Chapter 3

Affected Environment/Environmental Consequences

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.

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

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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 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

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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

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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).

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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).

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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

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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

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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

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