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

JUN 1 2009

OFFICE OF
WATER AND WATERSHEDS

Ms. Lynn J. Tomich Kent, Director
Water Division
Department of Environmental Conservation
555 Cordova St.
Anchorage, AK 99501-2617

Re: Approval of the Klag Bay Metals TMDLs

Dear Ms. Kent:

Alaska Department of Environmental Conservation (ADEC) submitted the Klag Bay Total Maximum Daily Loads (TMDLs) for metals to the U.S. Environmental Protection Agency on April 28, 2009. Following our review, EPA is pleased to approve the metals TMDLs for Klag Bay [Alaska ID Number 10203-602] in Sitka, Alaska.

Our review indicates that these allocations have been established at a level that, when fully implemented, will lead to the attainment of the water quality criteria addressed by these TMDLs. Therefore, ADEC does not need to include Klag Bay on the next 303(d) list of impaired waters for the pollutants covered by these TMDLs.

We greatly appreciate the opportunity to work with your staff throughout the development of this TMDL. In particular, we are impressed by the commitment and hard work shown by Tim Stevens of ADEC in developing these TMDLs.

By EPA's approval, this TMDL is now incorporated into the State's Water Quality Management Plan under Section 303(e) of the Clean Water Act. We look forward to continuing to work collaboratively on water quality issues in Klag Bay. If you have any questions, please feel free to call me at (206) 553-4198, or Martha Turvey of my staff at (206) 553-1354.

Sincerely,

Michael A. Bussell, Director
Office of Water and Watersheds

cc: Mr. Tim Stevens, Restoration and Protection Section, ADEC
Ms. Cindy Gilder, Manager, Restoration and Protection Section, ADEC
Ms. Nancy Sonafrank, Manager, Non-Point Source Water Pollution Control Program, ADEC

Total Maximum Daily Load (TMDL) for Toxic and other Deleterious Organic and Inorganic Substances in Klag Bay, Alaska

FINAL

April 2009

Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, AK 99501

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Total Maximum Daily Load (TMDL) for Toxic and other Deleterious Organic and Inorganic Substances in Klag Bay, Alaska

TMDL AT A GLANCE

Water Quality-Limited?	Yes
Alaska ID Number:	10203-602
Criteria of Concern:	Toxic and other Deleterious Organic and Inorganic Substances
Designated Uses Affected:	Water supply; water recreation; growth and propagation of fish, shellfish, other aquatic life, and wildlife
Major Source(s):	Historical mine tailings deposits
Loading Capacity:	Varies by parameter (see table below)
Wasteload Allocation:	Zero mg/kg
Load Allocation:	Varies by parameter (see table below)
Margin of Safety:	Explicit for mercury, copper, lead, silver, and zinc; and implicit for arsenic, manganese, and cobalt.

Metals	Highest Observed Sediment Concentration (mg/kg)	WLA (mg/kg)	LA (mg/kg)		MOS (mg/kg)	Loading Capacity (mg/kg)	% Reduction Needed to Meet the TMDL
			Background	Anthropogenic			
Mercury	4.53	0	0.106	0.029	0.015	0.15	96.7%
Arsenic	844.0	0	21.3	0.0	0.0	21.3	97.5%
Copper	97.8	0	21.35	9.25	3.4	34.0	65.2%
Lead	350.0	0	4.625	37.405	4.67	46.7	86.7%
Silver	8.0	0	0.6	0.3	0.1	1.0	87.5%
Zinc	357.0	0	64.95	70.05	15.0	150.0	58.0%
Cadmium	5.8	NA	9.75	NA	NA	9.75	TNN*
Manganese	728.0	0	181.5	0.0	0.0	181.5	75.1%
Cobalt	17.9	0	2.99	0.0	0.0	2.99	83.3%

*TNN = TMDL Not Needed

EXECUTIVE SUMMARY

Klag Bay is located approximately 170 miles southwest of Juneau and 50 miles northwest of Sitka, on the west side of on Chichagof Island, Alaska. The Klag Bay Watershed drainage is approximately 3,000 acres; much of the area around the bay is steep, mountainous, and heavily forested. The State of Alaska included Klag Bay on its 1996 303(d) list as water quality–limited due to Toxic & Other deleterious Organic and Inorganic Substances from mine tailings associated with historical mining.

This Total Maximum Daily Load (TMDL) establishes limits for metals entering Klag Bay from new operations. The TMDL is established to meet the requirements of Section 303(d)(1) of the Clean Water Act. A TMDL is composed of the sum of individual waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint sources and natural background loads. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. A TMDL represents the amount of a pollutant the waterbody can receive while maintaining compliance with applicable water quality standards.

Between 1906 and 1942, the Chichagof Mining Company operated gold and silver mines in the Klag Bay area. The mines used a mercury amalgamation process and cyanide method processing. Studies conducted by the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency documented that high levels of metals (arsenic, cobalt, copper, lead, manganese, mercury, silver, and zinc) remaining in the area were causing abnormalities in blue mussels. These findings resulted in the State of Alaska including Klag Bay on its 1996 303(d) list. During mining operations, an estimated 700,000 tons of tailings were deposited into the intertidal and subtidal zones and adjacent uplands. Approximately 54 acres encompassing the inner bay, tailings area and area up-gradient of the tailings are still considered impaired.

The Department of Environmental Conservation (DEC) developed this TMDL using the most stringent criteria, "Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife." These criteria specify that "…There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause or reasonably can be expected to cause, adverse effects on aquatic life or produce undesirable or nuisance aquatic life." Because this standard is non-numeric or narrative, DEC used the numeric toxicological screening criteria developed by the National Oceanic and Atmospheric Administration (NOAA) to establish the numeric target for this TMDL. For the TMDL target, DEC used the conservative but still predictive of toxicity limit known as the Effect Range Low (ERL), since below ERL criteria, minimal effects on aquatic life are observed; values at or above ERL levels are those at which toxicity may begin to be observed in sensitive species. ERL criteria were not available or deemed not appropriate for some metals, including arsenic, cobalt, and manganese. ERLs are not available for manganese and cobalt, and estimated background concentrations for arsenic are higher than the ERL, which may suggest naturally elevated presence of arsenic in the sediments and source rock within the area. Therefore, the TMDLs for arsenic, cobalt, and manganese were developed using the average background sample concentration as the numeric target, which represents a conservative approach to developing the TMDL given known available data and information.

The TMDL establishes the waste load allocation in Klag Bay as <u>zero mg/kg/day</u> and the load allocation as ERLs (minus 10% for the Margin of Safety) or average background levels. Based on the WLA, no future discharge of mine waste will be permitted in the area until such time as the

water quality standards are met or the TMDL is revised. If future activity is proposed at the Klag Bay site that may entail discharge of toxic or other deleterious organic and inorganic substance discharges into Klag Bay, the TMDL may be revised to include modified WLAs. Possible revision of the WLA in this TMDL will depend on analysis of relevant factors at that time. The TMDL also establishes an implicit MOS based on conservation assumptions in the TMDL analysis for arsenic, manganese, and cobalt, and an explicit 10% of the loading capacity for mercury, copper, lead, silver and zinc.

The TMDL recommends monitoring for natural recovery to determine whether concentrations of these contaminants are decreasing over time due to natural sedimentation process if the system is not disturbed. Monitoring will allow DEC to track the progress of changes in water and sediment and determine whether acceptable progress is being made. If acceptable progress is not being made through natural recovery, other options such as in-situ capping should be explored. Monitoring should be implemented on a schedule that allows for a statistical evaluation of surface and subsurface intervals. Future sampling efforts in Klag Bay also should include additional background samples in undisturbed areas near Klag Bay in order to further define background concentrations. The TMDL also recommends restricting future development which might disturb the existing tailings pile or marine sediments within the inner bay and posting warning signs about the contamination.

1.0 INTRODUCTION

1.1. Background and Scope of the TMDL

Section 303(d)(1)(C) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130) require that a Total Maximum Daily Load (TMDL) be established to achieve state water quality standards (WQS) when a waterbody is water quality-limited for a specific pollutant and will not meet WQS with the implementation of technology-based effluent limitations and other pollution control requirements. A TMDL identifies the amount of a pollutant that a waterbody can receive while still meeting WQS, and establishes discharge limits for existing and future discharge sources of the pollutant, including an appropriate margin of safety (MOS). Discharge limits for point sources are called wasteload allocations (WLAs); discharge limits for nonpoint sources are called load allocations (LAs). This report presents a TMDL to address sediment impairments associated with toxic and other deleterious organic and inorganic substances in Klag Bay resulting from the deposition of tailings from past mining activities.

Klag Bay is located approximately 170 miles southwest of Juneau and 50 miles northwest of Sitka, on the west side of Chichagof Island, Alaska (Figure 1). The former Chichagof Mine and its tailings pile are located on the south-eastern slope of Doolth Mountain and in the northwestern side of Klag Bay (Figures 2 and 3). Mining operations began in 1906 and continued to be operated by the Chichagof Mining Company until it was forced to close by the War Labor Board in 1942 (Ecology and Environment 1999).

During operation, the Chichagof Mine extracted gold and silver from two shafts at an elevation of 1,000 feet and 1,500 feet, respectively (USFWS 1986) (Figure 4). The mine used a mercury amalgamation process and a cyanide method for processing; although it is unclear to what extent the cyanide method was used. The mine deposited an estimated 500,000 tons of tailings into the intertidal and subtidal zones of Klag Bay during this time. The mine also deposited an additional approximate 200,000 tons of waste rock in the uplands adjacent to the bay (Ecology and Environment 1999). Tailings from the former Chichagof Mine operations remain in the bay and comprise much of the surface beach sediments at the foot of the former town site. The approximate extent of the tailings deposits are shown in Figures 2 and 5.

Figure 1. Location of Klag Bay, Alaska

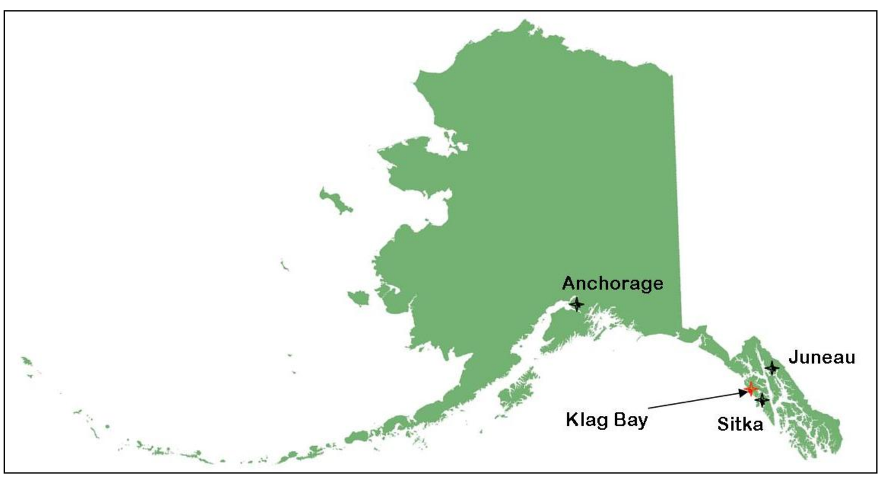


Figure 2. Location of approximate extent of existing mine tailing deposits in Klag Bay

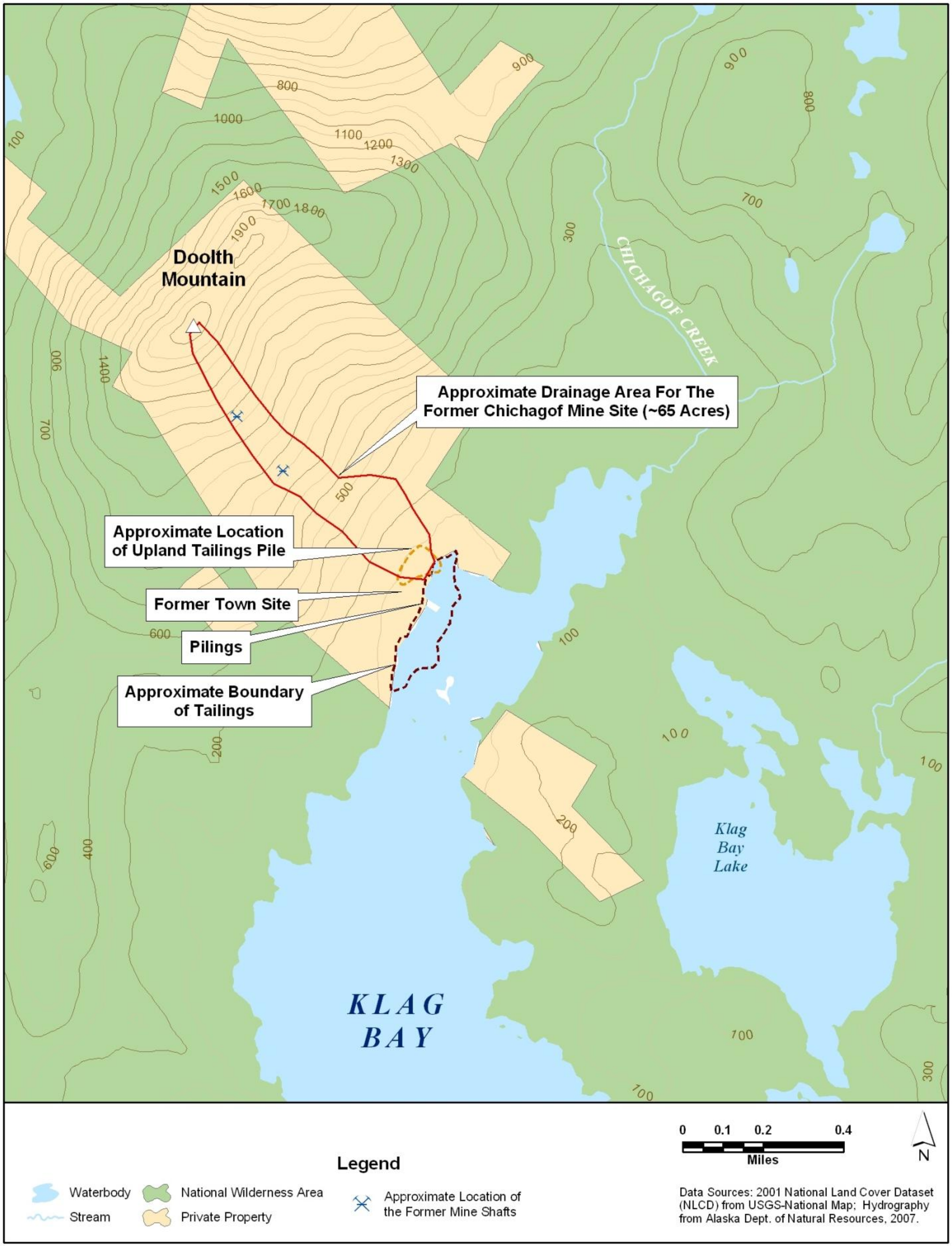
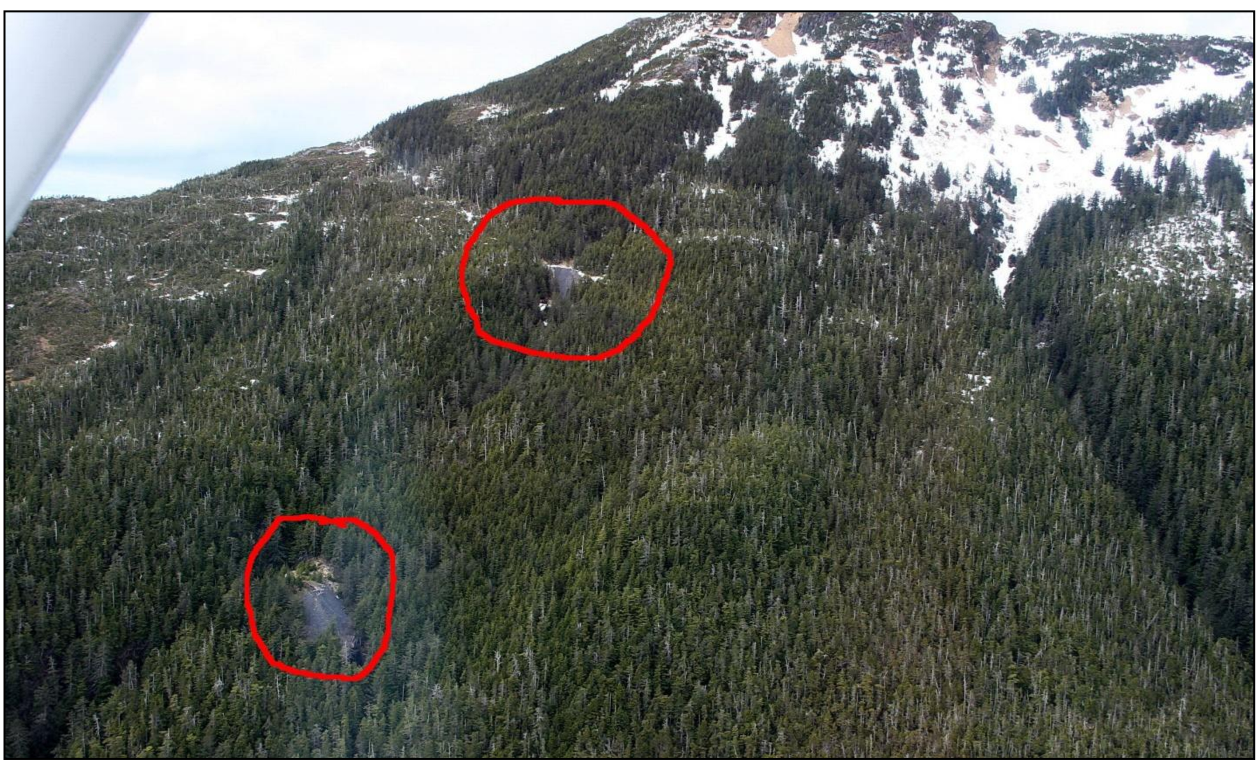


Figure 3. Photo of former Chichagof Mine site in Klag Bay (*photos from Philip Mooney)*

Figure 4. Photo of former Chichagof Mine site shafts (*photos from Philip Mooney)*



The site of the former Chichagof Mine is private property and currently owned by the Coastal Development Company, Inc. (CDC), although no active mining has occurred at the site since it was closed. Several of the abandoned structures are still located on the site, although in various states of ruin (Ecology and Environment 1999). Several companies have reportedly leased the property from the CDC during the 1980s and 1990s with interests in reopening the mine and reprocessing the mine tailings. However, none of the companies ever finalized the plans (Ecology and Environment 1999).

The mine tailings are believed to be leaching high levels of metals into the waters and causing abnormalities in mussels (USFWS 1986). To date, no known actions have been taken to address these impairments. Waters that do not meet Alaska's WQS are placed on Alaska's 303(d) list of impaired waterbodies. This list identifies the probable cause(s) of the impairment problems and the suspected source(s) of the pollutant(s) of concern. The Alaska Department of Environmental Conservation (ADEC) placed Klag Bay (Alaska ID Number 10203-602) on Alaska's CWA Section 303(d) list of water quality-limited waters ("impaired waters") in 1996 for non-attainment of WQS for toxic and other deleterious organic and inorganic substances in the bay's sediments. Alaska's Final 2008 Integrated Water Quality Monitoring and Assessment Report states:

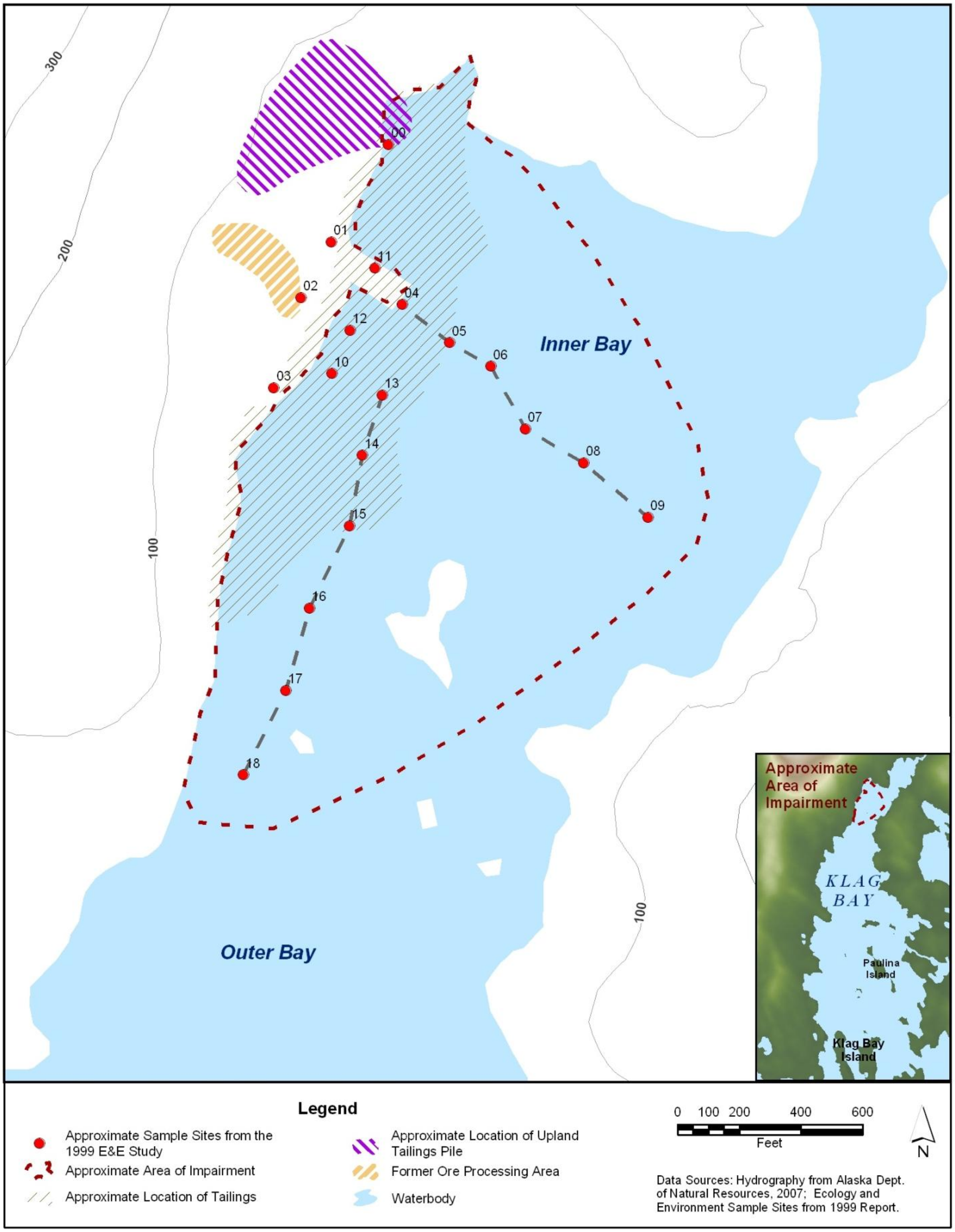
> *"Klag Bay was placed on the 1996 Section 303(d) list for non-attainment of the toxic & other deleterious organic and inorganic substances standard for metals. Past mining resulted in the deposition of large amounts of tailings in Klag Bay. A draft 1985 report (not finalized to date) on Klag Bay titled "Klag Bay Study" prepared by the U.S. Fish and Wildlife Service indicated high levels of metals from tailings are leaching into the bay. Contaminants are mercury, arsenic, cobalt, copper, and lead, silver. These metals caused abnormalities in numerous blue mussels. These abnormalities are considered an impairment of a designated use. A 1998 preliminary assessment confirmed lead, silver, arsenic and mercury in the intertidal sediments above NOAA screening benchmarks."*

The pollutant source identified on the section 303(d) list is mining. This report presents a TMDL to address impairments associated with toxic and other deleterious organic and inorganic substances in Klag Bay resulting from the deposition of tailings from past mining activities.

1.2. Area of Impairment

The original area of concern for Klag Bay, defined as 1.25 acres, was established based on best professional judgment (USEPA 2008). However, sediment sample data from 1999 indicate that the area of concern is likely much larger for some of the metals, as data show higher concentrations in the deeper waters of the inner bay (Appendix A). The mine tailings deposited along the shoreline were located in a tidally-influenced area and, therefore, were susceptible to transport within the inner bay during active mining operations. As a result, the approximate area of impairment was expanded to include a larger area that encompasses the inner bay, tailings area, and area upgradient of the tailings site (Figure 5). The 54-acre section of the bay identified in Figure 5 represents the approximated area of impairment as reflected by available data. As new data or information becomes available in the future, this approximate area of impairment can be re-evaluated.

Figure 5. Approximate area of impairment addressed by the Klag Bay TMDL



2.0 WATERSHED CHARACTERIZATION

2.1. Location and Physical Characterization

Klag Bay is located on Chichagof Island, approximately 50 miles northwest of Sitka, Alaska and within the Borough of Sitka. The bay is located within the West Chichagof Wilderness area and is part of the Tongass National Forest. Chichagof Creek flows into the head of Klag Bay to the north, and a series of lakes known as the Klag Bay lakes discharge into Klag Bay through Fish Camp Creek. The bay is interconnected with Lake Anna and Sister Lake through an outlet on the southeast side of the bay. Located on the northwest of side of the bay, Doolth Mountain rises to an elevation of approximately 2,159 feet (USGS 1975). Klag Bay has a direct watershed drainage area of approximately 3,000 acres. Much of the area around the bay is steep, mountainous, and heavily forested. The remains of mine tailings and other sediments create tidal flats at the foot of the former town site. The saltwater basin area around Chichagof Mine and former town site is only 12.5 meters deep at its deepest point (USFWS 1986); however, Klag Bay drops to a depth of over 30 meters towards the center of the bay and Klag Island. Many small islands are located in the bay.

2.2. Land Use

The land surrounding the former mine site is located within the West Chichagof Wilderness area, which is part of the Tongass National Forest (Figure 6). The former Chichagof mine is located on private property, but has not been in use since the 1940s (Ecology and Environment 1999). The private property boundaries for the Chichagof mine and others are shown in Figure 6. As shown in Figure 7, the majority of the wilderness area is composed of Evergreen and Deciduous Forest with mixed scrub and barren soils as defined by the 2001 National Land Cover Dataset (USGS 2003). The forest is comprised mostly of Sitka spruce and Western hemlock. Due to soil disturbances during the former mining operations, the town site is covered with small alders[1] (USFWS 1986). Much of the surrounding land is also noted to have poorly drained soils with muskeg vegetation types (USFWS 1980). Tailings lie higher up on the hillside, in the former town site, and on the intertidal areas. The intertidal areas are noted as unconsolidated silt and sand shore (Hughes 1986).

2.3. Waterbody and Stream Characteristics

Chichagof Creek flows into tidal flats at the creek's outlet in northern Klag Bay (Figure 6). The outlet of the Klag Lake system, a known spawning location for sockeye and coho salmon, discharges on the east side of the bay through Fish Camp Creek, south of the former Chichagof mine site (Stahl et al. 2007). No tidal current data are available for Klag Bay or nearby locations. However, currents have been documented at slightly greater than 2 knots at Klag Island (USFWS 1986).

The drainage area for the former Chichagof mine site is approximately 65 acres (Ecology and Environment 1999) (Figure 2). No streams are known to flow through the former Chichagof mine site but small drainages have been noted to run through the old town site; however, these drainages do not have fishery habitat and flow is at less than 1 cubic foot per second (cfs) (USFWS 1980). A spring has been observed to discharge at the base of one of the upland waste rock piles (Ecology and Environment 1999).

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[1] Alder is the common name of a genus of flowering plants (*Alnus*) belonging to the birch family. Alders are a pioneer species, often established after a disturbance, such as logging. Known as "King of the Water," they have a positive effect on aquatic biodiversity.

Figure 6. Land ownership around Klag Bay

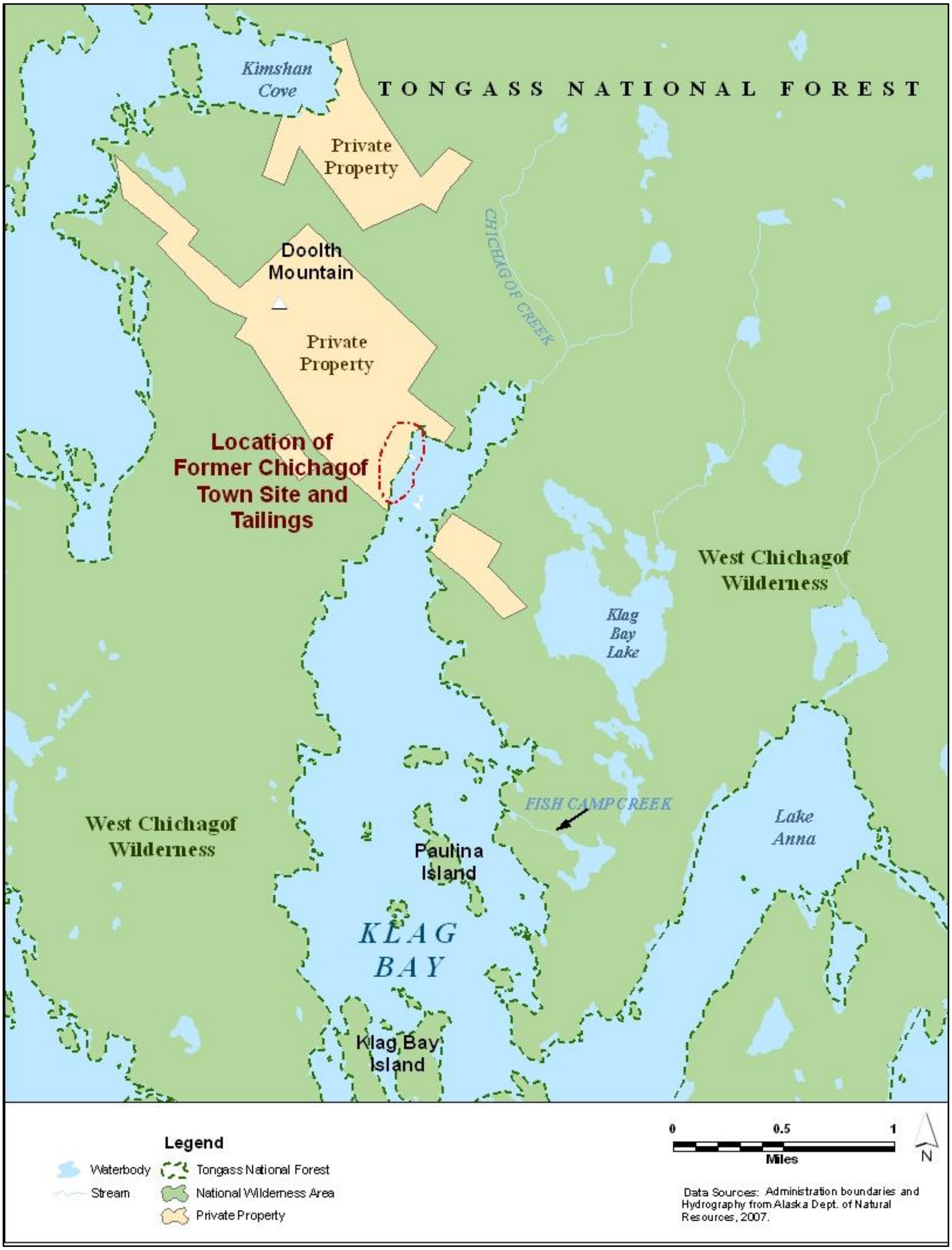
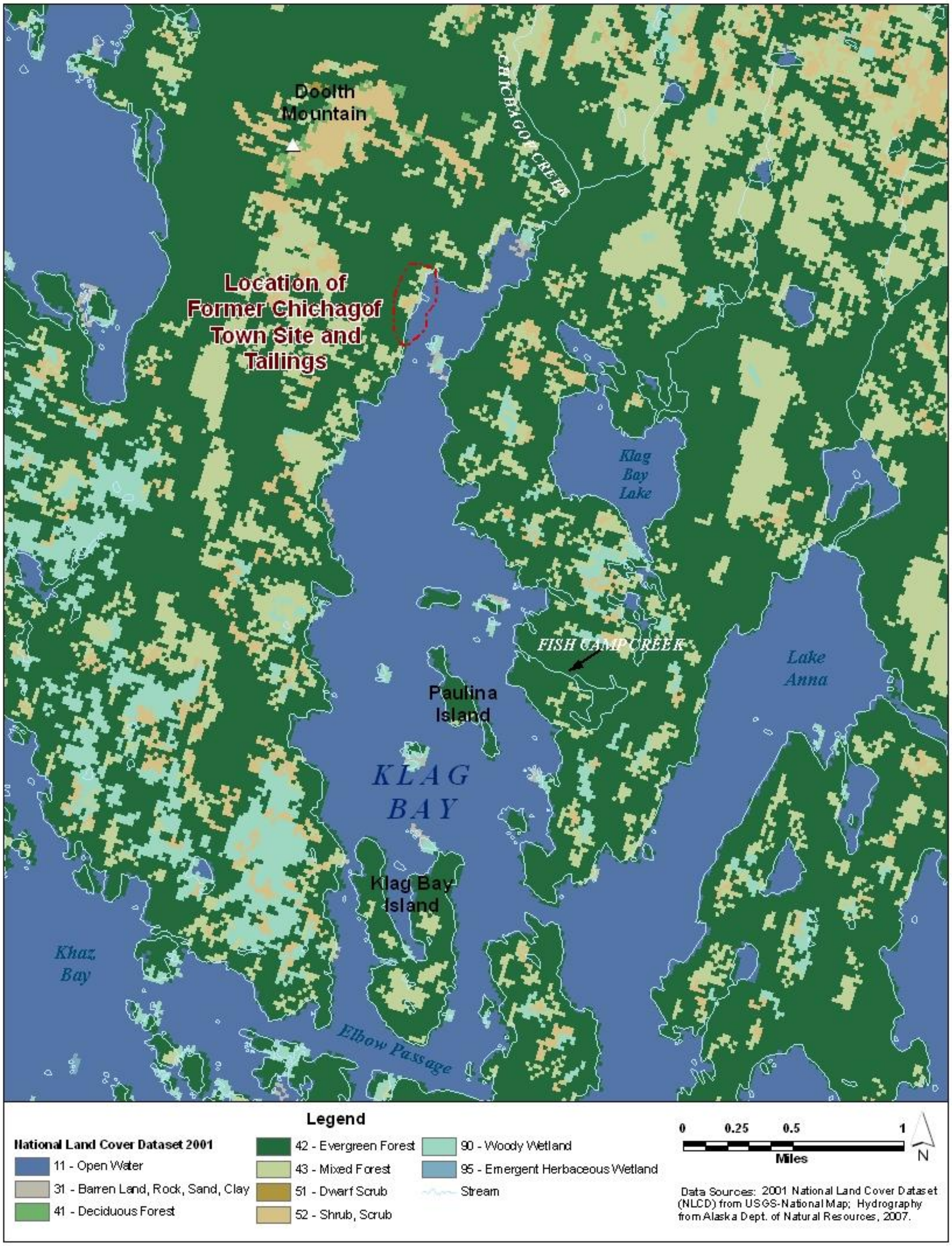


Figure 7. Land cover for the Klag Bay area (*based on 2001 NLCD*)



2.4. Climate

Southeast Alaska experiences heavy precipitation and tends to be warmer than other parts of the state. Precipitation can vary greatly over southeast Alaska depending on the proximity of the site to coastal waters and elevation of the site. The Western Regional Climate Center collects data for several climate stations in Southeast Alaska. The two nearest active stations to Klag Bay are: (1) Pelican 1E, which is approximately 20 miles to the north of Klag Bay and has data from 1967 to 2007; and (2) Sitka FAA Japonski Airport, which is approximately 50 miles southeast of Klag Bay and has data from 1949 to 2007. The Western Regional Climate Center has calculated average monthly precipitation since activation for both stations; Sitka Airport has an average annual precipitation of 85 inches and Pelican has an annual average of 148 inches. Average daytime temperature highs at Pelican range from the upper 20s in January to the mid 60s in August. The Sitka Airport tends to be about 5˚F warmer, with highs ranging from the mid 30s to the mid 60s.

2.5. Cultural History

No town or permanent residents are currently located at the former Chichagof mine site, nor are there any active industrial or commercial operations at the site. There are no roads leading to the bay, so it is only accessible by boat or plane.

Historically, the Sitka Tlingit clans claim ownership of Klag Bay where two villages were located prior to the 1800s. After the disappearance of their villages, some of the clan members continued to have smokehouses in the area and some of the abandoned buildings remain on the east side of the bay near fish camp creek. In the early 1900s, Sitka tribe members demonstrated their rights by posting signs to keep commercial fishermen out of the area (Goldschmidt et al. 1998).

Klag Bay and the connected Klag Lake system are still used for subsistence fishing of sockeye salmon by the Sitka Tlingit, as well as unidentified commercial sport fishing (Stahl et al. 2007). Klag Bay is the third most important producer of Sockeye salmon for subsistence users in Sitka (Lorrigan 2004). Subsistence and sport fishing are also known to occur on occasion in Chichagof Creek, north of the former mine site. The Sitka Tribe of Alaska, the U.S. Forest Service, and the Alaska Department of Fish and Game monitor subsistence fishing in Klag Bay and the Klag Lake system due to concerns of over-harvesting in the area (Stahl et al. 2007).

A commercial fishery is not currently located near Klag Bay. However, a commercial purse seine fishery in nearby Khaz Bay harvested a small number of sockeye from 1990 to 2005 and there is a potential for these fish to travel to Khaz Bay from the Klag Bay and Klag Lake system. While Klag Bay is closed to commercial seine fishing, commercial fishing is allowed in Sister and Anna Lakes, which connect to Klag Bay (Ecology and Environment 1999).

2.6. Biological Resources

Klag Bay is host to several fish species, notably sockeye and coho salmon who use Fish Camp Creek, which connects to the Klag Lake system, as a spawning habitat. In addition, there are smaller populations of pink and chum salmon, steelhead and cutthroat trout, Dolly Varden char, and threespine stickleback (Stahl et al. 2007). Chichagof Creek, north of the former mine site, is also host to pink, coho, and chum salmon runs. The salmon must pass near the mine tailings in order to reach Chichagof Creek; fry and molt are also reported to rear in the vicinity of the mine site (Ecology and Environment 1999). A 1986 study found that mercury, arsenic, and lead were detected above normally expected background levels in mussels (mercury and lead only), clam, and fish (yellowfin sole, Pacific tomcod, and kelp greenling) collected from Klag Bay (USFWS 1986).

Klag Bay is home to a variety of waterfowl and seabirds, which use the Chichagof Creek tidal flats as habitat. Sea otter also occasionally enter Klag Bay. Brown bear, Sitka black-tailed deer, mink, marten, and river otter are present on Chichagof Island and can potentially come in contact with the former mining site (USFWS 1980). In addition, bald eagles are common to the area and have been observed feeding on salmon at the mouth of Chichagof Creek.

In 2000, the U.S. Fish and Wildlife Service (USFWS) conducted a contaminant study on bald eagles and blue mussels to investigate potential impacts on these species due to the metal contaminants resulting from past mining activities. USFWS wanted to determine whether metal concentrations in resident birds warranted concerns, as some metals biomagnify in bald eagles. Nine adult bald eagles (seven males and two females) were trapped using floating herring lures and blood samples were collected. USFWS tested whole blood for a suite of metals, including total mercury and methylmercury (meHg). MeHg is the most toxic form of mercury and can bioconcentrate in fish, a primary food of eagles. Total mercury in blood ranged from 0.68 - 5.10 ppm wet weight (with a mean of 1.62), with MeHg constituting approximately 48 to 89 percent. These total mercury concentrations were comparable to residues reported in bald eagles from the Western United States. It appears from the data that bald eagles in the Klag Bay were bioaccumulating mercury, however it is unknown whether the source of the mercury is the Klag Bay sediments. Consequences of low-level mercury contamination are not known. USFWS did not collect information that would help determine any health effects to eagles in this study. . Arsenic, cadmium, copper, lead, selenium, and zinc were not detected at concentrations of concern in the bald eagle blood. USFWS also collected seven blue mussels for metals analysis. Blue mussel tissue concentrations of arsenic, barium, chromium, mercury, and lead were generally high in comparison to mussel data from other undeveloped Alaska sites. Table 1 summarizes the metal concentrations found in the bald eagle and blue mussel samples. The metals analyzed in the study include aluminum, arsenic, boron, barium, beryllium, cadmium, chromium, copper, iron, mercury, magnesium, manganese, molybdenum, nickel, lead, selenium, strontium, vanadium, and zinc; however, only metals with high concentrations are listed in Table 1.

Recently, additional bald eagle studies were conducted to determine whether heavy metal contamination is occurring due to consumption of salmon (Rudis 2008). The study found that the bald eagles are bioaccumulating mercury at about the same rate as bald eagles in the Western United States. Blue mussels were also sampled as part of this study and tissue concentrations of arsenic, barium, chromium, mercury, and lead were generally high in comparison to mussel data from other undeveloped Alaska sites.

Table 1. Sample results from the 2000 USFWS study in Klag Bay

Sample Number	Concentration (Dry Weight, ppm)				
	Mercury	Barium	Lead	Chromium	Arsenic
Sample: Bald Eagles					
62934506	7.16	<0.672	< 0.0081	< 0.0081	0.352
62934507	7.23	<0.708	< 0.0085	< 0.0085	1.33
62934508	8.16	< 0.696	< 0.0084	< 0.0084	1.36
62934509	4.09	< 0.625	< 0.0075	< 0.0075	1.57
62934510	5.29	< 0.688	< 0.0083	< 0.0083	0.661
62934556	15.5	< 0.651	< 0.0078	< 0.0078	1.04
62934557	8.96	0.671	< 0.008	< 0.008	0.811
62934558	3.88	< 0.694	< 0.0083	< 0.0083	1.15
62934559	11.9	< 0.76	< 0.0091	< 0.0091	0.748
Sample: Blue Mussels					
00kbC01A	0.784	15.5	4.14	6.74	14.4
00kbC01B	0.963	14.2	3.62	4.05	16.3
00kbC02A	0.292	7.41	< 0.963	1.99	6.08
00kbC02B	0.406	6.05	1.15	7.04	6.53
00kbM01A	0.581	7.49	7.98	23.2	16.6
00kbM02A	0.338	6.81	3.35	9.08	9.1
00kbM03A	0.21	8.94	1.59	9.49	8.52

3.0 APPLICABLE WATER QUALITY STANDARD

A TMDL identifies the amount of a pollutant that a waterbody can receive while still meeting applicable WQS. In Alaska, WQS include numeric and narrative water quality criteria that may not be exceeded in waters by human actions. Since Klag Bay is classified as marine waters, this section focuses on the applicable WQS for marine waters. Alaska's WQS regulations (18 Alaska Administrative Code [AAC] 70) designate seven specific designated uses for which water quality must be protected in marine waters, including: (1) aquaculture; (2) industrial; (3) contact recreation; (4) non-contact recreation; (5) growth and propagation of fish, shellfish, other aquatic life, wildlife; (6) seafood processing; and (7) harvesting raw mollusks or other aquatic life. Nearly all waterbodies in Alaska, including Klag Bay, are protected for all designated uses.

Alaska's WQS regulations (18 AAC 70) specify the pollutant limits, or criteria, necessary to protect the designated uses for a variety of parameters or pollutants for each of the seven marine water uses. The criteria are both narrative and numeric. The pollutants for which Alaska has developed water quality criteria for are: (1) color; (2) fecal coliform bacteria; (3) dissolved gas; (4) dissolved inorganic substances; (5) petroleum hydrocarbons, oils and grease; (6) pH; (7) radioactivity; (8) residues (floating solids, foam, debris, deposits); (9) sediment; (10) temperature; (11) toxic and other deleterious organic and inorganic substances; and (12) turbidity.

3.1. Parameter of Concern and Applicable Water Quality Criteria

Alaska included Klag Bay on its list of impaired waters due to exceedance of the "Toxic and other Deleterious Organic and Inorganic Substances" standard. Alaska developed this TMDL using the most stringent criteria of all the designated uses: "Growth and Propagation of Fish, Shellfish, Other

Aquatic Life, and Wildlife," which also is the use most directly affected by the toxic substance impairment in Klag Bay. For the "Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife" designated use, Alaska water quality criteria state that "…There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, adverse effects on aquatic life or produce undesirable or nuisance aquatic life, except as authorized by this chapter. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests" (18 AAC 70.020 (b)(23)). Table 2 summarizes the complete water quality criteria for toxic and other deleterious organic and inorganic substances.

Table 2. Alaska's water quality criteria for toxic substances and other deleterious organic and inorganic substances in marine waters (source: 18 AAC 70 Water Quality Standards, amended December 28, 2006, Alaska Department of Environmental Conservation).

(23) TOXIC AND OTHER DELETERIOUS ORGANIC AND INORGANIC SUBSTANCES, FOR MARINE WATER USES	
(A) Water Supply (i) aquaculture	Same as (23) (C).
(A) Water Supply (ii) seafood processing	The concentration of substances in water may not exceed the criteria shown in Table IV of the *Alaska Water Quality Criteria Manual*.
(A) Water Supply (iii) industrial	Concentrations of substances that pose hazards to worker contact may not be present.
(B) Water Recreation (i) contact recreation	There may be no concentrations of substances in water, that alone or in combination with other substances, make the water unfit or unsafe for the use.
(B) Water Recreation (ii) secondary recreation	Concentrations of substances that pose hazards to incidental human contact may not be present.
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	The concentration of substances in water may not exceed the criteria shown in Table IV and in Table V, column B of the *Alaska Water Quality Criteria Manual* (see note 5), or any chronic and acute criteria established in this chapter, for a toxic pollutant of concern, to protect sensitive and biologically important life stages of resident species of this state. There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, adverse effects on aquatic life or produce undesirable or nuisance aquatic life, except as authorized by this chapter. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests.
(D) Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life	Same as (23)(C).

3.2. Screening Criteria for Existing Water Quality Data

In order to further assess for water quality impairments based on the narrative water quality criteria, three screening criteria were compared to existing water quality data for Klag Bay. These screening criteria, referred to as the Threshold Effects Level (TEL), Effect Range-Low (ERL) and Probable Effects Level (PEL), are commonly used by the National Oceanic and Atmospheric Administration (NOAA) and others as benchmarks to assess whether concentrations of various contaminants have a probability of adverse biological effects. Based on a gradient of predicted increasing toxicity, a TEL is the lowest threshold criteria of the three; water quality concentrations below TELs ensure with a high degree of confidence that adverse biological effects are very rare. ERL is still on the conservative end of predicted toxicity, but higher than TEL; values at or above ERL levels are those at which toxicity may begin to be observed in sensitive species. Finally, PELs are criteria levels above which adverse effects are frequently expected. NOAA's Screening Quick Reference Tables are provided in Appendix B. For the purpose of establishing a target for most of the TMDLs, the ERL appears most appropriate for the primary reason that below ERL criteria, minimal effects on aquatic life are observed.

4.0 WATER QUALITY ANALYSIS

4.1. Summary of Existing Water Quality Data

To date, two studies present the extent of water quality data collected within Klag Bay over the past three decades (mid 80s to present). Specific details about each of the two studies and the water quality data are provided in the following pages, including a summary of data for metals in which sediment concentrations were in exceedance of the ERL screening criteria and/or higher than estimated background concentrations. Figures 8 and 9 show the approximate locations of the sediment sample sites from both the 1986 and 1999 studies. All of the site locations are approximated based on information provided in the reports for these studies. The report for the 1999 study provided global positioning system (GPS) data for each of the sample sites, which were used to develop a map showing the approximate locations of each of the sample sites (shown as red circles in Figures 8 and 9). GPS data were not available for the 1986 study; therefore, the site locations (shown as green circles in Figure 8 and 9) were approximated from a hard copy map (Appendix C).

Figure 8. Approximate sample locations from the 1986 USFWS and 1999 Ecology and Environment sediment studies in Klag Bay

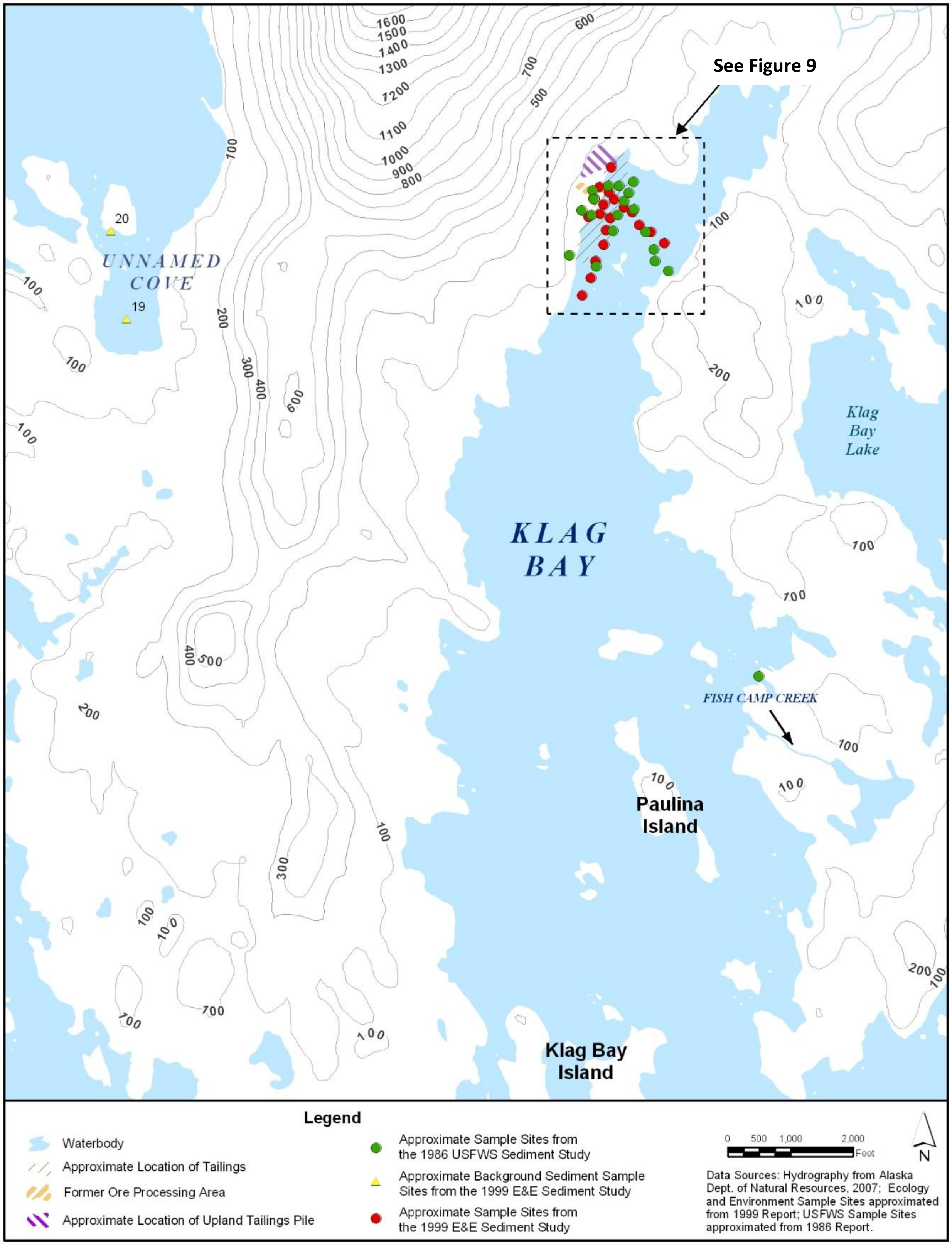
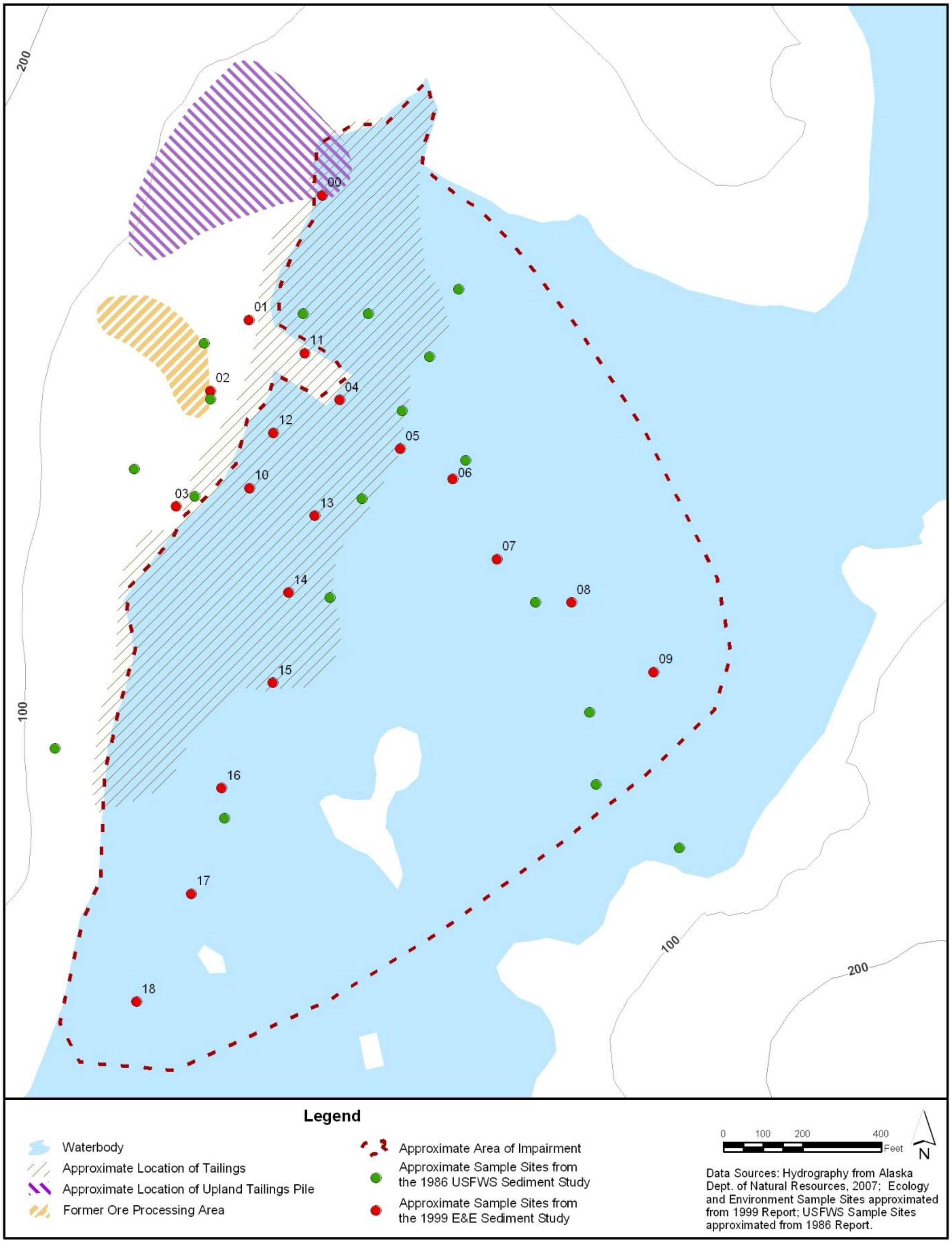


Figure 9. Approximate sample locations from the 1986 USFWS and 1999 Ecology and Environment sediment studies in Klag Bay



Study #1 – Combined Preliminary Assessment/Site Inspection Report, Klag Bay, Chichagof Island, Alaska, Ecology and Environment, Inc. (E&E), prepared for USEPA, March 1999

In September 1998, E&E conducted a Preliminary Assessment/Site Inspection (PA/SI) at the Klag Bay site. The purposes of the PA/SI were to conduct limited sampling to characterize the potential sources, determine off-site migration of contaminants, provide adequate information to determine whether the site was eligible for placement on the National Priorities List, and to document any threat or potential threat to public health or the environment posed by the Klag Bay site. The PA/SI involved the collection of samples from potential hazardous substance source areas located below the high tide line and from target areas potentially impacted through contaminant migration.

A total of 21 sediment samples were collected during the PA/SI; seven were collected from the original tailings deposition area located on shore, twelve were collected along two transect lines (East-West and North-South Transect Lines, six samples each) within Klag Bay, and two background samples were collected in an unnamed cove outside and northwest of Klag Bay. This cove was chosen as a background sample site because it has the same soil types as Klag Bay and its tributaries originate at the top of Doolth Mountain, where Klag Bay's tributaries also originate. GPS data from the 1999 E&E report were used to develop a map showing the approximate locations of the sample sites (shown as red circles in Figures 8 and 9).

Data for metals in which sediment concentrations were in exceedance of the ERL screening criteria or higher than estimated background concentrations were pulled from the report for use in developing metal-specific TMDLs. A summary of the sediment metal concentration data are provided in Table 3, with the ERL for each contaminant highlighted in orange. The sediment metal concentration data from the 1999 E&E study are also graphically summarized in Appendix D. Figure 10 shows the minimum and maximum sediment metal concentrations from the 1999 E&E study, along with the ERL and an average of the background concentrations.

Sediment concentrations of mercury and silver were fairly consistent along both transect lines, indicating that both contaminants may be migrating into the inner basin and out towards the entrance of Klag Bay. Sediment mercury concentrations in the samples ranged from 0.2 to 4.5 mg/kg compared to an ERL of 0.15 mg/kg. Sediment silver concentrations ranged between 0.4 to 8.0 mg/kg compared to an ERL of 1.0 mg/kg. Mercury and Silver were generally detected at higher concentrations in samples consisting of finer-grained sediments. Finer-grained sediments are more susceptible to resuspension due to tidal and current activity and this may explain why mercury and silver appear to have migrated further within the inner bay as compared to the other contaminants.

Sediment arsenic concentrations in the samples ranged from 44.4 to 844.0 mg/kg compared to an ERL of 8.2 mg/kg. Arsenic was detected at fairly consistent concentrations along the East-West transect line within the inner basin. Arsenic was also detected at elevated concentrations in the uplands tailings pile and the two sample points closest to the tailings deposition area along the North-South transect line within the inner basin. Both of these trends indicate that the migration of arsenic appears to be limited to within the inner basin. Sediment concentrations of lead ranged from 6.6 to 350.0 mg/kg compared to an ERL of 46.7 mg/kg. Lead was detected at fairly consistent concentrations in samples collected along the East-West transect line. Heaviest concentrations of lead were detected in the shoreline tailings in the vicinity of the wharf.

The results of the 1999 E&E sediment sampling study show that sediment concentrations of arsenic, lead, and mercury were generally higher along the East-West transect line (within the inner basin) as compared to samples taken along the North-South transect line, which indicates that the contaminants are tending to migrate in a southeasterly direction within the inner bay. This is consistent with conclusions made in the 1986 USFWS report.

Appendix D provide a comparison of metal concentration data between samples collected in the vicinity of the contaminated site and samples collected in the background (baseline) site. In addition, the contaminated site data are compared to ERL values. These comparisons provide a general idea of the degree to which metal concentrations exceed background (baseline) and ERL levels. As illustrated in Figure 10, background concentration samples were below the ERL values for all of the metals sampled with the exception of arsenic. In this case, background samples were 2 to 3 times higher than the ERL concentrations for arsenic, suggesting a naturally elevated presence of arsenic in the sediments and source rock within the area that should be further defined with additional background samples in the undisturbed areas near Klag Bay.

Table 3. Klag Bay marine sediment sample data from the 1999 E&E study

EPA Sample Number	Depth below ground surface	Concentration (mg/kg)								
		Mercury	Cobalt	Lead	Zinc	Arsenic	Silver	Copper	Manganese	Cadmium
Location: East-West Transect Line										
98384404	0-4"	0.459	11.8	79.8	136	248	0.4	49.9	394	0.2
98384405	0-4"	1.11	1.6	39.3	48.6	123	1.79	22.4	262	0.46
98384406	0-3"	1.19	1.3	35.2	45	111	1.89	23.9	252	0.63
98384407	0-4"	1.47	1.6	41.7	50.7	109	1.66	24	234	0.71
98384408	0-4"	1.81	1.7	51.5	64.3	136	2.38	29.5	229	1.39
98384409	0-4"	4.53	2.7	62.3	79	181	2.53	34.8	200	2.65
Location: North-South Transect Line										
98384413	0-3"	1.18	1.3	48.3	50.1	98.6	1.4	21.2	248	0.42
98384414	0-2"	0.239	2	6.55	31.0	50.7	1.1	9.78	247	0.34
98384415	0-2"	0.193	1.5	6.82	40.3	45.7	1.2	8.49	241	0.34
98384416	0-4"	0.522	0.88	8	29.3	44.4	1.2	11.6	250	0.45
98384417	0-3"	0.902	1.2	25.7	36.8	73.1	1.4	15.7	256	0.48
98384418	0-4"	0.629	10	50	39	80	8	20	157	4
Location: Shoreline Tailings										
98384400	0-6"	0.196	15.1	42	126	844	1.84	62.7	573	0.2
98384401	0-6"	0.957	17.9	350	163	161	0.49	57.6	728	0.2
98384402	0-6"	0.161	17.1	22.6	152	312	0.4	81.8	549	0.2
98384403	0-6"	0.593	7.58	155	123	137	7.35	70.9	467	0.2
98384410	0-6"	0.907	3.12	91.4	95	152	1.73	29.6	300	0.7
98384411	0-6"	1.07	8.26	51.6	113	306	1	36.2	440	0.32
98384412	0-6"	1.05	8.36	322	357	163	0.4	97.8	312	0.83
Background Samples										
8384419	0-4"	0.126	2.8	5.85	75.5	26.7	0.8	28.9	158	14.9
8384420	0-4"	0.085	3.18	3.4	54.4	15.9	0.4	13.8	205	4.6
Average		0.106	2.99	4.63	65	21.3	0.6	21.4	182	9.75
Effects Range-Low (ERL)		**0.15**	**n/a**	**46.7**	**150**	**8.2**	**1.0**	**34.0**	**n/a**	**1.2**

Study #2 – Klag Bay Study (Effects of Metals on Bay), USFWS, 1986

In 1986, USFWS conducted an initial investigation on contaminants due to past mining activities in Klag Bay. The study generated preliminary data and information for use in evaluating potential environmental impacts of two proposed mining schemes that would require dredging and/or displacement of the old tailings.

The study included the collection of fish, invertebrate, and marine sediment samples for analysis of metals to determine the extent of contamination. The sediment samples were collected within the inner basin of the subtidal zone, located at the north end of Klag Bay (Figures 8 and 9). The approximate locations of the sample sites for the 1986 USFWS study (shown as green circles in Figures 8 and 9) are not definite, nor based on GPS data; the site locations were approximated from a hard copy map made available in the 1986 report (Appendix C).

Data for metals in which sediment concentrations were in exceedance of the ERL screening criteria or higher than estimated background concentrations were pulled from the report for use in developing metal-specific TMDLs. A summary of the sediment metal concentration data are provided in Table 4, with the ERL for each contaminant highlighted in orange. The sediment metal concentration data from the 1986 USFWS study are also graphically summarized in Appendix E. Figure 10 shows the minimum and maximum sediment metal concentrations from the 1986 USFWS study, along with the ERL and an average of the background concentrations determined from the 1999 E&E study.

Sediment mercury concentrations (dry weight mean) within the inner basin of Klag Bay, where the tailings were deposited, ranged from 0.2 to 3.2 mg/kg, compared to an ERL of 0.15 mg/kg. The highest mercury concentrations were detected in the southeastern portion of the bay. Sediment arsenic concentrations (dry weight mean) ranged from 4.0 to 668 mg/kg, compared to an ERL of 8.2 mg/kg, with concentrations generally decreasing as the distance from the tailings pile increases. Sediment silver concentrations (dry weight mean) ranged from 0.8 to 2.4 mg/kg, compared to an ERL of 1.0 mg/kg. Sediment lead concentrations (dry weight mean) ranged from 3 to 151 mg/kg, compared to an ERL of 46.7 mg/kg. Sediment concentrations of cadmium, zinc, and aluminum generally followed the same trends as mercury, arsenic, silver, and lead.

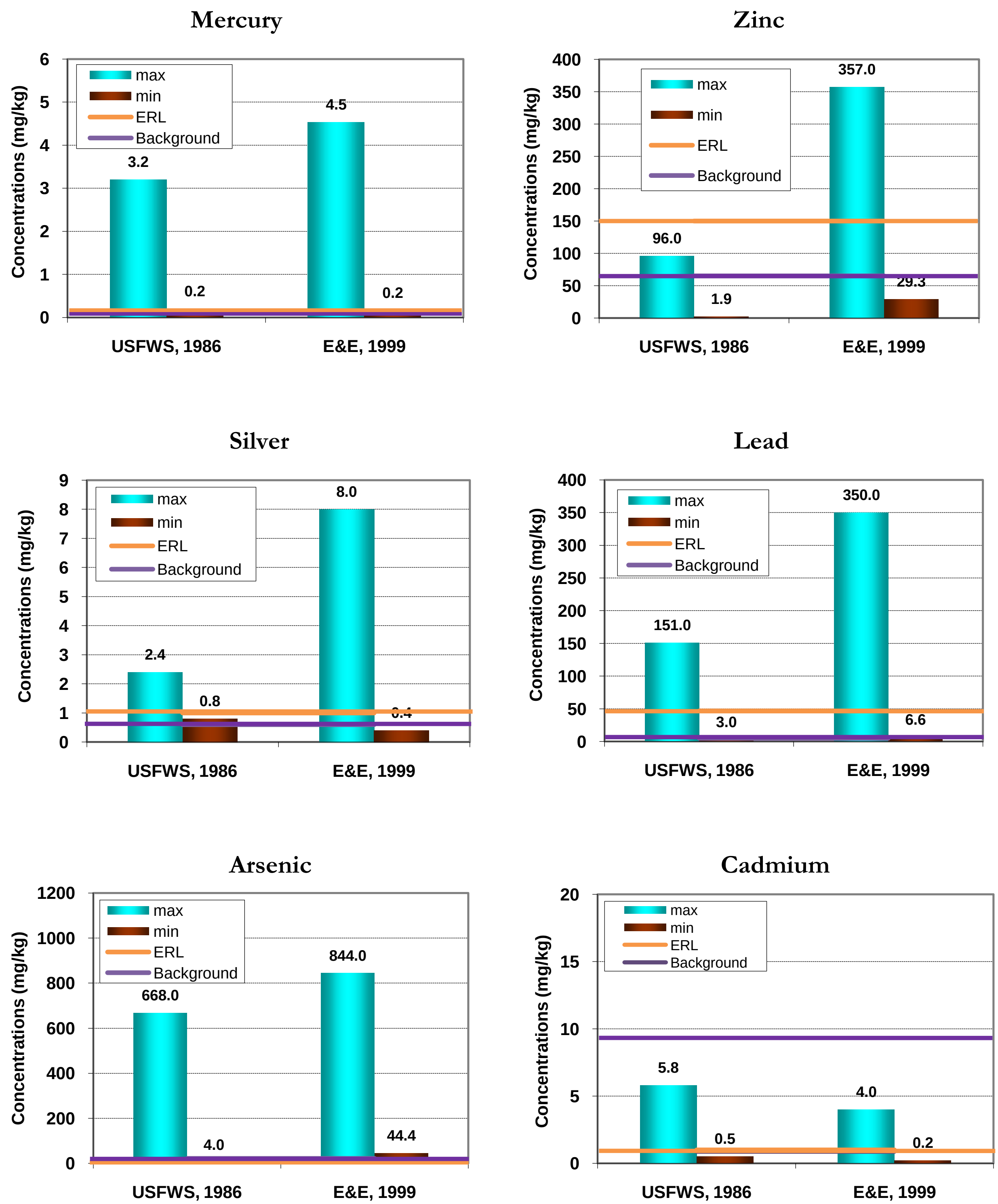
Findings of the 1986 USFWS study indicate that contamination of sediment appears to be restricted to the inner bay, as sediments beyond the inner bay (i.e., south towards the entrance of the bay at Vorota Island) contain concentrations close to "expected natural background concentrations" (USFWS 1986). Metals found at greater concentrations within the north and southwest portions of the inner bay are likely a result of prevailing currents and tidal activity within the bay. This deposition primarily occurred during the mining activity when waste rock was deposited along the shore. Tidal activity likely resuspended the freshly deposited, or still settling, tailings and currents washed them out into deeper waters towards the North – Northwest with the incoming flood tide. With the ebb tide, currents reversed and, in a clockwise direction, washed residual suspended sediment out to the south.

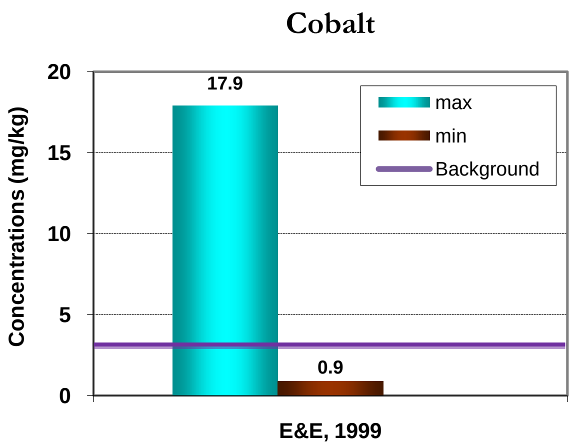
Samples were not collected at background sites as part of the 1986 USFWS study. Therefore, background concentration data from the 1999 E&E study were used for comparison purposes.

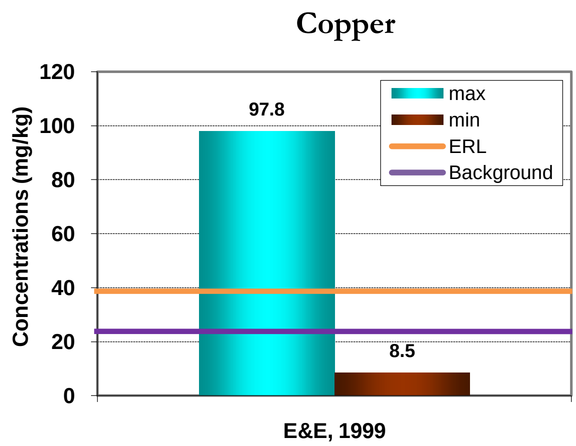
Table 4. Klag Bay marine sediment sample data from the 1986 USFWS study (as cited in Ecology and Environment 1999)

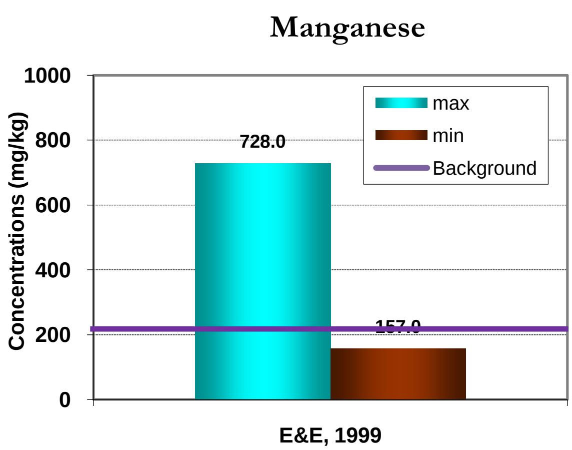
Distance from Tailings Pile (meter)	Water Depth (meter, reference Mean Lower Low Water)	Mean Concentration (dry weight means, mg/kg)					
		Mercury	Cadmium	Lead	Zinc	Arsenic	Silver
Location: South Track							
44	3.2	1.7	1.8	48	70	193	1.4
130	6.3	2.1	3.4	61	79	340	2.3
175	8.5	2.7	3.0	63	77	127	2.0
220	7.7	3.1	3.2	67	81	230	2.0
300	7.5	3.1	3.4	63	75	203	1.2
350	7.5	3.2	3.8	64	79	193	1.9
480	6.6	2.9	5.4	61	89	140	1.6
Location: Southwest Track							
87	7.3	3.0	5.8	63	96	668	2.1
130	9.4	1.9	2.0	56	61	173	1.6
175	10.4	1.6	1.5	41	60	127	1.2
240	2.1	1.4	0.9	17	31	68	1.0
260	8.1	0.6	0.6	14	26	47	0.8
1400	20.1	0.2	0.6	3	7	66	0.8
Location: Intertidal							
90	Intertidal	1.8	2.1	56	79	197	2.4
130	Intertidal	1.0	1.7	67	81	157	2.1
174	Intertidal	1.2	1.4	151	1.9	150	2.4
260	Intertidal	0.5	0.7	17	45	57	1.3
2000	Intertidal	0.2	0.5	7	44	4	0.8
Effects Range-Low (ERL)		**0.15**	**1.2**	**46.7**	**150**	**8.2**	**1.0**

Figure 10. Range of sediment metal concentrations from the 1986 USFWS and 1999 E&E studies. The estimated background concentration shown on these graphs was developed by taking an average of the two background concentrations from the 1999 E&E study.




Cobalt
20
15
10
5
0
Concentrations (mg/kg)
17.9
0.9
max
min
Background
E&E, 1999


Copper
120
100
80
60
40
20
0
Concentrations (mg/kg)
97.8
8.5
max
min
ERL
Background
E&E, 1999


Manganese
1000
800
600
400
200
0
Concentrations (mg/kg)
728.0
157.0
max
min
Background
E&E, 1999

4.2. Analysis of Existing Water Quality Data

The following factors need to be taken into consideration when evaluating and comparing data from the two sediment sampling studies available for Klag Bay:

1. ***Location of samples.*** Sample locations in the studies are not identical.
2. ***Quantity of samples.*** The number of samples collected in each study is inadequate to perform a meaningful statistical analysis of trends. However, it does provide sufficient data to evaluate the distribution of concentrations and to support a preliminary assessment of contaminants of concern to aquatic life.
3. ***Contaminant concentration values.*** In the 1999 E&E study, the sediment metal concentrations are presented in real values; however, the concentrations are presented in mean values in the 1986 USFWS study (real values are not available in the original report). Caution must be taken when comparing results from these two studies.

As described in the 1986 USFWS and 1999 E&E studies, the contamination of marine sediments appears to be restricted to the inner bay, though migrating in a southeasterly direction within the inner bay. Due to the absence of sampling data since 1999, it is unknown if the metal concentrations have continued to migrate further southeast within the inner bay or whether natural recovery has begun in the bay.

4.3. Impairment Assessment

As indicated in the 1986 USFWS and 1999 E&E studies, the following metals pose a potential toxicity threat to aquatic life based on the use of the ERL screening criteria as the TMDL target:

- ***Mercury:*** All of the samples from the studies have concentrations higher than the ERL concentration.
- ***Arsenic:*** Although background concentrations are likely to be above the ERL due to naturally elevated concentrations from the local parent rock (geology), 36 of the 37 (97%) samples have concentrations higher than the ERL concentration.
- ***Silver:*** 30 of the 37 (81%) samples have concentrations higher than the ERL concentration.
- ***Lead:*** 23 of the 37 (62%) samples have concentrations higher than the ERL concentration.
- ***Cadmium:*** 16 of the 37 (43%) samples have concentrations higher than the ERL concentration.
- ***Copper:*** 8 of the 19 (42%) samples have concentrations higher than the ERL concentration.
- ***Zinc:*** 3 of the 37 (8%) samples have concentrations higher than the ERL concentration.

The following metals have no established NOAA screening criteria, but are elevated above background levels, which may indicate a potential toxicity threat to aquatic life:

- ***Cobalt:*** 9 of the 17 (53%) samples have concentrations above the mean concentration of the two background samples.
- ***Manganese:*** 18 of the 19 (95%) samples have concentrations above the mean concentration of the two background samples.

The 1986 USFWS study included a limited number of fish and invertebrate samples to determine the extent of contamination due to the metals deposited from the past mining activities. The 1986 study found that mercury, arsenic, and lead were detected above normally expected background levels in mussels (mercury and lead only), clam, and fish (yellowfin sole, Pacific tomcod, and kelp greenling) collected from Klag Bay. Also, soft shell clams were found to have abnormal anatomical structure – the shell margins were uneven and the edge of the mantle was black instead of the normal white (USFWS, 1986). The 1999 E&E study only sampled marine sediments and did not collect data for fish or invertebrates.

The 1986 USFWS study concluded that, in general, sediment contamination seemed to be restricted to the inner bay with sediment concentrations beyond the inner bay being close to the expected natural background concentration. The 1999 E&E study also concluded that most migration of most metals appears to be limited to within the inner bay; however, the 1999 study indicated that some metals (mercury, silver, and lead) may be migrating toward the outer bay in a southeasterly direction. Additional studies will need to be conducted to further assess for potential migration of the contaminated sediments in the bay.

A bald eagle study was conducted in Klag Bay in 2008 to determine whether heavy metal contamination is occurring due to consumption of salmon found that the bald eagles are bioaccumulating mercury at about the same rate as bald eagles in the Western United States (Rudis 2008). Blue mussels were also sampled as part of this study and tissue concentrations of arsenic, barium, chromium, mercury, and lead were generally high in comparison to mussel data from other undeveloped Alaska sites.

5.0 SOURCE ASSESSMENT AND POLLUTION CONTROL EFFORTS

5.1. Point Sources

There are currently no active mining operations in the bay, or permanent human activity around the bay; consequently there are no known permitted point sources for Klag Bay. No National Pollution Discharge Elimination System (NPDES) Permits have been issued for facilities in Klag Bay. Any future sources will be subject to the wasteload allocations established in this TMDL (see Section 7.1). If future activity is proposed at the Klag Bay site that will entail discharge of toxic or other deleterious organic and inorganic substance discharges into Klag Bay, the TMDL may be revised to include modified WLAs. Possible revision of the WLA in this TMDL will depend on analysis of relevant factors at that time.

5.2. Nonpoint and Natural Sources

Mine tailing deposits in Klag Bay are the result of the former Chichagof Mine, which ceased operation in 1942. Although many of the metals (e.g., arsenic, lead, zinc, etc.) are naturally occurring in their original state, the mining activities expanded the exposure potential to these naturally occurring metals through excavation, crushing, treatment, and disposal of the mine tailings in Klag Bay. Approximately 500,000 tons of tailings were deposited along the shoreline of Klag Bay from the former Chichagof Mine operations. Naturally occurring levels of arsenic, lead, and zinc from the ore host rock in these tailings were concentrated by the milling and recovery process. Further, approximately 200,000 tons of mine waste rocks were deposited in the uplands pile adjacent to the

Klag Bay. In addition, trace mercury, likely from the amalgamation process, is also present in the bay (Ecology and Environment 1999).

The mine tailing deposits are located in the intertidal and subtidal zones of the bay, which provides a potentially significant, continuous unquantifiable loading of metals to the bay. While the upland pile is not located in the bay, a small spring was observed to discharge at the base of the pile. Also, the shoreline pile is subject to stormwater runoff that discharges directly to the bay or percolates through the pile and eventually discharges to the bay via submarine springs (Ecology and Environment 1999). Stormwater runoff from the site provides a potential source of continuous loading of metals from the contaminated sediments into the inner bay waters. Further, wider migration or export of the metals from the subtidal areas may continue to occur into the outer bay due to tidal influences.

There are no known undisturbed natural sources of toxic and other deleterious organic and inorganic substances known at the site. However, the background sediment samples collected in the unnamed cove, at the west of Doolth Mountain (Figure 8) during the 1999 E&E study did contain metal concentrations higher than the ERLs for arsenic and cadmium, which may suggest naturally elevated presence of these metals in the sediments and source rock within the area. Future studies should include the collection of additional background sediment samples for all metals in the unnamed cove, as well as in other locations that are considered characteristic of background conditions.

5.3. Summary of Past and Present Pollution Control Efforts

To date, no known actions have been taken to address these impairments.

6.0 DETERMINATION OF LOAD CAPACITY

6.1. Water Quality Target

The water quality target for a given pollutant in a TMDL is a numeric or narrative expression that serves as the goal for the TMDL, which equates to attainment of the WQS. The target is also the basis for establishing the loading capacity. Although a specific target and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether the targets and allocations are met but whether designated uses are supported and WQS are achieved. Where appropriate, a target is simply the applicable numeric water quality criterion for the pollutant causing the impairment. The water quality criterion for "Toxic and other Deleterious Organic and Inorganic Substances" is a narrative expression, which states that "There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, adverse effects on aquatic life or produce undesirable or nuisance aquatic life. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests" (18 AAC 70.020 (b)(2)).

For the purpose of establishing a TMDL target for toxic substances in Klag Bay, the ERL appears most appropriate for most of the metals for the primary reason that below ERL criteria, minimal effects on aquatic life are observed; values at or above ERL levels are those at which toxicity may begin to be observed in sensitive species. NOAA's Screening Quick Reference Table, which lists the ERLs, is provided in Appendix B. ERL criteria were not available or deemed not appropriate for some metals, including arsenic, cadmium, cobalt, and manganese. ERLs are not available for manganese and cobalt, and estimated background concentrations for arsenic and cadmium are higher than the ERLs for these metals, which may suggest naturally elevated presence of these metals in the sediments and source rock within the area. Therefore, the numeric TMDL targets for arsenic, cadmium, cobalt, and manganese were set equal to the mean background sample concentration, which represents a conservative approach to developing the TMDL given known available data and information. As discussed in the Implementation Section of this report (Section 8), future sampling efforts in Klag Bay should include additional background samples in undisturbed areas near Klag Bay in order to further define background concentrations. Table 5 summarizes the numeric targets that represent the sediment metal concentration endpoints for the Klag Bay TMDL.

Table 5. TMDL Targets for Klag Bay

Metals	TMDL Target	MOS
Mercury	0.15 mg/kg (ERL)	10% of TMDL target
Arsenic	21.3 mg/kg (mean background sample concentration)	Implicit in target
Copper	34.0 mg/kg (ERL)	10% of TMDL target
Lead	46.7 mg/kg (ERL)	10% of TMDL target
Silver	1.0 mg/kg (ERL)	10% of TMDL target
Zinc	150.0 mg/kg (ERL)	10% of TMDL target
Cadmium	9.75 mg/kg (mean measured background concentration)	Implicit in target
Manganese	181.5 mg/kg (mean measured background concentration)	Implicit in target
Cobalt	2.99 mg/kg (mean measured background concentration)	Implicit in target

6.2. Loading Capacity

The loading capacity (LC) for a given pollutant is the greatest amount of pollutant that a waterbody can receive without violating applicable WQS, as reflected by the water quality target and taking into account a margin of safety. If the target is a numeric criterion and discharge sources are present, the LC can be calculated as the highest pollutant load that will not cause the criterion to be exceeded (typically expressed as kg/day or another suitable time-based measure).

The TMDL for toxic substances in Klag Bay sediments is concentration-based (mg/kg), consistent with both Alaska's narrative water quality criterion (18 AAC 70.020 (b)(2)) and the numeric targets established for this TMDL. The loading capacities for toxic substances in Klag Bay are equal to the numeric targets identified in Section 6.1 and Table 5. To calculate the percent reductions required to meet the LC, the following formula was applied:

$$Percent\ Reduction = \frac{(Measured\ Concentration - \ TMDL\ Target)}{(Measured\ Concentration)} \times 100$$

7.0 POLLUTANT LOAD ALLOCATIONS

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources so that appropriate control measures can be implemented and WQS achieved. Individual WLAs are assigned to existing and future discharges regulated by NPDES permits (commonly called point sources) and loads from diffuse sources loads (commonly called nonpoint sources) are contained in LAs. A TMDL is expressed as the sum of all individual WLAs for point source loads, LAs for nonpoint source loads, and an appropriate margin of safety (MOS) that takes into account uncertainty, as follows:

$$TMDL = \sum WLA + \sum LA + MOS$$

7.1. Wasteload Allocation (WLA)

There are currently no active mining operations in the bay or permanent human activity around the bay; consequently there are no known permitted point source dischargers in Klag Bay. No NPDES permits have been issued for facilities in Klag Bay. Therefore, the WLA for all of the toxic substances of focus in this TMDL is set at 0 mg/kg for Klag Bay sediments, and all of the loading capacity is allocated as a gross allotment to the load allocation, minus the margin of safety and background concentrations, which are summarized in Table 6. Any future point source dischargers will be subject to the wasteload allocations established in this TMDL. If future activity is proposed at the Klag Bay site that will entail discharge of metals into Klag Bay, the TMDL may be revised to include modified WLAs. Possible revision of the WLA in this TMDL will depend on analysis of relevant factors at that time.

7.2. Load Allocation (LA)

Mine tailing deposits in Klag Bay are the result of the former Chichagof Mine, which ceased operation in 1942. There are no known existing nonpoint sources of toxic or other deleterious organic and inorganic substances affecting the impaired area other than background concentrations and historic/legacy toxic or other deleterious organic and inorganic substances. The load allocation for nonpoint sources of toxic or other deleterious organic and inorganic substances in Klag Bay is equal to the loading capacity, minus the margin of safety; further, the load allocation is allocated to background and anthropogenic sources using available data on mean background concentrations from the 1999 E&E study. The load allocation is summarized in Table 6. Since the targets for arsenic, cadmium, manganese, and cobalt are set equal to mean background conditions, there are no loads to allocate to anthropogenic sources or activities (past or present) for these particular metals.

During the TMDL analysis, it was determined that a TMDL is not needed for cadmium, as the highest observed sediment cadmium concentration in Klag Bay (5.8 mg/kg) does not exceed the target for the TMDL (9.75 mg/kg); however, it is suggested that future monitoring in Klag Bay include cadmium, including for samples at sites representative of expected background conditions.

Table 6. TMDL Load Allocations for Klag Bay

Metals	Highest Observed Sediment Concentration (mg/kg)	WLA (mg/kg)	LA (mg/kg)		MOS (mg/kg)	Loading Capacity (mg/kg)	% Reduction Needed to Meet the TMDL
			Background	Anthropogenic			
Mercury	4.53	0	0.106	0.029	0.015	0.15	96.7%
Arsenic	844.0	0	21.3	0.0	0.0	21.3	97.5%
Copper	97.8	0	21.35	9.25	3.4	34.0	65.2%
Lead	350.0	0	4.625	37.405	4.67	46.7	86.7%
Silver	8.0	0	0.6	0.3	0.1	1.0	87.5%
Zinc	357.0	0	64.95	70.05	15.0	150.0	58.0%
Cadmium	5.8	NA	9.75	NA	NA	9.75	TNN*
Manganese	728.0	0	181.5	0.0	0.0	181.5	75.1%
Cobalt	17.9	0	2.99	0.0	0.0	2.99	83.3%

*TNN = TMDL Not Needed

7.3. Margin of Safety (MOS)

A margin of safety (MOS) must be included in a TMDL to account for any uncertainty or lack of knowledge regarding the pollutant loads and the response of the receiving water. The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. As shown in Table 5, the MOS for mercury, copper, lead, silver, and zinc is explicit and 10% of the load is reserved for the MOS in order to account for uncertainties in the TMDL. The MOS for arsenic, cadmium, manganese, and cobalt is considered implicit through use of a conservative target for the TMDL (i.e., lowest mean background concentrations). Since the targets for arsenic, cadmium, manganese, and cobalt are essentially background conditions, there are no loads to allocate to anthropogenic sources or activities (past or present).

7.4. Seasonal Variation

TMDLs must be developed with consideration of seasonal variation. Seasonal variation in pollutant loadings, waterbody response, and impairment conditions can affect the development and expression of a TMDL. A TMDL should include wasteload and load allocations that ensure the waterbody will maintain water quality standards under all expected conditions.

The impairment in Klag Bay is not associated with a particular season or environmental condition. The impairment is a result of deposition of mine tailings from the former Chichagof Mine and the increased exposure potential of many naturally occurring metals (e.g., arsenic, lead, zinc, etc.) due to the excavation, crushing, treatment, and disposal of the mine tailings in Klag Bay. Therefore, development of the TMDL for specific seasons and conditions is not necessary; the wasteload and load allocations are established to be protective under all seasons and conditions.

7.5. Future Growth

There are no current or apparent future sources of toxic or other deleterious organic and inorganic substance discharges into Klag Bay. No future discharge of toxic or other deleterious organic and inorganic substance discharges into Klag Bay will be permitted until WQS are met or the TMDL is revised. Several companies have reportedly leased the former Chichagof Mine property from the CDC during the 1980s and 1990s with interests in reopening the mine and reprocessing the mine tailings. However, none of the companies ever finalized the plans (Ecology and Environment 1999). Nonetheless, the future of the mining industry and use of the former Chichagof Mine site could change. If future activity is proposed at the Klag Bay site that will entail discharge of toxic or other deleterious organic and inorganic substance discharges into Klag Bay, the TMDL may be revised to include modified WLAs. Possible revision of the WLA in this TMDL will depend on analysis of relevant factors at that time.

8.0 IMPLEMENTATION

8.1. Possible Future Actions

The 1986 USFWS study concludes that dredging of the sediment (to recover gold) would result in disturbance of contaminated sediments and may result in spreading these contaminants throughout the presently uncontaminated areas of Klag Bay. The study concluded that the concentrations of these contaminants will decrease with time, due to natural sedimentation processes, if the system is not disturbed.

Although sediment samples were collected at similar (but not identical) sites in both 1986 and 1999, the results of the studies are inconclusive with regards to potential changes in the sediment metal concentrations from 1986 to 1999. The number of samples collected in each study is inadequate to perform a meaningful statistical analysis of trends. Further, in the 1999 E&E study, the sediment metal concentrations are presented in real values; however, the concentrations are presented in mean values in the 1986 USFWS study (real values are not available in that report). Additional sampling may be able to provide more useful data for determining whether natural recovery or migration of the contaminated sediments is occurring in the bay.

Given that toxic substances in Klag Bay will persist for a substantial but unknown period, it is not feasible to establish an exact time frame in which Klag Bay will achieve recovery to a "natural condition," as immediate compliance with this target would require removal of all toxic substances and such action is not recommended for Klag Bay due to the high potential for resuspension of toxic substances in the water column, disruption to the fish and benthic community, technical feasibility, costs, and waste disposal issues. Therefore, monitored natural recovery (MNR) is the recommended alternative. If, however, natural recovery does not result in decreased concentrations of the metals and compliance with the targets set by this TMDL, then in-situ capping or other options should be explored.

"MNR is a remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediments…These processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants" (USEPA 2005). MNR includes various mechanisms that affect concentrations and/or availability of toxic substances at the surface and near surface of the sediment bed, including: conversion to a less toxic chemical form through transformation processes such as biodegradation; reduction of chemical mobility or bioavailability through processes binding contaminants to the sediment matrix; and reduction of exposure levels by a decrease in chemical concentrations in the near-surface sediment through burial or mixing-in-place with cleaner sediment. The monitoring component of MNR is needed to track the progress of changes in the matrices of interest (e.g., sediment, water, etc.) and determine whether the expected and/or acceptable changes are actually occurring. Monitoring should focus on those measures that will be used to determine compliance with the TMDL. Specific monitoring recommendations are outlined in Section 8.2.

In addition to MNR, the following additional actions are recommended for Klag Bay:

1. Conduct a site visit (in conjunction with the Contaminated Sites Program) to survey the tailings deposits and look for evidence for the potential for contaminants from the uplands waste rock pile to further leach into the bay's waters (e.g., via runoff).

2. Place restrictions in the inner bay and adjacent land areas to future development activity that may potentially disturb the existing tailings pile, or marine sediments within the inner bay. This includes working with the existing mine property owner in restricting activity in land areas upland of the former site of the town and wharf.

3. Post warning signs about the contamination.

4. Identify and contact potential stakeholders to inform them of the impairment, the restrictions, and warnings about fishing in the bay.

If future mining activity is proposed at the former Chichagof Mine site, ADEC may revise this TMDL, in conjunction with the process to issue a NPDES permit, to include modified wasteload allocations. Possible revision of the TMDL will depend on analysis of relevant factors at that time.

8.2. Follow-up Monitoring

Monitoring recommendations include planning and implementing a field sampling program to collect data to monitor changes in contaminant concentrations, and possibly the status of biological recovery at the site. The results of the assessment can be used by ADEC to determine whether the TMDL should be maintained, modified, or rescinded.

Statistically-based sediment chemistry monitoring should be implemented on a regular schedule (e.g., every 10 years) and should include both surface and subsurface sediment samples collected at regular intervals. At a minimum, the field sampling program should collect samples at all of the former sediment sample sites (Figure 11) in order to compare new data against previously collected data. Additional data collection sites should also be established to further assess the extent of potential contamination within and outside the estimated area of impairment. The minimum recommended new sites are shown in blue in Figure 11; additional sites outside of the estimated area of impairment may also be sampled in sufficient quantity to determine whether migration of the contaminated sediments is occurring in the bay.

Further, options for monitoring or assessing for the potential for additional leaching of contaminants from the uplands waste rock pile could be explored. Tidal currents and sediment re-suspension may be monitored to assess for pollutant transport potential. Sedimentation analyses (i.e., using sediment traps) may be conducted to determine sedimentation rates and estimate an approximate time frame for natural recovery via sediment burial. Finally, biological monitoring may be implemented to evaluate exposure and risk for the surrounding biological population (e.g., blue mussels, bald eagles, etc.)

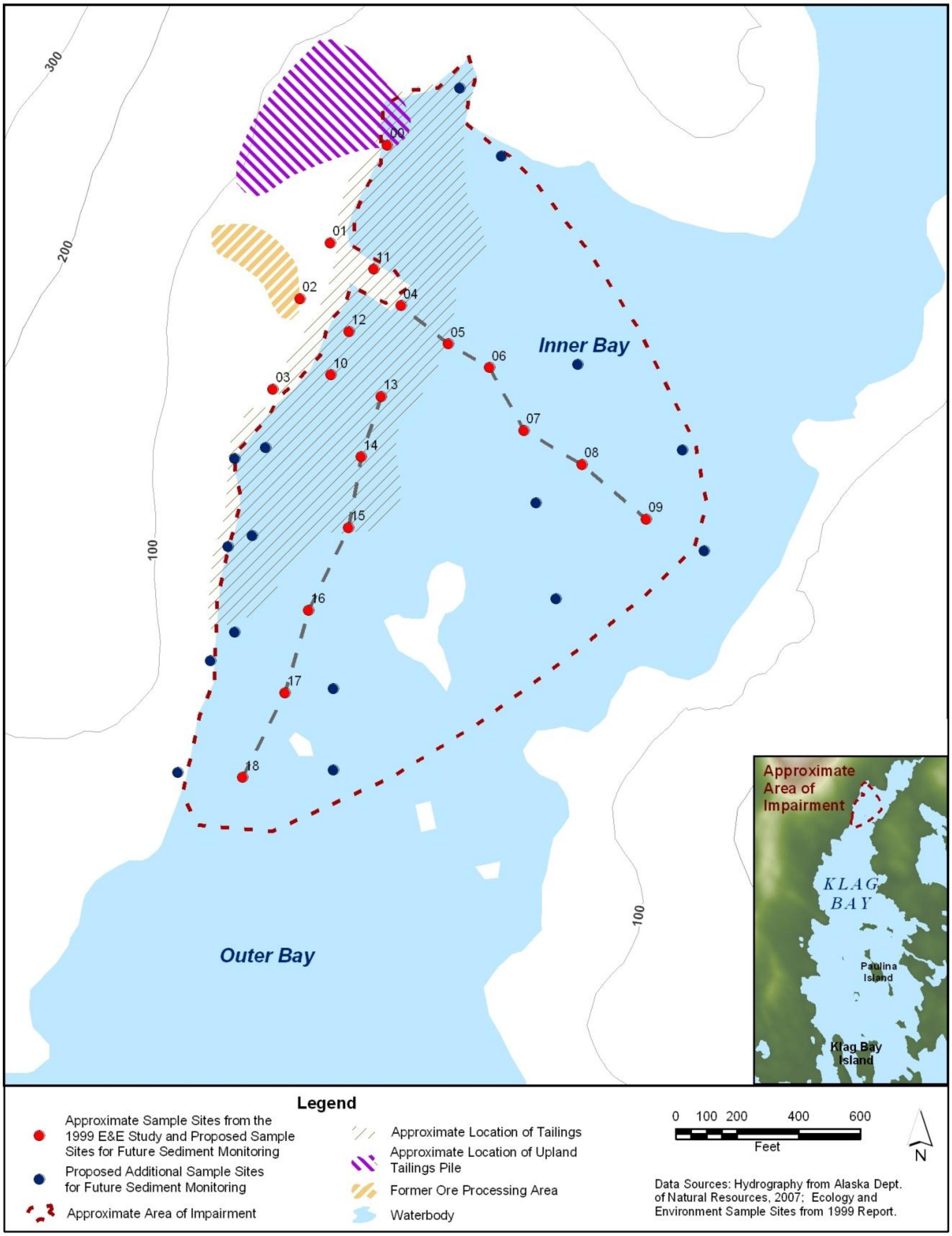
If results of each assessment cycle determine that the TMDL target is still not being attained, the TMDL may be modified in accordance with findings. If results determine that the TMDL target is met, the TMDL may be rescinded and Klag Bay may be moved from Category 4a (impaired waters with an EPA-approved TMDL) to Category 2 (attaining some use but insufficient data to determine if remaining uses are attained) of Alaska's Integrated Report.

9.0 PUBLIC PARTICIPATION

In February of 2009, DEC requested comments from agencies and interested stakeholders on the draft Klag Bay TMDL – no comments were received. On March 4, 2009, DEC began its public notice process by posting the draft Klag Bay TMDL on the State's Public Notice Web site, DEC's website, the Juneau Empire and the Daily Sitka Sentinel. A fact sheet describing the TMDL was also posted on the DEC's web site.

The public comment period closed April 2, 2009 – two comments were received on the Implementation section. A response to comments was prepared and submitted with the final transmittal to EPA.

Figure 11. Proposed follow-up monitoring sites.



10.0 REFERENCES

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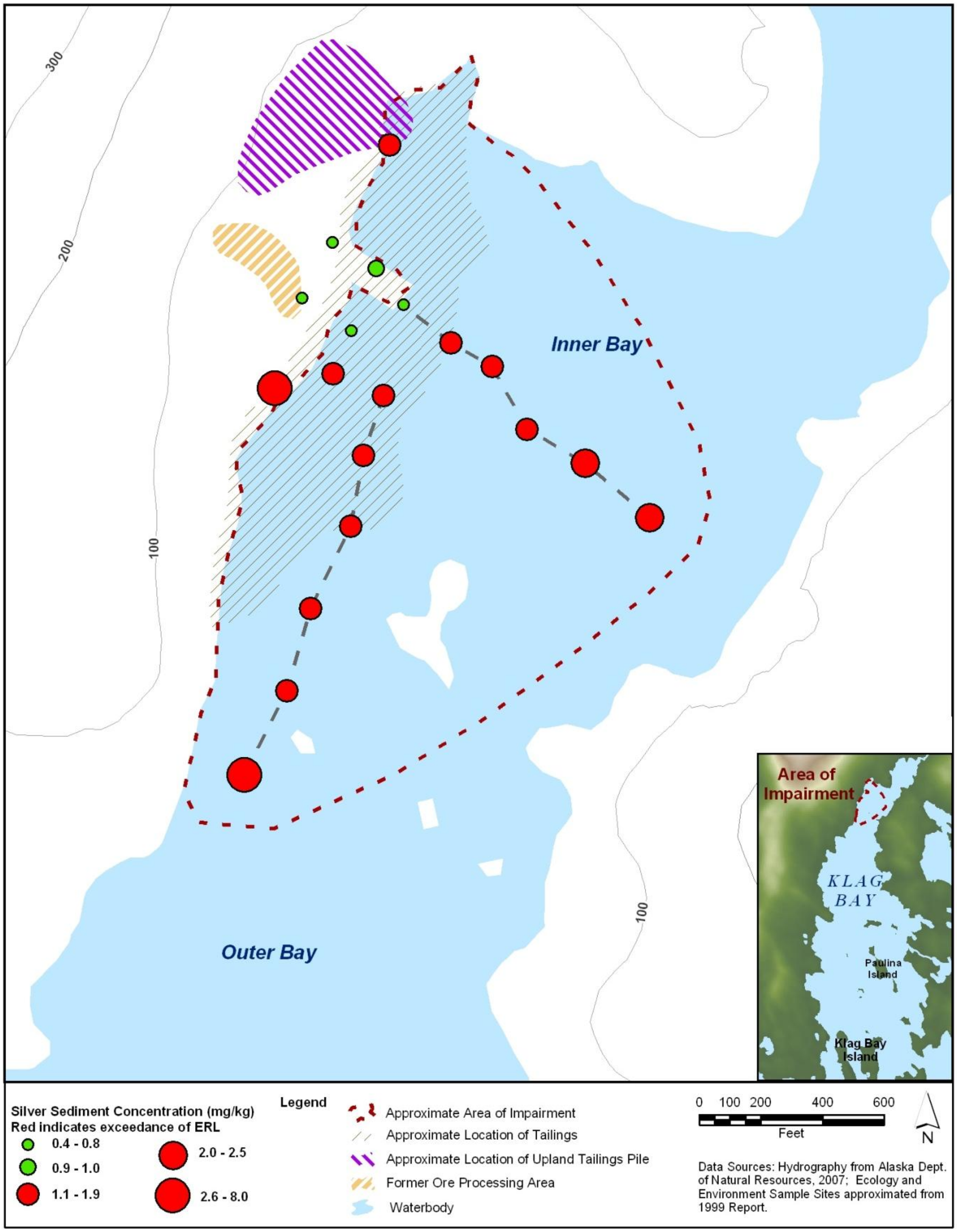
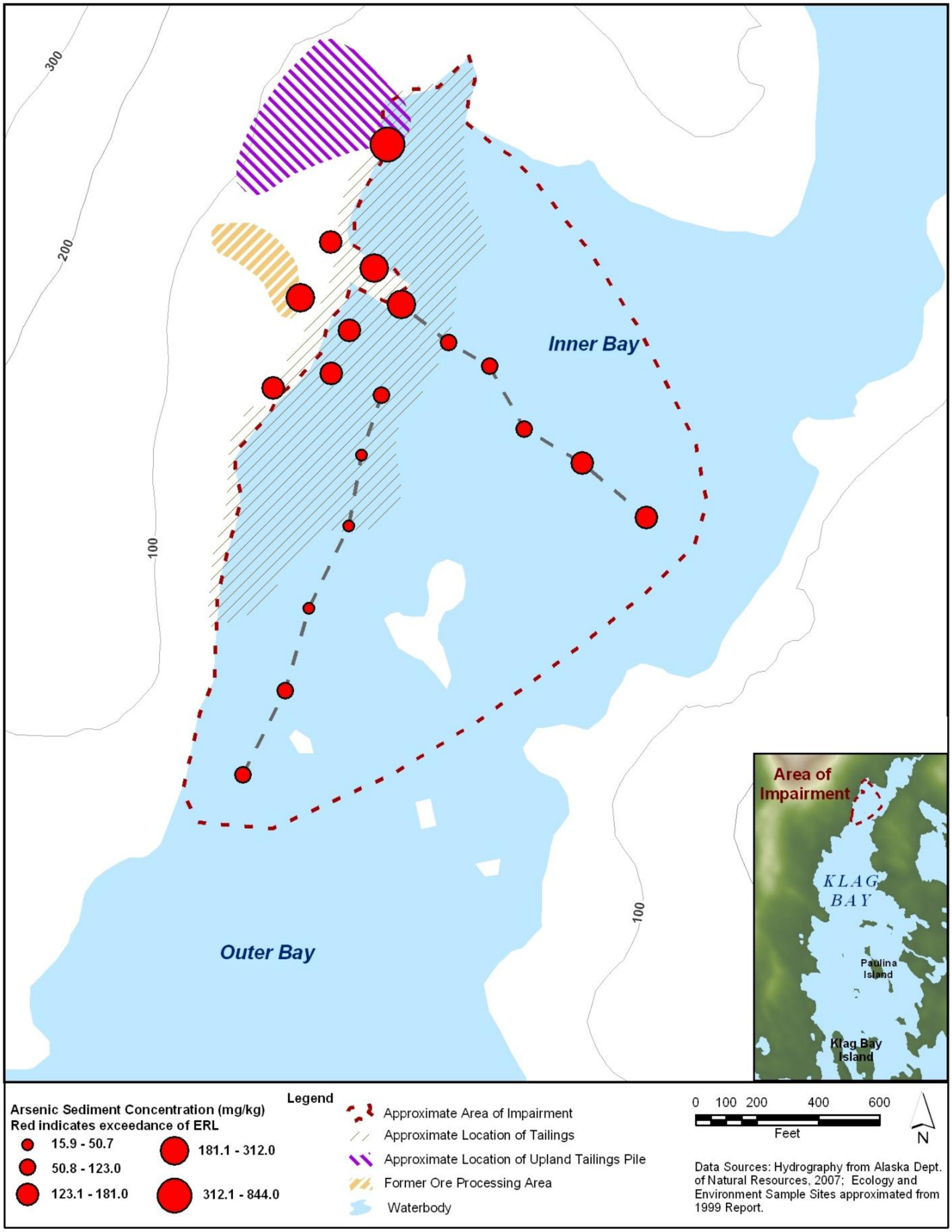
APPENDIX A. PROPORTIONAL ILLUSTRATIONS OF SEDIMENT METAL CONCENTRATIONS FROM THE 1999 E&E STUDY

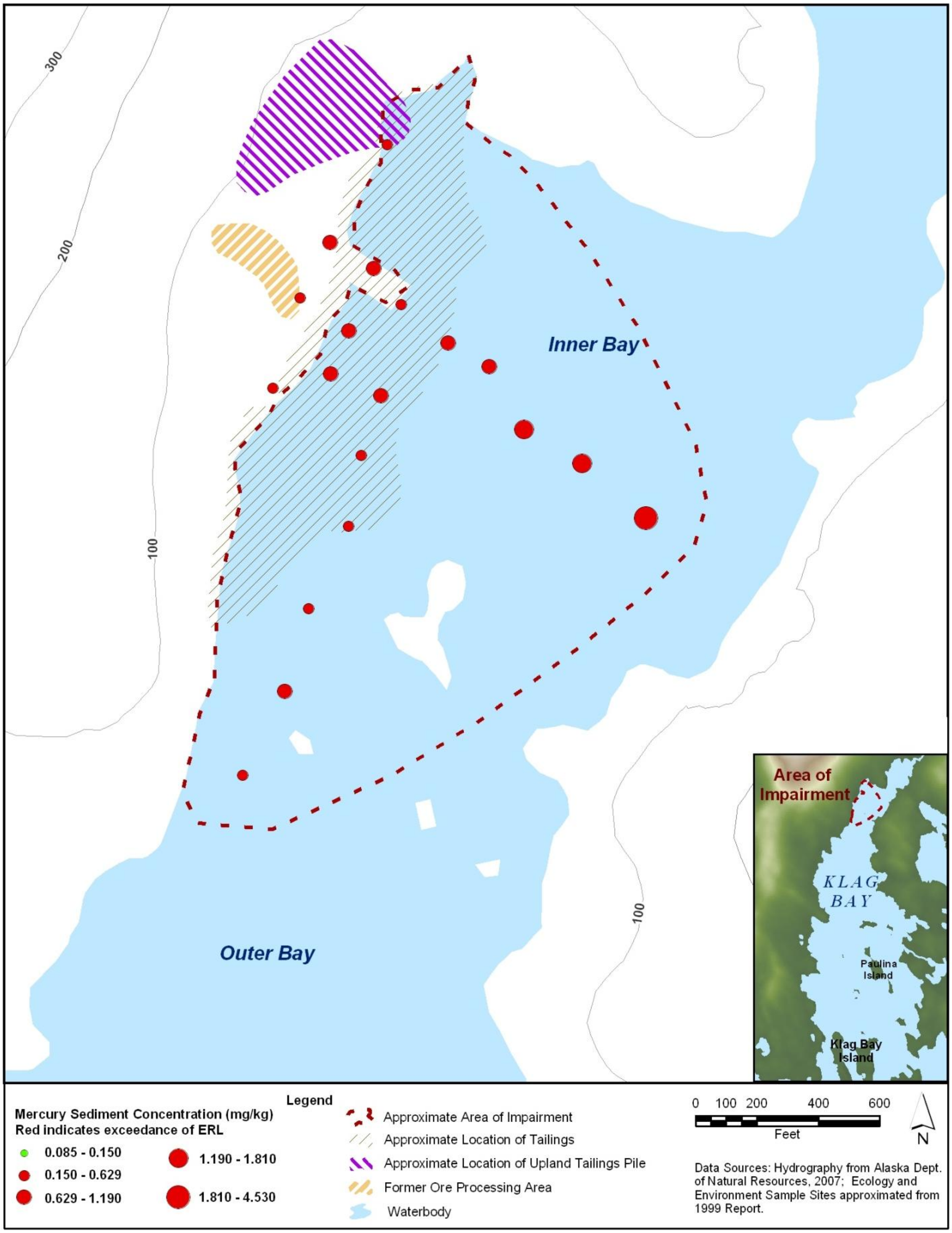
Silver



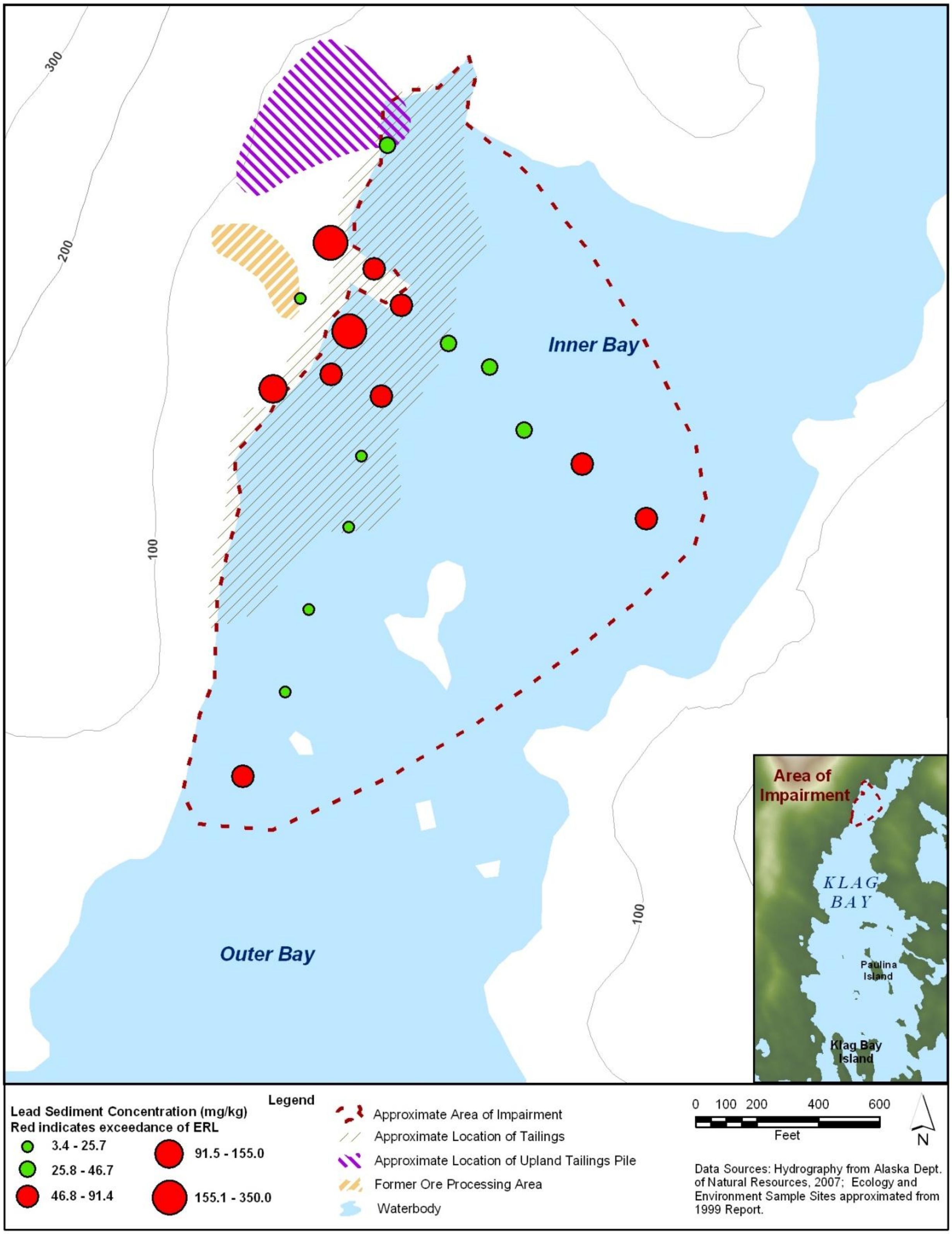
Arsenic


300
200
100
100
Inner Bay
Outer Bay
Area of Impairment
KLAG BAY
Paulina Island
Klag Bay Island
Legend
Arsenic Sediment Concentration (mg/kg)
Red indicates exceedance of ERL
15.9 - 50.7
50.8 - 123.0
123.1 - 181.0
181.1 - 312.0
312.1 - 844.0
Approximate Area of Impairment
Approximate Location of Tailings
Approximate Location of Upland Tailings Pile
Former Ore Processing Area
Waterbody
0 100 200 400 600
Feet
N
Data Sources: Hydrography from Alaska Dept. of Natural Resources, 2007; Ecology and Environment Sample Sites approximated from 1999 Report.

Mercury

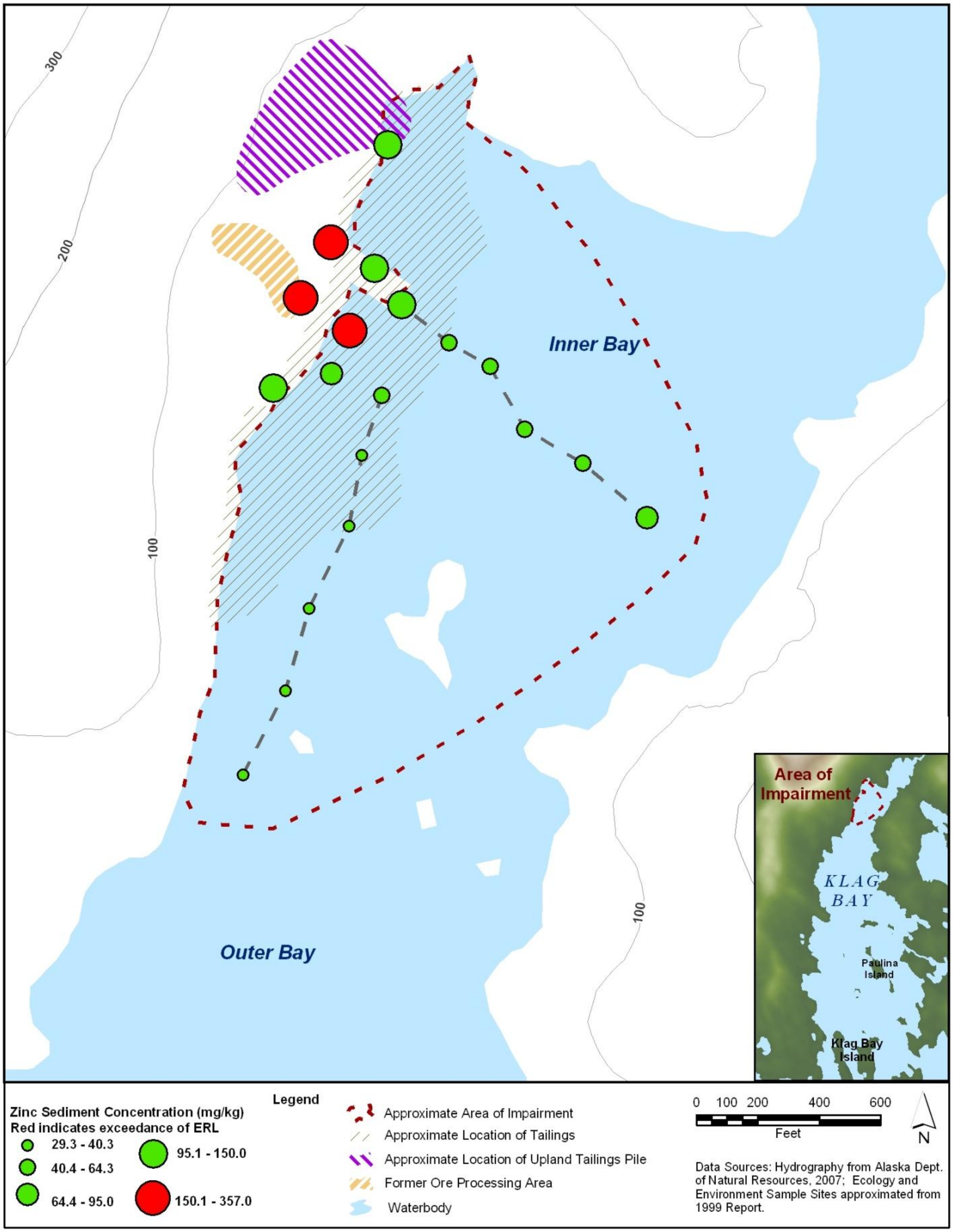

300
200
100
100
Inner Bay
Outer Bay
Area of Impairment
KLAG BAY
Paulina Island
Klag Bay Island
Legend
Mercury Sediment Concentration (mg/kg)
Red indicates exceedance of ERL
0.085 - 0.150
0.150 - 0.629
0.629 - 1.190
1.190 - 1.810
1.810 - 4.530
Approximate Area of Impairment
Approximate Location of Tailings
Approximate Location of Upland Tailings Pile
Former Ore Processing Area
Waterbody
0 100 200 400 600
Feet
N
Data Sources: Hydrography from Alaska Dept. of Natural Resources, 2007; Ecology and Environment Sample Sites approximated from 1999 Report.

Lead



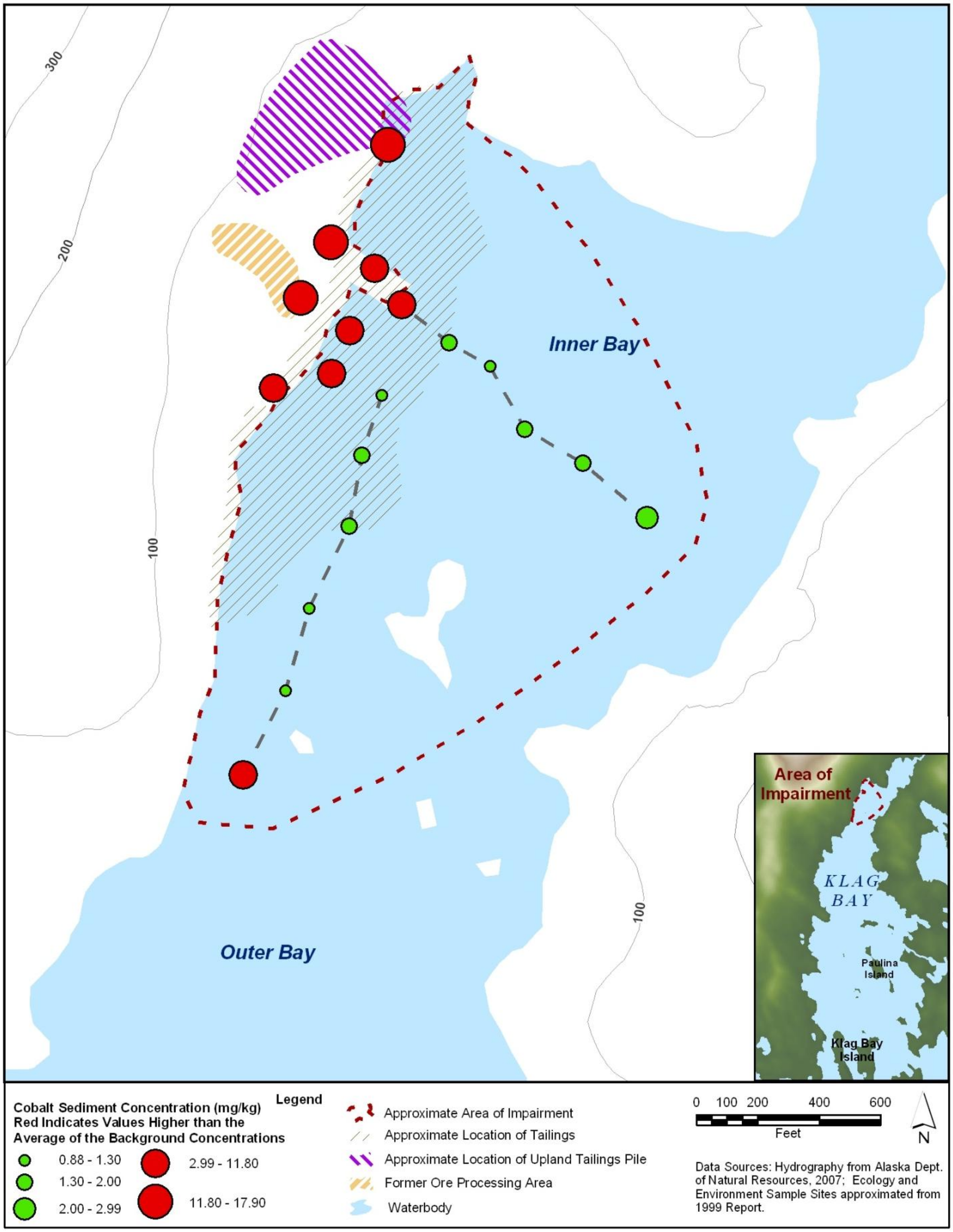
300
200
100
100
Inner Bay
Outer Bay
Area of Impairment
KLAG BAY
Paulina Island
Klag Bay Island
Legend
Lead Sediment Concentration (mg/kg)
Red indicates exceedance of ERL
3.4 - 25.7
25.8 - 46.7
46.8 - 91.4
91.5 - 155.0
155.1 - 350.0
Approximate Area of Impairment
Approximate Location of Tailings
Approximate Location of Upland Tailings Pile
Former Ore Processing Area
Waterbody
0 100 200 400 600
Feet
N
Data Sources: Hydrography from Alaska Dept. of Natural Resources, 2007; Ecology and Environment Sample Sites approximated from 1999 Report.

Zinc



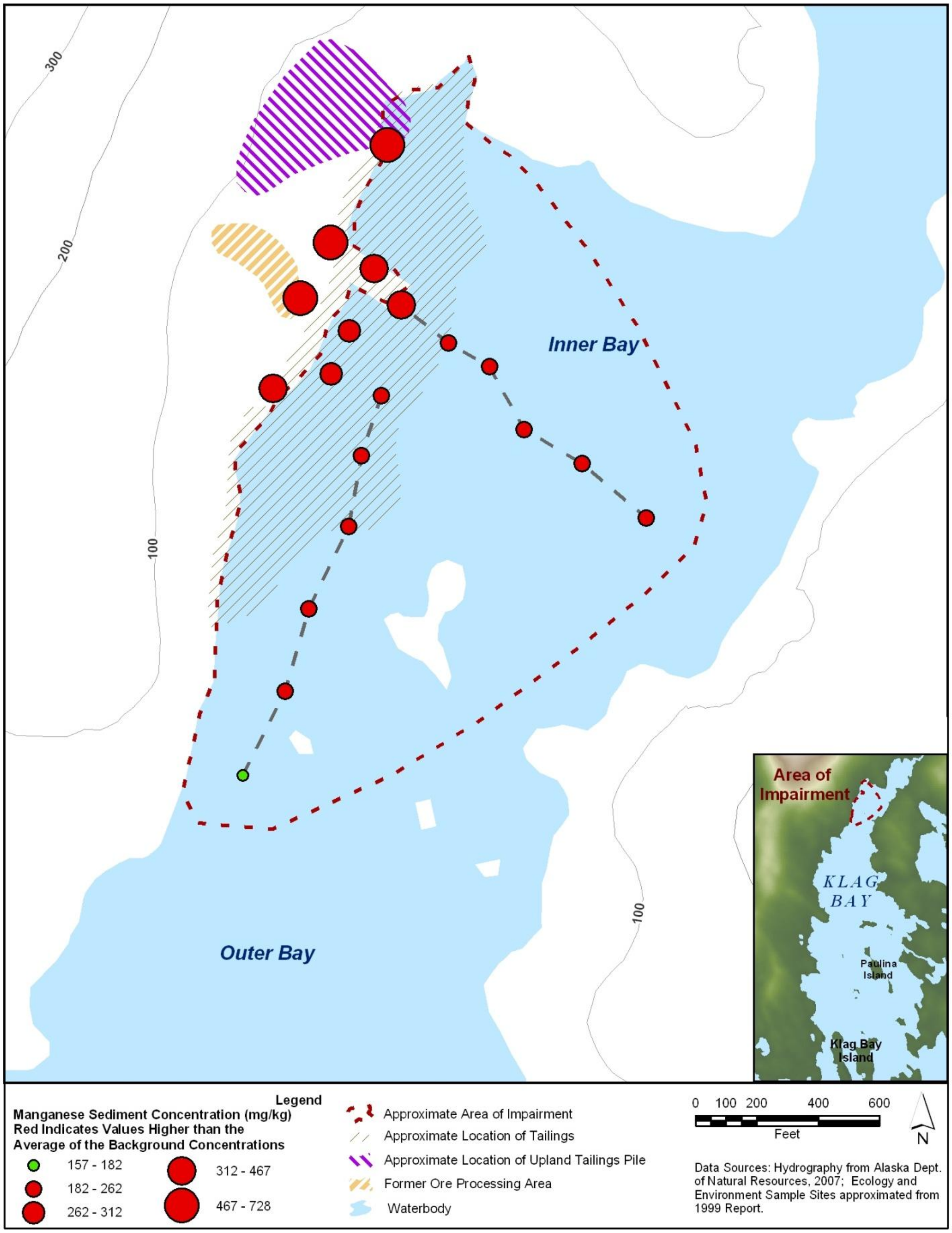
300
200
100
100
Inner Bay
Outer Bay
Area of Impairment
KLAG BAY
Paulina Island
Klag Bay Island
Legend
Zinc Sediment Concentration (mg/kg)
Red indicates exceedance of ERL
29.3 - 40.3
40.4 - 64.3
64.4 - 95.0
95.1 - 150.0
150.1 - 357.0
Approximate Area of Impairment
Approximate Location of Tailings
Approximate Location of Upland Tailings Pile
Former Ore Processing Area
Waterbody
0 100 200 400 600
Feet
N
Data Sources: Hydrography from Alaska Dept. of Natural Resources, 2007; Ecology and Environment Sample Sites approximated from 1999 Report.

Cobalt



300
200
100
100
Inner Bay
Outer Bay
Area of Impairment
KLAG BAY
Paulina Island
Klag Bay Island
Legend
Cobalt Sediment Concentration (mg/kg)
Red Indicates Values Higher than the Average of the Background Concentrations
0.88 - 1.30
1.30 - 2.00
2.00 - 2.99
2.99 - 11.80
11.80 - 17.90
Approximate Area of Impairment
Approximate Location of Tailings
Approximate Location of Upland Tailings Pile
Former Ore Processing Area
Waterbody
0 100 200 400 600
Feet
N
Data Sources: Hydrography from Alaska Dept. of Natural Resources, 2007; Ecology and Environment Sample Sites approximated from 1999 Report.

Manganese


300
200
100
100
Inner Bay
Outer Bay
Area of Impairment
KLAG BAY
Paulina Island
Klag Bay Island
Legend
Manganese Sediment Concentration (mg/kg)
Red Indicates Values Higher than the Average of the Background Concentrations
157 - 182
182 - 262
262 - 312
312 - 467
467 - 728
Approximate Area of Impairment
Approximate Location of Tailings
Approximate Location of Upland Tailings Pile
Former Ore Processing Area
Waterbody
0 100 200 400 600
Feet
N
Data Sources: Hydrography from Alaska Dept. of Natural Resources, 2007; Ecology and Environment Sample Sites approximated from 1999 Report.

APPENDIX B. NOAA's SCREENING QUICK REFERENCE TABLE

Screening Quick Reference Table for Inorganics in Solids

These tables were developed for internal use for screening purposes only: they do not represent official NOAA policy and do not constitute criteria or clean-up levels. All attempts have been made to ensure accuracy; however, NOAA is not liable for errors. Values are subject to changes as new data become available.

(values in ppb dry weight)

COMPOUND	FRESHWATER SEDIMENT					MARINE SEDIMENT					SOIL	
	"Background" [1]	Lowest ARCS *H. azteca* TEL	Threshold Effects Level (TEL)	Probable Effects Level (PEL)	Upper [2] Effects Threshold (UET)	Threshold Effects Level (TEL)	Effects Range-Low (ERL)	Probable Effects Level (PEL)	Effects Range Median (ERM)	Apparent [3] Effects Threshold (AET)	Background: Geometric Mean	Background: Range
Predicted Toxicity Gradient:	---------	Increasing →				Increasing →					---------	
ALUMINUM (Al) (%)	0.26%	2.55%								1.8% N	4.7%	0.5- >10%
ANTIMONY (Sb)	160				3,000 M					9,300 E	480	bd-8,800
ARSENIC (As)	1,100	10,798	5,900	17,000	17,000 I	7,240	8,200	41,600	70,000	35,000 B	5,200	bd-97,000
BARIUM (Ba)	700									48,000 A	440,000	10,000-0.5%
CADMIUM (Cd)	100-300	583	596	3,530	3,000 I	676	1,200	4,210	9,600	3,000 N		
CHROMIUM (Cr)	7,000-13,000	36,286	37,300	90,000	95,000 H	52,300	81,000	160,400	370,000	62,000 N	37,000	1000-0.2%
COBALT (Co)	10,000									10,000 N	6,700	bd-70,000
COPPER (Cu)	10,000-25,000	28,012	35,700	197,000	86,000 I	18,700	34,000	108,200	270,000	390,000 MO	17,000	bd-700,000
IRON (Fe) (%)	0.99-1.8 %	18.84%			4% I					22% N	1.8%	0.01- >10%
LEAD (Pb)	4,000-17,000	37,000	35,000	91,300	127,000 H	30,240	46,700	112,180	218,000	400,000 B	16,000	bd-700,000
MANGANESE (Mn)	400,000	630,000			1,100,000 I					260,000 N	330,000	bd-0.7%
MERCURY (Hg)	4-51		174	486	560 M	130	150	696	710	410 M	58	bd-4,600
NICKEL (Ni)	9,900	19,514	18,000	35,900	43,000 H	15,900	20,900	42,800	51,600	110,000 EL	13,000	bd-700,000
SELENIUM (Se)	290									1,000 A	260	bd-4,300
SILVER (Ag)	<500				4,500 H	730	1,000	1,770	3,700	3,100 B		
STRONTIUM (Sr)	49,000										120,000	bd-0.3%
TIN (Sn)	5,000					48 *				> 3,400 N as TBT	890	bd-10,000
VANADIUM (V)	50,000									57,000 N	58,000	bd-500,000
ZINC (Zn)	7,000-38,000	98,000	123,100	315,000	520,000 M	124,000	150,000	271,000	410,000	410,000 I	48,000	bd-0.29%
SULFIDES					130,000 M					4,500 MO		

1 "Background" values are derived from a compilation of sources, but come primarily from Int. Joint Comm. Sediment Subcommittee (1988).
2 Entry is lowest, reliable value among a compilation of AET levels: I - Infaunal community impacts; H - *Hyalella azteca* bioassay; M - Microtox bioassay
3 Entry is lowest value among AET levels: I - Infaunal community impacts; A-Amphipod; B-Bivalve; M-Microtox; O-Oyster larvae; E-Echinoderm larvae; L-Larval$_{max}$; or , N-Neanthes bioassays

* - Based upon EqP approach using currently proposed AWQC CCC.

SOURCES:

Sediment: PTI Environ. Serv., Contaminated Sediments Criteria Rpt., 1989; Wash. Dept. Ecol. Publ. 95-308, 1995 and 97-323a, 1997; J. Great Lakes Res. 22(3):624-638, 1996; Gries & Waldow, Puget Sound Dredged Disposal Analysis Rpt., 1996; Environ. Manage. 19(1):81-97, 1996; The AET Approach; Briefing Rpt. to the EPA SAB, Sept. 1988; Int. Joint Comm., Procedures for Assessment of Contaminated Sediment in the Great Lakes, 1988; Ecotox. (5):253-278, 1996; EPA Rpt. 905-R96-008, Sept. 1996.; WAC Chapter 173-204; J. Great Lakes Res. 22(3):602 - 623, 1996.

Soil: Shacklette and Boerngen 1984; USGS Prof. Paper 1270: bd denotes below detection limits.

FOR MORE INFORMATION CONTACT:

Michael Buchman
NOAA/ARD
7600 Sand Point Way N.E.
Seattle, Washington 98115-0070
Tel: 206•526•6340
Fax: 206•526•6865
Email: CFRD.SQUIRT@noaa.gov

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UPDATED FEB. 2004 HAZMAT REPORT 99-1

APPENDIX C. SAMPLE SITES MAP FROM THE 1986 USFWS STUDY

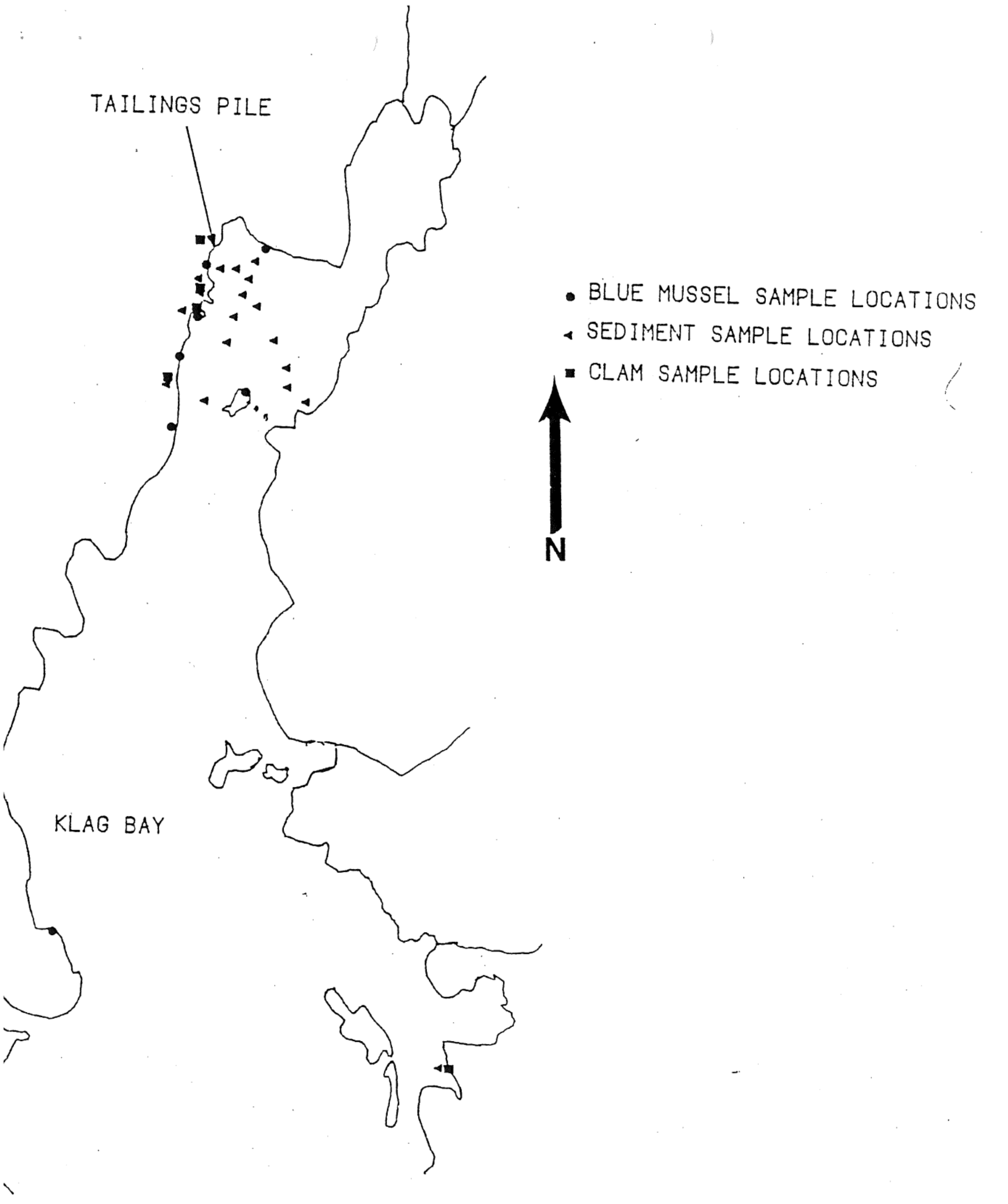
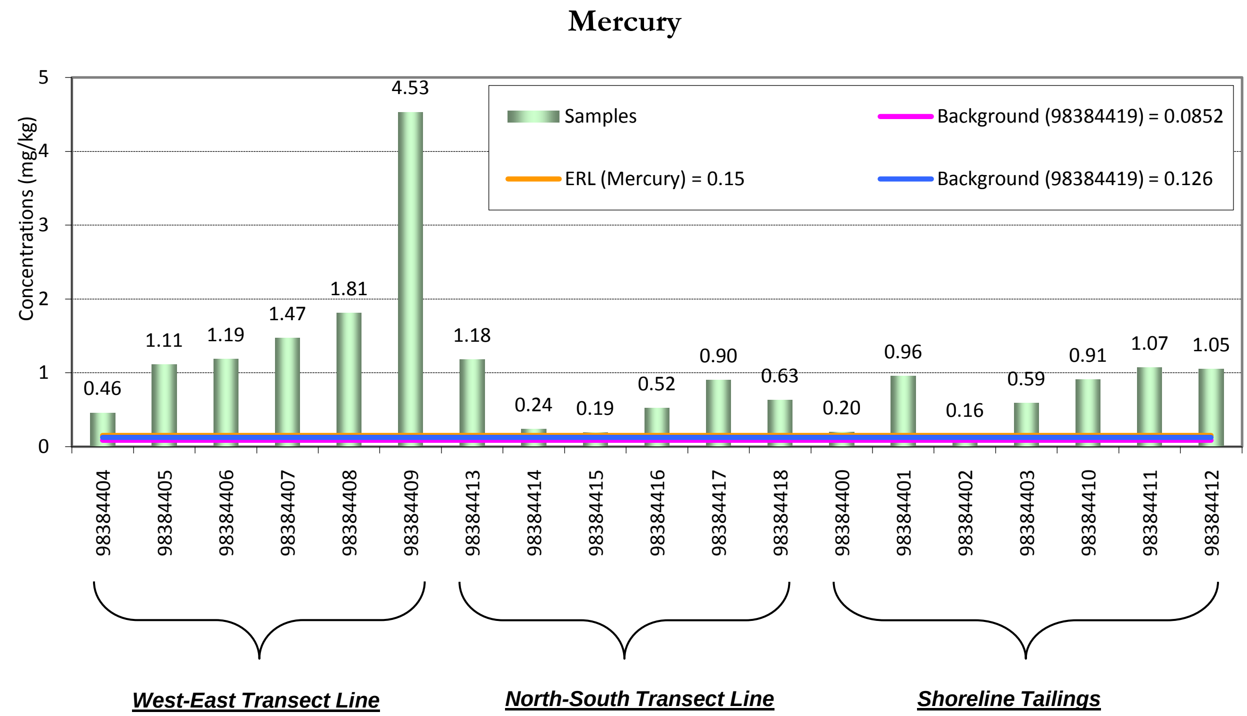
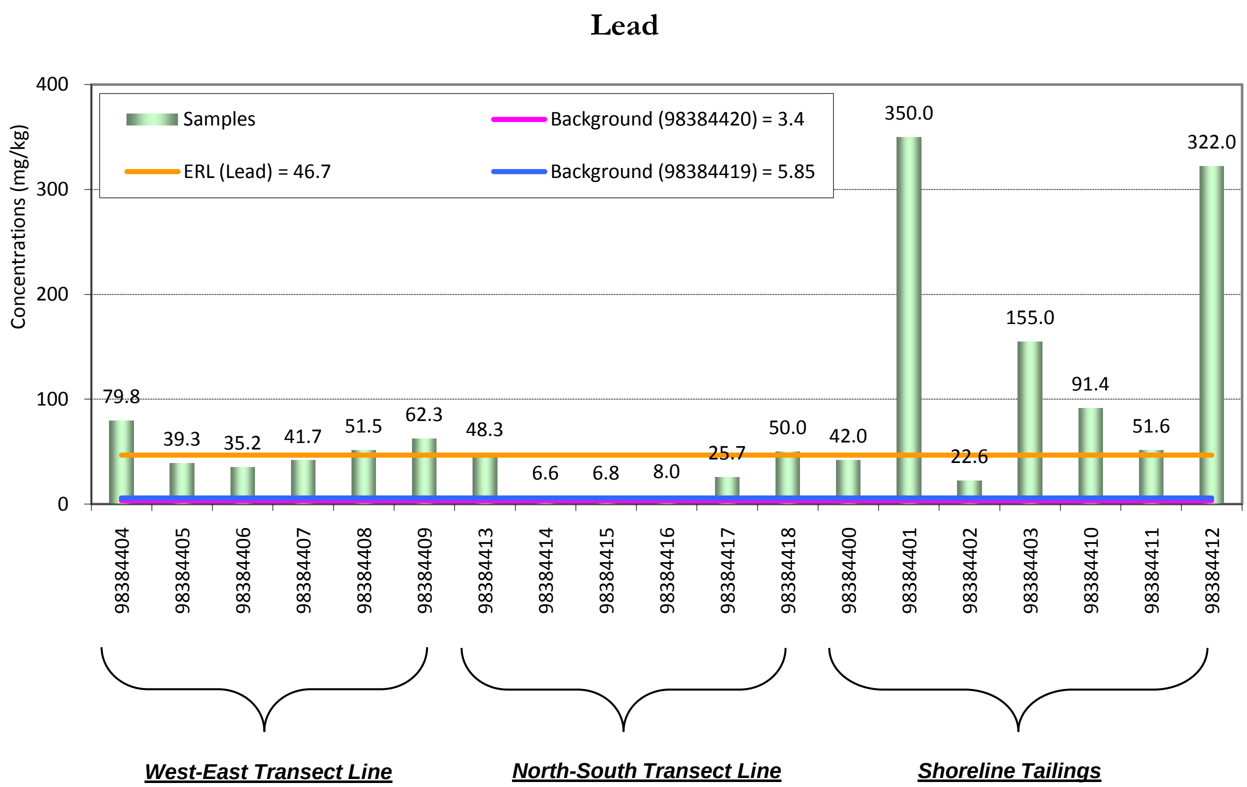


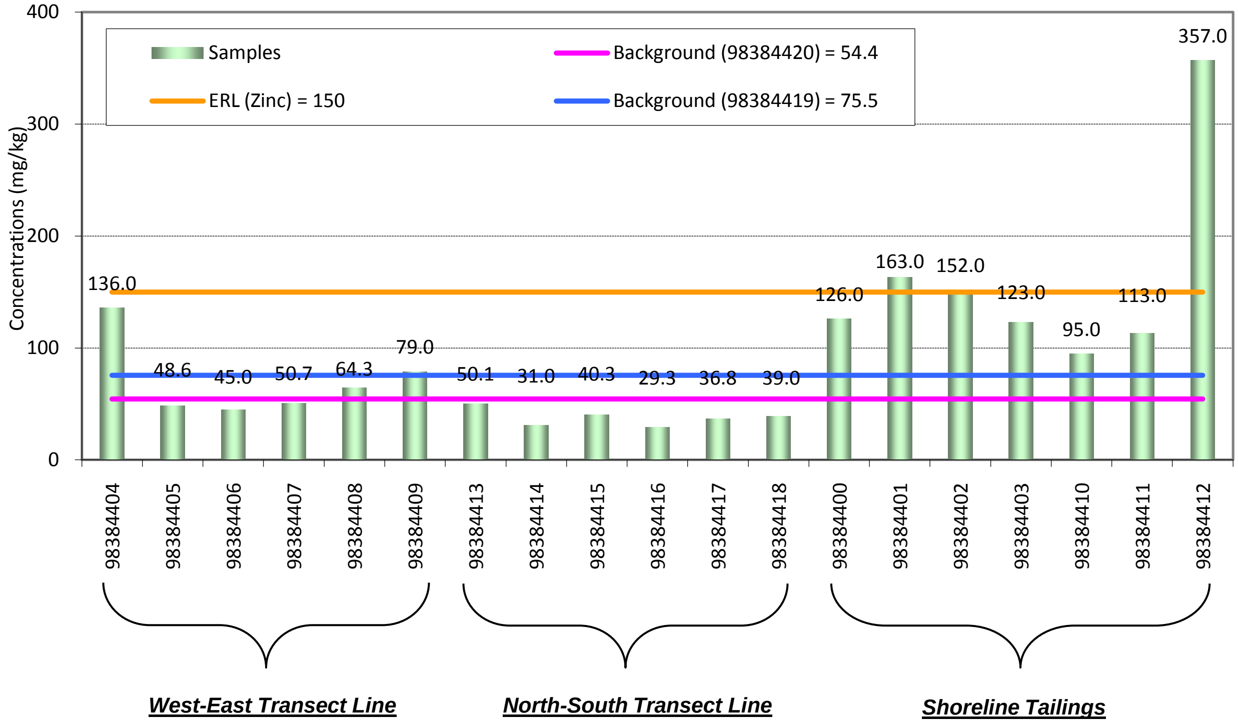
Figure 4. Sample locations in Klag Bay for sediment, blue mussels and clams.

APPENDIX D. SEDIMENT METAL CONCENTRATION DATAFROM THE 1999 E&E STUDY

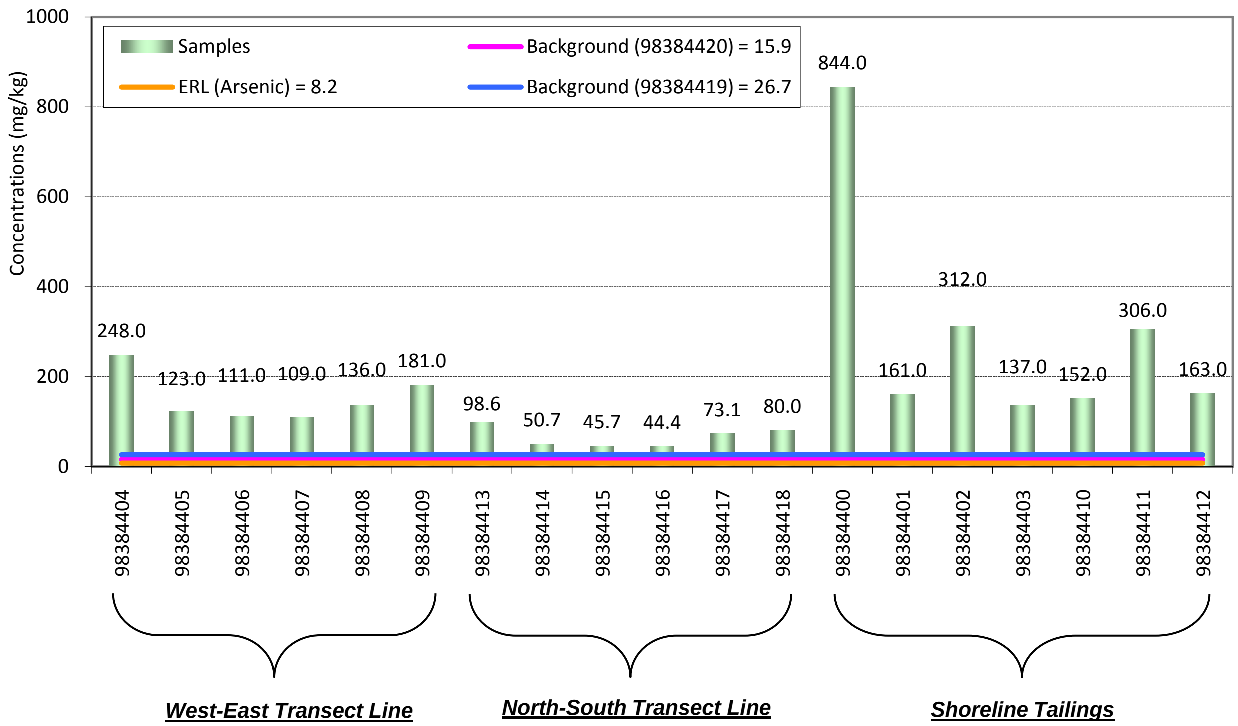




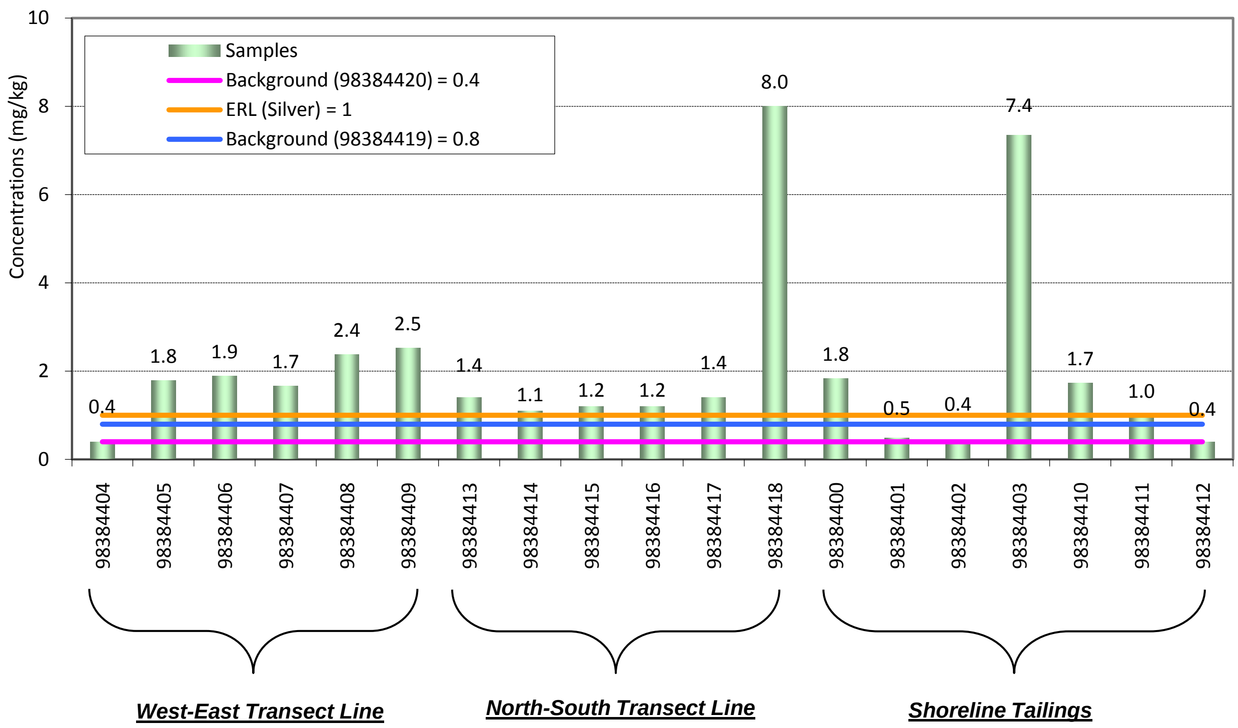
Zinc



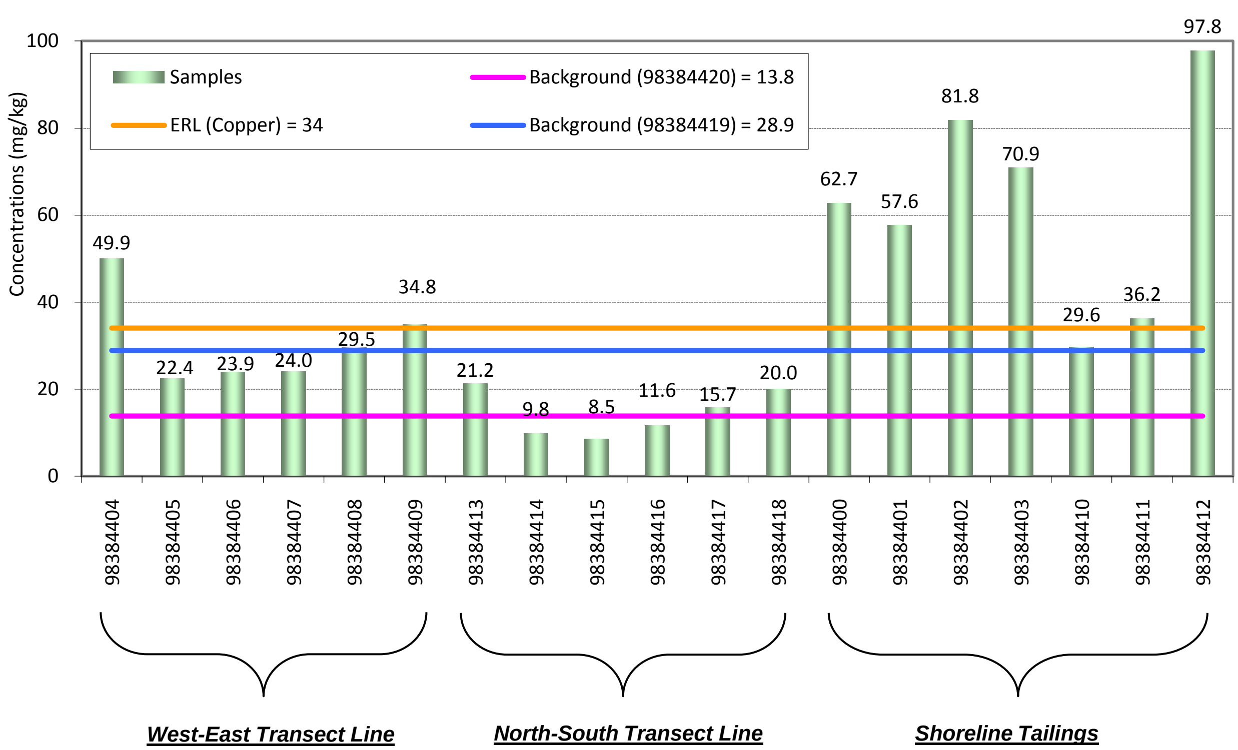
Arsenic



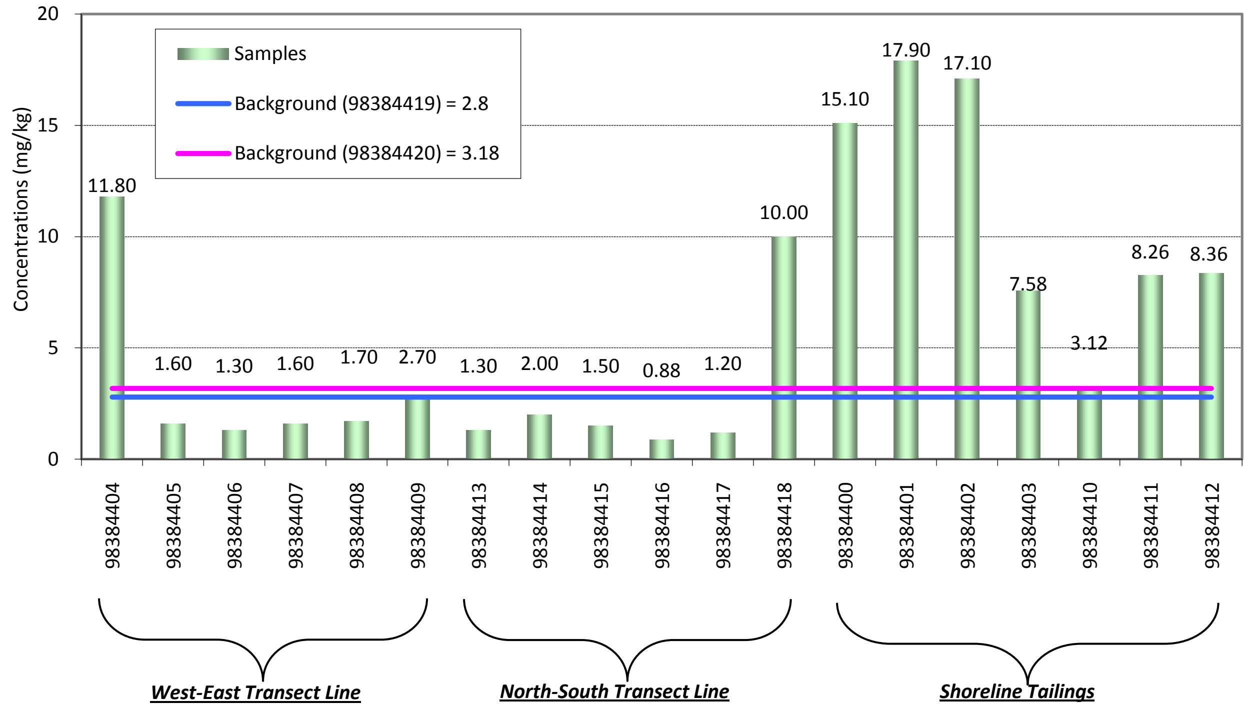
Silver



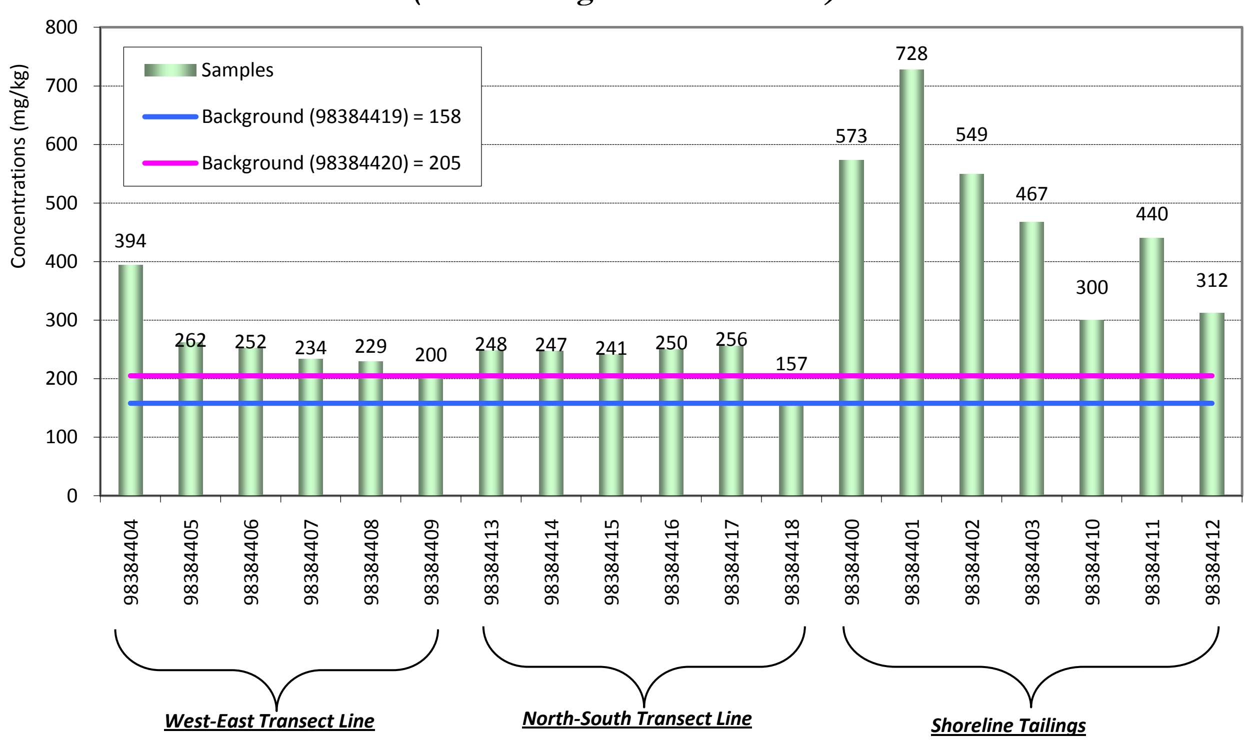
Copper



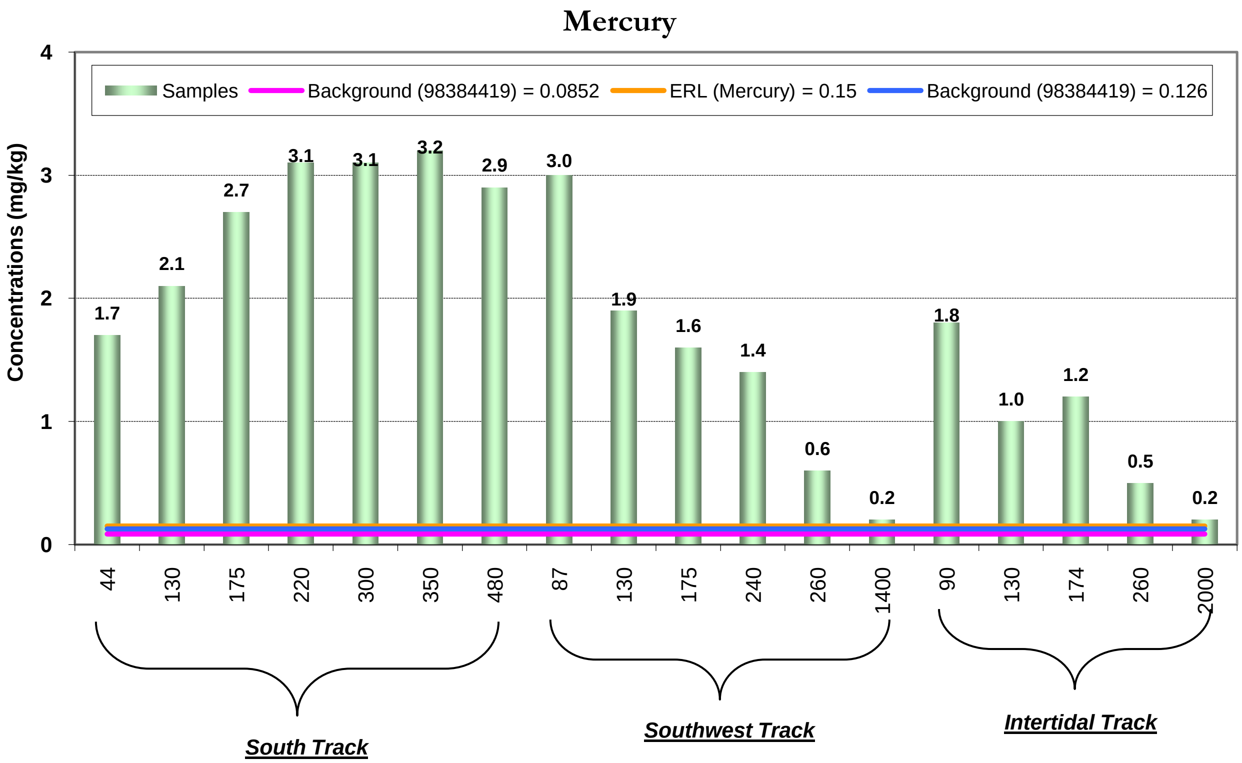
Cobalt
(no screening criteria available)

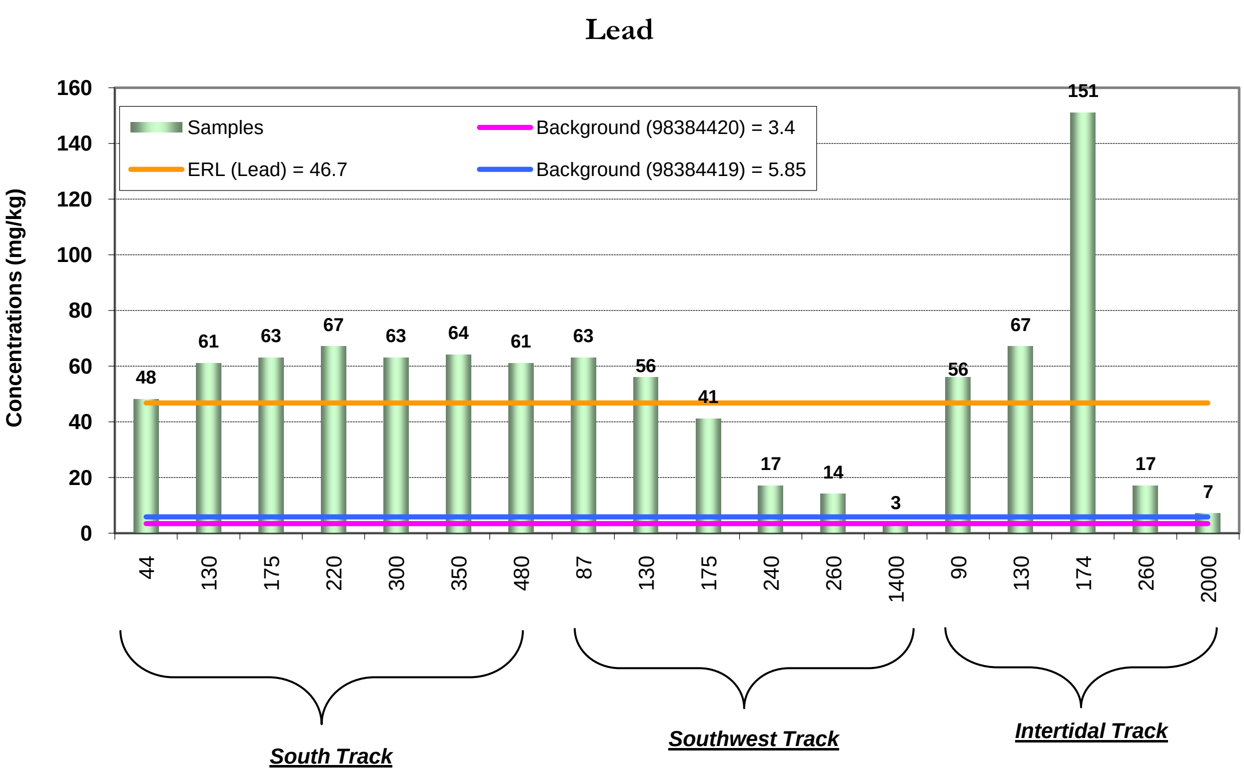


Manganese
(no screening criteria available)

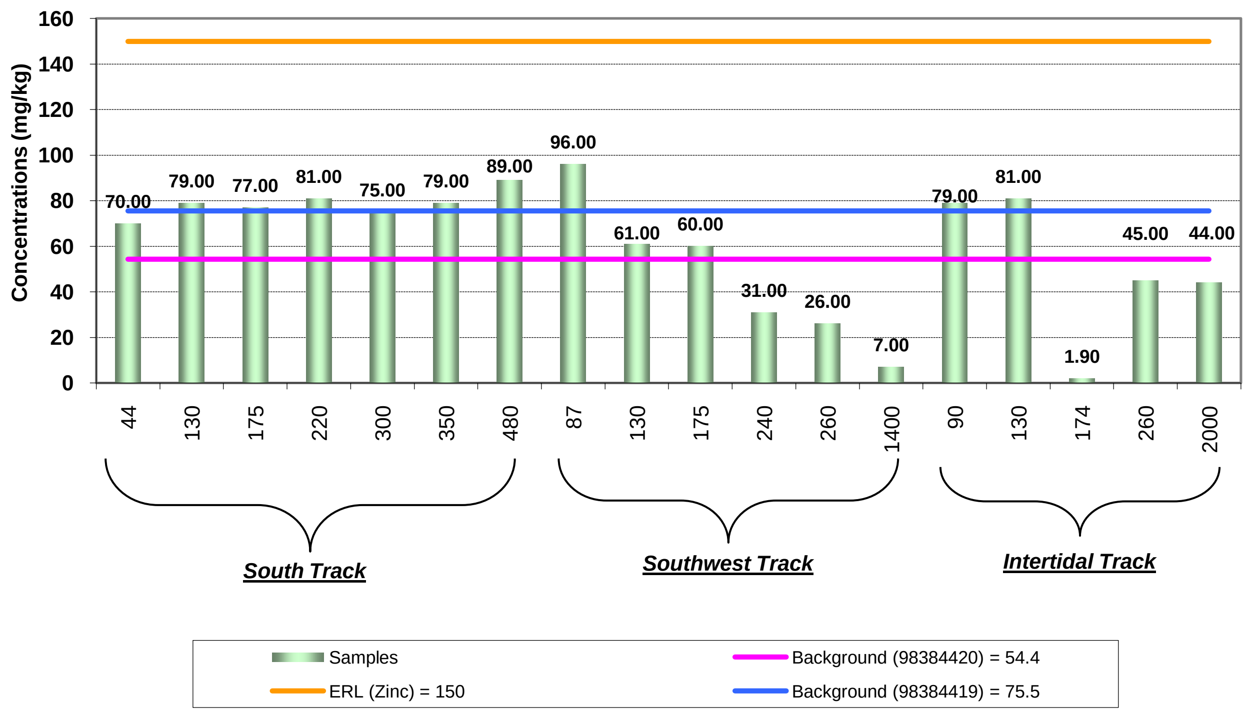


APPENDIX E. SEDIMENT METAL CONCENTRATION DATA FROM THE 1986 USFWS STUDY

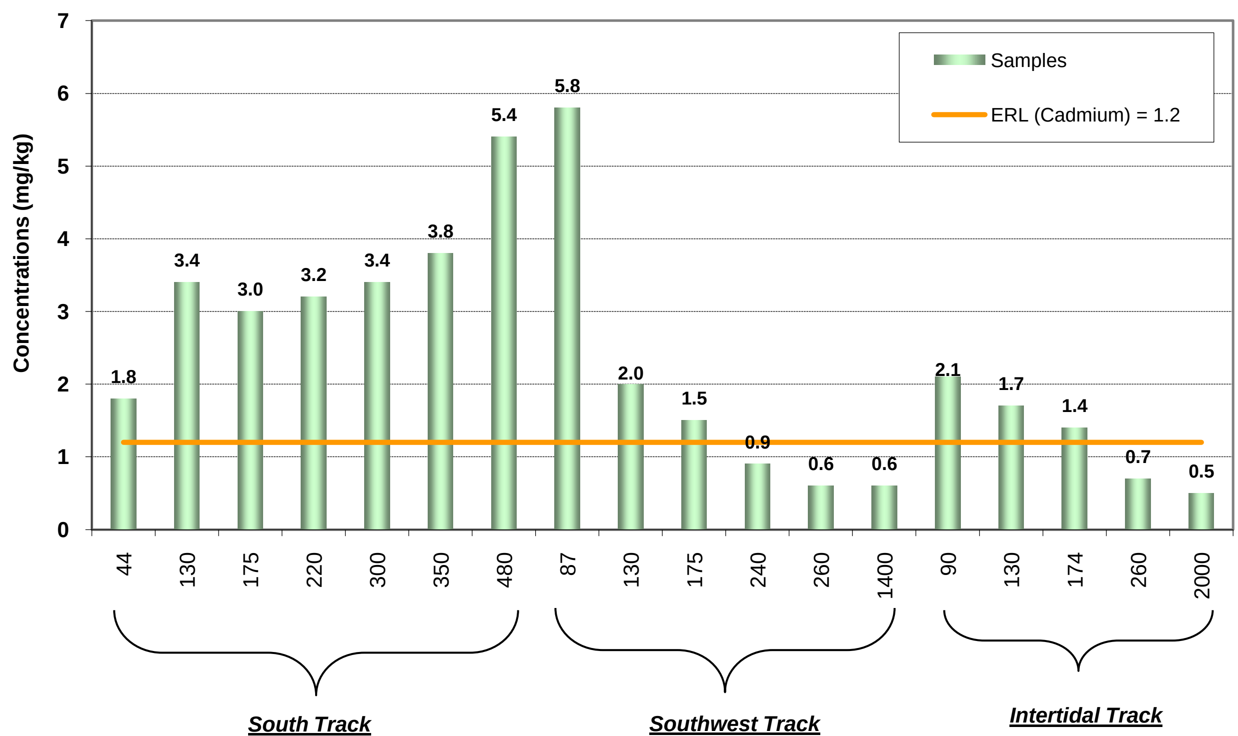




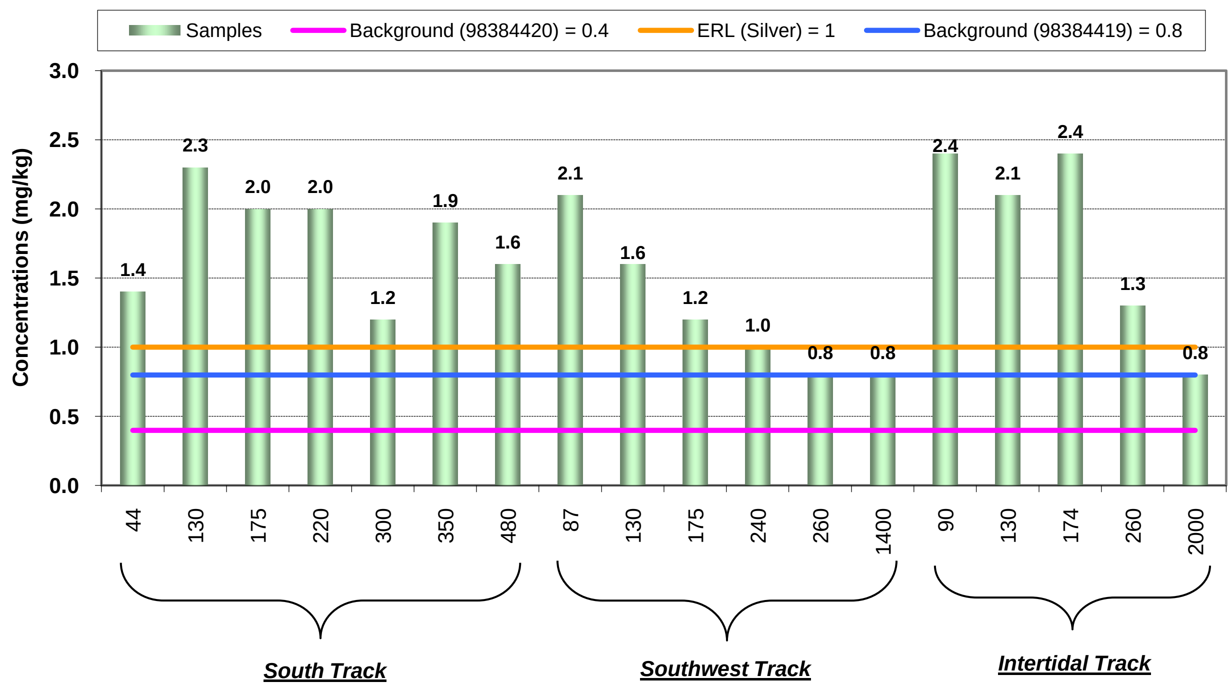
Zinc



Cadmium



Silver



Samples
Background (98384420) = 0.4
ERL (Silver) = 1
Background (98384419) = 0.8
Concentrations (mg/kg)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.4
2.3
2.0
2.0
1.2
1.9
1.6
2.1
1.6
1.2
1.0
0.8
0.8
2.4
2.1
2.4
1.3
0.8
44
130
175
220
300
350
480
87
130
175
240
260
1400
90
130
174
260
2000
South Track
Southwest Track
Intertidal Track