Work Plan

Treatability Study to Stabilize Intertidal Tailings Deposits

Salt Chuck Mine Remedial Investigation Tongass National Forest, Alaska

Prepared for

US Environmental Protection Agency

Region 10

May 23, 2013

Prepared by

CH2MHILL®

AES10

Architect and Engineering Services Contract

Contract No. 68-S7-04-01

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Acronyms and Abbreviations

BLM	Bureau of Land Management
cfs	cubic feet per second
EPA	U.S. Environmental Protection Agency
NAVD88	North American Vertical Datum 1988
NOAA	National Oceanic and Atmospheric Administration
RI	Remedial Investigation
R&M	R&M Engineering-Ketchikan, Inc.
TOC	total organic carbon
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

CHAPTER 1

Summary

This Treatability Study Work Plan describes the existing site conditions and design basis for the activities to be conducted in summer 2013 to test potential measures to stabilize eroding streambanks and tailings deposits in the intertidal area at the Salt Chuck Mine Superfund Site on Prince of Wales Island, in Southeast Alaska.

The Treatability Study has been developed based on input from U.S. Environmental Protection Agency (EPA), agency stakeholders that attended project meetings in Anchorage on February 12 to 13, 2013, subject matter experts, and available site data.

Note that the final remedy for the site will be identified during the Feasibility Study phase, and that the activities described for the Treatability Study will aid in developing the Feasibility Study.

Three types of erosion that are observed onsite include erosion of steep slopes or banks, erosion of the floodplain surfaces, and erosion of the tailings surfaces. Each of these erosion types may involve different processes, which may involve different types of stabilizing measures. There is a complex mixture of multiple natural forces at work onsite—stream (fluvial), tides, wind, and waves, which are all at work at various temporal scales (daily, seasonal, and episodic) and spatial scales

A topographic survey of the intertidal area was conducted in February 2013, which provided considerable information that was used to understand site conditions, develop a hydrodynamic model, and to estimate the potential elevation zones for establishing intertidal elevation.

A two-dimensional hydrodynamic model was constructed to simulate stream flows and tidal exchange near the former mill site in Salt Chuck Bay. The goal of the modeling effort was to quantify local current velocities under stream and tidal influences and characterize the potential for erosion of existing tailings deposits at the project site. Model simulations were conducted for existing conditions and focused on predicted peak velocities during ebb tide conditions with a range of stream inflows in Unnamed Stream A. Model results suggest that tidal exchange alone is not likely sufficient to produce substantial erosion of the tailings deposits, but streamflow events in Unnamed Stream A, particularly those with return periods on the order of 1 to 10 years (and greater), produce velocities sufficient to cause extensive erosion at certain locations. Model results for existing conditions at the project site identified two primary localized areas of increased velocity where erosion is likely to occur under storm stream flows and ebb tides. The Treatability Study includes the excavation of tailings from the flow path at these two streambank locations to reduce erosion and transport of tailings.

Despite over 70 years since mill operations ceased in 1941, natural colonization of vegetation on the tailings deposits has been limited. Natural colonization has been difficult due to the suspected unfavorable characteristics of the tailings deposits that are not typical of intertidal sediments (such as, relatively low organic content, low fertility, homogeneous surface without micro topography or defining structure, coarse texture (mostly fine sands with some silt and clay lenses), and possibly high copper concentrations. In addition, tides, wind, and waves may further erode sediments and dislodge seeds and young propagules and prevent establishment of vegetation.

Several head-cutting gullies are forming along the western side of the West Tailings Deposit. Gully formation can be rapid and result in considerable erosion and transport of sediment. Stabilizing such an area early to minimize additional erosion is included as part of this Treatability Study.

The Treatability Study will be implemented in summer 2013. The general approach of the Treatability Study will be to excavate tailings from the high flow path of Unnamed Stream A at two primary eroding locations. In addition, transplanting and seeding of vegetation will be conducted in test plots to evaluate whether vegetation can survive and establish, and stabilize areas of the broad exposed West Tailings Deposit. The performance of these activities will be evaluated in spring 2014 and documented. A simple erosion monitoring network will also be established to try to gain a better understanding of the relative and absolute amounts of erosion in different locations onsite where different processes are being studied.

CHAPTER 2

Introduction

This chapter summarizes the project purpose and scope, and describes, project definition, goal and objectives, the project area, and general approach of the Treatability Study.

2.1 Purpose and Scope

This Treatability Study Work Plan describes the existing site conditions and design basis for the activities to be conducted in summer 2013 to test potential measures to stabilize eroding streambanks and tailings deposits in the intertidal area at the Salt Chuck Mine Superfund Site on Prince of Wales Island, in Southeast Alaska (Figure 2-1).

The Treatability Study has been developed based on input from EPA, agency stakeholders that attended project meetings in Anchorage on February 12 to 13, 2013, subject matter experts, and available site data.

Note that the final remedy for the site will be identified during the Feasibility Study phase, and that the activities described for the Treatability Study will aid in developing the Feasibility Study.

CH2M HILL is under contract with the EPA to evaluate the feasibility of stabilizing the mine tailings deposits in the intertidal area adjacent to the former Salt Chuck mill on Prince of Wales Island in Southeast Alaska at the Salt Chuck Mine Superfund Site. Salt Chuck Mine was added to the EPA National Priorities List on March 4, 2010. The site is an inactive former copper, gold, silver, and platinum group elements, most notably palladium mine.

The Treatability Study is based on *Guidance for Conducting Treatability Studies under CERCLA* (EPA, 1992).

2.2 Treatability Study Problem Definition, Goal, and Objectives

2.2.1 Problem Definition

The problem definition that forms the basis of the Treatability Study is that:

> *Persistent ongoing erosion and transport of tailings deposits in the intertidal area at the Salt Chuck Mine site have resulted in and are increasing the potential for ecological exposure and risk in Salt Chuck Bay.*

The Salt Chuck Mine site has been in existence for nearly 90 years. Due to environmental and other factors, the containment and stability of the intertidal tailings have been eroded and transported over time, particularly as the man-made piling/whaling and the rock jetty barriers have deteriorated. Aerial photos over time demonstrate the degradation of the piles/whaling and the rock jetty, and changes in the channel alignment and morphology of Unnamed Stream A. This change in channel alignment/morphology and subsequent reduction in stability of the piling/whaling and rock jetty, whether due to cyclical rainfall/tidal patterns or climatic changes, have caused increased erosion, transport, and deposition of contaminated tailings into Salt Chuck Bay. Early analytical data would indicate, at least, an increased ecological risk potential in Salt Chuck Bay caused by this recent increase in erosion and changes in channel alignment/morphology (CH2M HILL, 2013a).

2.2.2 Goal

Therefore, the goal of this Treatability Study is to test, on a small scale, remedial alternatives that would be designed to minimize or mitigate this potential to spread contamination offsite and to minimize or mitigate exposure on the site itself.

2.2.3 Objectives

The specific objectives of this Treatability Study are:

1. Test erosion control measures using channel realignment of Unnamed Stream A.

2. Test the feasibility of excavating streambank tailings deposits in the intertidal area at specific locations demonstrated by modeling to be most unstable and erodible along Unnamed Stream A.
3. Test the ability to stabilize and potentially cap tailings to prevent/reduce exposure and, potentially improve aesthetics, by using revegetation techniques in the West Tailings area.
4. Identify key eroding locations and understand processes that can be addressed in the Treatability Study.
5. Develop targeted stabilizing measures at key eroding locations that can be implemented in summer 2013 to reduce erosion and transport of tailings to Salt Chuck Bay.
6. Aid in developing the Feasibility Study.
7. Minimize disturbance of sediment during construction.
8. Monitor the performance of the stabilizing measures.
9. Make sure that the Treatability Study actions are consistent with the final remedy.

2.3 Treatability Study Area

The Salt Chuck Mine Superfund Site includes the upland and intertidal areas. The Treatability Study will focus on the intertidal area.

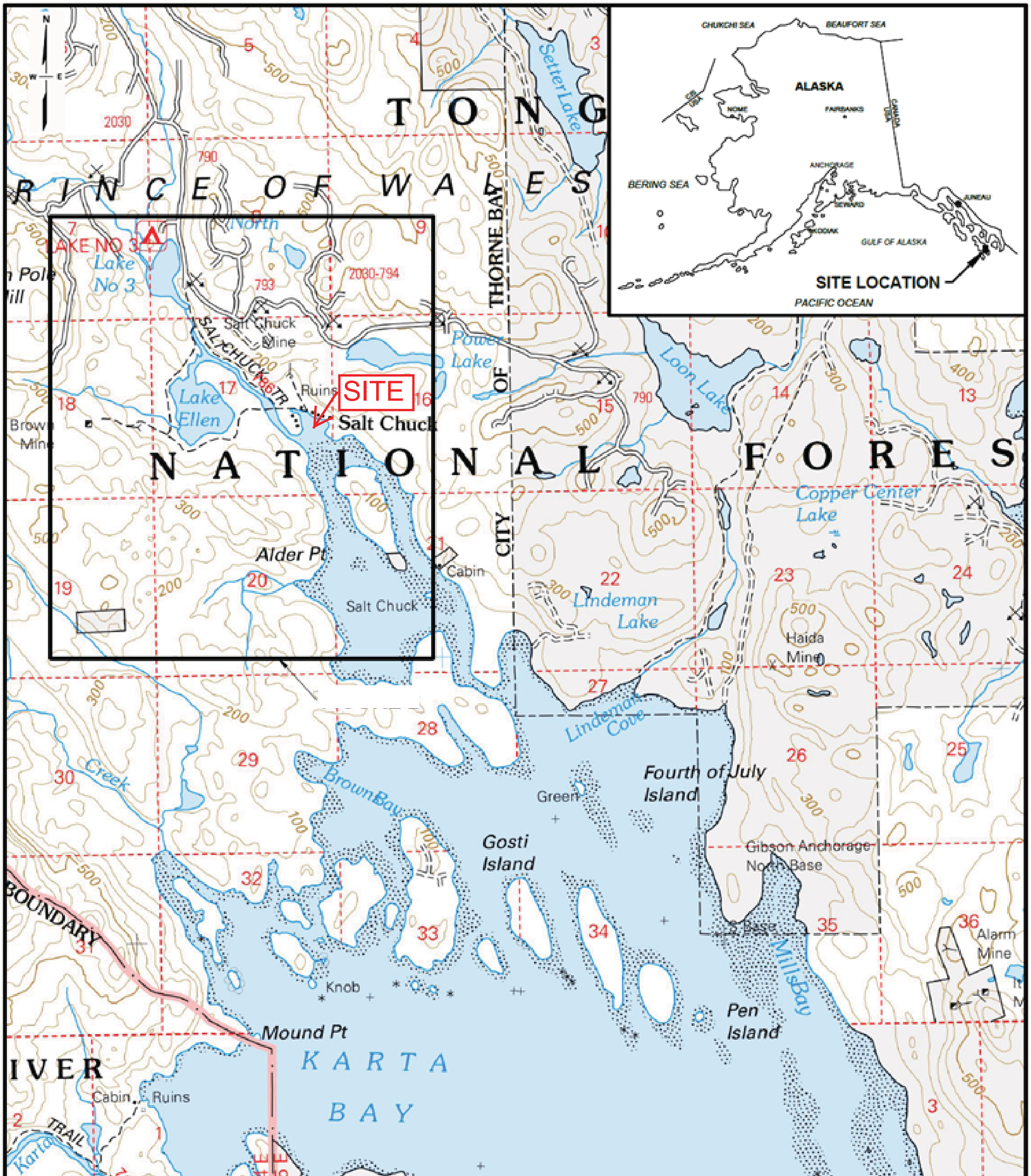
2.3.1 Chemical of Potential Concern

Historical investigations at the Salt Chuck Mine site have focused on the general constituent types that have been released to site media of concern. These previous site investigations are documented in the following documents:

- *Final Report, Removal Preliminary Assessment, Salt Chuck Mine, Ketchikan Ranger District, Tongass National Forest, Region 10 - Alaska* (Bureau of Land Management [BLM], 1998)
- *Draft Report Engineering Evaluation/Cost Analysis (EE/CA), Salt Chuck Mine Tongass National Forest, Alaska* (URS, 2007)
- *Near Final Completion Report Non-Time Critical Removal Action Salt Chuck Mine Mill Prince of Wales Island, Alaska* (North Wind, 2012)
- *Preliminary Findings for Pre-Remedial Investigation 2011 Field Sampling Activities Technical Memorandum* (CH2M HILL, 2012a)
- *Salt Chuck Mine – Preliminary Findings for Remedial Investigation 2012 Field Sampling Activities* (CH2M HILL, 2013b)

Based on these past site investigations, the general types of site-related contaminants identified include:

- **Metals** at both upland and intertidal areas.
- **Polynuclear aromatic hydrocarbons** at both upland and nearshore intertidal areas near the former mill site.
- **Petroleum hydrocarbons** at both upland and nearshore intertidal areas near the former mill site.



SOURCE: USDA FOREST SERVICE, 1:63,360 SERIES (TOPOGRAPHIC), CRAIG (C-2) QUADRANGLE

0 2,000 4,000 8,000
SCALE IN FEET

USDA FOREST SERVICE - ALASKA REGION

SITE LOCATION MAP

SALT CHUCK MINE
TONGASS NATIONAL FOREST, ALASKA

FIGURE 2-1

2.3.2 Project Area Overview

Landmarks and features within the project area are shown on Figure 2-2 and include:

Unnamed Stream A is the primary stream that flows through the intertidal area. Mine tailings have been historically placed in this stream and its floodplain. Over the years, the stream has formed a channel through and around the tailings deposits, which form the streambank and continue to erode. This stream has been referred to as Unnamed Stream or Unnamed Creek in previous project documents. In this Work Plan, the stream is referred to as Unnamed Stream A to distinguish it from a smaller stream on the eastern side of the site that is being referred to as Unnamed Stream B.

The **Tailings Spit** is the highest point in the intertidal area near the former mill site and is formed by a mound of tailings. The **West Tailings Deposit** is a large gradually sloping area that extends southward from the Tailings Spit and is composed of tailings.

The **Piles with Whaling** are piles with horizontal boards attached (called whaling) are located along the northern alignment of the West Tailings Deposit and Tailings Spit, and along the western side of the East Tailing Deposit. The piles with whaling are presumed to have been constructed (at least initially) to contain the tailings from migrating.

The **Rock Jetty** was constructed in the early 1900s (as evidenced in the 1929 photo shown in Figure 3-9). This feature is approximately 230 feet long by 15 feet wide and was constructed using uniform 4 to 8-inch quarry spalls (see Photo 3-6). This feature is presumed to have been constructed to contain the tailings from migrating into the access channel used to barge materials to and from the former mill site.

Figure 2-2. Overview of the Project Site and Intertidal Area
Photo courtesy of National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2007

2.4 Treatability Study General Approach

The general approach of the Treatability Study will be to excavate tailings from the high flow path of Unnamed Stream A at two primary eroding locations. In addition, transplanting and seeding of vegetation will be conducted in test plots to evaluate whether vegetation can survive and establish to stabilize areas of the broad exposed West Tailings Deposit. The performance of these activities will be evaluated in spring 2014 and documented.

2.5 Erosion Processes Evaluated

Erosion processes that are believed to mobilize tailings onsite will be evaluated for each erosion type observed, as summarized in Table 2-1.

TABLE 2-1
Summary of Erosion Types and Locations, and Estimated Erosion Processes
Treatability Study – Salt Chuck Mine

Erosion Type and Location Observed	Estimated Erosion Process
1. Erosion of steep slopes or banks	a. Slumping of approximately the lower one-third of steep banks caused by release of pore water from saturated tailings while surface water is below this point (typically during lower tides). b. Fluvial erosion of slumped material at the toe of the bank by Unnamed Stream A may be a rate-limiting process for slumping. c. Rill and rainsplash erosion on upper portion of steep banks, above zone of slumping.
2. Erosion of floodplain surface within former tailings pond (relatively low flat surface on inside bend of large meander upstream of tailings spit)	a. Surface erosion by overbank flow on portion of the floodplain that is overtopped during high tide and/or high flow events of Unnamed Stream. b. Rill formation and channel network development enhanced by ebb tides and direct rainfall on floodplain surface.
3. Surface erosion of the tailings deposits	a. Rainsplash and sheet flow caused by direct rainfall on tailings surface during low tide. Interaction of these two processes enhances their effectiveness at transporting sediment, because particles splashed into shallow sheet flow are delivered more efficiently to channel and bay. b. Rill and gully erosion on the tailings deposit surface. Ebb tides and direct rainfall on tailings deposits are creating rill networks that concentrate flow and cause erosion. Gully formation occurs where sloping rills intersect a buried, silt and/or clay stratigraphic layer in the tailings deposit. Gullies advance headward and widen near the channel of Unnamed Stream A. c. Wave and tidal action on the tailings deposit. Breaking waves on the tailings deposit surface may dislodge tailings/sediment particles. Advancing and retreating tides focused within the rill network likley transports dislodged particles. d. Wind action during low tides and high wind may also transport sand-sized tailings/sediment over the tailings deposit surface and exposed and unvegetated portions of the tailings spit.

Each of these processes may involve different types of stabilizing measures.

2.6 Treatability Study Work Plan Organization

This Treatability Study Work Plan includes the following components:

- **Chapter 1, Summary,** includes an overview summary of the Treatability Study.
- **Chapter 2, Introduction,** summarizes the project purpose and scope, and describes the project area, goal and objectives, and general approach of the Treatability Study
- **Chapter 3, Project Setting—Existing and Historical Conditions,** summarizes the existing conditions and some historical conditions of the project area.

- **Chapter 4, Streambank Stabilization,** summarizes the Treatability Study design for potential measures to stabilize eroding streambank tailings along Unnamed Stream A.
- **Chapter 5, West Tailings Deposit Stabilization,** summarizes the Treatability Study design for potential measures to stabilize the West Tailings Deposit.
- **Chapter 6, Treatability Study Schedule,** summarizes the schedule of the Treatability Study.
- **Chapter 7, Monitoring Plan,** summarizes the plan to monitor the results and performance of the stabilization measures implemented during the Treatability Study.
- **Chapter 8, References,** summarizes the references cited in the Treatability Study.

CHAPTER 3

Project Setting—Existing and Historical Conditions

This chapter summarizes the existing conditions and some historical conditions of the project area.

3.1 Oceanographic Setting

The oceanography of Southeast Alaska is closely linked to its complex geological structure and meteorology of the Northeast Pacific Ocean. Glaciers and geologic processes carved a complex of channels and fjords throughout the archipelago of islands, bays, and inlets. The region is bounded by steep mountains that, combined with seasonal storm activity, influence wind and precipitation patterns. These storms result in strong winds and heavy precipitation rates year-round, which significantly affect circulation fields.

Salt Chuck Bay is located on the southeastern side of Prince of Wales Island, approximately 40 miles northwest of Ketchikan. The bay is a shallow protected inlet on the extreme northwest end of Kasaan Bay, a long, narrow inlet west of the Kasaan Peninsula. Salt Chuck Bay was likely formed as a glacial trough that has become filled with sediment over recent geologic time. Although no National Oceanic and Atmospheric Administration (NOAA) bathymetric data could be found beyond Kasaan Bay, it appears (based on aerial photographs) to be on the order of only several feet deep. The extreme north end of Salt Chuck Bay is occupied by an extensive mudflat, which becomes exposed at lower tides. Unnamed Creek A enters Salt Chuck Bay from the northwest shore and meanders through the mudflat areas, dividing it into two around the north end of Unnamed Island.

By virtue of its location at the extreme end of Kasaan Bay and its numerous small islands, reefs, and outcroppings, the circulation within Salt Chuck Bay is probably limited. For this reason, circulation within the bay is likely predominately wind-driven, with some minor tidal forcing. Because of the orientation and size of the entrance of Salt Chuck Bay, sea swell, wind waves, and tidally-generated waves in Kasaan Bay are unlikely to affect the interior of the bay. The entrance to Salt Chuck Bay has considerable protection from swell and waves due to the shallow nature of the bay, and to the reefs, islands, and outcroppings that effectively block a portion of the bay entrance.

3.1.1 Tides

Tides in Southeast Alaska interact with the complex topography of the region, giving rise to a range of small-scale circulation phenomena (including tidal bores, internal hydraulic jumps, residual flows, and eddies). Many of these processes are likely modulated over the spring-neap tidal cycle and by changes in wind and freshwater runoff. The tides likely affect exchange of waters between main channels and fjords and bays comprising the archipelago. These circulation processes, however, are more commonly observed in the larger, more exposed and deeper locations. In smaller, more protected inlets and embayments such as Salt Chuck Bay, other processes are likely to be important. These various phenomena will be important in advecting, mobilizing, and/or retaining the tailings deposits within the of Salt Chuck Bay sediments.

The closest NOAA tide reference station to the project site is located at Ketchikan, AK (Station I.D. 9450625). Based on measured tides at this reference station, the mean range (i.e., difference in height between mean high water and mean low water) is 12.97 feet; the diurnal range (i.e., difference in height between mean higher high and mean lower low water) is 15.45 feet. As a comparison, and based on tides at this reference station, the predicted mean range for Lindeman Cove (i.e., the mouth of Salt Chuck Bay) is 13.30 feet, with a diurnal range of 15.8 feet. When comparing the tides measured at Ketchikan to those tides predicted for the Lindeman Cove/Kasaan Bay/Salt Chuck Bay region, there are clearly slight differences in magnitude (and likely timing as well).

3.1.2 Availability of Information

The Salt Chuck Mine project site is remote and removed from the main basins of Southeast Alaska. As a result there is a distinct lack of available information for Salt Chuck Bay (much less for the extreme north end of the bay where the mine was located). Several researchers at the Institute of Marine Science-University of Alaska Fairbanks conducted research in Southeast Alaska. Several papers published by the Institute of Marine Science staff stated there is a ”paucity of measurements in the region as a whole.” In fact, one research paper by Weingartner et al. (2009) stated that marine researchers remain “profoundly ignorant” of the oceanography and marine biogeography of Southeast Alaska. This is mainly for two reasons: 1) most of the marine research efforts in the region have focused on marine mammals, marine birds, and salmon; and 2) the regional geological diversity results in numerous interacting processes (i.e., winds, freshwater runoff, tides, geology) that cover a broad spectrum of time and space scales. For these reasons, these processes are likely to vary in importance from one area to another. Stated another way, the local topography and geology of Southeast Alaska are so diverse that information cannot necessarily be extrapolated from one location to another. Therefore, to get a firm understanding of the important processes operating within a particular area, site-specific studies are needed.

3.1.3 Drift Logs and Debris

The wind and wave action has resulted in the accumulation of wrack—drift logs and organic debris—on the south side of the Tailings Spit (Figure 2-1).

3.2 Physical Site Conditions

3.2.1 Intertidal Topography

In February 2013, R&M Engineering-Ketchikan Inc. (R&M) conducted topographic survey of the intertidal area during low tide conditions (R&M 2013). Figure 3-1 shows the surveyed topography of the intertidal area. The intertidal area onsite ranges from 1 foot elevation at Ellen Creek/Salt Chuck Bay to 15 foot elevation at the Tailings spit (North American Vertical Datum 1988 [NAVD88]). Water levels are presented in feet NAVD88, which at the project site is 3.84 feet below mean lower low water (that is, mean lower low water = NAVD88 + 3.84 feet).

3.2.2 Unnamed Stream A

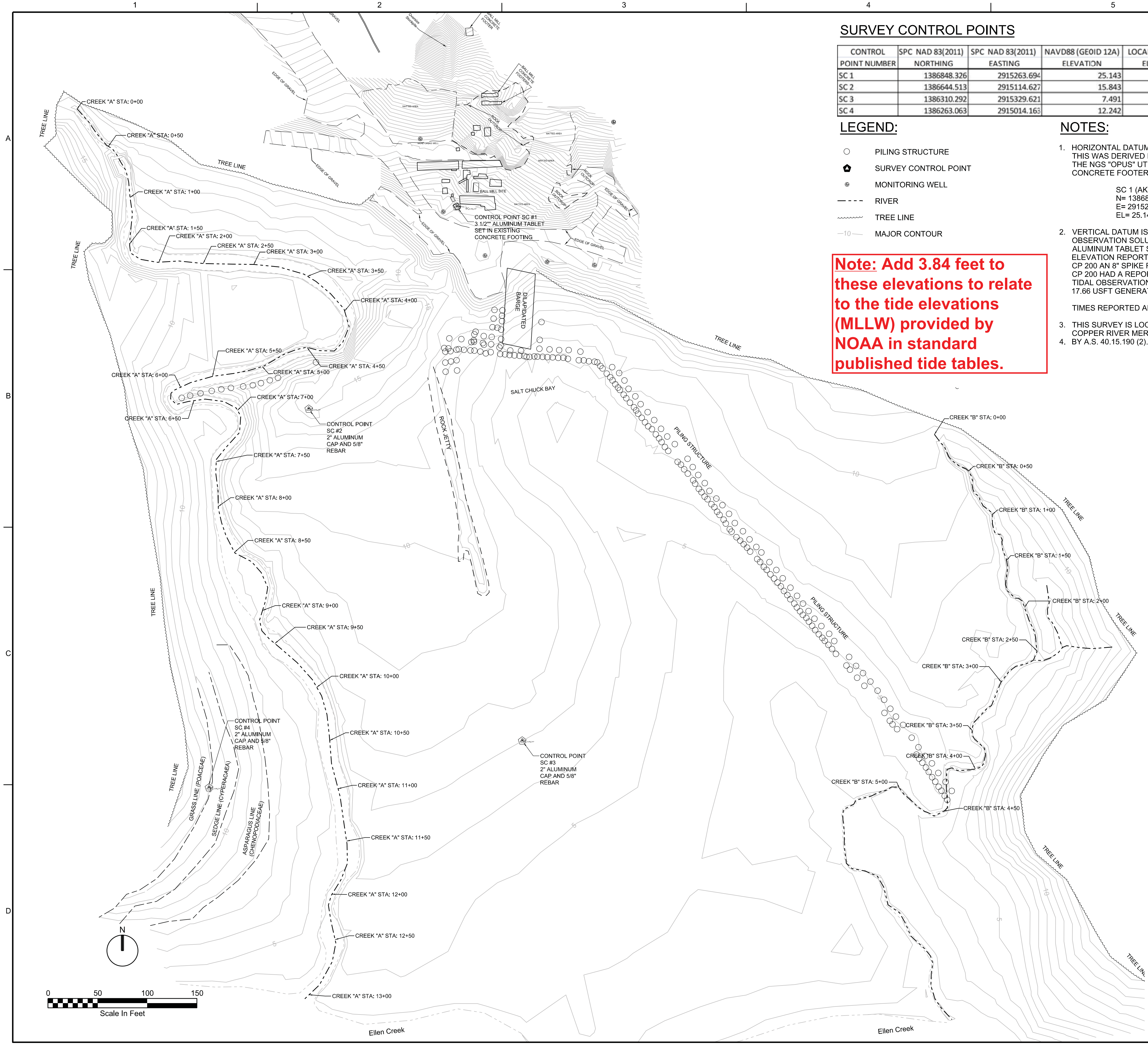
3.2.2.1 Channel Morphology of Intertidal Reach

The intertidal reach of Unnamed Stream A has been altered by placement of historical mine tailings and construction of the piles and whaling. These modifications have confined and restricted the channel flows, especially during large storm events. As a result, it has taken many decades of erosion and sediment transport to achieve the present day channel morphology of the intertidal reach shown in Figure 3-1.

The general characteristics of the intertidal reach of Unnamed Stream A are summarized in Table 3-1. The overall slope of the channel is 0.57 percent. However, there is an existing headcut and plunge pool within the upper 90 linear feet of the surveyed intertidal stream channel that results in nearly a 4-foot drop. As a result, the effective channel slope is approximately 0.34 percent when the upper 90 feet are excluded.

The streambed consists primarily of pebble gravel to sand size sediment/tailings, with an occasional boulder. For much of the channel length, at least one of the streambanks consists of exposed tailings deposits that are eroding.

Figure 3-1. 2013 Intertidal Topographic Survey



SURVEY CONTROL POINTS

CONTROL POINT NUMBER	SPC NAD 83(2011) NORTHING	SPC NAD 83(2011) EASTING	NAVD88 (GEOID 12A) ELEVATION	LOCAL TIDAL MLLW ELEVATION	NAD 83(2011) LATITUDE	NAD 83(2011) LONGITUDE	GEOID 12A HEIGHT	CONTROL DESCRIPTION
SC 1	1386848.326	2915263.694	25.143	28.983	N55°37'34.41274"	W132°33'25.49302"	12.06	SET_ALUM_TAB
SC 2	1386644.513	2915114.627	15.843	19.683	N55°37'32.42807"	W132°33'28.14669"	2.66	SET_ALUM_CAP
SC 3	1386310.292	2915329.621	7.491	11.331	N55°37'29.10023"	W132°33'24.49562"	-5.60	SET_ALUM_CAP
SC 4	1386263.063	2915014.163	12.242	16.082	N55°37'28.68512"	W132°33'30.00385"	-0.84	SET_ALUM_CAP

LEGEND:

- PILING STRUCTURE
- SURVEY CONTROL POINT
- MONITORING WELL
- RIVER
- TREE LINE
- MAJOR CONTOUR

Note: Add 3.84 feet to these elevations to relate to the tide elevations (MLLW) provided by NOAA in standard published tide tables.

NOTES:

1. HORIZONTAL DATUM IS ALASKA STATE PLANE, ZONE 1 US SURVEY FEET, NAD 83 (2011). THIS WAS DERIVED FROM MULTIPLE GPS OBSERVATION SOLUTIONS OBTAINED FROM THE NGS "OPUS" UTILITY. "SC 1" A 3 1/2" ALUMINUM TABLET SET IN AN EXISTING CONCRETE FOOTER AS SHOWN.

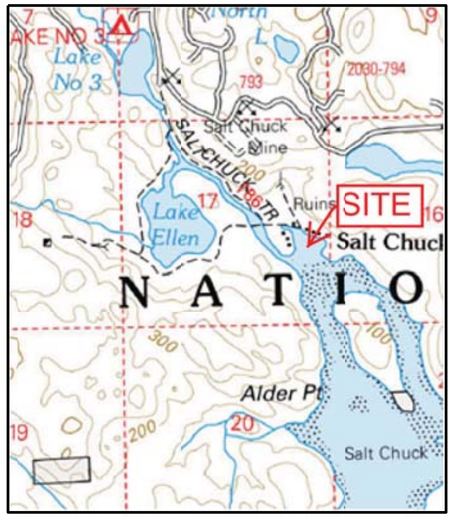
   SC 1 (AK SPC ZONE 1, NAD83(2011)
   N= 1386848.326
   E= 2915263.694
   EL= 25.143 NAVD 88 (GEOID 12A)

2. VERTICAL DATUM IS NAVD 88 (GEOID 12A). THIS WAS DERIVED FROM MULTIPLE GPS OBSERVATION SOLUTIONS OBTAINED FROM THE NGS "OPUS" UTILITY. "SC 1" A 3 1/2" ALUMINUM TABLET SET IN AN EXISTING CONCRETE FOOTER AS SHOWN. THE MLLW ELEVATION REPORTED IN THIS SURVEY IS BASED ON THE EXISTING CONTROL POINT CP 200 AN 8" SPIKE RECOVERED IN THE BARGE DECK AT THE FORMER MILL SITE. CP 200 HAD A REPORTED MLLW OF 21.50 USFT FROM OUR PREVIOUS TIME COORDINATED TIDAL OBSERVATIONS IN OCTOBER 2011. WE OBSERVED A NAVD 88 (GEOID 12A) OF 17.66 USFT GENERATING A 3.84 USFT OFFSET TO OUR NAVD 88 ELEVATION.

   TIMES REPORTED ARE AK STANDARD TIME.

3. THIS SURVEY IS LOCATED WITHIN SECTIONS 16 & 17 TOWNSHIP 72 SOUTH, RANGE 84 EAST, COPPER RIVER MERIDIAN. IT DOES NOT CONSTITUTE A BOUNDARY SURVEY AS DESCRIBED
4. BY A.S. 40.15.190 (2).

LOCATION MAP
NTS



VICINITY MAP
NTS

INDEX OF DRAWINGS

DWG	DRAWING NAME
C1	EXISTING CONDITIONS AND SURVEY CONTROL
C2	PROJECT VICINITY AND QUARRY SITES
C3	SITE PLAN
C4	EXCAVATION AND GRADING PLAN
C5	SECTIONS AND DETAILS
C6	REVEGETATION PLAN
C7	REVEGETATION DETAILS

NO.	DATE	REVISION	BY	APVD

DSGN K DAWSON | DR C ECKBERG | CHK P TOWNLEY | APVD H EHLERT

U.S. ENVIRONMENTAL PROTECTION AGENCY
PRINCE OF WALES ISLAND
ALASKA

CH2MHILL®

EXISTING CONDITIONS AND SURVEY CONTROL

1" = 50'
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	MARCH 2013
PROJ	421566
DWG	C1
SHEET	1

PRELIMINARY

FILENAME: DC001_421566.dgn PLOT DATE: 2013\03\27 PLOT TIME: 12:32:07 PM

The channel width varies from approximately 6 to 35 feet wide. In the narrowest reaches, the steam reaches maximum velocities that likely cause bed or bank erosion during large storm events.

TABLE 3-1
Summary of Channel Characteristics of the Intertidal Reach of Unnamed Stream A
Treatability Study – Salt Chuck Mine

Channel Characteristic	Observed or Surveyed Condition
Channel length	1,300 linear feet
Straight distance length	900 feet
Channel sinuosity	1.4 (channel length divided by straight distance length)
Channel slope Overall slope: Slope excluding headcut:	 0.0057 ft/ft (7.5 foot drop in 1,300 linear feet), or 0.57 % 0.0034 ft/ft (4.15 foot drop in 1,210 linear feet), or 0.34 %
Channel width (base flow)	6 to 35 feet
Streambed composition	medium to coarse sand size sediment/tailings, with occasional rocks
Channel bottom elevation range	3-10 feet NAVD88 (overall) 3 to 7 feet (when excluding the upper 90 feet of intertidal channel)

3.2.2.2 Stream Hydrology/Hydraulics

The drainage area for Unnamed Stream A is shown in Figure 3-2. This drainage area is estimated to be approximately 541 acres (approximately 0.8 square mile).

In July 2012, CH2M HILL measured streamflow from Unnamed Stream A just upstream from where it entered the intertidal area to be 19.7 cubic feet per second (cfs), which was representative of a storm flow because it followed a hard rainfall event. On May 5, 2013, CH2M HILL measured streamflow from Unnamed Stream A just upstream just upstream of the headcut in the intertidal area to be 0.9 cfs, which was representative of base flow conditions following a period of dry weather.

The U.S. Geological Survey (USGS) prepared a report titled *Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada* (USGS, 2003). Using the regression equation and characteristics of the drainage basin for Unnamed Stream A, peak flows were estimated as summarized in Table 3-2. These estimates provide at least a first approximation of the relative flows that have shaped the channel and tailings deposits in the intertidal area onsite.

TABLE 3-2
Estimated Peak Flows (Rounded) for Unnamed Stream A
Treatability Study – Salt Chuck Mine

Recurrence Interval	Estimated Streamflow (cfs) [a]	Estimated Range of Streamflow (cfs) [a] (95 percent confidence interval)
2-year	80	43-149
5-year	110	60-206
10-year	130	71-247
100-year	200	84-302

[a] Calculated using regression equation in USGS, 2003.

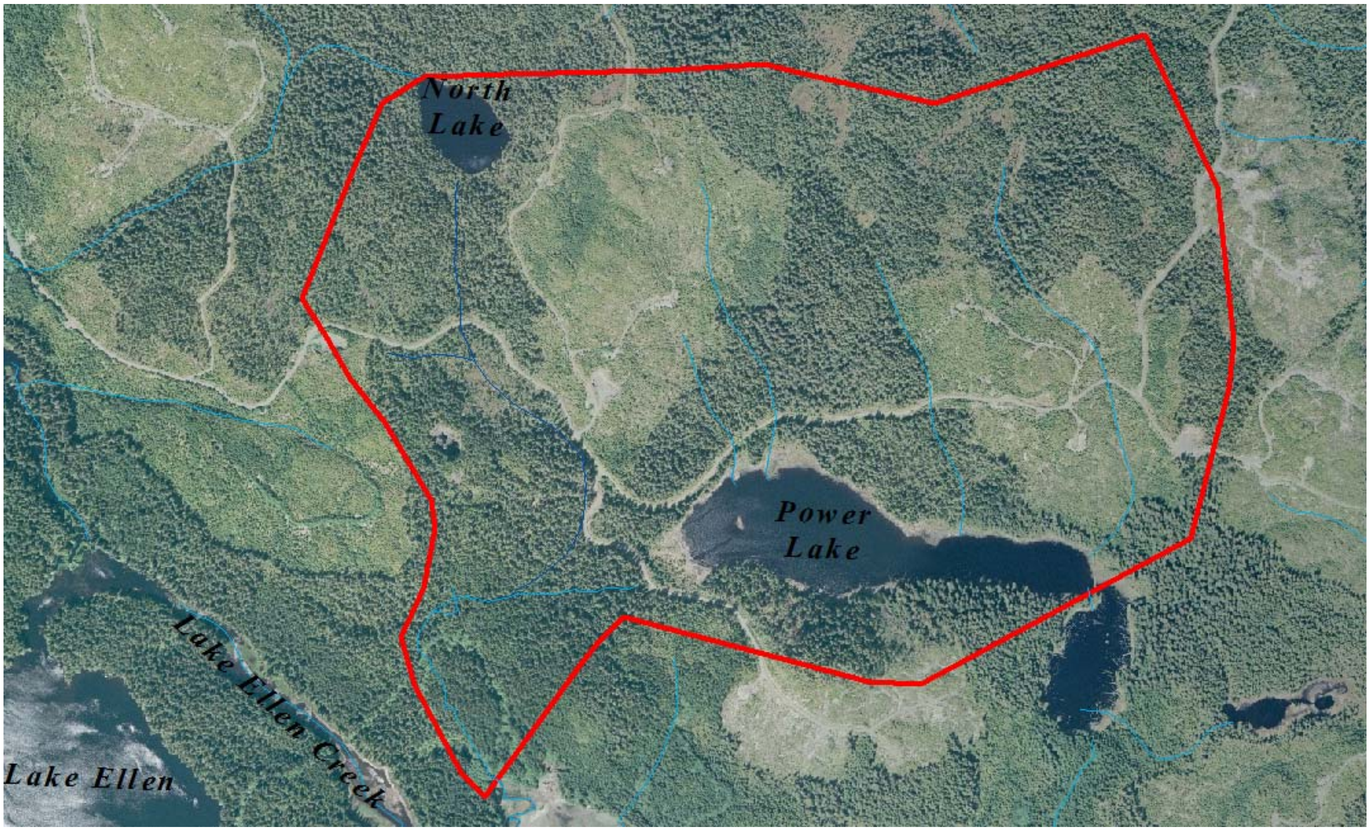


Figure 3-2. Drainage Area for Unnamed Stream A

3.2.3 Hydrodynamic Modeling for Streambank Stability Analysis

A two-dimensional hydrodynamic model was constructed to simulate stream flows and tidal exchange near the former mill site in Salt Chuck Bay. The goal of the modeling effort was to quantify local current velocities under stream and tidal influences and characterize the potential for erosion of existing tailings deposits at the project site. Model simulations were conducted for existing conditions and focused on predicted peak velocities during ebb tide conditions with a range in stream inflows in Unnamed Stream A. Model results indicate that tidal exchange alone is likely insufficient to produce any significant erosion of the tailings deposit, but storm events, particularly those with return periods on the order of 1 to 10 years (and greater), produce velocities sufficient to cause extensive erosion at certain locations. For more detail, see Appendix A for a Draft Technical Memorandum: *Salt Chuck Mine Remedial Investigation – Two Dimensional Hydrodynamic Modeling for Streambank Stability Analysis* (CH2M HILL, 2013c).

Predicted velocities throughout the project site were reviewed using time-varying contour plots of current magnitude. Snapshots in time of the distribution of current magnitudes at the site are presented below for a series of simulations. Figures 3-3A, B, and C show snapshots from model simulations with stream inflows of 40, 80, and 130 cfs, respectively, during the most rapidly falling stage of the ebbing tide. Model results demonstrate the marked increase in peak velocities with increases in stream flows.

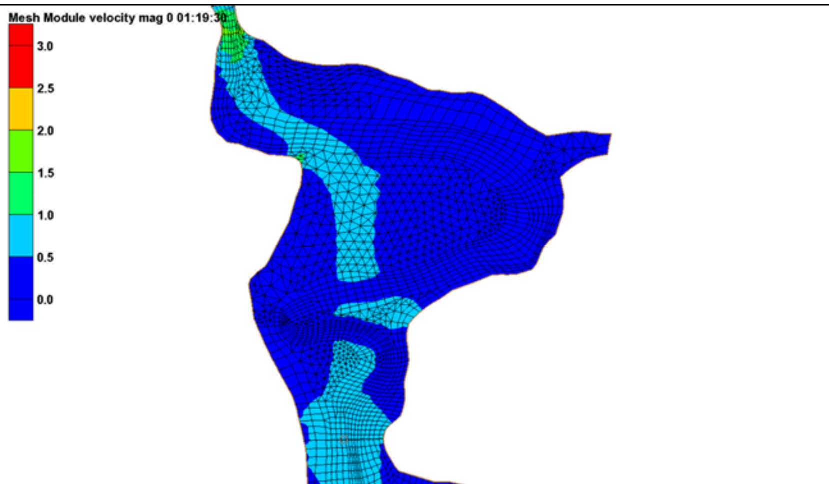


Figure 3-3A. Ebb Tide Velocity Magnitude for 40 cfs Stream Flows (reduced grid with maximum elevation of 10 feet NAVD88, simulation of partially drained site)

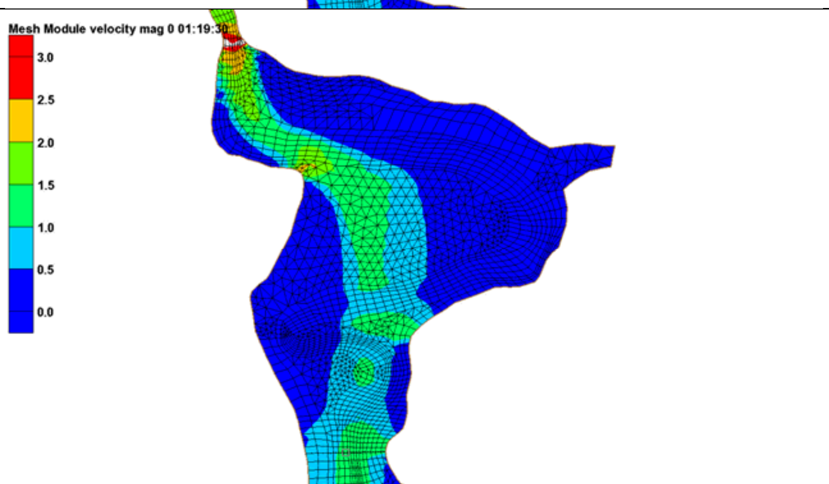


Figure 3-3B. Ebb Tide Velocity Magnitude for 80 cfs Stream Flows (reduced grid with maximum elevation of 10 feet NAVD88, simulation of partially drained site)

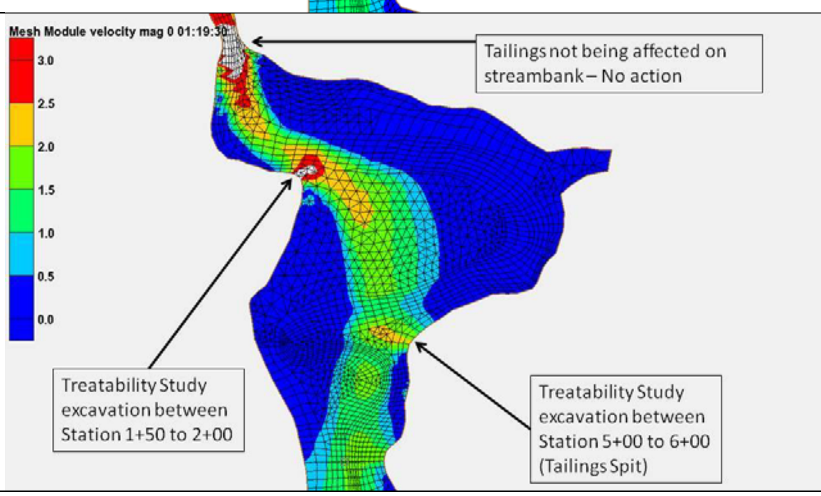


Figure 3-3C. Ebb Tide Velocity Magnitude for 130 cfs Stream Flows (reduced grid with maximum elevation of 10 feet NAVD88, simulation of partially drained site)

Model results for existing conditions at the project site identified two primary localized areas of increased velocity where erosion is likely to occur under storm stream flows and ebb tides, as indicated by the areas of yellow and red colors in Figures 3-3A, B, and C. This first location is between Station 1+50 and 2+00 on Unnamed Stream A, and the second is between Station 5+00 and 6+00 on Unnamed Stream A (see Photos 3-1 through 3-4). Therefore, this Treatability Study Work Plan includes the excavation of tailings from the flow path at these two locations to reduce erosion and transport of tailings, as further described in Chapter 4.

3.2.4 Gully Formation

A small head-cutting gully appears to be forming along the west side of the West Tailings Deposit (see Photo 3-5) near Station 8+80. Gully formation can be rapid and result in considerable erosion and transport of sediment. Stabilizing such an area early to minimize additional erosion may be warranted.

Photo 3-1. Streambank location of high velocity where erosion is likely occurring, between Station 1+50 and 2+00. Note exposed bank in background.

Photo 3-2. Close up view of streambank location of high velocity where erosion is likely occurring, between Station 1+50 and 2+00. The 5- to 6-foot high bank is at risk of episodic erosion and transport during high streamflow event.

Photo 3-3. Location of high velocity where erosion is likely occurring, between Station 5+00 and 6+00.

Photo 3-4. Location of high velocity where erosion is likely occurring, between Station 5+00 and 6+00.

Photo 3-5. Location of head-cutting gully near Station 8+80.

3.2.5 Sampling and Analysis of Sediment/Tailings

In 2011, CH2M HILL conducted a pre-Remedial Investigation (RI) onsite. In 2012, CH2M HILL conducted a Phase 1 RI field sampling activities onsite. Samples of the intertidal sediment/tailings were collected and analyzed (CH2M HILL, 2012a; CH2M HILL, 2013b).

3.2.5.1 Copper and Total Organic Carbon

Figures 3-4 and 3-5 show the locations where sediment/tailings were sampled by CH2M HILL near the West Tailings Deposit in August 2011 and July 2012, respectively. Analyses that are relevant to the Treatability Study are copper concentration and total organic carbon (TOC). The tailings are generally high in copper and low in TOC. Table 3-3 summarizes these results. Copper concentration and TOC are generally inversely proportional. Copper showed a range from 111 to 3,870 mg/kg. In addition, TOC in these samples ranged from 379 to 7,060 mg/kg.

Figure 3-6 (extracted from URS, 2007) shows copper concentrations with an isoconcentration contour near where sea asparagus will be transplanted on the West Tailings Deposit. In general, the data indicate that copper concentrations are lower at the southern portion of the West Tailings Deposit but increase in concentration in the northward direction toward the tailings spit.

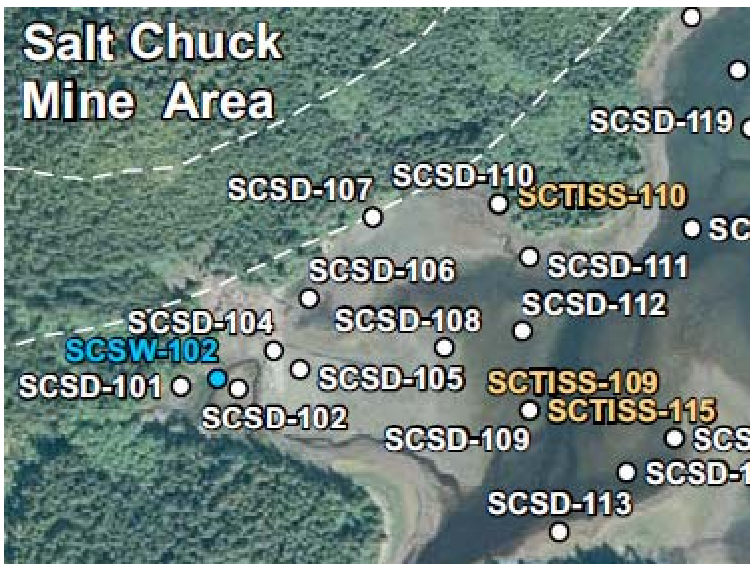


Figure 3-4. 2011 Intertidal Sediment/Tailings Sample Locations at Salt Chuck Bay
From CH2M HILL, 2012a

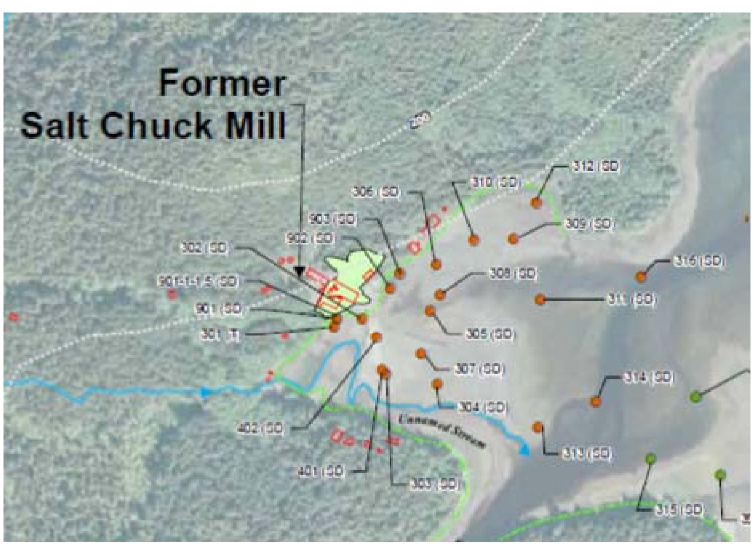


Figure 3-5. 2012 Intertidal Sediment/Tailings Sample Locations at Salt Chuck Bay
From CH2M HILL, 2013b

TABLE 3-3
Copper and Total Organic Carbon Results for Tailings Samples Collected in the Study Area, 2011 and 2012
Treatability Study – Salt Chuck Mine

Location ID	Sample Type	Sample ID	Date	Depth (feet)	Depth (feet)	Copper (mg/kg)	TOC (mg/kg)
SCSD-101	N	SCSD-101-0-0.5-08282011	28-Aug-11	0	0.5	641	7060
SCSD-102	N	SCSD-102-0-0.5-08282011	28-Aug-11	0	0.5	895	2970
SCSD-104	N	SCSD-104-0-0.5-08282011	28-Aug-11	0	0.5	882	825
SCSD-105	N	SCSD-105-0-0.5-08282011	28-Aug-11	0	0.5	1910	534
SCSD-105	N	SCSD-105-2-3-08292011	29-Aug-11	2	3	980	379
SCSD-301	N	SCSD-301-07292012	29-Jul-12	0	0.5	2530	1130
SCSD-302	N	SCSD-302-07302012	30-Jul-12	0	0.5	2650 J	590
SCSD-303	N	SCSD-303-07302012	30-Jul-12	0	0.5	2550 J	280
SCSD-304	N	SCSD-304-07292012	29-Jul-12	0	0.5	1100	720
SCSD-307	N	SCSD-307-07302012	30-Jul-12	0	0.5	1250	455
SCSD-401	N	SCSD-401-07302012	30-Jul-12	0	0.5	3110 J	630
SCSD-401	FD	SCSD-701-07302012FD	30-Jul-12	0	0.5	3870 J	551
SCSD-402	N	SCSD-402-07302012	30-Jul-12	0	0.5	1430 J	859
SCSD-901	N	SCSD-901-07292012	29-Jul-12	0	0.5	3210 J	-
SCSD-901-1-1.5	N	SCSD-901-1-1.5-07292012	29-Jul-12	1	1.5	111 J	-
SCSD-902	N	SCSD-902-08012012	01-Aug-12	0	0.5	1190	-

J = The analyte was positively identified; the quantitation is an estimation.
FD = Field duplicate sample
N = Normal sample

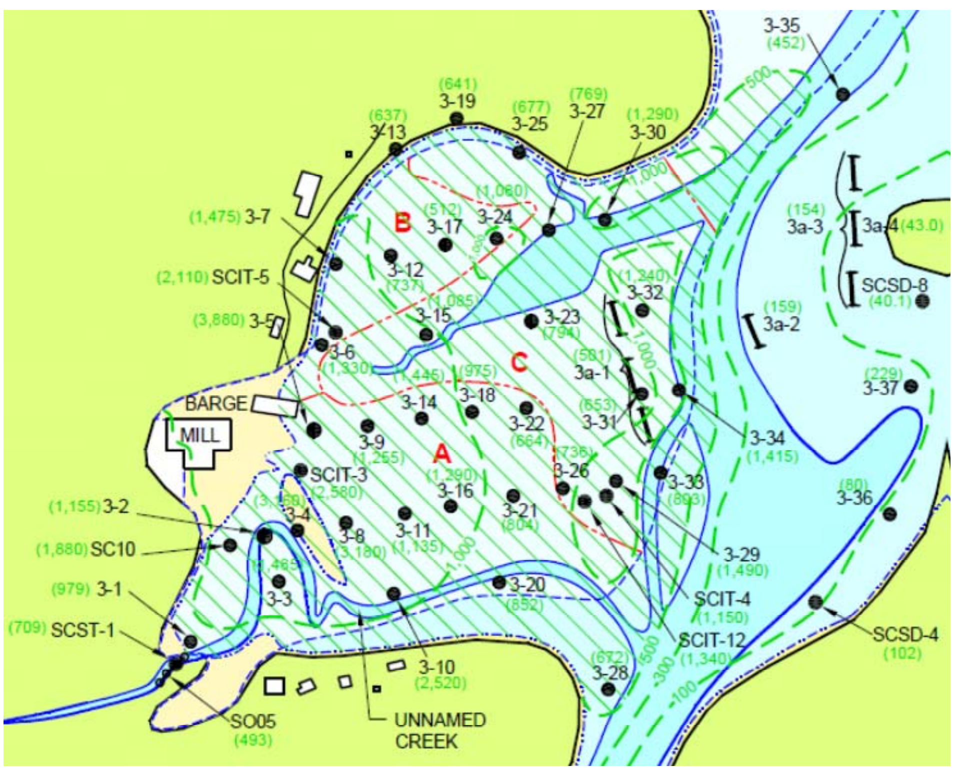


Figure 3-6. Distribution of Copper in Intertidal Tailings and Sediment – Northern Salt Chuck Bay
From Figure 2-10 in URS, 2007

Samples were also collected in 2011 and 2012 by CH2M HILL near Brown's Point to represent background sediment conditions. Table 3-4 summarizes concentrations of copper and TOC. Copper showed a range from 12.2 to 20.7 mg/kg. In addition, TOC showed a range from 13,000 to 31,800 mg/kg.

TABLE 3-4
Copper and Total Organic Carbon Results for Native Sediment Samples Collected in Browns Bay, 2012
Treatability Study – Salt Chuck Mine

Sample ID	Date	Top depth	Bottom depth	Units	Copper (mg/kg)	TOC (mg/kg)
SCSD-333-08022012	02-Aug-12	0	0.5	ft	13.3	19000
SCSD-334-08022012	02-Aug-12	0	0.5	ft	20.7	31800
SCSD-335-08022012	02-Aug-12	0	0.5	ft	20.5	13000
SCSD-336-08022012	02-Aug-12	0	0.5	ft	12.2	10400
SCSD-337-08022012	02-Aug-12	0	0.5	ft	14.1	23300

3.2.5.2 Grain Size

Sediment/tailings samples from the intertidal area onsite were also analyzed for grain size. Table 3-5 summarizes the grain size data, which show that grain size of the tailings is generally fine sand (i.e., sieve No. 140).

TABLE 3-5
Grain Size Distribution of Sediment/Tailings Samples Collected in the Study Area, 2011 and 2012
Treatability Study – Salt Chuck Mine

	Date	Depth (ft)	Particle size, 3/8 inch (9.525mm)	Particle size, Sieve No. 04, 4 mesh, (4.75mm)	Particle size, Sieve No. 10, 9 mesh, (2.00mm)	Particle size, Sieve No. 20, 20 mesh, (0.850mm)	Particle size, Sieve No. 40, 35 mesh, (0.425mm)	Particle size, Sieve No. 60, 60 mesh, (0.250mm)	Particle size, Sieve No. 140, 150 mesh, (0.106mm)	Particle size, Sieve No. 200, 200 mesh, (0.075mm)
SCSD-105	28-Aug-11	0-0.5	0	2.3	1.1	0	2	40.5	301.3	177.8
SCSD-301	29-Jul-12	0-0.5	3.2	2.5	3.5	1.89	7.57	38.79	219.52	93.20
SCSD-302	30-Jul-12	0-0.5	96.2	3.3	10.2	3.22	6.45	47.55	390.90	137.02
SCSD-401	28-Jul-12	0-0.5	0	100.6	112.3	112.89	78.09	24.06	10.73	2.22

Units for particle size = grams

3.2.5.3 pH

Analysis of acid-base accounting in combination with sulfur speciation indicates that the tailings and waste rock will not be acid generating in the long term (CH2M HILL, 2013d).

3.3 Vegetation

3.3.1 Observed Vegetation Establishment on Tailings Deposits

Despite over 70 years since mill operations ceased in 1941, natural colonization of vegetation on the tailings deposits has been limited. Colonization has been challenging due to the generally unfavorable characteristics of the tailings deposits that are uncharacteristic of intertidal sediments:

- Coarse mineral substrate
- Low organic matter (i.e., TOC)
- Low fertility
- Possible phytotoxic concentrations of copper and other metals
- Uniform exposed surface lacking topographic variation and microsites, such as rock or logs

As of result of the lack of established vegetation on the intertidal tailings deposits, gradual erosion and transport of tailings is suspected. In addition, wave and wind energy may further erode sediments and dislodge seeds and young propagules.

However, some individual plants have nevertheless established in areas of the tailings deposits. This has occurred in locations, which are generally protected from wind, waves, and scour; places where organic matter, fine sediment, and nutrients may accumulate. Photos 3-6 through 3-11 show examples of plants establishing on the tailings deposits onsite.

When Salt Chuck mine was in operation, tailings were deposited in the intertidal area. After mill operations ceased, the tailings were exposed to the natural forces (tides, waves, wind, and stream flow), which reshaped the tailings into their current condition.

Slow colonization by vegetation is characteristic of substantially disturbed sites that require the re-formation and development of soil processes. Substrate conditions are critical to plant and animal colonization and growth (Zedler, 2001).

Photo 3-6. Sea asparagus establishment among and around the rocks at the south end of the rock jetty.

Photo 3-7. Sea asparagus establishment at base of rock on tailings deposit.

Photo 3-8. Red alder establishment on the Tailings Spit.

Photo 3-9. Sea asparagus establishment near drainage channel immediately east of the rock jetty.

Photo 3-10. Patch of beach wildrye (*Leymus mollis*)—in the lower right corner—establishing in the protection of the north end of the rock jetty near the tailings spit.

Photo 3-11. Vegetation dominated by Lyngbye's sedge (*Carex lyngbyei*) on floodplain areas upstream of the tailings spit in area of historical mine tailings pond.

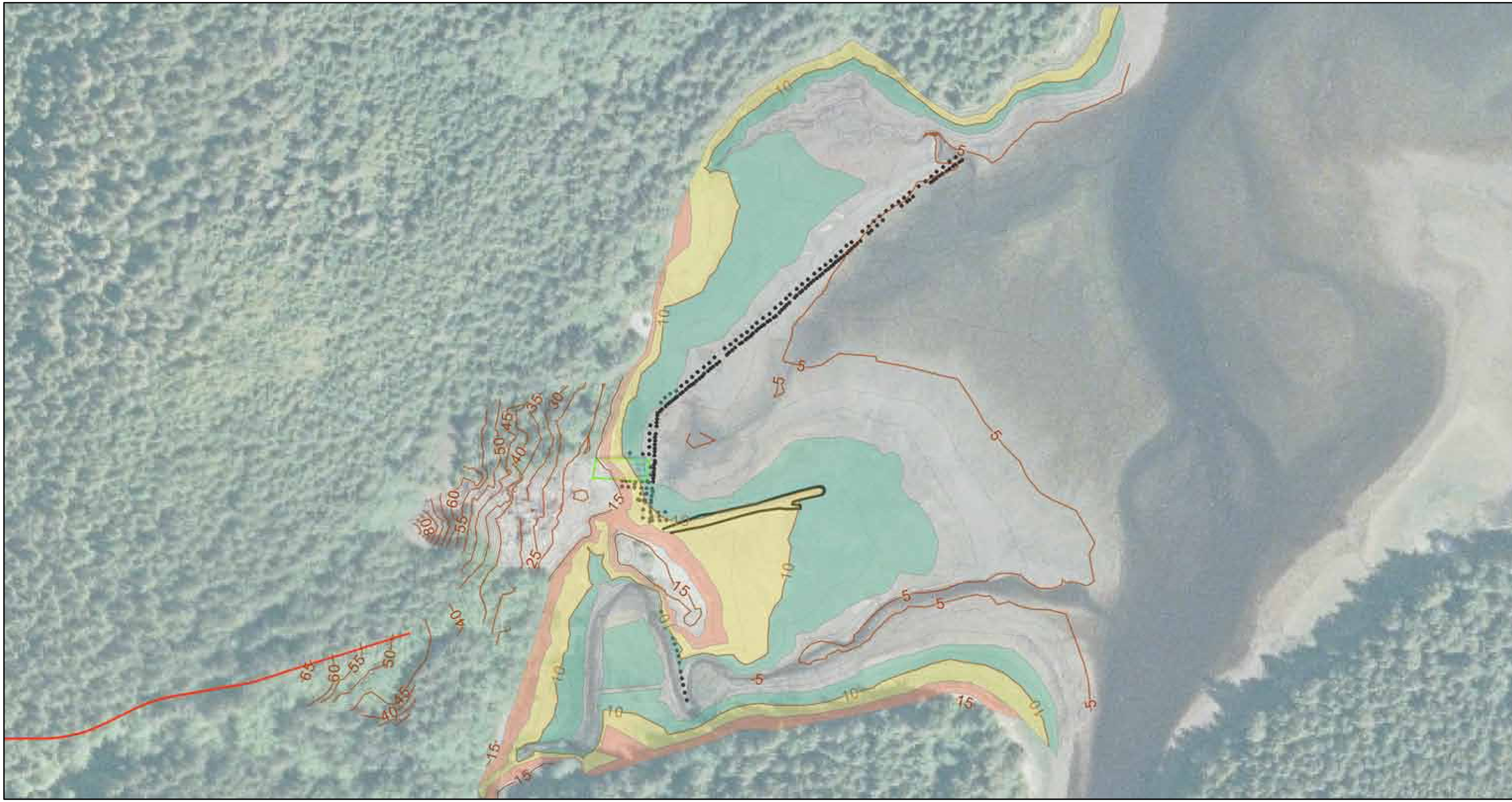
3.3.2 Plant Communities Distribution and Elevation Ranges

The most abundant intertidal vegetation is located on the southwestern edge of the site (Figure 2-1). Vegetation in this area is dominated by three main communities that occur at different elevations. In February 2013, R&M Engineering-Ketchikan, Inc. surveyed the elevations of the approximate breaks between established existing intertidal vegetation communities at a reference area in the southwestern edge of the site (R&M 2013). The intertidal plant communities and associated elevations are summarized in Table 3-6.

The elevation breaks were generally projected across the tailings deposits onsite. Figure 3-7 represents the potential elevation zones for establishing intertidal vegetation, which is generally lacking on the intertidal tailings deposits onsite. Actual plant establishment will vary depending on factors such as, tailings/sediment substrate conditions, freshwater influence, and variation in microsite topography.

TABLE 3-6
Intertidal Plant Communities and Associated Approximate Elevations
Treatability Study – Salt Chuck Mine

Vegetation Type	Species	Approximate Elevation Range (feet NAVD88)
Upland alder and conifer forest	*Alnus rubra, Tsuga heterophylla*	> 14
Beach wildrye	*Leymus mollis*	12-15
Bering hairgrass	*Deschampsia beringensis*	10-12
Sea asparagus Alkaligrass Lyngbye's sedge Seaside arrowgrass	*Salicornia virginica* *Puccinellia nutkaensis* *Carex lyngbyei* *Triglochin maritima*	8-10
Mud flat	*Fucus sp.*	< 8



Potential Elevation Zones for Establishing Intertidal Vegetation

- Beach Wildrye (12-14')
- Bering Hairgrass (10-12')
- Sea Asparagus (8-10')
- Major Elevation Contour (feet NAVD88)
- Minor Elevation Contour (feet NAVD88)
- Rock Jetty
- Barge
- Access Road
- Piling Structure

N

0 200 400 Feet

Notes:
(1) Aerial photography courtesy US Census Bureau; approximate date 2006. NAD83, UTM Zone 8N, Meters. Pixel size 1 meter.
(2) 1- foot contours and other features surveyed Febuary 2013 (NAVD88).
(3) This figure represents the potential elevation zones for establishing intertidal vegetation, which is generally lacking on the intertidal tailings deposits onsite. Potential elevation zones were established by surveying the elevations of the approximate breaks between established existing intertidal vegetation communities at a reference area in the southwestern edge of the site. The elevation breaks were then generally projected across the site. Actual plant establishment will vary depending on factors such as, tailings/sediment substrate conditions, freshwater influence, and variation in microsite topography

DRAFT

Figure 3-7
Potential Elevation Zones for Establishing Intertidal Vegetation
Salt Chuck Mine, Alaska

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3.3.3 Summary of Bench Test Pilot Studies

CH2M HILL conducted a laboratory bench test in fall 2012. Preliminary findings demonstrated that cut shoots (live cutting fragments) from the same species of sea asparagus (*Salicornia virginica*), which grows on the Oregon coast, when planted in tailings samples collected from the intertidal area at the Salt Chuck Mine site, developed new shoots and roots in several months. Sea asparagus is a robust species that will regenerate from live cutting fragments, as demonstrated by the bench test and by others (Zedler, 2001). The bench test also demonstrates that live cutting fragments can establish in the mine tailings from the site (under laboratory conditions using a variety from the Oregon coast).

Photos 3-12 and 3-13 show elongation of roots and shoots of sea asparagus grown in Salt Chuck Mine tailings from sample SCSD-304, which contained 1,100 mg/kg copper. However, sea asparagus planted in tailings from sample SCSD-301 (containing 2,530 mg/kg copper) had essentially no root growth. These preliminary results suggest a possible phytotoxic threshold that could be somewhere between 1,100 and 2,530 mg/kg. Sediment/tailings samples that were collected within the 8- to 10-foot elevation zone where sea asparagus will be transplanted appear to be relatively similar in copper concentration as sample 304 that was tested, which offers potential for using live cutting fragments of sea asparagus to colonize the intertidal areas of that elevation zone onsite.

Photo 3-12. Shoot elongation of a sea asparagus live cutting fragment after several months in Salt Chuck Mine tailings (sample SCSD-304).

Photo 3-13. Root development of sea asparagus live cutting fragments after several months in Salt Chuck Mine tailings (sample SCSD-304).

3.4 Historical Conditions

The first claims at Salt Chuck Mine were staked in 1905, when the mine was originally was known as the Goodro Mine (BLM, 1998). The mine and mill operated from 1905 to 1941 and processed over 326,000 tons of ore. The primary ores produced from the mine were copper, gold, silver, and platinum group elements, most notably palladium. Salt Chuck Mine was the most important copper producer in the Ketchikan Mining District, the only single lode palladium mine in Alaska, and of national importance as a palladium producer in the 1920s. The discovery that the ore contained palladium/platinum led to construction of the mill with a capacity of processing 30 tons of ore per day in 1917, and expanded to a capacity of 300 tons per day in 1923. Understanding the conditions during mining that led to the existing site conditions provides insight for designing stabilization measures.

Figure 3-8 shows a map of the project area in 1920 showing a “Tailings Pond” within the area immediately upstream of the existing tailings spit. Historical mill tailings were primarily placed in the intertidal area and within the channel and floodplain of Unnamed Stream A.

Figure 3-9 shows an aerial photo from 1929. By that time, the rock jetty, and piles with whaling are visible. In addition, there is a signature of what appears to be a braided low flow channel of Unnamed Stream A flowing around the south end of the rock jetty. There are other signatures of potential channel threads extending southward that may be overflow channels of Unnamed Stream A from higher flow events or may depict the tailrace or outflow from the mill site. This seems to indicate that the channel alignment for Unnamed Stream A was substantially altered during operation of the mill, compared to its current location, as well as its location before mining began.

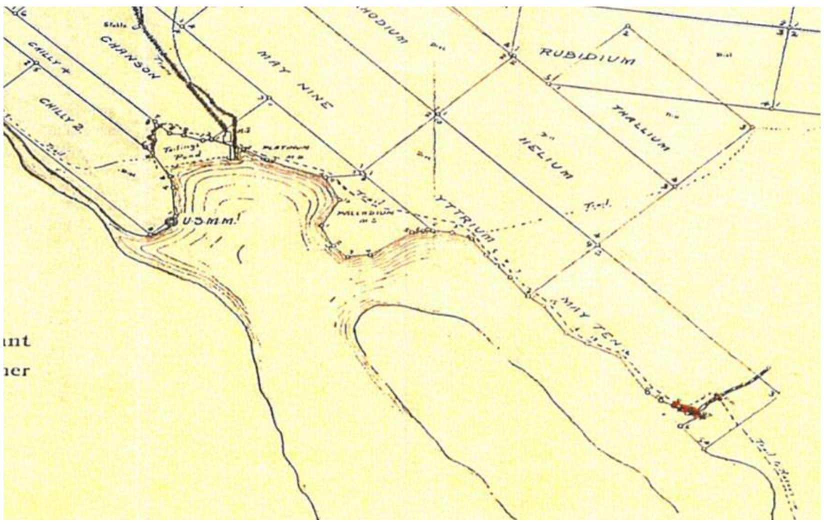


Figure 3-8. Map of the Project Area Showing “Tailings Pond” Where Historical Mill Tailings Were Initially Placed in 1920.

Figure 3-9. Aerial Photo of the Project Area during Operation of the Salt Chuck Mill in 1929.

CHAPTER 4

Streambank Stabilization

This chapter summarizes the Treatability Study design for potential measures to stabilize eroding streambank tailings along Unnamed Stream A.

4.1 Treatability Study Design for Streambank Stabilization

4.1.1 Objectives for Potential Streambank Stabilization Measures

The objectives for potential streambank stabilization measures are to:

1. Identify key eroding streambank locations and understand processes that can be addressed in the Treatability Study.
2. Develop targeted stabilizing measures at key eroding streambank locations.
3. Implement initial measures to stabilize eroding streambanks for Unnamed Stream A.
4. Develop and implement a strategy to monitor performance of streambank stabilization measures.
5. Evaluate performance of streambank stabilization measures.
6. Report results of streambank stabilization measures and recommendations for adaptive management.

4.1.2 Description of Streambank Stabilization Work

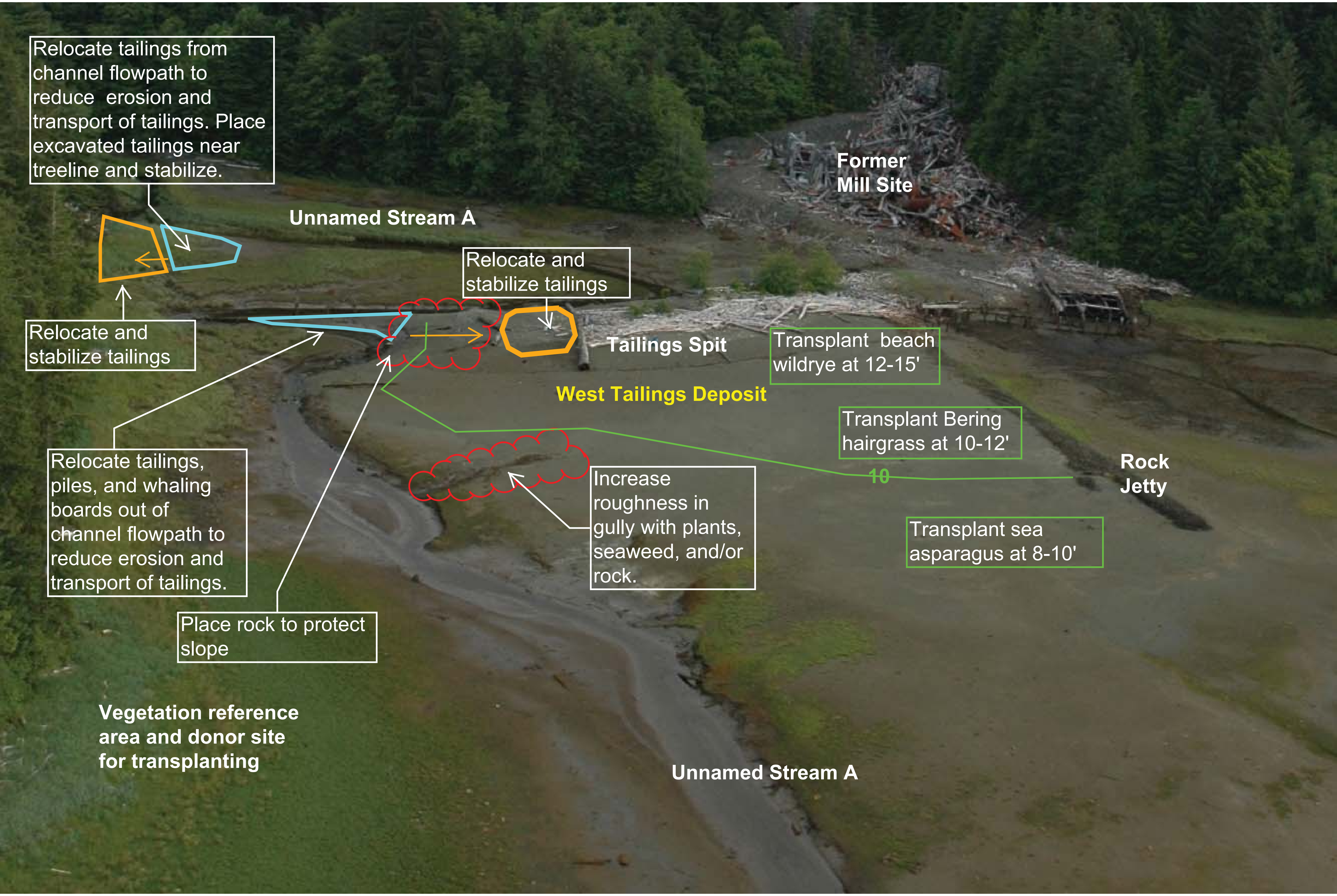
Two primary streambank erosion points were observed in the photos and the modeling described in Chapter 3 of this Work Plan. There is a high potential for these areas to continue to experience episodic erosion and substantial transport of mine tailings during large storm streamflows. As a result, the Treatability Study will focus on excavation of the tailings at the two primary streambank erosion points. These two locations are shown by the blue color polygons in Figure 4-1.

During work at both locations, tailings will be excavated from the path of the high-flow channel, and moved and placed nearby in a higher elevation in the intertidal area (at approximately the 12-foot elevation or higher).

Prior to excavation of tailings at the West Excavation area, existing vegetation within the limits of work will be stripped and stockpiled to the side and will be replaced on top of the excavation after work is completed. The purpose will be to use existing vegetation to recolonize the filled area after excavation.

During excavation work at the Tailing Spit, the contractor will isolate the work area from flowing water through use of sand bags or other temporary cofferdam to control erosion and sedimentation.

The model described in Chapter 3 was also used to evaluate changes to the existing channel geometry aimed at reducing the peak velocities and associated erosion. This first location is between Station 1+50 and 2+00 on Unnamed Stream A, and the second is between Station 5+00 and 6+00 on Unnamed Stream A. At the upstream station, the existing streambank will be set back approximately 30 feet. At the southern location, the western tip of the tailings spit (approx 85 linear feet) is removed and graded to be at the same elevation as the existing stream channel bottom. These channel refinements will allow a more direct flow path particularly for high streamflows during higher tides and should reduce peak velocities at these critical erosion points. The location and magnitude of these changes to the channel geometry is shown in Figure 4-2. The northern (upstream) location reflects removal of approximately 180 cubic yards of material, and the southern (tailing spit) location reflects removal of approximately 65 cubic yards of material.



(Photo Source: NOAA, July 2007)

Figure 4-1. Stabilization Design for 2013 Treatability Study - Salt Chuck Mine

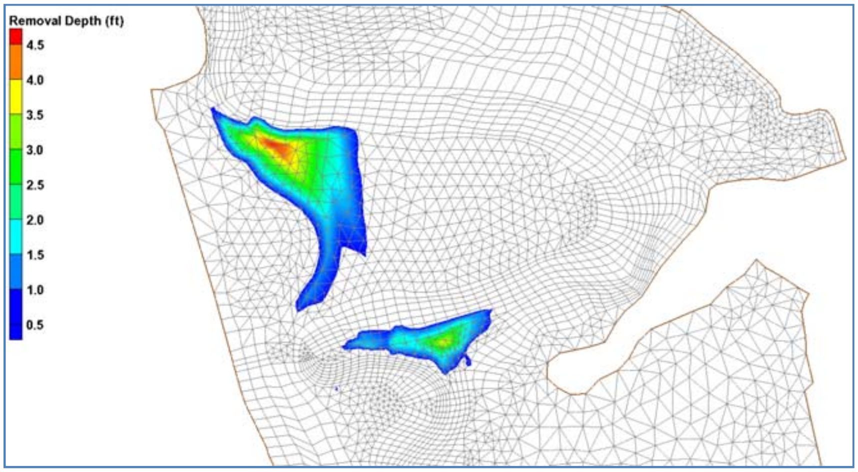


Figure 4-2. Removal Depths at Two Proposed Grading Locations Where Tailings Are within the Flow Path and Are Eroding.

A comparison of predicted velocities for the existing and proposed channel geometries is presented in Figure 4-3. Results for the proposed channel geometry indicate a reduction in peak velocities at the erosion points identified in the existing conditions simulations.

As the tide level drops, the velocities in Unnamed Stream A north of the tailings spit will increase as the available cross sectional flow area decreases. Predicted velocities in the stream are presented in Figure 4-4 for an 8.5-foot tide level with an 80 cfs stream flow. Results show that at an 8.5-foot tide elevation, a substantial portion of the flow is still short cutting over the low floodplain to exit the upper basin. Velocities approach or exceed 2 feet per second at several locations, including along the streambanks of both proposed excavation and grading sites. These elevated storm flow velocities are also present under existing conditions.

Velocities at three key locations were extracted from the model; these locations are shown in Figure 4-4. Velocity at the West Excavation Area increases quickly once the tide drops below approximately 11 feet NAVD88. Velocities exceed 1.5 feet per second for flows above 80 cfs, which is approximately the 2-year return interval flow. Similar results are shown for velocities near the excavation/grading at the west end of the tailings spit. The third location with elevated velocities is at a channel constriction near Station 7+75, where velocities approach 3.0 feet per second for storm flows.

These elevated velocities are at or near the maximum permissible velocity for sand banks according to various references (U.S. Army Corps of Engineers, 1994; Federal Highway Administration, 2001). These critical velocities are not seen in the upper basin under the proposed channel geometry at higher tidal elevations. Bank protection at these critical areas will reduce the potential for erosion of tailings during heavy rainfall events.

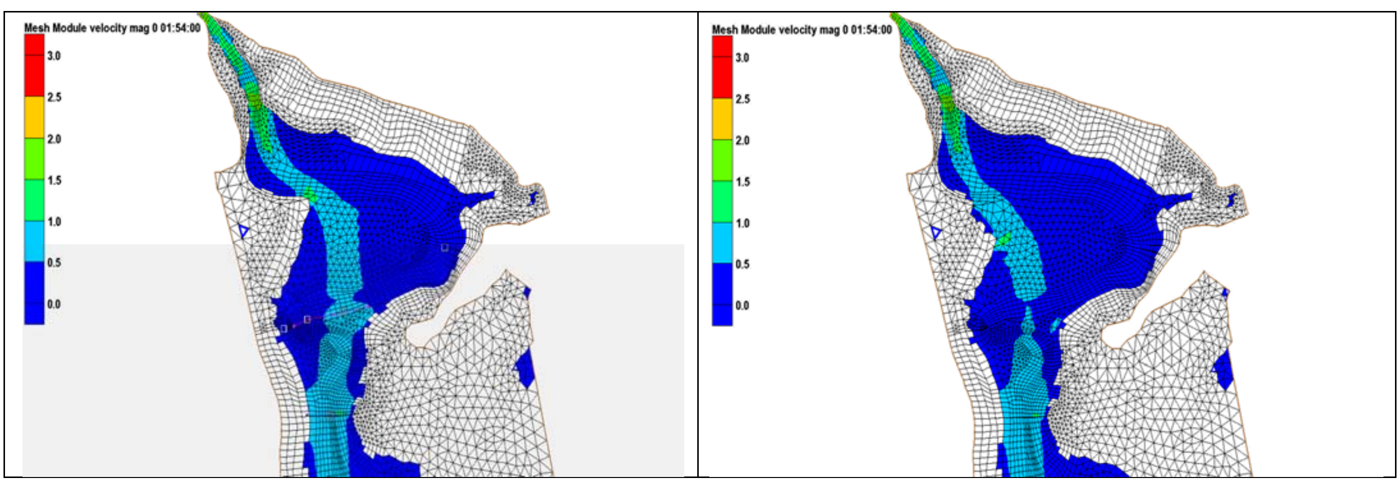


Figure 4-3. Comparison of Velocity Contours during Ebb Tide for Existing (Left) and Proposed (Right) Channel Geometry (40 cfs Stream Flow, Full Grid, Approx 10 feet Tide Elevation).

The channel straightening is limited to removing the western section of the tailings spit including piles and whaling boards. This straightening would shorten the channel length by approximately 50 feet. Based on channel characteristics presented in Table 3-1, the channel slope excluding the headcut would increase slightly from 0.0034 to 0.0036 ft/ft, which is a very small change in stream slope. This translates to a steepening of the channel slope by approximately 0.01 foot (or approximately 1/8 inch). This is unlikely to affect the stream velocity and result in a measureable headcut. In spring 2014, EPA will monitor the site and check for visual signs of head cutting.

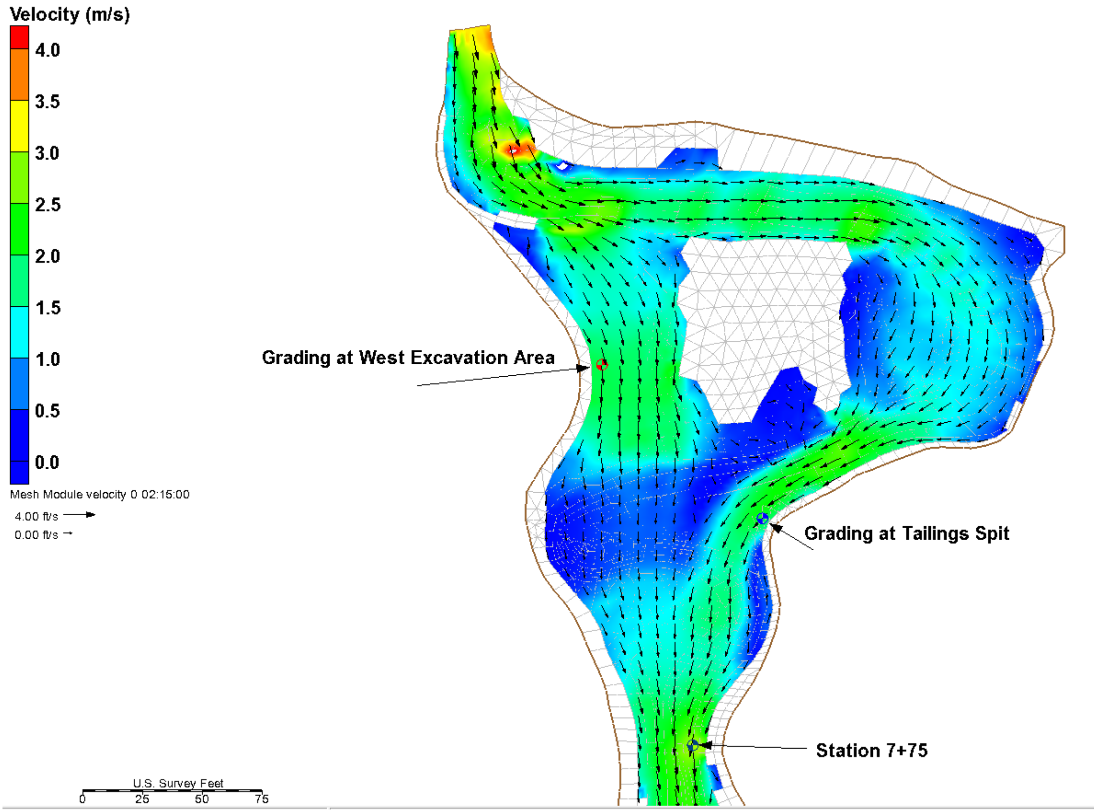


Figure 4-4. Predicted Velocity for Proposed Grading Geometry with 80 cfs Stream Flow and Water Level 8.5 feet NAVD88.

During storm inflows and tidal water levels below approximately 8 feet NAVD88, stream velocities may be sufficient to cause erosion, despite the proposed regrading. With predicted velocities near 2 feet per second, it is advisable to employ some means of bank protection to reduce the likelihood of continued erosion of the tailings during heavy rainfall events. Quarry stone 3 to 6 inches in diameter, which is available at quarries onsite, is sufficient to armor the banks against predicted velocities during storm events. Quarry rock placed on the regraded streambank to an elevation of 10 feet at the West excavation area and the tailings spit will protect against the highest predicted velocities.

Piles and whaling encountered during excavation at the Tailings Spit Excavation Area will be removed from the intertidal area and stockpiled near the former mill site.

In addition, to reduce the potential for erosion and sediment transport, quarry rock will also be placed in the head-cutting gully shown in Photo 3-5.

4.1.3 Construction Access

Equipment (assumed to be a low ground pressure tracked excavator) will access the intertidal area during low tide from the former mill site area.

To minimize the placement of rock onsite, the contractor will be required to provide temporary access to the excavation areas. Mud mats or similar type of temporary removable construction matting will be considered (see Appendix B). The contractor will be required to remove the temporary construction access upon completion.

To access the West Excavation Area, the contractor will be required to provide temporary access to cross Unnamed Stream A using mud mats or similar temporary removable construction matting. The contactor will be limited to only two crossings of Unnamed Stream A with a tracked excavator to minimize disturbance.

Because access roads will not be constructed, the contractor will need a method to transport rock that will be needed for limited bank armoring at both excavation locations. One method being considered is to use bulk transport bag (e.g., super sacks) to transport the rock. A typical one-ton bag can hold one cubic yard of dry material, or approximately 2,500 pounds.

Photo 4-1. Example of how an excavator could be used to transport rock in super sacks to remote areas where excavation will occur (use of a barge is not anticipated).

4.1.4 Rock

Estimated rock types, quantities, and sources are summarized in Table 4-1. Quantities are approximate and will be refined based on surveying, modeling, and Treatability Study design.

TABLE 4-1
Estimated Rock Types, Quantities, and Sources
Treatability Study – Salt Chuck Mine

Location for Use	Rock Type	Quantity (cubic yards)	Rock Source
Place rock armoring Tailing Spit Excavation Area	3-6-inch quarry rock	35	USFS quarry 1 and 2
Place rock armoring in West Excavation Area	3-6-inch quarry rock	45	USFS quarry 1 and 2
Place rock armoring in head-cutting gully	3-6-inch quarry rock	5-10	USFS quarry 1 and 2
Total		**90**	

USFS = U.S. Forest Service

4.1.5 Schedule/Tides

Construction work is planned at the end of August 2013. There is a neap tide, during which the high tides will not exceed 9 feet NAVD88, as shown in Figure 4-5. A neap tide is when the difference between high and low tide is least. Constructing during a neap tide period will extend the work hours and allow the contractor to leave the equipment on higher ground onsite without having to remove equipment from the intertidal area.

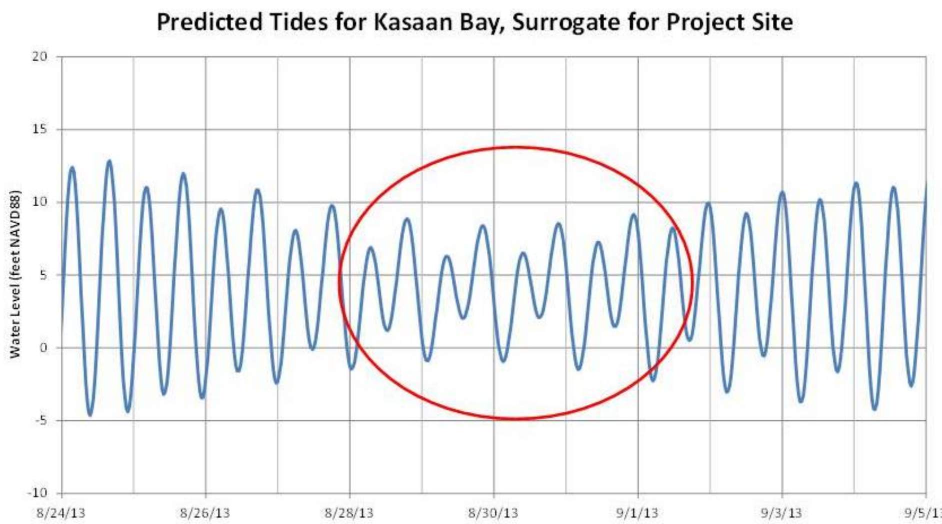


Figure 4-5. Target Construction Window during Neap Tide August 28 to September 1, 2013. Tides in feet NAVD88.

4.1.6 Equipment

A preliminary list of equipment likely to be used on the project includes:

- Excavator (2-3)
- Dump Trucks (1-2)
- Dozer Low Ground Pressure (LGP)(1)

4.1.7 Activities Considered but not Included

Several activities were considered but are not currently included in the Treatability Study, which are described briefly below.

East Sediment Storage Area. A sediment storage area was initially envisioned for placement of the material excavated from the tailings spit. This sediment storage would have been located in the intertidal area at the rock embankment near the former mill site. This approach was removed from the Treatability Study after it was considered preferable to place the excavated tailings nearby on existing tailings on the tailings spit rather than to move then to a new location.

Concentric Rock Weirs. Several rock weirs were initially envisioned to be placed concentrically on contours of the tailings deposits to contain and reduce erosion and transport of tailings, similar to the function of the existing rock jetty. The hydrodynamic modeling identified key streambank erosion locations where greater benefit would result from excavation of tailings shown to be in the flow path during large storm events. At that point, the focus shifted away from using the rock weirs. The West Tailings Deposit is not expected to experience the velocities shown to occur in Unnamed Stream A. Wave action on the West Tailings Deposit may well be a notable erosion process. However, potential stabilization of the West Tailings Deposit will be evaluated in the Treatability Study through potential revegetation measures rather than through rock armoring.

CHAPTER 5

West Tailings Deposit Stabilization

This chapter summarizes the Treatability Study design for potential measures to stabilize the West Tailings Deposit.

5.1 Treatability Study Design for Tailings Deposit Stabilization

5.1.1 Objectives for Potential Stabilization Measures at the West Tailings Deposit

The objectives for potential stabilization measures at the West Tailings Deposit are as follows.

1. Identify key eroding locations on the West Tailings Deposit and understand processes that can be addressed in the Treatability Study.
2. Develop targeted stabilizing measures at key eroding locations on the West Tailings Deposit.
3. Implement initial techniques to stabilize on the West Tailings Deposit.
4. Develop and implement a strategy to monitor performance of stabilization measures on the West Tailings Deposit.
5. Evaluate performance of stabilization techniques on the West Tailings Deposit.
6. Report results of techniques and recommendations for adaptive management on the West Tailings Deposit.

5.1.2 Description of Vegetation Transplanting Work

Existing vegetation from established donor areas onsite will be transplanted to test plots that will be laid out at corresponding elevations on the West Tailings Deposit (Figures 4-1 and 5-1). The vegetation plots will be marked with wood stakes at the sizes indicated below. Vegetation will be hand excavated with shovels, transplanted by hand in 5-gallon buckets and/or with wheel barrows or small hand-pulled wagons. No motorized vehicles will be used to transport the vegetation across Unnamed Stream A. Impacts to vegetation at donor areas will be minimized. Overharvesting will be avoided by scatter picking.

Variables that could affect the performance of the planting will be tested, such as:

- Species
- Plant material type (plugs, sprigs, live cuttings, seed)
- Fertilizer packets
- Marine-derived organic matter (seaweed)
- Rock protection

5.1.3 Transplanting Vegetation

The following dominant vegetation species, as described in Chapter 3, will be transplanted to the corresponding approximate elevations on the West Tailings Deposit as shown on Figure 3-7.

- Beach wildrye (*Leymus mollis*) – 12 to 15 feet NAVD88
- Bering hairgrass (*Deschampsia beringensis*) – 10 to 12 feet NAVD88
- Sea asparagus (*Salicornia virginica*) – 8 to 10 feet NAVD88

5.1.4 Transplanting Techniques

The following three techniques will be used during transplanting:

Photo 5-1. Plugs will be approximately 6-inch diameter masses of plants with established roots and attached soil. Photo from Moore et al. (2005).

Photo 5-2. Sprigs will be individual plants (with or without soil attached) that will be transplanted. A sprig of beach wildrye is shown

Photo 5-3. Live cuttings will be used only with sea asparagus, which can propagate vegetatively from cuttings (as was demonstrated during the bench test with sea asparagus from coastal Oregon).

Sea asparagus will be collected from donor areas onsite, such as the reference area at the southwestern edge of the site shown in Figure 2-2. A live cutting fragment of sea asparagus is defined as a plant fragment that has a minimum length of approximately 4 inches and a maximum length of 7 inches. In addition, the fragments should have at least five intact contiguous vegetative segments. Sea asparagus will be installed to a depth of 2 to 4 inches below ground surface so at least 50 percent of the cutting is buried.

In the *Beach Wildrye Planting Guide for Alaska*, Wright (2011) reports that Beach Wildrye is an extremely effective species for use in coastal revegetation, restoration and erosion control. Beach wildrye works best in sandy or gravelly soils. However, performance on mine tailings has not been tested (personal communication with Stoney Wright/Alaska Plant Materials Center, 4/10/13). Wright (2011) recommends a planting spacing of 3-4 feet, or less if the site is subject to severe erosion.

5.1.5 Rock with Vegetation

The existing natural shoreline near the Salt Chuck Mine consists of rock of various sizes interspersed with native vegetation. This natural rock bank with vegetation provides a natural armoring of the shoreline that has developed in response to erosive forces (wind, waves, tides).

Therefore, several test plots will include rocks alone and in combination with transplanted vegetation.

Photo 5-4. Rock with interspersed vegetation provides a natural armoring of the shoreline near Salt Chuck Mine.

5.2 Experimental Design and Procedures

5.2.1 Vegetation Transplanting

Intertidal vegetation will be transplanted using an experimental design to evaluate plant material types for each of three main planting species. This design will result in a total of 200 plants being transplanted as shown in Table 5-1 and Figure 5-1.

Planting species and plant material types

Three main species and several plant material types will be transplanted:

- Beach wildrye – plugs and sprigs
- Bering hairgrass – plugs
- Sea asparagus –plugs and live cutting fragments

Planting season

Vegetation will primarily be transplanted in late May when the plant materials are vigorous and actively growing and can establish during the summer growing season.

Plot size, plant spacing, and density

Intertidal wetland transplants (plugs, sprigs, and live cutting fragments) will be installed in 5-foot-wide by 10-foot-long plots to achieve a 2.5-foot spacing with 8 plants per plot (2 plants x 4 plants).

Vegetation Transplanting Treatments

Several experimental treatments will be tested, which include combinations of rock, organic matter (seaweed), and fertilizer packets.

It is hypothesized that rock will protect the transplanted plants and the sediment substrate from erosion (as evidenced by the vegetation that has naturally colonized in association with rocks onsite, particularly near the rock jetty). The rock will also provide structural diversity and roughness for catching organic matter (such as, sea weed, leaf litter, drift wood, seeds, and plant propagules) and sediment that arrives from tide water. The rock can also serve as a substrate for marine organisims to attach (such as, rock weed [*Fucus*] and barnacles), particularly at the lower tidal elevations onsite. The rock may also encourage future natural establishment of plants. Quarry rock will be used that is approximately 3-6 inches in diameter obtained locally.

Organic matter in the tailings sediments is low compared to native sediments. Using native local marine-derived seaweed (such as, rock weed) to amend soils has been a traditional way of increasing soil organic matter in gardens and cultivated soil in Alaska. Seaweed that has floated and/or deposited at the site will be collected.

Photo 5-5. Local sources of marine-derived organic matter (such as, rock weed or popper weed [*Fucus* sp.]) that drifts to the site will be collected and used in several test plots.

The soil is suspected to be low in fertility. A slow release fertilizer, contained in individual packets (similar to a tea bag) will be used. The coating on the fertilizer is specially formulated for slow release over 1-2 years. The packets are manufactured by Reforestation Technologies International, Salinas, CA, and were supplied by Landscape Alaska in Juneau, Alaska. The packets are formulated with nitrogen, phosphorus, and potassium (N-P-K) at a percentage analysis rate of 22-10-7.

Five experimental treatments will be applied to the transplanted vegetation (including a control):

- **Control** – No treatment will be applied.
- **Rock** – A single layer of quarry rock will be loosely placed around the transplanted plants. This treatment will be used to test the benefits of rock.
- **Rock with Seaweed** – A layer of native local seaweed will be collected and placed on the ground surface and pinned down with rock. This is hypothesized to serve as a natural mulch and erosion control blanket that will decompose. This treatment will be used to test the combined benefits of organic matter and rock.
- **Fertilizer** – One packet of slow release fertilizer will be installed several inches below the soil surface at the side of the planting hole in contact with the plant roots. This treatment will be used to test the benefit of improved soil fertility.
- **Rock with Fertilizer** – One packet of slow release fertilizer and a single layer of quarry rock will be installed as describe above. This treatment will be used to test the combined benefits of improved soil fertility and rock.

TABLE 5-1
Vegetation Transplanting Treatment Plots and Species/Plant Material Types
Treatability Study – Salt Chuck Mine

Species/Plant Material Type	Vegetation Transplanting Treatment Plots[a]					
	Plot 1 Control (X) (No Treatment)	**Plot 2** Rock (R)	**Plot 3** Rock with Seaweed (RS)	**Plot 4** Fertilizer (F)	**Plot 5** Rock with Fertilizer (RF)	**Total Number of Transplants**
Beach Wildrye	(Plot ID: BW-Plug or Sprig-Plot #)					
Plugs	8	8	8	8	8	40
Sprigs	8	8	8	8	8	40
Bering Hairgrass	(Plot ID: BH-Plug-Plot #)					
Plugs	8	8	8	8	8	40
Sea Asparagus	(Plot ID: SA-Plug or Cutting-Plot #)					
Plugs	8	8	8	8	8	40
Live Cuttings	8	8	8	8	8	40
Total Number of Transplants	**40**	**40**	**40**	**40**	**40**	**200**

[a] Plot size is 5 feet by 10 feet, with plant spaced 2.5 feet on center.

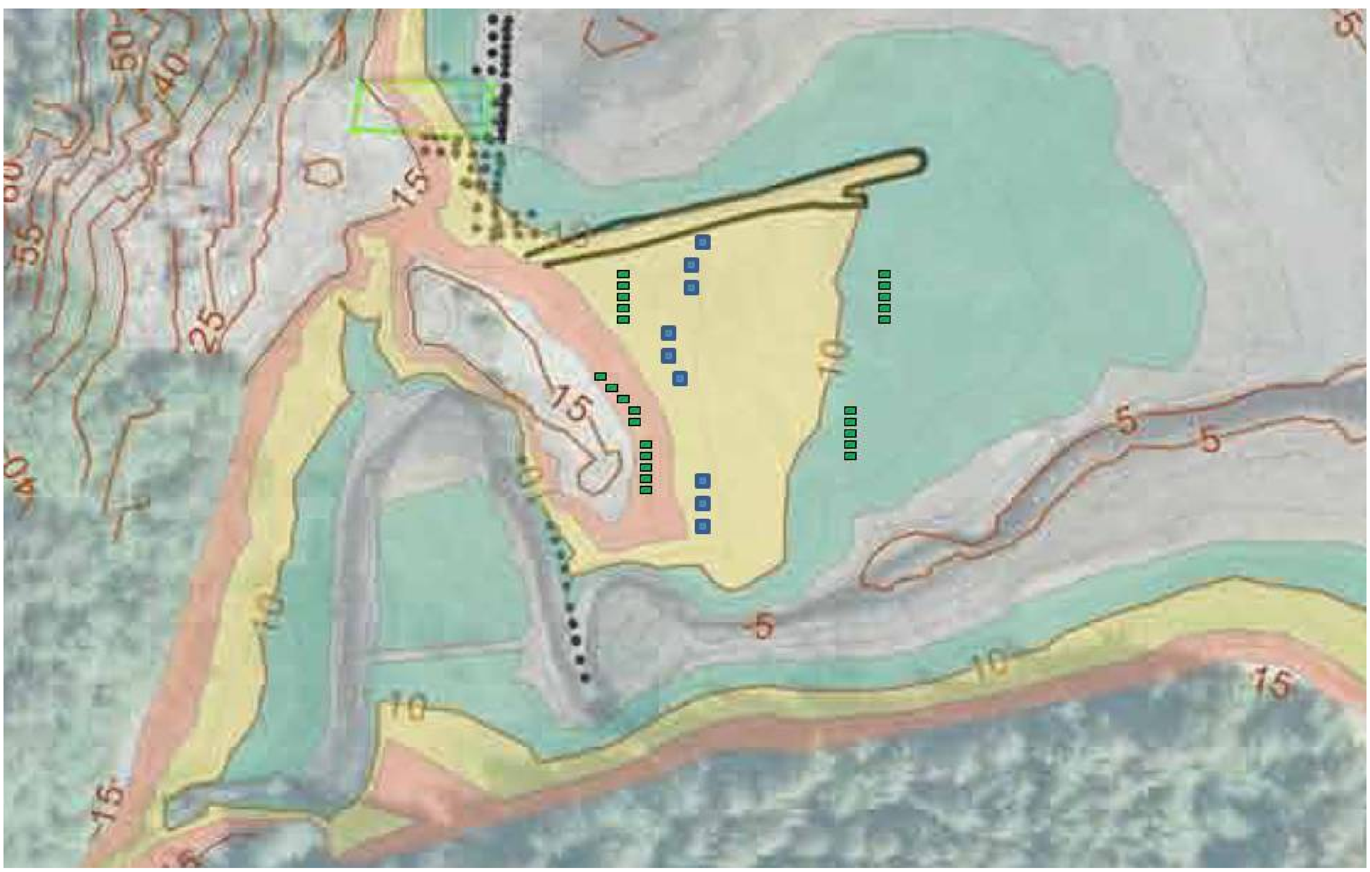


Figure 5-1. Preliminary Layout of Vegetation Plots. (Small green rectangles represent preliminary layout of 5x10-foot vegetation transplanting plots; small blue boxes represent 10x10-foot seed plots. Actual plot locations will be adjusted in the field).

5.2.2 Seeding

Seeding will also be tested using an experimental design to evaluate three main species that are readily available as commercial seed. This design will result in a total of 9 seed treatment plots as shown in Table 5-2 and Figure 5-1.

Species for seeding

Two hairgrass species will be tested (Bering hairgrass and tufted hairgrass [*Deschampsia cespitosa*]), because both have potential for establishment and may both occur onsite. Both are bunch grasses. Bering hairgrass is tolerant of moist and salty conditions.

Alkaligrass is a sod forming grass that is currently somewhat widespread onsite but is fairly sparse, except it shows decent natural colonization in the spaces between rocks in the rock jetty. According to Write (2011), alkaligrass is used on revegetation projects where the site is sometimes flooded by extremely high tides or storm surges. This species does best on silty or gravelly coastal soils and is most often found in southcentral and southeast Alaska. Alkaligrass is a common grass found in the nooks and crannies of rocks and boulders in the tidal zone.

Seeding season

Seeding will primarily occur in late May to allow establishment during the summer growing season.

Plot size

Seed will be sowed in 10-foot by 10-foot square plots.

Vegetation Transplanting Treatments

Several experimental treatments will be tested, which include combinations of rock and organic matter (seaweed). Three experimental treatments will be applied to the seed plots (including a control):

- **Control** – No treatment will be applied.
- **Rock** – A single layer of quarry rock will be loosely placed over the seeded ground. This treatment will be used to test the benefits of rock establishing seed.
- **Rock with Seaweed** – A layer of native local seaweed will be collected and placed on the seeded ground surface and pinned down with rock. This is hypothesized to serve as a natural mulch and erosion control blanket that will eventually decompose. This treatment will be used to test the combined benefits of organic matter and rock.

TABLE 5-2
Seed Treatment Plots and Seed Species
Treatability Study – Salt Chuck Mine

	Seed Treatment Plots[a]				**Plot ID**
Seed Species	**Plot 1** Control (X) (No Treatment)	**Plot 2** Rock (R)	**Plot 3** Rock with Seaweed (RS)	**Total Number of Pounds**	
Bering Hairgrass	0.1	0.1	0.1	0.1	BH-Seed-Plot#
Tufted Hairgrass	0.1	0.1	0.1	0.1	TH-Seed-Plot#
Alkali grass	0.1	0.1	0.1	0.1	AG-Seed-Plot#
Total Number of Pounds	**0.3**	**0.3**	**0.3**	**0.9**	

[a] Plot size is 10 feet by 10 feet.

5.2.3 Performance Criteria

Initial performance criteria for the transplanted vegetation are hypothesized as follows:

- At least 25 percent of the transplanted plants will survive.
- Percent areal cover of transplanted plants will increase at least 10 percent per year.

Survival rates for the species to be transplanted and seeded on these tailings is not known. The Treatability Study will test and help provide an estimate of survival and establishment for these species and plant material types used.

CHAPTER 6

Treatability Study Schedule

This chapter summarizes the schedule of the Treatability Study as summarized in Table 6-1.

TABLE 6-1
Schedule of Key Milestones for Treatability Study
Treatability Study – Salt Chuck Mine

Date	Activity	Notes
April 2013	CH2M HILL submits Draft Treatability Study Work Plan to EPA and agency stakeholders.	Mid April 2013
	Conference call with EPA and agency stakeholders to discuss comments and basis for the Treatability Study design.	Mid to late April 2013
May 2013	CH2M HILL performs site visit to verify Treatability Study design, installation of initial monitoring, and planning for Treatability Study implementation.	Early May 2013
	Comments on Draft Treatability Study Work Plan due from agency stakeholders.	May 14, 2013
	CH2M HILL conducts spring vegetation transplanting.	Late May 2013
August 2013	CH2M HILL implements Treatability Study to stabilize eroding streambanks and tailings deposits.	Late August 2013
September 2013	CH2M HILL prepares a Field Summary Report.	
Spring 2014	CH2M HILL monitors Treatability Study performance and prepares final Treatability Study Report.	

CHAPTER 7

Monitoring Plan

This chapter summarizes the plan to monitor the results and performance of the stabilization measures implemented during the Treatability Study.

7.1 Erosion Monitoring

Baseline monitoring will be established in May 2013 to evaluate the existing erosion conditions onsite at streambanks and on the tailings deposits. Wood or plastic stakes will be installed in the tailings/sediment at specific locations on the streambanks and tailings deposits. During subsequent site visits (such as, late May 2013, August 2013, and spring 2014), the amount of exposed stake will be measured and recorded to estimate a potential rate of erosion.

Also, if historical aerial photos (such as 1979, and possibly others) could be obtained from the U.S. Forest Service or other sources and geo-referenced, a comparison with the most current aerial photo (2006) may be possible to estimate possible channel migration and potential rate of erosion.

In spring 2014, a site visit will be performed to visually inspect the following:

- Tailings Spit excavation and sediment storage location;
- West excavation area and sediment storage location;
- Placement of quarry rock at the head-cutting gully location;
- Measurement of monitoring stakes where no stabilization measures were implemented; and
- Incidental observations of erosion or other notable features.

A simple erosion monitoring network will be established to try to gain a better understanding of the relative and absolute amounts of erosion in different locations onsite where different processes are being studied.

Photo 7-1. Installation of an erosion monitoring pin (white PVC) in a rill network on the floodplain upstream of the tailings spit in early May 2013.

7.2 Vegetation Monitoring

Baseline monitoring will be established in May 2013 to evaluate the existing vegetation conditions onsite. Notable populations of vegetation that are established on the tailings deposits will be documented through photographs and mapping.

In spring 2014, a site visit will be performed to monitor survival, establishment, and percent areal cover of transplanted and seeded vegetation in the experimental plots.

7.3 Photo Monitoring

During the implementation of the Treatability Study in summer 2013, photo points will be established to document and monitor the performance of the potential measures implemented as part of the Treatability Study as well as other general site conditions.

Photos will be taken at the same locations again during future site visits (e.g., spring 2014).

7.4 Monitoring Period

Initial performance of the Treatability Study will be monitored in spring 2014 by CH2M HILL.

7.5 Reporting

Following the monitoring in spring 2014, CH2M HILL will prepare a report to document the observations, and initial performance and results, and recommendations from the Treatability Study.

CHAPTER 8
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Appendix A
Technical Memorandum: Salt Chuck Mine Remedial Investigation – Two Dimensional Hydrodynamic Modeling for Streambank Stability Analysis

Salt Chuck Mine, Remedial Investigation Two-Dimensional Hydrodynamic Modeling for Streambank Stability Analysis

PREPARED FOR: Jacques Gusmano/EPA Region 10

COPY TO: Paul Townley/CH2M HILL
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PREPARED BY: Kyle Winslow/CH2M HILL

DATE: May 23, 2013

PROJECT NUMBER: 421566.TT.01

Introduction

A two-dimensional (2D) hydrodynamic model was constructed to simulate stream flows and tidal exchange near the former Salt Chuck Mine site on Prince of Wales Island in southeast Alaska. The goal of the modeling effort is to quantify local current velocities under stream and tidal influences and characterize the potential for erosion of existing tailings deposits at the project site. Furthermore, potential grading to reduce local peak velocities was evaluated. The modeling analysis was conducted with the Surfacewater Modeling System (SMS) and the RMA2 hydrodynamic model. The RMA2 model was developed in part by the U.S. Army Corps of Engineers (USACE); SMS is distributed commercially through Aquaveo (www.Aquaveo.com). SMS is widely used in the engineering community to model hydraulics and hydrodynamics in tidal and river systems.

Project Site

The project site is located on the eastern side of Prince of Wales Island in Southeast Alaska, at the northern end of Kasaan Bay. This former mill site is located at the northern end of an extensive mud flat bisected by Unnamed Stream A on the western side and a smaller creek (Unnamed Stream B) on the eastern side of the approximately 10-acre mudflat. Elevations at the site range from 15 feet North American Vertical Datum 1988 (NAVD88) to approximately 2 feet NAVD88. The site is bordered on the west, north, and east by dense forest. The site is bordered by Ellen Creek on the south (see Figures 1 and 2).

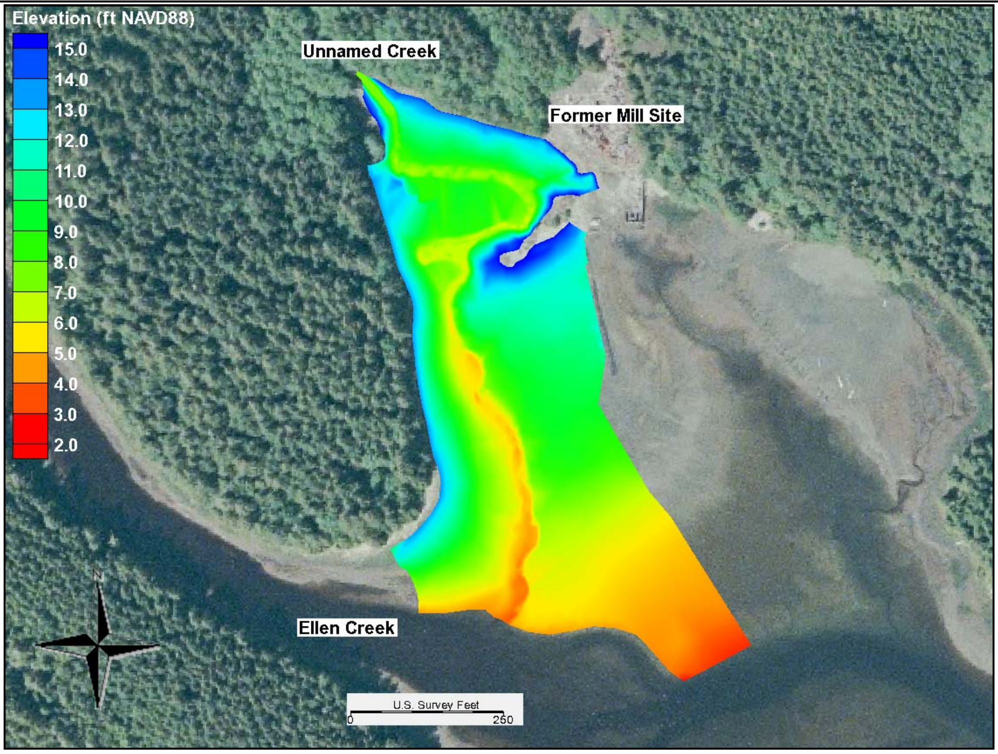


Figure 1. General Overview of Project Site and Model Coverage with Existing Elevation (Feet NAVD88).

Figure 2. Photograph of Project Site Looking North
Source: National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2007

Model Setup

The model grid was constructed with the help of a contour map of the site developed from topography survey data collected by R&M Engineering-Ketchikan at the site in February 2013 (R&M, 2013). A geo-referenced contour map with one-foot intervals was used to construct a base map of the model from which a boundary-fitted, 2D model grid was constructed. Efforts were made to construct a quasi-orthogonal grid aligned in the direction of primary flows throughout the bay. Once the grid was constructed, the survey points used to create the site contour map were interpolated to every node in the grid to provide the physical representation of the project site in the model software. Elevations at the site as represented by the 2D model are shown in Figure 1, as is the extent of the hydraulic model. The eastern portion of the project site was not included in the model grid for this analysis, because the focus was on flow conditions in the northern and western portions of the system associated with Unnamed Stream A.

During the topographic survey, tidal water surface elevations were recorded in space and time to provide a time series record of high tide elevations at the project site. These elevations were compared to several local predicted tides for a comparable period (February 15, 2013) to determine which predictions most closely matched observed conditions at the site.

Figure 3 presents predicted tidal elevations at several nearby tidal stations as provided by Nautical Software's Tides and Currents program (Nautical Software, 1996) and the National Oceanic and Atmospheric Administration (NOAA) Tides and Currents website (http://tidesandcurrents.noaa.gov). Results indicate that predictions for the village of Kasaan in Kassan Bay closely match the observed tidal range at the project site. Predictions for sites north of Kasaan and south of the project site demonstrate an increased tidal range compared to the site and that at Kasaan. This observation is likely a result of tidal amplification (increase in tidal range) towards the northern portion of Kassan Bay, followed by increased frictional effects, which reduce the tidal range as the tide progresses up Ellen Creek and into the project site. This comparative analysis resulted in predicted tides at Kassan being used to drive the tidal exchange at the project site. Predicted tides for January and February 2013 at Kasaan are shown in Figure 4 to demonstrate the variation in tidal range during spring and neap tidal cycles. Water levels are presented in feet NAVD88, which at the project site is 3.84 feet below mean lower low water (MLLW; MLLW = NAVD88 + 3.84 feet).

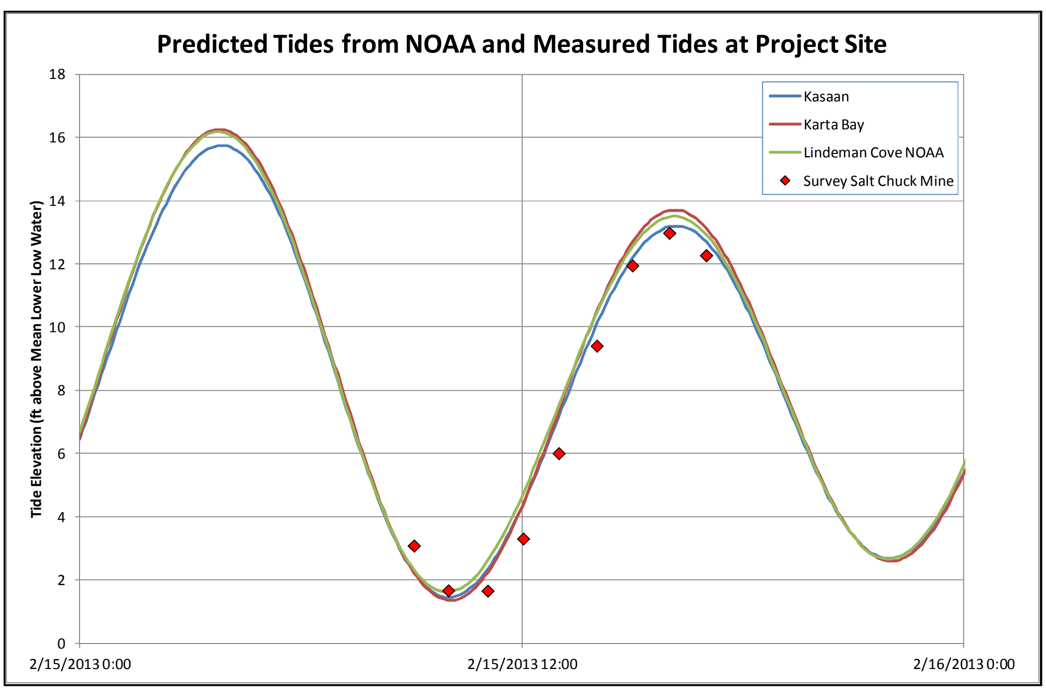


Figure 3. Predicted Tides throughout Kasaan Bay and Measured Tides at Project Site (feet MLLW).

Inflows from Unnamed Stream A were also applied as a boundary condition in the modeling analysis. Local site data indicated a stream flow rate of 19 cubic feet per second (cfs) during a minor storm event in July 2012 (CH2M HILL, unpublished data). Initial model simulations were conducted with an inflow of 40 cfs as a first estimate of larger storm inflows to the project site from the north. A subsequent review of river flow gauges in Southwest Alaska, when normalized for watershed size, indicate that estimates of the 2- and 10-year return interval events on Unnamed Stream A are approximately 80 and 130 cfs, respectively. Model simulations were conducted with both of these storm flows to ascertain the variability in predicted water velocities at the project site for storm events.

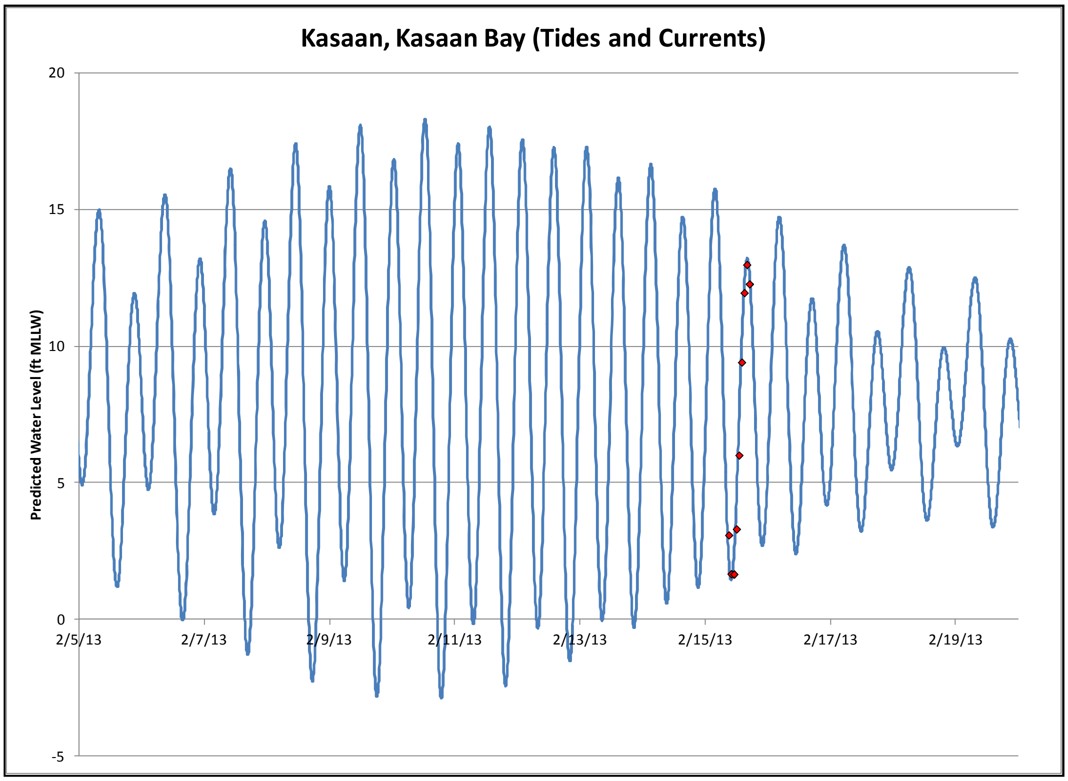


Figure 4. Predicted Tides for Kasaan and Measured Water Levels at the Project Site (February 15, 2013).

Model Simulations

Model simulations focused on understanding the velocity regime at the project site under the influence of tidal exchange and stream flows. Initial model simulations were conducted without any stream flow. Simulations were conducted for ebb tide only under the assumption that the draining of the site, coupled with stream flows, would yield critical design velocities. Initial tidal simulations indicated that peak velocities at the project site during ebb tide occur between tidal elevations of 8 and 10 feet. At higher tidal elevations, the rate of change in the tidal elevations (how quickly the tide is falling) is smaller and the outflow paths have a larger cross sectional area because the basin is relatively full. These factors combine to produce relatively low tidal velocities. At tidal elevations below 8 feet, the upper basin is almost completely drained and the tidal contribution to local velocities is below peak levels.

Model Results

Predicted velocities throughout the project site were reviewed using time-varying contour plots of current magnitude. Snapshots in time of the distribution of current magnitudes at the site are presented below for a series of simulations. Figures 5a, 5b, and 5c show a set of three snapshots from model simulations with stream inflows of 40, 80, and 130 cfs, respectively. Model results demonstrate the marked increase in peak velocities with increases in stream flows.

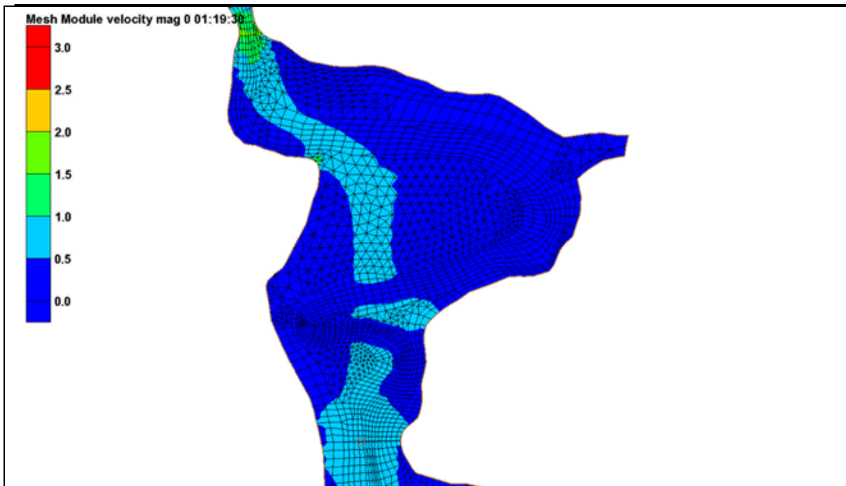


Figure 5a. Ebb Tide Velocity Magnitude for 40 cfs Stream Flows (reduced grid with maximum elevation of 10 feet NAVD88, simulation of partially drained site)

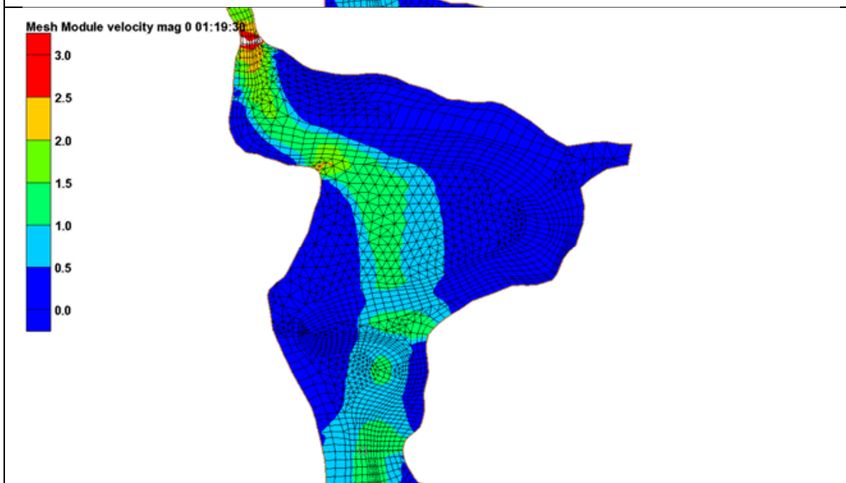


Figure 5b. Ebb Tide Velocity Magnitude for 80 cfs Stream Flows (reduced grid with maximum elevation of 10 feet NAVD88, simulation of partially drained site)

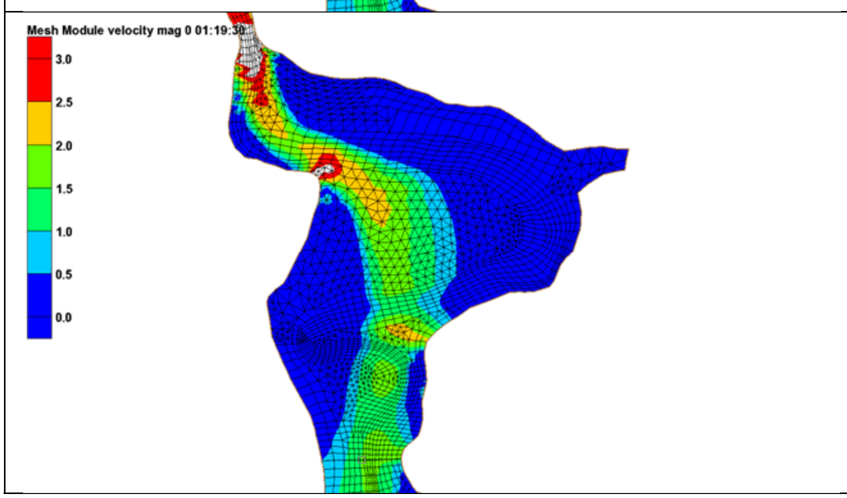


Figure 5c. Ebb Tide Velocity Magnitude for 130 cfs Stream Flows (reduced grid with maximum elevation of 10 feet NAVD88, simulation of partially drained site)

Model results for existing conditions at the project site identified local areas of increased velocity where erosion is likely to occur under storm stream flows and ebb tides. The model was used to evaluate changes to the existing channel geometry at two locations to reduce these peak velocities and associated erosion. This first location is between Station 1+50 and 2+00 on Unnamed Stream A, and the second is between Station 5+00 and 6+00 on Unnamed Stream A. At the upstream location, the existing streambank will be set back approximately 30 feet. At the southern location, the western tip of the tailings spit (approx 85 linear feet) will be removed and graded to be at the same elevation as the existing stream channel bottom. These changes would allow a more direct flow path and reduce peak velocities at these critical erosion points. The location and magnitude of these proposed excavation is shown in Figure 6. The northern (upstream) location reflects removal of approximately 180 cubic yards of material, and the southern (tailing spit) location reflects removal of approximately 65 cubic yards of material.

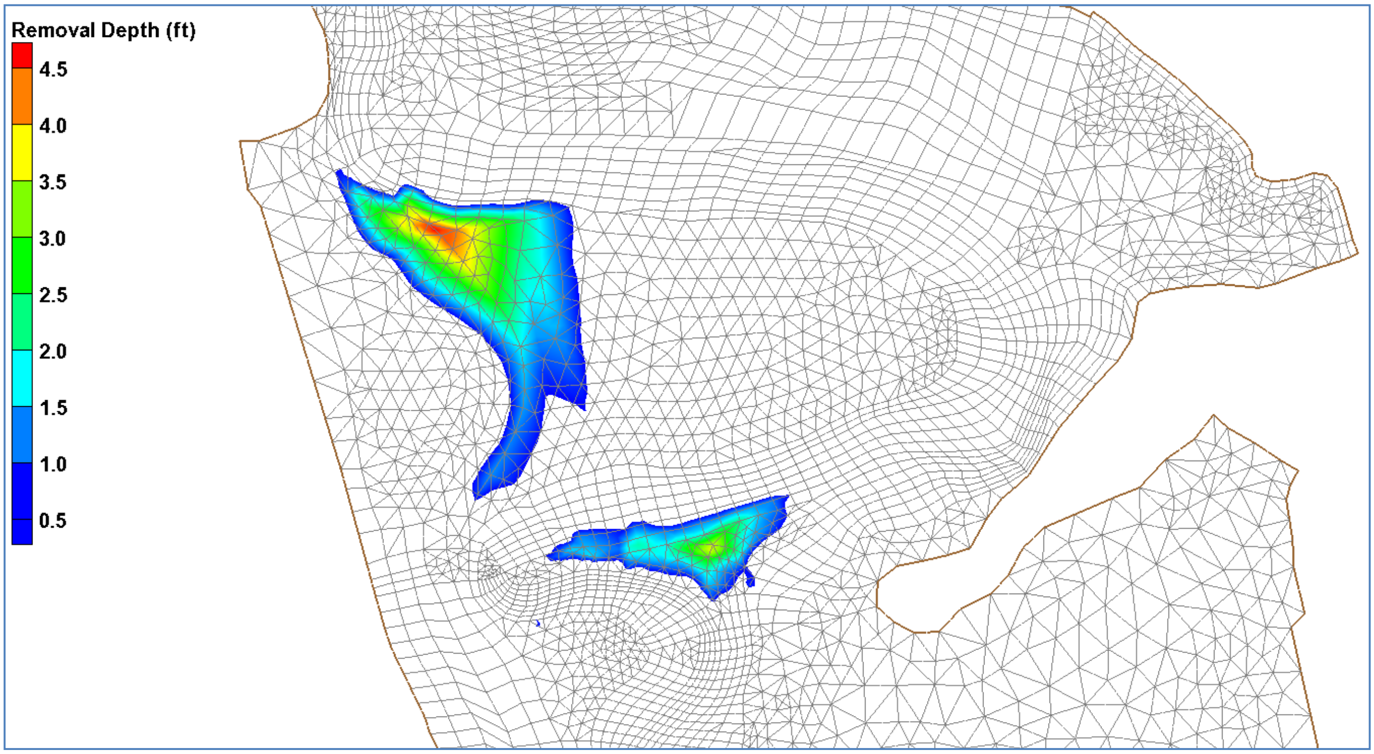


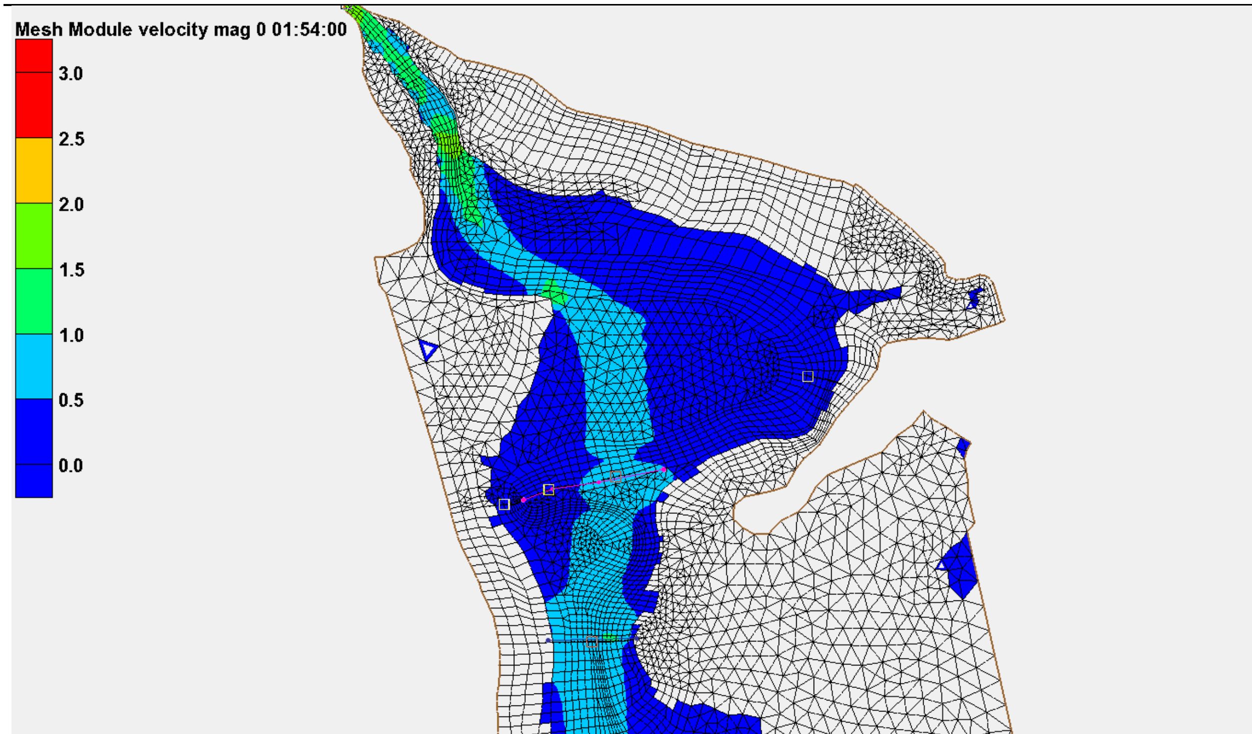
Figure 6. Proposed Excavation Locations, Depth Change Contours.

A comparison of predicted velocities for the existing and proposed channel geometry is presented in Figure 7. Results for the proposed channel geometry indicate a reduction in peak velocities at the erosion points identified in the existing conditions simulations.

As the tide level drops, the velocities in Unnamed Stream A north of the tailings spit will increase as the available cross sectional flow area decreases. Predicted velocities in the stream are presented in Figure 8 for an 8.5-foot tide level with an 80 cfs stream flow. Results show that at an 8.5-foot tide elevation, a substantial portion of the flow is still short cutting over the low floodplain to exit the upper basin. Velocities approach or exceed 2 feet per second at several locations, including along the streambanks of both of the proposed excavation locations. These elevated storm flow velocities would also be present under existing conditions.

Velocities at three key locations were extracted from the model; these locations are shown in Figure 8. Velocity at the West Excavation Area increases quickly once the tide drops below approximately 11 feet NAVD88, as shown in Figure 9. Velocities exceed 1.5 feet per second for flows above 80 cfs, which is approximately the 2-year return interval flow. Similar results are shown for velocities near the excavation/grading at the west end of the tailings spit (see Figure 10). The third location with elevated velocities is at a channel constriction near Station 7+75. Velocities here approach 3.0 feet per second for storm flows, as shown in Figure 11.

These elevated velocities are at or near the maximum permissible velocity for sand banks according to various references (USACE, 1994, Federal Highway Administration [FHWA], 2001). These critical velocities are not seen in the upper basin under the proposed channel geometry at higher tidal elevations. Streambank protection at these critical locations would substantially reduce the chance for erosion of tailings during heavy rainfall events.



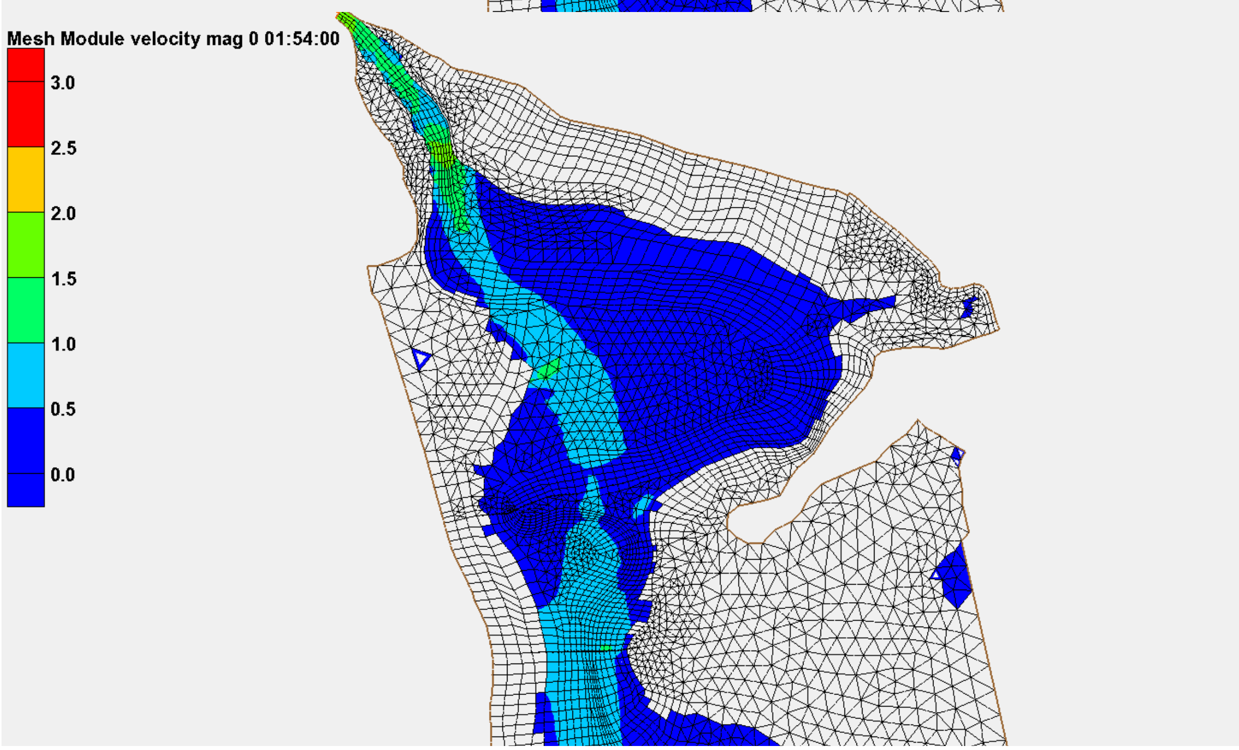


Figure 7. Comparison of Velocity Contours during Ebb Tide for Existing (Top) and Proposed (Bottom) Channel Geometry (40 cfs stream flow, full grid, approx 10 feet tide elevation).

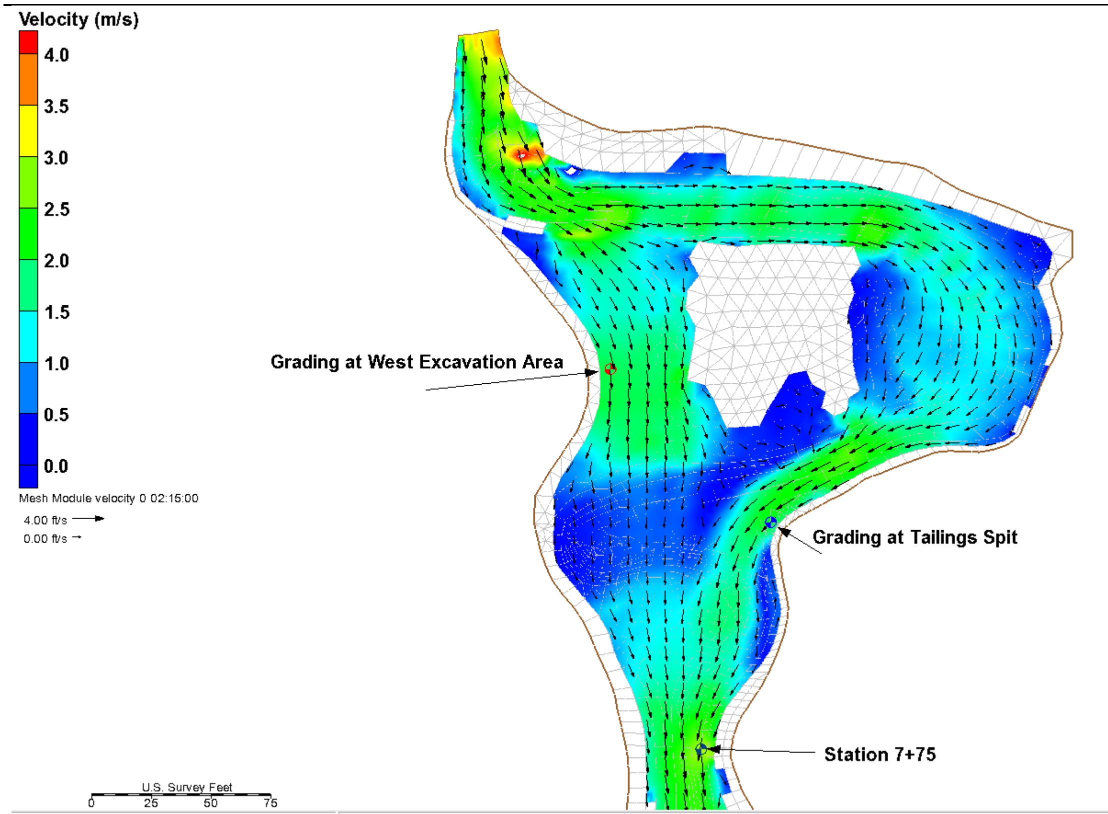


Figure 8. Predicted Velocity for Proposed Channel Geometry with 80 cfs Stream Flow and Water Level 8.5 feet NAVD88

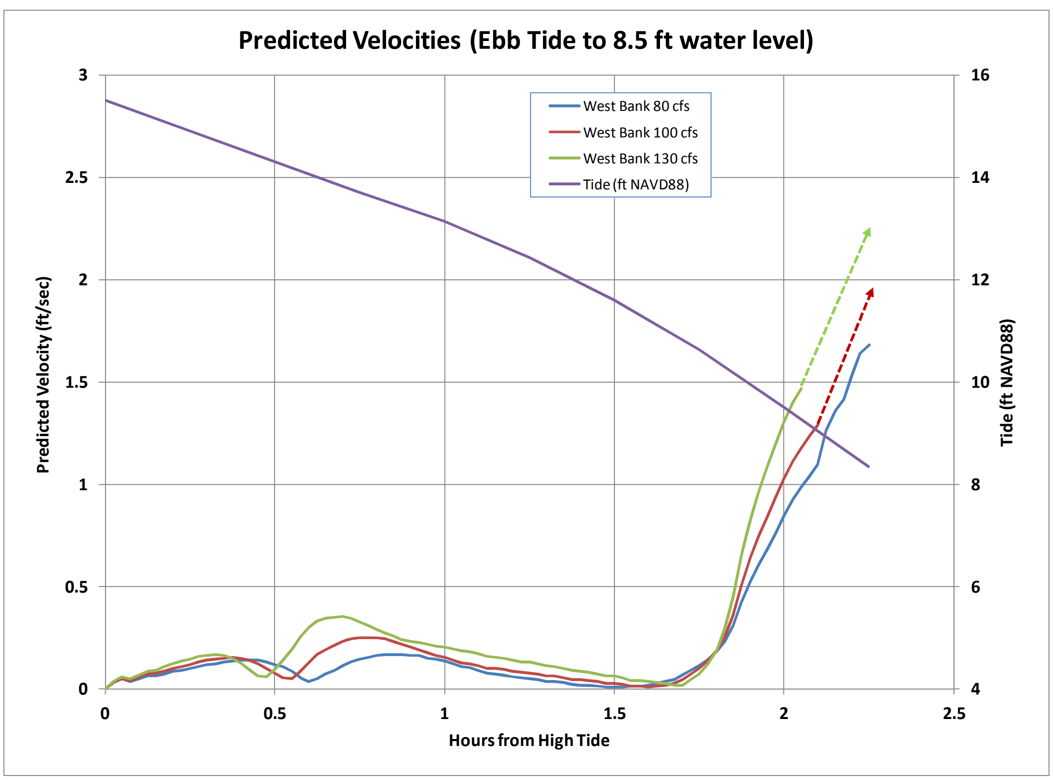


Figure 9. Predicted Velocity at Western Excavation Area for Three Storm Flows

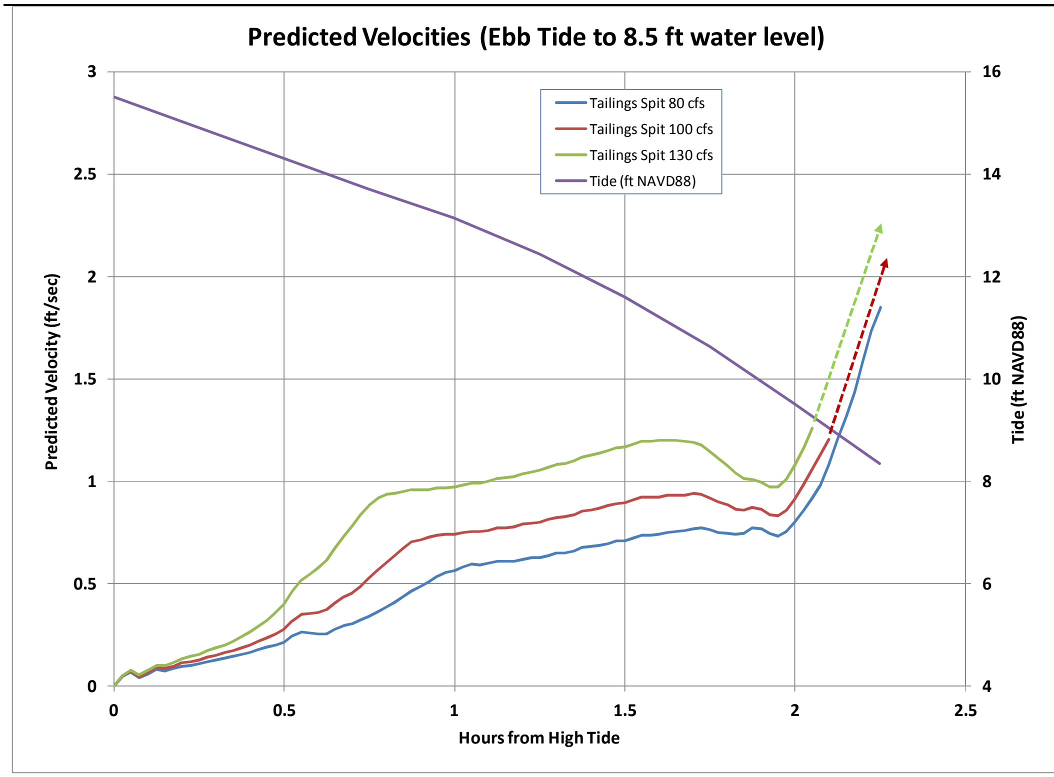


Figure 10. Predicted Velocity at Tailings Spit for Three Storm Flows

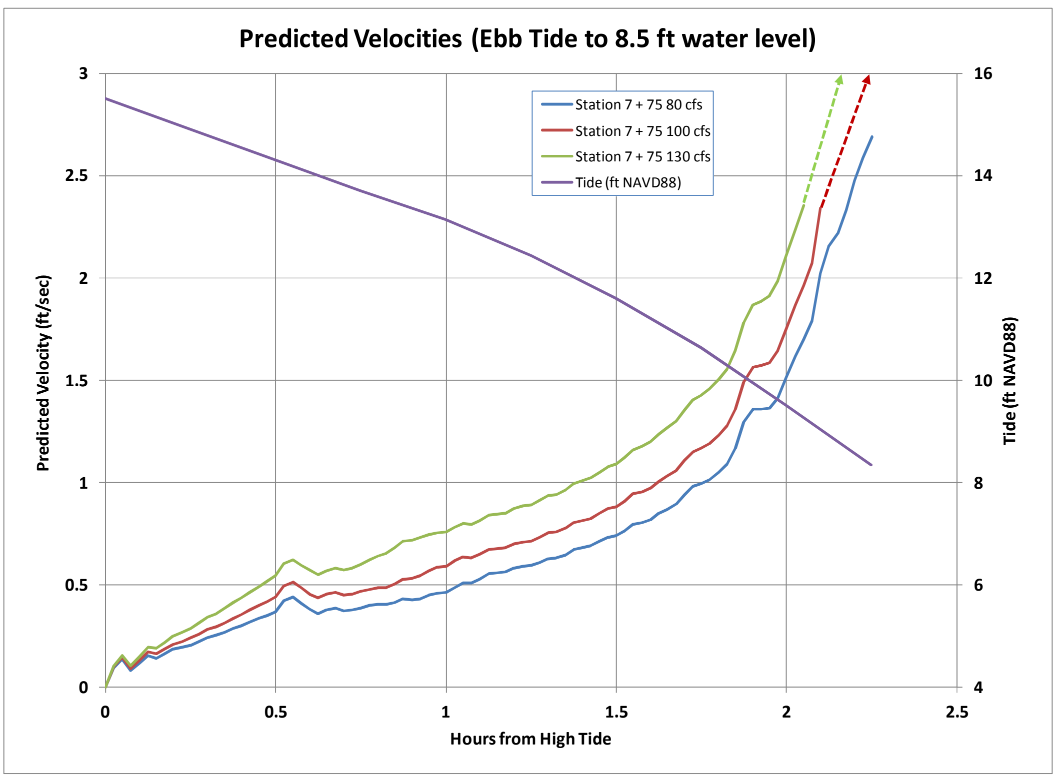


Figure 11. Predicted Velocity at Station 7 + 75 for Three Storm Flows

Tailings Plain Stability

Predicted tidal velocities on the tailings plain are generally low. Erosion of tailings south of the tailings spit may occur during high wind events as wind-waves from the south break on the tailings plain. The USACE Shore

Protection Manual (1984) was used to estimate shallow water wave heights for storm events with winds out of the south, the critical direction for maximum fetch at the project site. Available wind data from near the project site indicate potential high wind events of 50 miles per hour. This estimate for wind and a one-mile fetch would produce a 1.7-foot wave at the tailings spit.

Following calculations provided by the FHWA for sizing slope protection on embankments, estimates of the riprap required to protect against incident waves were determined (FHWA, 2011). Using the formula from the FHWA (2011), it was determined that 30-pound, 7-inch stone (W50 and d50, respectively) would be sufficient to protect against a 1.7-foot wave on a 3:1 (18.4 degree) slope. These results are reduced slightly for shallower slopes (i.e., 22-pound and 6.5-inch for 4:1 slope).

Summary

A 2D hydrodynamic model was constructed for near the former mill site at Salt Chuck Bay. Model simulations were conducted for existing conditions and focused on predicted peak velocities during ebb tide conditions with a range in stream inflows in Unnamed Stream A. Model results indicate that tidal exchange alone is likely insufficient to produce any significant erosion of the tailings deposit, but storm events, particularly those with return periods on the order of 1 to 10 years, produce velocities sufficient to cause extensive erosion at certain locations.

A model simulation was conducted to simulate reductions in velocity for minor regrading at two spots in the low flow stream channel north of the tailings spit. These changes involve excavating a portion of the right streambank at Station 1+50, and removing the western portion (85 linear feet) of the tailings spit. These actions were found to reduce critical erosive velocities at these key locations.

During storm inflows and tidal water levels below approximately 8 feet NAVD88, stream velocities may be sufficient to cause erosion despite the proposed regrading. With predicted velocities near 2 feet per second, it is advisable to employ some means of streambank protection to reduce the likelihood of continued erosion of the tailings during heavy rainfall events. Quarry stone 3 to 6 inches in diameter, which is available at quarries onsite, is sufficient to armor the streambanks against predicted velocities during storm events. Rock placed on the regraded streambank to an elevation of 10 feet at the West Excavation Area and the western end of the tailings spit would protect against the highest predicted velocities. The model also predicts elevated velocities at Station 7+75 on Unnamed Stream A, but photographic survey documentation does not indicate that this area is undergoing substantial erosion (Figure 12); therefore, streambank protection at this location may not be necessary.

Figure 12. Downstream view of Unnamed Creek A at Station 7+50, February 16, 2013

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Appendix B
Example of Removable Construction Matting: Nilex Mud Mats

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PRODUCTS

GEOTEXTILES

GEOGRIDS

GEOMEMBRANES

EROSION CONTROL

Erosion Control Blankets (ECB)

Turf Reinforcement Mats (TRMs)

Anchor Reinforced Vegetation System (ARV)

Scour Protection Mats

Concrete Revetments & Mattresses

Gabions

Cellular Confinement

Home > Products > Erosion Control > Mud Mats

Mud Mats

US Locations Only

Mud Mats can be used for construction site access, agricultur golf courses, parks, and other soft or sensitive ground conditi areas where vehicle access is required – just unroll and drive any muddy or swampy ground without getting stuck, rutting or tracking mud off-site.

Mud Mats consist of pocketed, double-wall, high-strength fabr with high tensile reinforcing ribs confined within each sleeve


SHAW