Van Stone Mine Remedial Investigation

Prepared for
Washington State
Department of Ecology

November 2013
17800-11

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CONTENTS

CONTENTS (Continued)

TABLES

CONTENTS (Continued)

Page

TABLES (Continued)

FIGURES

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTS

APPENDIX B
APRIL 10, 2012 TECHNICAL MEMORANDUM - RESULTS OF VAN STONE MINE BACKGROUND SAMPLING AND NATURAL BACKGROUND METAL CONCENTRATIONS

CONTENTS (Continued) Page

ACRONYMS AND ABBREVIATIONS

AOIs	areas of interest
ARAR	applicable and relevant or appropriate regulation
Asarco	American Smelting and Refining Company
asl	above sea level
ATV	all terrain vehicle
BFs	bioavailability factors
bgs	below ground surface
cfs	cubic feet per second
COCs	constituents of concern
COPCs	chemicals of potential concern
COPECs	chemicals of potential ecological concern
CSM	conceptual site model
DCN	document control number
DNR	Department of Natural Resources
DSO	Dam Safety Office
EA	emergency action
Ecology	Washington State Department of Ecology
Equinox	Equinox Resources (Washington), Inc.
EPCs	exposure point concentrations
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
FWS	U.S. Fish and Wildlife Service
gpm	gallons per minute
HHRA	Human Health Risk Assessment
LCS	laboratory control samples
LOAEL	lowest observed adverse effects level
MCL	Maximum Contaminant Level (from National Primary Drinking Water Regulations)
MDL	Method Detection Limit
MTCA	Model Toxics Control Act
North Line	North Tailings Pipeline
PCA	principal component analysis
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RPD	relative percent difference
SHA	Site Hazard Assessment
Site	Van Stone Mine Site
South Line	South Tailings Pipeline
SSL	soil screening level
START-2	Superfund Technical Assessment and Response Team

ACRONYMS AND ABBREVIATIONS (continued)

TPH	total petroleum hydrocarbons
UCLs	Upper Confidence Limits
WARM	Washington Ranking Method
WQS	Water Quality Standards
XRF	X-ray fluorescence

VAN STONE MINE REMEDIAL INVESTIGATION

1.0 INTRODUCTION

The Van Stone Mine is in the Colville Mountains, in the headwaters of Onion Creek, a tributary to the Columbia River. The mine is located in Section 33, Township 38 North, Range 40 East, Stevens County, Washington (Figure 1). The mine is generally considered part of a larger Northport (Aladdin) mining district. Mining operations focused on the extraction and milling of a lead-zinc ore deposit.

The Van Stone Mine was discovered by George Van Stone in 1920. From the time it was discovered through the mid-1930s, the mine area was explored. Willow Creek Mines began underground mining at the site in 1938. In 1950, American Smelting and Refining Company (Asarco) assumed ownership of the mine and operated and expanded the mine until 1970 when they ceased operations. During their operation, Asarco built and operated a 1,000-ton-per-day floatation mill. After 1971, mining continued intermittently under various owners until being put on standby status in 1993 by Equinox Resources (Washington), Inc. (Equinox).

The Van Stone Mine (Site) is reached by traveling 23 miles north from the town of Colville on Stevens County Highway 9425 and then turning east on Lotze Creek Road. Travelling about 0.5 miles southeast on Lotze Creek Road the first mine feature encountered is the Lower Tailings Pile. From the Lower Tailings Pile, travelling about 2.7 miles southeast on the Van Stone Mine Road gains access to the open pits and waste rock piles that mark the eastern extent of the Site. The Site and developments on surrounding land areas are shown on Figure 1.

1.1 Purpose of Remedial Investigation

The purpose of this Remedial Investigation (RI) is to evaluate the potential environmental impacts from historical mining operations and the extent of ongoing releases of contaminants at the Site. The RI complies with cleanup requirements administered by Ecology under the State of Washington's Model Toxics Control Act (MTCA) [WAC 173-3400-360 through 173-340-390]. The information presented in this RI will be used to evaluate site cleanup requirements under applicable regulations.

The Washington State Department of Ecology (Ecology) added the Van Stone Mine and Mill to its Confirmed and Suspected Contaminated Sites list on September 6, 2006, under Ecology Facility Site ID Number 1554858. Ecology then completed a site hazard assessment (SHA) of the Van Stone Mine as required under MTCA. The Site's hazard ranking, an estimate of the potential threat to human health and/or the environment relative to all other Washington state sites assessed at that time, was ranked as a 1 on a scale of 1 to 5 where 1 represents the highest relative risk and 5 the lowest. Ecology communicated the results of the SHA to Equinox in a February 7, 2007, letter and published the ranking of assessed/ranked sites that included the Van Stone Mine Site in the February 21, 2007, Special Issue of the Site Register.

Ecology is exercising its cleanup authority on the Site under the MTCA, according to state law [RCW 70.105D]. Under a recent federal bankruptcy court-approved reorganization plan, the State of Washington has been awarded payment for environmental contamination caused by former Asarco sites in Washington, including the Van Stone Mine.

1.2 Report Organization

Sections 2 and 3 of this report present the physical setting of the Site and the mine's history, respectively. Section 4 presents current site conditions and observations made during sample collection. Section 5 discusses the results of laboratory analysis, ARARs, and screening levels and exceedances of screening levels for soil, sediment, surface water, and groundwater on the Site. The laboratory results discussed in Section 5 and other sections of the report will refer to arsenic, antimony, and selenium as metals. Technically, these three elements are metalloids but to simplify the RI discussion they are referred to collectively with the other metals as "metals." Section 6 discusses fate and transport of constituents of concern (COCs). Site risks are summarized in Section 7; geotechnical concerns are described in Section 8; and conclusions are summarized in Section 9.

Historical reports were obtained from Ecology on December 15, 2010, and were reviewed for environmental and geotechnical data and the results of laboratory analyses. Each document from Ecology was assigned a document control number (DCN). When an Ecology file contained multiple documents, the documents were separated and assigned individual DCNs. The DCN numbering facilitated easy reference to the documents during work on the project.

1.3 Site Overview

The Van Stone Mine was developed using both open pit and underground mining methods. Since the discovery of the ore deposit in 1920 until the last mine operations shut down in 1993, approximately 328 acres were identified as “disturbed” (see DNR 2003, DCN 1020). Disturbed areas associated with mining activity are evident in Sections 29, 30, and 33 of Township 38N, Range 40E. Visible mine development includes two open pits (North Pit and South Pit), overburden stockpiles, waste rock piles, mill building concrete foundations, tailings conveyance pipelines, access and haul roads, and two tailings piles (Upper and Lower Tailings Piles).

The Site boundary for the Remedial Investigation/Feasibility Study (RI/FS) encompasses the mine and surrounding areas that may be, have been or continue to be impacted by past mining operations. The Site is located downgradient of the Onion Creek headwaters, which start at the eastern and southern topographic divide of the Onion Creek watershed (Figure 2). The RI uses the term “upper watershed” to denote the area starting just below the headwaters and extending downstream to the confluence with the West Fork of Onion Creek.

The RI uses five Areas of Interest (AOIs) to subdivide the Site (Figure 3). The AOIs were delineated based on the specific geographic location within the upper watershed, potential environmental impacts associated with mining activities, transport mechanisms for potentially impacted media, and the time sequence associated with the operation of the mine. Within the AOIs, potentially impacted media included surface water, groundwater, soil, and sediment. The AOIs are:

- AOI-1 encompasses the geographic areas of the Site where open pits were developed, waste rock was dumped, ore rock was milled and processed, chemicals were stored, and facility and vehicle maintenance was performed.

- AOI-2 encompasses the Upper Tailings Pile. Tailings were deposited on about 27 acres of property until 1961 when a tailings berm failed, releasing pond water and tailings which flowed overland in a westerly direction until entering the Southwest Tributary. AOI-2 covers the tailings pile and adjoining land where tailings may have been transported and deposited via erosion, wind, or berm failures.

- AOI-3 encompasses the Lower Tailings Pile and an adjacent water storage area. The Lower Tailings Pile covers about 40 acres of land. AOI-3 covers the tailings pile and adjoining land where tailings may have been transported and deposited via erosion, wind, or berm failures.

- AOI-4 encompasses the Tailings Conveyance Pipeline from the mill area to the Upper and Lower Tailings Piles. In addition, the AOI includes roads that may have been used as part of mining operations to access the mine/mill area, tailings piles, and conveyance pipelines.

- AOI-5 encompasses Onion Creek, the Northeast and Southeast Tributaries, and other smaller drainages to the Southeast Tributary that flow past mine features. The AOI includes creek channels and floodplains.

1.4 Demographics, Land Ownership, and Current Land Use

The upper watershed consists of mostly undeveloped forest land (Figure 1). Approximately 52 percent of the watershed is devoted to forestry. Forest land designation includes privately owned land, Department of Natural Resources lands, and the US Forest Service lands. While forestry is the primary land use in the Van Stone operations area, both the tailings storage area and mine site area are categorized as non-forested lands designated for mine use.

Other land uses include agriculture (mainly pasture land), small-scale ranching, rural residential, open pit quarries (construction aggregate), base metal mining (Van Stone lead-zinc operations), and several other minor mineral claims (Equinox 1999, DCN 1056). Recreational use is largely hunting, particularly while-tailed deer. The predominant land use is best described as mixed.

Areas near the Site are developed with several single family residences, mainly on private lands along Onion Creek and its tributaries. Onion Creek School House (District #30) is located at 2006 Lotze Creek Road, about 0.4 miles west of the Site. No Tribal Lands or Tribal cultural resource uses were identified in the historical documents that were reviewed for the Site.

Land parcel numbers and locations are shown on Figure 3 and parcel information for properties adjacent to the Van Stone Mine Site are presented in Table 1.

2.0 PHYSICAL SETTING

2.1 Meteorology

The Van Stone Mine elevation is about 3,500 feet above sea level (asl). Climate in the upper watershed is rain-snow dominated below an elevation of about 3,600 feet, and changes to snow dominated above 3,600 feet (Raines et. al. 1997). The rain-snow dominated portion of the upper watershed receives about 25 inches of average annual precipitation and the snow dominated portion of the upper watershed receives about 30 inches of average annual precipitation (Equinox 1999, DCN 1056).

2.1.1 Historical Climate Data

The closest weather station to the Site with publicly accessible historical climate records is located at the Colville Airport. The Colville Airport NOAA weather station (ID: COOP 451650) is approximately 16 miles southeast and about 1,800 feet lower in elevation than the Site. Records from the Colville Airport Weather Station show a maximum average temperature of 67.8 degrees Fahrenheit.

As part of a 1990 Tailings Disposal Design report (Equinox 1990, DCN 1037), Equinox used the following estimated precipitation at the Lower Tailings Pile.

Month	Mean Precipitation Inches	100-Year Precipitation Inches
Jan	3.91	6.47
Feb	2.66	4.40
Mar	2.30	3.80
Apr	2.06	3.41
May	2.91	4.95
Jun	2.62	4.33
Jul	1.40	2.32
Aug	2.00	3.31
Sep	1.69	2.80
Oct	2.19	3.62
Nov	3.64	6.02
Dec	4.53	7.49
	Total 32.00	Total 52.93

These estimates exceed the 25 inches of precipitation below 3,600 feet that Boise Cascade reported.

Pan evaporation at the Lower Tailings Pile was estimated to be 37.59 inches per year based on records from the Spokane Weather Station. The following are the 24-hour inches of precipitation, derived from isopluvial maps for Washington, which Equinox reported for design purposes.

100 Year	3.5 inches
50 Year	2.9 inches
10 Year	2.4 inches
5 Year	2.2 inches
2 Year	1.8 inches

2.1.2 Climate Data Acquired During the RI

Before conducting the Remedial Investigation (RI), Ecology held public meetings to gather input from the local community. At the meetings, a concern was raised that fine material on the tailings piles was potentially being blown off site by wind, particularly during the summer months. A review of historical data did not identify site-specific climate data suitable to evaluate potential tailings transport by wind.

To address this data gap, a semi-portable weather station was installed upslope and east of the Lower Tailings Pile. The weather station recorded data on wind velocity, wind direction, air temperature, and relative humidity from November 17, 2011, to June 21, 2012.

Appendix G presents the climate data collected at the weather station, an evaluation of the data, and the potential for windblown tailings material. The weather data analysis is summarized in the Fate and Transport Section of this RI.

2.2 Topography and Geographic Features of the Upper Watershed

The upper watershed varies from 4 to 6 miles in width and length. Throughout much of the upper watershed, the topography is dominated by long, steep sloping ridges and hills with moderate relief (Figure 1). The ridges subdivide the upper watershed into smaller drainage areas (Figure 2).

The upper watershed is drained by Onion Creek and two large tributaries: the Northeast Tributary and the Southeast Tributary. An east-west trending ridge separates the drainage areas of the Northeast and Southeast Tributaries in the upper watershed. In addition, two north-south trending ridges bound the drainage area of Onion Creek upgradient of the confluence with the Southeast Tributary.

Tributaries in the upper watershed appear to have narrow floodplains and are generally down-cutting rather than depositional in nature. This morphology changes on Onion Creek near the confluence with the Southeast Tributary. Onion Creek widens below the confluence and adjoining upland areas are broader and flatter.

The topography and drainage patterns in the upper watershed are important when considering the extent of mining impacts at the Site. The area drained by the Southeast Tributary encompasses the open pits, waste rock piles, Upper Tailings Pile, part of the tailings conveyance piping, and mine roads while the area drained by the Northeast Tributary encompass part of the tailings conveyance pipelines and the Lower Tailings Pile. Onion Creek, above the confluence with the Southeast Tributary, appears isolated from potential mining impacts.

2.3 Regional Geology, Site Geology, and Soils

2.3.1 Regional Geologic Setting

The Van Stone Mine is near the south end of the Kootenay Arc, otherwise known as the Selkirk Mountains Lead-Zinc Belt, extending southward from Revelstoke, British Columbia (Keston 1970). The rocks in which the ore deposits occur are Paleozoic marine sediment overlain in part by Mesozoic formations intruded by late Mesozoic batholiths. The important mineral deposits occur as replacement deposits in carbonate rocks, but vein-type ore bodies are found, to a lesser extent, in noncalcareous rocks. The bedrock surface is extensively covered by a thick mantle of fine to coarse outwash from continental glaciers.

2.3.2 Site Geology and Ore Deposit

The Van Stone Mine is located near the contact of the Cambrian age Metaline Limestone and the Spirit Pluton, an intrusive granite of Mesozoic age (Figure 2). Unconsolidated glacial sediment consisting of till, outwash, and lacustrine soil overlie approximately 50 percent of the mine and surrounding area. Bedrock outcrops on the Site and surrounding area are characterized as either folded, faulted Paleozoic sedimentary and metasedimentary rock, or Mesozoic granitic rock on side slopes and ridges of foothills.

The Metaline Limestone is described as a hard, crystalline dolomitic limestone with sizeable open and healed fractures. Brecciated dolomite contains pods and elongated masses of sphalerite and galena. The mineralization within the Metaline Limestone is discontinuous, which created problems for the small-scale mining operations in the area (DNR 1977, DCN 1066).

Mills noted irregular zones of jasperiod-tremolite alteration in the dolomite host unrelated to the sulfide mineralization. Tremolite, which has some asbestiform varieties, may have been excavated in small quantities and deposited with waste rock on the Site.

Soils in the North and South Pit area are of variable thickness and overlie Paleozoic metasedimentary rocks. A small amount of glacial overburden was removed to expose the ore deposits, but most of the overburden consisted of dolomitic limestone. The Spirit Pluton is not exposed at the tailings piles; a weathered zone of residual soil and/or colluvial material and glacial outwash covers the granite in these areas.

2.4 Surface Water, Groundwater, and Sediment

The Onion Creek watershed drains a catchment area of 47,360 acres. The creek drains in a northwesterly direction, and discharges to the Columbia River near the community of Onion Creek on Highway 25. The watershed ranges in elevation from 5,775 feet asl at the headwaters to 1,290 feet asl at the confluence with the Columbia River. Elevation of the mine is about 3,500 feet asl. Flood frequency analyses for each of the Onion Creek sub-basins (Boise Cascade Corporation 1997) indicate that the 2-, 25-, 50-, and 100-year return flood flows in Onion Creek just below the Lower Tailings Pile (western extent of the Site) are estimated at 87 cubic feet per second (cfs), 206 cfs, 234 cfs, and 262 cubic feet per second (cfs), respectively.

2.4.1 Surface Water - Onion Creek and Tributaries

The upper watershed is drained by Onion Creek and two large tributaries of Onion Creek: the Northeast Tributary and Southeast Tributary (Figure 1). While a few smaller, unnamed tributaries with year-round flow are described in this section, unnamed tributaries which are intermittent or do not flow near mine features are not described.

Onion Creek

Onion Creek originates about 3 miles south of the Lower Tailings Pile. From its headwaters north, or downgradient to the confluence with the Southeast Tributary, the watershed is topographically isolated from mining activity (Figure 1). Below the confluence, Onion Creek gains flow from the Southeast and Northeast Tributaries, which drain areas of the Site with mining impacts. In 1961, there was substantial erosion of Onion Creek caused by a slope failure of the Upper Tailings Pile during Asarco's operations. The failure released tailings from the Upper Tailings Pile which were conveyed downstream in the Southeast Tributary and discharged into Onion Creek.

Northeast Tributary

The Northeast Tributary trends in an east-west direction and joins Onion Creek about 1,500 feet upstream from the Onion Creek schoolhouse (Figure 2). The northeast tributary drains the northern area of the upper watershed. Most of the catchment area is located upgradient of the Lower Tailings Pile and outside the likely impacts of mining. The lower reach of the Northeast Tributary flows within 100 feet of the Lower Tailings Pile. During sample collection in June 2012, erosion and transport of material from the Lower Tailings Pile toward the Northeast Tributary was observed.

Southeast Tributary

The Southeast Tributary drains the southeastern portion of the upper watershed. From its headwaters, the Southeast Tributary flows southwesterly, is narrow and is generally characterized as a down-cutting, or erosional stream. About 1,500 feet upgradient of the confluence with Onion Creek, the Southeast Tributary begins a gradual transition with flood plain widening and areas of sediment deposition.

2.4.2 Groundwater

Groundwater at the Site occurs in both the unconsolidated glacial material and underlying weathered bedrock and fractured bedrock. Nineteen domestic water wells, listed in Ecology's water supply database (Table 2), are located within the general area of the Site (Figure 4). No public water supplies were identified in the upper portion of the watershed. However, the Onion Creek School obtains its potable water from a domestic well.

A review of the well logs indicate that 16 of the wells are completed in deep fractured granitic bedrock (Table 3), one well in weathered bedrock, and two in glacial material overlying bedrock. Wells close to the Site are summarized as follows:

- Two domestic wells (WL-6 and WL-7) are located along the Northeast Tributary. Both of these wells are completed in deep fractured bedrock. Well production is low with estimated yields of 1.5 to 4 gallons per minute (gpm).

- One domestic well (WL-1) is located along the Southeast Tributary north of the North Pit and north of the Northeast Tributary. The well is completed in fractured bedrock and well production is low with an estimated yield at 3 to 4 gpm.

Five domestic wells are located along Onion Creek and the Southeast Tributary south and west of the Lower Tailings Pile.

- WL-4 is located on the Southeast Tributary just above the confluence with Onion Creek. This well is completed in fractured granite from 79 to 92 feet below the ground surface (bgs) with a well yield estimated at 10 to 15 gpm.

- WL-14 and WL-15 are located close to the creek and west of WL-4. WL-14 is completed in weathered granite at a depth of 15 to 23 feet bgs. WL-15 is completed in fractured bedrock with likely fractures located between 40 to 120 feet bgs. The estimated yield of WL-15 is 7 gpm.

- WL-5-1 and WL-5-2 are located about 400 feet northeast of the creek and roughly 60 feet higher in elevation than WL-15. These wells are completed in fractured granite from 34 to 600 feet bgs. Estimated yields are low at 1.5 to 2 gpm.

- WL-20 is located at the Onion Creek School House, about 3,000 feet west of the Lower Tailings Pile. The well is completed in fractured granite. The estimated well yield is 20 to 25 gpm. A shallow water-bearing zone is noted on the well log at a depth of 20 to 21 feet bgs. Given the depth of the finished well, it is likely that steel casing was advanced during drilling to around 82 feet deep where competent bedrock was encountered.

2.4.3 Sediment

Sediment in the upper watershed is derived from the weathering and breakdown of rock formations and soil that washes into the creeks. Grain size and angularity of the sediment is strongly influenced by their distance from the headwaters of Onion Creek and the stream and tributary gradients. The sediment observed during site work and sediment sample collection was characterized as ranging from very coarse to fine grained.

2.5 Site Habitat

The upper Onion Creek watershed is a montane habitat characteristic of northeastern Washington. Conifer forests and associated wildlife characterize the general region in which the Site is located.

A comprehensive analysis of the entire Onion Creek watershed titled *Onion Creek Watershed Analysis* was carried out in March 1997 for Boise Cascade Corporation by a number of organizations including the Washington Department of Natural Resources, Ecology, Stevens County Conservation District, Vaagen Brothers Lumber, Arden Tree Farm, Inland Empire Paper, Maurice Williamson, and the Washington Farm Forest Association, (Raines et. al. 1997). According to the watershed analysis, approximately 52 percent of the Onion Creek watershed is devoted to forestry. Other land uses include agriculture, small-scale ranching, rural residential, open pit quarries, base metal mining (Van Stone lead-zinc operations), and several minor mineral claims. Riparian vegetation consists of small to medium mixed conifer stands ranging from sparse to dense growths. Canopy closure generally ranges from 90 percent to 100 percent. Deciduous species include trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera var. commutata*), and Sitka alder (*Alnus sinuata*).

Forests in the immediate operations area include interior Douglas-fir (*Pseudotsuga menziesii var. glauca*), grand fir (*Abies grandis*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta var. latifolia*), and Engelmann spruce (*Picea engelmannii*). The tailings facility is surrounded by lodgepole pine, interior Douglas-fir, grand fir, and some western larch. Forest cover in the area of the Site consists of mixed deciduous-coniferous cover, composed of aspen, paper birch, lodgepole pine, interior Douglas-fir, and western red-cedar (*Thuja plicata*).

Onion Creek has been categorized by Ecology as a Class AA (extraordinary) surface water body. Although there are 100-foot-high falls 1.2 miles upstream from the mouth of Onion Creek that prevent upstream migration, brook trout (*Salvelinus fontinalis*), and rainbow trout (*Oncorhynchus mykiss*) are found throughout the watershed (Boise Cascade 1997). The falls near the mouth of Onion Creek form a migration barrier to fish entering the upper portion of the watershed from the Columbia River. Salmonid species that have been observed in small numbers in the lower mile of Onion Creek below the falls include adfluvial kokanee (*Oncorhynchus nerka*), bull trout (*Salvelinus confluentus*), and cutthroat trout (*Oncorhynchus clarkii*). Bull trout do not occur above the falls (Boise Cascade 1997).

Other than the falls at the mouth of the creek, there are no other physical barriers to fish migration. Brook trout and rainbow trout, which were likely introduced, use the entire network of tributaries above the falls throughout all life stages and do not segregate into specific areas. The Northeast Tributary of Onion Creek is categorized as a confirmed fish-bearing Type 3 Stream for most of its length. There are two potential road barriers (culverts) on the Northeast

Fork of Onion Creek; one at the main Onion Creek road and one at a logging road crossing. While neither of these would preclude fish from the mine site area, fish have not been confirmed in the upper reaches of either tributary (Raines et. al. 1997).

The Site provides habitat for a range of wildlife including white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), and black bear (*Ursus americanus*). The Boise Cascade watershed report notes occasional reports of coyote (*Canis latrans*) and cougar (*Felis concolor*) in the area. Although there have been no detailed wildlife investigations of the mine site, it is expected that the area hosts a large spectrum of small mammals including bats (*Chiroptera*), mice, shrew, squirrels, chipmunks, gophers, voles, snowshoe hare (*Lagamorpha*), and members of the weasel family (*Mustelidae*).

Although there is very little standing or open water or wetland habitat in the area, the Van Stone property provides habitat for a large number of passerines, some waterfowl, upland game birds such as grouse and owls, and raptors such as hawks and eagles. Many of the species that frequent the area are migratory or transitory.

2.5.1 Special-Status Species

The Endangered Species Act (ESA) was established to protect and recover imperiled species and the ecosystems upon which they depend. Under the ESA, species may be listed as either endangered or threatened. Endangered means a species is in danger of extinction throughout all or a significant portion of its range. Threatened means a species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. All species of plants and animals, except pest insects and non-native species are eligible for listing as endangered or threatened. For the purposes of the ESA, Congress defined species to include subspecies, varieties, and, for vertebrates, distinct population segments.

Section 4 of the ESA specifies that a species must be listed as endangered or threatened solely on the basis of its biological status and threats to its existence. The U.S. Fish and Wildlife Service (FWS) also maintains a list of candidate species. These are species for which there is enough information to warrant proposing them for listing but that have not yet been proposed because of higher listing priorities.

In March 2012, the FWS Central Washington Field Office revised the ESA list of species in Stevens County (http://www.fws.gov/wafwo/speciesmap_new.html) as follows:

Listed Animals

- Bull trout (*Salvelinus confluentus*)
- Canada lynx (*Lynx canadensis*)
- Grizzly bear (*Ursus arctos horribilis*)

Major concerns that should be addressed in a Biological Assessment of project impacts to listed animal species include:

1. Level of use of the project area by listed species.
2. Effect of the project on listed species' primary food stocks, prey species, and foraging areas in all areas influenced by the project.
3. Impacts from project activities and implementation (e.g., increased noise levels, increased human activity and/or access, loss or degradation of habitat) that may result in disturbance to listed species and/or their avoidance of the project area.

Listed Plants

- *Spiranthes diluvialis* (Ute ladies'-tresses)

Major concerns that should be addressed in a Biological Assessment of project impacts to listed plant species include:

1. Distribution of taxon in the project vicinity.
2. Disturbance (trampling, uprooting, collecting, etc.) of individual plants and loss of habitat.
3. Changes in hydrology where taxon is found.

Designated

Critical habitat for the bull trout

Proposed

None

Candidate

- North American wolverine (*Gulo gulo luteus*) – contiguous U.S. DPS
- Yellow-billed cuckoo (*Coccyzus americanus*)
- Whitebark pine (*Pinus albicaulis*)

Species of Concern

- Bald eagle (*Haliaeetus leucocephalus*)
- Burrowing owl (*Athene cunicularia*)
- California floater (*Anodonta californiensis*)
- Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*)
- Fisher (*Martes pennanti*)
- Giant Columbia spire snail (*Fluminicola columbiana*)
- Kincaid meadow vole (*Microtus pennsylvanicus kincaidi*)
- Loggerhead shrike (*Lanius ludovicianus*)
- Long-eared myotis (*Myotis evotis*)
- Northern goshawk (*Accipiter gentilis*)
- Olive-sided flycatcher (*Contopus cooperi*)
- Pallid Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)
- Pygmy whitefish (*Prosopium coulteri*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Sagebrush lizard (*Sceloporus graciosus*)
- Westslope cutthroat trout (*Oncorhynchus clarki lewisi*)
- Triangle lobe moonwort (*Botrychium ascendens*)
- Crenulate moonwort (*Botrychium crenulatum*)
- Two-spiked moonwort (*Botrychium paradoxum*)
- Stalked moonwort (*Botrychium pedunculosum*)

3.0 SITE HISTORY

3.1 Historical Mining Activity

The Van Stone Mine has a long history of development. George Van Stone and Henry Maylor discovered a zinc-lead-silver ore deposit at the Site in 1920 and operated the mine until they transferred ownership of the mine and facilities to various parties. Operation and production at the mine were sporadic from 1938–1942, 1952–1970, and 1991–1993. In 1993, the mine was inactivated by the current owners, Equinox. During mine operations, the owners developed two open pits and several hundred feet of underground tunnels and produced 8.77 million tons of ore and waste rock.

Mining activities included drilling, blasting, and hauling rock from open pits and underground workings, milling and benefaction of ore, and disposal of waste rock and fine-grained mill tailings (the waste generated during ore processing) on the Site. Generally, mine operation consisted of hauling and dumping blasted waste rock near the open pits and hauling excavated ore by truck from the open pits or underground workings to staging areas at the rock house crusher plant.

Crushed rock was then fed by conveyor to a ball mill. Metals from the pulverized ore were separated in a dual-circuit flotation system that produced 55 percent zinc concentrate and 70 percent lead concentrate. Thickener tanks were used to separate the solids, or tailings, from the liquid. The final ore concentrates were trucked off site for further processing and tailings, the waste generated during processing, were routed via pipeline to tailings disposal areas.

Initially, the tailings were disposed of on land close to the open pits (Upper Tailings Pile). In 1961, following a major breach of the Upper Tailings Pile, a new disposal area (Lower Tailings Pile) was constructed about 2 miles downslope from the open pits. After 1961, tailings generated at the mill were disposed of on the Lower Tailings Pile.

During early mining and milling at the Site, tailings were conveyed through an 8-inch wood stave pipe. The wood stave pipe was replaced with a cement-asbestos pipe sometime during Asarco's operation of the mine after 1950. When mine operations were restarted by Equinox in the early 1990s, the cement-asbestos pipe was replaced with a black ABS continuous-weld pipe to convey tailings from the thickener tanks to the Lower Tailings Pile.

3.2 Mine Ownership

The chronology of Site activity including mine development, milling operations, and mine ownership was documented in the EPA Preliminary Potentially Responsible Party Search (EPA September 2003, DCN 1055). Portions of the search for historical operations and ownership changes are presented below, as reported by EPA.

1920 - Ore body is discovered by George Van Stone and Henry Maylor.

1926 - Under an unrecorded property lease, Hecla Mining conducted limited exploration and delineation of the ore body. The Van Stone Mining Company then signed a lease with an option to purchase a portion of the property.

1938 - Willow Creek Mines of Nevada purchased the property. Between 1938 and 1942, the combined development was limited to underground workings, mining the ore body, and shipment of a small quantity of ore.

1944 - The Van Stone Mining Co. (or Van Stone Lead Silver Mining Co.) releases their option to purchase the property.

1945 - According to one source, US Bureau of Mines conducted diamond drilling at the Site. This information could not be confirmed with the Department of Interior.

1947 - On April 18, the American Smelting & Refining Company (Asarco Inc.) received the following Water Right Permits:

- Water Right Permit 7398 for 0.40 cubic feet per second for mining, milling, and general camp use from the Southeast Fork of Onion Creek.
- Water Right Permit 5073 for 0.20 cubic feet per second for mining, milling, and general camp use from the Southeast Fork of Onion Creek.
- Water Right Permit 7397 for 0.20 cubic feet per second for mining, milling, and general camp use from the Northeast Fork of Onion Creek.
- Water Permit 7399 for 0.45 cubic feet per second for mining, milling, and general camp use from the Middle East Fork of Onion Creek.

1950 - Asarco Inc., bought the land and claims, along with approximately 1,200 adjoining acres, from Ernest Lotze and Louis Menegas.

1952 - Asarco Inc., operated the open-pit zinc mine and the mill 24 hours a day, 7 days a week under a government contract for the Defense Material Procurement Agency. Terms of the government contract are not known, but may have been extended for several years. P.A. Lewis was the general superintendent of the mine. Asarco built a 1,000-ton concentrator at the mill facility. Isbell Construction of Reno, Nevada, conducted the stripping and mining operations for Asarco. Ore was trucked to Marble, Washington, where the zinc was shipped to Anaconda Copper Company's Black Eagle, Montana, smelter, and the lead was sent to Asarco's smelter in East Helena, Montana. On June 24, Asarco received the Water Right Permit No. 2531 for 75 gallons per minute, or 10 acre feet per year (Northeast Quarter 114 of Northeast Third, 113 Section 30).

1955 - The mill reported having sufficient ore on hand for processing to last several years. Superintendents at the mine during the 1950s and 1960s were Nolan Probst and Walter Barlow. The General Manager was Norman Visnes.

1957 - The mine was shut down by Asarco Inc., due to low zinc prices.

1961 - The west end of the Upper Tailings Pile pond failed, releasing water into Onion Creek and flooding the Clugstone Creek county road. A new tailings pond was constructed in the Northwest Quarter of Section 29 and the Northeast Quarter of Section 30. The mill discharge pipe was extended and routed around the upper pond and across country approximately 2 miles to the new Lower

Tailings Pile. Richard LeCaire, a former employee of the mine and a fisheries biologist for the Colville Confederated Tribes, indicated, "...it was not uncommon for the tailings slurry pipe to break and go unnoticed for an 8-hour shift." (The mine produced about 1,000 tons of ore per 24-hour shift).

1965-66 - Asarco Inc., produced at the mine during these years; in 1966, production was 820 tons of zinc concentrate per month.

I967 - Asarco Inc., shut down operations in May.

1969 - The mine was opened for part of the year by Asarco Inc., under mine manager Al Kingman. A newspaper article (source not identified) indicated that 6,137 tons of zinc and 968 tons of lead were mined in 1969, according to the Asarco, Inc. annual report.

1970 - In April, Asarco Inc., discovered a new ore body in the western extension of the North Pit. However, the open-pit operation was closed in the following winter. Herb Buffan worked as a contract miner for Asarco Inc., and later became the powder foreman and then the pit foreman.

1971 - Department of Natural Resources research indicated that Asarco Inc., sold the property to Sumerian Mining Co. of Spokane (aka Atlas Mine and Mill Supply, aka Washington Resources LLC). Nandor Szombathy was president of Atlas Mine and Mill Supply. (While the title search did not confirm this purchase, a sale was identified in 1991 by this company to Equinox Resources [Washington] Inc.) On June 18, Callahan Mining Corporation of New York acquired the mill and mine property with mineral rights on 1,224 acres of property. Herb Buffan became general foreman at the mine/mill.

1975 - Callahan Mining Corporation with partners, US Borax and Chemical Corporation and British Newfoundland Exploration Ltd., began underground drifting (tunneling along a vein of ore) and diamond drilling at the mine. They drove a drift and some explorations into the pit wall to explore the ore body on the west end of the North pit.

1989 - The property was for sale by Callahan Mining Corporation.

1990 - Callahan Mining Corporation and Equinox Resources Ltd. conducted feasibility studies to determine if the mine/mill could be reopened. On July 5, Equinox Resources (Wash.) Inc., purchased the mill and mine from Callahan Mining Corporation, Pacific Coast Mines, Inc., and Sharondale Corporation. On the same date, Equinox Resources (Wash.) Inc., signed a Deed of Trust with Ticor Title, which stated that Cominco Ltd., was the beneficiary of the Deed of

Trust. The purpose of the Deed of Trust was to secure an agreement where $506,250 was loaned to Equinox Resources (Wash.) Inc. with the agreement that further funds could be loaned in the future by Cominco Ltd.

1991- Equinox Resources (Wash.) Inc., filed a preliminary Reclamation and Closure Plan with DNR, and then reactivated the open pit mine and concentrator. They were issued permit No. 12667 on January 1. On April 5, Atlas Mine and Mill Supply and Nandor Szombathy quitclaimed the property to Equinox Resources (Wash.) Inc. An article in an April edition of the Statesman-Examiner reported that ore would be shipped to Trail, British Columbia, for processing. In August, Equinox Resources (Wash.) Inc., received two promissory notes and secured them with a Security Agreement. One was from Equinox Resources Ltd. for $430,000 and the second was from Biscay Ltd. for $181,000. The Security Agreement contained provisions that specific earlier deeds and agreements would be paid before this agreement was satisfied. These included security agreements with Cominco Ltd. and Cominco American Ltd.

The Equinox Resources Ltd. 1990 Annual Report indicated that concentrates would be smelted at Cominco's Trail Smelter at an annual rate of 34,000 tons of zinc concentrate and 5,400 tons of lead concentrate. The mine was shut down in October.

1992 - The mine reopened in June or August (according to differing reports). Ore was shipped to Cominco in Trail, British Columbia, for processing. Ross Beaty was the contact at Equinox Resources (Wash.) Inc. In June 1992, Cominco reconveyed the earlier Deed of Trust back to Equinox Resources Inc.

1993 - In January, Equinox Resources (Wash.) closed down operations due to low zinc prices. The surface mine reclamation permit covers part of post-1991 rock dumps and was bonded for $95,000. According to EPA (RCW 1055) the tailings and mill site are partially bonded by the Department of Ecology for $245,000.

1998 - In June, Washington State Department of Ecology's Dam Safety Office (DSO) documented the failure of the Lower Tailings Pile pond membrane liner. The liner failure allowed seepage that threatened the stability of the dike around the pond, which was constructed of tailings material. In December, Ecology issued a State Waste Discharge Permit No. 5287 to reduce the level of water in the tailings pond to 2 feet below the failure point in the liner. The water from the pond was applied to nearby fields using a sprinkler. The permit also required final closure of the tailings pond.

2003 – The Ecology-issued State Waste Discharge Permit No. 5287 expired on June 30, 2003. Mano River Resources, Inc., parent company of Equinox Resources (Wash.) Inc., had the property for sale. Equinox failed to meet the requirements of their reclamation permit.

3.2.1 Current Ownership

Today, the Site comprises of 15 parcels of land (Figure 3), which are owned by either Equinox or the Vaagen Brothers Lumber Company Inc. (Vaagen Brothers). Current parcel ownership relative to facilities and land disturbance on the Site due to mining are summarized as:

Equinox Resources

- Mill facility
- Portions of the waste rock piles
- North and South Pits
- Tailings Conveyance Pipe Line
- Lower Tailings Pile

Vaagen Brothers

- Portions of the waste rock piles
- West End Pit
- Upper Tailings Pile

3.3 Enforcement and Reclamation History

Limited post-mining reclamation activities have been conducted at the Van Stone Mine since its closure in 1993. Since 1990, the Department of Natural Resources (DNR) has issued one surface mining reclamation permit and two correction actions for the Site.

The DNR issued a surface mining reclamation permit to Equinox on January 1, 1991, for portions of the post-1971 waste rock dumps authorized under the Surface Mining Act RCW 78.44. Since operations have ceased in 1993, Equinox has failed to meet the conditions of the reclamation permit. DNR issued a Notice of Corrective Action in 2000 and a revised permit in 2001.

Post-mining reclamation began in 1993 and since then, most of the crushing and refining equipment associated with the Mill Area (AOI-1) has been removed. Some sporadic reclamation activities at the Site have addressed small spills and dismantled the tailings pipeline that ran from the Mill Area (AOI-1) to the Upper

(AOI-2) and Lower Tailings Pile (AOI-3). Numerous structures and prominent mining features still stand at the Site, including the West End Pit (AOI-1), the Upper Tailings Pile (AOI-2), and the Lower Tailings Pile (AOI-3).

3.4 Previous Mine Site Investigations

Table 3 in the RI/FS Work Plan summarizes historical documents reviewed and laboratory data presented in each of the documents. Selected historical documents, which discuss various aspects of the Site, are summarized below.

3.4.1 Seepage Environmental Analysis, 1974 (DCN-1014)

Kealy et al. wrote a research paper on seepage of the slime zone of a tailings pond at Van Stone, titled “Seepage-Environmental Analysis of the Slime Zone of a Tailings Pond.” Their work included collecting soil and water samples and conducting geotechnical tests and laboratory investigations.

3.4.2 Ecology Site Inspection Report, 1986 (DCN-1035)

In March 1986, Ecology conducted a site inspection at Callahan Mines (Van Stone Mine) to determine the condition of the tailings ponds and whether they erode into Onion Creek. Water samples were collected from the tributaries, ponds on the Upper and Lower Tailings Piles, and West End Pit Lake. Laboratory analysis of the water samples indicated no evidence of metals impacts to the creeks at the time of sampling.

3.4.3 SEPA Environmental Report, January 1990 (DCN-1060)

This report by Equinox Resources (Washington) Inc., titled “Van Stone Mine Project,” includes the SEPA environmental checklist, waste discharge permit application, and Klohn Leonoff’s “Geotechnical and Water Quality Data Report for the Van Stone Tailings Facility, Colville WA” dated January 8, 1990 (DCN-1067). Klohn Leonoff’s report is a data summary of a geotechnical and water quality investigation at the Lower Tailings Pile. Geotechnical investigations included electric piezocone testing, and the drilling and installation of piezometers. One drill hole was converted into a monitoring well, and one groundwater sample was collected. Surface water samples from Onion Creek and the Northeast and Southeast Tributaries were collected and analyzed.

3.4.4 Groundwater and Surface Water Monitoring, Waste Discharge Permit, 1991 (DCN-1022)

The Waste Discharge Permit for the Van Stone Mine was issued on May 31, 1991 and expired on May 31, 1996. The permit included a water quality monitoring program and a hydrogeologic study. Surface water monitoring was required at eight locations and groundwater monitoring was required at two wells. Water quality was monitored from 1990 through 1998 and the data was presented in multiple reports (DCN-2000 through DCN-2040).

3.4.5 Reclamation and Closure Plan, 1999 (DCN-1056)

Equinox Resources filed a preliminary reclamation and closure plan with the Washington State Department of Natural Resources prior to reopening the mine in 1991. Beacon Hill Consultants (1999) Ltd., prepared a revised reclamation and closure plan for Equinox Resources for the Van Stone Mine in July 1999. The revised plan's objectives were to provide a systematic approach to decommissioning the mine and return all disturbed lands associated with mine operations to a mixed land use capability. The following goals were stated to achieve the plan's objectives:

- Long-term preservation of water quality within and downstream of the decommissioned operations;

- Long-term stability of engineered structures including the waste rock storage area, tailings storage facility, and open pit;

- Natural integration of disturbed lands into surrounding landscape, and restoration of the natural appearance of the area after mining ceases, to the greatest possible extent; and

- Establishment of a self-sustaining vegetative cover consistent with mixed land uses and wildlife needs.

3.4.6 Upper Columbia River Mines and Mills, Preliminary Assessments and Site Inspections Report, October 2002 (DCN-1041)

The Superfund Technical Assessment and Response Team (START-2) assessed the mines and mills in Stevens County, Washington. The Van Stone Mine site was visited in June 2001 and soil, water, and sediment samples were collected. Significant concentrations of cadmium, mercury, lead, and zinc were detected in waste rock samples, and samples collected from stained soil areas contained significant concentrations of all these metals plus copper. Tailings samples contained significant concentrations of lead and zinc only. Significant concentrations of lead and zinc, and zinc and cadmium were detected in two of the five sediment samples collected. A significant concentration of zinc was detected in the surface water sample collected from the mine pit water. Based on an evaluation of the data, it was recommended that further action under CERCLA or other authorities be taken at the site.

3.4.7 DNR Investigation, October 2002 (DCN-1036)

The Washington State Department of Natural Resources (DNR) Division of Geology and Earth Resources visited the site to collect samples from surface water, soil, and tailings piles. The analytical results indicated that surface water samples from the South Pit lake and Lower Tailings Pile ponds and soil samples from around the mill site contained elevated levels of metals.

3.4.8 Ecology Water Quality Sampling 2004 through 2006 (DCN-1026, DCN-1009, DCN-1018, DCN-1050, and DCN-1051)

Ecology conducted surface water sampling from the Lower Tailings Pile ponds and the Reclaimed Water Pond, and from surface water and sediment around the mine site.[1]

Results from the 2004 surface water sampling event indicate elevated levels of sulfate and TDS in the East Tailings Pond, West Tailings Pond, and Reclaim Pond samples; and high levels of pH and antimony in the West Tailings Pond sample.

In general, results from the 2005 and 2006 sampling event indicate elevated metal concentrations during higher flow times from the upstream, pit, downstream of pit, and downstream of tailings sample locations. However, the groundwater sample results for metals analyses for both high and low flow times were below the applicable groundwater criteria at the time.

3.4.9 Site Hazard Assessment, February 20, 2007 (DCN-1017)

Ecology conducted a Site Hazard Assessment (SHA) site visit of the Van Stone Mine on November 2, 2006. The site was scored and ranked based on results

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[1] The Ecology document (DCN-1009 and DCN 1051) calls the pond "Reclaim Pond" and it is just south of the west and east tailings pile.

from environmental samples collected throughout October 1985 through 1994, and referred to studies from 1975 to 1976. No environmental samples were collected during the 2006 site visit. The SHA ranked the site as “1” based on the overall relative threat to human health and the environment according to the Washington Ranking Method (WARM). A score of 1 represents the highest level of risk on a scale of 1 to 5.

3.4.10 Ecology Van Stone Creek Sampling Event, October 2010 (DCN-1001)

The Washington State Department of Ecology sampled surface water from creeks around Van Stone Mine on October 24, 2010. These samples were collected near the west pit lake, upper and lower tailings piles, and Onion Creek School. Samples were collected and submitted for dissolved and total metals analysis by EPA Method 200.8 and hardness by SM2340B. Six samples (1010062-05 through 1010053-10) had the following dissolved metal concentrations:

- Dissolved zinc concentrations ranged from 4.6 to 81.1 ug/L;
- Dissolved lead concentrations ranged from 0.072 to 10.9 ug/L;
- Dissolved copper concentrations ranged from 0.43 to 2.62 ug/L;
- Dissolved cadmium concentrations ranged from non-detect at 0.02 to 0.109 ug/L; and
- Dissolved arsenic concentrations ranged from 0.49 to 2.07 ug/L.

One sample (1010064-11) had the following total metal concentrations:

- Non-detect for zinc at a reporting limit of 5.0 ug/L;
- Lead concentration of 0.35 ug/L;
- Copper concentration of 0.66 ug/L;
- Non-detect for cadmium at a reporting limit of 0.10 ug/L; and
- Arsenic concentration of 0.44 ug/L.

Nine samples (1010062-01, 1010062-02, and 1010062-05 through 1010062-11) had hardness concentrations ranging from 118 to 2,760 mg/L.

4.0 REMEDIAL INVESTIGATION

RI field work was conducted in October and November 2011, and June 2012 during three field events (FE-1, FE-2, and FE-3 respectively). Background samples for soil, sediment and surface water were collected from the surrounding area outside the area of influence of the Site as part of FE-1 in October 2011.

Samples that were used to characterize the nature and extent of contamination was collected from each of the AOIs discussed below for chemical analysis of soil, sediment, surface water, and groundwater during FE-1, FE-2, and FE-3. Analytical results are discussed in this section. Geotechnical data is discussed in Section 8.

To evaluate the nature and extent of site contamination, soil data were collected from the tailings piles, Waste Rock Piles, haul roads, Mill Area, and stream banks along Onion Creek and the tributaries draining the site features. Sample collection was a combination of discrete sampling based on review of documents on historic mine operation, and visual observations during the field work. During and after sample collection, a portable Field X-Ray Fluorescence (XRF) instrument was used to evaluate the range of metal concentrations in site surface material (soil and waste rock). This information was used to help evaluate the likely extent of site impacts and guide sampling locations.

Background sample results are summarized in a technical memorandum, “Draft Results of Van Stone Mine Background Sampling and Natural Background Metal Concentrations,” dated March 16, 2012, and presented in Appendix B. Descriptions of soil, waste rock, sediment and water samples are presented in Tables A-1 through A-5 in Appendix A.

The results of laboratory analysis for surface soil, sediment, surface water, and groundwater are presented in Tables 17 through 20. The following subsections describe site conditions observed during field work and samples collected for background analysis and samples collected in each AOI to assess potential mining impacts on the Site.

Samples were named using a 3 part identification number containing the area, location, and matrix: Area-Location-Matrix with the following area identification:

- Area
    - UT – upper tailings pile
    - LT – lower tailings pile
    - NP – north pit
    - SP – south pit
    - T – transect sample at tailings or waste rock piles to determine extent of contamination
    - PL- samples collected along the pipeline
    - DR – samples collected along roads
    - OC – Onion Creek sample
    - MS – mill area sample

  - MW – groundwater monitoring well
  - RW – residential well

- Location – numeric station identifier

- Matrix, when applicable, i.e., when samples other than soil are collected from a station.
  - SS – surface soil
  - SD – sediment
  - SW – surface water

4.1 Characterization of Natural Background

A site visit was conducted in May 2011 to observe current conditions in the watershed. Observed conditions were found to be consistent with historical documents reviewed before the site visit. Based on the historical information and observed watershed conditions, investigators concluded that it was most likely that concentrations of hazardous substances on and near the Site are related to releases associated with mining activity rather than the result of other human activities. Thus, the conditions in the watershed outside the area impacted by the mine were consistent with using a natural background rather than an area background as defined in MTCA [173-340-200].

Two natural geologic formations in the vicinity of the Site were evaluated prior to establishing natural background concentrations: (1) the presence of outcrops of the dolomite host rock that were not mined or changed by mining activity, but which may contain naturally elevated metal concentrations, and (2) the lower tailings pile, which is located in a sub-watershed in Onion Creek in which the dominant rock types are glacial drift and igneous rock (Figure 1). Multiple samples were needed to assess natural background at the Site because of these two distinct geologic formations. For evaluation, the background samples were divided and pooled based upon which geologic formation the sample was associated with and a statistical comparison was made on the two data sets. Based on the evaluation, it was concluded that development of more than one background value for each chemical constituent was not warranted (Appendix C).

4.1.1 Sampling Locations and Sample Size

Fifteen background sample locations in the upper watershed were selected based on watershed geology, topography, habitat, aerial photography, rural development, and historical mining operations, including potential areas impacted by mining. The number of samples collected for each media (soil, sediment, and surface water) was based on a minimum of 10 samples required under MTCA for establishing a natural background. That number was increased to 15 to provide sufficient sample coverage if sample results were found not to be usable.

During the field work, 15 soil, sediment, and surface water samples were collected. One location (BG-12) was inadvertently located on the Southeast Tributary to Onion Creek, rather than a smaller creek tributary. The sample collected at location BG-12 is potentially in a mining-impacted area and was excluded from the final background sample set. Instead, the sample was included as part of the Site characterization data. The data analysis and background concentrations are presented in Appendix C.

Groundwater at the Site may be environmentally impacted; however, development of background for metals in groundwater was only partially addressed. This approach was based on discussions during work plan development with Ecology. A lack of historical information on groundwater quality, flow conditions in glacial material and underlying granitic rock (fracture flow), and the size (over 2 miles long) and topographic relief across the site makes natural background concentrations for metals in groundwater difficult to establish. As a starting point for evaluating potential groundwater mining impacts downgradient of the waste rock piles and tailings ponds, six candidate domestic wells were identified and groundwater samples were collected and submitted for laboratory analysis. Wells were selected based on locations, depths, and requests from several local residents to have their wells sampled as part of the study

4.2 AOI-1 – Mill Area, Open Pits, and Waste Rock Piles

4.2.1 Mill Area

Mill Area structures cataloged during the site characterization included twelve buildings, two water tanks, one bus, foundations for the rock crusher and processing facility, and a laydown yard.

Small amounts of potentially hazardous substances were observed in the office, explosives storage, maintenance buildings and in the rock core storage/garage building. The potential hazards found within each of the buildings are listed below.

Office, Explosives Storage, and Maintenance Building Potential Hazards

- Two drums labeled "Motor Oil" each contained approximately 5 to 10 gallons of liquid.
- Numerous small containers (less than 5 gallons) contained varying amounts of lubricants, paints, and unidentified substances.
- A floor drain coated with an oily residue was observed in the maintenance shed.
- Three unsecured aboveground storage tanks that appear to be empty are located in the maintenance garage.

Rock Core Storage/Garage Potential Hazards

- A 5-gallon bucket labeled "Solvent" was half full. The container was not opened to identify the substance.
- Unstable rock core boxes.
- Numerous boxes containing an unidentified white powder.

Field personnel did not enter locked buildings and did not collect samples of building materials or other substances stored in the structures at Ecology's direction due to concerns regarding some of the buildings' structural integrity, potential for exposure to rodent carried viruses and not having keyed access to all of the buildings. The limited assessment of building interiors did not allow for documentation of current building uses.

4.2.2 Open Pits

Mining operations primarily by Asarco and Equinox resulted in two large open pits at the Site (Figure 1). The largest open pit is the North Pit. Historical documents describe the North Pit as consisting of two distinct areas, the North Pit and the West End Pit. The second open pit is smaller and is referred to as the South Pit.

The North Pit is about 400 feet wide and approximately 1,000 feet long. At the east end of the North Pit floor, a large adit was observed. The adit was not entered. During inspection of the open pit, rock falls were observed that created unsafe conditions, which limited access to the pit walls.

The West End Pit is about 700 feet wide and 700 feet long. The West End Pit contains a pit lake (West End Pit Lake) that is approximately 4.5 acres in area and about 100 feet deep. The pit lake is formed within the pit excavation and behind a 30-foot-wide, rock-filled berm at the northwest end that is referred to as the Pit Lake Dam. This berm supports a road, which may be the reason it was built. Although the berm functions as a dam, there is no information to show that it was designed or built to be a dam. The pit lake contains an estimated 146 million gallons of water.

The pit lake maintains a relatively static water level around 3,515 feet asl. The pit lake discharges through a channel constructed on top of the northwest end of the dam. The rate of discharge varies, depending on time of year and intensity of precipitation, and drains into an unnamed stream channel that discharges to the Southeast Tributary.

In 1990, Equinox prepared a proposed Van Stone Mine project document (DCN-1070). The document contains cross-sections of underground mine workings and shows an adit at the bottom of the West End Pit. The adit is presumed to be underwater and could not be identified by traversing the accessible portions of the north and south rims of the pit.

The South Pit is smaller than the North Pit. It is located approximately 1,000 feet south of the West End Pit. The South Pit is entered through narrow openings at both ends. The maximum elevation difference from pit floor to pit rim is about 180 feet. Rockfalls were not observed during the field work at the South Pit. A small, shallow intermittent pond is present in the center of the pit floor. The pond is likely seasonal, resulting from spring snowmelt, seasonal precipitation, and limited discharge from pit wall seepage.

4.2.3 Waste Rock Piles

During mining, waste rock was deposited adjacent to both the North and South Pits. Waste rock varies in size from large boulders to fine rock flour. There are scattered areas around the open pits where excavated overburden was stockpiled. Six areas of waste rock were identified during our investigation: one area associated with North Pit and five areas associated with the South Pit.

The waste rock pile associated with excavation of the North Pit occupies about 63 acres. Waste rock was observed less than 100 feet from the Southeast Tributary of Onion Creek. Waste rock piles associated with excavation of the South Pit are smaller, ranging from about 2 to 12 acres. The total estimated area of waste rock piles is approximately 80 acres based on available air photos. The total volume is likely on the order of 1 to 2 million cubic yards, but there is a large uncertainty associated with this estimate since the depth of waste rock has not been surveyed.

4.2.4 Summary of Sample Collection

Samples collected from AOI-1 included 51 discrete soil samples and one field duplicate, nine 30-point composite soil samples, and three surface water samples. Table 4 summarizes the soil sample descriptions. Soil sample collection procedures are in Appendix A.

Soil Samples

To characterize impacts to soil in AOI-1, the following soil samples were collected:

- Eight sampling transects were established to assess the extent of waste rock impacts to Site soils. Twenty-two soil samples and one field duplicate were collected along transects and submitted for analysis.
- To characterize the metal concentrations in the waste rock, nine 30-point composite samples were collected and submitted for chemical analysis. Of the nine composite samples, six were screened by the laboratory for bulk asbestos.
- During the initial site reconnaissance, stained surface material in the rock crushing and mill area was observed. During FE-2, 10 discrete surface material samples were collected from the stained areas.
- Along the western side of the milling and waste rock areas, downslope erosion was observed. Eight discrete samples were collected to characterize the extent of eroded waste rock.
- During FE-1, as part of evaluating XRF calibration site material, two five-point composite soil samples were collected from the waste rock piles.

Transect Samples

Eight transects established in AOI-1 were labeled T-11 through T-18. Samples collected along T-11 through T-15 were screened for selected metal concentrations using XRF. Based on the XRF results, a limited number of soil samples were submitted to the laboratory for total metals analysis. Samples collected along T-16 through T-18 were not screened using XRF. Samples collected along these three transects were submitted for laboratory analysis of total metals. The general location of the eight transects is as follows:

- T-11 was located on the west side of the Waste Rock Piles, and extended to the northwest down slope through a previously logged area. Ten samples were collected and screened using XRF and three samples were submitted for laboratory analysis (T-11-SS-300, T-11-SS-900, and T-11-SS-1200).

- T-12 was located on the west side of the Waste Rock Piles, and extended northwest, downslope of the mine site, and crossed an unnamed tributary which drained the area between the two open pits. The area along T-12 was previously logged. Nine samples were collected and screened using XRF and three samples were submitted for laboratory analysis (T-12-SS-150, T-12-SS-450, and T-12-SS-750).

- T-13 was located along the northwest area of the waste rock piles, and extended northwest through a previously logged area. Eight samples were collected and screened using XRF and three samples were submitted for laboratory analysis (T-13-SS-150, T-13-SS-300, and T-13-SS-500).

- T-14 was located northwest of the North Pit at the visible extent of waste rock disposal. However, at the starting point of T-14, tailings were observed and limited reclamation activities had been undertaken. T-14 extended downslope to the northwest toward the Southeast Tributary. Eight samples were collected and screened using XRF and three samples were submitted for laboratory analysis (T-14-SS-300, T-14-SS-500, and T-14-SS-750).

- T-15 was located on the southeast side of the North Pit, close to the edge of the pit wall and extended southeast through a fairly flat, previously logged area. The area had visible waste rock and partially improved dirt roads. Nine samples were collected and screened using XRF and three samples were submitted for laboratory analysis (T-15-SS-200, T-15-SS-750, and T-15-SS-1000).

- T-16 was located northeast of North Pit waste rock. T-16 extended from the toe of the waste rock pile northeast through a previously logged area. Three samples were collected and submitted for laboratory analysis (T-16-SS-0, T-16-SS-315, and T-16-SS-770).

- T-17 was located southwest the South Pit and extended downslope to the northwest through a previously logged area. Two samples were collected and submitted for laboratory analysis (T-17-SS-0 and T-17-SS-500).

- T-18 was located northwest of the observable extent of the South Pit waste rock piles and extended northwest through a previously logged area. Two samples were collected and submitted for laboratory analysis (T-18-SS-0, T-18-SS-350).

Mill Area Stained Surface Material Samples

Samples were collected from stained surface material observed around the rock crushing and mill facility (samples MS-1 through MS-10). Table 5 includes a description of samples collected and Table 17 summarizes laboratory analysis.

Five-Point Composite Samples for XRF Comparison

Samples NP-1-SS and NP-3-SS were collected from the waste rock piles. The samples were collected during FE-1 and were used to compare the XRF readings to actual laboratory results on the same samples. Table 5 includes a description of samples collected, and Table 17 summarizes laboratory analysis.

Waste Rock 30-Point Composite Samples

Nine 30-point composite samples were collected from waste rock piles. Samples MS-1-COMP, MS-2-COMP and MS-3-COMP were collected from waste rock excavated from the North Pit. Sample MS-4-COMP was collected from the waste rock excavated from the North Pit but located south of the North Pit Lake.

Composite samples SWR-1-COMP and SWR-2-COMP were collected from South Pit waste rock located northwest of the South Pit. SWR-4-COMP and SWR-COMP were collected from South Pit waste rock disposed of east and southeast of the South pit. Composite sample SWR-3-COMP was collected from the South pit.

Downslope Erosion Areas

Samples MS-11 through MS-18 were collected from erosion areas downslope of the north and west sides of waste rock associated with the North Pit. Table 5 includes a description of samples collected.

Surface Water

Two samples of North Pit Lake water were collected. Surface water discharging over the West Pit Lake Dam (from the North Pit) was collected (WP-SW-1) and surface water was collected from a seep below the West Pit Lake Dam (NP-SW-1).

One surface water sample was collected from seasonal surface water present in the South Pit (SP-SW-1). Weather conditions (snow) prevented identification of seeps for sampling.

4.3 AOI-2 – Upper Tailings Pile

Tailings generated during ore processing at the Site were deposited on the Upper Tailings Pile, about 3,800 feet downslope and west of the North Pit. Tailings slurry was conveyed by pipeline from thickening tanks near the mill to the Upper Tailings Pile until 1961, when a major failure of the Upper Tailings Pile resulted in erosion and transport of tailings downslope into the Southeast Tributary. The tailings continued to flow downstream into Onion Creek and west past Stevens County Highway 9425. After the Upper Tailings Pile failure, a new tailings disposal location (Lower Tailings Pile) was developed downslope of the Upper Tailings Pile and used for tailings disposal after 1961 (see Section 5.3).

The Upper Tailings Pile covers approximately 9.5 acre and contains about 780,000 tons of tailings. Two ponds are present on the Upper Tailings Pile: the east and west ponds. The east and west ponds are separated by a waste-rock-lined drainage ditch as shown on Figure F1 in Appendix F.

The east pond had visible evidence that a liner was installed, and the west pond did not appear to be lined. However, exposed sections of the east pond liner were deteriorated and are unlikely to be functional. The ponds contained a substantial amount of water from seasonal precipitation. During field work, one surface water seep, UT-SW-1, was observed immediately downslope of the Upper Tailings Pile (Figure 8).

The east pond area was sparsely vegetated and the west pond area was moderately vegetated. Vegetation on the west pond included grasses, lodge-pole pine seedlings, small cottonwoods, and inland cedar saplings. Both ponds contained stands of bulrushes and grass covering about 10 percent of the ponded areas.

On the southern portion of the Upper Tailings Pile, abundant ruts and hand-made motorcycle jumps were evident, likely caused by dirt bike or All Terrain Vehicle (ATV) activity. The ruts were mostly observed in an area of the tailings where berm failure(s) had occurred.

In areas adjacent to the Upper Tailings Pile, there was evidence of activities not associated with historical mining operations including logging and off-road recreational vehicle use. Logging activity included newly improved logging roads, downed trees, brush piles, and machinery.

Observed Erosion Features

On April 27, 2011, as part of RI/FS work plan development, Hart Crowser conducted a site visit with Ecology project manager Brendan Dowling. During the site visit, physical conditions of the Upper Tailings Pile were observed. Along the southern portion of the Upper Tailings Pile berm, a slope failure was evident. The failure had resulted in substantial erosion and downslope transport of tailings beyond the toe of the tailings pile. Water was observed seeping from the tailings about 3 feet below the top of the tailings pile.

After the Site visit with Ecology and before the initial RI field effort started on June 1, 2011, the southern portion of the tailings pile failed again, releasing a mixture of pond water and tailings. This failure occurred at the same location that was observed during the April 27, 2011, site visit. Brendan Dowling noted that a substantial amount of pond water had again carried fine-grained tailings downgradient and into the Southeast Tributary. During a subsequent site visit on June 26, 2012, Brendan Dowling observed continuing failure of the tailings pile.

Ecology addressed the increasing instability and continuing failures of the Upper Tailings Pile by implementing an Emergency Action (EA) in the fall of 2012. The EA included regrading the failure area and constructing an engineered surface water channel and erosion controls. The EA was documented in a report titled Emergency Remedial Action Construction Completion Report, Upper Tailings Pile Van Stone Mine (Hart Crowser 2012).

4.3.1 Summary of Samples Collected

Samples collected from AOI-2 included 33 discrete soil samples and two field duplicates, two groundwater samples, and three surface water samples. Table 4 includes descriptions of transect samples collected and Table 6 includes descriptions of discrete soil samples collected in areas of potential tailings transport and deposition. Soil sample collection procedures are presented in Appendix A.

Soil Samples

To characterize impacts to soils in AOI-2, the following soil samples were collected and submitted for laboratory analysis:

- Five soil sampling transects were established to assess the extent of the Upper Tailings Pile. Fifteen soil samples were submitted for analysis.

- Two samples were collected from the Upper Tailings Pile and submitted for analysis.

- Sixteen soil samples and two field duplicates were collected from failure/erosion areas west and downslope of the Upper Tailings Pile, and from northern areas of the Upper Tailings Pile that may have been used to develop the tailings disposal area. All samples were submitted for analysis.

Transect Samples

Five transects established in AOI-2 were labeled T-6 through T-10. Samples collected along T-6 through T-10 were screened for selected metal concentrations using XRF. Based on the XRF results, a limited number of soil samples were submitted to the laboratory for total metals analysis. The general location of the eight transects is described as follows:

- T-6 was established on the southwest side of the Upper Tailings Pile and extended downslope to the southwest through forest and across a natural drainage. Seven samples were collected and screened using XRF and three samples were submitted to the laboratory (T-6-SS-100, T-6-SS-300, and T-6-SS-500).

- T-7 was established on the northwest side of the Upper Tailings Pile where a drainage ditch leaves the Upper Tailings Pile. T-7 extended west and crossed the Southeast Tributary. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-7-SS-100, T-7-SS-300, and T-7-SS-500).

- T-8 was established north of the Upper Tailings Pile at the visible extent of tailings. T-8 extended to the north-northwest across the Southeast Tributary and across the Van Stone Mine road. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-8-SS-100, T-8-SS-300, and T-8-SS-500).

- T-9 was established on the northeast side of the Upper Tailings Pile and extended upslope to the east to the tailings pipeline. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-9-SS-100, T-9-SS-300, and T-9-SS-500).

- T-10 was established on the southeast side of the Upper Tailings Pile, and extended upslope to the southeast to the tailings pipeline. The traversed area was logged. At the end of T-10, pipeline tailings were visible in a gully from what appeared to be a pipeline failure. Nine samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-10-SS-150, T-10-SS-500, and T-10-SS-750).

Five-Point Composite Samples for XRF Comparison

Three five-point composite samples were collected from the Upper Tailings Pile. One sample was collected from the southern area (UT-1-SS); one sample was collected from the breached area (UT-SS-2); and one sample was collected from the northern area (UT-SS-3). Samples UT-SS-2 and UT-SS-3 were submitted to the laboratory for analysis. The samples were collected during FE-1 and were used to compare the XRF readings to laboratory results on the same samples. Table 6 includes a description of samples collected, and Table 17 summarizes analytical results.

Downslope Erosion Areas

Sixteen discrete samples and two field duplicates were collected around the Upper Tailings Pile to delineate potential erosion areas. Table 6 includes a description of samples collected. During the field work in June 2012, the breach along the southwest portion of the Upper Tailings Pile was actively failing. Surface water mixed with tailings was flowing downslope to the west. The release extended into a small drainage, which discharged into the Southeast Tributary. New tailings deposited downslope from the failure ranged from a few inches to over a foot in depth and covered low-growing vegetation.

The soils samples were located as follows:

- UT-1, UT-2 and UT-3 were collected along the south end of the Upper Tailings Pile.

- UT-4, UT-5, and UT-6 were collected around the north end of the Upper Tailings Pile.

- UT-7 through UT-17 were collected downslope of where the Upper Tailings Pile had failed and released substantial tailings. To characterize the extent of the release, the following samples were collected:

    - Two samples of transported tailings were collected downslope of the failure (UT-7 and UT-11).

    - Two samples were collected beyond the visible tailings deposit (UT-9 and UT-10).

- Four samples were collected along a drainage trending to the northwest from the west side of the Upper Tailings Pile and discharging into the Southeast Tributary (UT-12, UT-13, UT-14, and UT-15).

- Two soil samples were collected from a drainage west of the Upper Tailings Pile (UT-16 and UT-17). This drainage originates on the Upper Tailings Pile and divides the north and south portions of the Upper Tailings Pile.

Two water samples (UT-SW-2 and UT-SW-3) were collected at the confluence of the Southeast Tributary and an unnamed tributary and are described in the surface water section below.

Groundwater Samples

Groundwater samples were collected from two monitoring wells (MW-4 and MW-5) installed just downgradient of the toe of the Upper Tailings Pile (Figure 8). The samples were submitted to the laboratory for analysis.

Surface Water Samples

A seep was observed west, or downgradient of, the Upper Tailings Pile (Figure 8). A surface water sample was collected from the seep (UT-SW-1). Two surface water samples were collected in the area impacted by the tailings release from the Upper Tailings Pile. One sample was collected at the point where tailings being released were entering a small drainage west of the Upper Tailings Pile (UT-SW-3). The second sample was collected downstream of UT-SW-3 (UT-SW-2). The three samples were submitted to the laboratory for analysis. Table A-1 in Appendix A includes a description of samples collected, and Table 17 summarizes the results of laboratory analysis.

4.4 AOI-3 – Lower Tailings Pile

The Lower Tailings Pile was constructed after the 1961 breach of the Upper Tailings Pile. It currently covers approximately 40 acres and contains approximately 1,820,000 tons of tailings (Figure 5). A secondary recovery and water storage area is located adjacent to the south side of the Lower Tailings Pile.

Precipitation falling on the Lower Tailings Pile is contained in two PVC-lined ponds. The ponds had been separated by an earthen dike. However, for improved water and erosion control, the dike was breached, connecting the two ponds. During the field work, there was standing water in the two ponds and in the adjacent secondary water storage area. Cracking and weather damage was visible in the exposed sections of the PVC pond liner. The PVC liner in the adjacent water storage area appeared to be in better condition and likely is capable of retaining water.

Both ponds on the Lower Tailings Pile contained stands of bulrushes and grass that cover about 10 percent of the total surface. Waterfowl and turtles were observed in both ponds along with numerous mule deer and elk tracks and scat in grass-covered areas.

Remnants of the 8-inch, cement-asbestos pipe and wood stave pipe were observed scatted in various places on the tailings pile. Household garbage was dumped below the southern toe of the tailings pile. Dumped materials included general household debris, a washer and dryer, an abandoned car, and approximately four truckloads of construction soil debris. Large rock barricades had been placed to limit vehicle access to the Lower Tailings Pile.

4.4.1 Observed Erosion Features

During the field work in October 2011, slopes of the Lower Tailings Pile were visibly eroded by downslope runoff and transported tailings. This condition was most evident on the north and west sides of the Lower Tailings Pile. Seasonal precipitation and localized water ponding appears to have caused visible areas of slope failure and released and transported tailings toward the Northeast Tributary.

During field work in June 2012, precipitation and surface water runoff was again observed to be actively eroding tailings in the northwest corner of the Lower Tailings Pile with tailings being washed over land into the Northeast Tributary.

Summary of Samples Collected

Samples collected from AOI-3 included 42 discrete soil samples, five field duplicates, and five groundwater samples. Table 4 describes samples collected along the transects and Table 7 describes samples collected in areas of potential tailings transport and deposition. Soil sample collection procedures followed are presented Appendix A.

Soil Samples

To characterize environmental impacts to soil in AOI-3, the following samples were collected:

- Five soil sampling transects were established to assess the extent of tailings migration from the Lower Tailings Pile. Fifteen soil samples with two field duplicates were submitted for laboratory analysis.

- Two soil samples were collected from the Lower Tailings Pile for use in XRF calibration checking and submitted for laboratory analysis.

- Twenty-five soil samples and three field duplicates were collected from potential down slope depositional areas to the north and west, and to a limited extent, south and east of the Lower Tailings Pile. The samples were submitted for laboratory analysis.

Transect Samples

Five transects were established in AOI-3 and labeled T-1 through T-5. Soil samples collected along T-1 through T-5 were screened for selected metal concentrations using XRF. Based on the XRF results, a limited number of soil samples were submitted to the laboratory for total metals analysis. The general location of the eight transects is described as follows:

- T-1 was established on the east side the Lower Tailings Pile and extended upslope in a southeast direction. The area traversed was logged. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-1-SS-100, T-1-SS-300, and T-1-SS-500).

- T-2 was established on the east side the Lower Tailings Pile and extended upslope in a southeast direction. The area traversed was logged. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-2-SS-100, T-2-SS-300, and T-2-SS-500).

- T-3 was established south of the Lower Tailings Pile, and extended to the south across an open meadow. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-3-SS-100, T-3-SS-300, and T-3-SS-500).

- T-4 was established west of the Lower Tailings Pile and extended in a westerly direction across the Van Stone Mine Road and Onion Creek. Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-4-SS-100, T-4-SS-300, and T-4-SS-500).

- T-5 was established at the northwest corner of the Lower Tailings Pile and extended to the northwest, across the Northeast Tributary and a road.

Seven samples were collected and analyzed by XRF and three samples were submitted to the laboratory (T-5-SS-100, T-5-SS-300, and T-5-SS-500).

Five-Point Composite Samples for XRF Comparison

Three five-point composite samples were collected from the Lower Tailings Pile (LT-1-SS, LT-2-SS, and LT-3). Samples LT-1-SS and LT-2-SS were submitted for laboratory analysis. The samples were collected and used to compare the XRF readings to laboratory results on the same samples. Table 7 includes a description of samples collected, and Table 17 summarizes the results of laboratory analysis.

Downslope Erosion Areas

Twenty-five discrete soil samples and three field duplicates were collected beyond the toe of the Lower Tailings Pile to assess the potential extent of environmental impact from observed or suspected areas of release and transport of tailings. Table 7 includes a description of samples collected. The soil samples were located as follows:

- Fifteen discrete soil samples (LT-1 through LT-15) were collected north of the Lower Tailings Pile to assess potential environmental impacts and the extent of downslope tailings migration toward the Northeast Tributary.

    - At the eastern end of the north side of the Lower Tailings Pile, erosion and transport of tailings was observed. Soil samples LT-6 through LT-9 were collected to delineate the extent of deposited tailings and assess the potential extent of environmental impact. LT-7 was collected in the area where tailings were deposited. LT-6 was collected north of the Northeast Tributary. LT-8, LT-9, and LT-10 were collected just south of the Northeast Tributary. Visible tailings were not observed in these samples.

    - At the northwest corner of the Lower Tailings Pile, erosion and transport of tailings was also observed. Soil samples (LT-11 through LT-15) were collected to assess the extent of transported tailings and the potential environmental impacts on this area. LT-11 was collected close to the bank of the Northeast Tributary where tailings were observed in the tributary. LT-12 was collected within the floodplain of the Northeast Tributary. During sample collection, it was noted that organic material had been deposited over the tailings. LT-13 was collected east of the visible extent of tailings and LT-14 was collected north of the Northeast

Tributary. Sample LT-15 was collected downstream from a culvert extending from the Lower Tailings Pile toward the Northeast Tributary.

- Seven soil samples (LT-16 through LT-21) were collected to gather additional soil data in areas between soil sampling transects where laboratory analysis of transect soil samples indicated elevated metal concentrations. Two samples (LT-16 and LT-17) were collected southwest of the Lower Tailings Pile. Two samples (LT-18 and LT-19) were collected south of the Lower Tailings Pile. Two samples (LT-20 and LT-21) were collected northeast of the Lower Tailings Pile.

- Three soil samples (LT-DP-1, LT-22, and LT-OC ROAD-CULVERT) were collected west of the Lower Tailings Pile, following a west-trending drainage. The samples were collected from a detention pond (LT-DP-1), a gully below the detention pond (LT-22), and the culvert located at the Onion Creek Road (LT-OC ROAD-CULVERT). One additional soil sample, LT-23, was collected on the west side of Onion Creek Road, downslope of the culvert, to assess whether tailings were transported and deposited beyond Onion Creek Road.

Groundwater Samples

During site investigation, three monitoring wells (MW-1, MW-2, and MW-3) were installed west and south of the Lower Tailings Pile. Drilling logs and well completion details are presented in Appendix A and on Figures A-2 through A-5. The three wells were completed in the glacial material overlying granitic bedrock.

Before the RI, Equinox had installed four wells adjacent to the Lower Tailings Pile. Five groundwater samples were collected from Hart Crowser and Equinox monitoring wells (MW-2, MW-3, W-1, W-2, and DH-2). Wells MW-1 and DH-5 were dry, and no groundwater samples were collected. Table 20 summarizes the results of laboratory analysis.

4.5 AOI-4 – Tailings Pipelines and Access Roads

Historical milling operations at the Site generated mill tailings, which were conveyed as a slurry mixture by pipeline to the Upper and Lower Tailings Piles. Based on a review of historical documents and field observations, two tailings pipelines were identified and investigated during RI field work: the South Tailings Pipeline (South Line) and the North Tailings Pipeline (North Line). The South Line trends west from the southwest corner of the open pit area to the Upper Tailings Pile. The tailings lines are no longer functional and are almost unidentifiable in some locations because of degradation of the wood piping and logging activities. The North Line starts below the Mill Area and trends west downslope to the Lower Tailings Pile. At points along both conveyance routes, the pipeline was elevated to maintain an even gradient and cross creeks. Tailings releases were observed along both lines in several areas (Figures 6 and 7).

A review of historical information indicates that the South Line to the Upper Tailings Pile operated from 1938 to 1961 when the Upper Tailings Pile failed. Following the Upper Tailings Pile failure, the Lower Tailings Pile was constructed and tailings slurry was conveyed along the North Line to the Lower Tailings Pile for disposal. After failure of the Upper Tailings Pile, the South Line was connected to the North Line. When the North Line was extended eastward to the thickening tanks, the South Line was abandoned. Based on our observations, the connection of the South Line to the North Line was visible. Additional information on each pipeline is presented below.

4.5.1 South Tailings Pipeline

The South Line conveyed tailings from near the West End Pit to the Upper Tailings Pile (Figure 7). It is unknown whether there was a historical tailings processing operation in this area or whether the tailings were processed near the Mill Area and conveyed from the mill to the South Line. No pipeline was observed connecting the Mill Area to the start of the South Line. Numerous tailings deposits were visible along the South Line.

The exposed pipeline is wire-wrapped wood stave pipe, which appears to be the primary material used to build the South Line. Near the Upper Tailings Pile, the wood stave pipe appears to transition to an unlined ditch that flows west between two 90 degree bends in the line. The last mapped section of the South Line runs north. Along this stretch of pipe, scattered wood pipe and metal culvert material were observed.

An access road appeared to parallel the wood pipeline. The road was extremely overgrown and unidentifiable in some locations. Logging activities likely obscured or buried many sections of the road.

4.5.2 South Line Releases

Tailings were observed near the South Line along much of the pipeline. The released tailings appeared to be associated with sections of the pipeline that were severely degraded and/or disturbed by logging. Most of the releases appear confined to the immediate vicinity of the pipeline.

Five tailings releases ranging from roughly 400 to 9,000 square feet were mapped. The largest tailings release appears to cover roughly 8,900 square feet and is approximately 300 feet long. The release is located approximately 1,500 feet downslope from the West End Pit. Four smaller releases covering less than 3,000 square feet were also observed along the South Line. Observed releases are shown on Figure 7.

4.5.3 North Tailings Pipeline

The North Line used three different types of pipeline to convey tailings from the thickening tanks and slurry pond west of the mill to the Lower Tailings Pile. The pipeline is no longer functional and many sections of the pipeline have been disturbed or destroyed by land use and/or degradation.

The North Line was built using a combination of wire-wrapped wood stave pipe and an elevated wood flume. Elevated wood flumes are located along the first 1,000 feet of the North Line along the north side of an access road. No elevated flumes were observed along the lower portion of the North Line; instead wire-wrapped wood piping appears to have been used during early operation of the line in the 1960s.

Newer PVC and asbestos-concrete piping was sporadically observed along the North Line. The PVC line is not visible along most of the pipeline, and concrete piping was not observed along the upper portion of the North Line. The PVC and concrete pipe appear to have been buried along the lower section of the conveyance route and may be buried along the upper portion, as well. The concrete and wood pipelines both appear to be associated with the large tailings releases described below.

The North Line runs adjacent to an access road that was used to service the line (Figures 5, 6, and 7). The road is overgrown and is no longer accessible by standard vehicles. In general, it appears that the wood stave pipeline was placed along the north side of the road and the concrete and PVC line was placed later along the south side of the road, but exceptions were noted for each type of piping. It appears that portions of the road may have been graded since mining operations stopped. The east portion of the road is relatively steep, and surface water was observed flowing in road ruts below the Mill Area. Scattered releases of tailings were observed on the access road.

4.5.4 North Line Releases

Four large tailings releases were observed along the North Line ranging from 6,000 to 33,000 square feet (Figures 6 and 7). Numerous smaller areas of tailings were also observed along the North Line, but were generally limited to small areas adjacent to the pipeline. Pipeline damage and deterioration was evident where most tailings releases were observed. Most of the elevated structures along the upper part of the pipeline were deteriorated or been destroyed. Mounds of tailings were visible in these areas.

The four largest North Line releases are shown on Figures 6 and 7 and described below.

- A roughly 33,000-square-foot release is approximately 700 feet west of the mill circuit thickeners and slurry pond. The release appears to be associated with an elevated wood tailings flume. Timber has been logged in the general area of the release, and logging operations may have disturbed and spread the tailings further. Tailings thicknesses ranged from large mounds near the pipeline to a thin veneer at the visible extent of the tailings.

- A second, roughly 8,600-square-foot release is approximately 1,000 feet west of the mill circuit thickeners and slurry pond. The area of tailings deposits is north of a small intermittent creek and south of the North Line access road. Tailings thicknesses range from a trace to approximately 12 inches. The creek forms the southern boundary of the release and drains to a wetland southwest of the release. The access road forms the northern boundary of the release and is located approximately 15 feet above the creek.

- A third, roughly 13,400-square-foot release is approximately 7,500 feet west of the mill circuit thickeners and slurry pond. The tailings deposits are on a southwest facing slope and extend from the North Line to the Van Stone Mine Road. An abandoned home is uphill of the area of visible tailings. Tailings ranged from a trace to 10 inches thick. Unconnected sections of pipe were observed scattered near the release.

- A fourth, roughly 5,900-square-foot release is approximately 8,000 feet west of the mill circuit thickeners and slurry pond. Tailings ranged from a trace to 8 inches thick. The release extends from the North Line about 300 feet down a southwest facing slope.

Numerous smaller releases were also documented along the North Line and are shown on Figures 6 and 7.

4.5.5 Description of Samples Collected

Samples collected from AOI-4 included 18 discrete soil samples from the South and North Lines and 15 discrete soil samples from mine access roads. Table 17 summarizes the results of laboratory analysis.

South Line

Five samples were collected from the South Line between the mine site and the Upper Tailings Pile (PL-3, PL-4, PL-5, PL-8, and PL-9). Table 8 describes the samples. Sample locations are generally described as follows:

- PL-3 was collected west of the North Pit and beyond the visible extent of waste rock or tailings.
- PL-4 was collected about 800 feet west of the North Pit waste rock and just upslope of a visible area of tailings.
- PL-5 was collected from visible tailings that extended about 350 feet along and adjacent to the South Line.
- PL-8 was collected downslope of the point at which the South Line turned 90 degrees in a northerly direction. About 150 feet of visible tailings extended west, or downslope, from where the South Line changed direction.
- PL-9 was collected at the northern extent of the Upper Tailings Pile.

North Line

Thirteen samples were collected from the North Line between the mine site and the Lower Tailings Pile (PL-1, PL-2, PL-6, PL-7, PL-10 through PL-15, Tailings Box, UT-LT-2000′, and UT-LT-4000′). Table 8 describes the samples collected.

- Three soils samples (Tailings Box, PL-1 and PL-2) were collected closest to the mine site, from two areas with large visible tailings releases located between 700 and 1,000 feet west, or downslope, of the mill circuit thickeners and slurry pond.
- Six samples (PL-6, UT-LT-2000′, PL-11, PL-13, PL-15, and UT-LT-4000′) were collected from visible tailings deposits noted along North Line (Figure 6).
- Four samples (PL-7, PL-10, PL-12, and PL-14) were beyond areas of visible tailings releases.

Access Roads

Fifteen soil samples were collected from the roads that provide access to the mines (Figures 5, 6, and 7). Table 9 describes the samples collected. The samples were collected at equal distances along the major roads (Samples DR-1 through DR-15). Samples were not collected along the access roads to the Lower Tailings Pile, Upper Tailings Pile, or the Mill Area. These roads were likely highly traveled during mining operations and are likely to be environmentally impacted. The Onion Creek and Lotze Creek roadbeds had apparently been improved with imported gravel, while the Van Stone Mine Road did not appear to be improved with imported gravel. The samples were analyzed for total metals.

The samples were collected sequentially with the lowest numbered sample closest to the state highway, and the highest numbered sample closest to the Site. Samples DR-1, DR-2, and DR-3 were collected on Onion Creek Road before the fork where Van Stone Mine Road branches off. Sample DR-5 was collected on the Lotze Creek Road. Samples DR-4 and DR-6 through DR-15 were collected along the Van Stone Mine Road.

4.6 AOI-5 –Onion Creek and Tributaries

Current conditions of Onion Creek and its tributaries are summarized from observations made during October 2011 field work. Onion Creek and the tributaries are shown on Figure 4.

4.6.1 Onion Creek

The upper reaches of Onion Creek, above the confluence with the Southeast Tributary, are unlikely to have been impacted by historical mine activity. Locations visited along the upper reaches of the creek were generally flat, 6 to 8 feet wide, and shallow (less than 1 foot deep).

Downstream from the confluence with the Southeast Tributary, Onion Creek remained flat, but widened to approximately 8 to 10 feet. During the field work, small areas of orange staining were observed in the streambed. The origin of the staining is unknown.

Downstream from the confluence with the Northeast Tributary, the creek widened from approximately 10 feet to 20 feet downstream from the culvert under SR 9425. The creek was still shallow, but deeper pools (2.5 to 3 feet deep) were observed. Again, small areas of orange staining were observed in the streambed.

4.6.2 Southeast Tributary

The upper reaches of the Southeast Tributary drain the area above the open pits and Mill Area. These reaches are considered outside the area of mining impacts (Figure 4). In the upper reaches, minor tributaries, 1.5 to 3 feet wide and generally less than 6 inches deep, were observed discharging water into the Southeast Tributary.

Downstream, to the area north of waste rock near the North Pit, the Southeast Tributary was approximately 3 feet wide and shallow (less than a foot deep). In this reach, some orange staining of creek bed gravel was observed. Scattered piping was also observed near the creek and is assumed to be associated with mining activity.

Further downstream, the Southeast Tributary is located within 500 feet of the Upper Tailings Pile (Figure 4). About 1,500 feet downstream of the Upper Tailings Pile, the tributary widens to approximately 5 feet, and ranges from 0.5 to 2 feet deep. Small areas of orange and pinkish-red staining on creek bed sand and gravel were observed.

Continuing downstream, toward the confluence with Onion Creek, the Southeast Tributary widened to 3 to 8 feet but remained generally shallow (less than 1 foot deep). Where the southeast tributary flows under Lotze Creek Road (about 1,200 feet upgradient of the Onion Creek confluence), the tributary had been widened to approximately 20 feet to create a pool about 4 feet deep. The pool is used to collect firefighting water. Some areas of orange staining on creek bed sand and gravel were observed, along with some very fine sand, similar to tailings.

An unnamed drainage to the Southeast Tributary drains the area between the North Pit and South Pit (Figure 4). The drainage ranged from 2 to 8 feet wide and was less than 1 foot deep. The West End Pit Lake discharges over the Pit Lake Dam into this drainage. Along the drainage, we observed waste rock, iron sulfide-bearing rock, fine-grained sand (similar to mine tailings), and various metal pipes near former mining and waste rock dumping areas.

4.6.3 Northeast Tributary

The Northeast Tributary drains an area of the upper watershed that, except for the Lower Tailings Pile, is isolated from historical mining activity (Figure 4). The portion of the tributary upgradient and east of the Lower Tailings Pile ranged from 1 to 3 feet wide, less than 1 foot deep, and flowed through formerly logged areas.

Starting at the northeast corner of the Lower Tailings Pile the tributary flows within 100 to 200 feet of the Lower Tailings Pile. Before discharging into Onion Creek, the Northeast Tributary is about 4 feet wide and shallow less than 1 foot deep. Minor pools and riffles were observed along the lower 2,000 feet of creek bed and limited areas of orange staining were observed on creek bed sand and gravel. Fine grained sand (similar to tailings) were also noted in these areas.

4.6.4 Summary of Samples Collected

Nineteen co-located surface water and sediment samples were collected from Onion Creek and associated tributaries (OC-1-SW through OC-19-SW, and OC-1-SD through OC-19-SD). One field duplicate was collected (OC-13-SW2 and OC-13-SD2). During FE-3, one sediment sample was collected from the Northeast Tributary (NT-SD-1). Background sample BG-12 was inadvertently collected from the Southeast Tributary. The analytical results of this sample are included with AOI-5 and excluded from background sample analysis. Descriptions of sediment samples collected are provided in Table 10.

Surface Water

Nineteen surface water samples were collected. General descriptions of the sampling locations and streambed conditions are described in Appendix A, Table A-2. Table A-3 summarizes the field measurements collected at the time of sample collection, and Table 19 summarizes the laboratory analysis.

Sediment

Nineteen sediment samples were collected. The samples were co-located with the surface water sample locations. Table 18 summarizes the results of laboratory analysis. Sediment sample locations are described as follows:

- OC-10-SD and OC-12-SD were located on the Southeast Tributary as it flows north of the mine site.

- OC-15-SD and OC-16-SD were located on the Southeast Tributary upgradient of where the North Line crossed the tributary.

- OC-9-SD, OC-11-SD, and OC-14-SD were located in a creek that drains the area between the North Pit and South Pit.

- OC-6-SD, C-7-SD, OC-8-SD, OC-17-SD, OC-18-SD, and BG-12-SD were located along the Southeast Tributary below the Upper Tailings Pile, and upgradient of the Onion Creek confluence.

- OC-4-SD was collected in Onion Creek downstream of joining the Southeast Tributary.

- OC-2-SD, OC-3-SD, and NT-SD-1 were collected in the Northeast Tributary, north of the Lower Tailings Pile. Samples OC-1-SD, OC-19-SD, and OC-13-SD were collected in Onion Creek, downstream from the confluence with the Northeast Tributary.

4.7 Data Quality and Reporting

Data quality is indicated by assessing their completeness, representativeness, accuracy, precision, and comparability. All analyses were performed in a manner consistent with the methods and guidelines stated in the SAP/QAPP. The chemistry data were reviewed and validated by Hart Crowser chemists. Overall, the data quality objectives (DQOs), as set forth in the SAP, were achieved, and the data for this project are acceptable for use, as qualified.

Results for several analytes were qualified as estimated concentrations based on exceedances of quality control criteria. A detailed chemical data quality review and chemical laboratory reports are presented in Appendix C. A brief evaluation of the data follows.

Precision

Laboratory Duplicates. A laboratory duplicate is a second laboratory sample taken from a submitted sample. The duplicate is then prepared along with the original. It is analyzed and compared to the first to assess the precision of the analytical method and the potential variability of the sample matrix. This comparison is reported as the relative percent difference (RPD). All sample duplicate results for submitted samples were within acceptability criteria or qualified.

Field Duplicates. A field duplicate is a second field sample collected from a selected monitoring well or soil core. The field duplicate sample serves as a check on laboratory quality as well as on potential variability in the sampling method and the sample matrix. The field duplicate is analyzed and compared to the first sample to assess the precision of the sampling and analytical methods. This comparison can be expressed as the RPD between the original and duplicate samples. All field duplicate results for submitted samples were within acceptability criteria or qualified.

Matrix Spike Sample Duplicate. A second matrix spike sample (or matrix spike duplicate [MSD]) is prepared as above and analyzed. This is compared to the initial matrix spike to assess the precision of the analytical method by calculating the RPD. For this method, both a percent recovery and an RPD are reported. No data qualifiers were posted.

Laboratory Control Sample Duplicates. A duplicate is a second analysis of laboratory control samples. The duplicate is prepared along with the original and is analyzed and compared to the first to assess the precision of the analytical method. The laboratory control sample RPDs were within the acceptability criteria. No data qualifiers were posted.

Accuracy

Surrogates. In a surrogate analysis, a known amount of a compound similar to the constituent of interest is added to a sample and measured. The surrogate analysis assesses the accuracy of a chemical measurement by comparing the measured value to the actual spiked value. Surrogate recoveries were all within acceptable limits or samples were qualified when surrogates fell outside control criteria.

Matrix Spike Samples. Matrix spike analyses are performed on samples submitted to the laboratory that are of the same matrix as the sample. This is spiked with known levels of the constituents of interest. These analyses are used to assess the potential for matrix interference with recovery or detection of the constituents of interest and the accuracy of the determination. The spiked sample results are compared to the expected result (i.e., sample concentration plus spike amount) and are reported as percent recovery. Matrix spike analytical results were all within acceptable ranges, or samples were evaluated and qualified when matrix spike results fell outside control criteria.

Laboratory Control Samples. Laboratory control samples (LCS) were used by the laboratory to assess the accuracy of the analytical equipment. The sample is prepared from the analyte-free matrix, which is then spiked with known levels of the constituents of interest (i.e., a standard). The concentrations are measured, and the results are compared to the known spiked levels. This comparison is expressed as percent recovery. All LCS results were within acceptable limits or samples were evaluated and qualified when LCS recoveries fell outside control criteria.

Representativeness

Representativeness is a measure of how closely the results reflect the actual concentration of the parameters in the medium sampled. It is not possible to measure this directly, so representativeness is controlled and ensured by using standard protocols for sample handling and custody, analyzing samples within prescribed holding times, and analyzing blank samples.

Sample Handling and Custody. We collected samples in general accordance with industry standards. These included requirements for collection, containers, labeling, packaging, shipping, and storage. Compliance with these procedures has been documented on chain of custody forms. Copies of the chain of custody forms are included with each laboratory report.

Holding Times. Collection dates for all samples submitted are documented on the chain of custody form. Collection and analysis dates are indicated in the laboratory report. Holding times were met for all samples.

Sample Quality. All samples were collected in general accordance with industry standards. The laboratory noted that ten samples contained water within the sample container or within the enclosing ziplock bag. The presence of water indicated the possibility of cross-contamination, and those samples were qualified as estimated (J).

Method Blanks. Method blanks are prepared by the laboratory and analyzed to check for the possibility that the sample may become contaminated during the analysis process. Blanks were analyzed for all analytical tests requested. Several method blanks for metals had low levels of metals between the Method Detection Limit (MDL) and the Reporting Limit (RL). Detections for affected metals in the associated samples were evaluated and qualified.

Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid. The completeness goal is essentially that a sufficient amount of valid data is generated to meet the objectives of the data. No results were rejected as a result of the QA/QC review; therefore, data for this project are 100 percent complete.

Comparability

Generally, all samples were analyzed in accordance with accepted methods of the EPA or Ecology. Because similar or the same methods were used, the quality of the data collected is consistent for all data sets and is therefore, comparable.

5.0 NATURE AND EXTENT OF CONTAMINATION

Soil, sediment, and surface water samples were collected and analyzed to establish natural background metal concentrations in the upper watershed. The natural background study conducted during the RI is presented in Appendix B. The Applicable and Relevant or Appropriate Regulations (ARARS) at the State and Federal level, developed in the RI/FS work plan, were compared to natural background concentrations and an appropriate set of screening levels for soil, sediment, surface water, and groundwater selected. ARARs and selected screening levels are presented in Tables 11 through 14.

To reduce the number of metals used in the evaluation of the nature and extent of site contamination, a principal component analysis (PCA) was used. The PCA identified correlations between the range of metals analyzed and a reduced set of metals that were appropriate in evaluating Site contamination. The following sections discuss site screening criteria and sample locations where screening levels were exceeded. Figures 6, 7, and 8 show sample locations for soil and sediment and at which locations the indicator metals: cadmium, lead, and zinc exceeded screening levels.

5.1 Site Screening Criteria

Natural background metal concentrations in soil were used as the default screening levels, unless the background metal concentrations fell below the regulatory criteria. Natural background concentrations for soil were used for antimony, arsenic, cadmium, lead, mercury, selenium, and zinc. Table 11 presents the draft screening levels for site soils.

Natural background metal concentrations for sediment were used as the default screening levels, unless the background metal concentrations fell below the regulatory criteria. If there were no regulatory criteria, the natural background concentration was used as the default screening level. Natural background concentrations in sediment were used for antimony, arsenic, beryllium, selenium, silver, and thallium. Washington State freshwater sediment quality criteria were promulgated (WAC 173-204-563) during preparation of this remedial investigation, however the criteria may not reliably predict benthic community toxicity in sediment impacted by metals mining, milling, or smelting. Bioassay testing for mining impacted sediment is recommended as a part of the feasibility study..

The low number of detectable metal concentrations in surface water background samples did not allow establishing natural background concentrations in surface water. Surface water screening levels for total and dissolved metals were selected based on the lowest potential ARARs in Table 13. These values were adjusted for hardness as described below.

- Surface water screening criteria for the metals cadmium, chromium, copper, lead, nickel, silver, and zinc are hardness-dependent. The preliminary screening levels used the Washington State surface water standard of 100 mg/L. Hardness was measured for the background surface water samples, and the average and median hardness results of the background samples were compared.

- The median surface water hardness was used to calculate screening levels for hardness-dependent metals rather than the average in order to obtain a better measure of the data central tendency that is not overly influenced by anomalously high or low values. The median for the background samples was 98, which was used to calculate surface water quality screening criteria.

Groundwater screening criteria for total metals were selected based on the lowest potential groundwater ARARs in Table 14. The screening criteria for arsenic and thallium were defaulted to the laboratory MDL.

5.1.1 Indicator Metals used in Identifying Exceedances of Screening Levels

Principal components analysis (PCA), was performed to evaluate correlations or associations among metal concentrations in soil and sediment. Indicator metals can be selected from the group of strongly correlated metals to describe the nature and extent of mine related contamination.

The degree of correlation between individual metals can be assessed by the correlation matrix. A correlation coefficient of 1.0 indicates a perfect correlation between metal concentrations, a value of –1.0 indicates a perfect negative correlation, and a value of 0.0 indicates no correlation. A correlation coefficient of greater than +0.5 was taken to indicate a relatively strong correlation between soil metal concentrations.

Background soil and sediment samples and samples where some metals were not analyzed were excluded from the evaluation since the statistical software (ProUCL and Systat) cannot evaluate missing data.

Soil

The factor loading plot for Van Stone Mine soil data is shown on Figure 8. Based on their proximity the following metals tend to be correlated with one another: antimony, arsenic, cadmium, lead, mercury, silver, thallium, and zinc. This correlation for pairs of metals is demonstrated by the soil correlation matrix presented in Table 15. Based on the correlations with most of the other metals and the frequency of detection, cadmium, lead, and zinc were chosen as soil indicator metals that indicate contamination from mine operations.

Sediment

The factor loading plot for Van Stone Mine sediment data is shown on Figure 8. Based on their proximity, the following metals tend to be correlated with one another: antimony, arsenic, cadmium, lead, mercury, and zinc. This correlation for pairs of metals is demonstrated by the soil correlation matrix presented in Table 15. Based on the correlations with most of the other metals and the frequency of detection, cadmium, lead, and zinc were chosen as sediment indicator metals that indicate contamination from mine operations.

5.2 Mining-Impacted Surface Soil

5.2.1 AOI-1: Open Pits, Mill, and Waste Rock

AOI-1 has the largest area of soil disturbance resulting from mining at the Site. Mining activity in this area included development of the open pits; excavation, hauling, and dumping of waste rock: rock crushing and milling operations; and mine and mill support and maintenance operations. Tables 16 and 17 present the analytical results of soil and sediment samples collected and identify screening level exceedances. Figure 7 shows the locations of soil and sediment samples collected and the exceedances of screening levels for indicator metals.

As shown on Figure 7, most of the land surface in AO-1 has been substantially altered by mining activity and has a very steep change in elevation across the disturbed area. Waste Rock Piles in AO-1 comprise the bulk of mine waste material and impact most of AOI-1. The open pits, while substantial mine features, have a much smaller geographic footprint compared to the waste rock piles.

Rock crushing and milling activities were primarily located in the northern portion of AOI-1. The crushing and milling processes generated tailings material and fine-grained rock flour. As shown on Figure 7, the finer grained material appears to have been eroded and transported by surface water runoff downslope to the northwest.

The Waste Rock Piles consist of mostly limestone and dolomite rocks, which range in grain size from large boulders to sand. Compared to the finer material generated from crushing and milling operations, this coarser pit-run material is less prone to erosion and transport by water. Soil sampling transects located out from the toe of the dumps show few screening level exceedances, and support limited transport of waste rock material by surface water runoff.

Stained soil observed in the rock crushing and milling areas were sampled during field work. These samples were found to contain high concentrations of several metals, and lower concentrations of total petroleum hydrocarbons (TPH), and volatiles. This area also was developed with maintenance buildings for servicing the mill circuit and mining equipment and storing equipment and mine materials.

Releases observed along tailings pipelines are discussed in Section 5.2.1.4.

AOI-1: Summary of Screening Level Exceedances

Analytical results of soil samples were compared to the soil screening levels (Tables 16 and 17). The following subsections summarize the samples in AOI-1, where screening level exceedances were identified.

Rock Crushing, Mill Facility, and Maintenance Support Areas

Samples collected from stained soil in and around the mill facility and rock crushing area (samples MS-1 through MS-10). Samples that exceeded screening levels shown in Table 17 are summarized below:

- In all samples, the screening levels for antimony, cadmium, lead, and zinc were exceeded. In addition, most of the samples also exceeded screening levels for arsenic, copper, and mercury.

- Sample MS-9 exceeded the chromium screening level; sample MS-5 exceeded the nickel screening level; and samples MS-6 and MS-8 exceeded silver and thallium screening levels.

- Samples MS-1, MS-5, MS-8, MS-9, and MS-10 exceeded the motor oil screening level. While there were multiple detections for diesel, there were no exceedances.

- Samples MS-1 and MS-5 exceeded the chrysene screening level. There were no other PAH exceedances.

- Sample MS-1 exceeded the benzene screening level. There were no other VOC exceedances.

- Screening levels for PCBs were not exceeded.

North Pit Waste Rock

Nine 30-point composite samples were collected from waste rock piles excavated from the North Pit. All waste rock composite samples had exceedances of metal screening levels. In addition, two 5-point composite samples were collected to compare XRF screening results with analytical results before FE-2 and FE-3. Samples that exceeded screening levels in Table 17 are summarized below.

In all composite samples, antimony, arsenic, cadmium, lead, and zinc screening levels were exceeded.

- In all composite samples except MS-1-COMP the mercury screening level was exceeded.

- Samples NP-1-SS and NP-3-SS were collected for XRF calibration against waste rock analytical results. The samples were analyzed for arsenic, cadmium, copper, lead, and zinc. All metals analyzed for in the samples exceeded screening levels, except NP-1-SS in which copper was not exceeded.

Areas Downslope/Upslope of North Pit Waste Rock Piles

Soil samples were analyzed for total metals. Samples that exceeded screening levels in Table 17 are summarized below:

- West of the North Pit and Waste Rock Piles, samples T-11-SS-300, T-11-SS-900 exceeded antimony, arsenic, cadmium, lead and zinc screening levels; and sample T-12-SS-450 exceeded cadmium, lead and zinc screening levels.

- Northwest of the North Pit and Waste Rock Piles, sample T-14-SS-300 exceeded cadmium, lead, and zinc screening level and sample T-14-SS-500 exceeded cadmium and zinc screening levels.

- Northeast of the North Pit, sample T-16-SS-0 exceeded antimony, arsenic, lead, and zinc screening levels and sample T-16-SS-315) exceeded antimony and lead screening levels.

- Southeast of the North Pit, eastern high wall sample T-15-SS-200 exceeded lead and zinc screening levels and sample T-15-SS-750 exceeded the zinc screening level.

- There were no exceedances for beryllium or selenium in any of the samples analyzed.

Downslope of the North Pit Waste Rock Piles between Transects

Between wide-spaced transects, discrete soil samples were collected to gather additional information on the potential extent on mining impacts. Samples MS-11 through MS-18 were collected from downslope areas west, north, and northeast of the North Pit Waste Rock Piles. The samples were analyzed for total metals. Samples that exceeded screening levels in Table 17 are summarized below.

- Samples MS-11, MS-13, MS-14, or MS-17 did not exceed screening levels for any metals.

- Sample MS-12 exceeded the zinc screening level.

- Sample MS-15 exceeded antimony, arsenic, cadmium, lead, mercury, and zinc screening levels and sample MS-16 exceeded antimony, cadmium, lead, mercury, and zinc screening levels.

- Sample MS-18 exceeded the lead screening level.

- None of the samples analyzed exceeded beryllium or selenium screening levels.

South Pit and South Pit Waste Rock Piles

Transects T-17 and T-18 extend west, or downslope from the South Pit Waste Rock Piles. Samples SWR Comp, and SWR-1 Comp through SWR-4 Comp were 30-point composite samples collected from the South Pit and South Pit Waste Rock Piles. Samples that exceeded screening levels in Table 17 are summarized below.

- Northwest from the Waste Rock Piles, sample T-17-SS-0 exceeded lead and zinc screening levels.

- Waste rock composite samples SWR-1 through SWR-4 and SWR Comp exceeded antimony, arsenic, cadmium, lead, mercury and zinc screening levels. Sample SWR-COMP also exceeded silver and thallium screening levels, while sample SWR-2-COMP exceeded the silver screening level.

AOI-2: Upper Tailings Pile

Evaluation of the potential extent of site contamination associated with the Upper Tailings Pile included establishing five soil sampling transects (T-6 through T-10) around and outward from the toe of the Upper Tailings Pile, collecting 17 discrete soil samples (UT-1 through UT-17, excluding unused sample number UT-8), and two 5-point composite samples for XRF comparison as discussed in Section 5.2.1.1. Samples that exceeded screening levels as shown in Table 17 are summarized below.

Upper Tailings Pile Sample Transects

Sampling Transects T-6 through T-10 are located to the west, north, and east of the Upper Tailings Pile. Samples collected along these transects helped evaluate the extent of environmental impacts of metals released from the Upper Tailings Pile. Samples that exceeded screening levels in Table 17 are summarized below:

- Southwest of the Upper Tailings Pile, sample T-6-SS-100 exceeded screening levels for antimony, arsenic, cadmium, and lead. Sample T-6-S-500 exceeded the cadmium screening level.

- Northwest of the Upper Tailings Pile, sample T-7-SS-100 exceeded cadmium, lead and zinc screening levels.

- Upslope from the southeast portion of the Upper Tailings Pile, sample T-10-SS-150 exceeded antimony and lead screening levels, and sample T-10-SS-500 exceeded arsenic and cadmium screening levels. These samples were downslope from a pipeline breach, and may reflect tailings associated with the breach rather than the Upper Tailings Pile.

Extent of Recent Upper Tailings Piles Failure

Three discrete soil samples were collected north of the Upper Tailings Pile, and three soil samples were collected south of the Upper Tailings Pile to evaluate the potential extent of site impacts. Ten discrete soil samples were collected to assess the extent of the recent Upper Tailings Pile failure. Samples that exceeded screening levels in Table 17 are summarized below.

- Samples UT-1 and UT-2 did not exceed screening levels. Sample UT-3 exceeded beryllium, cadmium, copper, lead, and zinc screening levels.

- Samples UT-4, UT-5, and UT-6 did not exceed screening levels.

- Samples UT-7 and UT-11, exceeded antimony, arsenic, cadmium, lead, mercury, and zinc screening levels.

- Sample UT-15 exceeded cadmium, lead and zinc screening levels, sample UT-16 exceeded the beryllium screening level, and sample UT-17 exceeded cadmium, lead, mercury, and zinc screening levels.

- Samples UT-2-SS and UT-3-SS were collected for XRF calibration against waste rock laboratory analytical results. The samples were analyzed for arsenic, cadmium, copper, lead, and zinc. All metals analyzed for in the samples exceeded screening levels.

- There were no exceedances of the screening levels for chromium, nickel, selenium, silver, or thallium in any of the samples.

AOI-3: Lower Tailings Pile

Evaluation of the potential extent of site contamination associated with the Lower Tailings Pile included establishing five soil sampling transects (T-1 through T-5) around and outward from the toe of the east, south, and west sides of the Upper Tailings Pile. Seventeen discrete soil samples (LT-1 through LT-17, LT-20 and LT-21), and two duplicate samples were collected on the north side of the Lower Tailings Pile. Four soil samples were collected along a ditch and culvert that trends west from the toe of the western side of the Upper Tailings Pile toward Onion Creek. Four soil samples were collected south of the Upper Tailings Pile and between soil sampling transects. In addition, two five-point composite samples were collected for XRF comparison as discussed in Section 5.2.1.1.

North of the Lower Tailings Pile, tailings materials were observed extending north to the northeast tributary. Seventeen discrete soil samples were collected north and northeast of the Lower Tailings Pile to evaluate the potential extent of site impacts from the release of metals toward the Northeast Tributary and potential wind transport to the northeast.

South of the Lower Tailings Pile, visible tailings materials could be observed on the Van Stone Mine Road where it passes close to the south edge of the Lower Tailings Pile. Two discrete soil samples were collected to assess the potential extent of metal impacts east of transect T-3. Four samples were collected along a drainage and culvert located on the west side of the Lower Tailings Pile.

Observations along this drainage showed tailings material extending from the Lower Tailings Pile to the Van Stone Mine Road.

Samples that exceeded screening levels in Table 17 are summarized below.

East Side of Lower Tailings Pile

- Southeast of the east side of the Lower Tailings Pile, sample T-1-SS-100 exceeded antimony, arsenic, cadmium, copper, and zinc screening levels and sample T-2-SS-300 exceeded arsenic, cadmium, lead, and zinc screening levels.

South Side of Lower Tailings Pile

- South of the south side of the Lower Tailings Pile, sample T-3-SS-300 exceeded antimony, arsenic, cadmium, copper, lead, and zinc screening levels.

- Samples T-18 and T-19 did not exceed screening levels.

West Side of Lower Tailings Pile

- West of the west side of the Lower Tailings Pile, sample T-4-SS-100 exceeded antimony, arsenic, cadmium, lead, and zinc screening levels.

- Sample LT-DP-1 exceeded antimony, arsenic, cadmium, copper, lead, mercury, and zinc screening levels.

- Sample LT-22 exceeded antimony, arsenic, cadmium, copper, lead, and zinc screening levels. Sample LT-OC Road Culvert exceeded cadmium, lead, and zinc screening levels.

- Sample T-23 did not exceed screening levels.

North Side of Lower Tailings Pile

- Sample LT-3 exceeded the antimony screening level; sample T-6 exceeded the beryllium screening level; T-7 exceeded cadmium, lead and zinc screening levels; sample T-10 exceeded lead and zinc screening levels, sample T-11 exceeded antimony, arsenic, cadmium, copper, lead, and zinc screening levels, and sample T-12 exceeded antimony, arsenic, cadmium, lead, and zinc screening levels.

AOI-4: Pipeline and Access Roads

Two major pipelines conveyed tailings slurry from the Mill Area to the Upper and Lower Tailings Piles. The route of the South Line is west from the southwest corner of an open pit area to the Upper Tailings Pile. The tailings lines are no longer functional and are almost unidentifiable in some locations due to degradation of the wood piping and logging activities. The North Line starts below the Mill Area and trends west downslope to the Lower Tailings Pile. At points along both conveyance routes, the pipeline was elevated to maintain an even gradient and to cross creeks.

The routes of the pipelines were traversed to observe current conditions and identify locations at which tailings had been released. There were multiple releases of tailings observed along the pipeline route. Logging activities on the hillsides near the pipelines may have spread tailings materials around the surface soil. Tailings releases that were observed along both pipelines are identified on Figures 6 and 7. Given the age of the pipelines and the logging that has occurred in the upper watershed, it is unlikely that all releases from pipeline breaks have been located.

South Line

Figure 7 shows the South Line route through the Site. The South Line was traversed during RI field work; Section 4.5.2 of the RI discusses the releases of tailings observed. Several small areas of tailings and one larger area of tailings are shown on Figure 7. Tailings releases were not observed along the northerly trending section of the pipeline located east of the upper pond east basin. Soil samples did not exceed screening levels. Samples that exceeded screening levels in Table 17 are summarized below.

- Sample PL-5 exceeded antimony, cadmium, lead, and zinc screening levels and sample PL-8 exceeded antimony, arsenic, cadmium, copper, lead, mercury, and zinc screening levels.

- There were no exceedances of the screening criteria for beryllium, chromium, nickel, selenium, silver, or thallium screening levels in any of the samples.

North Line

On Figures 6, 7, and 8, the route of the North Line through the Site is shown. The North Line was traversed during RI field work; Section 4.5.4 of the RI discusses the tailings releases observed. The largest areas of observed tailings releases along the North Line were from the Mill Area west about 1,800 feet and from the Mill Area about 7,000 to 7,800 feet downslope. Samples that exceeded screening levels in Table 17 are summarized below.

- Samples PL-1, PL-2, PL-6, PL-11, PL-13, PL-15, TAILINGS BOX, UT-LT-2000′, and UT-LT-4000′ all exceeded antimony, arsenic, cadmium, lead, and zinc screening levels, except for PL-11, which did not exceed antimony.

- Samples PL-1, TAILINGS BOX, and UT-LT-2000′ exceeded the copper screening level and PL-1, PL-15, and TAILINGS BOX exceeded the mercury screening level.

Access Roads

Samples were collected from Lotze Creek Road (D-R-1 through DR-5) and the Van Stone Mine Road (DR-6 through DR-15). The Lotze Creek Road surface appeared to be graded with imported gravel, which did not appear to be mine waste rock. Other access roads to the mine site, Lower Tailings Pile, and Upper Tailings Pile were presumed to contain waste rock or tailings, and were not sampled. Samples that exceeded screening levels in Table 17 are summarized below.

Lotze Creek Road

- Samples DR-1, DR-2, Dr-3, and DR-5 exceeded antimony, arsenic and cadmium screening levels. There were no exceedances of the screening levels for beryllium, chromium, mercury, nickel, selenium, silver, thallium, or zinc in any of the samples.

- Sample DR-1- exceeded the copper screening level.

Van Stone Mine Road

Sample DR-15 exceeded the antimony and lead screening levels. There were no other exceedances in the samples collected and analyzed.

5.3 Mining-Impacted Surface Water

Surface water samples were analyzed for dissolved metals, hardness, dissolved solids, suspended solids, and alkalinity. Analytical results for metals were compared to the screening levels in Table 19. Hardness-dependent metals screening criteria were calculated based on the median hardness (98 mg/L) of the background surface water samples.

5.3.1 AOI-1 Open Pits, Mill, and Waste Rock

Three surface water samples were collected: two from the North Pit and one from the South Pit (Figure 8). Samples that exceeded screening levels in Table 19 are summarized below.

- Sample NP-SW-1, the North Pit seep water, exceeded the cadmium screening level.
- Sample WP-SW-1, surface water discharge from the west end of the Pit Lake Dam, did not exceed screening levels.
- Sample SP-SW-1, collected from the South Pit pond, exceeded cadmium, lead, and zinc screening levels.
- Reporting limits for arsenic and thallium in surface water samples exceeded the screening levels.

5.3.2 AOI-2 Upper Tailings Pile

Three surface water samples, UT-SW-1, UT-SW-2, and UT-SW-3, were collected (Figure 8). UT-SW-1 was a seep discharge located west of the toe of the Upper Tailings Pile. UT-SW-2 and UT-SW-3 were samples of surface water at the point where water flowing from the Upper Tailings Pile failure was observed discharging into a drainage that flowed into the Southeast Tributary. Samples that exceeded screening levels in Table 19 are summarized below.

- Sample UT-SW-1 did not exceed screening levels.
- Sample UT-SW-2 exceeded cadmium, lead, and zinc screening levels, and sample UT-SW-3 exceeded the copper screening level.

5.3.3 AOI-5 Onion Creek and Tributaries

Twenty surface water samples were collected in Onion Creek, the Northwest and Southwest Tributaries, and two drainages to the Southwest Tributary (Figure 8). The surface water samples were analyzed for dissolved metals including low-level dissolved mercury, total mercury, hardness and alkalinity.

Chemical release and transport of metals in surface water appears moderated by the limestone and dolomite rock in which the lead-zinc deposit is hosted. The limestone and dolomite buffers the pH, reducing the potential for acid rock conditions associated with sulfide ore deposits. This is supported by the surface water analytical results discussed below, which, except for two samples, do not exceed screening levels. Samples that exceeded screening levels in Table 19 are summarized below.

- Dissolved cadmium in samples OC-9-SW and OC-11-SW were reported as estimated values below the reporting limit (T qualified), but the values exceeded the screening level of 0.2 ug/L.
- Dissolved zinc was found above the screening level of 104 ug/L in samples OC-9-SW and OC-11-SW. Samples OC-9-SW and OC-11-SW are located downstream on the tributary that flows past the pit lake at the mine site.
- Total mercury was found above the reporting limit in several samples, but all results were below the preliminary screening level of 0.012 ug/L.
- The reporting limits for dissolved arsenic and thallium exceeded the screening levels.
- Analytical results for dissolved arsenic, beryllium, chromium, nickel, selenium, silver, and thallium were non-detect at the MDL for all twenty samples.
- Analytical results for dissolved cadmium, copper, and lead were non-detect at the MDL or below the reporting limit for all twenty samples.

5.4 Mining-Impacted Sediment

Twenty-one sediment samples were collected in Onion Creek, the Northwest and Southwest Tributaries, and two drainages to the Southwest Tributary. Sediment samples were analyzed for total metals and total organic carbon. Samples that exceeded screening levels in Table 18 are summarized below.

5.4.1 AOI-5 Onion Creek and Tributaries

Analytical results for total selenium, silver, and thallium were non-detect at the MDL or below the RL for all twenty samples. There were no exceedances of screening criteria for beryllium, chromium, copper, mercury, or nickel in the twenty sediment samples analyzed.

Onion Creek

- Sediment samples OC-4-SD, OC-13-SD, and OC-19-SD, exceeded the zinc screening level.

Northeast Tributary

- The three sediment samples, OC-2-SD, OC-3-SD, and NT-SD-1 collected on the tributary did not exceed screening levels.

Southeast Tributary

- Sediment samples OC-5-SD and BG-12-SD, and OC-17-SD exceeded cadmium and zinc screening levels. Samples OC-7-SD, OC-8-SD, and OC-18-SD exceeded cadmium, lead, and zinc screening levels. Sample OC-15-SD exceeded arsenic and zinc screening levels.

- Three samples, OC-9-SD, OC-11-SD, and OC-14-SD, were located in the drainage flowing between the North and South Pits. All three samples exceeded antimony, cadmium, lead, and zinc screening levels. Sample OC-11-SD also exceeded the arsenic screening level.

5.5 Mining-Impacted Groundwater

Seven groundwater monitoring wells and seven residential wells were sampled to evaluate groundwater conditions adjacent to the Upper and Lower Tailings Piles. The samples were analyzed for total metals, hardness, dissolved solids, suspended solids, and alkalinity. Samples that exceeded screening levels in Table 20 are summarized below.

5.5.1 AOI-2 Upper Tailings Pile

Two groundwater samples were collected from monitoring wells at the toe of the Upper Tailings Pile (MW-4 and MW-5). Groundwater collected from wells MW-4 and MW-5 did not exceed screening levels. However, the reporting limits for arsenic and thallium exceeded the screening criteria.

5.5.2 AOI-3 Lower Tailings Pile

Five groundwater samples were collected from monitoring wells around the Lower Tailings Pile.

- Groundwater collected from well W-1 did not exceed screening levels.

- Groundwater collected from MW-2 exceeded chromium and nickel screening levels.

- Groundwater collected from W-2 exceeded the lead screening level.

- Groundwater collected from MW-3 exceeded thallium at the detection limit of the laboratory instrument.

- Groundwater collected from DH-2 exceeded antimony, arsenic, cadmium, and lead screening levels.

- Wells MW-1 and DH-5 were dry, and no samples were collected.

- Reporting limits exceeded the screening levels for arsenic and thallium.

- There were no exceedances of screening levels for beryllium, copper, mercury, selenium, silver, or zinc in any of the five wells.

5.5.3 Residential Wells

Seven residential wells were sampled and Ecology sent notification letters to owners in March 2012 reporting analytical results. Of the seven residential wells sampled, only one well exceeded groundwater screening levels. Groundwater collected from residential well RW-2 exceeded the arsenic screening level, however the concentration was below the drinking water MCL.

6.0 FATE AND TRANSPORT

This section describes the processes that control the release and transport of metals from site sources. The fate and transport of metals are influenced by both their physical and chemical properties and the characteristics of the surrounding environment.

The Van Stone Mine processed its ore onsite to extract useful metals contained in minerals. The ore minerals were concentrated in a mill on the site and then shipped off site to be refined further. Since it was not practical to recover all the minerals in the ore, non-recovered metal-rich minerals remain on site in: (1) the walls of the excavations (mine openings); (2) in rock removed to access the ore (waste rock); and (3) in waste residues (tailings) remaining from the on-site ore processing.

6.1 Potential Physical Transport Mechanisms and Routes

Metal transport can be influenced by both physical and geochemical processes. Physical transport of metals occurred or can potentially occur by any of the following processes:

- Physical releases and spills from the tailings pipelines during historical mine operations;
- Water erosion of waste rock and tailings;
- Windblown waste rock and tailings;
- Failure of the tailings pile impoundments and/or Pit Lake Dam;
- Migration of total or dissolved metals in contaminated groundwater and surface water; and
- Leaching and dissolving of metals from waste rock and tailings.

6.1.1 Releases from Tailings Pipelines

During mine operations, fine-grained tailings were conveyed from the Mill Area to two tailings impoundments (Upper Tailings Pile and Lower Tailings Pile) by pipelines. Fine-grained tailings were initially conveyed to the Upper Tailings Pile and later to the Lower Tailings Pile through wood stave pipe, asbestos-cement pipe and PVC pipe.

Visible evidence of multiple tailings releases were observed along the North and South pipeline alignments. The tailings deposits appear to be associated with sections of the pipeline that have been degraded and/or disturbed by logging activities. Most of the releases appear confined to the immediate vicinity of the pipeline. However, since the tailings were transported as a water-based slurry, releases would have flowed downhill toward Onion Creek or its tributaries. In addition, erosion, surface water runoff, and logging operations may have transported tailings away from the pipelines. Water from the tailings slurry would also have infiltrated into the ground, potentially transporting dissolved metals to groundwater.

6.1.2 Erosion of Waste Rock and Tailings

Precipitation and snowmelt can erode and transport fine-grained material. Active erosion features were observed at both the Upper and Lower Tailings Piles. Overall, the slopes on the tailings piles appeared steep and showed evidence of surface erosion likely caused by seasonal precipitation. Erosion from the slopes of the Upper Tailings Pile was observed to transport fine-grained tailings downgradient and into an unnamed tributary that drains into the Southeast Tributary, and then into Onion Creek. Erosion from the slopes of the Lower Tailings Pile was observed to transport fine-grained tailings downgradient and into the Northeast Tributary, which then drains into Onion Creek.

6.1.3 Wind-blown Erosion of Waste Rock and Tailings

Wind can also erode and transport fine-grained material from waste rock and tailings piles. Factors that influence the amount and distance of material that is transported include wind velocity and duration, particle size, particle density, and particle angularity. Appendix G provides an analysis of climate data collected as part of the RI.

6.1.4 Failure of the Tailings Piles Impoundments and/or Pit Lake Dam

There have been several breaches of both the upper and lower tailings pond dams. In April 1961, the tailings dam at the west end of the west pond of the Upper Tailings Pile failed, sending water down an unnamed tributary into the Southeast Tributary and then into Onion Creek, which flooded downstream past the Onion Creek schoolhouse. The flood reportedly widened Onion Creek by 20 to 30 feet and created a debris dam that plugged a culvert at the county road; the debris dam eventually failed. During spring 2011, the southwest portion of the Upper Tailings Pile failed, releasing a mixture of water (snowmelt or other precipitation) and fine-grained tailings. This failure occurred at the same general area of the 1961 breach.

In early 1995, snowmelt runoff reportedly caused the Lower Tailings Pile embankment to breach at Discharge No. 1. This resulted in considerable erosion and transport of fine-grained tailings into the Northeast Tributary of Onion Creek.

Observed active erosion in these breach areas provides an ongoing transport pathway of tailings to Onion Creek and its tributaries.

The West End Pit Lake located in the North Pit covers approximately 4.5 acres and is 100 feet deep. Its static elevation is approximately 3,515 feet, and it contains an estimated 146 million gallons of water. It is dammed by a 30-foot-wide, rock-fill berm that allows water to seep into the adjacent unnamed tributary to the Southeast Tributary of Onion Creek. The static water level of the pit lake is generally maintained by a discharge channel located on top of the northwest corner of the Pit Lake Dam. This drainage provides direct surface water and groundwater transport pathways for dissolved and suspended metals to migrate into groundwater and into Onion Creek and its tributaries.

6.1.5 Metals Leaching

Precipitation and snowmelt can leach metals from waste rock, tailings, and exposed bedrock, and can transport fine-grained waste and dissolved metals to surface water and groundwater. The rate of leaching and mass of metals leached is highly dependent upon the chemical speciation of the metal, surface area of the solid material, water and soil pH, and the amount of precipitation.

Chemical species is the most significant fact influencing leaching. Metal oxides, hydroxides, sulfides, carbonates, and silica-aluminates typically have low solubility in water within a pH range of 6.0 to 8.0. At lower pH which is often associated with acid mine drainage, solubility and leaching rates increase, especially for metal sulfides and carbonates, however this is not an issue at the Van Stone mine.

6.2 Potential Geochemical Transport Mechanisms

Waste rock and tailings can react with surface water and air to form more soluble metal compounds that can then be leached and transported by surface water or groundwater. For example, iron sulfide reacts with air and water according to the following equation to form a hydrous iron oxide precipitate and sulfuric acid, which can then leach and mobilize other metals.

$4FeS + 10H_2O + 9O_2 \text{->} 4Fe(OH)_3 + 4H_2SO_4$

Dissolution of calcite and dolomite formations buffers the water in Onion Creek and generally maintains the pH above 8.0. Under these conditions, there is sufficient capacity to neutralize any sulfuric acid that might be formed by metal sulfides oxidation. Most heavy metals that might be leached by this acid-generating process would precipitate as their hydroxides or would be adsorbed to aluminosilicate minerals and be removed from solution near seepage areas. Arsenic is an exception to this general trend, since it exists as negatively charged oxyanions that becomes more mobile with increasing pH. However, at the moderate pH found in Onion Creek, arsenic binds strongly to iron (III) oxides (ferrihydrite) and becomes immobilized.

6.3 Contaminant Persistence and Mobility

Metals do not degrade and, therefore, persist in the environment. Metals mobility is primarily controlled by chemical speciation which affects their leaching rate and solubility as well as adsorption properties.

6.3.1 Dissolved Metal Mobility

Metals in the Van Stone ore body are mainly present as metal sulfides, which exhibit extremely low solubility and are immobile under neutral to basic pH and anoxic conditions. While iron sulfide can react with air and water to form a hydrous iron oxide precipitate (ferrihydrite) and sulfuric acid, which can then leach and mobilize other metals, high concentrations of calcite and dolomite buffer surface and groundwater, neutralizing any acid and precipitating metals as their insoluble hydrous oxides. Therefore, metal leaching and transport of dissolved metals is not a significant pathway for surface water or groundwater.

6.3.2 Physical Mobility

Physical transport of fine particles of tailings and waste rock is the primary transport mechanism for metals at the Van Stone site. The ultimate sink for metals is sediment in Onion Creek and its tributaries.

Historical failures of the tailings pit dams have resulted in large releases of metal-contaminated tailings into the creeks. Historical and ongoing erosion of the tailings piles transports fine-grained tailings downslope into tributaries of Onion Creek.

7.0 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

The baseline Human Health Risk Assessment (HHRA) was prepared for the Site in accordance with the Washington State Model Toxics Control Act (MTCA; Washington Administrative Code [WAC] 173-340) (Ecology 2007). The Ecological Risk Assessment (ERA) was prepared for the Site to assess potential hazards to ecological receptors from exposure to mine waste and contaminated media at the Site. The ERA was performed in accordance with MTCA (WAC 173-340, Ecology 2007). The human health risk assessment is presented in Appendix H and the ecological risk assessment if presented in Appendix I.

The purposes of the risk assessments are to: (1) evaluate potential risk at a site and determine the primary causes of that risk; (2) help determine whether remediation response actions are necessary; and (3) modify preliminary screening levels (or support a "no-action" alternative) when appropriate. The results of the risk assessments are used by the risk manager of the Site to provide information for the decision making process.

Figure 11 presents a Conceptual Site Model (CSM) of the Site. The CSM identifies the sources, impacted media, exposure routes and receptors evaluated in the risk assessments.

7.1 Summary of Site Risks

The HHRA and ERA used the data set developed for the Van Stone Mine Site RI. The risk assessments narrowed the focus to Chemicals of Potential Concern (COPCs) for human health and Chemicals of Potential Ecological Concern (COPECs) for ecological risks by screening for frequency of detection, and comparison of site-wide (HHRA) maximum contaminant concentrations and maximum concentrations within each AOI (ERA) with site-specific background levels and risk-based criteria. The screening identified numerous metals as COPCs for human health in soil and groundwater, arsenic and cadmium in sediment, and antimony in surface water. The ERA also identified numerous COPECs for potential risks to ecological receptors in soil, zinc in sediment of Onion Creek, and cadmium, lead, and zinc in surface water.

For the HHRA, the Site was evaluated assuming unrestricted land use with residents having access to the entire Site. This assumption is health protective under MTCA and is considered conservative; the extent of potential residential exposure at the Site is unknown. For the ERA, ecological receptors used to quantitatively assess risk consisted of terrestrial plants, soil invertebrates, birds, and mammals; while aquatic organisms, benthic invertebrates, and piscivorous wildlife were also identified as potential receptors. All receptors were assumed to be exposed to both vegetated and relatively non-vegetated (i.e., waste rock and tailings piles) areas of the Site. Bioavailability Factors (BFs) were included to quantify Exposure Point Concentrations (EPCs) for metals for all ecological receptors.

EPCs were identified as the Upper Confidence Limits (UCLs) of the mean concentrations (or maximum concentrations where data were insufficient) of each COPC within each type of media in each AOI. For surface water and sediment exposures in the ERA, individual sample concentrations were used as the EPCs. To calculate risk in the HHRA, the EPCs were compared to MTCA Method B carcinogenic and noncarcinogenic preliminary screening levels; risks associated with exposure to lead were discussed relative to the Method A preliminary screening level. For the ERA, risks were calculated by comparison of the EPCs to Lowest Observed Adverse Effects Level (LOAEL)-based Eco-Soil Screening Levels (SSLs), State Water Quality Standards (WQS), consensus-based criteria published by MacDonald et al. (2000) for sediment and Ecology's new sediment management standards [Chapter 173-204 WAC]. Uncertainty of the evaluation and quantification of risk in the HHRA and ERA are presented in Appendix H and Appendix I, respectively.

Tables 21 and 22 present a summary of human health risk at the Site and a summary of unacceptable risk by exposure route and COC, respectively. Table 23 presents a summary of ecological risks in soil and surface water by receptor. The following sections present the findings of the Human Health and Ecological risks by AOI.

7.2 AOI-1 – Mill Area

Human Health Risks – Ingestion of soil/sediment in AOI-1 was found to pose an unacceptable carcinogenic risk due to arsenic, and unacceptable noncarcinogenic risk due to arsenic, cadmium, and zinc.

MTCA regulations specify that cleanup levels should not be less than natural background concentrations. If the natural background arsenic and cadmium concentrations are used rather than the lower ARAR-based screening levels, the total carcinogenic risk for all chemicals and exposure pathways would be less than the 1×10^{-5} target. The noncarcinogenic risk would also be less than the target hazard quotient of 1.0. Lead poses an unacceptable risk, and a preliminary screening level different from the Method A value of 250 mg/kg was not quantified. Additionally, antimony, arsenic, cadmium, and zinc were identified as soil COCs for the protection of groundwater pathway.

Ecological Risks – Cadmium, lead, and zinc are COECs for AOI-1, and all three pose potential risks to birds and small mammals. Lead and zinc also pose risks to plants, and zinc poses a risk to soil invertebrates. Highest concentrations of COECs are found in stained soil at the Mill Area and in waste rock samples.

Surface waters of the south pit lake of AO-I1 were found to present risks to aquatic receptors due to cadmium, lead, and zinc. Whether aquatic receptors may use or be present in the south pit lake is unknown.

7.3 AOI-2 – Upper Tailings Pile Area

Human Health Risks – Ingestion of arsenic in soil/sediment in AOI-2 poses unacceptable carcinogenic risk; however, total risks for all COPCs and pathways meet the target carcinogenic and noncarcinogenic risk criteria. Lead poses an unacceptable risk in AOI-2, and a preliminary screening level different from the Method A value of 250 mg/kg was not quantified. In addition, cadmium was identified as a soil COC via the protection of groundwater pathway.

Ecological Risks – Zinc poses risks to soil invertebrates, birds, and small mammals at AOI-2 due to exceedances of site-specific background levels. Surface water discharging from the AOI-2 Upper Tailings Pile was found to present risks to aquatic receptors due to lead and zinc. Whether aquatic receptors may be exposed to the discharge water is uncertain.

7.4 AOI-3 – Lower Tailings Pile Area

Human Health Risks – Ingestion of soil/sediment in AOI-3 poses unacceptable carcinogenic risk due to arsenic. Groundwater ingestion in AOI-3 poses an unacceptable carcinogenic risk due to arsenic and an unacceptable noncarcinogenic risk due to antimony, arsenic, cadmium, chromium, and nickel. If the detection limit of 0.0038 mg/L (which exceeds the ARAR-based screening level) is used as the preliminary screening level for arsenic in groundwater, calculated carcinogenic risk would still exceed the target carcinogenic risk level for multiple pathways or COCs. If preliminary screening levels were adjusted to method detection limits for antimony, arsenic, cadmium, chromium, and nickel, total noncarcinogenic risk from multiple pathways would still exceed the target risk.

In addition, lead poses unacceptable risk in AOI-3, as well as cadmium in the soil for protection of groundwater pathway.

Ecological Risks – Zinc poses risks to soil invertebrates at AOI-3 due to exceedances of site-specific background levels. Lead and zinc are COECs for AOI-3 because of their potential risks to birds and small mammals. The highest concentrations are found in tailings pile samples and, overall, the tailings piles have sparse vegetation.

7.5 AOI-4 – Tailings Pipeline and Road Area

Human Health Risks –The target carcinogenic risk of 1 x 10^{-5} and target HI of 1 are met for multiple substances and multiple pathways in AOI-4; however, soil ingestion poses unacceptable carcinogenic risk for arsenic. Lead poses an unacceptable risk in AOI-4 and a preliminary screening level different from the Method A value of 250 mg/kg was not quantified. Soil arsenic and cadmium concentrations were identified as potential threats to groundwater in AOI-4. The risk is driven by potential exposure to elevated metal concentrations from spills from the pipeline.

Ecological Risks – Zinc poses risks to soil invertebrates, birds, and small mammals at AOI-4 due to exceedances of site-specific background levels.

7.6 AOI-5 – Onion Creek

Human Health Risks – The target carcinogenic risk of 1 x 10^{-5} and target HI of 1 are met for multiple substances and multiple pathways in AOI-5. However, arsenic alone poses unacceptable carcinogenic risk via the ingestion of soils/sediment pathway.

Ecological Risks – Surface waters of AOI-5 do not pose a risk to aquatic receptors. For sediment, five locations in Onion Creek were found to present potential risks due to zinc, which is a COEC for Onion Creek sediment. Whether the levels of zinc in sediment at those locations have impacted the benthic macroinvertebrate communities under present conditions is unknown.

8.0 GEOTECHNICAL CHARACTERIZATION OF MINE FEATURES

Results of stability analyses completed for this remedial investigation indicate that the Upper and Lower Tailings Pile slopes and the Pit Lake Dam do not meet Ecology's minimum factor of safety requirements for dams. Additionally, there is a moderate risk that a wedge failure along the pit high wall could negatively affect stability of the Pit Lake Dam. The stability analyses indicate that, in their present condition, the Pit Lake Dam, pit high wall, and tailings piles pose a risk to human health and the environment, particularly in the event of an earthquake that meets or exceeds Ecology's dam safety criteria. Details of the stability analyses of the Pit Lake Dam, pit high wall, and tailings piles are included in Appendices D, E, and F, respectively.

The feasibility study will identify, evaluate, and recommend appropriate remedial action alternatives that would reduce or mitigate current and potential future risks to human health and the environment associated with potential instability of the tailings piles, Pit Lake Dam, and pit high wall.

This RI did not analyze the stability of the waste rock piles because: (1) these piles do not fall under Ecology's dam safety guidelines, and (2) slope instability of the waste rock piles appears unlikely to cause a risk to downstream residents or aquatic receptors.

Several conceptual remedial action alternatives addressing stability concerns at the site have preliminarily been developed based on available information and the stability analysis conducted as part of this remedial investigation. A brief overview of these alternatives is provided below.

The potential instability of the tailings piles could be mitigated by regrading, capping, and revegetating the piles. Under this alternative, upland diversion ditches would be constructed or maintained to minimize surface run-on, the top surface of the piles would be regraded to minimize surface water ponding and infiltration, the side slopes of the tailings piles would be flattened to a stable configuration, the regraded and flattened surfaces would be capped with a layer of soil, and native vegetation would be planted to reduce the risk of erosion. Pending further discussion of the results of the ecological risk assessment, (see Sections 7.3 and 7.4) the cap may also include a geomembrane. Some potential options for regrading and flattening the side slopes of the tailings piles include:

- Excavating material from the existing slopes, and placing and compacting the material on top of the pile, increasing the height of the pile without increasing the footprint;

- Excavating material from the existing slopes, and placing and compacting the material at the base of the pile, increasing the footprint of the pile without changing the height; and

- Placing waste rock, presently stockpiled at the main pit, over the existing slopes to create a flatter slope and provide a buttress at the toe of the side slopes.

The instability of the Pit Lake Dam could be potentially be mitigated by constructing a buttress at the downstream toe of the dam or by removing the dam. Currently there is insufficient topographic survey information to assess feasibility of a downstream buttress.

The buttress alternative involves placing waste rock that is presently stockpiled near the dam at the downstream toe of the Pit Lake Dam. The required size of the buttress would be determined by completing additional slope stability analyses. An engineered filter zone would be required at the contact between the buttress and the face of the dam to mitigate instability caused by internal erosion and piping.

The dam removal alternative involves breaching the dam and lowering the water level of the pit lake in a controlled manner. Under this alternative, all hazards associated with the dam would be eliminated including the potential for instability of the pit high wall to cause overtopping of the berm.

In a MTCA feasibility study, a no-action alternative that involves no engineering controls would also be evaluated to provide a baseline against which the other alternatives can be compared. A variation of this alternative could include monitoring of tailings pile slopes and the Pit Lake Dam to evaluate the potential for slope failure.

9.0 SUMMARY AND CONCLUSIONS

9.1 AOI-1 – Open Pits, Mill, and Waste Rock Areas

9.1.1 Nature and Extent of Contamination

Waste rock deposited from mining excavation of the North and South Pits exceeds screening levels for the indicator metals (copper, lead, and zinc) at all waste rock piles. While the extent of the impacts in the northwest direction has not been fully characterized, two soil samples (TS14-SS-750 and MS-17) do indicate some limit on the extent of soil impacts. Sample results from east and south of the waste rock piles indicate the extent of soil contamination is limited.

Surface water samples were collected from the North Pit Lake discharge, a West End Seep, and seasonally ponded water from the South Pit. Of the three samples, only the water sample collected from the South Pit exceeded screening levels for lead and zinc.

Groundwater quality is unknown. Monitoring wells were not installed since flows are limited to bedrock fractures near the North Pit Lake and there is no groundwater use in this area of the Site. However, due to the carbonate mineral deposits in the area, the relatively high alkalinity and pH would limit metal dissolution and transport.

9.1.2 Risk Assessment Findings

The excess carcinogenetic risk based on incidental soil ingestion of arsenic is 2×10^{-5}. While no individual soil COC presented an unacceptable non-carcinogenic risk (hazard quotient greater than 1.0) the cumulative hazard quotient is 2. In addition, antimony, arsenic, cadmium, and zinc soil concentrations were found to exceed MTCA method B screening levels for groundwater protection.

Surface water concentrations were below risk based levels both for drinking water and ingestion of fish.

Cadmium, lead, and zinc are the three chemicals of ecologic concern posing the highest risks (HQ>5) to birds and small mammals. Lead and zinc pose the highest risk to plants, zinc poses the highest risk to soil invertebrates, and lead and zinc pose the highest risk to aquatic macroinvertebrates.

9.1.3 Physical Hazards

The high pit walls have the following potential physical hazards which may need to be addressed in the feasibility study.

- There is a high hazard due to individual rock falls, but the resulting overall risk is considered low, due to the small volume of rock in such events and because people are rarely in the area that would be involved in an individual rock fall event.

- The hazard due to plane failure of the bedrock is low. The fracture orientations, low persistence, and other rock characteristics at the Site do not present a significant plane failure potential.

- The hazard of wedge failure above the North Pit Lake is high. However, the risk would be high only if a failure large enough to generate waves capable of overtopping the pit lake dam occurred.

- The potential for an overburden soil land slide in the southeast corner of the pit was not evaluated. The potential for a landslide into the Pit Lake and subsequent overtopping of the pit lake dam is a reasonable concern that should be evaluated further.

9.2 AOI-2 – Upper Tailings Pile

9.2.1 Nature and Extent of Contamination

Soil samples collected from the Upper Tailings Pile exceed screening levels of the indicator metals however, contaminant migration from the Upper Tailings Pile appears limited to the western areas downslope from the toe of the Upper Tailings Pile. There appears to be little or no migration in areas north, east, and south of the Upper Tailings Pile.

Groundwater collected from two monitoring wells located on the west side of the Upper Tailings Pile did not exceed screening levels.

9.2.2 Risk Assessment Findings

The excess carcinogenetic risk based on incidental soil ingestion of arsenic is 8 x 10^{-6}. The cumulative hazard quotient for noncarcinogenic risk is less than 1.0. Cadmium soil concentrations did exceed the MTCA method B screening level for groundwater protection.

Surface water concentrations were below risk based levels both for drinking water and ingestion of fish.

The ERA identified lead and zinc as the COECs with the highest risk to aquatic receptors. Zinc poses risks to soil invertebrates, birds, and small mammals at AOI 2 due to exceedances of site-specific background levels.

9.2.3 Physical Hazards

The results of the tailings stability assessment conducted during the RI (Appendix F) show that the existing slopes do not meet Ecology's dam safety criteria for both seismic and non-seismic conditions. Instability of the tailings slopes would likely exacerbate existing erosion problems and transport of the tailings to terrestrial ecological and perhaps aquatic receptors.

9.3 AOI-3 – Lower Tailings Pile

9.3.1 Nature and Extent of Contamination

There are elevated metal concentrations extending north and west from the Lower Tailings Pile. Seasonal erosion and migration of material from the Lower Tailings Pile resulted in transport of tailings toward the Northeast Tributary of Onion Creek. Soil impacts occur close to the bank of the Northwest Tributary.

In the northwestern portion of the Lower Tailings Pile there are two shallow ditches and/or piping, likely used to convey water from the base of the tailings pile, where indicator metals exceeded screening levels.

In addition, there are a number of screening level exceedances south and southeast of the tailings pile along access roads that may have been constructed with waste rock or tailings.

Three new monitoring wells, three existing site wells, and seven residential wells were sampled. Groundwater from only one residential well exceeded the screening level for arsenic, but the concentration was below the drinking water MCL and the owner was notified.

9.3.2 Risk Assessment Findings

The excess carcinogenetic risk based on incidental soil ingestion of arsenic is 8×10^{-6}. The cumulative hazard quotient for noncarcinogenic risk was less than 1.0. Cadmium and lead soil concentrations exceeded MTCA Method B screening levels for protection of groundwater.

Excess carcinogenetic risk based on drinking water ingestion of arsenic was 3 x 10^{-4}. Hazard quotients for non-carcinogenetic risks were 1.0 or greater for antimony, arsenic, chromium, and nickel. The groundwater lead concentration exceeded the state MCL.

The ERA found that soil cadmium, lead, and zinc produced risk to birds and small mammals. Lead and zinc were COECs for plants while zinc was the only COEC for invertebrates. Zinc poses risks to soil invertebrates at AOI-3 due to exceedances of site-specific background levels.

9.3.3 Physical Hazards

The results of the slope stability analysis conducted during the RI show that the existing slopes do not meet Ecology's dam safety criteria for both seismic and non-seismic conditions. Water ponded on the tailings pile and ongoing erosion of the Lower Tailings Pile slopes may contribute to potential future instability. Instability of the tailings slopes would likely exacerbate existing erosion problems and transport of the tailings to terrestrial ecological and perhaps aquatic receptors.

9.4 AOI-4 – Pipeline and Access Roads

9.4.1 Nature and Extent of Contamination

There were exceedances of indicator metals along much of the pipeline. Highest concentrations are located in the first 1,500 feet of the pipe line alignment starting at the Mill and appear to be associated with visible tailings. A second area of elevated metal concentrations is about halfway between the Mill and the Lower Tailings Pile.

One sample collected from the Van Stone Mine Road exceeded the screening level for lead. Four samples collected from the Lotze Creek Road between the Lower Tailings Pile and Stevens County Highway 9425, exceeded screening levels for antimony, arsenic, and cadmium and one sample exceeded the screening level for copper.

9.4.2 Risk Assessment Findings

For AOI-4 the excess carcinogenetic risk based on incidental soil ingestion of arsenic was 1 x 10^{-5}. The cumulative hazard quotient for noncarcinogenic risk was less than 1.0.

Arsenic and cadmium soil concentrations exceeded MTCA Method B screening levels for protection of groundwater.

Cadmium, lead, and zinc in soil produced risk to birds and small mammals while zinc was the primary COEC for plants and invertebrates.

9.4.3 Physical Hazards

No physical hazards were identified in AOI-4.

9.5 AOI-5 – Onion Creek and Tributaries

9.5.1 Nature and Extent of Contamination

None of the surface water samples exceeded the screening levels for the indicator metals.

None of the three samples collected in the Northeast Tributary, which flows past the Lower Tailings Pile exceeded the screening levels for indicator metals.

All three sediment samples collected from the unnamed tributary upgradient of the Upper Tailings Pile that drains the area between the North and South Pits exceeded screening levels for the indicator metals.

On the Southeast Tributary, downgradient of the Upper Tailings Pile, sediment concentrations for indicator metal screening levels were exceeded while downgradient of the confluence with Onion Creek, zinc is the only indicator metal exceeding the screening level.

9.5.2 Risk Assessment Findings

Surface water concentrations were below risk based levels both for drinking water and ingestion of fish.

The excess carcinogenetic risk based on incidental sediment ingestion of arsenic was 4×10^{-6}. The cumulative hazard quotient for noncarcinogenic risk was less than 1.0.

Zinc in sediment and surface water poses risk to aquatic macroinvertebrates.

9.5.3 Physical Hazards

No physical hazards were identified in AOI-5 during the RI.

9.6 Recommendations

Site soils and mine features (Waste Rock Piles and open pits) in AOI-1, the Upper Tailings Pile (AOI-2), and Lower Tailings Pile (AOI-3) have the largest aerial extent and greatest number of exceedances of indicator metals. In addition, areas with limited or localized environmental impacts include the tailings pipeline alignments (soils) and sediments in Onion Creek downgradient of the Upper Tailings Pile, and sediments in an unnamed tributary that drains the area between the North Pit and South Pit.

The HHRA and ERA conducted for the Site indicate that the highest risks are associated with the waste rock piles, tailings piles, and releases of tailings along the tailings pipelines.

Recommendations for addressing impacts at the Site include:

Remedial alternatives should be developed and evaluated to stabilize and isolate the waste in the waste rock piles, Upper Tailings Pile, and Lower Tailings Pile. Isolation of the waste rock piles and the Upper Tailings Pile and Lower Tailings Pile needs to address the HHRA and ERA target risk limits that were exceeded.

The waste rock and tailings piles could be isolated by consolidation and capping. This would typically include regrading slopes for stability, and run-on / runoff controls. Caps would need to be protective of potential human and ecological receptors, and institutional controls could be implemented to reduce risk of future disturbance that would lead to exposure of hazardous substances to the environment.

Isolated areas of impacted soils, and tailings associated with releases from the slurry pipeline, could be addressed by consolidation into the main tailings piles prior to capping.

Identification and analysis of cleanup alternatives should consider the use of remediation levels to facilitate dealing with “hot spots” while minimizing the environmental impact that would result from remedial actions to address disbursed tailings (e.g., deposited by erosion downgradient of the tailings piles).

Since wastes would be left on site, the extent of consolidation and capping, or other cleanup alternatives, would need to be evaluated using a quantitative risk assessment (WAC 173-340-357). The evaluation would also need to determine whether cleanup alternatives are permanent to the maximum extent practicable (WAC 173-340-360(3).

Stream sediments in areas that exceed preliminary screening levels should be further evaluated using the procedures for mine sites presented in WAC 173-204-563(2)(p), since these standards were not final at the time this study was accomplished. Depending on results of that evaluation, source control followed by monitored natural attenuation due to geomorphic processes should be evaluated to determine if that that may eliminate the need for more intrusive remediation.

Additional considerations to be addressed include:

- Significant instability of the pit wall is possible and could impair the integrity of the Pit Lake Dam and cause downstream flooding. The existing conditions do not satisfy Ecology's dam safety requirements for static or seismic stability.

- The Mill Area and existing locked buildings have not been fully characterized and this will need to be addressed in the feasibility study. Also, Ecology may wish to determine if the open pits and existing building will be left intact or addressed in the remedial action.

- The RI work plan identified several domestic wells for the limited initial characterization of groundwater quality. Based on the data collected from residential wells and monitoring wells close to the Upper Tailings Pile and Lower Tailings Pile, groundwater impacts appear to be limited in extent. However, groundwater characterization is incomplete, and continued monitoring of groundwater should be done to develop a base line condition. Fracture flow isolates groundwater recharge and flow near the West End Pit. Given the circumneutral pH of surface water and the carbonate rock types in the pit, groundwater cleanup may not be warranted.

- The Van Stone Mine Road and Lotze Creek Roads were not found to exceed HHRA and ERA target levels. However, Lotze Creek Road did contain several metals (antimony, arsenic, and cadmium) that exceeded screening levels. These metals did not exceed screening levels on the mine road, which may indicate that the elevated metals detected on Lotze Creek Road may have originated from fill imported and used for road improvements, and, therefore, are not associated with mine waste.

10.0 REFERENCES

DNR 1977 (DCN 1066). Zinc and Lead Ore Deposits in Carbonate Rocks, Stevens County, Washington. Bulletin No. 70. Prepared by James Mills, 1977.

DNR 2005 2003 (DCN 1020). Report on Certain Aspects of the Van Stone Mine, Stevens County, Washington. March 31, 2003.

DNR 2005 (DCN 1036). Inactive And Abandoned Mine Lands—Van Stone mine, Northport Mining District, Stevens County, Washington. Washington Division Of Geology and Earth Resources, Information Circular 100. December 2005.

Ecology 1986 (DCN-1035). Site Inspection Report, Callahan Mines, Colville, Washington, Washington State Department of Ecology. March 1986.

Ecology 1991 (DCN 1022). Groundwater and Surface Water Monitoring Waste Discharge Permit No. 5287. Washington State Department of Ecology. May 31,1991.

Ecology 2004a (DCN 1026). Results from September 19, 2004 Sampling of Tailings and Reclaim Water Ponds. Letter from Pat Hallinan, Water Quality Section, Washington State Department of Ecology. November 18, 2004.

Ecology 2005 (DCN 1050). Results from October 18, 2005 Sampling of Tailings and Reclaim Water Ponds. Letter from Robert Raforth, Water Quality Section, Washington State Department of Ecology. December 28, 2005.

Ecology 2006a (DCN 1009). Tabulated Results from 2005 - 2006 Sampling of Tailings and Reclaim Water Ponds.

Ecology 2006b (DCN 1018). Tabulated Results from 2005 - 2006 Sampling of Tailings and Reclaim Water Ponds.

Ecology 2007 (DCN 1017). Site Hazard Assessment Work Sheet, Van Stone Mine. Washington State Department of Ecology. February 27, 2007.

Ecology 2010 (DCN 1001). Van Stone Creek Sampling Metals Results and Quality Assurance Review. Prepared by Dean Momohara, Manchester Environmental Laboratory. November 22, 2010.

EPA 2002 (DCN 1041). Preliminary Assessments and Site Inspections Report, Upper Columbia River Mines and Mills, Stevens County, Washington, TDD: 01-02-0028. October 2002.

EPA 2003 (DCN 1055). Preliminary Potential Responsible Party Search. September 30, 2003.

Equinox Resources (Washington) Inc. (Equinox) 1990a (DCN 1037). Tailings Disposal Design Report. Prepared by Klohn Leonoff Consulting Engineers. September 5, 1990.

Equinox Resources (Washington) Inc. (Equinox) 1990b (DCN 1060). State Environmental Policy Act (SEPA) Report. Prepared by Klohn Leonoff Consulting Engineers. January 1990.

Equinox 1999 (DCN 1056). Reclamation and Closure Plan. Prepared by Beacon Hill Consultants Ltd. July 1999.

Kealy et al. 1974. (DCN-1014). C. Daniel Kealy, R. Busch, and M. McDonald. Seepage-Environmental Analysis of the Slime Zone of a Tailings Pond, U.S. Bureau of Mines 1974.

Keston, S.N. 1970. The Van Stone Mine, Stevens County, Washington. Washington DNR Bulletin 61, Lead-Zinc Deposits in the Kootenay Arc, Northeastern Washington and Adjacent British Columbia,

Lentz , R. T. 2002 (DCN 1042). Physical limnology and geochemistry of two circumneutral pH mine pit lakes in NE Washington: American Society for Surface Mining and Reclamation. 2002 National Meeting, paper, p. 17.

MacDonald et al. 2000. D. Macdonald, C. Ingersoll, and T. Berger. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology, Vol. 39, pp 20 – 31, 2000.

Mills, J. W. 1977. Zinc and lead ore deposits in carbonate rocks, Stevens County, Washington: Washington Division of Geology and Earth Resources Bulletin 70, p. 171.

Neitzel, T. W. 1972. Geology of the Van Stone mine, Stevens County, Washington: Washington State University Master of Science thesis, p. 47.

Raines, M. et. al. 1997. Onion Creek watershed Analysis. Published by Boise Cascade Corporation, available from Washington Department of Natural Resources, Division of Geology and Earth Resources, call number: TC425 O6 R155o 1997.

Stevens County Assessor website 2011. http://www.co.stevens.wa.us/assessor/assessor.htm

Yates, R. G.; G. E. Becraft; A. B. Campbell; R. C. Pearson 1964. Tectonic framework of northeastern Washington, northern Idaho, and northwestern Montana [abstract]: American Institute of Mining, Metallurgical, and Petroleum Engineers; Canadian Institute of Mining and Metallurgy Joint Meeting, [1 p.].

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