Millwright Apprenticeship Program graduates were hired by the Red Dog Mine, with starting salaries averaging $57,000. During the 2006–2007 academic year, the ATC awarded 197 certificates of completion for long-term (six to nine months) training programs, 400 certificates for short-term programs (less than one month), and 39 general educational development diplomas. If mine operations cease, this institution would likely stop receiving funding and close down. According to the NWAB School District Superintendent, ATC's impacts on regional employment are critical and closure of the school would be very harmful to the region.

3.17.2.4 Effects of Existing Operations on Socioeconomics

The conception and implementation of the Red Dog Mine began as and has continued to be an iterative process involving the participation of many people. In 1982 NANA entered an agreement with Cominco (which later became Teck Cominco) with the goal to "develop one of the richest zinc deposits in the world; provide employment; and protect the subsistence lifestyle of the people in the region" (NANA-

Cominco brochure, n.d., p.7). The main goal of the NANA-Cominco partnership was to meet the needs and address the concerns of the residents of the borough.

In two public hearings, one on May 2, 1984, in Anchorage, and another on May 3, 1984, in Kotzebue, community members, NANA employees, mineral development agencies, the State of Alaska, and environmental groups presented their concerns about the Red Dog Mine EIS and the many ways the mine's development could play out. Approximately 60 people attended each of the hearings. The central concern raised in the hearings was the protection of the traditional way of life of the Iñupiaq people. The main expectation was increased social and economic welfare of the residents of the NWAB through jobs and regional income. Creating a partnership between Teck, which operates the mine, and NANA, the regional for-profit corporation established under ANCSA that owns the land on which the mine operates, and of which most of the residents of the NWAB are shareholders, was the principle way to address the needs and concerns of the people living in the NWAB.

Red Dog Mine Employment. Red Dog Mine employment as of September 2007 included 465 full-time and 78 part-time workers, including Teck, NANA Management Services, and NANA/Lynden jobs at the Red Dog Mine (Teck 2008). Total 2007 payroll for these workers is estimated at $45.8 million. NANA shareholders accounted for 55.5 percent of the mine's full-time employees and 91 percent of the part-time employees (Table 3.17-20).

Table 3.17-20 Red Dog Mine Employment Including NANA Regional Corporation Shareholder Hire, September 2007

	Full-time			Part-time		
	Total	NANA	Percentage of NANA Shareholders	Total	NANA	Percentage of NANA Shareholders
Teck	370	203	54.9	42	38	90.5
NANA/Lynden	52	23	44.2	3	2	66.7
NANA Management Services	43	32	74.4	33	31	93.9
Overall Total	465	258	55.5	78	71	91.0

Source: Teck 2008

According to Teck records, 100 current employees at Red Dog reside in the NWAB. In 2007, those employees earned $9 million. The largest concentration of Red Dog Mine employees is in Kotzebue (where 20 employees now reside), Noatak (17 employees), and Noorvik (18 employees) (see Table 3.17-21). Over the life of the mine, 237 different Kotzebue residents and 108 Noatak residents have been employed at the mine. Another 15 NWAB residents from Noatak have been employed by NANA Management Services or NANA/Lynden.

Local-level employment data also illustrates that employment at the Red Dog Mine may have facilitated community residents to relocate to Anchorage, for lifestyle and/or economic reasons (Teck provides transportation between the mine and Anchorage). For example, Teck records indicate that 20 Kotzebue residents who worked at the Red Dog Mine moved to Anchorage (or elsewhere in Alaska). Twelve Ambler residents migrated out of the community, as did nine Noorvik residents. Table 3.17-21 presents information about the distribution of employees from within the NWAB.

Since 1989, jobs at the Red Dog Mine have generated $118.6 million in payroll for the residents of the NWAB (Teck 2008) (Table 3.17-22). Employees from elsewhere in Alaska earned a cumulative total of $306.5 million, including $24.8 million in 2007. Non-Alaskans employed at the mine have earned a cumulative total of $130.2 million, including $8.3 million in 2007.

Table 3.17-21 Teck Employment of Northwest Arctic Borough Residents by Community

Community	Population (2007)	Teck Employment Since 1989	Other Red Dog Mine Employment Since 1989	Migrated Employees	Current Teck Employees
Ambler	277	68	0	12	6
Buckland	461	59	0	0	7
Deering	133	16	0	0	3
Kiana	391	80	0	7	5
Kivalina	398	80	20	3	12
Kobuk	119	3	0	0	0
Kotzebue	3,133	237	0	20	20
Noatak	489	108	15	2	17
Noorvik	636	125	0	9	18
Selawik	828	78	0	2	9
Shungnak	269	37	0	5	3

Source: ADLWD and Teck 2008

Table 3.17-22 Red Dog Mine Employee Cumulative Gross Payroll, by Place of Residence, 1989–2007

	1989–2007 Payroll (Cumulative)	2007 Payroll
NWAB	$118,583,605	$8,991,193
Ambler	9,436,340	642,590
Buckland	9,721,001	767,877
Deering	2,517,295	*
Kiana	9,795,259	685,359
Kivalina	7,203,088	649,958
Kobuk	304,812	0
Kotzebue	28,276,920	2,093,475
Noatak	21,734,608	1,569,588
Noorvik	15,382,736	1,430,923
Selawik	960,061	*
Shungnak	4,521,484	*
Other Alaska Total	306,515,324	24,750,018
Anchorage	153,068,356	12,860,875
Wasilla	47,206,723	3,920,537
Palmer	19,408,800	2,039,788
Fairbanks	13,175,082	859,156
Eagle River	11,257,164	332,585
Other Alaska	62,399,200	4,737,077
Outside Alaska	130,236,637	8,311,931
Total Shareholders	244,038,446	20,893,104
Total Non-shareholders	311,297,120	21,160,037
Total Gross Payroll (1989–2007)	$555,335,566	$42,053,142

Source: Teck 2008
* Data suppressed due to confidentiality of data.

Since 1989, NANA shareholders have earned a total of $244.0 million in payroll, 44 percent of the total payroll generated at the Red Dog Mine over the 19-year period. NANA shareholders earned $20.9 million in payroll in 2007, half of the mine's total payroll. Since 1989, NANA shareholders have earned a total of

$244.0 million in payroll, 44 percent of the total payroll generated at the Red Dog Mine over the 19-year period (tables 3.17-23 and 3.17-24).

Table 3.17-23 Teck Employee Wages, 1982–2006

Year	NANA Non-Shareholders	NANA Shareholders	Teck Total Wages
1982–1989	$3,873,080	$1,388,757	$5,261,837
1990	7,611,651	6,310,100	13,921,751
1991	11,650,718	8,848,608	20,499,326
1992	13,454,495	9,245,507	22,700,002
1993	13,293,269	8,949,906	22,243,175
1994	14,723,490	9,358,753	24,082,243
1995	15,488,092	10,045,629	25,533,721
1996	16,418,014	10,652,703	27,070,717
1997	17,532,841	11,887,635	29,420,476
1998	19,136,624	13,695,093	32,831,717
1999	17,744,731	14,843,486	32,588,217
2000	19,675,432	16,450,076	36,125,508
2001	20,267,806	17,891,380	38,159,186
2002	20,915,818	17,471,430	38,387,248
2003	21,258,923	16,527,650	37,786,573
2004	18,779,275	15,019,936	33,799,211
2005	18,918,989	16,169,481	35,088,470
2006	18,462,164	19,239,068	37,701,232

Source: Teck 2008

Table 3.17-24 Red Dog Mine Wages, 2002–2006

Year	NANA Non-Shareholders	NANA Shareholders	Teck Total Wages	NANA Mgmt. Services Wages	NANA/Lynden Wages	Total Wages
2002	$20,915,818	$17,471,430	$38,387,248	$3,092,291	$3,571,108	$45,050,647
2003	21,258,923	16,527,650	37,786,573	3,122,563	4,089,650	44,998,786
2004	18,779,275	15,019,936	33,799,211	2,966,502	4,089,728	40,855,441
2005	18,918,989	16,169,481	35,088,470	2,945,125	3,905,846	41,939,441
2006	18,462,164	19,239,068	37,701,232	3,132,041	3,878,850	44,712,123

Source: Teck 2008

Out-Migration. A rough idea of the effect that employment at the Red Dog Mine has on out-migration can be determined by linking Alaska Department of Labor data containing addresses from the PFD files with employment data. The following analysis considers data for 16- to 64-year-olds in the NWAB collected from the first quarter of each year from 1992 through 2008. People are counted as movers if their zip code in the first quarter of year 1 differs from the first quarter of year 2. The analysis considers totals for Teck employees, other private sector employees, state and local government employees and others. Note that the “other” category includes self-employed, unemployed, and people not in the labor force. These data allow examination of migration and employment.

Table 3.17-25 shows that the population has been increasing by about 1.6 percent per year since 1992. Although the number of people moving away has increased, the out-migration rate (percentage of the population who moved outside of the NWAB) has remained relatively steady from 1992 to 2007.

Table 3.17-25 Out-migration of NWAB Residents, 1992–2007

Year	Residents 16 to 64	Migrants out of NWAB	Out-migration rate (percent)
1992	3,309	381	12
1993	3,384	349	10
1994	3,541	468	13
1995	3,522	440	12
1996	3,533	402	11
1997	3,627	452	12
1998	3,676	451	12
1999	3,755	460	12
2000	3,856	519	13
2001	3,787	476	13
2002	3,843	416	11
2003	3,977	428	11
2004	4,074	523	13
2005	4,115	518	13
2006	4,101	463	11
2007	4,193	465	11

Figure 3.50 shows that Teck employees account for a small number of out-migrants, about 20 people per year (4 percent of total out-migration). An average of 84 state and local government employees move away each year. Others, including students, self-employed, and unemployed make up the largest group, and average about 203 per year.

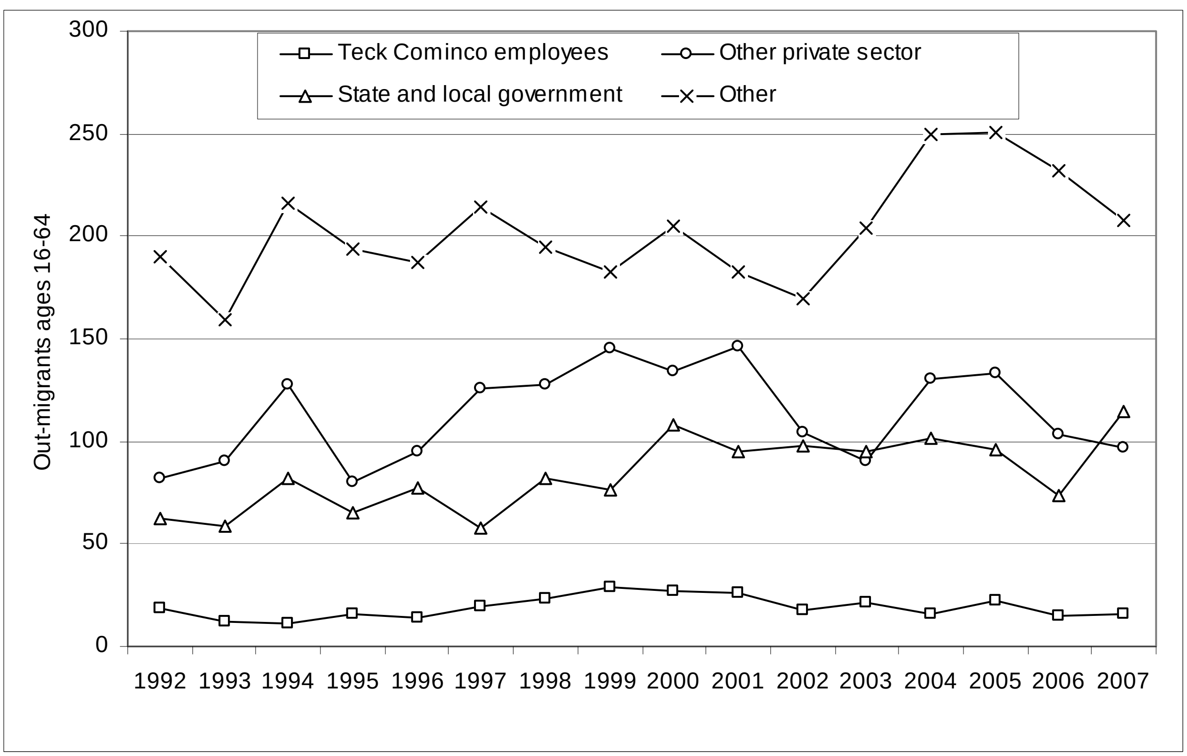
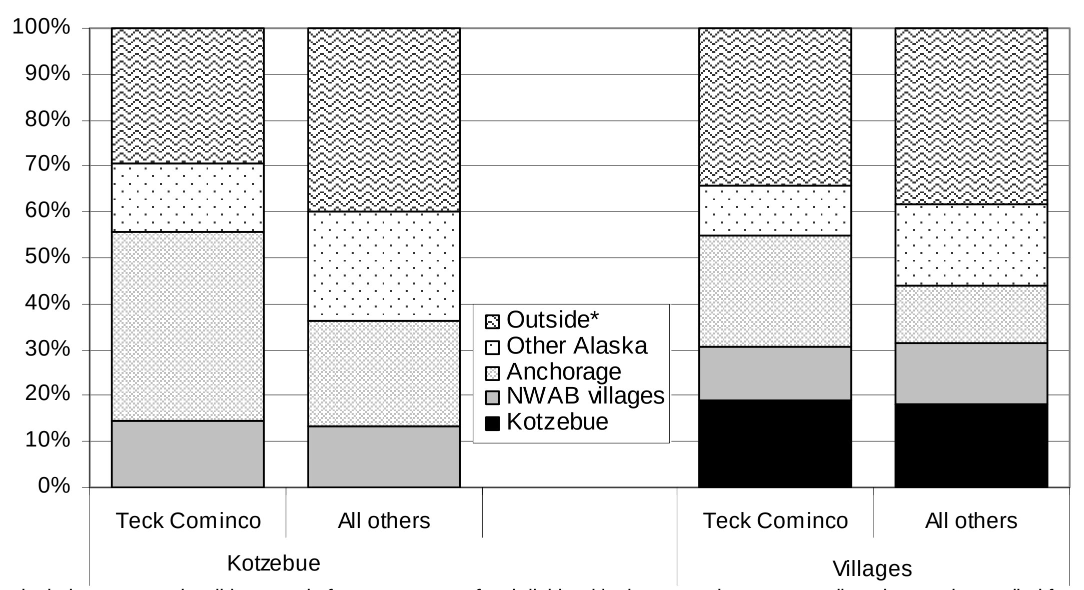


Figure 3.50 Out-migration by Employment Status 1992-2007

The data show that while raw numbers for out-migrants indicate that Teck employees are a relatively small number, the percentage of Teck employees that have moved (e.g., 20 out of approximately 400) is higher than in other employment categories. These data indicate that from 1992 through 2007, a slightly larger share of Teck employees moved out of the NWAB. Out-migration rates for Teck employees ranged from 15 percent to just over 25 percent at its peak in 1997. Out-migration rates for the other groups generally ranged between 7 and 14 percent.

Figure 3.51 combines data from 1992 to 2007 and shows the destinations of people leaving Kotzebue and the NWAB villages, comparing Teck employees to all other out-migrants. The first two columns show people moving from Kotzebue, while the last two columns show people moving from the villages. The percent of Teck employees moving within the NWAB are similar to other movers: about 13 percent of movers from Kotzebue and about 30 percent of those moving from a village. Overall, the largest share of people leaving the NWAB move outside of Alaska. These include teachers and other workers who are originally from other states. Teck employees are less likely than others to move outside of Alaska. Teck employees in both Kotzebue and the villages are more likely than others to move to Anchorage, and less likely to move elsewhere in Alaska. Detailed data on place of employment following moves is not available; however, many of these movers may become commuters from Anchorage to the Red Dog Mine.



*These include anyone who did not apply for a permanent fund dividend in the second year, as well as those who applied from out of state.

Figure 3.51 People Moving from Kotzebue and Villages (ages 16–64) by Destination 1992–2007

Royalty Payments to NANA Regional Corporation. As owner of the Red Dog Mine property, NANA earns royalties on the net earnings of the mine. Through most of the life of the mine, NANA earned royalties equal to 4.5 percent of net smelter returns. However, with full recovery of certain capital expenditures by year-end 2007, NANA is now earning a royalty equal to 25 percent of net production from the mine under a net proceeds royalty system. NANA's share of net production will increase by increments of 5 percent every five years, up to a maximum of 50 percent. The royalty paid to NANA under the old net smelter system can be calculated using the equation:

Net Smelter Royalty (old system) = 4.5% x Production (pounds) x Zinc Price ($/pound)

The royalty paid to NANA under the new net proceeds system can be calculated using the equation:

Net Proceeds Royalty (new system) = (% of net proceeds [starting at 25%]) x Production (pounds) x (Zinc Price [$/pound] – Cost of Mining Zinc [$/pound])

The switch in Teck's royalty payment from a net smelter to a net proceeds royalty, increases NANA's royalty payments while exposing the royalties to greater price vulnerability. Through 2007, NANA earned $220 million in total cumulative royalties from its ownership interest in the Red Dog Mine (Table 3.17-26).

Table 3.17-26 Teck Royalty Payments to NANA Regional Corporation, 1982–2007

Year	Royalty	Cumulative
1982–1989	$7,594,566	$7,594,566
1990	1,492,589	9,087,155
1991	2,082,514	11,169,669
1992	4,528,457	15,698,126
1993	1,785,902	17,484,028
1994	2,346,425	19,830,453
1995	4,632,009	24,462,462
1996	5,851,529	30,313,991
1997	8,915,537	39,229,528
1998	5,270,574	44,500,102
1999	6,638,128	51,138,230
2000	11,099,199	62,237,429
2001	7,190,964	69,428,393
2002	8,990,745	78,419,138
2003	4,901,460	83,320,598
2004	13,728,521	97,049,119
2005	17,139,159	114,188,278
2006	33,952,840	148,141,118
2007	72,313,266	220,454,384

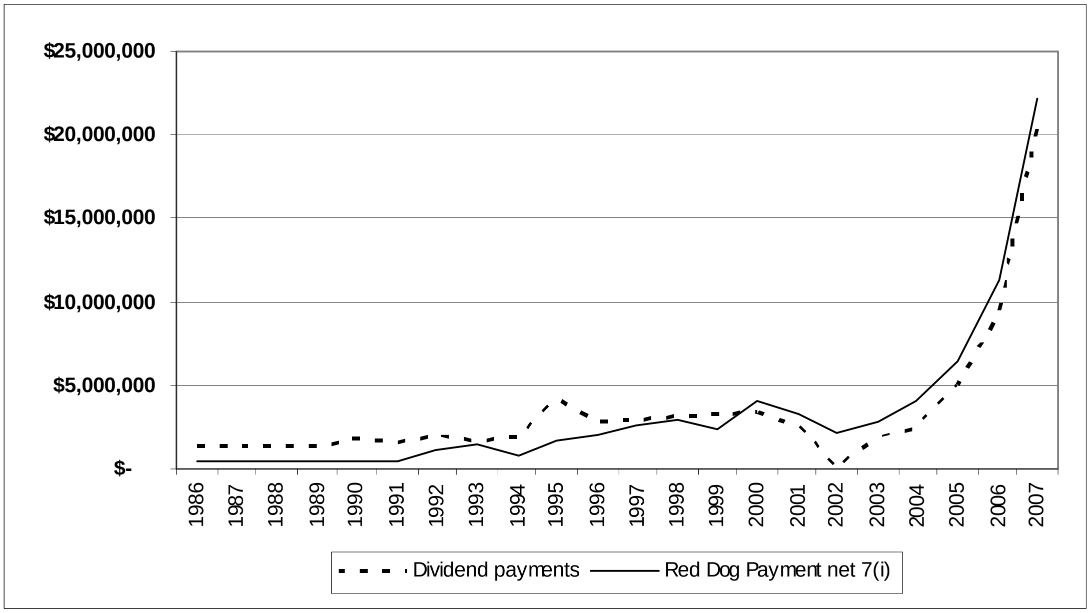
Source: Teck 2008

Royalty payments to NANA climbed steadily in recent years as the price of zinc increased the mine's net smelter returns. Teck paid royalties based on the net proceeds system for only a fraction of 2007. The 2008 royalty payment will be the first entirely calculated using the net proceeds system.

Currently, Teck's royalty payments to NANA indirectly increase the income of the residents of the region through NANA dividends. Analysis of NANA Annual Reports suggests that NANA likely has used much of the Teck royalty payments to pay dividends to NANA shareholders. Figure 3.52 shows a graphical relationship of Red Dog Mine royalties and the total dividend paid to NANA shareholders between 1986 and 2007.

Beyond the income for NANA and its shareholders, royalties from the Red Dog Mine have a substantial impact on the regional economy, and the statewide economy. The majority of these royalty revenues are actually distributed to other ANCSA regional and village corporations. The 7(i) provision of ANCSA requires that 70 percent of all revenues received by each regional corporation from timber resource development and subsurface resource development (excluding industrial minerals) from ANCSA-conveyed land be divided annually among the 12 regional corporations according to the number of Alaska Natives enrolled in each region. Regional corporations must then further distribute these funds to village corporations. Therefore, as a result of the 7(i) provisions of ANCSA, Red Dog Mine royalties flow throughout Alaska's economy.

As these shared royalties flow through the Alaska economy, additional income is created. These multiplier effects are difficult to predict and depend on where and how the royalty money is actually spent. Each regional corporation is likely to use its money in different ways. The indirect employment and income effects of these royalties are described later in this section.



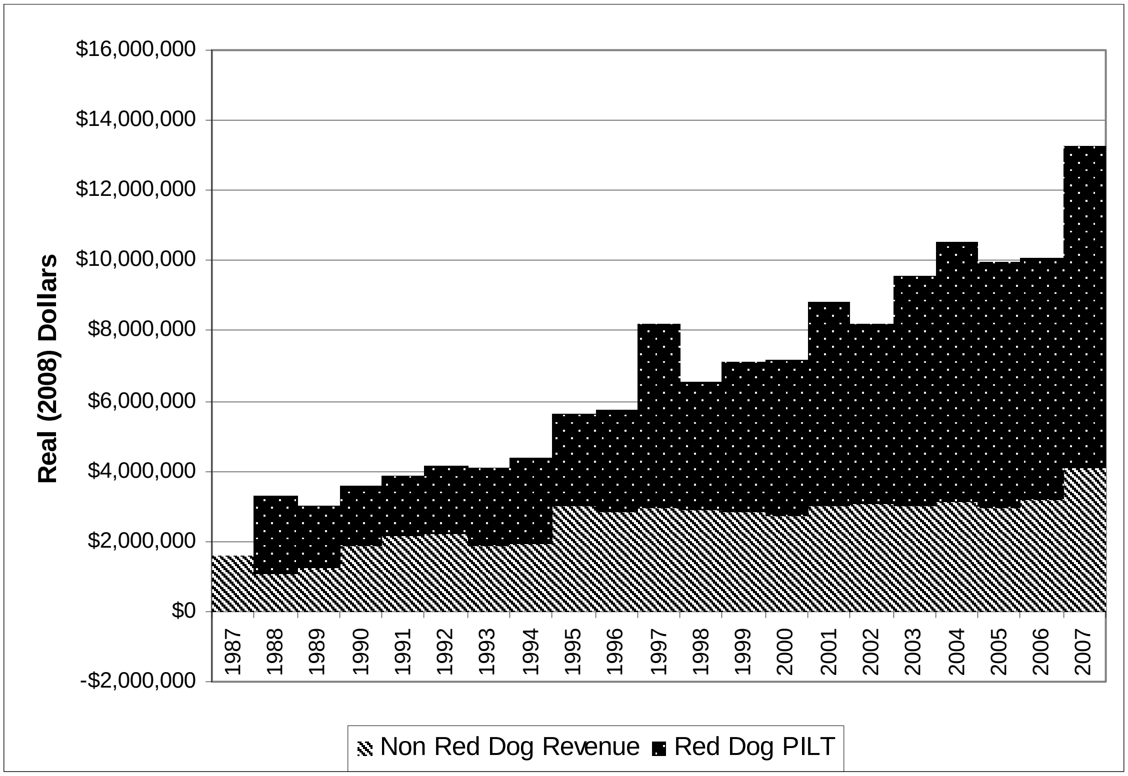
Source: NANA Annual Reports, 1990–2007.

Figure 3.52 Dividend Payments and Net NANA Royalties

Teck Payments In Lieu of Taxes to the NWAB. As stated in the NWAB's FY 2007 Basic Financial Statements and Supplementary Information, an agreement between the NWAB and Teck stipulates that the NWAB will receive quarterly PILT from Teck to fund programs and services designed to support villages within the NWAB. These services may directly or indirectly aid the Red Dog Mine. NWAB annual revenues steadily increased since borough formation with the Red Dog PILT constituting a growing share (Figure 3.53). Since 2003, almost 70 percent of NWAB revenues have come from Red Dog PILT.

In addition to quarterly base payments from Teck, which started in 1988 and will span the life of the mining operation, the NWAB receives "zinc price escalator payments" when the London Metal Exchange 12-month average price per pound for zinc exceeds $0.60 per pound. These payments are set at $50,000 per $0.01 over the $0.60 base price.

Pending suspension or closure of the Red Dog Mine, the Teck-NWAB agreement will remain in effect for a period of 12 months following the suspension or closure. All payments will be required according to schedule during this period. At the end of the 12-month period, the agreement can be terminated without penalty.



Source: NWAB Annual Reports, 1988-2007

Figure 3.53 Northwest Arctic Borough General Fund Revenue Source

According to the NWAB financial statement, the NWAB received payments totaling $8,621,473 from Teck in FY 2007 (Table 3.17-27). Of that, $2,293,473 was based on the zinc price escalator. The NWAB is scheduled to receive $6,528,000 in payments from the mining company in FY 2008, plus any payments based on the zinc price escalator.

Red Dog Mine Related Purchases of Goods and Services. In 2007, Teck purchased approximately $131 million in goods and services from Alaska businesses and organizations. (This does not include royalty payments to NANA, tax payments to the State of Alaska, the PILT to NWAB, or payroll to its own employees). Approximately 350 different Alaska businesses and organizations received payment from Teck in 2007. Roughly $71 million of this spending occurred with NANA affiliates. Payments made to specific vendors are confidential and therefore not disclosed in this assessment.

The impact of spending with vendors in the NWAB is difficult to isolate because many of these businesses have a statewide presence, including the NWAB. It is likely that in certain instances, the volume of business related to the Red Dog Mine in specific sectors of the economy is such that there are indirect benefits for other customers of those vendors. For example, in 2007 the Red Dog Mine spent approximately $4 million on air transportation services to, from, and within the NWAB. This volume of business in this sector of the economy likely results in economies of scale that reduce cost and improve service for air transportation users unrelated to the mine.

Table 3.17-27 Teck Payments In Lieu of Taxes, 1991–2007

Fiscal Year	PILT	Cumulative
1991	$3,750,000	$3,750,000
1992	1,150,000	4,900,000
1993	1,350,000	6,250,000
1994	1,550,000	7,800,000
1995	1,750,000	9,550,000
1996	1,950,000	11,500,000
1997	3,725,000	15,225,000
1998	2,525,000	17,750,000
1999	2,900,000	20,650,000
2000	3,500,000	24,150,000
2001	4,375,000	28,525,000
2002	4,200,000	32,725,000
2003	4,800,000	37,525,000
2004	5,875,000	43,400,000
2005	6,145,000	49,545,000
2006	6,328,000	55,873,000
2007	8,621,473*	64,494,473

Source: Teck 2008
Note: A slight discrepancy exists between NWAB and Teck FY 2007 PILT figures.

Teck spending also includes approximately $950,000 in contributions to non-profit organizations in Alaska, including $600,000 to organizations in the NWAB. Contributions were made to large regional organizations, such as the NWAB School District and Maniilaq Association, village government organizations, youth organizations such as the Boys and Girls Club of Northwest Alaska, and a variety of others. Approximately 55 different non-profit organizations from around Alaska received a contribution from the Red Dog Mine, including 30 located in the NWAB.

In addition to cash contributions, the Red Dog Mine has made in-kind contributions to meet specific needs within the NWAB. In 2005 and 2006, Red Dog Mine personnel assembled and assisted in the transportation of flood control equipment needed to respond to emergency coastal erosion problems in Kivalina. The mine also provided personnel, equipment, and materials to repair erosion damage.

Red Dog Mine Related Total Direct and Indirect Employment and Payroll. Direct Red Dog Mine employment as of September 2007 included 465 full-time and 78 part-time workers, for a total of 543 jobs, including Teck, NANA Management Services, and NANA/Lynden jobs at the Red Dog Mine. Total 2007 payroll for these workers is estimated to be $45.8 million (including $38.8 million paid to Teck employees) (Table 3.17-28). Based on an analysis using the model Impact Analysis for Planning (IMPLAN), indirect and induced labor income related to the Red Dog Mine is estimated at $217 million for 2007, resulting in a total statewide labor income impact of $263 million.

In 2007, Teck spent $321 million in Alaska in support of Red Dog Mine operations, including purchases of goods and services, royalty and tax payments, and its own payroll (Table 3.17-28). As money spent by Teck circulates through the regional and statewide economies, additional income is created. This “multiplier effect” includes indirect and induced economic impacts. Indirect impacts include jobs and income in businesses that provide goods and services to the mine. This includes the 350 businesses and organizations described in the preceding discussion of vendor payments. Induced impacts include jobs and income associated with providing goods and services to the Red Dog Mine labor force and their dependents (jobs and income created as a result of the spending of payroll dollars by Red Dog Mine employees). Induced impacts are felt throughout the private and public sector.

Table 3.17-28 Teck Red Dog Mine Related Expenditures in Alaska, 2007

Source	2007 Amount
Vendors and Affiliates	$100.7 million
Payments to State Government	108.8 million
Royalties to NANA	72.3 million
Direct Teck/Red Dog Mine Payroll	38.8 million
Total Alaska Spending	**$320.6 million**

Source: Teck 2008

Multipliers are used to capture these indirect and induced economic impacts. Precisely measuring multipliers related to Red Dog Mine spending requires very detailed information about local economies—information that is not available for the NWAB (or any other local area of Alaska). In the absence of detailed data regarding the economy, models such as IMPLAN can provide reasonable multipliers for sectors of the economy that are affected by visitor spending. IMPLAN is a predictive input-output model of regional and state economies that is widely used to measure the economic impact of industries and industrial/commercial development.

The degree of the multiplier effect (the size of the multiplier) depends on a number of factors, including the relative amount of local spending on goods and services by the businesses that serve the mine, the residency of the labor force, average wages paid to workers at the mine, the residency of the owners of mine-affected businesses, and the level of service and support sector development in the area to meet the needs of the mine. In general, multipliers are lowest for non-locally owned businesses operating in small communities and employing a large percentage of non-resident workers. Multipliers are highest for locally owned businesses operating in urban settings and employing resident workers who are paid high wages.

The Red Dog Mine is an enclave economy within the region. The economic impact of the mine on the regional economy is relatively small because most of the goods and services purchased, by both the mine and the residents of the region, come from outside the region. The Teck/NANA agreement attempts to mitigate this effect by requiring local hire preference but non-labor inputs to the mine are almost exclusively imported from outside the region.

When cash does flow from the Red Dog Mine into the local economy it still has a small impact because of the region's small economic multipliers. Local residents and business spend most of their cash outside the region to buy goods and services that are not available in the region. According to IMPLAN economic multipliers, $1 million in wages in the NWAB creates 0.8 jobs and $1 million in wages in Anchorage creates 5.1 jobs. Therefore, a Teck employee living in the NWAB will have a smaller economic impact on the NWAB than a Teck employee living in Anchorage will have on the Anchorage economy.

It is more difficult to measure indirect and induced employment related to the Red Dog Mine during this period of rapidly increasing royalty and tax payments. Models such as IMPLAN are most useful for measuring indirect economic impacts at a relatively steady level of direct impact. Translating the very high labor income impact of the Red Dog Mine in 2007 into annual equivalent employment generates very high indirect employment, approximately 3,400 jobs statewide. However, this likely overstates the number of jobs in Alaska that are linked to the Red Dog Mine because the economy has not had time to adjust, in terms of employment, to the large increase in royalties and taxes flowing into it in 2007. Estimated indirect and induced employment related to the Red Dog Mine reported in the following table, 1,695 jobs, is based on average royalties and taxes paid over the past five years (Table 3.17-29).

Table 3.17-29 Total Direct and Indirect Red Dog Mine Related Employment, Labor Income, and Expenditures in Alaska, 2007

Source	Direct	Indirect and Induced	Total
Employment	543	1,695	2,238
Labor Income	$45.8 million	$217 million	$263 million
Non-Payroll Spending	$274.8 million	$108 million	$383 million

Source: Direct figures from Teck 2008; indirect and induced figures are McDowell Group estimates.
Note: Direct labor income includes payroll for NANA Management Services and NANA/Lynden.

Table 3.17-30 presents Red Dog Mine related indirect and induced statewide labor income. This labor income includes approximately $46 million linked to Red Dog Mine purchases of goods and services in Alaska, $100 million linked to payments to governments, $65 million linked to royalties, and $6 million liked to direct payroll. Labor income includes wages, salaries, and proprietor's profits.

Table 3.17-30 Red Dog Mine Related Indirect and Induced Labor Income, 2007

Source	2007 Amount	Indirect and Induced Labor Income
Purchases of Goods and Services in Alaska	$100.7 million	$46 million
Payments to State Government	108.8 million	100 million
Royalties	72.3 million	65 million
Direct Teck Payroll	38.8 million	6 million
Total	**$320.6 million**	**$217 million**

Source: McDowell Group estimates 2008

Calculations of indirect and induced economic impacts in the NWAB are more uncertain and therefore should be viewed as broad approximations. In particular, the amount of royalties that stays within and impacts the NWAB economy is difficult to quantify. For purposes of this portion of the analysis, it is assumed that half of NANA's share of Red Dog Mine royalties flows through the NWAB economy, with the other half flowing through other areas of the State's economy, primarily Anchorage. Further, the employment and income effects of spending with local vendors are also difficult to quantify without very detailed research into the purchasing and employment patterns of the vendors.

As noted above, direct employment and labor income related to the Red Dog Mine includes the 543 full-time and part-time jobs at the mine and $45.8 million in payroll (with 104 jobs held by residents of the NWAB, accounting for $8.3 million in annual payroll). Recognizing the uncertainty in the estimates, indirect and induced employment and labor income is estimated at 120 jobs and $7 million in labor income (Table 3.17-31). The low multipliers indicated by these estimates are indicative of the relatively undeveloped service and supply sectors of the NWAB (relative to Anchorage and Fairbanks, where many of the services and supplies required at the mine are available). This analysis indicates that the Red Dog Mine directly or indirectly accounts for about 20 percent of all employment in the NWAB region.

Table 3.17-31 Direct and Indirect Red Dog Mine Related Employment, Labor Income, and Expenditures in the Northwest Arctic Borough, 2007

Source	Direct	Indirect and Induced	Total
Employment	543	120	663
Labor Income	$45.8 million	$7 million	$53 million
Spending	$21 million	$2 million	$23 million

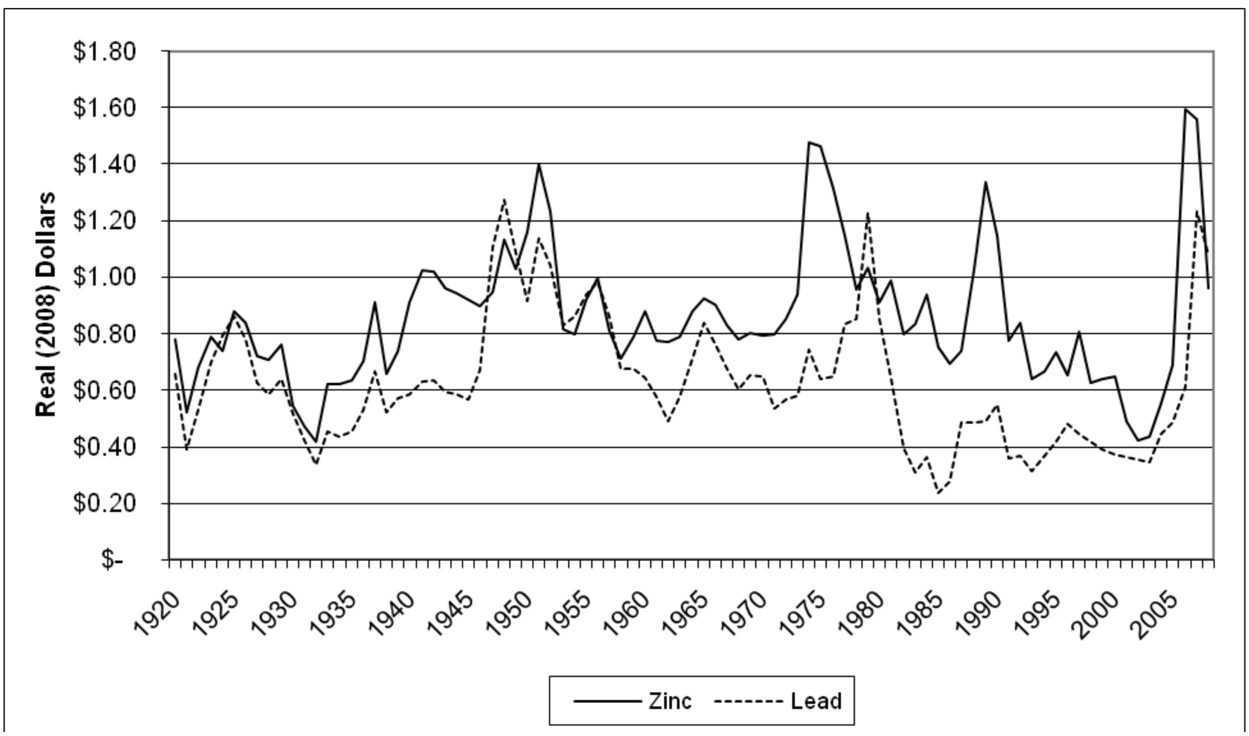
Source: McDowell Group estimates 2008

3.17.3 Socioeconomics – Environmental Consequences

3.17.3.1 Effects Common to All Alternatives

Zinc Price Vulnerability

Red Dog Mine revenues are directly based on zinc, lead and, to a lesser extent, silver prices. Red Dog profits and operations, NANA royalties, and NWAB PILT are all determined by the size of Red Dog's revenues. The value of Red Dog Mine revenues can be calculated as the quantity of mineral concentrates produced multiplied by their respective prices. Of the two drivers of mine revenues, zinc and lead prices (Figure 3.54) are more volatile than metal production levels. Zinc and lead production have been steady since the mine expansion in 1997 (Figure 3.55). Volatile zinc prices create financial vulnerability for Teck, NANA and the NWAB. These financial vulnerabilities created by zinc prices are common to all alternatives.



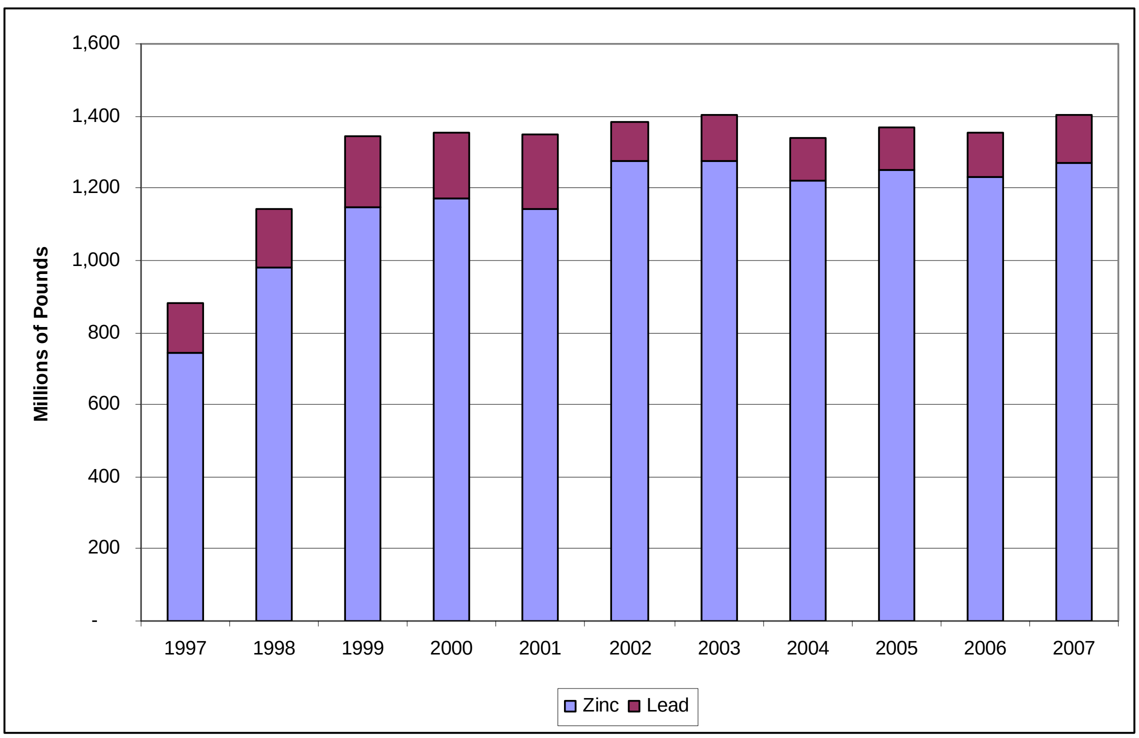
Source: USGS, Historical Statistics for Mineral and Material Commodities in the United States 2008, International Monetary Fund, IMF Primary Commodity Funds 2008, ISER calculations.

Figure 3.54 Lead and Zinc Prices

Zinc is the primary metal produced at Red Dog (Figure 3.55) and, as a result, zinc prices have a larger effect on the economic impact of the Red Dog Mine than silver or lead prices. Zinc will remain the primary metal produced for the remaining life of the Main Pit as well as for the Aqqaluk extension. Therefore, only zinc production and prices are used to examine the economic impact of all alternatives.

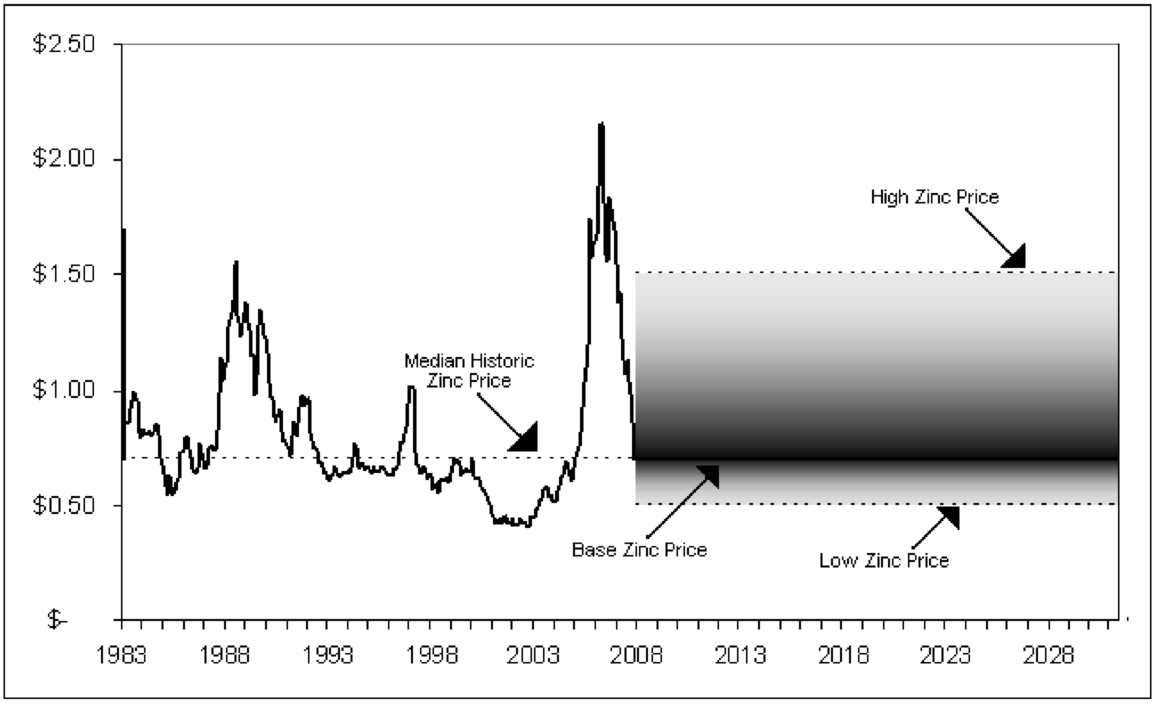
Zinc prices, in addition to production volumes and costs, need to be forecasted to estimate the economic impact of each alternative. For the base case, this analysis follows the price assumption used by the State of Alaska Department of Revenue in its Fall 2008 Revenue Sources Book (ADR 2008) projecting that the zinc price will decrease from its 2007 price of $1.47 per pound to around $0.70 per pound. The $0.70 per pound is used as the basis for estimates presented in this analysis. The 25-year monthly median price is also approximately $0.70 per pound (Figure 3.56), which means that half the time it was higher than this and half the time lower. In actuality, the price will continue to be volatile and could range anywhere from the historic high of $2.00 per pound down to $0.40 per pound. Figure 3.56 shows the relationship between historical zinc prices and the forecasted zinc price used in this analysis.

Price Vulnerability and Red Dog Operations. Zinc prices must remain above a certain price or it would be in Teck's financial interests to cease mining operations. Teck's cost of mining zinc has three components: fixed costs (i.e., sunk capital, long-term leases), variable costs that are independent of zinc prices (i.e., wages, fuel), and variable costs that are dependent on zinc prices (i.e., royalties, income taxes, PILT). If the price of zinc drops below the price-independent variable cost of producing zinc for a period of some time, the mine, barring legal obligations, would cease operation. At that point Teck would be losing more money by continuing to mine than by closing the mine.



Source: Teck Annual Reports, 1997-2008

Figure 3.55 Red Dog Metal Production



International Monetary Fund, IMF Primary Commodity Funds 2008, ISER calculations.

Figure 3.56 Zinc Price Assumptions

The price of zinc might be substantially higher than the forecast and yield windfall benefits for NANA and the NWAB as well as Teck. However, if zinc prices were to collapse, closing the Red Dog Mine before its scheduled closure would create substantial regional economic impacts. The impacts of an unscheduled closure would be similar to the impacts of Alternative A (discussed in Section 3.17.3.2). Economic stability is essential to the region and influences all aspects of residents' lives, including subsistence and general health. To address forgone income from Red Dog operations, a regional long-term economic planning process could be initiated to promote economic stability in the region across all phases of development, including abandonment and rehabilitation. Appropriate economic expertise could be used.

A regional economic planning process could provide a highly effective planning tool to allow regional, tribal, and local governments to engage in a long-term economic planning process targeted at minimizing the adverse effects of an economic downturn at the conclusion of mining activities. The effectiveness of this measure would be proportional to the degree to which it successfully prevented a rapid and severe economic downturn at the conclusion of mining.

Price Vulnerability and the NWAB PILT. Under its agreement with Teck, the NWAB receives a PILT, which finances government activities. The PILT is paid in quarterly installments with the annual amount paid increasing by $100,000 every year. In addition to the base payment, the NWAB also receives a zinc price escalator payment of $50,000 annually for every $0.01 per pound the annual average zinc price (based on the London Metal Exchange settlement price) exceeds an adjustable 1996 base price of $0.60 per pound.

In FY 2007, the NWAB received $8,721,473, of which $6,428,000 was base payment and $2,293,473 was based on the zinc price escalator. The zinc price escalator creates some price vulnerability for the NWAB but, because the base payments make up the majority of the PILT, the financial risk to the borough is relatively small.

Price Vulnerability and NANA Royalties. As discussed in Section 3.17.2.4, Teck's royalty payment in 2007 switched from a net smelter royalty to a net proceeds royalty, increasing NANA's royalty payments as well as the price vulnerability.

The Aqqaluk extension would be expected to yield nearly 20 billion pounds of zinc. If NANA were to receive an average royalty share of 35 percent over the future life of the mine (alternatives B through D), then a $0.01 per pound difference in the price of zinc over the life of the extension would change the cumulative royalty paid to NANA by nearly $70 million.

Analysis of Teck annual financial and production reports suggest that the cost of producing zinc at Red Dog averages roughly $0.50 per pound. While NANA could expect its future net proceeds royalties to be much higher than the net smelter royalties it has received in the past, the value of the net proceeds royalty is highly uncertain and much more dependent on the price of zinc. NANA would only be receiving more under the new royalty system if zinc is valued above a certain price (Table 3.17-32). Table 3.17-32 shows the price, assuming a $0.50 per pound cost to produce, for each royalty level that zinc must remain above for the net proceeds royalty to be greater than net smelter royalty. If the price of zinc were to drop below the cost of production, then NANA would receive no royalty.

Table 3.17-32 Royalty System Break Even Price

Year	NANA Royalty Share (percent)	Zinc Price ($/pound)
2007	25	$ 0.61
2012	30	$ 0.59
2017	35	$ 0.57
2022	40	$ 0.56
2027	45	$ 0.56
2032	50	$ 0.55

Source: NANA Annual Reports, ISER estimates

Table 3.17-33 shows the royalty NANA would receive in a given year (2008 as an example) under various zinc prices, assuming 1.2 billion pounds of zinc production and costs of $0.50 per pound. Note that zinc prices were below $0.50 per pound as recently as 2003 and over $1.50 in 2007, making each price scenario reasonable. Understanding the uncertainty and potential variability of royalty payments to NANA is key to understanding potential effects on NANA shareholder dividends.

Table 3.17-33 Royalty Payments to NANA at Different Prices (baseline price scenario highlighted)

2008 Zinc Price ($/pound)	Zinc Production (millions of pounds)	NANA Royalty ($ millions)
1.50	1,240	310
1.40	1,240	279
1.30	1,240	248
1.20	1,240	217
1.10	1,240	186
1.00	1,240	155
0.90	1,240	124
0.80	1,240	93
0.70	1,240	62
0.60	1,240	31
0.50	1,240	0

Source: NANA Annual Report, 2008 and ISER calculations, 2008

Impacts of Royalty Payments on Shareholder Dividends. Currently, Teck's royalty payments to NANA indirectly increase the income of the residents of the region through NANA dividends. Analysis of NANA Annual Reports suggests that NANA likely has used much of the Teck royalty payments to pay dividends to NANA shareholders. Figure 3.52, presented previously, shows a graphical relationship of Red Dog Mine royalties net 7(i) sharing and the total dividend paid to NANA shareholders between 1986 and 2007. It is not possible to predict the relationship between Red Dog Mine royalties and NANA dividends paid to shareholders based on past patterns. However, for the purpose of this analysis, it is assumed that 90 percent of Red Dog royalties, after 7(i) revenue sharing, would be paid out in dividends, similar to what has been done in the past.

NANA's Red Dog royalty payments are subject to 7(i) sharing. Seventy percent of the royalty is shared by the 12 land owning Alaska Native Regional Corporations. Since NANA also receives a portion of 7(i) payments, the amount NANA ends up sharing is only 62 percent of its royalty (Teck 2007) with the remaining 38 percent potentially available as dividend payments. Fifty-five percent of NANA shareholders live in the NANA region. To illustrate the potential input to the economy as a result of the dividend payout within the NWAB, this analysis assumes that 90 percent of Teck royalties would be paid out in dividends. (Note that this does not necessarily mean that NANA would continue to distribute 90 percent of the dividends in the future.) Based on these assumptions, an estimated 19 percent (38 percent of royalty x 90 percent x 55 percent) of royalties from the Red Dog Mine would enter the regional economy as personal income. At a price of $0.70 per pound a royalty of $62 million would create approximately $12 million in additional regional income. For comparison, the 2007 royalty was slightly more than that amount ($72 million), and Teck employees living in the region were paid just under $9 million in wages (Teck 2007).

The royalty is meaningful when evaluating the economic impact of the proposed alternatives. A 25 percent net proceeds royalty means that every additional dollar spent by Teck results in $0.25 less in royalty payments, because each additional dollar spent in mine operations by Teck reduces its profits by one dollar. If the regional income was increased by the 19 percent share of the royalty payment (calculated above), then each additional dollar spent by Teck in mine operations would decrease that additional regional income by almost $0.05 (i.e., for each million dollars spent by the operation, the royalty payment would be reduced by $50,000). This is important because each alternative, especially alternatives C and D, pose measurable costs. These costs would be reflected in royalty payments to NANA and could therefore affect dividends paid to all NANA shareholders.

3.17.3.2 Effects of Alternative A – No Action Alternative

The existing conditions would continue to occur through 2011. At that time the Red Dog Mine would end production and begin closure. Socioeconomic consequences include direct impacts and indirect impacts. Mine closure would include the following direct impacts:

- Direct employment and payroll of 543 full- and part-time jobs and $45.8 million in annual payroll (based on 2007 payroll) would be dramatically reduced. NANA shareholders hold 56 percent of these jobs. An estimated 25 jobs would be retained to manage post-closure activities, including the wastewater treatment operations. Annual payroll would be less than $2 million (based on 2007 payroll); many of the jobs could be held by NANA shareholders.
- Job loss would include the 103 Red Dog Mine employees who reside in the NWAB. These employees earned $8.3 million in payroll in 2007.
- Beginning in 2012, NANA would forgo its share (approximately 38 percent) of an estimated $155 million royalty (based on estimates explained above) and all future royalties that would be earned under the other alternatives. Regional and village corporations throughout Alaska would

forgo approximately 70 percent of Red Dog Mine royalties (through sharing according to the 7(i) provisions of ANSCA). The loss of royalty payments would be permanent.

- NANA businesses would forgo $71.3 million in gross revenue. Other businesses providing goods and services to the mine would forgo $29 million in gross revenue.
- The NWAB would forgo approximately $8 million annually in PILT from the Red Dog Mine. The Red Dog Mine PILT accounted for two-thirds NWAB General Fund revenues in 2007.
- State government would forgo $70 million in mining license and corporate income taxes, based on 2007 payments.

The total cumulative amount of payroll forgone with mine closure in 2011 rather than 2031 would be $856 million, based on an estimate of $45.8 million in annual payroll (including Teck, NANA Management Services, and NANA/Lynden payroll at the Red Dog Mine). The net present (2008) value of lost payroll for the years 2013 through 2031 is $332 million, assuming a 7 percent private sector discount rate. The total cumulative amount of royalties forgone with mine closure in 2011 rather than 2031 would be over $1.2 billion based on an estimate of annual royalties of $62 million.

Impact on NANA

Directly, NANA businesses would forgo $71.3 million in gross revenue that would come from the continued operation of the mine. Other businesses providing goods and services to the mine would forgo $29 million in gross revenue.

All royalties to NANA would cease in 2012, the year after the end of production at the Red Dog Mine. Assuming zinc prices of $0.70 per pound and costs of $0.50 per pound for the final years of the Main Pit's production, the net proceeds royalty would result in annual NANA royalties of $62 million. These royalties are markedly greater than the typical NANA royalty received under the net smelter royalty system. For perspective, NANA received only an estimated $242 million (in real 2008 dollars) in net smelter revenues from 1982 to 2007.

Under Alternative A cumulative royalty payments to NANA during the remaining life of the Red Dog Mine would be an estimated $248 million based on the same zinc value estimates. This amount represents more than the aggregate of royalties paid to NANA to date, but substantially less than the total royalty payments that NANA would receive under all other alternatives.

Impact on the NWAB

NWAB annual revenues have steadily increased since borough formation with the Red Dog Mine PILT having constituted a growing share, as discussed previously (see Figure 3.53). Since 2003, almost 70 percent of NWAB revenues have come from the Red Dog Mine PILT. PILT forgone from the Red Dog Mine could have drastic consequences for the NWAB. Following mine closure in 2011, the NWAB could drastically cut back on services, or could potentially choose to dissolve if it could not replace the Teck revenue with another local revenue source (e.g., sales or property tax). The loss of the NWAB government could be partially offset by increased local presence of the state and federal governments, lessening the economic impact on the region.

Mine closure would include the following direct and indirect impacts:

- Difficulty in repaying the remaining NWAB School District bonds.
- One million dollars in annual contributions to non-profit organizations would be lost, including $600,000 to organizations in the NWAB, based on 2007 contribution levels.

- Indirect and induced labor income of $63 million forgone annually, which are the result of royalties circulating through the Alaska economy, based on royalty payments made in 2007.
- Indirect and induced labor income of $100 million, which are the result of taxes and other payments to state government circulating through the Alaska economy would be forgone, based on tax and fee payments made in 2007.

In summary, $263 million in direct, indirect, and induced labor income in Alaska would be forgone, based on 2007 data as a result of Red Dog Mine closure in 2011. This is the sum of all direct payroll, payroll with businesses that provide goods and services to the Red Dog Mine, payroll and personal income associated with royalty payments, and labor income associated with payments to governments.

Net changes in the regional economy associated with mine closure would depend on other forces at work in local and regional economies. If other sectors of the economy were to be expanding at the time of—and following—mine closure, the effects of mine closure may be partially offset. However, there is little likelihood of such offsetting economic activity in the NWAB by 2011. Following mine closure, transfer payments flowing into the NWAB economy would increase, as unemployment benefits were paid out. These payments would be temporary, however. The tourism industry has some limited potential for growth, but on a small scale relative to the economic influence of the Red Dog Mine.

In the long term, mine development, other than that related to the Red Dog Mine, might provide employment opportunities for NWAB residents (and others) trained in mining industry occupations. However, the project with the highest potential for development, Mantra Mining Inc.'s Arctic Deposit in the Ambler District, is likely eight to 10 years in the future, if development were to occur at all. Further, that project would be located on State of Alaska patented mining claims rather than NANA property, and therefore would not generate royalties for NANA or other Alaska Native corporations, nor would it necessarily employ a high percentage of NANA shareholders.

Impact on Local Workforce

The completion of mining operations in 2011 would result in the loss of the majority of jobs at the mine, including those with NANA/Lynden and NANA Management Services. Operators of the water treatment plants would continue to be employed, along with a small number of management and support positions. During reclamation and closure, a number of heavy equipment operators would also remain employed for a period of two to five years until reclamation and closure were complete.

3.17.3.3 Effects of Alternative B – Applicant's Proposed Action

Impact on NANA

Teck began paying NANA royalties based on net proceeds in the fourth quarter of 2007. This royalty regimen change preceded the proposed Aqqaluk extension by a little more than two years. NANA would expect payments from Teck to be much larger under the net proceeds royalty system than the net smelter returns royalty system, except in the case of historically low zinc prices.

NANA's share of net proceeds began at 25 percent in 2007 and is set to increase by 5 percent every five years. This increased share of net proceeds would likely be offset by declining production and increasing cost of production. Figure 3.57 shows the expected NANA royalty over the life of the Aqqaluk extension as proposed under alternatives B, C and D. The y-axis has no values because not enough price and cost information is known to make a reasonable estimate of the value of future royalties. Based on forecasted production, the known schedule of net proceed share increases, and stable price and cost scenarios, the expected year-to-year changes in royalty with respect to the three alternatives are shown in Figure 3.57.

Annual Red Dog Mine zinc production would decline over the life of the mine, but the increasing NANA royalty share would offset the decline, assuming constant zinc prices and mining costs.

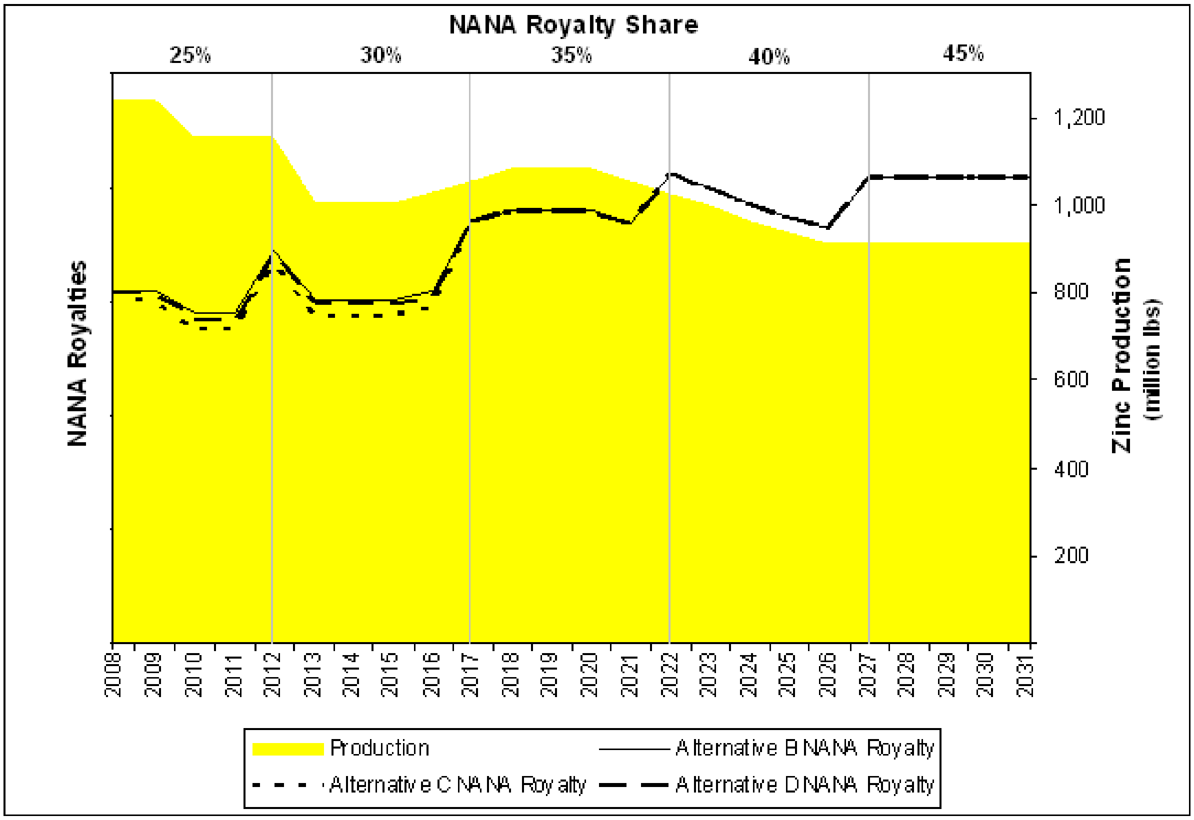


Figure 3.57 NANA Royalty Share, Amount and Red Dog Zinc Production

Impact on the NWAB

Alternative B would have no impact on NWAB government funding until the end of mining in 2031. Until that time, Teck would continue to pay PILT at the current rate because increased mining costs would have no impact on the PILT. The additional payments based on the zinc price escalator would continue to be variable because of its dependence on the price of zinc. The analysis assumes that the economic effects to the NWAB would not be significant when the mine closes in 2031 since the NWAB would have time to plan and develop contingencies for offsetting the lost PILT.

Impact on Local Workforce

Under Alternative B, the workforce would not be expected to change noticeably beyond the current levels of employment. Job opportunities at the mine would continue through 2031. Alternative B represents the highest level of royalty payments over the duration of the mine life compared to all other alternatives.

3.17.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

Alternative C is different from Alternative B in three regards: concentrate would be transported to the port site via a slurry pipeline instead of concentrate trucks, tailings impoundment wastewater would be discharged at the port site instead of Red Dog Creek, and closure would be designed to minimize water treatment needs at the mine site. Alternative C would include the following economic effects.

Impact on NANA

As noted under Alternative B, NANA would expect Teck dividends to be much larger under the new royalty system, except in the case of historically low zinc prices. Under Alternative C, approximately $293 million in construction costs would be expected over two years, beginning in 2009 (Table 3.17-34). Assuming 10 years of depreciation, NANA would be paid approximately $72 million less in total royalties under Alternative C than under Alternative B. The total decreased royalty would be comparable to the effect of a one-year zinc price decrease of $0.25 per pound. Figure 3.57 compares NANA royalties under Alternative C to alternatives B and D with the capital cost depreciated over 10 years.

Table 3.17-34 Alternative C Capital Costs

Construction Component	Estimated Costs ($ millions)
Bench and Wastewater Pipeline	66.2
Water Treatment Plant	68
Concentrate Pipeline	43.4
Concentrate Filtering and Handling	80
Diesel Pipeline	35.7
Total	**293.3**

Source: Teck 2008

Impact on the NWAB

Alternative C would have no impact on NWAB government funding until the end of mining in 2031. Until that time, Teck would continue to pay PILT at the current rate regardless of mining costs. The additional payments to NWAB based on the zinc price escalator would continue to be variable because of their dependence on zinc prices. The additional payments based on the zinc price escalator would continue to be variable because of its dependence on the price of zinc. The analysis assumes that the economic effects to the NWAB would not be significant when the mine closes in 2031 since the NWAB would have time to plan and develop contingencies for offsetting the lost PILT.

Impact on Local Workforce

Some change in employment would occur as a result of pipeline transportation of concentrates rather than trucking. Teck would need to hire additional employees to run a dewatering facility and maintain pipelines. At the same time NANA/Lynden would need fewer drivers and mechanics and the contract could potentially be eliminated altogether. The possibility exists that the few remaining trucking jobs (trucking of supplies from the port to the mine site would still occur) could be done by Teck employees. It is expected that there would be a net decrease in employment at NANA/Lynden of approximately 40 transportation related jobs.

This decrease in employment would be temporarily offset by construction employment. Teck expects to employ 128 workers during the first year of construction and 268 the second year. Construction will likely involve a NANA company (or companies) with approximately half of the workers expected to be NANA shareholders residing in the region. Over the life of the extension, Alternative C would likely decrease total mine related wages.

3.17.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

Alternative D is different from Alternative B in three regards: wastewater would be discharged to the Chukchi Sea instead of Red Dog Creek (similar to Alternative C), enhanced dust control measures would be implemented, and the road and port site would be closed during certain times of the year to reduce subsistence impacts. Alternative D would include the following economic effects.

Impact on NANA

Under Alternative D, approximately $67 million in construction costs would be expected over two years, beginning in 2009 (Table 3.17-35). During the 10 years of depreciation, NANA would be paid approximately $22 million less in royalties under Alternative D than under Alternative B. The total decreased royalty is comparable to the effect of a one-year zinc price decrease of $0.08 per pound. Figure 3.57 compares NANA royalties under Alternative D to alternatives B and C with the capital cost depreciated over 10 years.

Table 3.17-35 Alternative D Capital Costs

Construction Component	Estimated Costs ($ millions)
Bench and Wastewater Pipeline	66.2
Truck Washes	1
Total	67.2

Source: Teck 2008

Impact on NWAB

Alternative D would have no impact on NWAB government funding until the end of mining in 2031. Until that time, Teck would continue to pay PILT at the current rate regardless of mining costs. The additional zinc price escalator payments would be the same as alternatives B and C and would continue to be variable because of its dependence on the price of zinc. The analysis assumes that the economic effects to the NWAB would not be significant when the mine closes in 2031 since the NWAB would have time to plan and develop contingencies for offsetting the lost PILT.

Impact on Local Workforce

Under Alternative D, 128 workers could be employed in the first year of construction and 108 during the second year. Construction would likely involve a NANA company (or companies) with approximately half of the workers expected to be NANA shareholders residing in the region. The construction would provide a short-term employment boost with no long-term decline in mining wages.

3.17.4 Socioeconomics – Summary

The Red Dog Mine provides substantial benefit to the NWAB, NANA, and NANA shareholders by providing local employment opportunities, PILT, royalties, and dividends. Alternative A would see the end of operations in 2011, 20 years sooner than the other alternatives. Closure in 2011 would result in the loss of $8 million annually in PILT to NWAB, and an estimated loss of $155 million in annual NANA royalties, $70 million in annual payments to the state, and over 500 jobs held by employees from inside and outside the region. Alternatives B through D would allow these production related benefits to continue through 2031. However, the costs associated with the pipeline bench under Alternatives C and D would result in slightly less income to NANA than Alternative B. Because of costs associated with the extra pipelines, Alternative C would be the most costly in terms of infrastructure costs although some savings may be realized by eliminating the concentrate trucks. Thus NANA dividends would be greatest under Alternative B, followed by alternatives D and C.

3.18 Environmental Justice

3.18.1 Background

This section addresses environmental justice and is formatted differently than other resource sections in the SEIS. The analysis describes policies and guidance related to environmental justice, and assesseshow environmental justice applies in the region and the effect the project may have in terms of environmental justice.

Environmental justice became a focus following President Clinton's issuance of Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. The Executive Order requires federal agencies to develop strategies to address environmental justice concerns within the context of agency operations. EPA defines environmental justice as:

> The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs or policies (EPA 1998).

EPA's guidance on incorporating environmental justice in NEPA analyses notes that "fair treatment" calls for identifying potential disproportionately high and adverse effects and identifying alternatives that could mitigate those impacts (EPA 1998). The area surrounding the Red Dog Mine and, indeed, the entire NWAB is inhabited by Alaska Iñupiat Natives, where they make up in excess of 80 percent of the population (U.S. Census Bureau 2008). Alaska Natives are a recognized minority and therefore warrant environmental justice consideration. The extension of operations at the Red Dog Mine has the potential to affect this population in terms of environmental justice.

The census data also indicates that the NWAB includes what are considered low-income populations (see Section 3.17 for additional detail on socioeconomics). However, the census data does not necessarily present a clear picture, since the economy of an Alaska Native community may not be based primarily on income, but on subsistence resource use. Therefore, income and poverty levels may not be a good indicator in determining "low-income populations" under Environmental Justice. Appendix F, Community Descriptions, and Appendix G, Social Conditions, provide more detail on life and the social setting within the NWAB.

From the beginning of the NEPA process, EPA and the Corps have worked to ensure that local communities have been sufficiently involved in the decision-making process, and that the analysis has considered the potential for disproportionately high and adverse effects to the local population.

3.18.1.1 Communication and Outreach

Government-to-Government Consultation

Acknowledging the importance of environmental justice throughout the NEPA process, EPA structured the process with the intent of reaching out to the local populations to the extent possible. Prior to scoping, EPA sent letters and email messages to the tribal governments inviting them to request government-to-government consultation and/or participate in the SEIS process as a cooperating agency. Consistent with

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*, the initial scoping process for the SEIS included an offer from EPA to the tribal governments (IRA tribal councils) within the NWAB to conduct government-to-government meetings to discuss the project. EPA contacted the IRA tribal councils in Ambler, Buckland, Candle, Deering, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, and Shugnak and offered an opportunity to meet on a government-to-government basis to provide information and discuss any concerns that might exist about the upcoming SEIS. Kivalina was the only village that expressed interest, and representatives from EPA, NPS, and the Corps met with members from Kivalina's IRA council on October 5, 2007. During that meeting, the agencies provided information on the project and the process and listened to comments and concerns from the council. Issues identified during the meeting included the effect of the mine's ongoing operations on subsistence and, in particular, the effects of traffic on caribou hunting and the DMTS port on the movement of beluga whales. The council members also discussed concerns about water quality in the Wulik River, both as a drinking water source for the village and as a source of subsistence fish. EPA, NPS, and the Corps conducted a second government-to-government meeting with the Kivalina IRA council on January 12, 2009, before the Kivalina public meeting on the draft SEIS and draft NPDES permit.

In its comments on the draft SEIS, Trustees for Alaska, representing the Point Hope IRA council, requested government-to-government consultation. As discussed in Section 1.4.1, a consultation meeting did not occur due to lack of response to EPA's most recent communications.

Scoping

On August 31, 2007, EPA published in the Federal Register a Notice of Intent to prepare the SEIS for the Red Dog Mine. The notice included a request for input from the public and announced public meetings in Anchorage, Kivalina, Kotzebue, and Noatak. The same day, EPA distributed the *Scoping Document for the Red Dog Mine Extension – Aqqaluk Project Supplemental Environmental Impact Statement* to provide additional detail on existing operations at the Red Dog Mine, the proposed extension, the permitting process, and the NEPA process. In addition, EPA worked with Maniilaq to distribute a scoping summary document door to door to all homes in Kivalina and Noatak. The scoping summary document provided a more concise description of the project and process, and again provided the dates of the public meetings and requested comments from the residents.

Scoping meetings were held in the NWAB on October 3, 2007, in Kotzebue, October 4, 2007, in Noatak, and October 5, 2007, in Kivalina. Meetings consisted of an open house during which representatives from EPA, the Corps, NPS, ADNR, ADEC, NWAB, and Maniilaq presented details on the project and answered questions from members of the communities. The meetings were followed by an opportunity for people to provide oral comments, although written comments were also accepted. An Iñupiaq translator attended the meetings in Noatak and Kivalina and was available to the audience upon their request.

EPA identified an approach for the villages to participate throughout the process by encouraging the tribal governments to participate as cooperating agencies in developing the SEIS, with Maniilaq providing the coordination and resources. Through a resolution with each tribal government and a MOU with EPA, Maniilaq represents the cooperating agency interests of the Native communities of Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawick, and Shugnak. Maniilaq has participated in all preliminary reviews of the draft SEIS and has attended regular cooperating agency meetings and teleconferences.

3.18.2 Environmental Justice – Baseline Conditions

Unlike many NEPA analyses where baseline conditions reflect the environment in a pre-project condition, this analysis is being undertaken where ongoing activities have already resulted in environmental effects. The approach to this analysis has been to consider baseline conditions as those that currently exist. This situation was reflected in comments that EPA received during the meetings with the Kivalina IRA council and with residents of Kivalina and Noatak. Comments reflected a concern by people not only about the potential effects of future expansion of mining activities at the Red Dog Mine, but also about the effects that have occurred since the mine began operations in 1989.

Residents of Noatak voiced concerns about being "left behind" as the resource on their lands was being developed. People also were concerned about the potential for contaminated water to make its way into the Noatak River drainage. Alaska Natives in Kivalina expressed concerns about a range of topics, generally relating to the mine's effects on subsistence activities. A number of people cited concerns about the quality of drinking water, which comes from the Wulik River downstream from the mine's outfall. They questioned how the NPDES permit would prevent pollution of the creek and raised concerns about changes to the permit that would eliminate or increase limits in some cases. They further noted issues related to dead fish, and concerns related to the quantity of dust generated by the truck traffic. One commenter stated that they have changed where they collect berries because of concerns about contaminants in the fugitive dust generated in the vicinity of the port. More than one commenter also noted some frustration that despite participating in public meetings and hearings and providing input, they feel their concerns have not been addressed. While a number of residents identified concerns about the mine, others expressed support for the mine and the jobs it brings to the region.

The surface water quality section of the SEIS (see Section 3.5) provides data on water quality in the Wulik River and Kivalina's drinking water supply. The surface water data and assessment indicate that Kivalina's drinking water meets drinking water standards and, therefore, is safe to drink. Subsistence and harvest surveys were conducted in response to scoping concerns and in support of the SEIS. These surveys covered a broad range of subsistence foods including caribou, fish, marine mammals, berries, etc. (see Section 3.12). Analysis of the subsistence and harvest survey data showed a decrease in per capita harvests of caribou compared to data from the 1990s in both Kivalina and Noatak. Subsistence hunters in Kivalina reported changes in the migration patterns of caribou and beluga whales, with the majority of observers attributing the changes to mine related activities (DMTS operations).

Section 3.13 provides an assessment of public health and found that existing operations may have affected the consumption of subsistence food by residents of Kivalina because of changes to caribou distribution patterns and concerns about potential contamination of meat and other subsistence resources. Consumption patterns and associated health issues may also be experienced by mine workers who would normally participate in subsistence activities, but instead maintain regular work schedules. Changes in the nature of the participation in subsistence activities could reach beyond health and mental well-being and, in some cases, may affect cultural identity, although there is currently no site-specific data to verify this.

The human health portion of a combined human health and ecological risk assessment (DMTS risk assessment – Exponent 2007a) conducted in response to contaminants in fugitive dust from the DMTS road used a "Combined Worker/Subsistence Use" scenario to characterize exposure pathways and potential effects. Data provided in the DMTS risk assessment indicate that concentrations of metals in caribou warrant further study (see the HHRA summary in Section 3.13.2) but do not justify avoiding eating caribou.

Section 3.17 discusses the effects on socioeconomics and documents the generally positive effects that the mine has had on NANA shareholders and residents of the NWAB. Payments to the NWAB have resulted in an improvement in the general well-being of borough residents through better funding of local services, including the local school district. Although the mine has brought economic benefit to the NWAB, income discrepancies exist. For example, while 203 employees at the site in 2007 were NANA shareholders, only 100 lived within the NWAB. This is reflected in payroll numbers: NANA shareholders accounted for slightly less than 50 percent of the 2007 payroll, while NWAB residents accounted for slightly more than 21 percent of the payroll. With a goal of 100 percent Native hire in Teck's operating agreement with NANA, the difference in employment is a disproportionate effect in terms of environmental justice. NANA and Teck are aware of the discrepancy and have undertaken a number of programs (discussed in Appendix G) to improve hiring opportunities for NWAB residents.

Economic multipliers, which are used to show how income (such as wages) moves through a community or region, show differences between the NWAB and urban areas. One model used to calculate multiplier effects shows that $1 million in wages in the NWAB would create 0.8 jobs while $1 million in wages in Anchorage would create 5.1 jobs (see Section 3.17.2.4). Therefore, the NWAB receives a smaller economic benefit for each dollar spent in the community compared to Anchorage (or other urban centers). While the Red Dog Mine operation has no effect on the multiplier since it is based on local economic conditions and patterns, the NWAB experiences the economic difference nonetheless. The difference in multipliers is a function of rural versus urban economies and is independent of the NWAB's status as an environmental justice community.

Considering the NWAB on an overall basis, the presence of the Red Dog Mine has provided positive effects in terms of socioeconomics, providing a major source of income to both NANA and the NWAB. However, residents of Kivalina have indicated that the mine's ongoing operations have had adverse effects on subsistence resources. Similar to comments received in response to scoping, respondents to the subsistence survey (discussed in detail in Section 3.12.2) noted changes in the migration patterns of both caribou and beluga whale, with the majority of responses attributing the changes to mine (or port) related activities. The data available do not indicate that operations at the Red Dog Mine are creating adverse effects on the residents of Noatak.

3.18.3 Environmental Justice – Environmental Consequences

EPA guidance on environmental justice calls for alternatives to be developed so that the extent of disproportional effects on environmental justice communities can be evaluated. In this case, an analysis characterizing the degree of disproportional effects cannot be accomplished since all populations in the immediate vicinity of the mine (residents of Kivalina and Noatak), and most of the entire NWAB, are defined as environmental justice populations. However, components of alternatives were specifically developed in response to concerns about the effects to subsistence resources, fugitive dust, and water quality. Alternative C and D include a wastewater discharge pipeline that would eliminate the discharge in Red Dog Creek, which is upstream of Kivalina's drinking water intake in the Wulik River. Alternative C includes replacing concentrate trucks with a slurry pipeline that would greatly reduce localized impacts on caribou movement and also reduce fugitive dust. Alternative D includes waiting to open the DMTS port until after the summer beluga whale migration is finished and closing the DMTS road for a month during the fall caribou migration to have a positive effect on subsistence harvests for these two species. The remainder of this subsection discusses the environmental justice effects of the proposed action and alternatives.

3.18.3.1 Effects Common to All Alternatives

Under all alternatives, the economic discrepancies between the NWAB and Anchorage would continue since the economic structure of the NWAB would not change. Therefore, areas outside the NWAB would receive greater economic benefit from the wages of Teck employees or through the purchase of goods and services for the operation of the mine. This effect is related to the nature of the economy rather than the characterization of the NWAB as an environmental justice community and is not a condition that can be mitigated. The discrepancies in employment between NWAB residents and non-residents would continue under all alternatives. Teck and NANA would continue to support educational programs, although these efforts are unlikely to result in meeting the goal of 100 percent Native hire nor would they necessarily ensure that jobs went to NWAB residents.

3.18.3.2 Effects of Alternative A – No Action

Under the No Action alternative, the end of mine production in 2011 would have substantial economic effects as described in Section 3.17. Adverse effects of early closure of the mine would affect the entire environmental justice population within the NWAB. Within this community, the effect would only be disproportional to the mine's employees, who would not only be affected by the likely loss of services from the NWAB and loss of NANA dividends, but also the loss of their jobs. The early closure could have a positive effect on subsistence resources and associated health and well-being for the residents of Kivalina since the negative effects of mining operations on these resources would cease. However, citizens of Kivalina would suffer the same adverse economic effects as the other NWAB residents.

3.18.3.3 Effects of Alternative B – Applicant's Proposed Action

Alternative B would essentially maintain the status quo in terms of environmental justice effects. NANA shareholders and the NWAB would continue to receive benefits from the mine's production. As noted in Section 3.17.3, Teck's royalty payments to NANA could increase substantially, providing an economic boost to its shareholders who are part of the environmental justice communities within the NWAB. Subsistence related effects observed by residents of Kivalina stemming from the operation of the DMTS would likely continue to occur (see Section 3.12.2 for more detail) at levels similar to those currently being experienced.

3.18.3.4 Effects of Alternative C – Concentrate and Wastewater Pipelines

The effects of Alternative C would be similar to the effects of Alternative B in terms of economics, although the cost of the pipelines would result in smaller royalty payments to NANA. However, the elimination of the majority of truck traffic on the DMTS road would have a positive effect on the distribution of caribou in the area, which could also have a beneficial effect in terms of subsistence. In addition, concerns related to fugitive dust would be reduced.

The elimination of the discharge in Red Dog Creek would have a positive effect on Kivalina's perception of contaminants in their drinking water and subsistence resources in the Wulik River.While some Kivalina residents suggested moving the discharge from Red Dog Creek to the Chukchi Sea as a way to address concerns about drinking water quality and fish in the Wulik River. Relocation of the outfall to the Chukchi Sea would result in increased metals concentrations in Red Dog Creek that could cause adverse effects on aquatic life in the creek, although effects would not extend to Ikalukrok Creek or the Wulik River. The change would not affect water quality at the intake for Kivalina's water supply. Concerns about drinking water quality could return following the return of the discharge point to Red Dog Creek at the end of mining activities. Although moving the outfall to the Chukchi Sea is responsive to concerns raised by Kivalina residents, other commenters expressed concern with potential impacts of the marine discharge on water quality, fish, and marine mammals.

3.18.3.5 Effects of Alternative D – Wastewater Pipeline and Additional Measures

The economic effects of Alternative D on NANA shareholders and the NWAB would be between alternatives B and C because of the costs involved with a single pipeline. Residents of Kivalina could see improvement in subsistence harvests of both beluga whales and caribou, depending on the effectiveness of the road and port closures and the degree to which the facilities have been producing adverse effects. Similar to Alternative C, relocation of the outfall from Red Dog Creek could alleviate concerns related to drinking water and freshwater fish; however, new concerns could arise in relation to contaminants near the marine outfall. The relocation of the outfall to the Chukchi Sea would have an adverse effect on water quality in Red Dog Creek and, potentially, on aquatic life present in that creek. The change would not affect water quality at the intake for Kivalina's water supply.

3.18.4 Environmental Justice – Summary

Throughout preparation of the SEIS, EPA has afforded residents of the NWAB opportunity to provide input and participate in the NEPA process. The analysis considers the entire NWAB as an environmental justice community based on the minority status and low-income aspects of the population. Based on concerns raised during scoping, the SEIS provides a detailed evaluation of the project effects on subsistence resources and alternatives that were developed to reduce these effects. Alternatives C and D provide for reductions in actual and perceived impacts on subsistence harvest of caribou, marine mammals, berries, and fish. Concerns about contamination of Kivalina's drinking water supply are addressed by the marine discharge under these alternatives. Finally, the SEIS describes the socioeconomic and public health effects of the project on local residents. While the socioeconomic issues discussed in this section exist, they are outside EPA's regulatory authority. Overall, EPA has determined that the effects of the proposed action and alternatives would not cause significant disproportional adverse effects on the NWAB.

3.19 Cumulative Effects

This section of the SEIS presents a discussion of the potential cumulative effects associated with the proposed action. The discussion is presented in four parts, as follows:

- The basis for the assessment, including the regulatory framework, the alternative chosen for this evaluation, the long list of potentially relevant past, present, and reasonably foreseeable actions in the Red Dog region, that were initially considered, and the process and criteria followed in selecting a short list of relevant past, present, and reasonably foreseeable actions for this evaluation;
- Brief descriptions of the short list of relevant (past, present, and reasonably foreseeable) actions selected for this cumulative effects evaluation;
- The potential cumulative effects associated with the proposed action (preferred alternative) when combined with the selected relevant past, present, and reasonably foreseeable actions; and
- The conclusions reached in this evaluation.

3.19.1 Basis for Assessment

3.19.1.1 Regulatory Framework

This evaluation of potential cumulative effects from the proposed action is consistent with the following regulations and guidance:

- Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR §§ 1500–1508);
- EPA's Procedures for Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act (40 CFR § 6);
- Council on Environmental Quality's *Considering Cumulative Effects under the National Environmental Policy Act* January 1997; and

- EPA's *Consideration of Cumulative Impacts in EPA Review of NEPA Documents* EPA 315-R-99-002/May 1999.

Cumulative effects are generally defined in the regulations as the impact on the environment (typically for a specific ecosystem) resulting from the incremental impact of a proposed action when added to other past, present and reasonably foreseeable future actions in that area. Such cumulative impacts can result from the additive effect over a period of time from actions that may individually have minor impacts, but collectively may have significant impacts.

3.19.1.2 Alternatives Chosen for Evaluation

The cumulative impacts analysis considers all the alternatives assessed in this SEIS, but focuses on the effects of Alternative B; the Applicant's proposed action. Impacts from Alternative B focus primarily on water quality within the Red Dog Creek and Wulik River drainages while Alternative C (and D) would tend to concentrate effects along the DMTS road. These aspects of alternatives B and C form the basis for the cumulative effects assessment since the footprint of the other alternatives would be smaller than these two.

3.19.1.3 Initial Long-List of Potentially Relevant Actions

Based on a preliminary review of published material, available information about the northwest arctic region on various agency and corporate websites, and in discussions with interested stakeholders, the following initial long list of existing, proposed, and reasonably foreseeable actions in the region was compiled, to be assessed for inclusion in this cumulative effects evaluation:

- Additional Red Dog Mine activities (e.g., mining of the Qanaiyaq deposit; continued Natural Gas Exploration; exploration and mining of the Paalaaq deposit);
- Red Dog Mine tailings wastewater pipeline;
- Production at the Rock Creek mine (near Nome);
- Development of Nome road system;
- Development of Point Hope multi-purpose road;
- Navigation improvements at the DMTS port;
- North Slope oil production;
- Production from the Northwest National Petroleum Reserve (NPR);
- Alpine Oil Field production;
- Production from South NPR-A;
- NW arctic transportation plan;
- Western arctic coal reserves;
- Su and Lik deposits;
- Anarraaq deposit;
- Drenchwater deposit;
- Kivalina relocation;
- Construction of a road to Noatak;
- Expansion of the Noatak Airport;
- Drake Construction gravel mine, Noatak River;
- Kobuk-Seward Peninsula resource management plan; and
- Global climate change.

3.19.1.4 Selection of Short List of Relevant Past, Present, and Reasonably Foreseeable Actions

The long list of potentially relevant past, present, and reasonably foreseeable actions was circulated to key stakeholder agencies to enlist their help in assessing the actions for relevance in this evaluation of cumulative effects. Based on the input received from the agencies, and the identification and evaluation of potential effects of the proposed actions and alternatives included in the SEIS, some general criteria were developed to help assess the relevance of the long list of past, present, and future actions for inclusion in this cumulative effects evaluation. The relationships of the general criteria to the environmental resources included in the SEIS are summarized in Table 3.19-1.

The general criteria summarized in Table 3.19-1, together with information from discussions with key stakeholders, agencies, and use of local knowledge were applied to the long list of existing, planned, and reasonably foreseeable actions in the Red Dog region to determine their relevance for this cumulative effects evaluation. Table 3.19-2 summarizes this assessment, and identifies the short list of actions derived from this process that have been included in this cumulative effects evaluation. Brief descriptions of actions selected for this evaluation are presented in the next section.

Table 3.19-1 Relationship of Selection Criteria to Environmental Resources in the SEIS

Environmental Resource	Selection Criteria	
General	1	Actions are planned (beyond speculation), are located in reasonable proximity, and are implementable within the operating life of the proposed action.
General	2	Actions have international or global importance (e.g., climate change).
Air Quality	3	Actions are within the same general airshed as the proposed action.
Geochemistry	4	Actions are within the same watershed or aquifer as the proposed action.
Geotechnical Stability	5	Actions are within the same watershed as the proposed action.
Water Resources	6	Actions are within the same watershed or aquifer as the proposed action.
Vegetation	7	Actions involve vegetative zones and geographic distribution of plant communities that overlap with those affected by the proposed action.
Wetlands	8	Actions involve wetland zones and geographic distribution of wetlands that overlap with those affected by the proposed action.
Wildlife	9	Actions occur within wildlife habitats, ranges, or migratory corridors that overlap with those affected by the proposed action.
Aquatic Resources	10	Actions occur within aquatic habitats or migratory corridors that overlap with those affected by the proposed action.
Land Use and Recreation	11	Actions occur within geographic areas that overlap with the study area for the proposed action (NW portion of Game Management Unit 23).
Subsistence	12	Actions involve locations, habitats, ranges, or migratory corridors of subsistence resources that overlap with those affected by the proposed action.
Public Health	13	Actions would have effects on public health that could have additive effects with the proposed action.
Cultural Resources	14	Actions occur within geographic areas that overlap with the study area for the proposed action.
Transportation	15	Actions that could use or tie into the DMTS (port and road).
Noise	16	Actions are close enough to noise zones produced by the proposed action to result in additive noise effects.
Socioeconomics	17	Actions occur within the NWAB that could affect the area in terms of economics, commerce, or culture.

Table 3.19-2 General Criteria Applied in Selecting Relevant Actions for this Evaluation

Action	Relevant for this evaluation?	Basis of Selection for this evaluation (Refer to Table 3.19-1 for descriptions of criteria)	Resources Potentially Affected
Qanaiyaq Deposit	Y	Development is addressed as part of the Aqqaluk mine plan, including mining within the same period as mining of the Aqqaluk Deposit. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Red Dog Mine Natural Gas Exploration	Y	Exploration activities are currently underway and are expected to continue into the period during which the Aqqaluk Deposit would be developed. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Paalaaq Deposit	Y	Exploration activities are reasonably foreseeable as the Aqqaluk Deposit is developed. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Red Dog Mine Tailings Wastewater Pipeline	Y	Construction of the new 52-mile pipeline planned in near term as part of the settlement agreement to move the location of the Red Dog Mine wastewater discharge outfall to Chukchi Sea. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Rock Creek Exploration	N	Not selected for evaluation. Planned action is mineral exploration and mining in the Nome area. Although the action would likely take place within the operating life of the Aqqaluk Extension, it is considered too distant from the Red Dog area to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project.	N/A
Nome Road System	N	Not selected for evaluation. Planned action is the development of a major roadway linking the communities in the Nome area. Although the action may take place within the operating life of the Aqqaluk Extension, it is considered too distant from the Red Dog area to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project.	N/A
Point Hope Multi-Purpose Road	N	Not selected for evaluation. Planned action is the development of an evacuation roadway for Point Hope. Although the action may take place within the operating life of the Aqqaluk Extension, it is considered to be too speculative to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project.	N/A

Action	Relevant for this evaluation?	Basis of Selection for this evaluation (Refer to Table 3.19-1 for descriptions of criteria)	Resources Potentially Affected
DMTS Navigation Improvements	Y	Implementation is possible during the life of operations for the Aqqaluk Extension Project if a proponent is identified. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
North Slope Oil Production	N	Not selected for evaluation. Planned action is the development and production of underground oil reserves in the North Slope area. Although the action would likely take place within the operating life of the Aqqaluk Extension, it is considered too distant from the Red Dog area to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project.	N/A
Northwest NPR Production	N	Not selected for evaluation. Planned action is the development and production of underground oil reserves in northwestern portion of the National Petroleum Reserve. Although the action may take place within the operating life of the Aqqaluk Extension, it is considered too distant from the Red Dog area to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project.	N/A
Alpine Oil Field Production	N	Not selected for evaluation. Planned action is the development and production of underground oil reserves along the north coast of Alaska on the Beaufort Sea. Although the action may take place within the operating life of the Aqqaluk Extension, it is considered too distant from the Red Dog area to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project.	N/A
South NPR-A Production	N	Not selected for evaluation. Planned action is the development and production of underground oil reserves in south portion of the NPR. The BLM, as of mid-2007, discontinued its planning efforts in the south portion of the NPR, in consideration of the high level of public concern about potential impacts on subsistence resources, especially on the WAH. The herd’s primary calving area is within this area.	N/A
NW Arctic Transportation Plan	N	Not selected for evaluation. Plan provides a framework and guidance for potential transportation links, improvements, and expansions in northwest Alaska, but no projects are identified for implementation in the foreseeable future that would involve the Red Dog area.	N/A
Western Arctic Coal Reserves	N	Not selected for evaluation. Planned action is the exploration and baseline data collection for coal deposits in an area about 70 miles north of Red Dog. These activities would continue to occur within the operating life of the Aqqaluk Extension Project. The actions planned are fairly distant from the Red Dog area, and are not likely to contribute to an evaluation of potential cumulative effects associated with the Aqqaluk Extension Project. Development of the project is not reasonably foreseeable, and a current account indicates that use of the DMTS port facility would not necessarily be required or desirable.	N/A

Action	Relevant for this evaluation?	Basis of Selection for this evaluation (Refer to Table 3.19-1 for descriptions of criteria)	Resources Potentially Affected
Su and Lik Deposits	Y	Exploration activities at Su and Lik deposits are ongoing and are likely to continue during the life of the Aqqaluk Extension Project. The mineral resources are not defined to the extent that development of either property is reasonably foreseeable. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Anarraaq Deposit	Y	Exploration activities have been conducted in the past and are likely to be conducted during the life of the Aqqaluk Extension project. The mineral resource is not defined to the extent that development of the property is reasonably foreseeable. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Drenchwater Deposit	N	Not selected for evaluation. Planned action is the exploration of mineral deposits in an area about 90 miles east of Red Dog. Drenchwater and other deposits in the vicinity are within the NPR, which is closed to mining. Therefore, the potential for development and production of the Drenchwater Deposit is low. Its distance from Red Dog makes it unlikely that effects of the existing level of exploration (e.g., USGS) would contribute in any manner to cumulative effects associated with the Aqqaluk Extension Project.	N/A
Drake Construction Gravel Mine	N	Proposed gravel pit 18 miles north of Kotzebue on the Noatak River. Gravel would be mined seasonally (between June and September) and transported to Kotzebue by tug and barge. Mining would occur in five-acre sections to a total of 40 acres over 20 years. The project would involve construction of a 1,250-foot haul road, barge landing, and stockpile site for excavated material. The project is over 30 miles from Noatak and considered too distant from the Red Dog area to contribute to cumulative effects from the Aqqaluk Extension Project.	N/A
Kivalina Relocation	Y	Kivalina is being threatened by coastal erosion and relocation has been and will continue to be a priority for the village, state, and federal authorities. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Construction of a Road to Noatak	Y	Selected for evaluation. Action is possible development of a roadway up to 35 miles long linking the village of Noatak to the DMTS road. A road is being considered and a possible route has been identified. No funding has been committed to developing specific plans, although the road is identified as the top priority in Noatak's *Top Ten Capital Project Priorities 2006 – 2011*. Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics

Action	Relevant for this evaluation?	Basis of Selection for this evaluation (Refer to Table 3.19-1 for descriptions of criteria)	Resources Potentially Affected
Expansion of the Noatak Airport	Y	Selected for this cumulative effects evaluation. Applicable selection criteria include: 1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17.	Air Quality, Water Resources, Vegetation, Wetlands, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Cultural Resources, Transportation, Noise, Socioeconomics
Kobuk-Seward Resource Management Plan	N	Not selected for evaluation. Plan provides a framework and vision for management of recreation, subsistence, minerals, access and travel on the nearly 12 million acres of BLM-administered land in this region. No projects are identified for implementation that would involve the Red Dog area.	N/A
Global Climate Change	Y	Selected for this cumulative effects evaluation. Applicable selection criteria include: 2, 3, 9, 10, 11, 12, 13, and 17.	International and global importance, Air Quality, Geotechnical Stability, Wildlife, Aquatic Resources, Land Use and Recreation, Subsistence, Public Health, Socioeconomics

3.19.2 Descriptions of Selected Relevant Actions

3.19.2.1 Natural Gas Exploration at Red Dog

Teck is developing wells that will be used to explore and characterize natural gas reserves in the Red Dog Mine area in hopes of finding producible quantities to supplement (and eventually replace) the diesel fuel presently being used to generate electricity for the mining operation. Some exploration activities have already been initiated, and more are planned. Activities include access road, drill pad, and test well construction, and quality testing and characterization of the product. Sites for exploration may include those both within and outside the Wulik drainage basin.

3.19.2.2 Red Dog Qanaiyaq Deposit

The Qanaiyaq Deposit is located south of the Main Deposit, immediately east of the existing waste rock dump. Activities conducted to date at the site include access road and drill pad construction, exploration drilling, and bulk sampling. Although the metallurgy and geochemical properties of the Qanaiyaq Deposit would require additional characterization prior to its development, the indicated resource for the deposit is approximately 5 million tons of ore, which includes about 24 percent zinc and 6 percent lead. It is likely that Teck would mine the Qanaiyaq Deposit concurrently with the Aqqaluk Deposit, between 2016 and 2025. The existing waste rock dump would have adequate capacity to handle the approximately 14 million tons of waste rock that would be generated, and the tailings impoundment would have adequate capacity for the additional tailings generated. Surface water runoff from the Qanaiyaq Deposit has been and will continue to be collected by the existing Red Dog Mine water collection system. Although not yet fully characterized, the geochemical properties of the Qanaiyaq waste material are not expected to be substantially different from that generated in developing the Main and Aqqaluk pits.

3.19.2.3 Paalaaq and Anarraaq Deposits

Paalaaq and Anarraaq are potential underground resources located north of the present Red Dog Mine operations. The planned action is the exploration and possible metallurgical and geochemical characterization of these deposits. The Paalaaq Deposit is located near the existing Aqqaluk Pit, and the Anarraaq Deposit is located about 15 miles northwest of the present mine.

Planned activities involved in the exploration action would include construction of access roads and drill pads, exploration drilling, and bulk sampling. The Paalaaq Deposit could be accessed by existing access roads, while access to the Anarraaq Deposit would need to be by helicopter. The number of helicopter trips necessary to support exploration activities can not be projected at this time. Metallurgical and geochemical characterization of the deposits may be performed at a later time.

3.19.2.4 Red Dog Mine Tailings Wastewater Pipeline

Based on the consent decree in Adams v. Teck Cominco Alaska, Inc. (now Teck), Teck is obligated to install a wastewater pipeline to the Chukchi Sea. After reissuance of the current NPDES permit under consideration in this SEIS, Teck would make an application to EPA for modifying their NPDES permit to change the wastewater discharge outfall location from Red Dog Creek to the Chukchi Sea at the DMTS port. With this planned project, wastewater from Treatment Plant 002 would flow by gravity via a 52-mile pipeline incorporated into the DMTS road to an outfall at the port. The pipeline would be buried in a bench incorporated into the DMTS road. The pipeline under consideration is the same as included as an element of alternatives C and D throughout the analysis (see Section 2.2, Overview of Project Alternatives).

3.19.2.5 Lik and Su Deposits

The Lik Deposit is located about 12 miles west-northwest of the Red Dog Deposit, and is currently under exploration. Recent metallurgical results for the 26.7 million-ton deposit indicate the deposit is composed of about 9 percent zinc, 3 percent lead, and 1.5 ounce/ton silver. Teck is a 50 percent partner in the joint venture with Zazu Metals Corporation, which has an exclusive right to obtain 80 percent of the property. The adjacent Su Deposit is 100 percent controlled by Teck, where initial phases of exploration were conducted in the 1980s. The deposit likely contains 38 million tons of ore composed of about 8 percent zinc, 2 percent lead, and 1 ounce/ton silver. Activities involved in exploration would include construction of access roads and drill pads, exploration drilling, bulk sampling, and metallurgical and geochemical characterization of the deposits. The sites are currently accessed by helicopter.

3.19.2.6 DMTS Navigation Improvements

Navigation improvements at the port site are being considered by NANA to reduce the costs of transporting fuel used in northwest Alaska and loading concentrates from the Red Dog Mine. The port site is an industrial port located in the NWAB, about 80 miles north of Kotzebue on the southeastern coast of the Chukchi Sea. Several alternatives to meet project objectives were initially considered, and a Trestle-Channel Alternative is the recommended plan. The Trestle-Channel Alternative would construct a 1,400-foot long trestle from the shore to a new offshore loading platform, and a 18,000-foot channel from the loading platform to the 50-foot mean-lower-low-water depth contour that would allow navigation by bulk freighters and tanker ships. About 3.5 acres would be disturbed in this area. The proposed project would increase ore concentrate loading efficiency, and allow direct offloading of fuel from tanker ships rather than from the barges used currently.

3.19.2.7 Kivalina Relocation

The village of Kivalina plans to move to a new site in the foreseeable future. The current village encompasses approximately 25 acres and has a 3,000-foot gravel runway. The preferred site is about a mile south of the present community location. The relocation would require construction of an entirely new site built on imported fill that would raise it above the existing flood and erosion threat that has become exacerbated by global climate change. The higher elevation and more stable ground would allow for the use of standard arctic construction techniques. Early estimates indicate that about four million cubic yards of fill would be required. The existing town site would be demolished and the debris disposed of in accordance with local, state, and federal regulations. The land would be allowed to revert back to natural conditions, which may include the eventual erosion and/or encroachment by the sea.

3.19.2.8 Noatak Airport Upgrade

The Noatak airstrip is being threatened by erosion and is in a location that limits community growth. The 4,000-foot airstrip and associated facilities are likely to be relocated farther from the Noatak River in the foreseeable future, and be modified to handle heavier aircraft (e.g., airline turbojets) to better serve the growing needs of Noatak and the surrounding region. The new airport at Noatak might be expected to cover about 50 acres, and have a lengthened runway, wider aprons and taxiway, and expanded outbuildings. Most air traffic in the foreseeable future would continue to be single-engine and light twin-engine aircraft, with occasional large jet traffic when the Red Dog Mine airstrip was closed or was below meteorological minimums. In the more distant future, if a road connection to the DMTS was implemented, the new airport could serve as an alternate to the existing Red Dog Mine airport.

3.19.2.9 Road to Noatak

At present, goods, fuel, and materials are provided to Noatak via air cargo or overland via snow machine during winter months. The village was formerly served by a river barge in the Noatak River; however, erosion and changes to the channel have eliminated barge access. The village has expressed a desire to have a 35-mile road connect the DMTS road and Noatak. Alternative routes are being considered by the Alaska Department of Transportation and Public Facilities (ADOTPF 2004). One route would bypass Cape Krusenstern National Monument and avoid any major river and stream crossings, although any of the routes would cross through mainly undisturbed habitat, and would require some wetlands to be filled as part of construction. About 120 acres of land would be disturbed along the 35-mile route, assuming a 30-foot right-of-way. With the proposed road, residents of Noatak would have reliable land access to the DMTS port, which could be used along with air transport to supply fuel and other goods to the village. No funding has been committed to this potential road project, although at the local level Noatak has identified this road as a Capital Project Priority (Noatak 2006).

3.19.2.10 Global Climate Change

Climate change refers to large scale changes in temperatures and precipitation patterns over time, resulting from natural variability and/or human activity. While climate change is not a project in the traditional sense of a cumulative effects analysis, it has been included in this evaluation because it is an existing and ongoing condition that is likely to affect the proposed action and may cumulatively affect aspects of the proposed action, alternatives, and the other projects under evaluation.

Human activities, such as the burning of fossil fuels, are increasing the levels of greenhouse gases in the atmosphere including carbon dioxide and methane (EPA 2008b). The combined “radiative forcing” associated with these increased concentrations is changing the balance between the radiation coming into the atmosphere and the radiation going out, resulting in a net warming of the Earth (Solomon et al. 2007; United Nations Environment Programme 2008).

Direct evidence of climate change has been documented by the International Panel on Climate Change (Solomon et al. 2007). Impacts of climate change are experienced more intensely in the arctic region. These changes include increases in precipitation, and a shift in the type of precipitation from snow to rain (Hassol 2004). Arctic temperatures on average have increased at almost twice the global average rate, with greatest warming occurring over land and at high northern latitudes. As a result, glaciers, snow cover, and arctic sea ice have declined, which has contributed to a steady rise in sea level. Permafrost in many arctic areas is exhibiting increases in thaw depths, and longer thaw periods annually.

In the arctic regions, sea ice is projected to continue to shrink, and the behavior of sea and shore-fast ice to change. Snow cover is projected to continue to contract, and increased thawing of permafrost in many regions is also projected to continue.

3.19.3 Cumulative Effects – Environmental Consequences

The above-described actions, which are reasonably foreseeable to occur in or affect the general vicinity of Red Dog, have been selected for this cumulative effects evaluation. The actions comprise primarily two types of activities: (1) exploration of both hard rock mineral deposits (Paalaaq, Anarraaq, Su, and Lik) and natural gas, and mineral production (Qanaiyaq Deposit); and (2) development and operation of expanded or new facilities and infrastructure (DMTS port navigation improvements, Noatak road, Noatak airport upgrade, and the Kivalina relocation). The effects of global climate change are also considered.

The potential cumulative effects of the proposed action, when considered together with these past, present and reasonably foreseeable actions (relevant actions), are discussed below. They are arranged by the environmental resource areas evaluated in the previous sections of this SEIS. The cumulative effects of the proposed action and these relevant actions on the phenomenon of global climate change are also included in this discussion. However, it must be noted that it is very difficult to quantify how climate change may affect or be affected by the resources identified below, and therefore, these discussions are qualitative.

Air Quality

Short-term cumulative adverse effects on air quality could result from construction of exploration drill pads and roads, transportation and stockpiling of mining products, and during construction associated with relevant actions. Effects from emissions, including greenhouse gases, could occur from stationary and mobile combustion engines. Fugitive dust would be generated during construction of facilities, as well as during project operations, including travel along the DMTS road, as part of the proposed action, and the Noatak road.

Most mobile sources of emissions (e.g., pad construction) associated with exploration would be of limited duration, although diesel emissions from drilling operations may occur intermittently throughout the year. In these cases, the emission sources would be limited to a small number of engines at each location. Information available on the Qanaiyaq Deposit indicates that it would be developed at some point during the mining of the Aqqaluk Deposit and is not anticipated to increase production levels. Qanaiyaq, therefore, would only indirectly cumulatively contribute to any potential future releases of transportation related fugitive dust or concentrate that could occur. Development of the Qanaiyaq Pit would occur over a period of years and would serve as a source for fugitive dust, which would overlap in time and location with activities associated with the proposed action. While the additional dust generated would be of a cumulative nature, the mine’s air permits would continue to require that all emissions levels meet NAAQS at the mine’s industrial boundary.

Construction activities associated with the Noatak airport upgrade, the Noatak road, the wastewater pipeline, the DMTS port, and the Kivalina relocation site would be of longer duration, lasting perhaps a season. Construction activities would overlap in time with the proposed action, although individual projects may not overlap with each other. The spatial overlap with the proposed action would be limited for the Noatak road and non-existent for the Noatak airport. The Kivalina relocation could occur at the same time and within the same airshed as construction of the wastewater pipeline and the proposed action. Use of the DMTS road and Noatak road would overlap during the snow-free months since it is unlikely that the Noatak road would be maintained in the winter. Where the areas overlap, the cumulative effect of fugitive dust would be slightly greater levels of dust present on vegetation and in surface water compared to the proposed action alone. Only the dust associated with the DMTS road and concentrate would be likely to contain elevated metals concentrations. The potential cumulative effects of accumulations of fugitive dust on or metals taken in by vegetation and other biota along the DMTS road are discussed later in this section under Vegetation, Wildlife, Subsistence, and Public Health.

Because combustion of fossil fuels produce emission byproducts that include greenhouse gases, it is expected that the proposed action and the other relevant projects would contribute incrementally to global climate change. The magnitude of greenhouse gas emissions associated with any one of the relevant projects is inconsequential compared to that of the proposed action. On a global scale, even the emissions from the proposed action are minimal (0.0027 percent of annual U.S. carbon emissions). Because the magnitude of the emissions associated with these projects is minor, and their sources are intermittent and fairly dispersed, these contributions are anticipated to result in less than significant cumulative effects on global climate change.

Mining and construction activities would be regulated under air permits issued by ADEC, and all other stationary and mobile emissions would be regulated according to Alaska and federal regulations. Existing air quality in the airshed associated with these past, present, and reasonably foreseeable projects is expected to remain within NAAQS. Therefore, it is anticipated that potential cumulative effects on air quality, based on the incremental effects of the existing and relevant projects considered in this cumulative effects evaluation, would be less than significant.

Geochemistry

Among the past, present, and reasonably foreseeable actions being evaluated, it is anticipated that potential geochemical effects would be limited to those relevant actions involving mining (only the Aqqaluk Extension and Qanaiyaq). Changes in rates of reaction and production of acid rock drainage are not expected to change substantially if temperatures were to rise as a result of global climate change. Sicne there are currently no plans to mine the deposits that are under exploration, the geochemistry cumulative impacts of mining these deposits are not considered.

The two relevant actions would occur within the same drainage basin (Wulik River); therefore, adverse cumulative effects on water quality in the Wulik drainage are possible. Because wastewater from the combined mining operation would be treated before release, and the discharge quality would be governed by applicable permits, the potential cumulative effects on geochemistry are expected to be less than significant. The geochemical contribution of the metals in fugitive dust would not change in terms of proportions since mining, processing, and transportation of the Qanaiyaq Deposit would occur within the operational lifespan of the Aqqaluk Deposit and at levels consistent with existing operations. The rate of aerial deposition of metals associated with fugitive dust would be less than that which has occurred as a result of previous operations because of the improvements in dust control measures that have been implemented over the life of the existing operation. Data are unavailable to determine the current rate of deposition. Based on existing conditions and data presented in Teck’s DMTS risk assessment, cumulative changes in the geochemical environment are not expected to be significant.

Geotechnical Stability

Potential cumulative effects on geological resources such as geotechnical stability would be limited to the proposed action and mining of the Qanaiyaq Deposit. While development of the Qanaiyaq Deposit in the vicinity of the Aqqaluk Deposit would increase the amount of tailings in the impoundment and waste rock in the backfilled Main Pit, these facilities have adequate capacity to accommodate the additional material without expanding beyond boundaries considered in the analysis of the proposed action. Also, this material would not cumulatively alter the geotechnical stability of any of the waste disposal facilities over the project life or beyond.

Changes to (or loss of) permafrost in the region as a result of global climate change could adversely affect the stability of any of the past, present, or reasonably foreseeable projects under consideration. The continued use of the DMTS (with or without navigation improvements, construction of the Noatak road, and the Kivalina relocation) could all be subject to differential settling with changes in permafrost conditions. It is anticipated that the condition of permafrost would be assessed and monitored for each project site and adequately addressed through appropriate engineering controls at the time the projects were implemented. None of the effects associated with any of the other relevant actions would produce cumulative effects since there would be no interdependence between these actions and the proposed project in terms of geotechnical stability.

Water Resources

Past and present actions related to the Red Dog Mine operations, the proposed action, exploration of hard rock and natural gas deposits, development of the Qanaiyaq Deposit, and the Kivalina relocation could all occur within the Wulik River drainage and could overlap in time. Thus, these projects could potentially produce adverse cumulative effects on fresh water quality. Cumulative adverse effects on marine water could occur as a result of the DMTS port improvements, along with the past and present use of the DMTS port, the proposed action, and the marine outfall for the wastewater discharge pipeline. Cumulative impacts to surface waters in the Noatak River drainage could occur from sediment and runoff from the Noatak road and Noatak airport improvements; however, these effects would not overlap in either time or space with the proposed action or past and present operations at the Red Dog Mine.

Global climate change resulting in increased permafrost melting could contribute to greater surface water and groundwater volume, and affect water quality and quantity in the vicinity of the planned projects. While climate-related changes in surface water and groundwater characteristics could produce significant changes to structure (e.g., bed and bank) and behavior (e.g. flood period and duration) of streams and rivers in the area, none of the past, present, or reasonably foreseeable projects are expected to contribute to additional changes to regional water resources because any effects from these projects on water resources would be highly localized.

The planned exploration activities would involve a relatively low level of activity that would have minimal effect on water quality. The combined mining of the Aqqaluk and Qanaiyaq deposits could potentially have adverse cumulative effects on the water quality in the Wulik River drainage. However, because wastewater from the mining operations would be treated, and the discharge quality would be governed by applicable permits, the potential cumulative effects on water quality are anticipated to be less than significant. Construction of the DMTS port navigation improvements and installation of the marine outfall for the wastewater discharge pipeline could result in the localized generation of sediment and increases in turbidity, which would be short term; best management practices would be expected to minimize impacts. The water quality of the marine outfall for the mine tailings wastewater would be required meet NPDES limits thereby limiting the extent to which it would contribute to cumulative effects in the near-shore waters of the Chukchi Sea. Therefore, the cumulative effects on water quality from the past, present, and reasonably foreseeable projects under evaluation are considered to be less than significant.

Vegetation

Direct cumulative effects on vegetation (loss of vegetation) in the vicinity of the proposed action would occur primarily from: (1) the past and present disturbance associated with construction and operation of the Red Dog Mine and DMTS; (2) development of the Qanaiyaq Deposit; (3) construction of the wastewater discharge pipeline; and (4) construction of the Noatak road. Wells for exploration for natural gas have been developed and will remain, for at least the immediate future, adjacent to the Aqqaluk Deposit; this disturbance is relatively small (approximately 11.8 acres) but contributes to the cumulative acres of vegetation impacted. Other exploration activities are and would be discontinuous with the other actions, although they could overlap in timing with some of the other relevant actions; the extent of impacts would be limited, localized, and short term. Existing disturbances at the site include the DMTS account for approximately 2,100 acres. The wastewater discharge pipeline would be built in a bench incorporated into the existing DMTS road. The increase in disturbed acreage within the road right-of-way would be approximately 145 acres in addition to the approximately 413 acres that would be disturbed under the proposed action. Development of the Qanaiyaq Deposit would disturb an additional 36 acres, although this area is not well vegetated. The extent of disturbance from construction of the Noatak road cannot be determined at this time because the route is unknown. However, each of these projects would overlap in time and space until the mining operation was completed and the operational areas of the mine reclaimed. Improvements to the Noatak airport and the Kivalina relocation may also result in vegetation loss, but effects from these projects would be more localized and would not overlap in location with the other projects. The loss of vegetation represents a reduction in wildlife habitat and more area subject to erosion from runoff and snowmelt; erosion is typically controlled through best management practices, ditches, and settling ponds.

Indirect cumulative effects on vegetation would occur from fugitive dust that has already been deposited along the DMTS road, in addition to continued operations under the proposed action and the construction and use of the Noatak road. Such dust associated with the DMTS road could also contain metals that have already had an effect on species composition and cover in the vicinity of the DMTS. Future deposition would continue but at a lesser rate than that which occurred prior to Teck implementing the dust control measures discussed in Section 3.2.2.2. However, cumulative effects could result in additional changes in species composition and changes in plant cover in the affected areas. Changes are, and could continue to be, noticeable on a localized basis within the road corridor. Climate change could have a larger effect on the distribution of vegetation communities in the vicinity of the proposed action because of changes in the hydrologic patterns within the landscape, and the climatic regime itself. One example of climate-based changes in vegetation communities would be for trees (currently absent from the landscape) to extend into areas currently covered by tundra species. These changes would occur over the longer term and, in and of themselves, may not be detrimental to the sustainability of the landscape or habitat value.

The extent to which the effects would be significant depends on the effect of the change in vegetation communities across the landscape; for example, maintaining ecologically intact plant communities is of greater importance within Cape Krusenstern National Monument than in areas outside the monument. The degree to which fugitive dust related effects lessen or increase in the future will reflect the success achieved by Teck’s dust control measures. The appearance of effects from past and present operations have taken a period of time to manifest themselves; likewise, improvements in the dust control measures will take time to show a corresponding improvement on the ground. The draft fugitive dust risk management plan includes monitoring measures for vegetation that could be used to determine long-term trends. Neither EPA nor the Corps has the authority under their respective permitting authority to require dust control measures that may be necessary to avoid cumulative effects from future activities.

Wetlands

Direct cumulative effects on wetlands (i.e., loss of wetlands) would occur primarily from (1) the past and present disturbance associated with construction and operation of the Red Dog Mine and DMTS; (2) portions of the roads and pads associated with natural gas exploration; (3) construction of the wastewater discharge pipeline; and (4) construction of the Noatak road. These projects could overlap in both time and space and thus result in cumulative impacts. Improvements to the Noatak airport and the Kivalina relocation could also result in loss of wetlands, and effects from these projects could occur within the same time frame as the others, but would be localized. Wetlands are not prevalent in the area that would be developed for mining the Qanaiyaq Deposit.

As noted above, these construction activities would produce a direct loss of wetlands as a result of fill, but could also cause localized changes in drainage patterns that could result in changes to wetland community composition in areas immediately upstream and downstream from construction. Changes in community composition could produce changes in the functional values of wetlands, including habitat. Climate change over the long term could also cause shifts in community composition and functional values of wetlands, although over a much broader scale than changes caused by construction-related activities. These may or may not compound the localized effects created by construction related impacts.

Indirect cumulative effects on wetlands would occur from fugitive dust generated from continued use of the road for transporting concentrate from mining the Aqqaluk and Qanaiyaq deposits, and traffic generated along the Noatak road. These effects would be cumulative over time and could result in reduced productivity and changes in community composition similar to the changes observed along the DMTS road. These effects along the Noatak road would likely be much less than along the DMTS road since the dust would not contain high concentrations of metals, and much less traffic would travel on the Noatak road. While the direct and indirect effects of past, present, and reasonably foreseeable actions have affected wetlands and could continue to affect wetlands, project related losses are not anticipated to be significant in terms of wetland function and value. Changes in the appearance of wetland communities as a result of long-term climate change could be significant; however, it is unclear whether the effect of those changes would be adverse.

Wildlife

Similar to vegetation and wetlands, direct and indirect cumulative effects on wildlife would occur primarily from (1) the past and present disturbance associated with construction and operation of the Red Dog Mine and DMTS; (2) roads and pads associated with natural gas exploration; (3) construction of the wastewater discharge pipeline; and (4) construction and operation of the Noatak road. Habitat loss resulting from the development of the Qanaiyaq Deposit would not contribute substantially since the area already has low habitat value and is immediately adjacent to existing operations. Types of direct effects would include habitat loss, short-term disruption of foraging and nesting activities, longer term disruption of migration patterns, and wildlife mortality from vehicle collisions. Improvements to the Noatak airport and the Kivalina relocation could also result in loss of habitat and short-term disruption of normal activities, but effects from these projects would be localized. Climate change over the long term could cause a shift in the types of habitats, which could also contribute to changes in wildlife migration patterns.

The incorporation of the wastewater pipeline into a bench in the DMTS road would remove a minor amount of additional habitat but, outside of the construction period, would have no additional effect on wildlife use patterns that may have already been altered as a result of past and present activities. Migration patterns of some species may also be further incrementally disrupted by the presence and use of the new Noatak road combined with use of the DMTS. However, the Noatak road would carry much less traffic that the DMTS road. Indirect effects could include bioaccumulation of metals in animal tissue from ingesting or inhaling fugitive dust generated along the DMTS road from past and present operations, as well as from future use of the road for transporting concentrate from the Aqqaluk and Qanaiyaq deposits. Teck's DMTS risk assessment, discussed in Section 3.9, concluded that exposure to metals did not present elevated risks to most wildlife species. Small mammals and ptarmigan in the immediate vicinity of the DMTS may continue to experience elevated risks from exposure; however, the effect is not expected to be significant to populations in the region.

The cumulative amount of wildlife habitat lost to the development of the projects under consideration is a small fraction of the overall habitat that is regionally available in the vicinity of the reasonably foreseeable actions. The migratory pattern of caribou is highly variable from year to year and the distribution varies on a localized basis. Therefore, it is possible that use of the roads could cause greater effects in some years than in others, depending on the season and the intensity of use in the area.

However, the cumulative effects on wildlife from the past, present, and reasonably forseeable projects under evaluation are expected to be less than significant.

Aquatic Resources

Mining operations and the wastewater discharge outfall located in Red Dog Creek under past and present actions has resulted in changes to the water quality in Red Dog Creek. The change in water quality has allowed aquatic life to expand into sections of the creek that had been devoid of life in pre-mining conditions. Potential adverse cumulative effects on fresh water aquatic resources (fish and benthic invertebrates) could occur within the Wulik River drainage from exploration activities in combination with the proposed action and mining of the Qanaiyaq Deposit. Short-term effects on aquatic resources could include increased turbidity, increased sediment generated, temporary physical disruption of habitats during construction, and possible spills of contaminants from the relevant actions.

The ongoing and future exploration activities would involve a relatively low level of activity with corresponding limited opportunity to contribute sediments or other discharges to the local drainages. Therefore, they would be expected to have minimal incremental effect on aquatic resources in the Wulik River drainage. The combined mining of the Aqqaluk and Qanaiyaq deposits would, on the other hand, have greater potential to create adverse cumulative effects on the aquatic resources in the drainage through increased sediment loading and wastewater discharges.

Sediment would be controlled with best management practices identified within the storm water management plan (part of the NPDES permit requirements). Wastewater from the combined mining operations would be treated and the discharge quality controlled by applicable permits. Therefore the potential cumulative effects on aquatic resources from the planned mining are expected to be less than significant. The relocation of the wastewater outfall from Red Dog Creek to the Chukchi Sea would also contribute adverse effects to aquatic resources in the Wulik River drainage, although the impacts would primarily be limited to Red Dog Creek itself. Long-term effects would include a loss of habitat from changes to water quality or physical changes such as sedimentation in spawning gravels.

Cumulative aquatic resources effects associated with construction of the Noatak road and Noatak airport improvements would, for the most part, occur within the Noatak River drainage and, therefore, not overlap with the proposed action or past and present actions. The amount of sediment input from the Noatak road within the portion of the Omikvorok River that overlaps with the DMTS road would be minimal. The Kivalina relocation would presumably occur within the Wulik River drainage but the effects would be localized and at a location well removed from the portion of the river where its contributions would be considered cumulative.

Global climate change resulting in a loss of permafrost could contribute to greater surface water and groundwater volumes, and indirectly affect aquatic resources in the vicinity of the relevant projects through changes in water temperature, chemistry, and flow regimes. The effects of such changes cannot be determined at this time, because climate change prediction data are not accurate enough to predict localized impacts.

Cumulative adverse effects on marine aquatic resources could occur at the DMTS port from past and present actions related to the concentrate transfer, as well as future activities associated with the proposed action, navigation improvements for the DMTS port, and operation and construction of the marine wastewater discharge pipeline outfall. Cumulative effects would primarily occur as short-term increases in sediments and turbidity during construction activities. Best management practices (e.g., sediment control) required through Section 10 permits would limit construction effects. Since construction of the pipeline and port improvements would take place sequentially rather than concurrently, wave action and currents would serve to reduce turbidity quickly after construction and prevent an accumulation of fine materials in the immediate vicinity of the port facilities. The marine discharge of wastewater would need to meet NPDES permit limits and require a mixing zone of less than 10 cubic feet, therefore limiting the area affected by the outfall. Spills either from concentrate loading operations, supply unloading or fuel transfers, could cause significant localized effects to marine aquatic resources over the short term until the spill is cleaned up. Overall, cumulative effects are not anticipated to produce significant adverse impacts to aquatic resources within the Wulik River drainage or in the shallow waters within the Chukchi Sea. As discussed in detail in Section 3.10.3.4, moving the location of the outfall from Red Dog Creek to the Chukchi Sea could have an adverse effect on aquatic resources within a segment of Red Dog Creek.

Land Use and Recreation

Sources of potential adverse cumulative effects on land use and recreation include primarily: (1) past and present actions related to Red Dog Mine and DMTS operations; (2) the proposed action; (3) planned exploration activities at Red Dog (natural gas), and at the Su, Lik, and Anarraaq deposits; (4) mining of the Qanaiyaq deposit; (5) development of the Noatak road; and (6) the Kivalina relocation. Past and present actions related to Red Dog Mine operations have had an effect on remote recreation because they represent an industrial activity in a location that could overlap with users expecting a wilderness experience, particularly within Cape Krusenstern National Monument and in the upper Wulik River drainage. The proposed action and relevant projects could contribute to this effect, compounding it specifically because of the dispersed nature of the activities, including helicopter flights and heavy equipment operations. Adverse cumulative effects on remote recreational users could continue for the duration of the activities. Also, the construction period for the Noatak road and the Kivalina relocation could have a similar effect, and the road itself and new Kivalina community would constitute a change in land use from the undeveloped tundra and upland areas that presently exist. However, the presence of the Noatak road might also promote recreation in the area.

The wastewater pipeline would be built as part of the existing DMTS road, and within the existing developed footprint at the port. Therefore, this planned project would not result in a change of land use and would have limited cumulative effect compared to past and present actions, in terms of recreation. The improvements at the Noatak airport would likewise not result in significant land use or recreational changes.

Changes to (or loss of) permafrost in the region as a result of global climate change could adversely affect the suitability of land for certain future land uses, including building and recreation. It is anticipated that the condition of permafrost would be assessed and monitored as future project or recreation sites were identified, and adequately addressed through appropriate engineering controls at the time projects were implemented. Cumulative effects on land use and recreation from past, present, or reasonably foreseeable projects and from global climate change are anticipated to be less than significant.

Subsistence

The cumulative effects study area for subsistence includes the villages of Kivalina and Noatak and their customary subsistence use areas. As discussed in Section 3.12, past and present transportation related mining activities have had some effect on subsistence resources including localized changes in the behavior of both caribou and beluga, and locations for berry harvesting. The proposed action, DMTS port navigation improvements, wastewater pipeline, Noatak road, and Kivalina relocation are reasonably foreseeable actions, in addition to global climate change, that could have incremental cumulative effects on subsistence resources.

Transportation related activities associated with the proposed action are likely to extend the effects, similar to those that currently exist, through the duration of the operation. The proposed DMTS port navigation improvements and facilities associated with the wastewater pipeline outfall could have adverse effects on the subsistence harvest of beluga whales for hunters in Kivalina, although these effects would not apply to subsistence hunters in Noatak. The timing of these construction operations could be governed through Section 10 permits to avoid the subsistence harvest seasons, thus minimizing impacts. The presence of a larger port facility may increase the displacement of belugas from the shoreline although the degree to which this change could occur compared to the existing situation cannot be determined. Operation of the marine outfall (wastewater pipeline) under the NPDES permitting program is not anticipated to contribute to subsistence effects, although it is possible that a perception of contamination of subsistence resources in the vicinity of the outfall could occur. The installation of the mine wastewater pipeline and the continued operation of the DMTS road would incrementally extend the localized adverse effects for subsistence hunters that have already been observed for caribou (see Section 3.12.2). The presence of the Noatak road could have a further incremental adverse effect on caribou migration, although it could also facilitate access to hunting in different areas via four-wheelers.

Global climate change could affect the behavior and distribution of subsistence resources by altering the presence and patterns of sea ice and permafrost, causing changes in the distribution of surface water and groundwater, vegetation, and habitat. The importance of sea ice to the subsistence lifestyle in the Kivalina area means that climate change could bring significant changes to subsistence activities in the region over the long term.

The relocation of Kivalina could result in some changes in subsistence patterns by altering access to resources at different times of the year compared to its current location. These changes could be positive or negative (or both) but are unlikely to contribute incrementally with other projects. Mining activity associated with the proposed action and Qanaiyaq Deposit, as well as the exploration activities, are not anticipated to affect subsistence resources since they are generally removed from subsistence use areas. The planned improvements at the Noatak airport would not result in cumulative impacts to subsistence resources since the construction activities would be of short duration and local to Noatak. Mitigation measures identified earlier in this SEIS could alleviate some of the potential cumulative effects on subsistence resources identified above. Therefore, while moderate-level cumulative effects on certain subsistence resources are anticipated (e.g., beluga, caribou), the overall cumulative effects from projects on subsistence resources are not expected to be significant. Global climate change, regardless of the other projects, could result in significant adverse effects on subsistence if it were to cause dramatic changes in sea ice behavior and wildlife habitat.

Public Health

Potential cumulative adverse effects on public health could occur as a result of past and present mining operations combined with the proposed action, development of the Qanaiyaq Deposit, DMTS port improvements, and construction of the Noatak road and wastewater discharge pipeline. The principal pathway for cumulative health effects is through emission of fugitive dust during transportation and stockpiling of ore and waste rock, and construction of most of the relevant actions. The draft fugitive dust risk management plan would be in effect for the proposed action to identify and reduce concerns that have resulted from past and present actions. The draft fugitive dust risk management plan did not identify health concerns related to the existing contaminants in the environment; the draft fugitive dust risk management plan is intended to monitor, identify, and if necessary, respond to future concerns that may be identified. Therefore, while the proposed action would represent a cumulative contribution to the fugitive dust that has been deposited as a result of past and present activity, the dust is not expected to contribute to adverse health effects. While the positive effect of subsistence foods on health is understood, the relationship between harvest levels, diet, and health are not. The proposed action and the Noatak road could contribute cumulatively over time and space to effects on caribou harvest when combined with past and present actions. Likewise continued operation of the DMTS port under the proposed action and DMTS port improvements could combine with past and present activities and contribute cumulatively over time to affect the presence of beluga in the vicinity of the port. Changes in the subsistence harvest of caribou and/or beluga cannot be directly linked to adverse health effects, although some indirect effects on health could potentially occur.

Stationary and mobile emissions from many of the actions would also occur; however, the distributed nature of those sources and the distance between them and the villages would make it unlikely that they would contribute cumulatively to adverse health effects. Removing the existing outfall from Red Dog Creek with the wastewater discharge pipeline would result in water quality changes within the creek; the changes would be imperceptible at the intake for Kivalina's water system downstream and thus would not contribute to cumulative effects.

The improvement in sanitary conditions that would accompany the Kivalina relocation would provide a dramatic improvement in the health of residents. DMTS port improvements combined with the Noatak road could potentially affect the health of Noatak residents if the combination allowed for the easier delivery for a wider range of food products; whether the effect on health was beneficial or adverse would depend on the nature of the food. Kivalina could also potentially take similar advantage of port shipments if reliable access between the village and the port could be established. Other benefits to health could come in the form of improved socioeconomic benefits that may be garnered through construction aspects of the other relevant projects, although these benefits would be short term. Overall, none of the past, present, or reasonably foreseeable projects, in conjunction with the proposed action, are expected to have significant cumulative effects on health.

Cultural Resources

Much of the area surrounding the project area is located with in the Cape Krusenstern National Historic Landmark and is likely to contain cultural resources. Impacts to cultural resources as a result of any of the activities under consideration could occur in the form of direct loss or destruction, or indirectly from a loss of context, where the history or significance of a piece is lost because it has been removed from its original setting. Future activities, including the proposed action, development of the Qanaiyaq Deposit, and construction of the wastewater discharge pipeline would all result in ground-disturbing activities that could, in turn, affect cultural resources. Since Teck would be responsible for each of these actions, they would be governed by the *Integrated Plan for the Management of Cultural Resources in the Red Dog Project Area*. Past and present actions have also been undertaken within the requirements of the plan.

Construction of the Noatak road, DMTS port improvements, the Kivalina relocation, and expansion of the Noatak airport would all require ground disturbance, and thus could have the potential to affect cultural resources. Each activity would be subject to investigation and consultation procedures prescribed under the Section 106 process of the NHPA. Prior to any planned disturbance at these project sites, the areas would be surveyed to determine the presence or absence of archaeological and historic evidence, and sites containing such evidence would be evaluated for listing on the NRHP. Eligible sites would either be avoided or would undergo data recovery and documentation under strict protocols. Coastal erosion, exacerbated by global climate change, also has the potential to adversely affect cultural properties. Effects caused by coastal erosion would not be mitigated.

The cumulative nature of the effects of these projects would be regional rather than local. Because projects would need to follow the Section 106 guidelines regarding the presence of cultural resources, effects from the development of any of the relevant projects under consideration would be minimized. Therefore, it is expected that potential cumulative effects on cultural resources would not be significant.

Transportation

Cumulative effects from past, present, and reasonably foreseeable projects would be primarily associated with the DMTS road and port. The proposed action and development of the Qanaiyaq Deposit would result in continued use of the road and port through 2031, the date initially considered for the length of the project under the 1984 EIS. Construction of the Noatak road could increase traffic on portions of the DMTS road, depending on the use. The increase in traffic would primarily be between the DMTS port and the Noatak road. Since the volume of traffic using the Noatak road is expected to be relatively minor, the effects on the local transportation system would be minimal. The use of the port would likewise continue through 2031. Improvements to the port could result in a higher level of traffic in and out of the port. Global warming could extend the shipping season, which would benefit the recipients of the shipped goods but has the potential to adversely affect marine resources. Improvement of the Noatak airport would provide access to larger aircraft and could increase the reliability and safety of air traffic in and out of the village. With the potential exception of the Noatak road, improvements to the Noatak airport would not contribute cumulatively to effects with the proposed action, or other past, present, or reasonably foreseeable projects in terms of affecting transportation. It is possible that the combination of the Noatak road and airport improvements could allow alternative access to the mine during the summer season if weather conditions precluded landings at the Red Dog airfield. The cumulative effect in that case would be additional traffic on the Noatak road and DMTS road between Noatak and the mine. This type of access would be limited in frequency and would represent only a small amount of traffic. Cumulative effects from the proposed action and past, present, and reasonably foreseeable future activities would not be significant.

Noise

Noise would be generated during construction and/or operation of all of the foreseeable actions considered in this cumulative effects evaluation except for global climate change. Sources of noise would include construction of facilities and new roads, as well as the use of both existing and new roadways during operation. Helicopters generate noise on an irregular basis in supporting exploration as well as past and present actions, and would be necessary under the proposed action. The actions with potential cumulative noise effects include: (1) ongoing past, present and future use and maintenance of the DMTS road; (2) construction and maintenance of the wastewater discharge pipeline; (3) construction, operation and maintenance of the navigation improvements for the DMTS port; (4) construction and maintenance of the Noatak road; (5) mining of the Qanaiyaq Deposit; (6) improvements to the Noatak airport; and (7) Kivalina relocation.

Exploration activities are widely dispersed and would generally not overlap with each other, past and present mining activities, or with the proposed action except for the very short-term linkages that could occur with helicopter flights. The proposed action in combination with past and present mining activity, as well as with the development of the Qanaiyaq Deposit, would extend the duration of noises associated with the project and the “noise boundaries” beyond the current limits of activity. Mining of Qanaiyaq and the proposed action would represent the greatest extent of cumulative effects at the mine site. Construction of the wastewater pipeline, if it happened to coincide with navigation improvements of the DMTS port, would represent the greatest extent of cumulative noise effects in the DMTS port area. Construction of the outfall at the DMTS port would be of short duration (a matter of weeks) while dredging and construction of the port facilities would extend for a longer time. Construction of the Noatak road could overlap with the proposed action and, potentially, with construction of the wastewater pipeline, although the duration when noise from each of these activities would occur cumulatively would be of short duration (less than a season). Noise associated with each of these activities could result in the localized displacement of wildlife (and potentially some marine aquatic resources at the DMTS port) for the duration of the noise-generating activities. Use of the Noatak road would be intermittent and the location would likely be such that noise from its use would not overlap with noise generated by any of the other projects. The Kivalina relocation could also generate noise during construction, but effects would be temporary, localized, and would not contribute cumulatively. Therefore, the cumulative noise effects from the past, present, and reasonably forseeable projects under evaluation are expected to be less than significant.

Socioeconomics

The proposed action would extend the past and present operations of the Red Dog Mine through 2031. Development of the Qanaiyaq Deposit during that same time frame as the proposed action would contribute to the socioeconomic benefit by maintaining current (or near-current) production levels through 2031. Production levels are reflected in employment at the mine and dividends paid to NANA shareholders. Navigation improvements to the DMTS port may improve economics for Red Dog operations, which, in turn, could have some additional socioeconomic benefit for NANA shareholders. Improvements at the DMTS port, or even continued operations of existing facilities, if done along with the Noatak road, could also provide socioeconomic benefit to Noatak. The residents of Noatak could benefit from the Noatak road because access to the port could decrease the costs of some materials and goods that are currently delivered by air. Kivalina could potentially benefit from access to the port as well, if a reliable access was maintained. Relocation of Kivalina could provide some socioeconomic benefit to the village and NWAB by reducing the costs related to maintaining shoreline protection at the village. The costs of maintaining shoreline protection are compounded by changes experienced by global warming. Exploration activities would contribute minimally to socioeconomics on a cumulative basis. Construction of any of the projects could result in a short-term increase in jobs for residents of the NWAB although the multiplier for how those wages would flow through the borough would be less than for larger cities.

In terms of cumulative effects, residents of Noatak would receive the greatest cumulative benefit if all the relevant projects were to go forward, since there would be benefits of extending operations at Red Dog reflected in NANA shareholder dividends and employment opportunities, in addition to the reduction in the cost of living if the Noatak road was to result in an access point for goods shipped through the DMTS port. Kivalina residents could experience positive and adverse socioeconomic effects from the proposed action and relevant actions. Continued operations would provide the potential for employment opportunities for the duration of operations. However, depending on the distribution of caribou and beluga in the future, the costs associated with traveling to hunt these species could adversely affect Kivalina’s socioeconomics to the extent that the extra distance hunters would have to travel resulted from mine related operations. These costs would be similar to those already being incurred. While both positive and adverse socioeconomic effects are likely to occur if one or more projects were to be implemented, none of the socioeconomic effects are expected to be significant.

Environmental Justice

Cumulative effects on the NWAB in terms of environmental justice would primarily occur as a continuation of the effects of past and present actions under the proposed action. Disproportionate employment at the mine discussed in Section 3.18 is likely to continue throughout operations. Employment conditions at the mine and the economic structure of the NWAB are unlikely to undergo substantial changes in the future. The nature of the work at Red Dog (extended rotating shifts) is likely to remain one impediment to employment, particularly within a region where subsistence activities play an important role in everyday life. That is not to say that ongoing training programs supported by both Teck and NANA would not continue to improve opportunities for employment of local residents. A clearly articulated subsistence leave policy (as noted in Section 3.12.2.7) could also potentially contribute to making employment more attractive. Benefits to the community, in the form of NANA dividends and PILTs to NWAB, would continue for the duration of mining. Overall, effects of the proposed action considered with past and present actions would not result in significant disproportionate effects to an environmental justice community.

3.19.4 Cumulative Effects – Summary

Table 3.19-3 summarizes the findings of the cumulative effects analysis.

Table 3.19-3 Summary of Cumulative Effects by Resource Area

Resource	Impacts
Air Quality	Some incremental emissions increase from development of the proposed action and Qanaiyaq Deposit but would be required to meet NAAQS at facility boundary. Similarly, all other projects would be required to meet federal and Alaska air regulations. Construction of the wastewater pipeline, Noatak road, and airport expansion, and Kivalina re-location could add dust, but cumulative impacts would be short-term and minimized by dust control. Limited traffic on Noatak road would also have minimal cumulative effects. Global climate change impacts would be limited by low cumulative, project emissions when considered in the context of U.S.-wide emissions.
Geochemistry	No changes in discharge quality are anticipated from development of Qanaiyaq Deposit since water will be treated prior to discharge. Dust generation from mining Qanaiyaq would cause increased area and volume of disturbance at the mine site. Some incremental impacts in metals releases along the road, but lower than previous conditions because of dust control.
Geotechnical Stability	No cumulative geotechnical effects. Dam stability is assured through the State of Alaska's Dam Certification program. Recent design documents take into consideration the loss of permafrost due to natural and man-made conditions.
Water Resources	No cumulative effects on water resources, except from construction of the marine discharge pipeline. Any construction projects would include BMPs to minimize effects on water quality. Construction of the pipeline would lead to reduced flow and lower water quality, although it would be better than pre-mining conditions in Red Dog Creek (see Section 3.5).
Vegetation	Cumulative effects would be associated with past and present operation of the Red Dog Mine, the Proposed Action, natural gas exploration, global climate change, and the Noatak road. Construction of the water discharge pipeline would directly impact an additional 145 acres beyond the 413 acres associated with the proposed action. Other effects of exploration and natural gas development would be minor. Construction of the Noatak road and Kivalina relocation would have direct, cumulative impacts on vegetation, but the impacts would be localized. Dust from the Noatak road would indirectly cause impacts on vegetation. Global climate change could significantly change vegetative communities in the region over the long term.
Wetlands	All of the proposed projects could have impacts on wetlands, but effects would be limited in area and would be localized. Global climate change could have significant impacts on wetland communities in the region.
Wildlife	Future habitat loss associated with development of the proposed action and Qanaiyaq Deposit would be minor since the area is already disturbed. Losses associated with mineral exploration, natural gas development, the Noatak airport improvements, and Kivalina relocation would also be localized and minor. Construction of the Noatak road could have direct effects on caribou migration, although traffic would be less than on the DMTS road. Indirect cumulative effects from dust would also be limited and localized. Global climate change may have broad impacts on wildlife movement, habitat, and populations in the region.
Aquatic Resources	No cumulative effects on water resources, except from construction of the wastewater discharge pipeline. Construction of the pipeline would lead to reduced flow and water quality in Red Dog Creek, which could cause aquatic life impacts (see Section 3.9).

Resource	Impacts
Land Use/Recreation	Cumulative effects of all projects on land use and recreation are expected to be less than significant because of the remote nature of, and limited access to, the area.
Subsistence	DMTS port improvements and construction of the wastewater discharge pipeline could cause cumulative effects on Beluga whales, although construction could be timed to avoid critical periods. Kivalina relocation could affect subsistence patterns, but impacts are likely to be independent of other projects. The Noatak road could cause cumulative effects on caribou migration, although traffic would be limited. It may also provide improved access to hunting areas. Global climate change would likely have broad impacts on subsistence, including effects associated with changes in sea ice, vegetation, water resources and habitat.
Public Health	All of the projects that involve construction and development that create jobs could increase the positive health benefits associated with economic gains in the region. Construction related effects would, however, be short term. Construction of the wastewater discharge pipeline could alleviate the public health concerns of Kivalina residents related to perceived contamination of their drinking water supply. Increased dust from the Noatak road would not pose an additional risk. The road could further affect caribou movement and harvest, and resulting changes in subsistence may affect diet, and consequently, public health. DMTS improvements and construction of the wastewater pipeline might cause additional impacts on beluga whale migration and harvest, but they could be timed to avoid harvest periods.
Cultural Resources	No significant impacts to cultural resources. All projects would be subject to the requirements of the NHPA.
Transportation	The Noatak airport expansion and road could lead to improved access, although traffic on the road would be light. Improvements to the DMTS port may lead to additional ship traffic, and global climate change might lead to a longer open water season.
Noise	All of the proposed development activities would cause cumulative noise activities during construction and operation, but the effects would be localized and minor.
Socioeconomics	All of the projects that involve construction and development, and create jobs, could increase the positive health benefits associated with economic gain in the region. Construction related effects would, however, be short-term. Residents of Kivalina could benefit from the relocation, while the increased access to Noatak via the road and the airport expansion could provide cumulative economic benefits to residents. The cost of construction of the wastewater pipeline could reduce annual payments to NANA shareholders.
Environmental Justice	Construction of the wastewater discharge pipeline would address concerns voiced by Kivalina residents. Overall, there would be no cumulative environmental justice impacts.

3.20 Irretrievable and Irreversible Commitment of Resources

An irreversible commitment of resources applies primarily to the loss of non-renewable resources (e.g., minerals or cultural resources) and resources that are renewable only over a long period of time (e.g., soil productivity). Irretrievable commitments apply to loss of production or use of renewable resources. These opportunities are forgone for the period of the proposed action, during which the resource cannot be used. These decisions are reversible, but the utilization opportunities forgone are irretrievable. Table 3.20-1 presents the irreversible and irretrievable commitment of resources for development of the Aqqaluk Deposit.

Table 3.20-1 Irreversible and Irretrievable Resource Commitments

Resource	Alternative A	Alternative B	Alternative C	Alternative D
Air quality	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Geochemistry/ Geology	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Loss of 62 million tons of ore, 7.7 million tons of low grade ore, and 95 million tons of waste rock from the Aqqaluk Deposit.	Same as Alternative B.	Same as Alternative B.
Surface water hydrology	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Same as Alternative A.	Irretrievable stream flow reduction by 18 to 38 percent in Main Stem Red Dog Creek with marine discharge during operations.	Same as Alternative C, except that flow impacts on Red Dog Creek continue after closure.
Surface Water Quality	No foreseeable or predicted irreversible or irretrievable commitments beyond those previously evaluated.	Same as Alternative A.	Lower water quality in Main Stem Red Dog Creek with marine discharge to Chukchi Sea.	Same as Alternative C, except that water quality impacts on Red Dog Creek continue after closure.
Groundwater	No foreseeable or predicted irreversible or irretrievable impacts; not previously evaluated.	Irretrievable, but very localized, groundwater impacts in immediate vicinity of Aqqaluk Pit.	Same as Alternative B.	Same as Alternative B.
Aquatic Resources	No foreseeable or predicted irreversible or irretrievable impacts; not previously evaluated.	No foreseeable or predicted irreversible or irretrievable impacts.	Potential irretrievable loss of habitat in Main Stem Red Dog Creek due to marine discharge of treated water during operations.	Same as Alternative C, except potential habitat loss of resources continue after closure.
Wildlife	No foreseeable or predicted irreversible or irretrievable impacts; not previously evaluated.	Irreversible commitment of wildlife habitat associated with Aqqaluk Pit (119 acres) and expanded tailings impoundment (27.3 acres). Improved water quality in the impoundment over time may create new, different habitat. Irreversible risk (slight) to small mammals and ptarmigan from fugitive dust emissions.	Same impacts on habitat at mine site as Alternative B. Irretrievable loss of 145 acres of habitat for species with small home ranges associated with pipeline bench during operation but restored at closure. Lower risk to small mammals and ptarmigan from reduced fugitive dust emissions.	Same as Alternative C, except pipeline bench habitat not restored after closure and risks to mammals and ptarmigan greater than Alternative C but less then Alternative B.

Resource	Alternative A	Alternative B	Alternative C	Alternative D
Vegetation and Wetlands	No foreseeable or predicted commitment relative to land use or recreation; not previously evaluated.	Some additional irreversible change in vegetative species composition likely due to fugitive dust deposition from road. 413 acres of vegetation irretrievably impacted by Aqqaluk Pit development and tailings impoundment expansion. Some areas revegetated through reclamation after closure. Permanent loss of 145 acres of wetlands at the mine.	Same as Alternative B at mine site, except tailings impoundment reclaimed with dry cover. Irretrievable loss of 145 acres of vegetation and 125.5 acres of wetland during operations due to pipeline bench. Reduced future impacts on vegetative species composition along road.	Same as Alternative C, except pipeline impacts are irreversible since discharge pipeline remains after closure. Vegetation impacts along road less than Alternative B and more than Alternative C.
Land Use and Recreation	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Socioeconomics	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Subsistence	Irretrievable loss of subsistence opportunities associated with (1) perception of fugitive dust contamination, (2) traffic along the road (caribou), (3) vegetation near the road and port site (berries), and (4) marine mammals at port (beluga whales). Irretrievable impacts through 2011 on beluga and caribou, vegetation impacts may be irretrievable.	Same as Alternative A except irretrievable impacts occur through 2031.	Caribou impacts reduced by pipeline. Other impacts the same as Alternative B, except reduced dust emissions may mitigate some perceived impacts on berries.	Caribou impacts reduced by road closure during migrations. Marine mammal impacts reduced by delayed port opening. Other impacts the same as Alternative B.
Cultural Resources	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated, except one site potentially impacted by erosion at the port.	Irreversible impacts on two sites within Aqqaluk Pit. Same as Alternative A at the port.	Same as Alternative B, except that pipeline bench has not been surveyed (sites and impacts unknown).	Same as Alternative C.

Resource	Alternative A	Alternative B	Alternative C	Alternative D
Noise	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.
Transportation	No foreseeable or predicted irreversible or irretrievable commitments; not previously evaluated.	Same as Alternative A.	Same as Alternative A.	Same as Alternative A.

Chapter 4

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CHAPTER 4 LIST OF PREPARERS

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Chapter 5

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Chapter 6

Glossary

CHAPTER 6 GLOSSARY

100-year flood	A stream discharge that occurs on the average of once every 100 years.
Acid-base accounting	A test method to predict acid mine drainage. The “static” test compares a waste rock’s maximum potential acidity with its maximum neutralization potential.
Acid-generating potential	The long-term potential of a material or waste to generate acid, as related to acid mine drainage.
Acid mine (rock) drainage	Drainage of water from areas that have been mined for mineral ores. The water has a low pH because of its contact with sulfur-bearing material. Dissolved metals, including heavy metals, might be present. Acid mine drainage might be harmful to aquatic organisms and to drinking water supplies.
Acre-foot (ac-ft)	The amount of water that covers an acre of land to a depth of 1 foot; equal to 325,827 gallons.
Adsorb	To take up and hold by the physical or chemical forces of molecules.
Airshed	An area of land over which the pattern of air movement is influenced by major topographic features.
Alkaline	Having the qualities of a base; basic (pH greater than 7.0).
Alkaline chlorination	A treatment method by chemical reaction used to break down by chlorination the toxic cyanide radical (NC) into nontoxic sodium bicarbonate, nitrogen, sodium chloride, and water. This method can be used to treat mill effluent and tailings.
Alkalinity	A measure of the alkali content of a sample occasionally expressed as the number of milliequivalents of hydrogen ion that can be neutralized.
Alluvium	Material, including clay, silt, sand, gravel, and mud, deposited by flowing water.
Alternatives	For National Environmental Policy Act purposes, alternatives to the Proposed Action examined in an environmental impact statement or environmental assessment. The discussion of alternatives must “sharply [define] the issues and [provide] a clear basis for choice…by the decision maker and the public” (40 CFR 1502.14).
Ameliorate	To influence or alter conditions so as to cause improvement.
Anadromous	Describes fish that migrate upstream from salt water to fresh water to spawn (breed), such as salmon, some trout and char species, and shad. Also describes the fishery or habitat used for spawning by these species.
Aquatic	Growing, living, frequenting, or taking place in water. In this SEIS, used to indicate habitat, vegetation, and wildlife in fresh water.

Aquifer	A zone, stratum, or group of strata acting as a hydraulic unit that stores or transmits water in sufficient quantities for beneficial use.
Aspect	The direction toward which a slope faces.
Attainment area	A geographic region within which National Ambient Air Quality Standards (NAAQS) are met. Three categories of attainment— Class I, Class II, and Class III—are defined by the level of degradation of air quality which may be permitted.
Ball mill	Equipment used to reduce ore particles to a finer size. It includes a large rotating cylinder partially filled with steel balls.
Base drain	A drain for water at the bottom of an impoundment or a storm runoff catchment.
Base flow	A sustained or fair-weather flow of a stream.
Baseline data	Data gathered prior to the Proposed Action to characterize predevelopment site conditions.
Bathymetry	The measurement of depths of water in an ocean, lake, or sea.
Benthic	All underwater bottom terrain from the shoreline to the greatest deeps.
Berm	An earthen embankment; dike.
Best available control technology	Pollution control as defined by EPA for a specific emission or pollutant stream and required for meeting pollution control regulations.
Bioaccumulation	Pertaining to concentration of a compound, usually potentially toxic, in the tissues of an organism.
Bioassay	The study of living organisms to measure the effect of a substance, factor, or condition by comparing before-and-after exposure or other data.
Biodegradable	Capable of being broken down by the action of living organisms such as microorganisms.
Biomass	The amount (weight or mass) of living material.
Biomonitoring	The use of living organisms to test the suitability of effluents for discharge into receiving waters and to test the quality of such waters downstream from the discharge.
Biota	All living material in a given area; often refers to vegetation.
Bond	An agreed-to sum of money which, under contract, one party pays another party under the condition that when certain obligations or acts are met, the money will be returned; an example is mining reclamation. See Reclamation guarantee.
Borough	An area incorporated for the purpose of self-government; a municipal corporation.

Borrow area	Source area for earthen construction material, such as sand and gravel, till, or topsoil used in construction or reclamation.
Cadmium	A tin-white, malleable, ductile, toxic, bivalent metallic element used in electroplating of iron and steel and in the manufacture of
Carbon monoxide	A colorless, odorless, very toxic gas formed as a product of incomplete combustion of carbon.
Catchment area	The drainage area or basin drained by a river, stream, or system of streams.
Char	Fish that is closely related to trout. The char genus (*Salvelinus*) comprises Dolly Varden present in the project area.
Climax plant community	The stabilized plant community on a particular site. The relative composition of species does not change so long as the environment remains the same.
Closure	The final stage of mining, which involves closing all mine openings, regrading, and reclaiming.
Colluvial	Describes soil material that has moved downhill and has accumulated on lower slopes and at the bottom of a hill, consisting of alluvium in part and also containing angular fragments of the original rocks; i.e., cliff and avalanche debris.
Concentrate	The ore that contains the mineral sought following the concentration process (e.g., flotation, gravity).
Conductivity (electrical)	An electrical measurement to determine the amount of salinity or total dissolved solids in soils, surface water, and groundwater.
Cone of depression	The geometry or shape of an inverted cone on the water table or artesian pressure surface caused by pumping of a well. The cone of depression disappears over time after well pumping ceases.
Copper	A red, ductile, malleable native metal found in hydrothermal deposits, cavities of basic igneous rocks, and zones of oxidization of copper veins.
Council on Environmental Quality (CEQ)	A body established by the National Environmental Protection Act (NEPA) to draft regulations for implementing and monitoring NEPA. CEQ regulations are presented in 40 CFR/Parts 1500– 1508.
Cover	Living or nonliving material (e.g., vegetation) used by fish and wildlife for protection from predators and to ameliorate conditions of weather.
Criteria	Standards on which a judgment or decision can be based. Water quality criteria can be based on various standards, including aquatic life or human health.
Cubic feet per second (cfs)	One cubic foot per second (cfs) equals 448.33 gallons per mi

Cumulative impacts	Combined impacts of past, present, and reasonable foreseeably future actions. For example, the impacts of a proposed timber sale and the development of a mine together result in cumulative impacts.
Demography	A statistical study of the characteristics of human populations with reference to size, density, growth, distribution, migration, and effect on social and economic conditions.
Depletion	Use of water in a manner that makes it no longer available to other users in the same system.
Deposit	A natural accumulation, such as precious metals, minerals, coal, gas, oil, and dust, that may be pursued for its intrinsic value; gold deposit.
Development	The work of driving openings to and into a proven ore body to prepare it for mining and transporting the ore.
Dewatering	The reduction of aquatic habitats by diversion of stream flow; removal of water from underground mine workings.
Dilution	The act of mixing or thinning and thereby decreasing a certain strength or concentration.
Direct impacts	Impacts that are caused by the action and occur at the same time and place (40 CFR 1508.7). Synonymous with direct effects.
Discharge	The volume of water flowing past a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.
Dispersion	The act of distributing or separating into lower concentrations or less dense units.
Diversion	Removing water from its natural course of location, or controlling water in its natural course of location, by means of a ditch, canal, flume, reservoir, bypass, pipeline, conduit, well, pump, or other structure or device.
Earthquake	Sudden movement of the earth resulting from faulting, volcanism, or other mechanisms within the earth.
Effluent discharge	Disposal of water previously used, as in a milling process.
Endangered species	Any species that is in danger of extinction throughout all or a significant portion of its range.
Environmental Impact Statement (EIS)	A detailed written statement of the potential environmental effects resulting from a action proposed by a federal agency required by section 102(2)(c) of the National Environmental Policy Act (40 CFR 1508.11).
Ephemeral stream	A stream channel that is normally dry; stream flow occurs for short periods of time in response to storm events.
Erosion	The wearing away of the land surface by running water, wind, ice, or other agents.

Estuarine	Of, relating to, or formed in a place where an ocean tide meets the current of a freshwater stream.
Exploration	The search for economic deposits of minerals, ore, gas, oil, or coal through the practices of geology, geochemistry, geophysics, drilling, shaft sinking, and/or mapping.
Fault	A displacement of rock along a shear surface.
Feasibility study	As applied to mining, a study that follows discovery of a mineral and is prepared by the mining company or an independent consultant. Its purpose is to analyze the rate of monetary return that can be expected from the mine at a certain rate of production. Based on this study, a decision to develop the ore body may be made.
Fines	Fine particulate matter; specifically, particles less than 0.4 mm in diameter.
Fishery	All activities related to human harvest of a fisheries resource.
Flocculation	The addition of an agent to a settling pond that causes suspended particles to aggregate and settle out more rapidly than they would under natural conditions.
Flotation	An ore concentration process that separates ground ore from waste in a mixture of ore, water, and chemicals. When air is forced through the ore/water mixture, the chemicals cause certain minerals to adhere to the air bubbles and float to the top in a froth, thus effecting a separation.
Flotation circuit	The portion of the milling process where the flotation process occurs. See Flotation.
Flotation concentrate	The layer of mineral-laden foam built up at the surface of a flotation cell.
Fry	A recently hatched fish.
Fugitive dust	Dust particles suspended randomly in the air from road travel, excavation, or rock-loading operations.
Fugitive emissions	Emissions not caught by a capture system.
Geomorphic	Pertaining to the form of the surface of the earth.
Geotechnical	Related to branch of engineering that is essentially concerned with the engineering design aspects of slope stability, settlement, earth pressures, bearing capacity, seepage control, and erosion.
Geotextile	A synthetic fabric used in the construction of earthen structures, such as embankments, landfills, and roads.
Grade	The content of precious metals per volume of rock (expressed in ounces per ton).

Gradient	The inclination or the rate of regular or graded ascent or descent (as of a slope, roadway, or pipeline).
Gypsum	A naturally hydrated calcium sulfate, $CaSO_4 \cdot 2H_2O$, white or colorless, sometimes tinted grayish, reddish, yellowish, bluish, or brownish. Insoluble in water; soluble in ammonium salts, acids, and sodium chlorides.
Habitat	The natural environment of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influences affecting living conditions.
Hardness	Quality of water that prevents lathering because of the presence of calcium and magnesium salts, which form insoluble soaps.
Hazardous waste	By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special EPA lists.
Heavy metals	A group of elements, usually acquired by organisms in trace amounts, that are often toxic in higher concentrations. Heavy metals include copper, lead, mercury, molybdenum, nickel, cobalt, chromium, iron, silver, and others.
Herbaceous	Lacking woody tissue; used to describe vegetation.
Heterogeneous	Not uniform in structure or composition.
Hydraulic barrier	An abrupt change in geology or soil type that inhibits the flow of water.
Hydraulic conductivity	A measure of the ability of soil to permit the flow of groundwater under a pressure gradient; permeability.
Hydrogen sulfide	A colorless, flammable, poisonous gas.
Hydrologic system	All physical factors, such as precipitation, stream flow, snowmelt, and groundwater, that affect the hydrology of a specific area.
Hydrophytic	Pertaining to aquatic plants that require an abundance of water for growth.
Impermeable	Having a texture that does not permit the passage of fluids through its mass.
Impoundment	The accumulation of any form of water in a reservoir or other storage area.
Incised	Cut into.
Increment	The amount of change from an existing concentration or amount, such as air pollutant concentrations.
Indigenous	Originating, developing, or produced naturally in a particular land, region, or environment; native.

Indirect impacts	Effects that are caused by the action and occur later in time farther removed in distance but are still reasonably foreseeable (40 CFR 1508.8). Synonymous with indirect effects.
Infauna	Aquatic animals living in and on soft bottom substrates.
Infiltration	The movement of water or some other fluid into the soil through pores or other openings.
ISO container	A container that conforms to criteria established by the International Standards Organization for the transport of hazardous materials.
Jurisdictional wetland	A wetland area delineated or identified by specific technical criteria, field indicators, and other information for purposes of public agency jurisdiction. The public agencies that administer jurisdictional wetlands are the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, EPA, and the USDA Natural Resources Conservation Service.
Lime	Calcium oxide. Sometimes used as an abbreviated name for any rock consisting predominantly of calcium carbonate.
Long-term impacts	Impacts that result in permanent changes to the environment. An example is a topographic change resulting from tailings disposal in a creek drainage.
Marine discharge	Disposal of mine water, treated sewage, and/or stormwater bypass.
Marine outfall	The mouth or outlet of a river, stream, or pipeline where it enters the sea.
Median	The value of the middle number of a data set such that half of the data values are greater than the median and half of the data values are less than the median.
Microclimate	The local climate of a given area or habitat characterized by uniformity over the site.
Migratory	Moving from place to place, daily or seasonally.
Milling	The act or process of grinding, extraction, or mineral processing.
Mine drainage	Gravity flow of water from a mine to a point remote from the mining operations.
Mine Safety and Health Administration (MSHA)	A federal agency under the Department of Labor that regulates worker health and safety in mining operations.
Minimum stream flow	A set amount of water to be maintained in a watercourse for the
requirement	purpose of reasonably maintaining the environment.
Mining plan	*See Operating plan.*
Mitigation measure	A step planned or taken to lessen the effects of an action.

Mixing zone	An area between an effluent discharge point and the associated water quality compliance monitoring station.
Monitoring	Continued testing of specific environmental parameters and of project waste streams for purposes of comparing with permit stipulations, pollution control regulations, mitigation plan goals, and so forth.
National Environmental Policy Act of 1969 (NEPA)	National charter for protection of the environment. It establishes policy, sets goals, and provides means for carrying out the policy. The regulations for implementing the act are at 40 CFR parts 1500–1508.
National Pollutant Discharge Elimination System (NPDES)	A program authorized by sections 318, 402, and 405 of the Clean Water Act, and implemented by regulations at 40 CFR part 122. The NPDES program requires permits for the discharge of pollutants from any point source into waters of the United States.
National Register of Historic Places (NRHP)	A list, maintained by the National Park Service, of areas that have been designated as being of historical significance.
NEPA process	All measures necessary to comply with the requirements of section 2 and Title I of NEPA.
New Source Performance Standards	Standards set by EPA defining the allowable pollutant discharge (air and water) and applicable pollution control for new facilities by industrial category (Clean Air Act and Clean Water Act).
Nonpoint pollution	Pollution caused by sources that are nonstationary. In mining, nonpoint air pollution results from such activities as blasting and hauling minerals over roads, as well as dust from mineral stockpiles, tailings, and waste dumps prior to mulching and/or revegetation.
Oligotrophic	Having a deficiency in plant nutrients that is usually accompanied by an abundance of dissolved oxygen.
Operating plan	Plan submitted by the mining operator that outlines the steps the mining company will take to mine and reclaim the site. The operating plan is submitted prior to starting mining operations. Synonymous with the term mining plan (36 CFR part 228).
Ore	Any deposit of rock from which a valuable mineral can be economically extracted.
Ore body	Generally, a solid and fairly continuous mass of ore, which might include low-grade ore and waste as well as pay ore, but is individualized by form or character from adjoining rock.
Ore reserve	Ore of which the grade and tonnage have been established with reasonable assurance by drilling and other means.
Organic matter	Matter composed of once-living organisms (carbon compounds).
Organism	A living individual of any plant or animal species.

Orographic effects	Pertaining to relief factors such as hills, mountains, plateaus, valleys, and slopes; usually used to describe weather patterns.
Outfall	A structure (pipeline) extending into a body of water for the purpose of discharging a waste stream, storm runoff, or water.
Oxide	A compound of oxygen with one or more elements or radicals.
Ozone	Form of oxygen (O3) found largely in the stratosphere; a product of reaction between ultraviolet light and oxygen, or formed during combustion of hydrocarbon fuels.
Palustrine	Of, or relating to, shallow ponds, marshes, or swamps.
Palustrine forested	A forested wetland dominated by woody vegetation more than 20 feet tall.
Palustrine scrub-shrub	A wetland area dominated by woody vegetation less than 20 feet tall.
Peak flow	Highest flow; can be quantified as daily or instantaneous.
Permeability	The capacity of a material for transmitting a fluid. Degree of permeability depends on the size and shape of the pores, their interconnections, and the extent of the latter.
pH	Symbol for the negative common logarithm of the hydrogen ion concentration (acidity) of a solution. The pH scale runs from 0 to 14, with a pH of 7 considered neutral. A pH number below 7 indicates acidity, and a pH value above 7 indicates alkalinity or a base.
Physiography	A science that deals with the features and phenomena of nature; physical geography.
Piezometer	A device for measuring moderate pressures of liquids.
Piezometric head	The level to which a liquid rises in a piezometer, representing the static pressure of a waterbody.
Piezometric surface	Any imaginary surface coinciding with the hydraulic pressure level of water in a confined aquifer, or the surface representing the static head of groundwater and defined by the level to which water will rise in a well. A water table is a particular piezometric surface.
Plan of Operations	*See Operating plan.*
Plate filter	A filter used to remove gold precipitate from solution.
Point source	Stationary sources of potential pollutants. In terms of mining, some examples of point sources are crushing and screening equipment, conveyors, and pond outlet pipes.
Pollution	Human-caused or natural alteration of the physical, biological, and radiological integrity of water, air, or other aspects of the environment producing undesired effects.

Polychaete	Any of a class of mostly marine, annelid worms, having on most segments a pair of fleshy, leg-like appendages bearing numerous bristles.
Portal	The entrance to a tunnel or underground mine.
Potable water	Suitable, safe, or prepared for drinking.
Potentiometric surface	Surface to which water in an aquifer would rise by hydrostatic pressure.
Precipitation	The process of removing solid or liquid particles from a gas or smoke; the process of forming a precipitate from a solution (flocculation); rain, mist, snow, and the like.
Prehistoric	Relating to the times just preceding the period of recorded history.
Prevention of Significant Deterioration (PSD)	Under the provisions of the federal Clean Air Act, a proposed new source of air pollution may be required to apply for a PSD permit if certain emission limits are expected to be exceeded.
Pristine	Pertaining to pure, original, uncontaminated conditions.
Probable maximum flood (PMF)	A flood calculated to be the largest probable under any circumstances.
Probable maximum precipitation (PMP)	The theoretical physical maximum amount of precipitation that could occur at a given point or location.
Process area	The area that encompasses the adit, mill, and processing facilities.
Process water	Water required for use within the mill system.
Project area	The area within which all surface disturbance and development activity would occur.
Public scoping	An early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR 1501.7).
Pyrite	A common mineral consisting of iron disulfide (FeS2) with a pale brass-yellow color and brilliant metallic luster. It is burned to make sulfur dioxide and sulfuric acid.
Pyritic	Relating to or resembling pyrite, a common mineral; iron disulfide.
Receiving waters	A river, lake, ocean, stream, or other watercourse into which wastewater or treated effluent is discharged.
Reclamation	Returning an area to a productive land use by regrading and reseeding areas disturbed during mining activity.

Record of Decision (ROD)	A document that discloses the decision on an environmental impact statement and the reasons why the decision was made; it is signed by the official responsible for implementing the identified action. The environmental consequences disclosed in an EIS are considered by the responsible official in reaching a decision (40 CFR 1505.2).
Redox	A chemical reaction in which one component loses electrons (is oxidized) and another gains electrons (is reduced).
Residence time	The amount of time a receptor organism or object is in contact with a source.
Resident	A species that is found in a particular habitat for a particular time period (e.g., winter, summer, year-round) as opposed to species found only when passing through during migration.
Richter Scale	A numerical (logarithmic) measure of earthquake magnitude.
Riparian	A type of ecological community that occurs adjacent to streams and rivers. It is characterized by certain types of vegetation, soils, hydrology, and fauna that are suited to conditions more moist than those normally found in the area.
Riprap	A layer of large rocks placed together to prevent erosion of embankments, causeways, or other surfaces.
Riverine	Of or relating to rivers, creeks, and streams.
Runoff	Precipitation that is not retained on the site where it falls and not absorbed by the soil; natural drainage away from an area.
Salinity	A measure of the dissolved salts in sea water.
Salmonids	Fish species (salmon, trout, and char) that belong to the same family; salmonidae.
Saturation	The extent or degree to which the voids in a material contain oil, gas, or water. Usually expressed in percent related to total void pore space.
Section 10 Permit	A permit issued under section 10 of the Rivers and Harbors Act of 1899. Section 10 requires a permit for any structure or work that might obstruct traditionally navigable waters. This permit is issued by the U.S. Army Corps of Engineers.
Section 404 Permit	A permit issued under Section 404 of the Clean Water Act. Section 404 specifies that anyone wishing to place dredged or fill materials into the waters of the United States and adjacent jurisdictional wetlands must apply to the U.S. Army Corps of Engineers for approval.
Sedentary	Not migratory; staying in one place; stationary.
Sediment	Material suspended in liquid or air; also, the same material once it has been deposited by water.
Sediment basin	A pond, depression, or other device used to trap and hold sediment.

Sediment loading	The mass of solid erosion products deposited by or carried in water or air.
Sediment pond	Structure constructed by excavation or by building an embankment whose purpose is to retain water and allow for settlement of fines (suspended solids) and reduction in turbidity.
Seepage	The slow movement of gravitational water through the soil.
Selenium	A nonmetallic, toxic element related to sulfur and tellurium; a by-product of the electrolytic refining of copper.
Semiautogenous	Produced or created without external help or influence.
Sensitive species	A plant or animal listed by a state or federal agency as being of environmental concern; includes threatened and endangered species.
Settling ponds	*See Sediment pond.*
Short-term impacts	Impacts occurring during project construction and operation, and ceasing upon project closure and reclamation.
Significant issues	Of the issues raised during the scoping process for an environmental impact statement, certain issues are determined to be “significant’ by the lead public agency. Determining which issues are significant, and thus meriting detailed study in the EIS, is the final step of the scoping process and varies with each project and each location. Significant issues are used to develop alternatives.
Slurry	A watery mixture or suspension of insoluble matter, such as mud or lime.
Sodium hydroxide	A common laboratory reagent that is strongly alkaline when in solution with water.
Solid waste	Garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities.
Spawn	To produce or deposit eggs or sperm; the eggs or sperm product (fish reproduction).
Spill Prevention, Containment, and Countermeasure (SPCC) Plan	A plan that USEPA requires of facilities storing more than a given threshold of fuel or hazardous material. It is a contingency plan for avoidance of, containment of, and response to hazardous materials spills or leaks.
Stockpiling	Storage of soils or rock material.
Stormwater	Overland flow generated as the result of a storm event.

Strata	A tabular mass or thin sheet of earth of one kind formed by natural causes usually in a series of layers of varying makeup; sedimentary units.
Stream channel geometry	The cross section of a stream channel (end view).
Stream flow	The discharge (flow of water) in a natural channel.
Stream gradient	The rate of fall or loss of elevation over the physical length of a segment or total stream usually expressed in feet change per feet in distance (%).
Study area	The zone around the project area within which most potential direct and indirect effects on a specific resource would occur.
Subaqueous	Living, formed, or found under water.
Subsidence	A local lowering of land surface caused by the collapse of rock and soil into an underground void or by the removal of groundwater; it can result in stability failures such as landslides and mine roof cave-ins.
Subsistence use	Section 803 of the Alaska National Interest Lands Conservation Act defines subsistence use as follows: “The customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of the non-edible by-products of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade.”
Substrate	An underlayer of earth or rock.
Succession	Changes in the plant communities composing an ecosystem as the ecosystem evolves from one type to another; e.g., wetland becoming grassy meadows.
Sulfide	A compound of sulfur with more than one element. Except for the sulfides of the alkali metals, the metallic sulfides are usually insoluble in water and occur in many cases as minerals.
Sump	In the case of an underground mine, an excavation made underground to collect water, from which water is pumped to the surface or to another sump nearer the surface.
Surficial	Characteristic of, relating to, formed on, situated at, or occurring on the earth’s surface; especially, consisting of unconsolidated residual, alluvial, or glacial deposits lying on the bedrock.
Synchronous	Recurring or operating at exactly the same periods.
Tailings	The noneconomic constituents of the ground ore material that remain after the valuable minerals have been removed from raw materials.

Taxa (taxon)	Any group of organisms, populations, or the like considered to be sufficiently distinct from other such groups to be treated as a separate unit.
Terrestrial	Of or relating to the earth, soil, or land; an inhabitant of the earth or land.
Thermistor	A resistor made of semiconductors having resistance that varies rapidly and predictably with temperature.
Threatened species	A plant or wildlife species that is officially designated by the U.S. Fish and Wildlife Service as having its existence threatened and is protected by the federal Threatened and Endangered Species Act.
Tideland	Land that is overflowed by the tide but exposed during times of low water.
Topography	The physical configuration of a land surface.
Toxicity tests	Laboratory analyses generally used to determine the degree of danger posed by a substance to animal or plant life.
Trace metals	Metals present in minor amounts in the earth's crust (trace elements).
Transmissivity (coefficient of)	A measure of the ability of an aquifer to transmit water.
Turbidity	Reduced water clarity resulting from the presence of suspended matter.
Understory	A foliage layer lying beneath and shaded by the main canopy of a forest.
Visual resources	The visual quality of the landscape. The Forest Service manages viewsheds as a resource, establishing specific management objectives for different areas of Forest Service land.
Waste rock	Also known as development rock, waste rock is the non-ore rock extracted to gain access into the ore zone. It contains no gold or gold below the economic cutoff level.
Water balance	A measure of continuity of water flow in a fixed or open system.
Watershed	The entire land area that contributes water to a particular drainage system or stream.
Waters of the United States	All waters that are currently or could have been used in interstate or foreign commerce, including waters that are subject to the ebb and flow of the tide; wetlands; and lakes, rivers, streams, mudflats, sandflats, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds.
Weathering	The process whereby larger particles of soils and rock are reduced to finer particles by wind, water, temperature changes, plant and bacteria action, and chemical reaction.

Wetlands	Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.
Wilderness	Land designated by Congress as a component of the National Wilderness Preservation System.
Xanthates	A class of chemicals known as “collector” chemicals that attach to floating minerals, making them normally incapable of adhering to the froth in a flotation circuit.

Chapter 7

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