KENNECOTT
GREENS CREEK MINING COMPANY

STAGE II TAILINGS EXPANSION
HYDROLOGIC ANALYSIS

Submitted To:
Greens Creek Mining Company
Juneau, Alaska

Submitted By:
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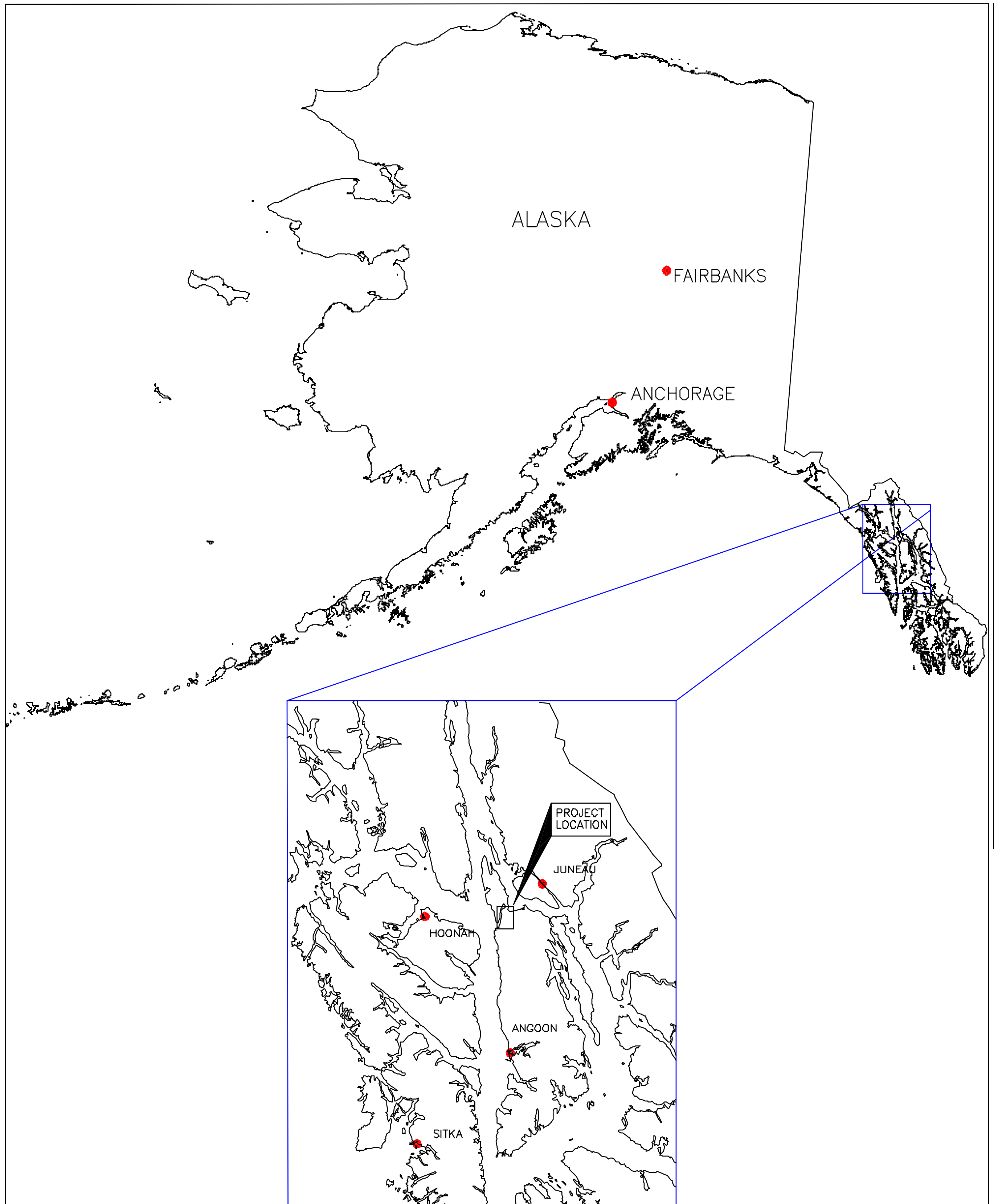
1.0 INTRODUCTION

The Kennecott Greens Creek Mine (KGCMC) is a precious and base metal mine producing gold, silver, zinc and lead from underground operations. The mine is located approximately 18 miles southwest of Juneau, Alaska on Admiralty Island (Figure 1). Mined ore is milled on the mine site and flotation-separated into three concentrates for shipment to smelting operations located elsewhere. The milling produces a tailing product, that is de-watered, and filter pressed into a cake with a moisture content of approximately 12-14 wt.% (44% to 51% saturation). Much of the tailings material is used as underground backfill. Overall approximately 50% of the tailings are transported for disposal at a tailings “impoundment” or repository facility located near the drainage divide of Upper Cannery Creek and Tributary Creek. This tailing material is placed and compacted as a solid on a “dry” tailings pile. This pile is itself an engineered structure, within an engineered containment system, on a closely managed tailings repository facility. The tailings pile was originally located and constructed at the existing site in 1989. Operations were curtailed in 1993 due to low metal prices. Mining and milling recommenced in 1996 and have been conducted continuously since.

Tailings placement resumed in 1996 at the original site and has continued to the present. During this period, three extensions of the tailings site have been constructed under the original permitting. These included an extension to the south starting in 1996, construction of the West Buttress, which commenced in 1999 and extension to the east, which began in 2000. Portions of these three areas are still active. The site modification/expansion examined here is referred to as the Stage II expansion. The Stage II expansion includes subparts referred to as the Northwest, West, Pond 6, East Ridge, and Pit 5 areas (Figure 1 and 2).

Environmental Design Engineering Consultants (EDE) has been involved with this project since 1995. Environmental Design Engineering Consultants is currently part of a team working to complete the hydrologic analysis and engineering of the Stage II expansion.



KEY PLAN
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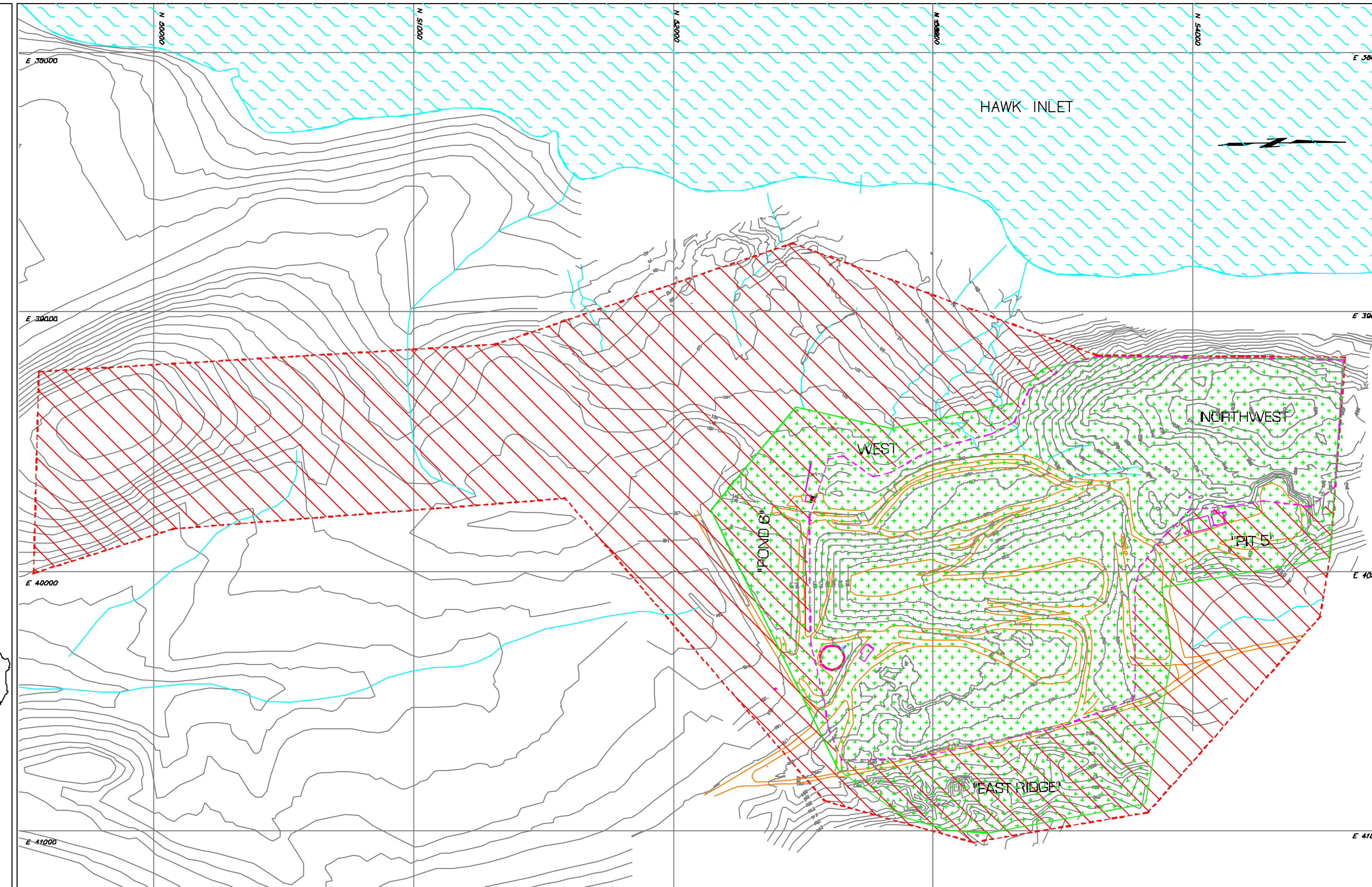

SITE LOCATION MAP
SCALE: 1" = 600'

LEGEND

- NORTHWEST TAILINGS BOUNDARY
- PROPOSED LEASE AREA (140.4 ACRES)
- STAGE II AREA OF TAILINGS PLACEMENT (67.6 ACRES)
- STREAMS
- ROADS
- 10' CONTOUR LINE

FIGURE 1

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

SITE LOCATION MAP

DATE: 10/2/01 DRAWING BY: CDG DESIGN BY: BNN REVIEWED BY: BNN PROJ OR REF. ----	PREPARED BY: EDE CONSULTANTS SHERIDAN, WYOMING PHONE: (307)672-3793 EDE DWG # HYDROANALYSIS/FIGURE1
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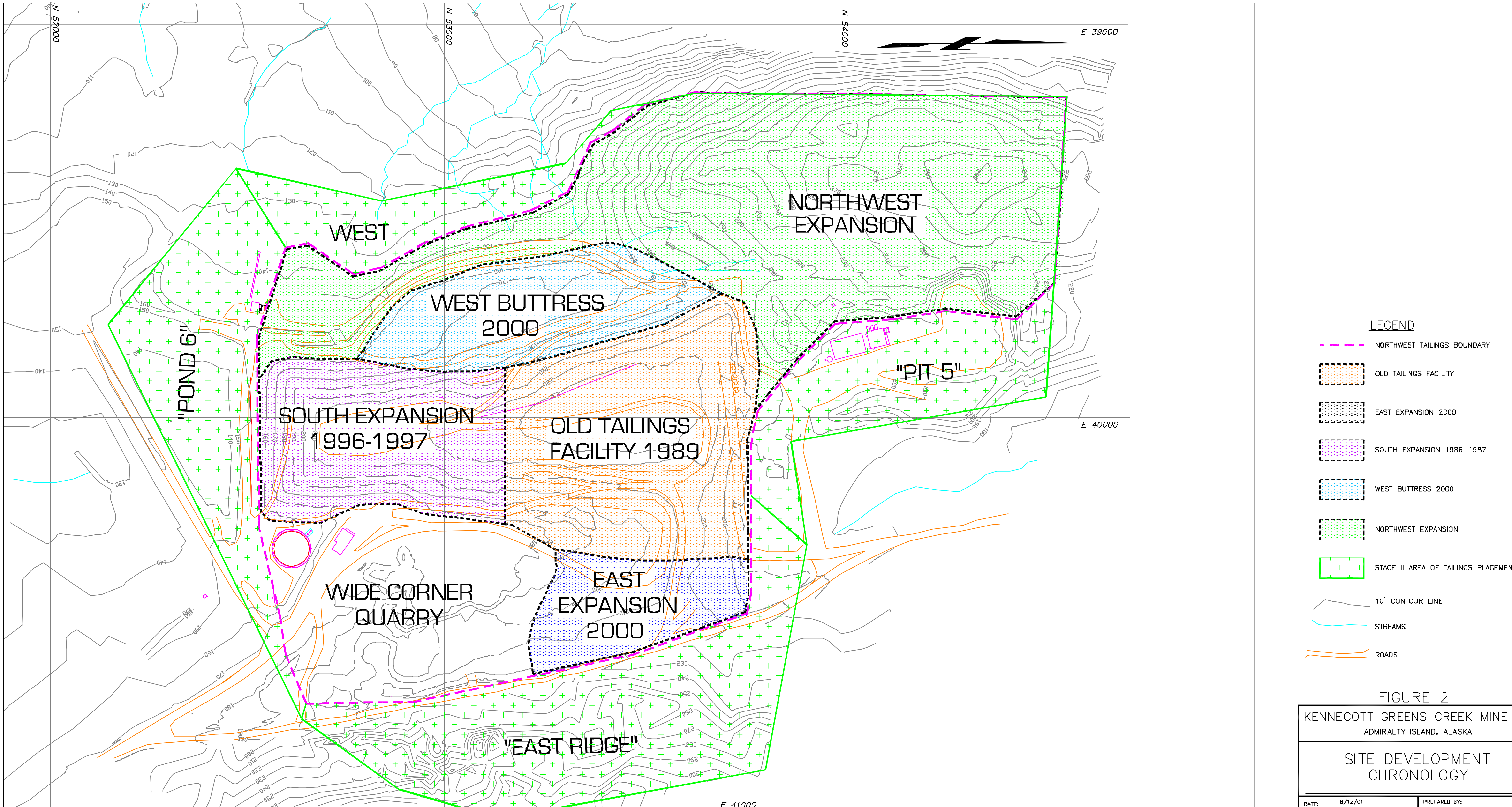

FIGURE 2

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

SITE DEVELOPMENT CHRONOLOGY

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1.1 Report Purpose

The existing permitted tailings repository site does not contain sufficient volume to provide storage for projected future mill tailings materials. In order to provide additional storage capacity, KGCMC is seeking to alter the geometry of the existing tailings pile and expand the footprint of the tailings and associated infrastructure at the existing site.

This report has been prepared for four general purposes:

- First, the report is intended to describe the hydrologic conditions of the existing tailings repository, and the proposed Stage II expansion area inclusive of sub-areas referred to as the Northwest, West, Pond 6, East Ridge, and Pit 5 expansions (Figures 1 and 2).
- Second, the report provides a description and quantification of the hydrologic control features of the existing site and the interaction between these features and the hydrologic regime.
- Third, the report provides the basis for examination of the Stage II expansion area and a hydrologic analysis of the proposed enlargement and the hydrologic controls necessary for that facility.
- Fourth, the report examines the hydrologic conditions anticipated following the site closure/reclamation and attainment of a steady state closure condition. It is the objective of this report to present a clear understanding of the hydrologic regime and the function of engineered structures integral to the management of water associated with the tailings facilities. This report does not address water quality, tailings geochemistry or water treatment. These subjects are addressed in a separate tailings repository geochemical analysis report.

1.2 Report Organization

A great deal of geologic and hydrologic information is available for the site. Much of the information incorporated in this report builds upon many earlier reports, and studies. A good deal of basic information regarding geology, stratigraphy, and lithology has been condensed from detailed reports. This report focuses the greatest detail on the hydrology of the near term development of the Northwest expansion. However information and discussion is provided for the anticipated hydrologic effects and water management needs for the entire Stage II site. A comprehensive listing of the references used in this report is included in Section 6.0.

Site hydrology information has been brought together in an integrated way during the development of two prior reports addressing tailings site hydrology (EDE Consultants, 1997 and EDE Consultants, 1999) and in lesser detail in a number of other reports (KGCMC, 1995; SRK, 1996; KGCMC, 1998; Klohn-Crippen, 1999; Shepherd-Miller, 2000). In order to understand the site hydrology both conceptually and quantitatively, information from these reports is used by reference. This report is intended to provide first, a conceptual description of the hydrologic regime and second, a quantitative description of the hydrology with extrapolation to the expansion site. This report contains supporting data and graphics presentations to assist in understanding this complex site.

The general format of the report includes major sections addressing the site hydrology (Section 2.0), current site water management (Section 3.0), Stage II expansion water management (Section 4.0) and post closure water management (Section 5.0) with subsections divided into surface and groundwater. Each subsection is relatively detailed to provide full documentation of information, data, calculations and assumptions.

2.0 SITE HYDROLOGY

2.1 General Site Description

The tailings pile location is shown on Figure 1. The pile occupies a relatively broad gently sloping area within the upper part of the Tributary Creek valley close to the drainage divide with Cannery Creek. The site is immediately adjacent to the Pit 5 rock quarry. The repository is bounded to the north by a bedrock knoll just west of the Pit 5 quarry. This knoll is a portion of the area proposed for tailings placement along with the area immediately to the south of the knoll, and the area currently occupied by tailings. A steep mountain slope rises to the east of the repository. To the west lies a gently sloping muskeg area that steepens as it approaches the ocean at Hawk Inlet. The southwest corner is another bedrock knoll that slopes off to the east to Tributary Creek and to the west toward Hawk Inlet.

Tailings currently occupy 23.2 acres within the existing tailings and facility lease area of approximately 56 acres. The Northwest expansion will increase the total footprint area to approximately 45.6 acres and the entire Stage II tailings footprint expansion will increase the total area to 67.6 acres. The proposed expansion, including the extension to the southwest for possible reclamation materials storage and the highland quarry, is approximately 88 acres and combined with the current lease area totals 144 acres (Figure 1).

2.2 Regional Hydrology

The site is located on Admiralty Island in southeast Alaska. The most significant regional hydrologic feature of this area is the precipitation level. Southeast Alaska is characterized as a temperate rain forest. Consistent with this is the large amount of precipitation both in the form of rain and snow. Regional precipitation amounts vary widely and are dependent upon orographic influences of the mountainous terrain. In general the Southeast Alaska regional annual precipitation at sites near sea level is between 40 inches (Angoon) and 225 inches (Port Walter) per year (US NWS, Climate Database).

There is no known aquifer system that could be described as a regional system. The aquifer systems known to exist in this area are typical of aquifer systems in the glaciated environment of southeast Alaska and include water-bearing units of peat, glacial till, marine and fluvial sediments and bedrock.

The surface water hydrology also has no large scale or regional features associated with the site. The surface drainage regime is typical of small watersheds of the mountainous regions of southeast Alaska. The most significant hydrologic features with respect to surface water and ground water are local in extent and function, not regional in scope.

2.3 Local Hydrology

The dominating influence on the local hydrology, as with the regional hydrology, is the large amount of precipitation received at the tailings site. Automated precipitation monitoring data have been collected at the tailings site since 1997. During the four year period of 1997 through 2000 the average annual precipitation at the tailings site was 53.0 inches. This is consistent with the other meteorological measurements in the general area. The National Weather Service Climate Database reports that Angoon, near the southern end of Admiralty Island has an average annual precipitation of 42.2 inches for a 40 year period of record. Juneau has four reporting stations (1 current, 3 at various time windows from 1949 to present). In the Juneau area, the longest single station period of record is the airport, which reports an average annual precipitation of 56.5 inches over a 51 year period of record. Auke Bay, north of Juneau reports an annual average of 62.4 inches for a 37 year period of record. Given the surrounding records, it appears that although the data at the tailings site is limited it fits well with other sites within a 20 to 40 mile radius and at similar elevation. Precipitation data and summaries are presented in Appendix A. The following discussions of the surface and groundwater hydrology are specific to the tailings site.

2.4 Surface Water

Significant surface water features are presented on Figure 3. Surface water at the tailings site consists of several drainage features only two of which are perennial streams,

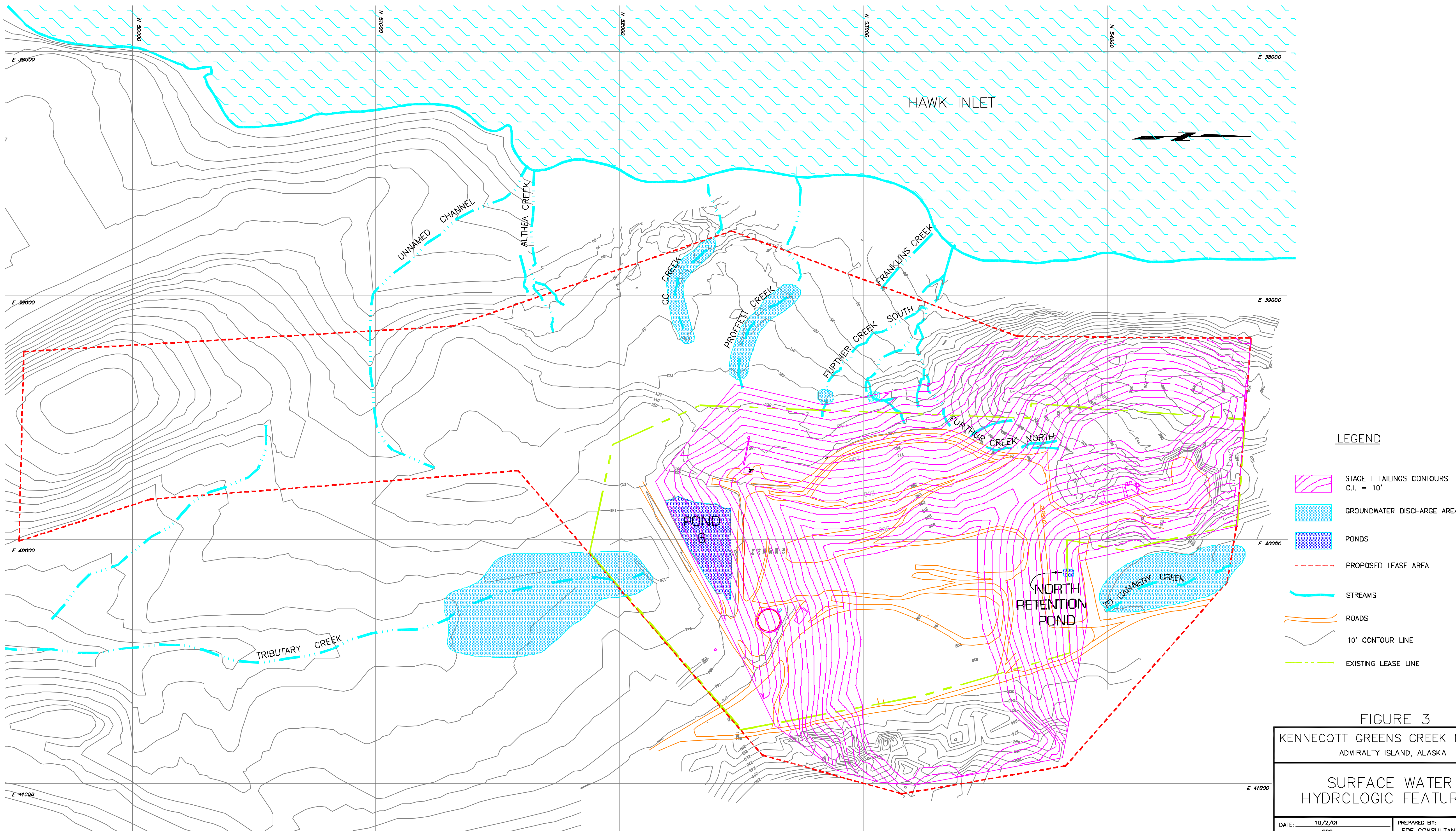


FIGURE 3

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

SURFACE WATER HYDROLOGIC FEATURES

DATE: 10/2/01	PREPARED BY: EDE CONSULTANTS SHERIDAN, WYOMING PHONE: (307)672-3793
DRAWING BY: CDG	
DESIGN BY: BNN	
REVIEWED BY: BNN	EDE DWG # HYDROANALYSIS/FIGURE3
PROJ OR REF. ----	
SCALE: 1" = 400'	SHEET: 1 OF 1

Cannery Creek and Tributary Creek. Two man-made ponds are present within the tailings repository facility area. These are Pond 6 and the North Retention Pond both of which are designed and used for storm water runoff surge retention. Within the expansion area, there are several small channels that appear intermittent or ephemeral. North of the tailings pile, Cannery Creek flows from its origin on the hill slope to the northeast of the site. A groundwater discharge area forms a bog to the east of Pit 5 and north of the Pit 5 access road. This bog is a tributary to Cannery Creek proper. Cannery Creek flows west-northwest and is a low gradient perennial muskeg stream. Cannery Creek appears to gain flow as one proceeds downstream, though the flow volumes are low. No discharge measurements are available for tributaries of Cannery Creek near the tailings site due the difficulty in obtaining accurate flows under diffuse muskeg/peat bog flow conditions. It has been observed that even during dry periods, flow/wet conditions are observed in the Cannery Creek bog east of the Pit 5 quarry even though no visible surface flows are tributary to the creek in this immediate area. From this observation, and supporting groundwater potentiometric analyses, it appears that Cannery Creek is a discharge area for groundwater whose most immediate sources are the peat and the gravelly sand underlying the peat. The sand source may indirectly discharge to the creek via the peat, as the sand and the peat are in hydraulic communication. As a discharge area for shallow groundwater, Cannery Creek controls groundwater levels in the peat and gravelly sand along the north and northeast side of the tailings repository. More discussion of the surface water/groundwater relationship is presented later in this report.

Tributary Creek is immediately south of the tailings repository and Pond 6. This creek is perennial and, as with Cannery Creek, is groundwater fed during base flow conditions and receives local runoff during rainfall and snowmelt. The extreme headwaters of Tributary Creek now lie within the tailings repository boundaries and the steep slopes to the east. No discharge measurements are available for Tributary Creek at the tailings site, again due to the difficulty in obtaining accurate flows under diffuse muskeg flow conditions. Flow/wet conditions are observed in this headwater area during relatively dry periods without visible surface tributaries, which suggests that Tributary

Creek is also a local groundwater discharge area for the aquifers south of the tailings pond system.

Surface flows to the east of the tailings repository are via small ephemeral channels, overland flow, or shallow peat flow. The east side tailings repository has a lined perimeter interceptor ditch that collects upslope flows from the mountain slope to the east and routes them to Cannery Creek to the north or Tributary Creek to the south.

Surface water to the west of the existing site consists of shallow peat flow and several small intermittent and ephemeral channels. These channels are shown on Figure 3. Observations of these channels along with examination of the peat potentiometric surfaces suggest that these channels also receive peat discharges when the peat receives a recharge event (rainfall or snowmelt). In addition, recent observations have been made of several small seeps with somewhat elevated sulfate that appear to be anomalous. Among these is the "Duck Blind Seep, which is associated with a drain inside a flow meter vault for the water treatment plant discharge pipeline. This seep is less than 0.1 gpm and appears to be the result of flow into pipeline bedding. These features have been thoroughly investigated by Greens Creek and a comprehensive report written to address the nature and potential sources of these features and provide an action plan for monitoring and mitigation if necessary. A complete copy of this report "Update of Information and Action Plan on Seeps West of the Current Tailings Disposal Facility" January, 2002 is attached to this report as Appendix D.

The bedrock knob to the northwest and the bedrock knob to the southeast of the tailings area do not have discrete channelized flows. Surface discharges from these areas are apparently through the thin peat veneer at the peat-bedrock contact.

With respect to the tailings pile, surface flows consist of direct runoff from the pile to perimeter collection ditches. Runoff from the pile is routed via these ditches to the northwest corner of Pond 6 or to the North Retention Pond along with tailings area facilities runoff. Ultimately these waters are piped to the Pit 5 water treatment plant for treatment and discharge to Hawk Inlet as regulated under the mine's NPDES permit.

2.5 Groundwater

The existing groundwater flow regime is complex, but reasonably well understood by virtue of the groundwater monitoring network within and around the tailings facilities. Wells and piezometers have been constructed during several drilling campaigns since 1988. A total of 82 wells and piezometers have been constructed in and around the site. Figure 4 shows the 64 currently active monitoring well and piezometer network at the tailings site. Groundwater potentiometric data have been gathered at the facility since 1994.

The following discussion of groundwater is subdivided into a presentation that examines the groundwater flow regime in a conceptual way utilizing direct measurement data to verify the developed concepts. The second portion of the discussion presents a numeric analysis of the groundwater regime utilizing test data (infiltrometer, geotech, slug test, pumping tests) and monitoring data (well measurements, piezometer readings, meteorological/precipitation).

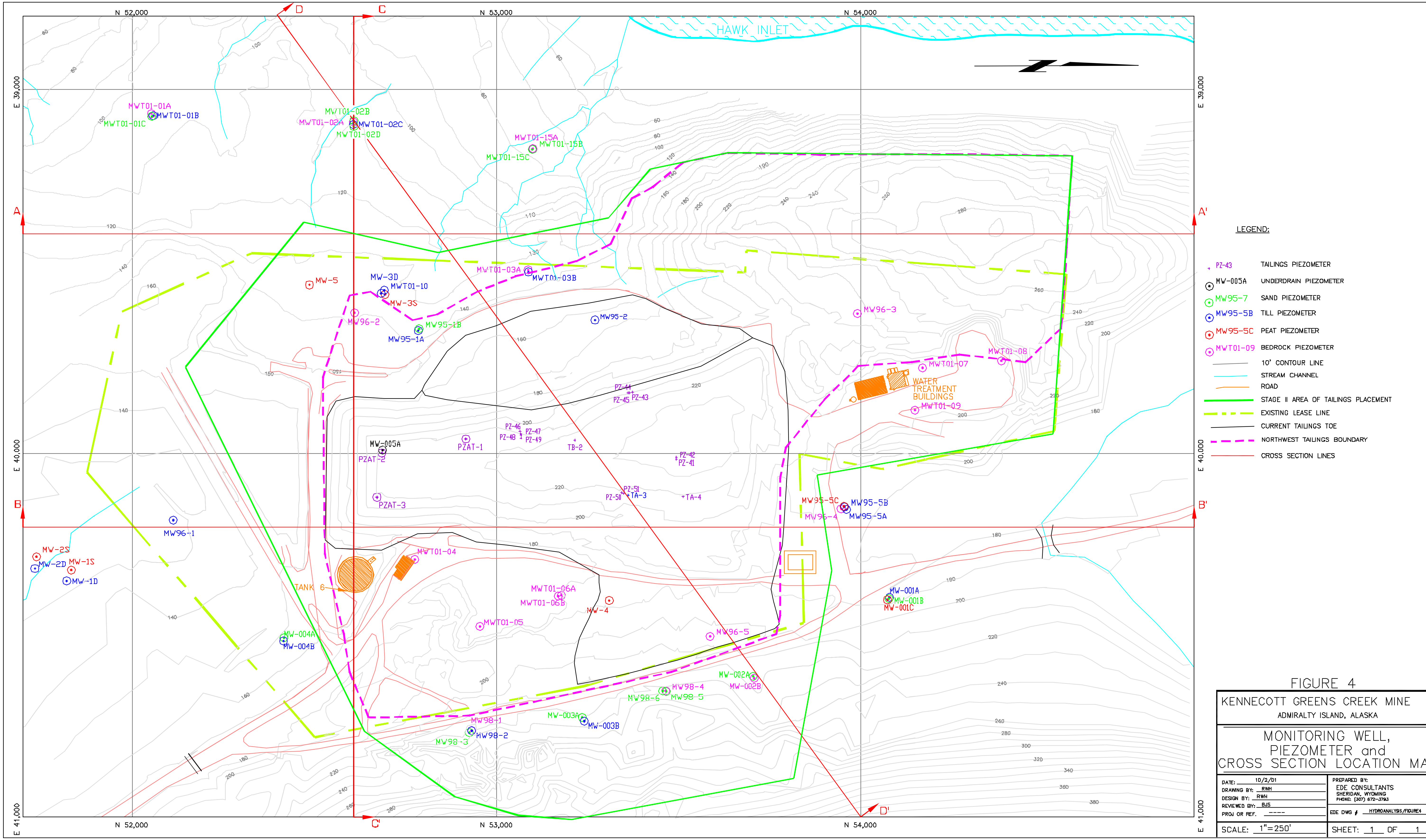

HAWK INLET
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
A
A'
B
B'
C
C'
D
D'
MWT01-01A
MWT01-01B
MWT01-01C
MWT01-02B
MWT01-02A
MWT01-02C
MWT01-02D
MWT01-15A
MWT01-15B
MWT01-15C
MWT01-03A
MWT01-03B
MW-5
MW-3D
MWT01-10
MW-3S
MW96-2
MW95-1B
MW95-1A
MW95-2
MW96-3
MWT01-08
MWT01-07
WATER TREATMENT BUILDINGS
MWT01-09
MW-005A
PZAT-2
PZAT-1
PZAT-3
PZ-44
PZ-45
PZ-43
PZ-46
PZ-47
PZ-48
PZ-49
TB-2
PZ-42
PZ-41
PZ-51
PZ-50
TA-3
TA-4
MW95-5C
MW95-5B
MW95-5A
MW96-4
MW96-1
MW-2S
MW-2D
MW-1S
MW-1D
TANK 6
MWT01-04
MWT01-06A
MWT01-06B
MW-4
MWT01-05
MW96-5
MW-001A
MW-001B
MW-001C
MW-004A
MW-004B
MW-002A
MW-002B
MW98-4
MW98-5
MW98-6
MW-003A
MW-003B
MW98-1
MW98-2
MW98-3
LEGEND:
PZ-43 TAILINGS PIEZOMETER
MW-005A UNDERDRAIN PIEZOMETER
MW95-7 SAND PIEZOMETER
MW95-5B TILL PIEZOMETER
MW95-5C PEAT PIEZOMETER
MWT01-09 BEDROCK PIEZOMETER
10' CONTOUR LINE
STREAM CHANNEL
ROAD
STAGE II AREA OF TAILINGS PLACEMENT
EXISTING LEASE LINE
CURRENT TAILINGS TOE
NORTHWEST TAILINGS BOUNDARY
CROSS SECTION LINES
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
MONITORING WELL,
PIEZOMETER and
CROSS SECTION LOCATION MAP
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793
EDE DWG # HYDROANALYSIS/FIGURE4
SCALE: 1"=250'
SHEET: 1 OF 1

FIGURE 4

2.5.1 Groundwater Flow Concepts

Understanding the groundwater flow regime is important in designing and assessing the effectiveness of diversion and containment structures to assure that tailings contact water is minimized, contained, captured, or otherwise controlled. Logical ways to approach the conceptual description of the groundwater flow regime in the tailings area is to first provide a general description of the water bearing units and their relationship to one another and then describe the flow regime from up gradient to down-gradient in each unit as if traveling the same path as the groundwater.

It is necessary to include some discussion of the hydrologic control structures existing in the tailings area and their influence on the groundwater flow regime. However, the primary purpose of this section of the report is to present a generalized description of the groundwater conditions. Details of the control structures are provided in Section 3.0 of this report.

The general concept of the groundwater flow in the tailings area is based upon groundwater monitoring data, site geology, surface hydrology, and site operations. Geologic and hydrologic information has been accumulated over the past 15 years through exploratory drilling, geotechnical drilling, monitoring well construction and on-going well level monitoring. Additional information was gathered for the Stage II expansion area as a part of this study including the construction of additional monitoring wells, conducting aquifer tests, and collecting water level measurements. Groundwater is present in different strata within the tailings area, and includes the peat/sand, till, and bedrock. A layer exists overlying the till that is composed of silty clay that retards or prevents vertical flow between strata above the clay (tailings, peat, sand) and the strata below it (till, bedrock). Water pressures within these strata vary depending upon whether the materials allow flow between them or not, and their proximity to the recharge and discharge zones of groundwater within these layers. Groundwater flow within the bedrock high located to the northwest of the existing tailings pile appears to conform to flow paths essentially perpendicular to the topography. Figure 5 presents a generalized conceptual diagram of these layers and the relative water pressures (potentiometric heads) within each layer while Figure 5B portrays the area-wide conceptual groundwater flow. As can be seen by these diagrams, the flow within the peat and the sand communicate and behave as a single water-bearing unit with different flow rates due to differences in the type of material (peat vs. sand) moreover, the flow in the upper units is confined by the underlying silty clays. Figure 6 depicts the plan view of groundwater flow direction and the areas of groundwater recharge and discharge. Bedrock flow follows a general east to west gradient as with the unconsolidated units. However, there is some localized flow in the Northwest/pit 5 area that appears to generally follow topography with flows to the east and north, suggesting that this northwest bedrock knob is a local groundwater recharge area. The groundwater recharge to the various strata, in the form of rainwater and snow-melt water, is from the mountain slope immediately to the east of the tailings impoundment site. The unconsolidated units pinch out as the east ridge slope rises up and bedrock becomes exposed. It appears that it is within this zone that groundwater recharge occurs and the groundwater moves down the geologic structure and down gradient toward the ocean at Hawk Inlet.

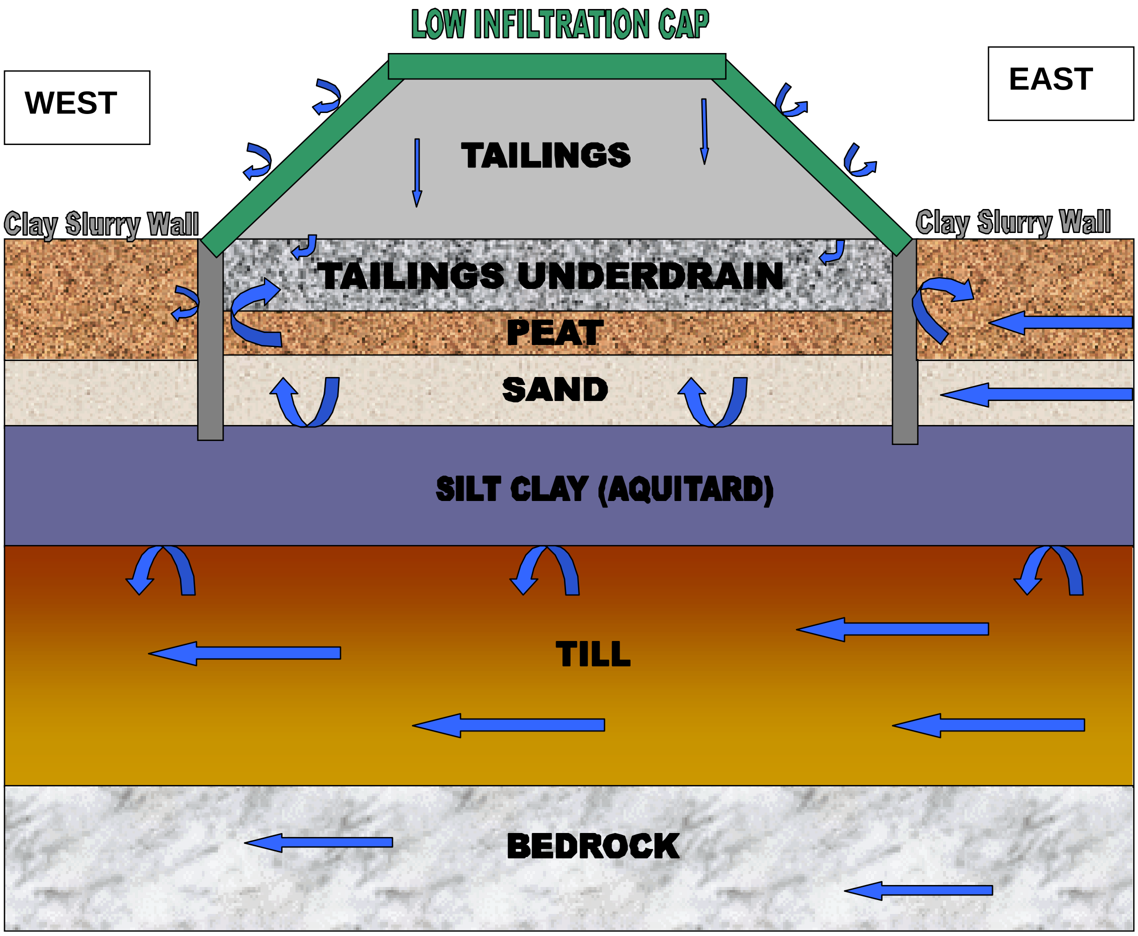
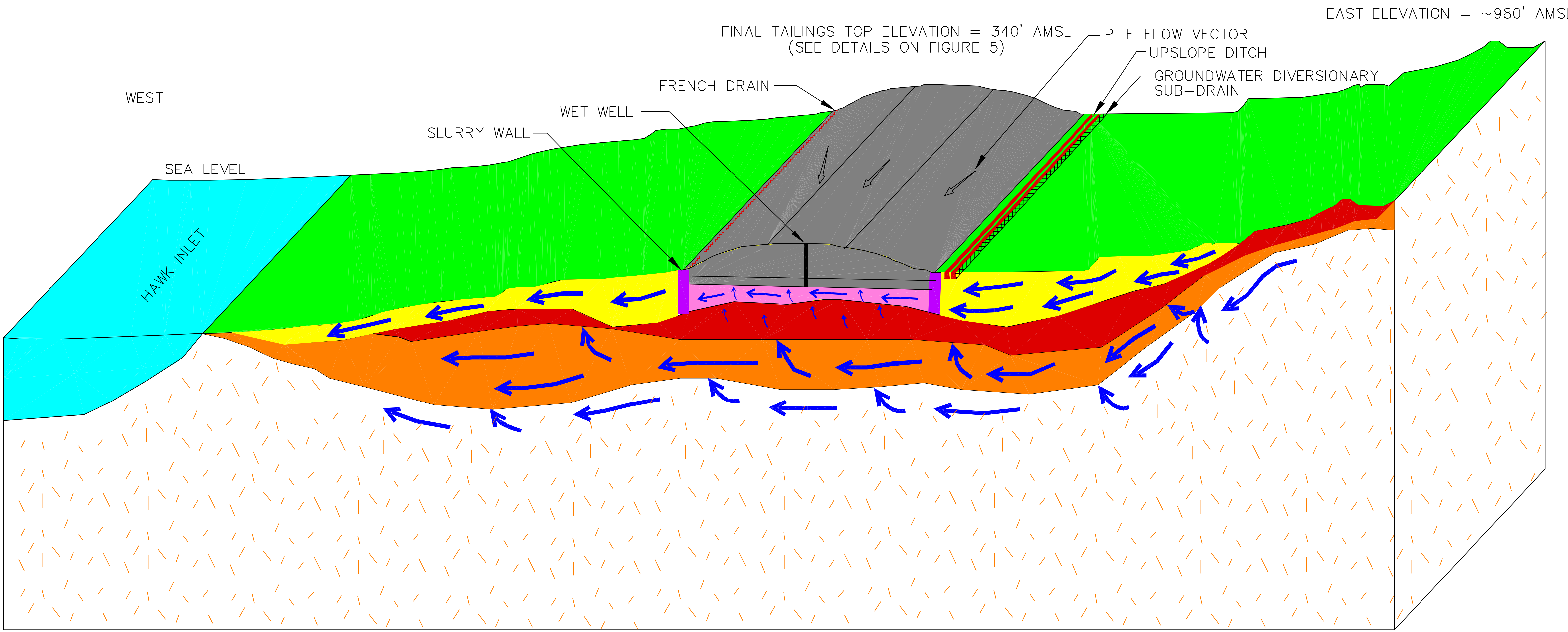


Figure 5 - Conceptual Groundwater Flow at the Tailings Site

Note: This drawing is a generalized and idealized depiction of the local groundwater flow regime associated with the tailings repository. It is not intended to be a specific indication of hydrologic controls, water management, tailings pile geometry, or other engineering or geologic details.

The groundwater within the peat and the sand also comes to the surface at both Cannery Creek to the north of the tailings site and at Tributary Creek to the south of the tailings site. These two groundwater discharge areas control the local direction of groundwater flow and also regulate the amount of water traveling through these strata.

The tailings site has some groundwater control structures built in and around the site to control the amount of groundwater that potentially comes in contact with tailings materials. These structures include vertical clay barriers (slurry walls) and french drain diversions.



LEGEND

= TAILINGS	= TILL
= PEAT/SAND	= BEDROCK
= SILT/CLAY	= UNDERDRAIN
= SLURRY WALL	

NOTE: NO SCALE

NOTE:
THIS DRAWING IS A GENERALIZED AND CONCEPTUAL DEPICTION OF THE LARGE SCALE GROUNDWATER FLOW REGIME ASSOCIATED WITH THE TAILINGS REPOSITORY. IT IS NOT INTENDED TO BE A SPECIFIC INDICATION OF HYDROLOGIC CONTROLS, WATER MANAGEMENT, TAILINGS PILE GEOMETRY OR OTHER ENGINEERING DETAILS.

FIGURE 5B

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

AREA-WIDE CONCEPTUAL
GROUNDWATER FLOW

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DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----

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GCMC DWG # HYDROANALYSIS/FIGURE5B

SCALE: NONE
SHEET: 1 OF 1

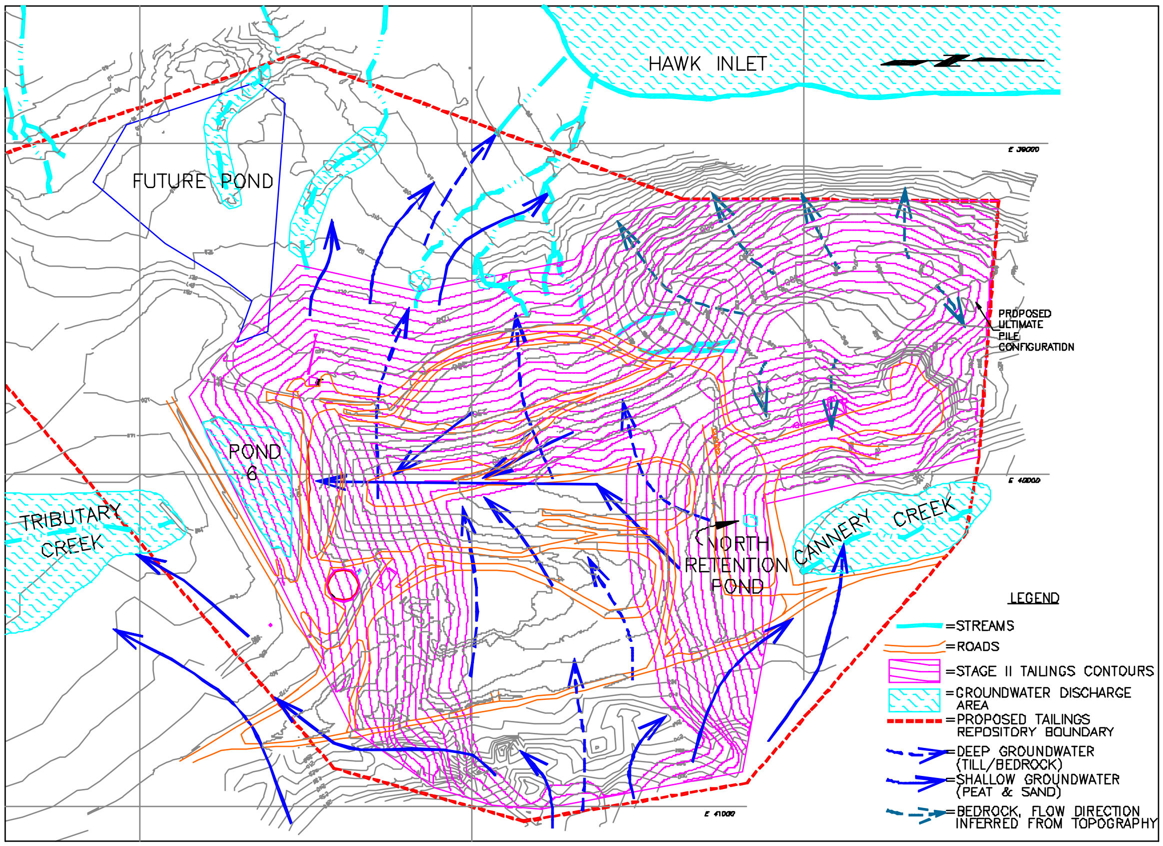
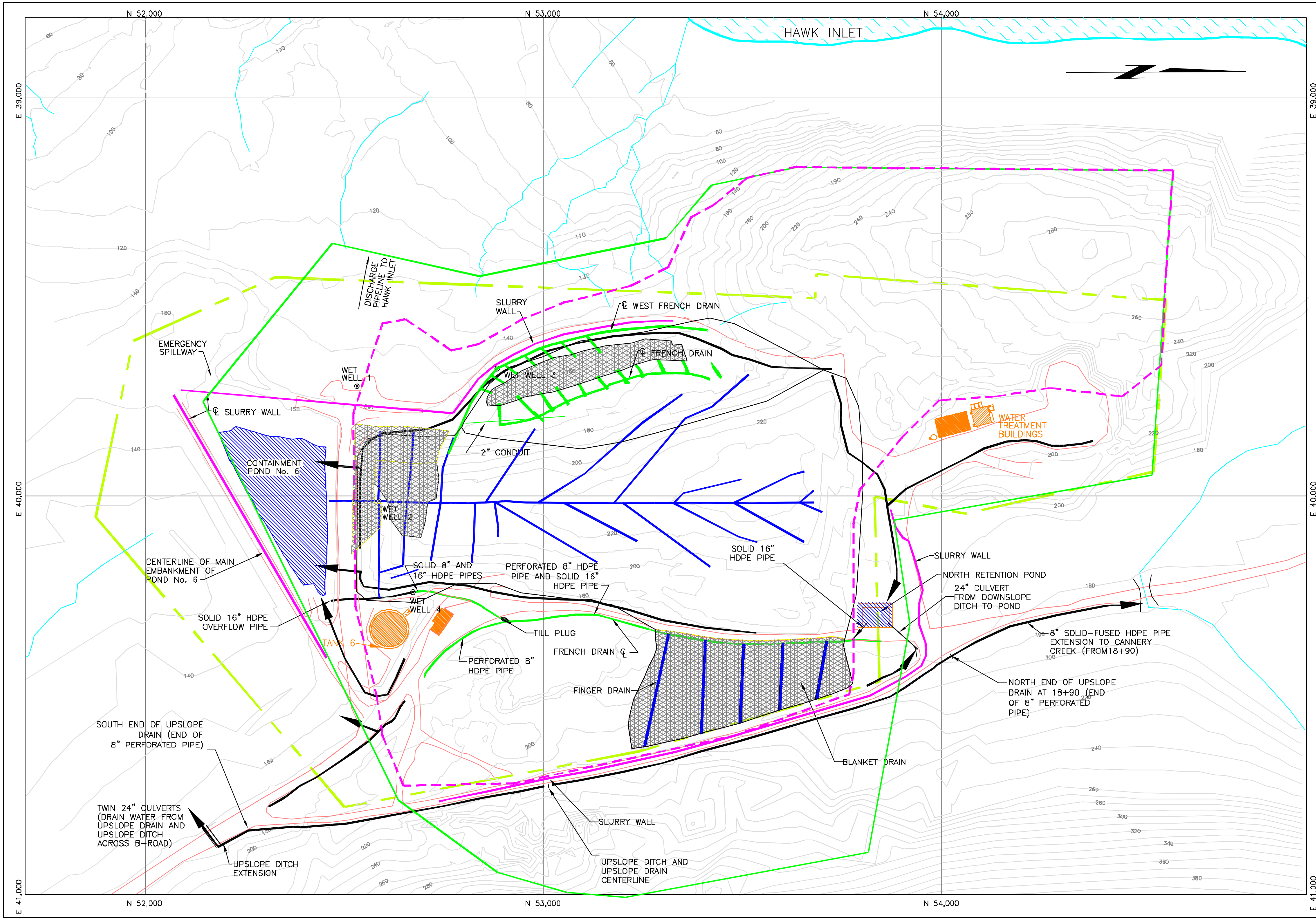


Figure 6 - Generalized Groundwater Flow Pattern

Figure 7 shows how these structures function to minimize the amount of groundwater entering the tailings repository site from the shallow water bearing units of the peat/sand. Water within the tailings pile is from several sources. Primary is water remaining from the processing of the tailings in the mill. The tailings are filter pressed to remove most of this water, leaving a residual water content of 12-14 percent (44% to 51% saturation). No free-draining water remains when the new tailings are placed and compacted on the site. A portion of the annual precipitation infiltrates into the tailings and contributes water to the pile. Precipitation that infiltrates through the tailings pile, and groundwater inflows not captured and diverted by the upslope french drains or diverted by the clay slurry walls is collected by the tailings pile under-drain system. This captured water is



LEGEND:

- BLANKET DRAIN
- SLURRY WALL
- FRENCH DRAIN
- DRAINAGE DITCH
- FINGER DRAIN
- WET WELL
- CONTAINMENT POND
- 20' CONTOUR LINE
- STREAM CHANNEL
- ROAD
- STAGE II AREA OF TAILINGS PLACEMENT
- EXISTING LEASE LINE
- CURRENT TAILINGS TOE
- NORTHWEST TAILINGS BOUNDARY

FIGURE 7

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

EXISTING TAILINGS FACILITY HYDROLOGIC CONTROLS

DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----

PREPARED BY:
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GCMC DWG # HYDROANALYSIS/FIGURE7

SCALE: 1"=250'

SHEET: 1 OF 1

collected in sumps (wet wells) and pumped to the KGCMC Pit 5 water treatment plant for treatment prior to discharge into Hawk Inlet as regulated under the mine's NPDES permit. West of the tailings pile, the geology changes somewhat, but the groundwater flow remains toward Hawk Inlet to the west. The proposed Northwest expansion of the tailings pile adds more tailings to the existing footprint by increasing the pile height. The majority of the Northwest tailings placement outside of the existing tailings footprint will be on the high bedrock knob to the northwest of the existing tailings pile. This bedrock area does not have the underlying clay layer or other low permeability layer, and therefore will be constructed with a low permeability liner over the bedrock and an under-drain system to collect drainage water from the tailings pile. Although the bedrock has significantly low permeability characteristics at depth, the liner will improve the under-drain collection system by overlying the shallow fractured bedrock zone expected as a result of site development (quarrying) in this area. Furthermore, note on Figure 2 that under full Stage II development tailings placement may be made to the east (East Ridge), over Pond 6 (Pond 6), at the Pit 5 quarry (Pit 5) and to the west (West). Water management in these areas will utilize combinations of natural liners, constructed diversions and engineered, low permeability liner systems. During active tailings placement, and mine operations the captured tailings contact water will continue to be routed to the water treatment plant to be treated to meet applicable water quality standards/discharge limits and then discharged.

2.5.2 Groundwater Quantitative Analysis

Numerous investigations have been conducted to understand and quantify the groundwater flow systems at the tailings site. The following discussion presents several possible scenarios including interpretations of these studies and combines these data to provide a more detailed image of the groundwater flow regime along with quantifying a realistic range of possible flow rates, directions, and timing. This discussion begins with a detailed review of the site geology and hydrologic characteristics of the geologic matrix that comprises the groundwater flow system and presents critical hydraulic analysis of the behavior of water within and around the tailings pile.

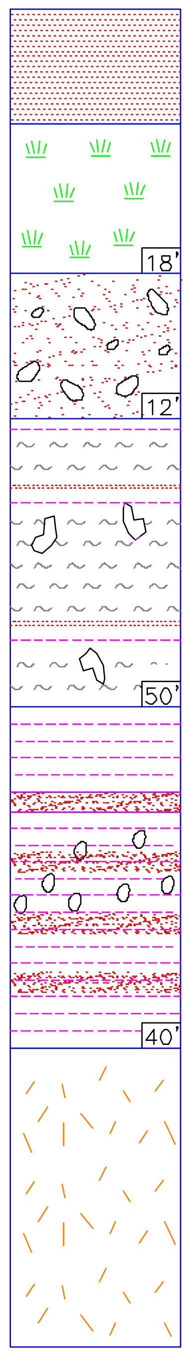
2.5.2.1 Site Geology

The site geology is complex and is principally the result of glaciation and glacial deposition along with some marine deposition. Many reports have been written which describe the geology of the site in detail as part of the original site designs, and subsequent geotechnical studies of the site (USDA, Forest Service, 1983; USDA, Forest Service, 1988; SRK, 1992; SRK, 1996; Klohn Crippen, 1999; Klohn Crippen, 2001).

The stratigraphy varies over the site but generally consists of 6 strata including the tailings, from the top down, of 1) tailings, 2) peat, 3) gravelly sand, 4) silty clay, 5) silty to sandy till , and 6) bedrock. This general stratigraphy is true for the existing tailings site and for the proposed Stage II expansion area. Figure 8 summarizes geologic and hydrologic properties of the major lithologic units. The expansion area to the northwest is on a bedrock high where the peat layer is thin and the sand and till layers are absent. Figures 9, 10, 11, and 12 portray the peat, sand, clay and till isopachs.

KGCMC tailings are derived from processing of finely ground ore to make base-metal sulfide and precious metal concentrates. The physical extent and characteristics of the tailings are well defined. The unconsolidated underlying strata including the peat, gravelly sand, silty clay, and till are quite variable in extent, thickness and lithology. In particular the gravelly sand is horizontally discontinuous and at locations of bedrock highs the till, sand and peat may be absent. Within the till there is wide variability in

Section &
Max. Observed
Thickness (ft.)



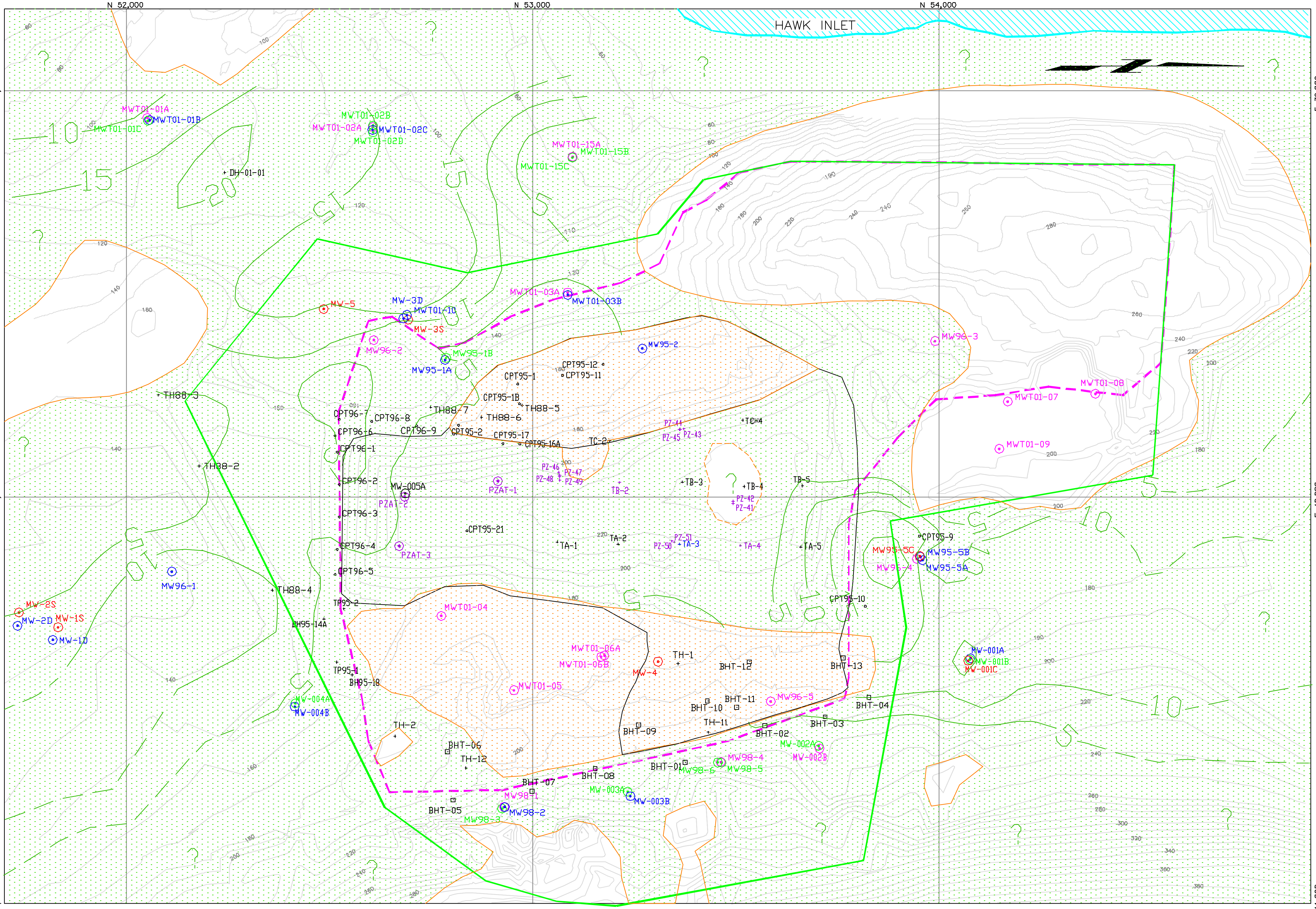
Hydrostratigraphic Units	Geologic Units
TAILING PILE – MATERIAL PLACED WITH 12% TO 14% MOISTURE CONTENT, PILE CONTAINS DISTINCT SATURATED AND UNSATURATED ZONES. NOTE THAT SMALL, ISOLATED SEMI-PERCHED SATURATED LENSES HAVE BEEN REPORTED. K_{Avg} = 1.88E–6cm/sec.	TAILING MATERIAL – FINE GRAINED SAND TO SILT SIZED SPENT ORE. 78–96% PASSES THROUGH A 200 MESH SIEVE. MATERIAL IS COMPACTED TO 90% STANDARD PROCTOR DURING PLACEMENT.
PEAT/SHALLOW SAND – MOST WELLS COMPLETED IN BOTH UNITS, THOUGH SOME DATA ON PEAT AND SHALLOW SAND ALONE. APPEAR TO BE IN COMMUNICATION BUT HAVE DISTINCT WATER QUALITY CHARACTERISTICS. PEAT K_{Avg} =2.30E–4cm/sec, PEAT/SAND K_{Avg} =3.11E–5cm/sec	PEAT – AMORPHOUS TO FIBROUS, DENSE ORGANIC MATTER, OFTEN CONTAINS ROOT MASS AND STUMPS
	GRAVELY SAND – ALLUVIAL TRANSITION ZONE (SOMETIMES DOMINATELY MARINE SANDS) MWT01–15B COARSE GRAINED, MODERATE SILT, TRACE SHELL FRAGMENTS.
MARINE CLAY TO SILT – CONFINING AQUITARD BETWEEN TILL AND SHALLOW SAND. NORMALLY WET BUT DOES NOT READILY YIELD WATER. WATER GENERALLY CONFINED TO THIN SILTY LENSES. K=2.15E–7 to 9.55E–9cm/sec. FROM KLOHN–CRIPPEN LABORATORY TESTING.	CLAY TO SILT – OFTEN SILTY CLAYS, SOME THIN SAND INTERVALS, TRACE GRAVEL OR COBBLES
GLACIAL TILL – HISTORICALLY CONFINED BY CLAY, HOWEVER COARSE LOCALES HAVE BEEN NEAR DRY (MWT01–02B). ARTESIAN CHARACTERISTICS EVIDENCED. IN MOST LOCATIONS. K_{Avg} =1.07E–4cm/sec	GLACIAL TILL – SILT TO SAND, DOMINATELY SILT W/TRACE FINE TO COARSE SAND, SOME GRAVEL, TRACE COBBLES, LITTLE BEDDING AND ABSENCE OF SHELL FRAGMENTS
BEDROCK – NORMALLY CONFINED BY OVERLYING TILL, GROUNDWATER ASSOCIATED W/FRACTURES, THOUGH FRACTURES NOT READILY APPARENT. MODERATE HEADS, LOW PRODUCING K_{Avg}=1.62E–5cm/sec (NATIVE GROUND). K_{Avg}=5.66E–5cm/sec (DISTURBED GROUND).	BEDROCK – TALCY TO SERICITIC PHYLLITE, OFTEN ABUNDANT GRAPHITE W/SOME PYRITE. SILICEOUS. DEPTHS TO TOP 0 TO 100FT.

FIGURE 8

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

TAILINGS SITE GENERAL
HYDROSTRATIGRAPHIC COLUMN

DATE: 10/2/01 DRAWING BY: CDG DESIGN BY: BJS REVIEWED BY: BNN PROJ OR REF. ----	PREPARED BY: EDE CONSULTANTS SHERIDAN, WYOMING PHONE: (307) 672-3793 GCMC DWG # HYDROANALYSIS/FIGURE8.DWG
SCALE: NONE	SHEET: 1 OF 1



LEGEND:

- PEAT EXCAVATED PRIOR TO TAILINGS PLACEMENT
- APPROXIMATE PEAT AQUIFER EXTENTS
- PEAT THICKNESS ISOPLETHS (C.I. = 5 FT.)
- APPROXIMATE EDGE OF PEAT AQUIFER
- INFERRED EDGE OF PEAT DEPOSIT
- CURRENT TAILINGS TOE
- STAGE II AREA OF TAILINGS PLACEMENT
- NORTHWEST TAILINGS BOUNDARY
- 10' CONTOUR LINE
- PZ-43 TAILINGS PIEZOMETER
- MW-005A UNDERDRAIN PIEZOMETER
- MW95-7 SAND PIEZOMETER
- MW95-5B TILL PIEZOMETER
- MW95-5C PEAT PIEZOMETER
- MWT01-09 BEDROCK PIEZOMETER
- GEOTECHNICAL DATA POINT
- ? UNKNOWN PEAT THICKNESS

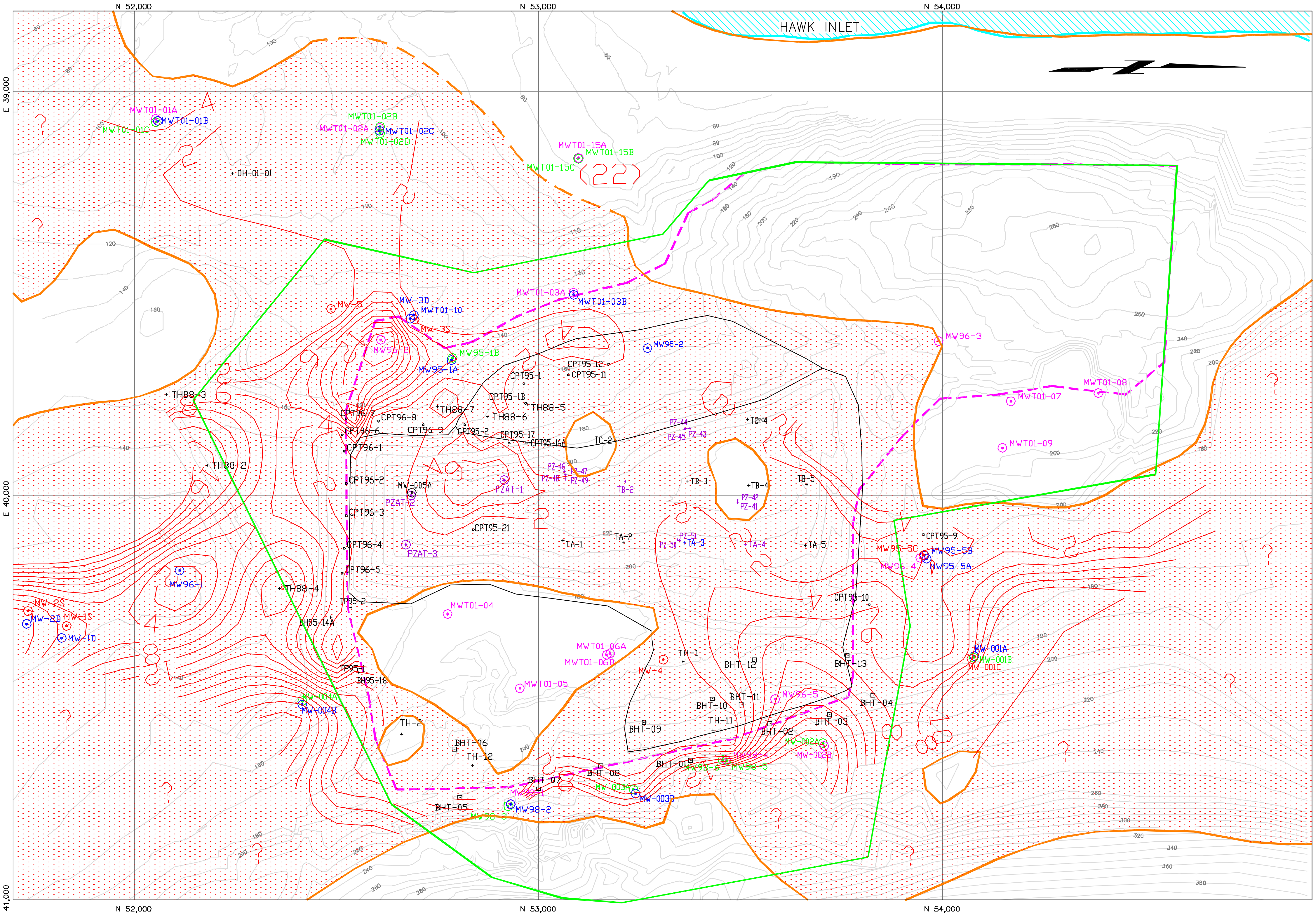
ISOPLETHS DRAWN FROM STRUCTURE MAPPING BASED ON WELL INFORMATION, BOREHOLE INFORMATION, AND NOTABLE TOPOGRAPHIC FEATURES (BEDROCK HIGHS, ETC.) AS APPROXIMATIONS ONLY.

FIGURE 9

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

PEAT ISOPACH MAP

DATE: 10/2/01	PREPARED BY: EDE CONSULTANTS, SHERIDAN, WYOMING, PHONE: (307) 672-3793
DRAWING BY: RWH	
DESIGN BY: RWH	
REVIEWED BY: BJS	
PROJ OR REF: ----	EDE DWG: HYDROANALYSIS/FIGURE9
SCALE: 1"=250'	SHEET: 1 OF 1



LEGEND:

- APPROXIMATE SAND AQUIFER EXTENTS
- SAND THICKNESS ISOPLETHS (C.I. = 2 FT.)
- APPROXIMATE EDGE OF SAND AQUIFER
- INFERRED EDGE OF SAND DEPOSIT
- CURRENT TAILINGS TOE
- STAGE II AREA OF TAILINGS PLACEMENT
- NORTHWEST TAILINGS BOUNDARY
- 10' CONTOUR LINE
- PZ-43 TAILINGS PIEZOMETER
- MW-005A UNDERDRAIN PIEZOMETER
- MW95-7 SAND PIEZOMETER
- MW95-5B TILL PIEZOMETER
- MW95-5C PEAT PIEZOMETER
- MWT01-09 BEDROCK PIEZOMETER
- GEOTECHNICAL DATA POINT
- ? UNKNOWN SAND THICKNESS
- (22) SAND THICKNESS OF SEPARATE BEACH TERRACE DEPOSIT. NOT INTERPRETED TO BE STRATIGRAPHICALLY EQUIVALENT TO OTHER SAND DEPOSITS SHOWN HERE.

ISOPLETHS DRAWN FROM STRUCTURE MAPPING BASED ON WELL INFORMATION, BOREHOLE INFORMATION, AND NOTABLE TOPOGRAPHIC FEATURES (BEDROCK HIGHS, ETC.) AS APPROXIMATIONS ONLY.

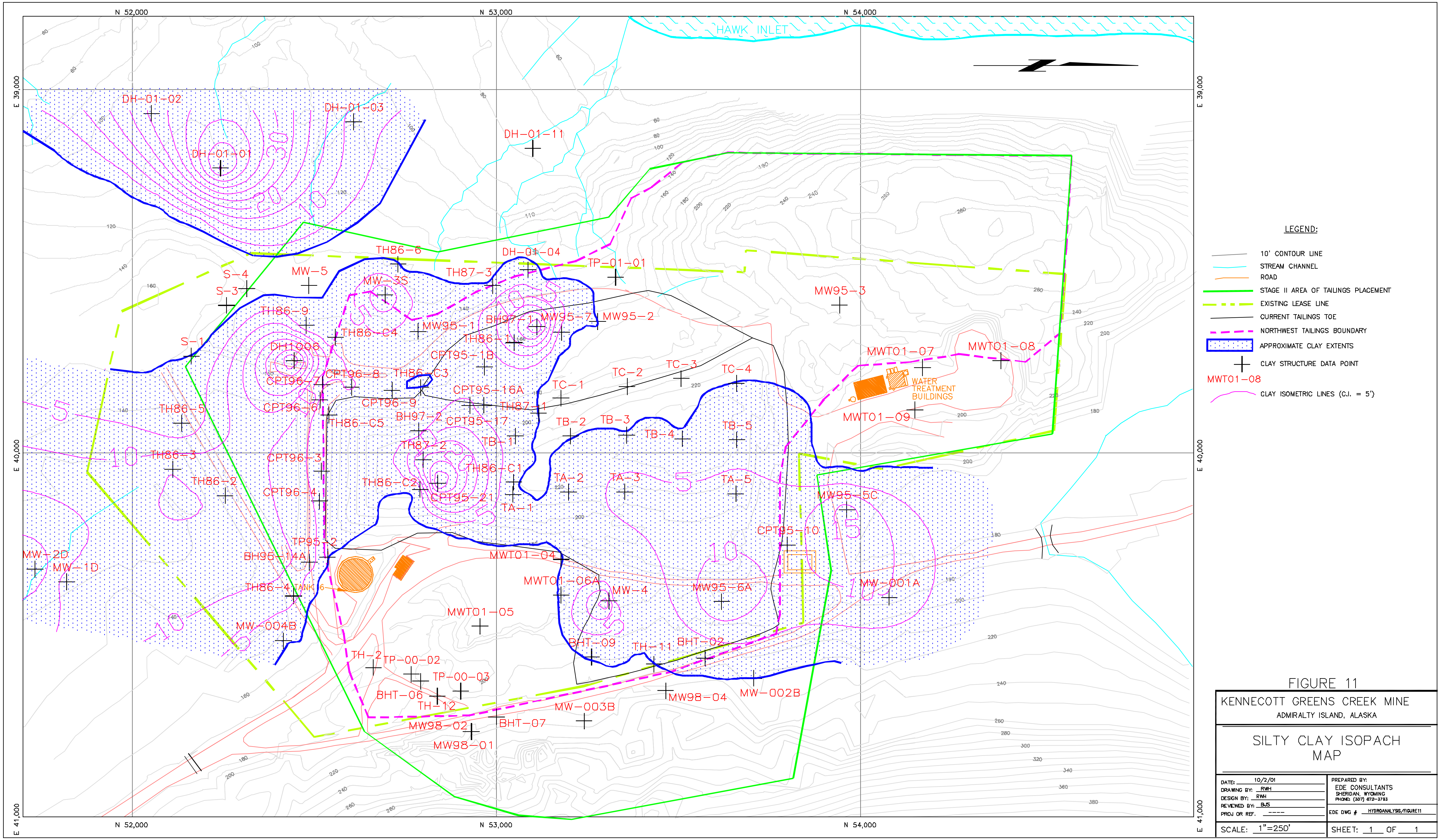
FIGURE 10

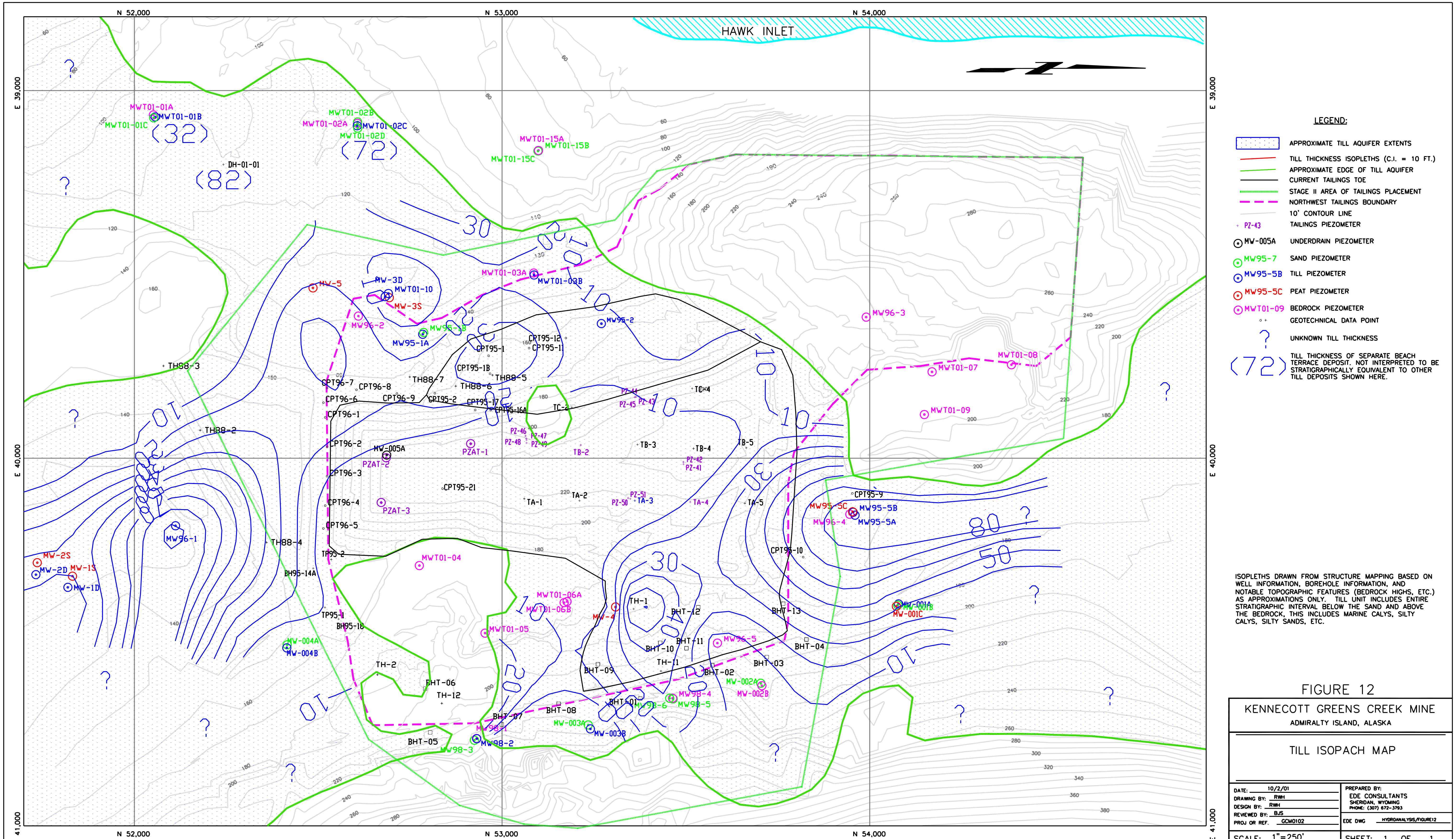
KENNECOTT GREENS CREEK MINE

ADMIRALTY ISLAND, ALASKA

SAND ISOPACH MAP

DATE: 10/2/01	PREPARED BY: EDE CONSULTANTS, SHERIDAN, WYOMING, PHONE: (307) 672-3793
DRAWING BY: RWH	
DESIGN BY: RWH	
REVIEWED BY: BJS	
PROJ OR REF. GCMD1D2	EDE DWG HYDROANALYSIS/FIGURE10
SCALE: 1"=250'	SHEET: 1 OF 1


HAWK INLET
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
LEGEND:
10' CONTOUR LINE
STREAM CHANNEL
ROAD
STAGE II AREA OF TAILINGS PLACEMENT
EXISTING LEASE LINE
CURRENT TAILINGS TOE
NORTHWEST TAILINGS BOUNDARY
APPROXIMATE CLAY EXTENTS
CLAY STRUCTURE DATA POINT
MWT01-08
CLAY ISOMETRIC LINES (C.I. = 5')
WATER TREATMENT BUILDINGS
TANK 6
DH-01-02
DH-01-03
DH-01-01
DH-01-11
DH-01-04
TP-01-01
TH86-6
TH87-3
MW-5
MW-3S
S-4
S-3
S-1
TH86-9
TH86-C4
MW95-1
BH97-1
MW95-7
MW95-2
MW95-3
DH1006
TH86-1
CPT95-18
CPT96-8
TH86-C3
CPT95-16A
TC-1
TC-2
TC-3
TC-4
MWT01-07
MWT01-08
MWT01-09
CPT96-6
CPT96-9
TH87-1
TH86-5
TH86-C5
BH97-2
CPT95-17
TB-2
TB-3
TB-4
TB-5
TB-1
TH87-2
TH86-3
CPT96-3
TH86-C1
TA-2
TA-3
TA-5
TH86-2
TH86-C2
CPT96-4
CPT95-21
TA-1
MW95-5C
CPT95-10
TP95-2
MW-2D
MW-1D
BH95-14A
MWT01-04
MWT01-06A
MW-4
MW95-6A
MW-001A
TH86-4
MW-004B
MWT01-05
BHT-09
TH-11
BHT-02
TH-2
TP-00-02
TP-00-03
BHT-06
TH-12
MW98-04
MW-002B
MW-003B
MW98-02
BHT-07
MW98-01
FIGURE 11
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
SILTY CLAY ISOPACH MAP
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793
EDE DWG # HYDROANALYSIS/FIGURE11
SCALE: 1"=250'
SHEET: 1 OF 1



HAWK INLET
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
LEGEND:
APPROXIMATE TILL AQUIFER EXTENTS
TILL THICKNESS ISOPLETHS (C.I. = 10 FT.)
APPROXIMATE EDGE OF TILL AQUIFER
CURRENT TAILINGS TOE
STAGE II AREA OF TAILINGS PLACEMENT
NORTHWEST TAILINGS BOUNDARY
10' CONTOUR LINE
PZ-43 TAILINGS PIEZOMETER
MW-005A UNDERDRAIN PIEZOMETER
MW95-7 SAND PIEZOMETER
MW95-5B TILL PIEZOMETER
MW95-5C PEAT PIEZOMETER
MWT01-09 BEDROCK PIEZOMETER
GEOTECHNICAL DATA POINT
? UNKNOWN TILL THICKNESS
(72) TILL THICKNESS OF SEPARATE BEACH TERRACE DEPOSIT. NOT INTERPRETED TO BE STRATIGRAPHICALLY EQUIVALENT TO OTHER TILL DEPOSITS SHOWN HERE.
ISOPLETHS DRAWN FROM STRUCTURE MAPPING BASED ON WELL INFORMATION, BOREHOLE INFORMATION, AND NOTABLE TOPOGRAPHIC FEATURES (BEDROCK HIGHS, ETC.) AS APPROXIMATIONS ONLY. TILL UNIT INCLUDES ENTIRE STRATIGRAPHIC INTERVAL BELOW THE SAND AND ABOVE THE BEDROCK, THIS INCLUDES MARINE CALYS, SILTY SANDS, SILTY CALYS, SILTY SANDS, ETC.
FIGURE 12
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
TILL ISOPACH MAP
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. GCM0102
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793
EDE DWG HYDROANALYSIS/FIGURE12
SCALE: 1"=250'
SHEET: 1 OF 1

lithology, enabling differentiation into several sub-units consisting of a silty clay member and a silty sandy till member. One lithologic unit of major significance to the groundwater movements within the tailings area is the silty clay layer that overlies the coarse till unit. This unit is of lacustrine or marine origin, is laminated, and varies from 0 to 50 ft thick with the thickest extent to the southwest of the existing tailings facility. The clay layer is relatively continuous across the site, inter-tongued with the underlying till and is a vertical conductivity barrier for groundwater movement. It is these 6 basic strata, which were considered in both the conceptual and numeric hydrologic analysis.

The materials that compose the various stratigraphic units provide insight into the nature and hydrologic behavior of the material from a conceptual perspective. Tailings in the existing facility exhibit the following particle size distribution: 76 to 96 percent are finer than 200 mesh (0.075 mm), 64 to 85 percent are finer than 400 mesh (0.038 mm) and 5 to 12 percent are clay sized (<0.002 mm). The tailings are compacted in place to a specification of at least 90% Standard Proctor density at a moisture content of 12% to 14% by weight. The tailings material has a specific gravity of 3.6 and a dry proctor density of 134.2 lbs./cu. ft. Using these values the void ratio, porosity, and degree of saturation can be computed:

$$\text{Porosity} = \eta = 1 - (\gamma_d / 62.4G_s) \times 100$$
$$\eta = 1\text{- } (134.2 \text{ lbs/ft}^3/62.4 \text{ 1bs/ ft}^3 \times 3.6) \times 100 = 59\%$$

A porosity of 59% is equal to a void ratio (e) of 0.59. The degree of saturation can be computed by:

$$S = (V_w / V_v) = (wGx / e)$$

where: S = degree of Saturation
V_w = Volume of water
V_v = Volume of voids
w = water content in terms of ratio of weight of water to dry weight of soil
e = void ratio
G_s = apparent specific gravity

$$S = ((.13)(2.15)/0.59)x100 = 47\%$$

The porosity of 59% is relatively high but consistent with expected porosities of clay size fraction materials of 40% to 70% (Driscoll, 1986 and Freeze and Cherry, 1979).

The degree of saturation is computed to be approximately 47% when the tailings arrive at the repository. Due to the fine-grained texture of this tailings material, the resultant hydraulic conductivity is extremely low. Four in-situ hydraulic conductivity tests have been conducted with consistent results. These tests show the average hydraulic conductivity to be 1.88 x 10^{-6} cm/sec and ranged from 3.47 x 10^{-8} cm/sec to 6.78 x 10^{-6} cm/sec (EDE; Feb, 1997)(EDE; August, 2000). In addition to the falling head and rising head well tests, double ring infiltrometer studies were conducted on the tailings material (EDE; Feb, 1997) (EDE; July, 2000). The results of these tests show the infiltration rates to average 0.093 cm/hr (2.5 x 10^{-5} cm/sec). Due to testing differences, infiltration rates do not directly correlate to pump test/slug test saturated zone hydraulic conductivity.

The peat is composed of a soft, amorphous, fine, fibrous, organic mass. Particle size analyses are not applicable to peat materials. The material thickness ranges over the site from less than 1 ft. at bedrock highs, to approximately 18 ft. at the northeast corner and the southwest corner of the site. Figure 9 shows the occurrence of peat and thickness isopach. The peat is essentially universally present everywhere on the site at some thickness with the exception of areas where it has been deliberately excavated. Beneath the existing tailings peat is present excepting 3 areas. Two of these areas are due to construction excavation and the third is near well TB-4. Based upon the well log for TB-4 there may be a discontinuity in the peat deposit associated with a local bedrock high.

The density of the peat material is typically very low, but varies with overburden loading. The hydraulic characteristics of the peat change considerably under loading and subsequent compression. The peat has a hydraulic conductivity ranging from 1 x 10^{-3} cm/sec in an undisturbed state to 1 x 10^{-6} cm/sec or less under compressive loading (SRK, 1996). In situ testing indicates that the average hydraulic conductivity of uncompressed peat is 2.30 x 10^{-4} cm/sec (EDE, 1997, 2000). The hydraulic conductivity of peat under embankments of 10 ft. high or higher is 1 x 10^{-6} cm/ sec or lower. Therefore under virtually the entire footprint of the existing pile, the hydraulic conductivity of the peat is likely 10^{-6} cm/sec or less (SRK, 1996). Such low conductivity achieves a level of conductivity low enough to function as a natural liner and hydraulic barrier.

The sand layer occurs discontinuously over the site, and is composed of sand and gravel with some silt and clay (typically less than 20%). Where present the sand layer material thickness beneath the existing tailings ranges from non-existent to four feet. Outside the footprint of the tailings the thickness ranges from 0 ft. to 26 ft. near well MW-004A, but thickness of 2 to 4 feet predominate. Figure 10 shows the occurrence of sand and thickness isopach. At bedrock highs the sand is absent. The density of the sand material is loose to compact. Due to the generally thin nature of the deposit, permeability measurements both in the field and in the lab have been difficult to obtain, moreover, the gravelly sand and peat are in vertical communication and thus behave as a single aquifer. In-situ pumping tests indicate that the permeability ranges from 8.14×10^{-4} cm/sec to 1.31×10^{-6} cm/sec (EDE Consultants, 1996, 1999, 2000, 2001).

The silty clay component underlying the sand layer varies greatly in thickness and extent, due primarily to the inter-tonguing with similar sized sediments of a different depositional origin as well as infilling and deposition within topographic lows. Typically, the silty clay is grey-blue, can be hard or very soft (depending on moisture content), and is marine or lacustrine in origin. Figure 11 indicates approximate clay extents and thicknesses. While locations with thick sections of homogenous clay have been discovered, normally there is a trace silt or sand aspect, often seen as thin lenses within the clay. Some work (SRK 1996) indicated that grain size analysis portrayed a 40% by weight silt component, 30% clay and 30% sand thus the silty clay nomenclature for the unit. Grain size distribution analysis from the expansion area was conducted in early 2001 (Klohn-Crippen, 2001). In summary, results from the silty clay indicate 0-3.7% gravel, 2.1-34% sand, 41-51.5% silt, and 30-50% clay while till samples had 13.6-24.2% gravel, 34-57.3% sand, 27.9-41% silt and 0-18% clay. The significant differences in grain size distribution and presence of shell fragments portray the more quiescent marine setting versus the more variable and energetic nature of the glacio-fluvial environment observed in the underlying sediments. Hydraulic conductivities derived from laboratory testing of shelby tube samples have values ranging from 2.15 x 10^{-7} cm/sec to 9.55 x 10^{-9} cm/sec for the silty clay unit (Klohn-Crippen, 2001). Permeabilities in these ranges indicate the significant barrier capabilities of the aquitard and will be discussed further in Section 3.0 and 4.0 in this report.

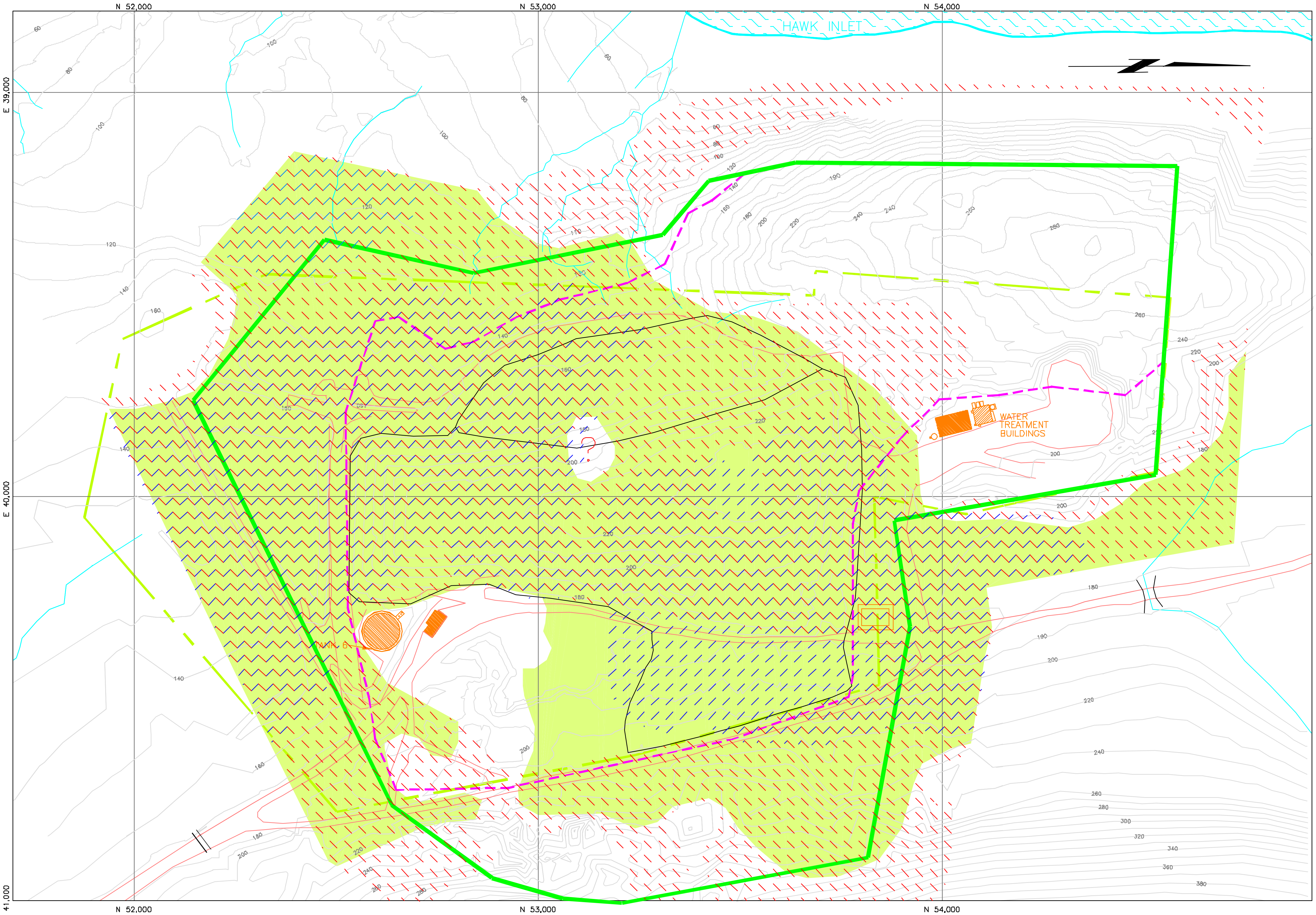
The till material is variable in composition both vertically and horizontally, ranging from a grey silty clay to a silty gravel. Although referred to as "till" this unit is a combination of fluvial deposits and glacial till by virtue of the presence of bedding and segregation (sorting). The till unit varies in thickness from absent in some areas to a thickness in excess of 60 ft. in other areas, and an overall average of approximately 15 ft. Figure 12 shows the occurrence of till and thickness isopach. The till can contain trace coarse sediments ranging in size from gravel to cobbles. However, immediately below the silty clay layer the silty till unit between the silty clay and bedrock consists of varved sequences of inter-bedded clays and sands grading into non-layered silts (SRK, 1996). This unit averages 11 feet in thickness and blankets most of the tailings placement area. Grain size analysis indicates that the unit is poorly sorted with approximately 10 to 35% gravel by weight, 35 to 60% sand and 10 to 40% silt and clay (SRK, 1996)—note that these values correlate rather well with laboratory analysis conducted by Klohn-Crippen in 2001. In-situ rising/falling head tests as well as lab consolidation tests indicate a hydraulic conductivity range from 10^{-5} cm/sec to 10^{-7} cm/sec, but are generally about 10^{-6} cm/sec. Taken as a unit, this silty till falls within the range of hydraulic behavior of a liner rather than a transmissive hydrologic unit. Within the till unit a silty clay layer generally occurs that, if present, forms an internal aquitard/aquiclude. The role of this unit in water management is discussed in Section 3.0 and 4.0 of this report.

The complexity of the till material and the inter-bedding of glacial-fluvial sediments results in a wide range of hydraulic conductivity values and in-situ hydraulic conductivity measurements are highly dependent upon the completion zone of the well/piezometer. In general, results of the field tests (EDE Consultants, 1995, 1999, 2000, 2001) show that the till materials exhibit low hydraulic conductivity, on the order of 7 x 10^{-4} in the silty sand aspects to 2 x 10^{-8}cm/sec in the finer grained portions. Note that these values are averages and somewhat skewed toward the high end due to completion of wells in seemingly more permeable aspects of the formation. Historically, till aquifer characteristics have included high, often artesian pressures due to the confinement by the silty clay and silty till overlying the coarser glacial sediments.

The extents of the peat, clay, and till present beneath the area of full Stage II tailings placement is significant because these three geologic units generally have hydraulic conductivities of 1 x 10^{-6} cm/sec or less as detailed above. The low hydraulic conductivities of these units collectively provide a barrier to tailings water passing through tailings and contacting groundwater aquifers. As is noted in Section 3, the hydraulic head within the till aquifer is great enough to preclude infiltration from the upper level clay, sand, and peat aquifers under most of the existing and some of the Northwest tailings placement area. This till hydraulic head coupled with the low conductivities of the compressed peat, clay, silty clay, sandy clay and low permeability layers of the till (SRK, 1996) will be further discussed in Sections 2.5.2.2 and 3. This head permeability relationship is shown to provide a natural barrier/liner to infiltration of tailings water to groundwater beneath the pile.

Figure 13 shows the combined distribution of the peat, clay, and till structures beneath the area of Stage II tailings placement. Examination of this figure shows that the silty clay unit is the primary hydraulic barrier, while other units such as the compressed peat, silty till, combined with the silty clay provide a multi-layered hydraulic barrier to tailings water movement. In areas of the Stage II development where no peat, clay, or till are present beneath tailings placement (typically bedrock highs) a liner will be installed prior to tailings placement. Such bedrock exposures occur in the Northwest and East Ridge and Pit 5 placement areas. Figure 26 shows the existing and planned configuration of tailings pile under-liners for the current pile, the Northwest expansion and the full Stage II build-out. The small area just east of the west buttress that shows the apparent lack of sedimentary structures may be an artifact of drill refusal on a boulder rather than bedrock. Photos taken during excavation of the west buttress area support this hypothesis.

The bedrock consists of hard, banded schist and phyllite. The nature of the bedrock with respect to fractures and material hardness varies over the property. In addition the conductivity varies depending on whether the bedrock is undisturbed bedrock, or bedrock associated with quarrying operations or road construction which has enhanced fracturing due to blasting and heavy equipment operations. Native bedrock testing indicates that the hydraulic conductivity of the bedrock is quite low (10^{-5} cm/sec to 10^{-7} cm/sec) (SRK, 1996: EDE Consultants, 1998, 2001). Testing of disturbed area bedrock yielded results showing a higher hydraulic conductivity but still low at 9.03×10^{-5} cm/sec to 7.48×10^{-6} cm/sec and in general significantly lower conductivities occur at depths greater than 20 feet beneath top of native or disturbed bedrock.



LEGEND:

- 10' CONTOUR LINE
- STREAM CHANNEL
- ROAD
- STAGE II AREA OF TAILINGS PLACEMENT
- EXISTING LEASE LINE
- CURRENT TAILINGS TOE
- NORTHWEST TAILINGS BOUNDARY
- APPROXIMATE PEAT EXTENT
- APPROXIMATE CLAY EXTENT
- APPROXIMATE TILL EXTENT
- UNCERTAIN BOREHOLE DATA

NOTE:
PEAT HYDRAULIC CONDUCTIVITY~10^{-6} cm/s AFTER CONSOLIDATION LOADING BY TAILS
CLAY HYDRAULIC CONDUCTIVITY~10^{-7} TO 10^{-10} cm/s
TILL HYDRAULIC CONDUCTIVITY~10^{-6} cm/s TO 10^{-8} cm/S

FIGURE 13

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

DISTRIBUTION OF LOW PERMEABILITY STRATA (10^{-6} cm/s OR LESS) BENEATH STAGE II TAILINGS PLACEMENT

DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----

PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793

EDE DWG # HYDROANALYSIS/FIGUREPERMEABILITY2

SCALE: 1"=250'
SHEET: 1 OF 1

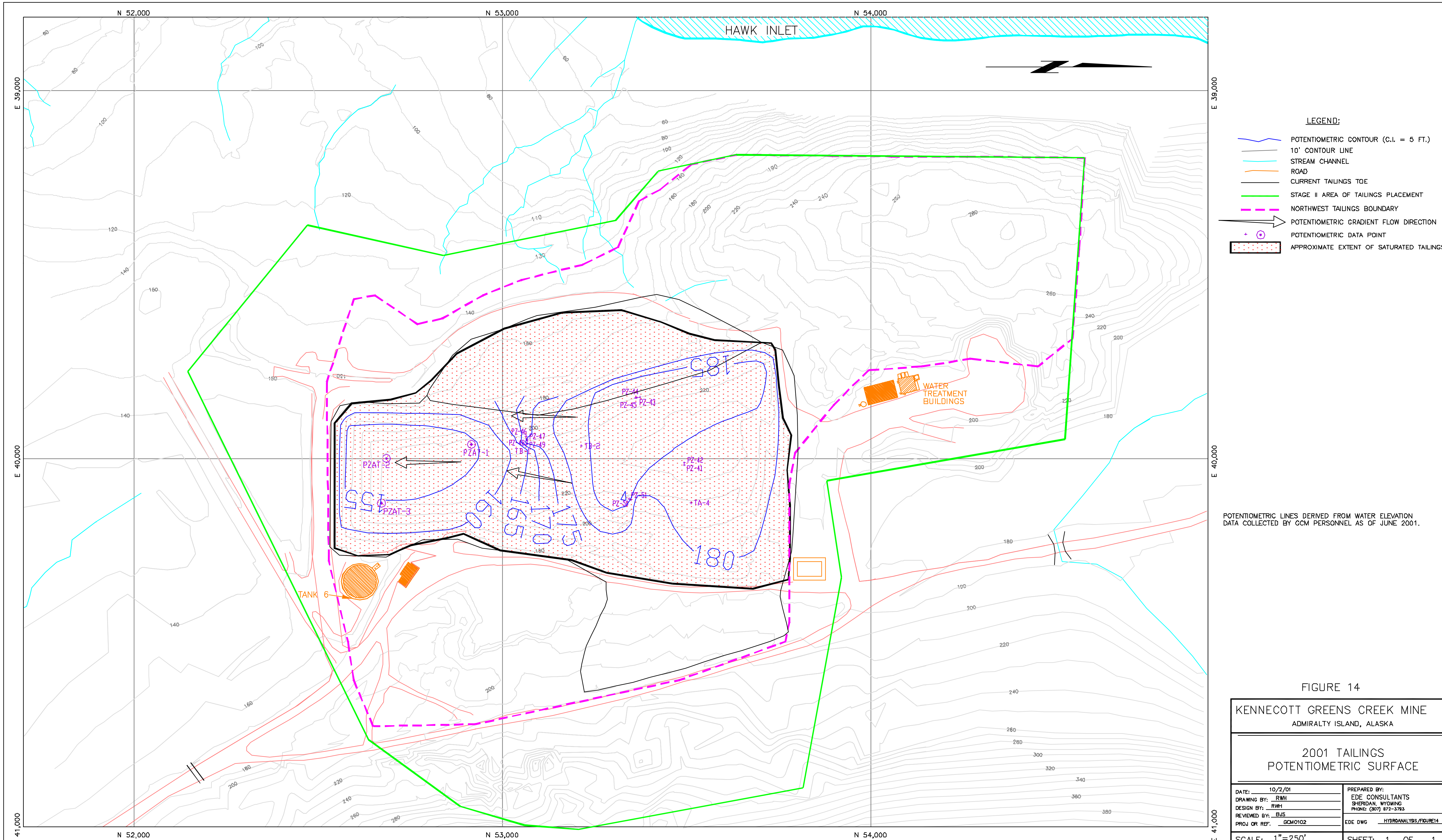
2.5.2.2 Groundwater Flow

In general, the groundwater flow direction for all water bearing formations is from east to west. There are local variations driven by geologic structure, water management devices/structures, and groundwater discharge areas. There are no active monitoring wells completed in the peat sand aquifer under the existing tailings pile. However potentiometric elevations in the aquifer are probably most accurately reflected in the under-drain well MWT-00-05 (136.05 ft. AMSL). In addition, as described earlier, the compressed peat beneath the tailings pile functions more as a low permeability liner than a conductive hydrologic unit. The recent potentiometric surfaces for all water bearing units at the site are shown as:

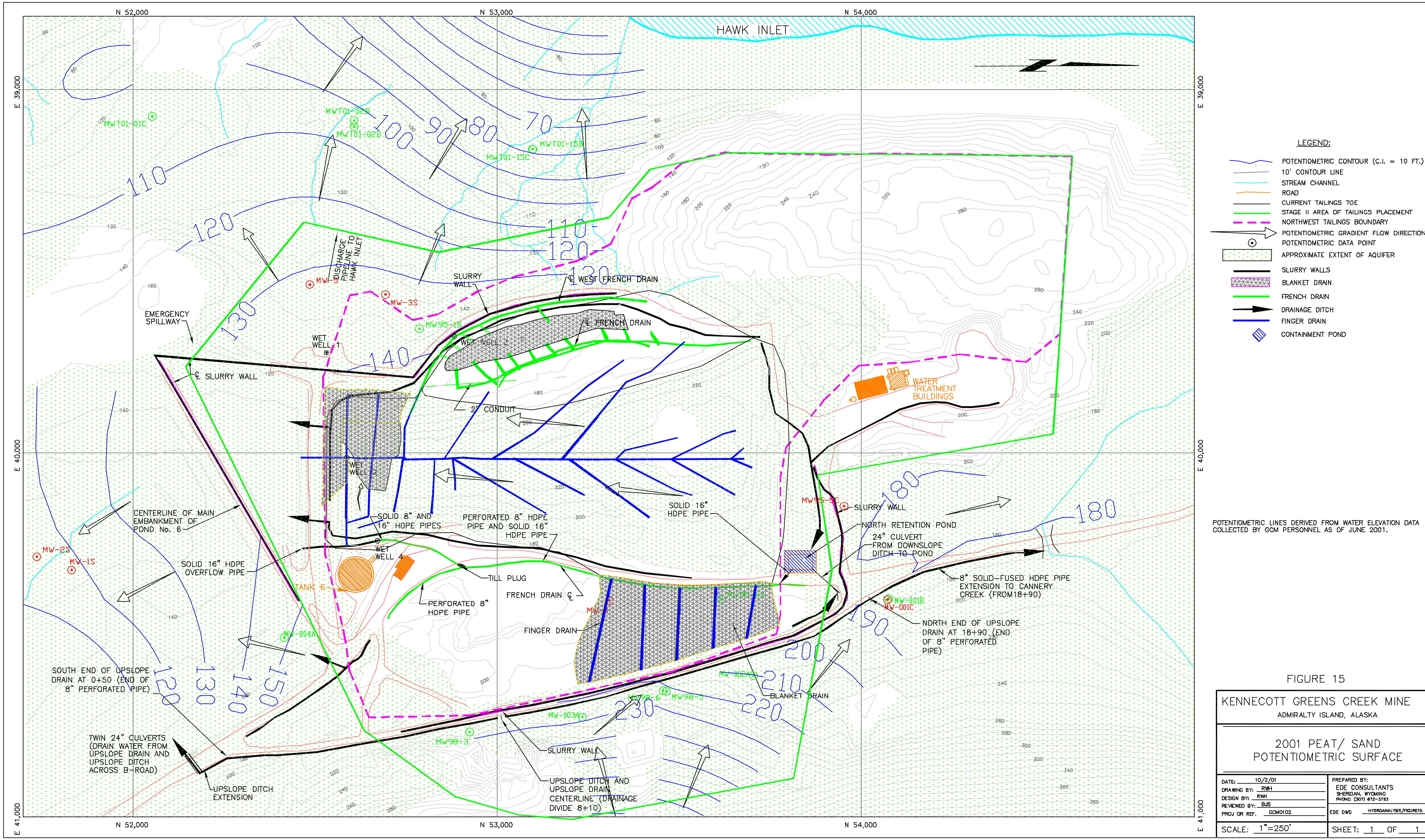
- Tailings – Figure 14
- Peat/Sand – Figure 15
- Till – Figure 16
- Bedrock – Figure 17
- Post Closure Tailings – Figure 18

These potentiometric maps depict the groundwater occurrence, flow direction, and flow gradient using flow vectors normal to the equipotential lines of head for each water bearing formation. Figures 19 thru 22 depict hydrogeologic cross sections through the tailings area. Figure 4 shows cross section locations. The following discussion presents the details of the groundwater flow regime for each stratum, beginning with the tailings and proceeding downward in order of occurrence.

Water movement in the tailings is both saturated flow and unsaturated flow. Under active mining, milling and tailings placement activities, the tailings are directly exposed to precipitation in the form of rain and snow. The tailings pile is sloped to promote runoff and minimize ponding. This decreases the opportunity for infiltration recharge to occur. In addition the tailings material is compacted to at least a 90% Proctor maximum density for pile stability, which also reduces infiltration. Testing has been conducted on the tailings to determine the infiltration rates as discussed in Section 2.5.2.1. Infiltrating



HAWK INLET
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
WATER TREATMENT BUILDINGS
TANK 6
PZAT-1
PZAT-2
PZAT-3
TB-2
TA-4
PZ-41
PZ-42
PZ-43
PZ-44
PZ-45
PZ-47
PZ-49
PZ-51
155
160
165
170
175
180
185
LEGEND:
POTENTIOMETRIC CONTOUR (C.I. = 5 FT.)
10' CONTOUR LINE
STREAM CHANNEL
ROAD
CURRENT TAILINGS TOE
STAGE II AREA OF TAILINGS PLACEMENT
NORTHWEST TAILINGS BOUNDARY
POTENTIOMETRIC GRADIENT FLOW DIRECTION
POTENTIOMETRIC DATA POINT
APPROXIMATE EXTENT OF SATURATED TAILINGS
POTENTIOMETRIC LINES DERIVED FROM WATER ELEVATION DATA COLLECTED BY GCM PERSONNEL AS OF JUNE 2001.
FIGURE 14
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
2001 TAILINGS
POTENTIOMETRIC SURFACE
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. GCM0102
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793
EDE DWG HYDROANALYSIS/FIGURE14
SCALE: 1"=250'
SHEET: 1 OF 1


HAWK INLET
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
LEGEND:
POTENTIOMETRIC CONTOUR (C.I. = 10 FT.)
10' CONTOUR LINE
STREAM CHANNEL
ROAD
CURRENT TAILINGS TOE
STAGE II AREA OF TAILINGS PLACEMENT
NORTHWEST TAILINGS BOUNDARY
POTENTIOMETRIC GRADIENT FLOW DIRECTION
POTENTIOMETRIC DATA POINT
APPROXIMATE EXTENT OF AQUIFER
SLURRY WALLS
BLANKET DRAIN
FRENCH DRAIN
DRAINAGE DITCH
FINGER DRAIN
CONTAINMENT POND
POTENTIOMETRIC LINES DERIVED FROM WATER ELEVATION DATA COLLECTED BY GCM PERSONNEL AS OF JUNE 2001.
MWT01-01C
MWT01-02B
MWT01-02D
MWT01-15B
MWT01-15C
DISCHARGE PIPELINE TO HAWK INLET
MW-3
MW-3S
MW95-1B
SLURRY WALL
℄ WEST FRENCH DRAIN
℄ FRENCH DRAIN
WET WELL 1
WET WELL 2
WET WELL 3
WET WELL 4
EMERGENCY SPILLWAY
℄ SLURRY WALL
2" CONDUIT
WATER TREATMENT BUILDINGS
CENTERLINE OF MAIN EMBANKMENT OF POND No. 6
SOLID 8" AND 16" HDPE PIPES
PERFORATED 8" HDPE PIPE AND SOLID 16" HDPE PIPE
SOLID 16" HDPE PIPE
MW95-5C
SLURRY WALL
NORTH RETENTION POND
24" CULVERT FROM DOWNSLOPE DITCH TO POND
MW-2S
MW-1S
SOLID 16" HDPE OVERFLOW PIPE
TANK 6
TILL PLUG
FRENCH DRAIN ℄
PERFORATED 8" HDPE PIPE
FINGER DRAIN
8" SOLID-FUSED HDPE PIPE EXTENSION TO CANNERY CREEK (FROM18+90)
MW-001B
MW-001C
NORTH END OF UPSLOPE DRAIN AT 18+90 (END OF 8" PERFORATED PIPE)
MW-004A
SOUTH END OF UPSLOPE DRAIN AT 0+50 (END OF 8" PERFORATED PIPE)
BLANKET DRAIN
MW-002A
MW98-6
MW98-5
MW-003A
MW98-3
TWIN 24" CULVERTS (DRAIN WATER FROM UPSLOPE DRAIN AND UPSLOPE DITCH ACROSS B-ROAD)
UPSLOPE DITCH EXTENSION
SLURRY WALL
UPSLOPE DITCH AND UPSLOPE DRAIN CENTERLINE (DRAINAGE DIVIDE 8+10)
70
80
90
100
110
120
130
140
150
180
190
200
210
220
230
FIGURE 15
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
2001 PEAT/ SAND POTENTIOMETRIC SURFACE
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. GCM0102
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3783
EDE DWG HYDROANALYSIS/FIGURE15
SCALE: 1"=250'
SHEET: 1 OF 1

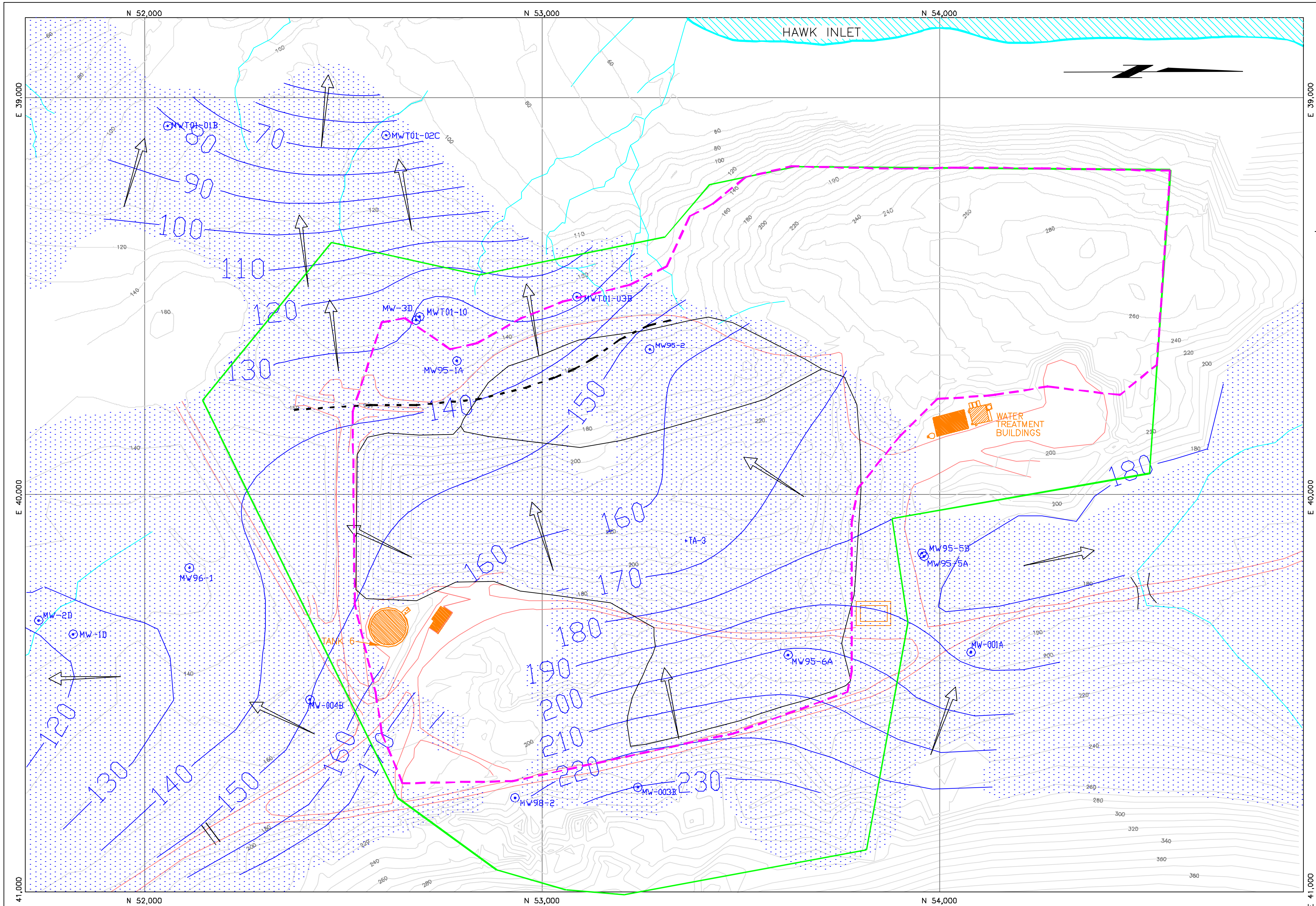


FIGURE 16

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

2001 TILL
POTENTIOMETRIC SURFACE

DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. GCMD1D2

PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793

EDE DWG HYDRDANALYSIS/FIGURE16

SCALE: 1"=250'
SHEET: 1 OF 1

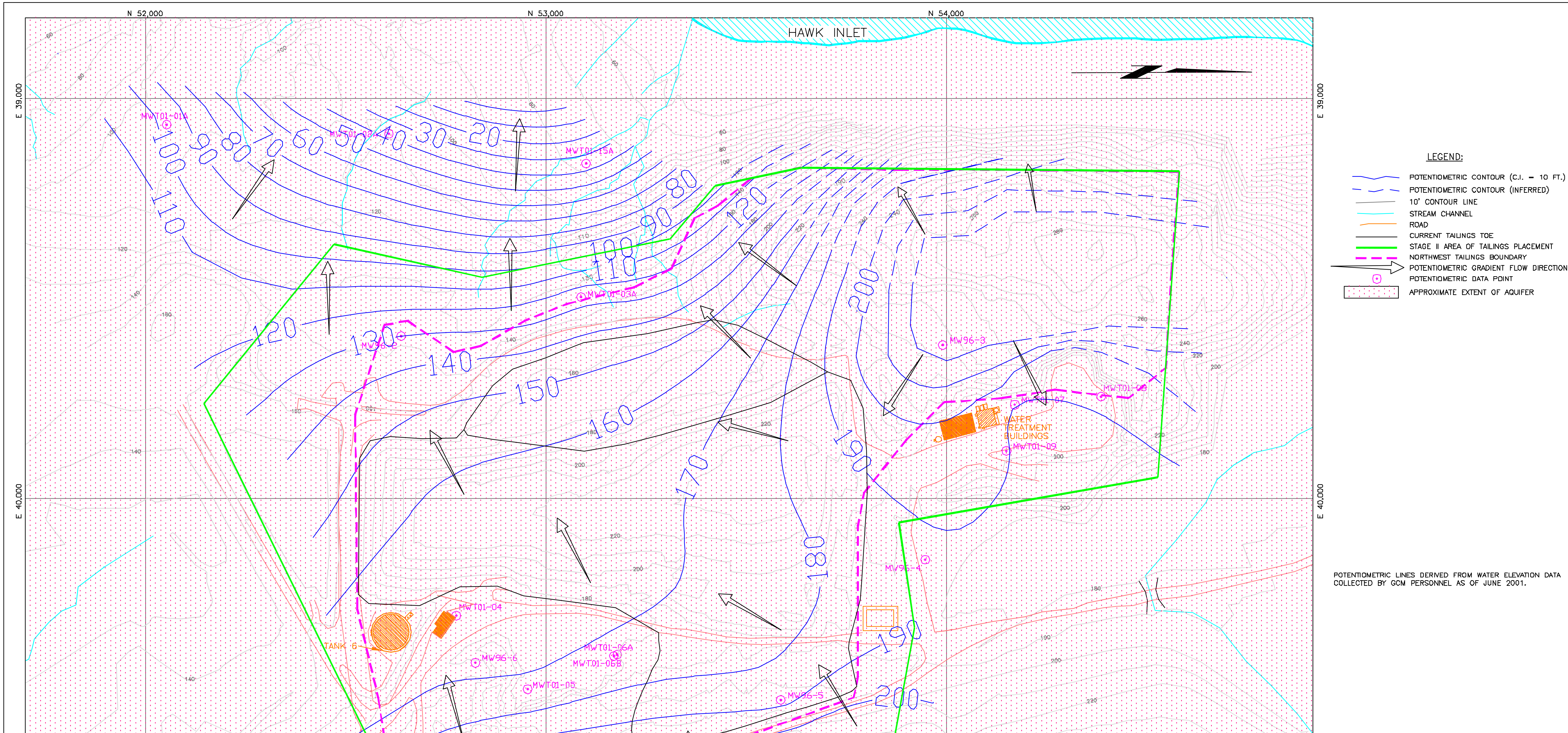


FIGURE 17

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

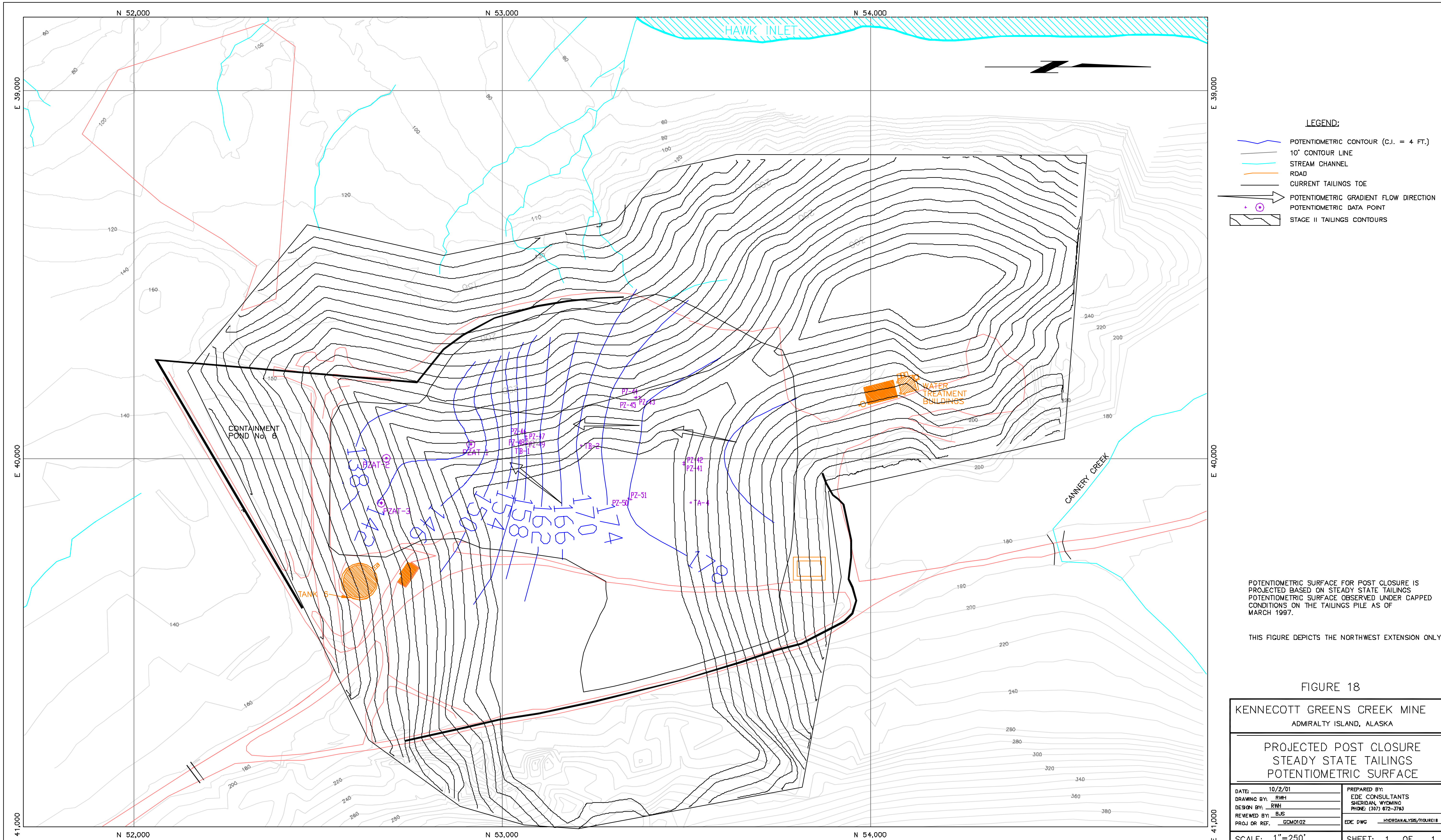
2001 BEDROCK
POTENTIOMETRIC SURFACE

DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. GCM0102

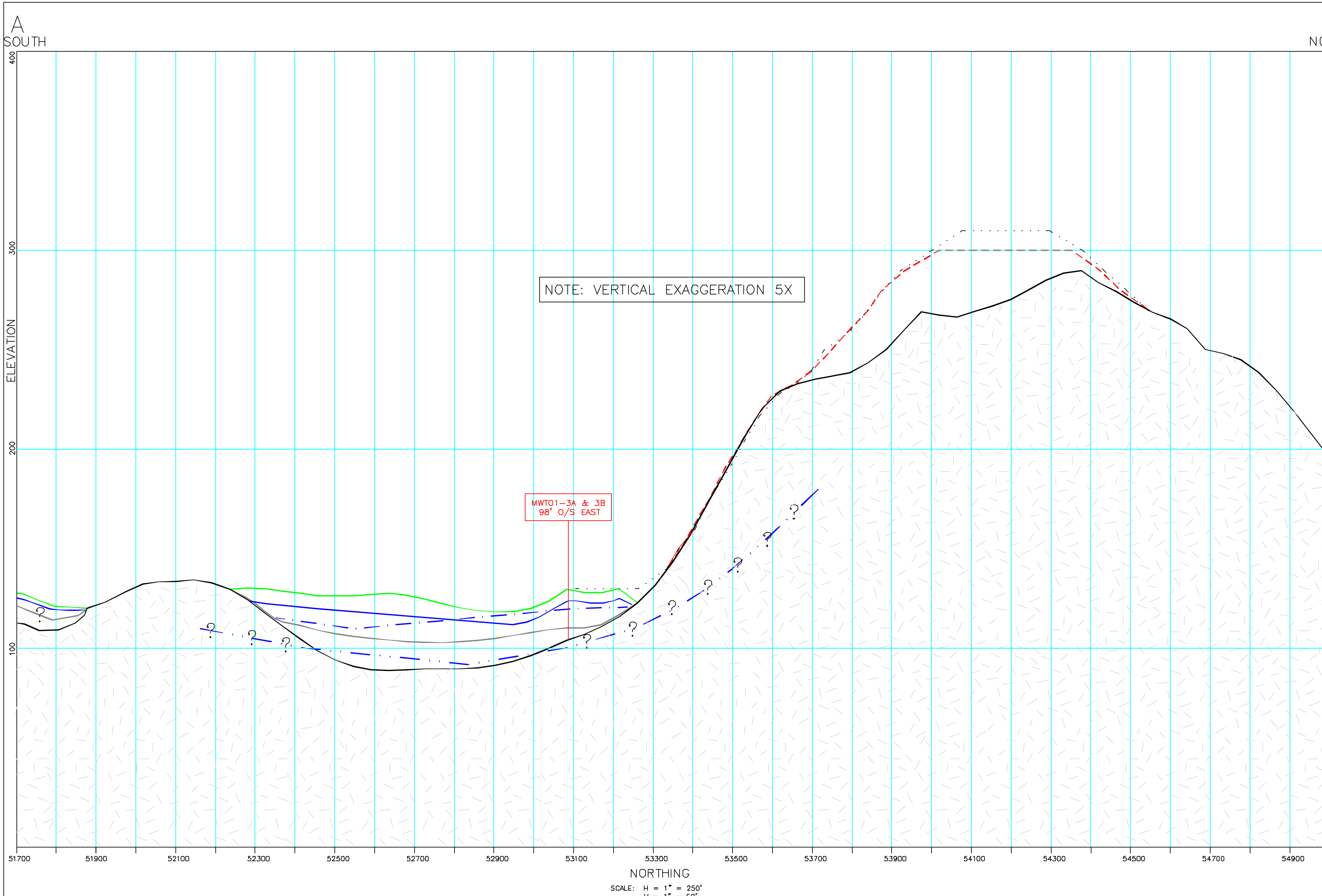
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793

EDE DWG HYDROANALYSIS/FIGURE17

SCALE: 1"=250'
SHEET: 1 OF 1



N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
HAWK INLET
CONTAINMENT POND No. 6
PZAT-2
PZAT-3
PZAT-1
PZ-46
PZ-47
PZ-48
PZ-49
TB-1
TB-2
PZ-44
PZ-45
PZ-43
PZ-42
PZ-41
PZ-50
PZ-51
TA-4
TANK 6
WATER TREATMENT BUILDINGS
CANNERY CREEK
138
142
146
150
154
158
162
166
170
174
178
LEGEND:
POTENTIOMETRIC CONTOUR (C.I. = 4 FT.)
10' CONTOUR LINE
STREAM CHANNEL
ROAD
CURRENT TAILINGS TOE
POTENTIOMETRIC GRADIENT FLOW DIRECTION
POTENTIOMETRIC DATA POINT
STAGE II TAILINGS CONTOURS
POTENTIOMETRIC SURFACE FOR POST CLOSURE IS PROJECTED BASED ON STEADY STATE TAILINGS POTENTIOMETRIC SURFACE OBSERVED UNDER CAPPED CONDITIONS ON THE TAILINGS PILE AS OF MARCH 1997.
THIS FIGURE DEPICTS THE NORTHWEST EXTENSION ONLY
FIGURE 18
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
PROJECTED POST CLOSURE
STEADY STATE TAILINGS
POTENTIOMETRIC SURFACE
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. GCM0102
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3763
EDE DWG HYDROANALYSIS/FIGURE18
SCALE: 1"=250'
SHEET: 1 OF 1



NOTES:

1. ELEVATIONS DEVELOPED FROM GRIDDED AND CONTOURED SURFACES DERIVED FROM BOREHOLE LOGS. ACTUAL CONDITIONS BETWEEN HOLES MAY DIFFER FROM THAT SHOWN.
2. SEVERAL MONITORING WELLS/BOREHOLES NOTED ALONG SECTION FOR REFERENCE.
3. NORTHWEST TAILINGS DESIGN AND PRESENT TAILINGS INFORMATION PROVIDED BY KGCMC MAY AND JUNE 2001.
4. WATER LEVEL DATA COLLECTED BY KGCMC PERSONNEL AS OF JUNE 2001.
5. FOR CORRELATION PURPOSES, TILL UNIT INCLUDES ENTIRE STRATIGRAPHIC INTERVAL BELOW SAND AND ABOVE THE BEDROCK.

SEE FIGURE 4 FOR CROSS SECTION LOCATIONS

LEGEND:

- PROPOSED ULTIMATE PILE
- NORTHWEST TAILINGS DESIGN
- BEDROCK TOP
- BEDROCK WATER LEVEL
- PEAT TOP
- PEAT WATER LEVEL
- TILL TOP
- TILL WATER LEVEL
- BASEMENT ROCK

FIGURE 19

KENNECOTT GREENS CREEK MINE

ADMIRALTY ISLAND, ALASKA

HYDROGEOLOGIC SECTION A–A'

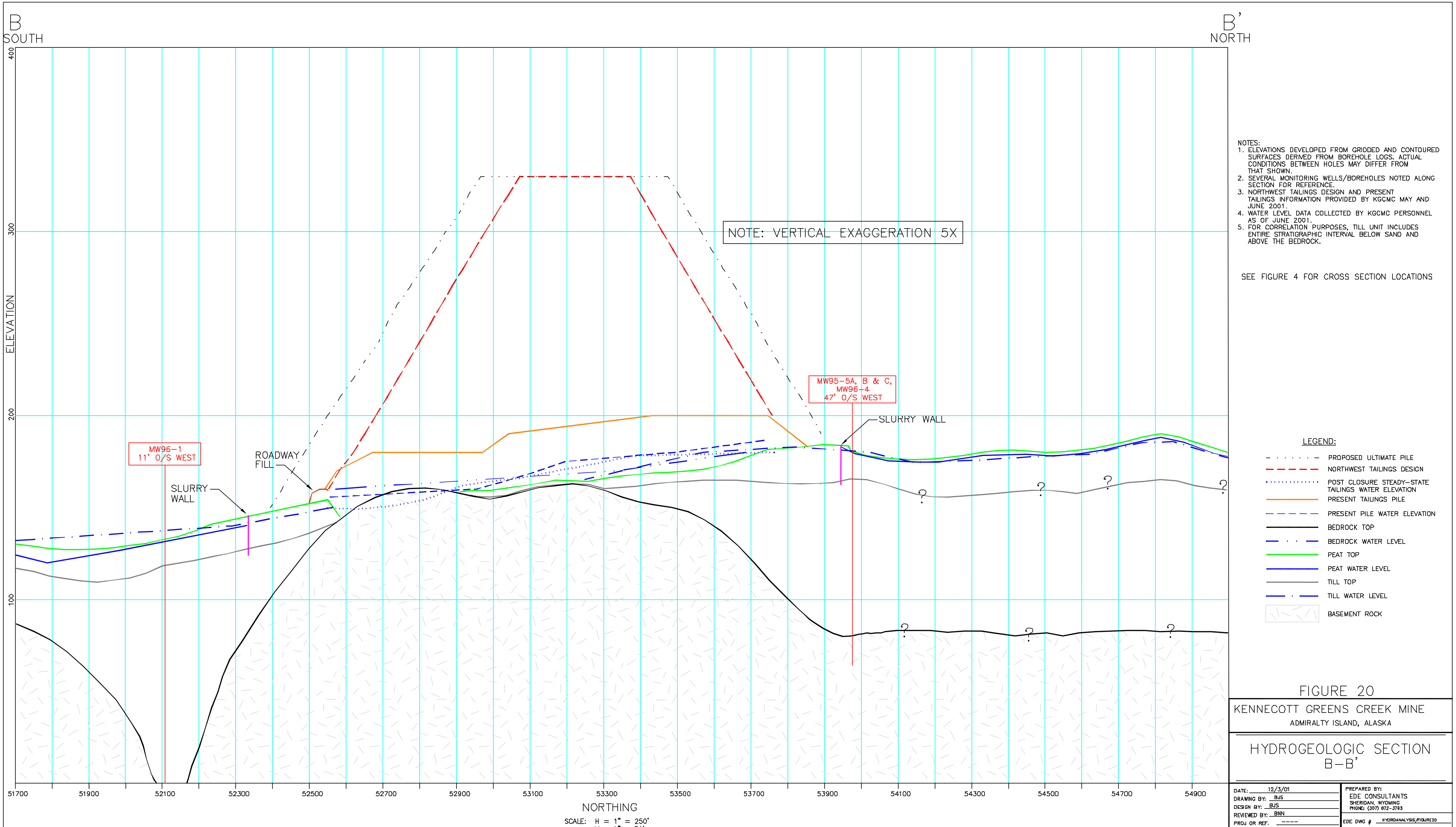
DATE: 12/3/01
DRAWING BY: BJS
DESIGN BY: BJS
REVIEWED BY: BNN
PROJ OR REF. ----

PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793

EDE DWG # HYDROANALYSIS/FIGURE18

SCALE: AS NOTED

SHEET: 1 OF 1



NOTES:
1. ELEVATIONS DEVELOPED FROM GRIDDED AND CONTOURED SURFACES DERIVED FROM BOREHOLE LOGS. ACTUAL CONDITIONS BETWEEN HOLES MAY DIFFER FROM THAT SHOWN.
2. SEVERAL MONITORING WELLS/BOREHOLES NOTED ALONG SECTION FOR REFERENCE.
3. NORTHWEST TAILINGS DESIGN AND PRESENT TAILINGS INFORMATION PROVIDED BY KGCMC MAY AND JUNE 2001.
4. WATER LEVEL DATA COLLECTED BY KGCMC PERSONNEL AS OF JUNE 2001.
5. FOR CORRELATION PURPOSES, TILL UNIT INCLUDES ENTIRE STRATIGRAPHIC INTERVAL BELOW SAND AND ABOVE THE BEDROCK.

SEE FIGURE 4 FOR CROSS SECTION LOCATIONS

FIGURE 20

KENNECOTT GREENS CREEK MINE

ADMIRALTY ISLAND, ALASKA

HYDROGEOLOGIC SECTION B-B'

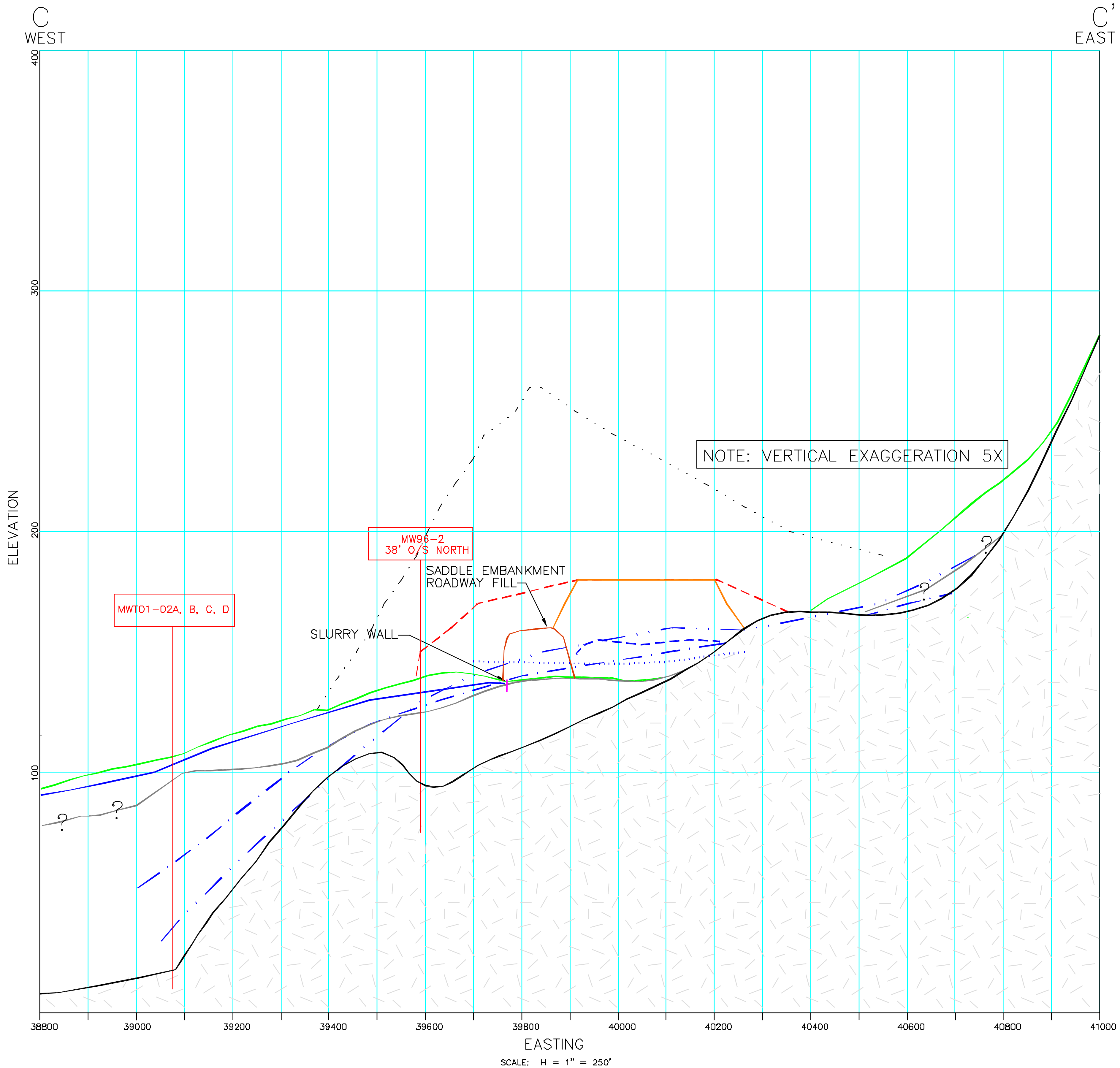
DATE: 12/3/01
DRAWING BY: BJS
DESIGN BY: BJS
REVIEWED BY: BNN
PROJ OR REF. ----

PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793

EDE DWG # HYDROANALYSIS/FIGURE20

SCALE: AS NOTED

SHEET: 1 OF 1



NOTES:
1. ELEVATIONS DEVELOPED FROM GRIDDED AND CONTOURED SURFACES DERIVED FROM BOREHOLE LOGS. ACTUAL CONDITIONS BETWEEN HOLES MAY DIFFER FROM THAT SHOWN.
2. SEVERAL MONITORING WELLS/BOREHOLES NOTED ALONG SECTION FOR REFERENCE.
3. NORTHWEST TAILINGS DESIGN AND PRESENT TAILINGS INFORMATION PROVIDED BY KGCMC MAY AND JUNE 2001.
4. WATER LEVEL DATA COLLECTED BY KGCMC PERSONNEL AS OF JUNE 2001.
5. FOR CORRELATION PURPOSES, TILL UNIT INCLUDES ENTIRE STRATIGRAPHIC INTERVAL BELOW SAND AND ABOVE THE BEDROCK.

SEE FIGURE 4 FOR CROSS SECTION LOCATIONS

LEGEND:

- PROPOSED ULTIMATE PILE
- NORTHWEST TAILINGS DESIGN
- POST CLOSURE STEADY-STATE TAILINGS WATER ELEVATION
- PRESENT TAILINGS PILE
- PRESENT PILE WATER ELEVATION
- BEDROCK TOP
- BEDROCK WATER LEVEL
- PEAT TOP
- PEAT WATER LEVEL
- TILL TOP
- TILL WATER LEVEL
- BASEMENT ROCK

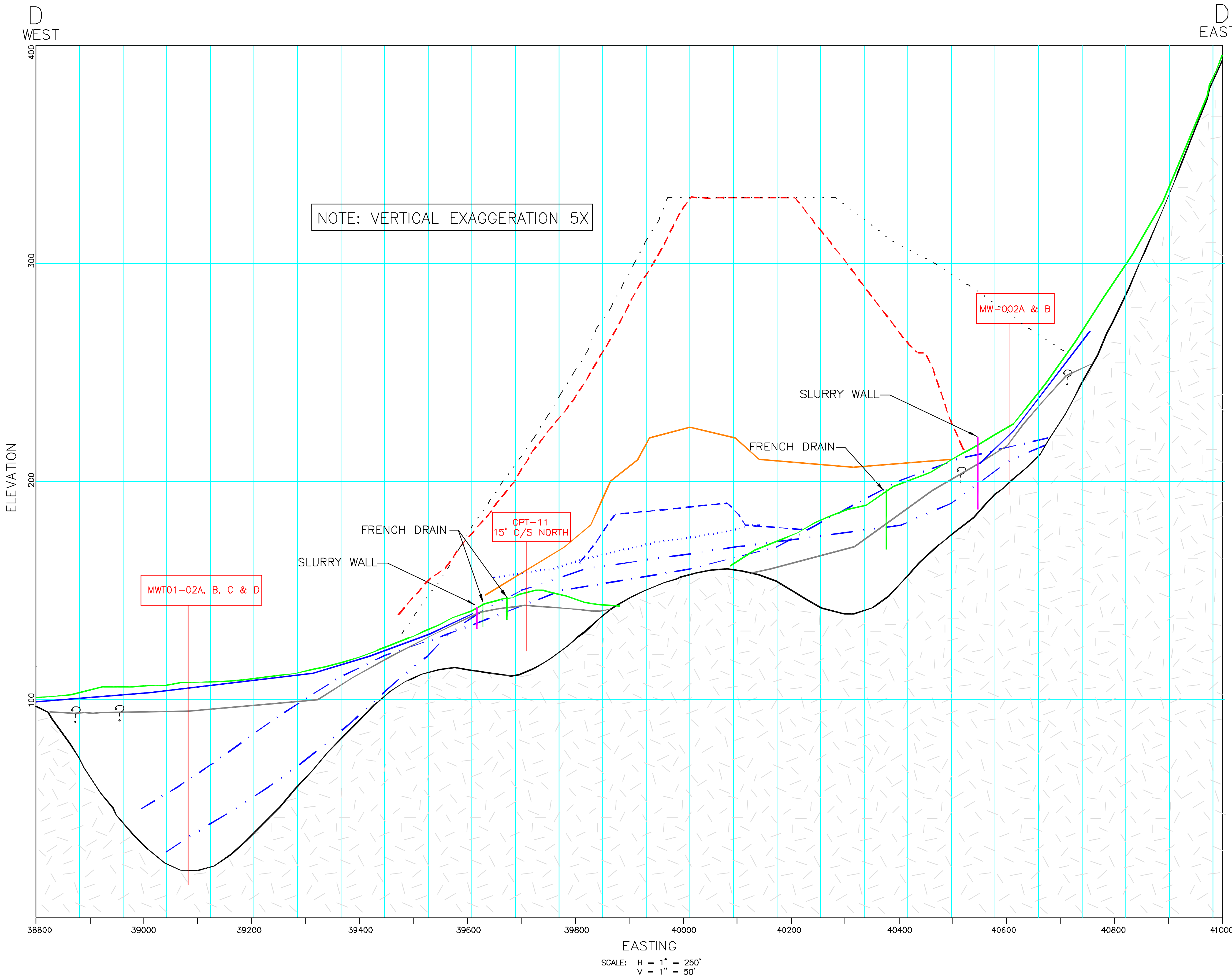
FIGURE 21

KENNECOTT GREENS CREEK MINE

ADMIRALTY ISLAND, ALASKA

HYDROGEOLOGIC SECTION
C–C'

DATE: 12/3/01 DRAWING BY: BJS DESIGN BY: BJS REVIEWED BY: BNN PROJ OR REF. ----	PREPARED BY: EDE CONSULTANTS SHERIDAN, WYOMING PHONE: (307) 672-3793 EDE DWG # HYDROANALYSIS/FIGURE21
SCALE: AS NOTED	SHEET: 1 OF 1



NOTES:

1. ELEVATIONS DEVELOPED FROM GRIDDED AND CONTOURED SURFACES DERIVED FROM BOREHOLE LOGS. ACTUAL CONDITIONS BETWEEN HOLES MAY DIFFER FROM THAT SHOWN.
2. SEVERAL MONITORING WELLS/BOREHOLES NOTED ALONG SECTION FOR REFERENCE.
3. NORTHWEST TAILINGS DESIGN AND PRESENT TAILINGS INFORMATION PROVIDED BY KGCMC MAY AND JUNE 2001.
4. WATER LEVEL DATA COLLECTED BY KGCMC PERSONNEL AS OF JUNE 2001.
5. FOR CORRELATION PURPOSES, TILL UNIT INCLUDES ENTIRE STRATIGRAPHIC INTERVAL BELOW SAND AND ABOVE THE BEDROCK.

SEE FIGURE 4 FOR CROSS SECTION LOCATIONS

LEGEND:

- PROPOSED ULTIMATE PILE
- NORTHWEST TAILINGS DESIGN
- POST CLOSURE STEADY-STATE TAILINGS WATER ELEVATION
- PRESENT TAILINGS PILE
- PRESENT PILE WATER ELEVATION
- BEDROCK TOP
- BEDROCK WATER LEVEL
- PEAT TOP
- PEAT WATER LEVEL
- TILL TOP
- TILL WATER LEVEL
- BASEMENT ROCK

FIGURE 22

KENNECOTT GREENS CREEK MINE

ADMIRALTY ISLAND, ALASKA

HYDROGEOLOGIC SECTION
D-D'

DATE: 12/3/01 DRAWING BY: BJS DESIGN BY: BJS REVIEWED BY: BNN PROJ OR REF. ----	PREPARED BY: EDE CONSULTANTS SHERIDAN, WYOMING PHONE: (307) 672-3793 EDE DWG # HYDROANALYSIS/FIGURE22
SCALE: AS NOTED	SHEET: 1 OF 1

water percolates through the upper tailings under unsaturated flow conditions, eventually reaching the water table within the tailings. Tailings water eventually exits the tailings pile via the system of under-drains comprised of finger drains and blanket drains. The drainage collected by these structures is routed to Wet Well #2, Wet Well #3, and Wet Well #4 (Figure 7). The drainage water is then pumped from the wet wells to treatment. Figure 14 presents the current potentiometric surface of the tailings material. The flow gradient is toward the blanket drains and toward the pumped wet well sumps as would be expected.

On a smaller scale there exist indications of hydraulic anisotropy in the tailings pile expressed as seeps. There are two known seeps that exist within the tailings repository. At the north side of the tailings pile there is an old access road and seepage is evident in a small drainage ditch nest to the roadway. Another access road site on the southeast corner of the tailings also has a very small seep. Flow is intermittent and when present represent and estimated total of much less than 1 gpm and are often dry. Both of these seeps are captured by water control facilities and the water is treated and discharged.

The appearance of these seeps in conjunction with the roadways suggests that the roadways provide preferential pathways for water flow. The pile undoubtedly contains some variation in hydraulic due to this roadway construction, however it is probably insignificant to the bulk behavior of the pile. The roadways are constructed to provide a means of tailings haul truck access onto the tailings pile. The manner in which these roadway function as preferential pathways has been observed in the field. The roads are constructed by placing development rock along the traffic route. The roadways are heavily trafficked with loaded and unloaded trucks and heavy equipment. The rocks become in-filled with tailings and create a high-density zone, which better supports traffic. The edges of the roadway may be the exception. The net result is that the majority of the roadway has a higher density, lower porosity and lower permeability than the surrounding tailings. This zone is edged with less compacted rock at the roadway edge that serve as small preferential flow pathways. In addition, the presence of this rock on the surface may decrease the runoff and increase the infiltration rate locally. As the pile is expanded these areas are covered with compacted tailings. This potentially leaves a macro pore zone along each roadway. Such macro pore zones may cause some lateral redistribution of water. Vertical redistribution is less likely as the majority of the roadway is essentially horizontal and the locations shift laterally with time as the pile is constructed upward and outward. However, flow rate through these macro pore zones is limited by the lowest permeability material through which water must ingress or egress. In this case that material is tailings since eventually these pathways are encapsulated with tailings. Areas where these preferential pathways daylight the edge of the pile because they have not yet been fully covered may result in the seeps observed.

The relative magnitude of the potential hydrologic influence can be estimated. The surface area of haulage roads on the tailings pile at any point in time is less than 2.3% based on mapped locations of roadways and most of which is ultra-compacted due to haulage traffic. The volume of rock applied to the access roads is quite small compared to the volume of unadulterated tailings, estimated between 1% and 2%. This means that 97.7 % of the tailings area and 99% of the volume of the tailings is comprised of milled, relatively uniform, engineered, machine compacted, construction controlled, density measured and documented material. Given the uniformity of the material, the placement techniques, the construction quality assurance within a few percent uniformity, and meeting minimum density standards, it is most accurate to describe the pile as isotropic and homogeneous when compared to native aquifer materials.

An additional feature of the tailings pile that may result in hydraulic heterogeneity is a result of compactive loading. As the pile is constructed in lifts and machine compacted, the compaction may leave minor differences in permeability laterally due to creation of layers. However, over time as the pile increases in thickness, this effect, if any, is altered, as the material loading will result in compression of the tailings. Tailings with a 40 ft. overburden load will be of greater density, lower porosity, and lower hydraulic conductivity.

Stand-pipe piezometers/wells were constructed into the tailings pile in 1994 and pneumatic piezometers were installed in 1995 and subsequent years. Additional wells have been added in 1998, 2000, and 2001. Water level data from these monitoring points have been collected periodically since that time. Time series plots (hydrographs) of the water levels within these tailings monitoring points are presented in Appendix B. Examination of hydrographs of wells and piezometers located in the old tailings pile shows a marked decline of approximately 10 ft. to 12 ft. in water level followed by an increase in water level to previous levels. This head decrease occurred during a period of approximately 5 years - the direct result of a temporary PVC plastic sheeting cap placed on the old tailings pile to exclude infiltration and to reduce the amount of runoff in contact with tailings material. The cap was installed in August of 1995 and removed in stages to allow tailings placement beginning in about March of 1997.

Figure 23 shows the hydrograph for well TB-2, which is a typical representation of the tailings pile response to the cap installation and removal. Inspection of Figure 23 shows that as the source of infiltration water (rainfall/snowmelt) was eliminated by the temporary cap, the tailings material began a drain-down of the water within the pile from an initial water elevation of 183.5 ft. amsl. By March of 1997 the water levels became steady at an elevation approximately 171 ft. amsl for a net drop of 12.5 ft.

The average rate of drainage from the pile into the tailings pile under-drain system was estimated using this monitored drain-down data. The potentiometric surface of the pile in March of 1997 was subtracted from the potentiometric surface of August 1995. The resulting volume dewatered was then adjusted to account for the pile effective or drainable porosity. Silts and clays have a range of total porosities of 35% to 50% and an effective porosity (specific yield) range of 1 to 10% (Driscoll, 1986). For the analysis specific yields of 5% and 10% were selected for computing the drain-down water volume. Though the specific yield of 10% for silt-clay materials is on the high end of the range, this was used by design to provide a conservative analysis to avoid under-design/underestimation. If a less conservative, but still reasonable assumption of a 5% specific yield (s.y.) were used, all volume related computations would be reduced by ½.

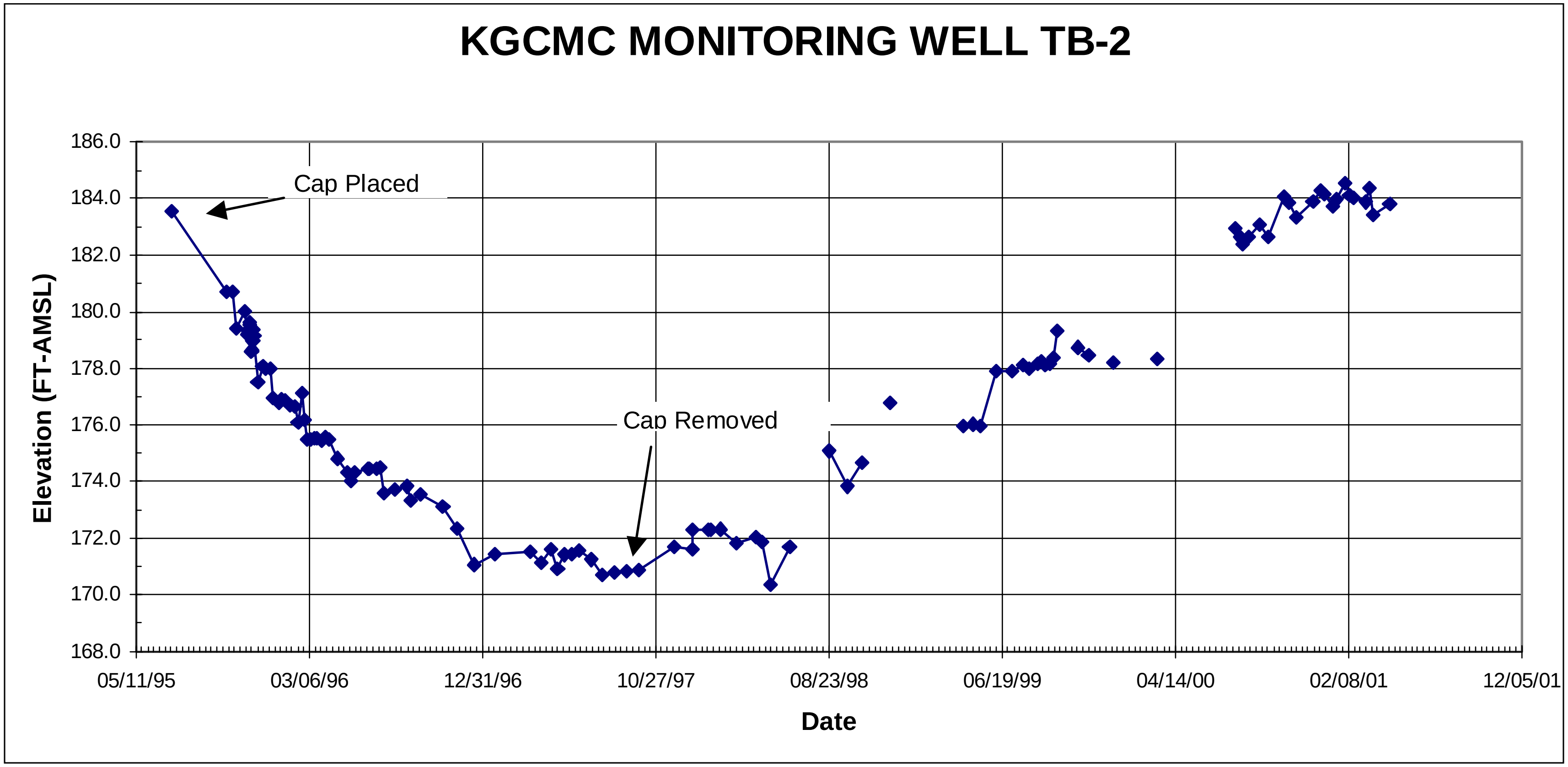
For the 10% s.y. case, and using the 517 day drain-down time, an average underflow rate of 4.6 gpm was calculated to drain out of the old tailings pile into the under-drain system. Using an s.y. of 5% the average underflow rate would be 2.3 gpm.

This analysis was repeated in reverse to estimate the rate of recharge once the cap was removed. The tailings volumetric potentiometric surface differences were calculated between September 1997 (when removal of the cap commenced) and December 2001. The water accumulation rate to raise the in-situ water level in the pile for the recharge period of 1369 days was computed to be as follows:

Effective Porosity	**Drain-down Flow Rate**	**Recharge Rate**	**Recharge Flux**
5%	2.3 gpm	3.5 gpm	3.4×10^{-6} gpm/sq. ft.
10%	4.6 gpm	7.0 gpm	7.7×10^{-6} gpm/sq. ft.

Computations show it would require between 1.2 gpm and 2.4 gpm to bring the water level back up to the pre-cap potentiometric elevation. Since saturated zone water is calculated to exit the pile at a rate of between 2.3 gpm and 4.6 gpm, this is added to the 1.2 gpm to 2.4 gpm necessary to raise the water level 12.5 ft. in 1369 days. Therefore, the net infiltration into the old pile is estimated at 3.5 gpm to 7.0 gpm. Based on this rate the maximum unit flux through the uncapped pile is approximately 7.7×10^{-6} gpm/sq. ft.

As the hydraulic head in the pile rises, the under-drain flow rate increases until equilibrium elevation (head) is achieved. As observed in the well and piezometers data, this elevation appears to be nominally 185 ft amsl (at well TB-2). A cross check of these values was conducted using precipitation depths. The total depth of precipitation infiltrating the pile to achieve the under-drain steady state discharge rate was estimated using the pile area and the annual estimated discharge water volume. This was compared against the annual precipitation depth for the tailings site. The calculated infiltrated water



Total Depth (ft. BLS): 59	Screen Top (ft BLS): 48.5	Land Surface Elevation (ft. AMSL): 206.21
Completion Zone: Tailings	Screen Bottom (ft BLS): 59	Top of Casing Elevation (ft. AMSL): 208.71
Notes: Partial Completion		

Figure 23 TB-2 Hydrograph

volume to achieve this is 0.6 ft. (6.6 inches) per year at a 10% s.y., and 0.3 ft. (3.3 inches) at an s.y. of 5%. This is approximately 12% and 6 % respectively, of the annual precipitation of 52.9 inches per year. For bare surfaced (uncapped) tailings, and relatively low site evaporation rates, 12% may be plausible.

Additional information can be extracted from a review of the monitored water level data and the potentiometric surface maps for the water bearing units around and beneath the tailings pile. Examination of the tailings monitoring hydrographs in Appendix B, and Figure 23 show that following drain-down over approximately 2 years, the water levels stabilized in the pile for some period prior to rising again following cap removal. This drain down-steady state elevation may be an indicator of the post closure water elevation that can be expected following capping of the tailings pile and site reclamation. Using the drain down elevation data points an approximation of the post closure tailings water surface was made and is presented in Figure 18.

Figure 20 (cross section B-B') shows a north-south cross section through the tailings and underlying strata. The potentiometric heads for each strata are also shown. These heads are all confined and generally above the bottom of the tailings, particularly the till and the bedrock aquifers, although there may be areas near the southern extent of the tailings where the till head gradient appears to equal levels in the underdrain system. This suggests that it would be difficult for the tailings water to migrate downward against the groundwater head gradient into these underlying units. Upward leakage from the underlying aquifers may be captured within the tailings pile under-drain system as is suggested by the wet well flow data. Though the resolution or detail in existing data is not available to prove or disprove their existence, areas between drains may exist that do not drain as freely as areas closer to drain features. The potentiometric heads in these areas have the potential to be somewhat higher than more efficiently drained locales. Due to the confining nature of the underlying silty clay in conjunction with the slurry wall features, downward leakage is anticipated to be captured within the tailings underdrain system designed specifically for this purpose.

The proposed Northwest tailings placement footprint is predominately over the top of the existing tailings. The existing tailings pile will be constructed higher than currently configured and new tailings placement under the Northwest tailings expansion will cover the entirety of the existing tailings pile. Additional tailings will be placed on a bed-rock high to the northwest of existing tailings and immediately to the west of the existing tailings in a relatively narrow extension of about 100 to 200 ft. (see Figure 2). The tailing pile will be extended in height over the current footprint. The approximate current elevation of the tailings pile is 235 ft. amsl with a current design height of 250 ft. The proposed expansion will bring the design height to approximately 330 ft. amsl for an overall height of approximately 160 ft. above the original ground. This increases the thickness of the tailings a maximum of 80ft. beyond the current maximum design thickness of approximately 80 ft. The additional thickness of tailings, assuming that the texture and placement of tailings remains the same, will not affect the steady state hydraulics, only the hydraulic response to perturbations such as a wet year with high infiltration volumes. Such responses will be slower and the lag time greater due to a longer travel path through the vadose zone for each recharge event. The steady state potentiometric surface capped (approx. 170 ft. amsl at the center of the pile and 135 ft. near the southwest corner) or uncapped (approx. 185 ft. amsl) as discussed above should remain the same regardless of the tailings thickness since the saturated thickness is determined by the equilibration of the infiltration, exfiltration (underflow) and the underlying heads.

The expanded tailings pile under the Northwest pile design will contribute additional volume of water to the under-drain system proportional to the increased surface area for infiltration and increased area of under-drain. Given this proportionality and applying the previously determined maximum un-capped flux rate of infiltrative meteoric water through the tailings of 7.7×10^{-6} gpm/sq. ft. into the Northwest tailing pile footprint of 45.6 acres, yields a estimated under-drain tailings infiltration water flow of 13.3 gpm (does not include groundwater inflow component). Inclusive of the groundwater inflow the maximum expected underdrain water drainage rate for the Northwest expansion build-out footprint, uncapped pile, during/immediately following operations is estimated to be approximately 28.3 gpm. The full Stage II development build out including the Northwest, West, Pit 5, Pond 6 and East Ridge areas increases the area to 67.9 acres and the potential tailings maximum under-drain discharge including infiltration and groundwater to 30.4 gpm. Using the information regarding the hydrologic response of the tailings to the temporary cap as discussed above, the drain-down of the saturated zone of the tailings will take approximately 2.5 years. The unsaturated zone will require somewhat longer than that to achieve a post closure psuedo steady state flow condition. However, the steady state piezometric surface within the pile is expected to stabilize within the 2.5 year period.

The empirical data suggests that it may require an infiltration rate of 7.7×10^{-6} gpm/sq. ft. to maintain a minimal saturated interval as the previous analysis has shown, if the infiltration rate is less than 7.7×10^{-6} gpm/sq. ft. the saturated thickness of the pile will be minimized and the unsaturated flow thickness maximized.

One estimate of the post closure (capped) drainage rate was presented in the EDE 1997 Tailings Repository Groundwater Flow Model. That model predicted that for the tailings pile configured approximately as it is as of spring 2001, the steady state drainage rate of tailings water into the under-drain system was to be approximately 1.4 gpm (EDE Consultants, 1997). This model-derived value for the existing pile suggests a capped post closure steady state flux of 1.6×10^{-6} gpm/sq. ft.

An estimated post closure tailings pile steady state flow rate to the under-drain system can be calculated from the design information provided with the closure cap design (Unsaturated Soils Engineering, Ltd., 1999)(USEL) and follow-up report to adjust the design to tailings by O'Kane Consultants Inc "Cover System Performance at the Kennecott Greens Creek Mine", January, 2002. The selected design for the closure cap was presented in the USEL report. The O'Kane report remodeled the cap system with respect to tailings and arrived at an estimated net infiltration into the tailings of approximately 0.72 inches per year. This is well below the estimated uncapped maximum infiltration rate of 6.5 inches per year calculated above. Testing currently being conducted on a test plot of the cap design on waste rock suggests that up to 10% of annual infiltration may reach the tailings through the cap. In the interest of examining multiple plausible scenarios, it is assumed that the net infiltration into the tailings post cap construction could be as high as 10% of annual infiltration (5.3 inches), or something in-between the modeled quantity and such a maximum. The following infiltration values were used to estimate the range of tailings water discharge post closure for the full Stage II build-out:

Infiltration Volume	**Infiltration Unit Flux**	**Pile Steady State Discharge**
1”	1.18e-6 gpm/sq.ft.	3.5 gpm
3”	3.55e-6 gpm/sq.ft.	10.5 gpm
6”	7.10e-6 gpm/sq.ft.	21.0 gpm

It should be noted that the 1” infiltration volume is near the modeled prediction of infiltration for a tailings cap. The 3” value is near the modeled prediction of infiltration into a capped development rock repository, and the extremely conservative 6” value is roughly 10% of annual precipitation, and near the computed uncapped pile infiltration rate.

The calculated discharges include only the tailings water vertical drainage and do not include the contribution of native groundwater intercepted by the tailings under drain system. As described earlier in the report, though engineered structures are in place at the repository and additional structures are planned for the Northwest and Stage II expansions, some component of groundwater enters the site through control structures and through upward leakage from the underlying till aquifer that has a net positive head relative to the base of the tailings. This groundwater is intercepted by the tailings underdrain system. The contribution of native groundwater intercepted by the tailings under drain system was computed using recent flow measurement data from the water collection sumps (wet wells) located within/near the tailings pile to route water to storage and treatment.

The tailings impoundment currently has three wet wells that capture ground and surface flows; Wet Wells 2, 3, and 4. These wet wells receive flow from native groundwater, tailings infiltration, and a portion of precipitation surface runoff. The surface runoff is tributary to the wet wells via pile perimeter french drain infiltration. Each wet well pump system is equipped with a flow meter and daily readings are taken of the cumulative amount of water pumped from each wet well. The flow meters record only effluent from the wet wells, so the actual contribution to the flow rate at each wet well from groundwater, infiltration and runoff is not precisely known.

For purposes of the water balance/management liberal approximations of the contributions from these three flow sources were made for each wet well to provide a conservative analysis with respect to volumes of water to be handled and treated during operations. Appendix E presents the flow meter readings for Wet Wells 2 (01/01/00 thru 10/23/01), 3 (10/28/00 thru 10/23/01), and 4 (01/22/01 thru 10/16/01). The Wet Well 4 flow meter malfunctioned through most of 2001until 8/25/01, therefore data from 8/25/01 to 10/16/01 was used for the average flow calculations.

Calculations of estimated flow contributions at each wet well and tailings area surface runoff are presented in Appendix F. Wet wells are constructed to capture subsurface flows from groundwater and infiltration. However, in assigning proportions of the average flow out of the wet wells to one of each of the three possible sources, it becomes apparent that the majority of the average surface runoff in the drainage areas up-gradient of Wet Wells 2 and 3 reports to the wet wells. Therefore, the average runoff expected in the drainage areas associated with Wet Wells 2 and 3 is assigned as reporting to those wet wells in the flow approximations presented here.

Above average runoff from precipitation events create direct surface discharge. Graphs of precipitation versus wet well flow that precipitation events show increase the flows within Wet Wells 2 and 3 in response. Precipitation also increases flows within Wet Well 4, where collected runoff from the North Retention Pond is directly discharged to the wet well. Graphs of time vs. flow and precipitation are presented in Appendix F and show these relationships at the wet wells. The remainder of surface runoff not captured at the wet wells reports directly to Pond 6 via the perimeter collection ditches.

Table 1 summarizes the measured and calculated average flow rates from the wet well sources contributing to the tailings area water management system.

Table 1
Wet Well Flows Reporting to Tailings Area Water Management

Source	average gpm
Wet Well 2 Groundwater Inflow	7.4
Wet Well 2 Surface Infiltration	4.9
Wet Well 2 Area Runoff	29.9
Wet Well 2 Effluent	**42.2**
Wet Well 3 Groundwater Inflow	2.5
Wet Well 3 Surface Infiltration	1.2
Wet Well 3 Area Runoff	6.2
Wet Well 3 Effluent	**9.9**
Wet Well 4 Groundwater Inflow	5.1
Wet Well 4 Surface Infiltration	1.4
Wet Well 4 Area Runoff	0.0
North Retention Pond	27.7
Wet Well 4 Effluent	**34.2**

Examination of the above summary shows that the contribution of native groundwater to the underdrain system and subsequently to the wet wells currently totals approximately 15 gpm. Under the full Stage II build-out, the estimated native groundwater contribution to the underdrain system following site closure is estimated to be approximately the same since it is currently planned to place an engineered liner at the base of the tailings which would preclude the groundwater influx component.

The condition of surface water reporting to the wet wells via infiltration through the french drains will not exist post-closure as these areas will be covered with tailings and capped to preclude/minimize infiltration. The Stage II expansion is designed to have an engineered liner that will minimize groundwater interception and therefore is not anticipated to contribute significant additional groundwater to the under drain and wet well collection system.

Groundwater flow direction, gradient and elevation head in the peat/sand is depicted in Figure 15. Flow in the peat/sand generally follows topography since the peat follows topography and is a water table aquifer. Hydrologic control structures in the form of french drains and slurry walls are designed to control the ingress of peat/sand water into the tailings repository area. On the east side of the tailings repository, the peat potentiometric surface and flow vectors show how this water is redirected to the discharge areas at the headwaters of Tributary Creek and Cannery Creek. The groundwater gradient is a relatively steep 0.10 ft/ft., a reflection of the steep topography to the east. Prior to the construction of drain and slurry wall control structures, it is quite likely that the flow regime was relatively continuous through the tailings area from east to west, however due to vertical loading by the tailings placement, compression of the peat and to some degree compression of the sand would result in reduced hydraulic conductivity. This is particularly significant in the peat where laboratory values indicated that compression to a hydraulic conductivity of 10^{-6} cm/sec with as little loading as 10 ft. of tailings material will occur (SRK, 1996). The current average tailing thickness is approximately 30 ft.

During 2001 several shallow well points were driven into the peat/sand aquifer materials. Water level measurements were collected to determine the local head level or gradient difference, if any, across the western slurry wall. The width of the access road precluded measurements close together. It is not entirely surprising that the levels are similar in that there is local recharge down gradient of the slurry wall in the form of precipitation and runoff from the ridge northwest of the pile. The peat is saturated to within a few inches of ground surface in that area. The peat/sand unit has been effectively removed from the uphill side of the slurry wall in the West Buttress area and a french drain installed that prevents buildup of head/pressure below the pile and against the slurry wall. The french drain water reports to wet wells 2 and 3.

West and down gradient of the tailings pile the peat potentiometric surface and flow vectors show flow westward toward Hawk inlet. Along this area there are several small channels or more accurately, gullies incised into the peat/sand. The potentiometric surface intersects these features creating discharge areas for the peat west of the tailings repository. The groundwater gradient in this area is relatively low at 0.08 ft./ft.

The peat/sand is essentially a very localized water bearing formation. The series of slurry walls east, south, north and west of the tailings pile constitute a barrier that minimizes horizontal groundwater movement into or out of these strata in the vicinity of the tailings pile. Combined with reduced hydraulic conductivity from compressive compaction, the peat/sand aquifer continuity across the site is truncated and the contribution of water from these strata is small. The slurry walls and under-drains promote southward groundwater flow in this unit.

Time series plots (hydrographs) of the water levels within peat, sand, till, and bedrock are presented in Appendix C. Figures 19, 20, 21, and 22 show cross sections through several areas of the tailings site. Figure 4 shows the cross section locations. These figures also show the relative positioning of the peat/sand to other strata and to the potentiometric heads of these strata.

The coarse till underlying the silty-clay and silty till layers is a confined aquifer due to the overlying low permeability materials and exhibits significant piezometric head to, in some cases, several feet above land surface. Note that there are some locations west of the present pile but within the Stage II expansion area that do not indicate upward gradients in the till—these are most evident on Figure 21 where the till potentiometric surface slopes to the west below the peat/sand water table. If tailing placement were to occur over this area to the west of the present pile a man-made liner system would be utilized to facilitate containment. Figure 16 shows the till potentiometric surface, flow vectors, and gradient as of December 2000. The general groundwater flow direction in the till is from east to west similar to the peat. The lower coarse till aquifer is unaffected by hydrologic control structures such as the french drains or slurry walls. The french drains are completed above the clay/silty clay layer and the slurry walls are keyed into the clay/silty clay layer therefore neither of these structures physically encroach on the underlying till layer.

The silty clay layer and underlying the silty till are strata of interest since collectively they serve as a low permeability under-liner to the tailings pile. Significantly, under post closure conditions the groundwater hydraulic heads may preclude vertical migration downward through the clay/silty clay into the underlying till or bedrock. This is most evident on Figures 20, 21, and 22 where the till and bedrock potentiometric surface is above the pile base. Till gradients from the east average .065 ft/ft and increase to .126 ft/ft in the West Tailings area. Although the till potentiometric heads are above the pile base the actual physical contribution of till water to the tailings under drain system is probably quite minimal due to the low transmissivity of the silty till aquitard itself, the presence of the very low permeability silt/clay layer overlying the till and the presence of the sand to intercept the small amount of upward leakage that may occur and the low permeability of the compressed peat overlying the sand.

The bedrock aquifer is situated below the coarse till and the confining silty till, and silty clay layers. In the northwest and southwest bedrock highs protrude through to the surface. In general the bedrock aquifer is a confined aquifer where there are overlying sediments. The bedrock high areas northwest, southwest and southeast of the tailings pile are under water table conditions. These exposed bedrock areas may serve as local bedrock recharge areas as evidenced by the shape of the potentiometric surface (Figure 17) in the proximity of these exposed bedrock areas. The flow gradient of the bedrock is variable depending on the proximity to local recharge, but averages approximately 0.14 ft/ft. and over-all is toward Hawk Inlet to the west. A localized gradient from the bedrock knob in the northwest shows flow to the north and east toward the peat bog associated with Cannery Creek. Wells recently completed and sampled in the pit 5 area show elevated sulfate concentrations most likely a result of sulfide oxidation of the exposed bedrock in the pit 5 area. An analysis of these water quality samples and conditions in this area is contained in a supplemental report “Update of Information and Action Plan on Seeps West of the Current Tailings Disposal Facility” January, 2002 which is attached to this report as Appendix D. Although the gradient of the potentiometric surface suggests flow toward the Cannery Creek bog, the hydraulic conductivity is very low (1e-6 cm/sec or less). In addition, immediately to the east and beneath the peat the bedrock drops away and is in-filled with a thick layer of peat and silty glacial tills upwards of 100 ft in thickness. Within this area well MW96-4 shows highly confined hydraulic conditions within the bedrock with the potentiometric surface reflective of the pit 5 potentiometric elevation. This is evidence that the till is a confining layer over the bedrock and upward leakage from the bedrock through the till into the Cannery Creek bog is minimal or does not occur. Establishment of confining conditions over a small horizontal distance, and given a high angle to near vertical contact of the till and bedrock between pit 5 and the Cannery Creek bog, it appears that horizontal discharge of the bedrock from pit 5 to the east through the till layer and into the Cannery Creek Bog is extremely low or does not occur.

The Northwest tailings expansion proposes to place tailings material on top of the bedrock knob to the northwest of the existing tailings pile (Figure 2). The potentiometric surface in this area suggests that water table conditions exist. This combined with the absence of low permeability glacial sediments (the silty clay layer) indicate that the area will require the construction of a low permeability liner and under drain beneath the tailings material to prevent potential migration of tailings drainage water into the bedrock aquifer. This is particularly true for the shallow bedrock zone, which is expected to be fractured by quarry and surface development in preparation of tailings development. Further discussion of the proposed liner is presented in Section 3.0 “Stage II Expansion Water Management”. The Stage II tailings placement may also extend to the exposed bedrock at Pit 5 and bedrock exposures within the East Ridge area. It is anticipated that these exposed bedrock areas if developed for tailings placement will require construction of an engineered liner. A liner design for this type of exposed bedrock area is area is contained in KGCMC’s existing tailings area wide corner quarry liner design, which has been approved by regulatory agencies for implementation on the existing facility.

3.0 NORTHWEST AND STAGE II EXPANSION WATER MANAGEMENT

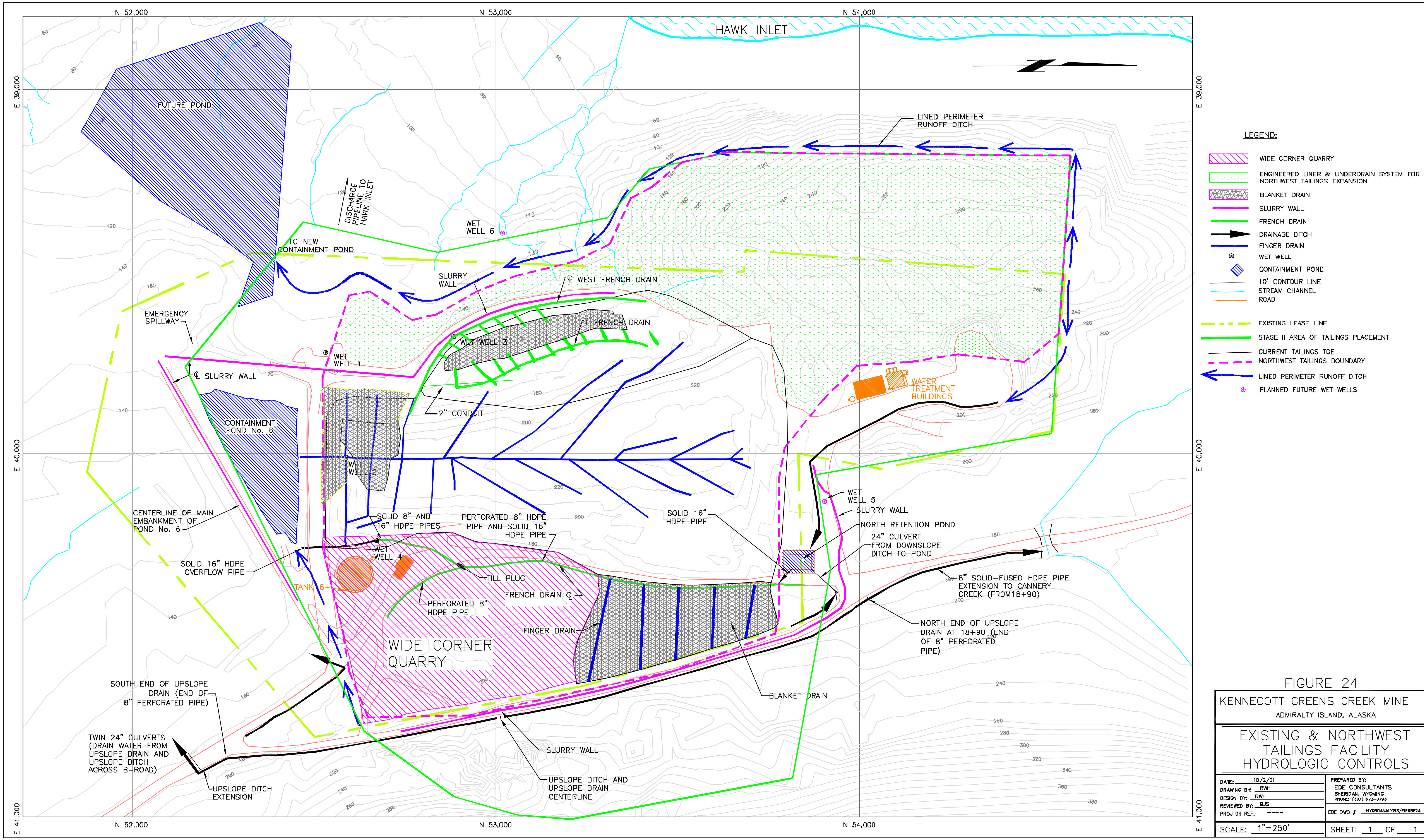
The existing tailings site has successfully employed a combination of diversions, collection ditches, french drains, finger drains, blanket drains, sumps and temporary capping to manage water in and around the tailings repository. These same, proven techniques will be used for water management in and around the Northwest expansion and Stage II expansion during active operations. The purpose of this section of the report is to examine the water management techniques to be employed and their potential effects on the surface and groundwater hydrology. This discussion is not intended to present a detailed water management plan.

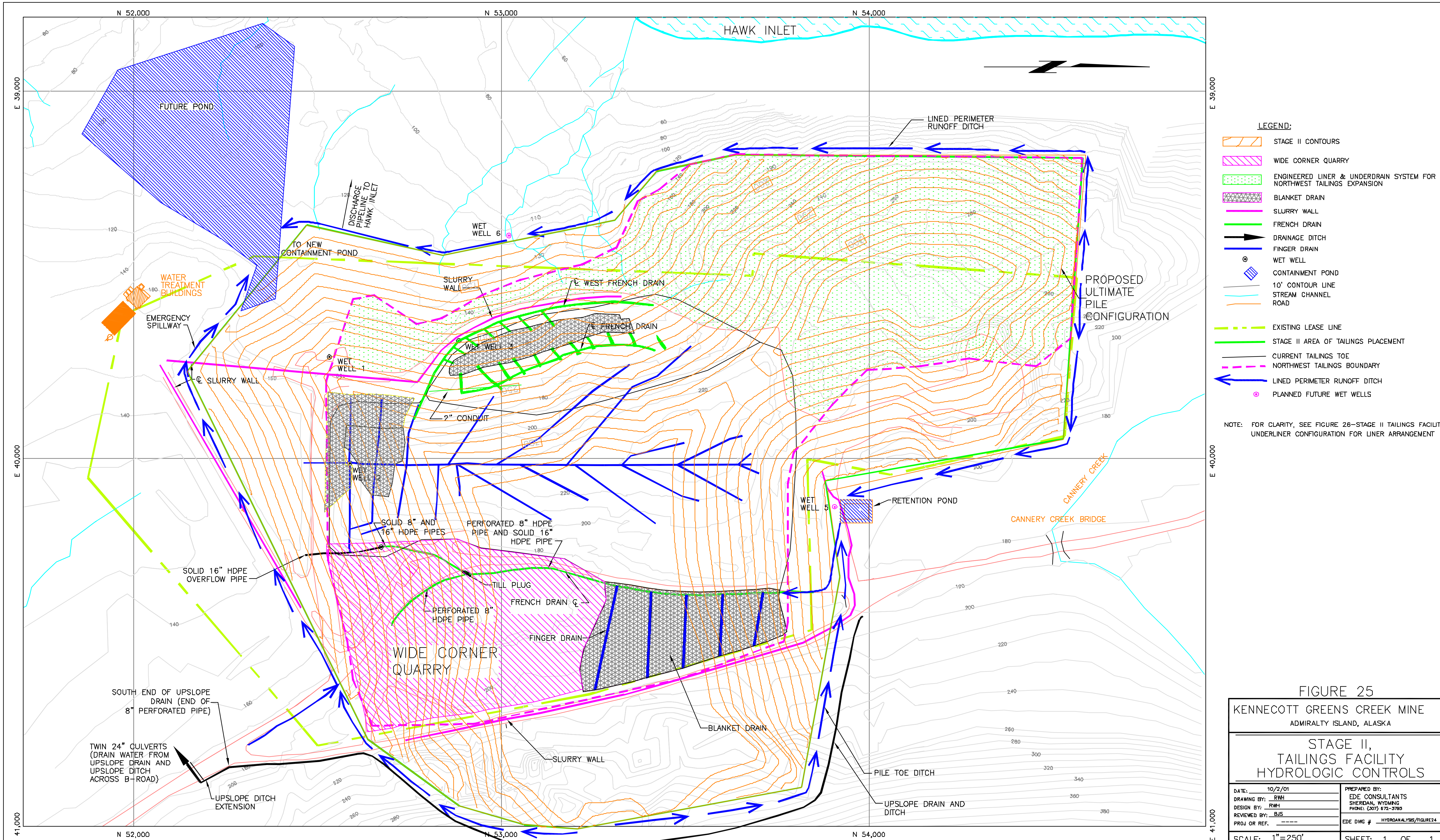
3.1 Surface Water

Surface water management of the expanded tailings repository will follow past practice of using a perimeter ditch around the tailings pile to collect surface runoff that has contacted tailings material. Figure 24 shows the existing water management features along with proposed future structures associated with the Northwest expansion. Figure 25 shows the proposed future structures associated with the full Stage II constructed pile. Collected surface water runoff due to rain and snowmelt will increase as a result of the additional acreage of the tailings footprint. To address this increase, a second storm water surge pond will be constructed to the south of the tailings expansion and west of the existing Pond 6. Captured runoff water will continue to be routed to the existing water treatment facilities at Pit 5. The hydrologic effect of surface water management is that local area runoff to native muskeg will be decreased slightly, although experience at the existing tailing repository has shown that the water levels in the peat will remain unaffected.

3.2 Groundwater

Groundwater management for the Northwest expansion area is simpler in concept than in the existing tailings. The existing tailings sites relies on a series of slurry walls and french drains to divert or prevent ingress to or egress from the tailings site (Figure 7). As described earlier in this report, the fundamental groundwater conditions beneath the


HAWK INLET
FUTURE POND
DISCHARGE PIPELINE TO HAWK INLET
TO NEW CONTAINMENT POND
WET WELL 6
LINED PERIMETER RUNOFF DITCH
SLURRY WALL
℄ WEST FRENCH DRAIN
℄ FRENCH DRAIN
EMERGENCY SPILLWAY
WET WELL 1
WET WELL 3
℄ SLURRY WALL
CONTAINMENT POND No. 6
2" CONDUIT
WATER TREATMENT BUILDINGS
WET WELL 2
CENTERLINE OF MAIN EMBANKMENT OF POND No. 6
SOLID 8" AND 16" HDPE PIPES
PERFORATED 8" HDPE PIPE AND SOLID 16" HDPE PIPE
SOLID 16" HDPE PIPE
WET WELL 5
SLURRY WALL
NORTH RETENTION POND
24" CULVERT FROM DOWNSLOPE DITCH TO POND
WET WELL 4
SOLID 16" HDPE OVERFLOW PIPE
TANK 6
TILL PLUG
FRENCH DRAIN ℄
PERFORATED 8" HDPE PIPE
8" SOLID-FUSED HDPE PIPE EXTENSION TO CANNERY CREEK (FROM18+90)
WIDE CORNER QUARRY
FINGER DRAIN
NORTH END OF UPSLOPE DRAIN AT 18+90 (END OF 8" PERFORATED PIPE)
BLANKET DRAIN
SOUTH END OF UPSLOPE DRAIN (END OF 8" PERFORATED PIPE)
TWIN 24" CULVERTS (DRAIN WATER FROM UPSLOPE DRAIN AND UPSLOPE DITCH ACROSS B-ROAD)
SLURRY WALL
UPSLOPE DITCH EXTENSION
UPSLOPE DITCH AND UPSLOPE DRAIN CENTERLINE
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
LEGEND:
WIDE CORNER QUARRY
ENGINEERED LINER & UNDERDRAIN SYSTEM FOR NORTHWEST TAILINGS EXPANSION
BLANKET DRAIN
SLURRY WALL
FRENCH DRAIN
DRAINAGE DITCH
FINGER DRAIN
WET WELL
CONTAINMENT POND
10' CONTOUR LINE
STREAM CHANNEL
ROAD
EXISTING LEASE LINE
STAGE II AREA OF TAILINGS PLACEMENT
CURRENT TAILINGS TOE
NORTHWEST TAILINGS BOUNDARY
LINED PERIMETER RUNOFF DITCH
PLANNED FUTURE WET WELLS
FIGURE 24
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
EXISTING & NORTHWEST TAILINGS FACILITY HYDROLOGIC CONTROLS
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----
PREPARED BY: EDE CONSULTANTS SHERIDAN, WYOMING
EDE DWG # HYDROANALYSIS/FIGURE24
SCALE: 1"=250'
SHEET: 1 OF 1



HAWK INLET
FUTURE POND
DISCHARGE PIPELINE TO HAWK INLET
TO NEW CONTAINMENT POND
WATER TREATMENT BUILDINGS
EMERGENCY SPILLWAY
℄ SLURRY WALL
WET WELL 6
WET WELL 1
WET WELL 2
WET WELL 3
WET WELL 5
SLURRY WALL
℄ WEST FRENCH DRAIN
℄ FRENCH DRAIN
2" CONDUIT
LINED PERIMETER RUNOFF DITCH
PROPOSED ULTIMATE PILE CONFIGURATION
RETENTION POND
CANNERY CREEK
CANNERY CREEK BRIDGE
SOLID 8" AND 16" HDPE PIPES
PERFORATED 8" HDPE PIPE AND SOLID 16" HDPE PIPE
SOLID 16" HDPE OVERFLOW PIPE
TILL PLUG
FRENCH DRAIN ℄
PERFORATED 8" HDPE PIPE
FINGER DRAIN
WIDE CORNER QUARRY
BLANKET DRAIN
SLURRY WALL
PILE TOE DITCH
UPSLOPE DRAIN AND DITCH
SOUTH END OF UPSLOPE DRAIN (END OF 8" PERFORATED PIPE)
TWIN 24" CULVERTS (DRAIN WATER FROM UPSLOPE DRAIN AND UPSLOPE DITCH ACROSS B-ROAD)
UPSLOPE DITCH EXTENSION
N 52,000
N 53,000
N 54,000
E 39,000
E 40,000
E 41,000
LEGEND:
STAGE II CONTOURS
WIDE CORNER QUARRY
ENGINEERED LINER & UNDERDRAIN SYSTEM FOR NORTHWEST TAILINGS EXPANSION
BLANKET DRAIN
SLURRY WALL
FRENCH DRAIN
DRAINAGE DITCH
FINGER DRAIN
WET WELL
CONTAINMENT POND
10' CONTOUR LINE
STREAM CHANNEL
ROAD
EXISTING LEASE LINE
STAGE II AREA OF TAILINGS PLACEMENT
CURRENT TAILINGS TOE
NORTHWEST TAILINGS BOUNDARY
LINED PERIMETER RUNOFF DITCH
PLANNED FUTURE WET WELLS
NOTE: FOR CLARITY, SEE FIGURE 26–STAGE II TAILINGS FACILITY UNDERLINER CONFIGURATION FOR LINER ARRANGEMENT
FIGURE 25
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
STAGE II, TAILINGS FACILITY HYDROLOGIC CONTROLS
DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----
PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3793
EDE DWG # HYDROANALYSIS/FIGURE24
SCALE: 1"=250'
SHEET: 1 OF 1

proposed expansion area differ from the existing containment area in that the majority of the tailings outside of the current footprint are to be placed on bedrock. The bedrock aquifer at the northwest bedrock high, wide corner and pit 5 where tailings are to be placed is under water table conditions, as glacial-fluvial sediments do not confine it. The expansion area tailings repository will be constructed with a low permeability liner coupled with an under-drain system to capture infiltration drainage from the tailings pile. This eliminates the need for french drains or slurry walls because infiltrative drainage will be intercepted at the base of the pile minimizing the opportunity for the drainage water to co-mingle with the underlying non-contact shallow aquifer water and migrate away from the pile. The design of the under liner and under drain has not been finalized however it is anticipated that the system may be similar to the wide corner quarry liner design that consists of a polyethylene liner (HDPE) over a compacted earth bedding layer of imported sand/gravel. On top of the geomembrane, a Geocomposite of a Geo-Net drain net sandwiched between felted geotextile fabrics may be placed. The geotextile with provide filter protection for the Geo-Net to limit the potential for clogging and protect the Geo-Net and underlying geomembrane. On top of the membrane-geocomposite a service layer of drain gravel/sand with a specific gradation envelope to minimize invasion of tailings fines are planned to be placed (Klohn-Crippen, 2001). An engineered liner may also include imported and locally available earth materials.

The increased footprint of the Northwest expansion area under-drain system will capture only tailings infiltrative drainage water and no underlying groundwater contribution, thereby reducing the amount of water contacting tailings to only tailings drainage. Minimizing the volume of contact water, and reducing mixing with other water sources, is important for current treatment logistics and costs, but is also important for post-closure long-term management. The captured drainage will then be routed to the Pit 5 water treatment plant for treatment and discharge to Hawk Inlet as regulated under the mine's NPDES permit. As expansion of tailings placement is planned toward the Pit 5 area, the Pit 5 water treatment plant will be moved to a new location. It is anticipated that it will be relocated to the bedrock knob to the southwest of the tailing repository as shown on Figure 25.

The potential hydrologic effect of an engineered liner is anticipated to be limited to the reduction in the recharge to bedrock at the northeast bedrock high. With the tailings and the liner placed on the bedrock, the infiltrative recharge to the bedrock beneath the tailings pile will be minimized. It is expected that this will have local effect on the bedrock potentiometric surface. There are other bedrock outcrops to the east and south that will continue to provide recharge to the broader bedrock aquifer. The local effect as suggested by the potentiometric surface map for the bedrock as it is currently projected (Figure 17) will be to flatten the bedrock aquifer high in the immediate area of the repository. The decrease in the gradient due to the flattened potentiometric surface will decrease the flow velocity and quantity away from this area in all directions. Several possibilities exist for establishment of a new potentiometric surface. One of these is that since the bedrock appears to be bounded on the east by low permeability confining till as the bedrock structure drops steeply deeper, the potentiometric surface may tend to become stagnant or establish the principal flow direction westward.

4.0 CLOSURE AND POST-CLOSURE WATER MANAGEMENT

Management of water during the operational phase of the tailings repository involves the capture of tailings contact runoff and the capture of tailings infiltrative drainage. During this phase the quantity of water that must be managed is at a maximum. The tailings pile is not capped or vegetated. Infiltration is deliberately held to a minimum through diligent compaction and maintenance of positive drainage slopes on the pile, but this has the inverse effect of maximizing the runoff volume. The absence of a cap during operation and active pile construction means that although efforts are made to minimize infiltration, the infiltration rates will be at a maximum when compared to anticipated post closure rates as discussed in Section 2.5.2.2. The closure period covers the transition from this maximum water condition, to the post closure state when efforts to minimize water contact and active management are put into place. The purpose of this section of the report is to examine the post closure water management techniques to be employed and their potential effects on the surface and groundwater hydrology. This discussion is not intended to present a detailed water management plan.

4.1 Surface Water

Upon completion of the tailings pile final build-out, the site will enter the closure phase. During closure, construction efforts are directed toward installing features that secure the site in a final reclamation state. Surface water sources that require treatment during this phase include the tailings pile itself and the surrounding facilities. Figure 25 shows the anticipated configuration of hydrologic controls during operation and at full build-out. As the closure efforts progress, construction of the tailings pile capping system will occur. The quantity of runoff that occurs directly from tailings will be progressively reduced as the tailings pile is capped. The runoff from the capped portion of the pile will continue to be collected and treated to control sediment concentrations. However, once vegetative stabilization of the cap has occurred, the runoff will be allowed to return to adjacent native areas through the post closure integrated water management system. The water management system will handle all captured water, which includes runoff and tailings pile underflow.

Following the completion of construction of the cap and reclamation of the majority of the surrounding support facilities, the site will enter the post-closure phase. The reclaimed surfaces will consist of native soils and vegetation and will produce runoff similar to surrounding ambient conditions.

4.2 Groundwater

The closure phase for groundwater management commences following final tailings pile build-out at the site. Groundwater that is currently captured and treated consists of tailings infiltrative water discharge to the under-drain systems and a component of groundwater from underlying strata beneath the pile. This water will continue to be captured through the drain system, into the wet-wells and subsequently transferred to treatment throughout the operational and closure phases.

During closure, the pile will be capped. As discussed in Section 2.5.2.2, the amount of tailings infiltration drainage will be reduced significantly and drain down of the pile will begin. This saturated zone drain down will be substantially complete within 2.5 years of the completion of the cap construction. Allowing a single construction season for cap construction following site build-out, and allowing for both saturated zone drain down and subsequent unsaturated zone drain down, it is estimated that the existing tailings and Stage II expansion post closure tailings pile maximum drainage rate of between 3.5 gpm and 21.0 gpm (see Section 2.5.2.2) will be achieved within 3.5 + years (1 year construction, 2.5 year saturated zone drain down).

Groundwater infiltration into the under-drain system was projected in Section 2.5.2.2 was estimated to be 15 gpm. Inclusive of the native groundwater infiltration the total projected tailings infiltration and groundwater discharge from the tailings repository is estimated to be no greater than 36 gpm for all the Stage II tailings placement areas and may be as low as 19 gpm. Additional wet well flow measurements during operation will assist in optimizing the estimate of the groundwater infiltration rate. The incremental areas of Stage II expansion beyond the Northwest development do not include a groundwater inflow component due to the anticipated use of an engineered under-liner that will be designed to preclude ingress of groundwater in these areas.

Depending upon the post closure water quality leaving the pile underdrain collection system, the construction of a post closure drainage water treatment system may be necessary. It is beyond the scope of this report to provide details regarding the post-closure water treatment strategy. However, a more detailed discussion of post closure water quality predictions, treatment options and discharge alternatives is presented in the Stage II Tailings Geochemistry Report (EDE, KGCMC, January 2002). In the interim period between capping and post closure treatment system startup (if needed), tailings pile under-drain water will be treated at the relocated water treatment plant. In any case, the water treatment plant will continue in active operation until such time as the captured water meets the design/operational criteria of the post closure drainage water management/treatment system or applicable water quality standards.

The effects of water management practices on the groundwater flow hydrology during closure and the post closure period are expected to be minimal, but positive in terms of water management. As described earlier in this report, the aquifer systems outside of the tailings containment area are separated from the conditions within the tailings pile footprint by slurry walls, a natural clay under-liner, and a constructed drain and liner system for the Northwest expansion area. The slurry walls form a perimeter around the existing pile and are keyed into the underlying clay. This minimizes ingress of non-contact water, and egress of tailings contact water via the peat/sand layers.

Upon pile drain-down a post closure potentiometric surface is anticipated to be established at the center of the pile at approximately 170 ft. amsl as described in Section 2.5.2.2 and along the west side and southwest side at approximately 140 ft amsl (the elevation of the blanket drains under current southwest tails is approximately 138’). The under-drain system removes both tailings infiltrative drainage water and peat/sand aquifer water. The drains in combination with the slurry walls will minimize lateral recharge. In conjunction with the cap minimizing vertical recharge, these features may cause a depression in the peat/sand aquifer water level within the containment area as compared to the heads in the peat/sand immediately outside of the slurry wall. Should the gradient outside the slurry wall be equal (as is currently the condition) or lower, it is anticipated that the gradient away from the facility will be small. The slurry walls were designed and constructed to achieve a net hydraulic conductivity of 1x 10^{-6} cm/sec or less (SRK, 1996). Construction testing yielded data indicating that the as-built slurry wall conductivity is approximately $1x10^{-8}$ cm/sec. Given that the saturated head level in the uncapped pile is currently at an anticipated maximum and the head differential across the slurry walls is not measurable, the net potential flux through the bentonite slurry walls, if any, would be extremely low.

Under post closure conditions, vertical migration of tailings drainage water into the till and bedrock aquifers are prevented due to heads within these aquifers higher than the pile under-drain. Within the proposed Northwest expansion to the west and northwest, the presence of the constructed low permeability liner and drain will eliminate infiltration of recharge waters to this bedrock high resulting in a flattening of the potentiometric surface in the bedrock locally as described in Section 3.2. Vertical and horizontal migration of tailings drainage water is prevented in this area due to the presence of the under-drain and liner system. Similarly, Stage II expansion into Pit 5, the Wide Corner and Pond 6 are anticipated to use synthetic liners as well. Figure 26 shows the locations of anticipated tailings under-liners. Overall, post-closure, an integrated water management strategy will be used to direct site waters along their original flow paths.

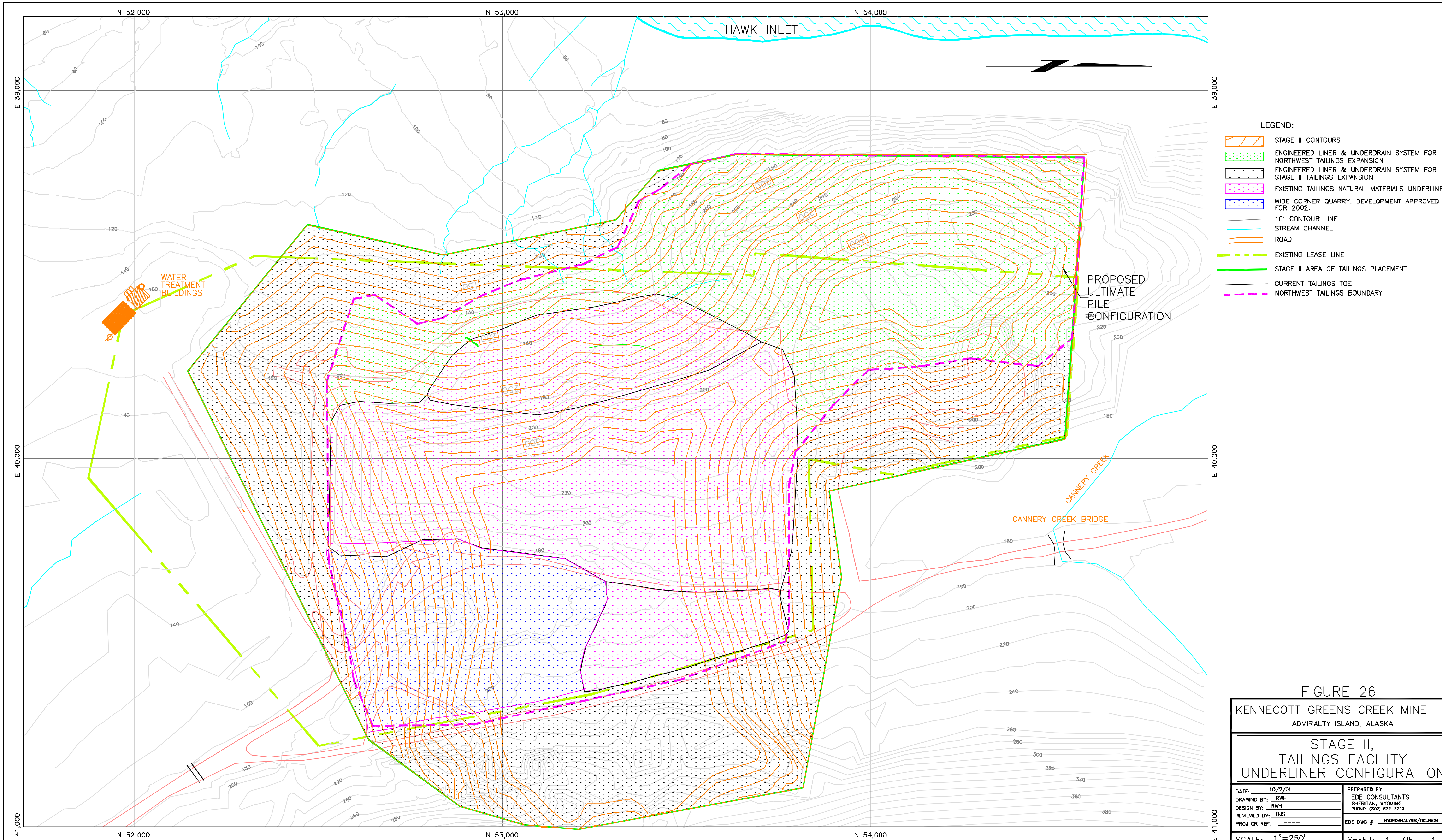


FIGURE 26

KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

STAGE II,
TAILINGS FACILITY
UNDERLINER CONFIGURATION

DATE: 10/2/01
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: BJS
PROJ OR REF. ----

PREPARED BY:
EDE CONSULTANTS
SHERIDAN, WYOMING
PHONE: (307) 672-3783

EDE DWG # HYDRDANALYSIS/FIGURE24

SCALE: 1"=250'
SHEET: 1 OF 1

5.0 SUMMARY AND CONCLUSIONS

The groundwater flow regime in and around the tailings repository is complex but owing to an extensive groundwater monitoring network and data collection, the system is well understood. Temporary capping of the tailings pile produced an excellent full-scale field test and empirical data about the behavior of water flow into and out of the tailings pile. Drain down time following capping and closure of the pile is expected to require no more than 6 years. Post closure steady state infiltrative drainage rates from the existing tailing pile and Stage II expanded pile are anticipated to be between 3.5 gpm and a maximum of 21 gpm. Native groundwater interception is anticipated to contribute an additional maximum 15 gpm to the under drain flow for Stage II maximum build-out.

A series of slurry walls surrounding the site, are keyed into a natural low permeability clay or silty clay layer to minimize horizontal ingress or egress of water from the tailings site via the peat/sand aquifer. The existing tailings pile itself is underlain by naturally occurring low permeability materials (10^{-6} cm/sec or less) including compressed peat, clay, silty clay, and silty till units. The till and bedrock aquifers are physically and hydraulically isolated from the tailings by the compressed peat, clay/silty clay layer, silty till and post closure following tailings saturated zone drain-down a net positive potentiometric head as compared to the head in the tailings pile will be established. A constructed liner system and under-drain beneath the proposed Northwest expansion and other Stage II tailings placement areas will minimize the risk of infiltration of tailings pile drainage to the bedrock groundwater aquifer.

Post closure, the final potentiometric head in the pile is expected to be approximately 170 ft. above mean sea level at the center of the pile as evidenced by the temporary cap data, and approximately 140 ft. amsl. at the low point in the southwest corner of the tailings pile. This anticipated post closure piezometric head within the tailings impoundment will minimize the egress of tailings waters to adjacent areas by the series of slurry walls and diversion drains. Engineered containment features such as liners and existing slurry walls associated with the pile combined, with slightly positive groundwater head in the till and bedrock below the clay layer will minimize the risk of uncontrolled migration of tailings contact water from the containment area. Tailings pile geochemistry; post closure water quality estimates and post closure water management are addressed in an associated report, “Tailings Geochemical Loading Analysis”, January 2002.

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Appendix A

Precipitation Data and Summaries

Greens Creek Mine
Continuous Data Annual Summary
Tailings Site

For period 1/1/97 to 5/31/01

Station : Outfall (NPDES)   Parameter : Total Precipitation (Inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1997	1.55	5.34	3.16	3.74	1.87	2.24	6.40	4.06	5.62	4.56	3.01	8.81	50.36
1998	1.48	1.29	2.60	2.23	2.16	2.34	4.38	5.78	5.75	9.33	1.98	4.40	43.72
1999	5.10	7.77	1.66	5.56	4.78	2.41	4.33	6.56	7.86	8.74	5.42	8.76	68.95
2000	3.02	0.94	3.67	4.32	2.47	3.80	4.02	4.47	8.32	5.98	4.34	3.49	48.84
2001	5.78	3.27	2.67	3.15	3.65								18.52

1997	Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1	0.00	0.02	0.00	1.12	0.01	0.41	0.00	0.00	0.00	0.00	0.09	0.76
	2	0.00	0.00	0.00	0.34	0.00	0.11	0.00	0.00	0.14	0.00	0.00	1.53
	3	0.00	0.41	0.00	0.00	0.00	0.00	0.06	0.00	0.12	0.00	0.00	0.05
	4	0.01	0.03	0.00	0.00	0.00	0.03	0.00	0.41	0.31	0.12	0.64	0.00
	5	0.12	0.29	0.01	0.00	0.00	0.03	0.00	0.13	0.00	0.31	0.01	0.00
	6	0.01	0.23	0.11	0.00	0.07	0.04	1.10	0.34	0.00	0.03	0.06	0.10
	7	0.01	0.06	0.01	0.00	0.06	0.00	0.00	0.01	0.01	0.00	0.00	0.31
	8	0.00	0.01	0.01	0.03	0.03	0.67	0.04	0.00	0.02	0.00	0.00	0.01
	9	0.17	0.00	0.00	0.00	0.14	0.17	0.03	0.01	0.06	0.00	0.00	0.04
	10	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.05	0.00	0.00	0.09	0.26
	11	0.00	0.03	0.00	0.21	1.00	0.00	0.41	0.00	0.01	0.00	0.27	0.17
	12	0.00	0.02	0.00	0.02	0.02	0.00	0.38	0.28	0.00	0.00	0.01	0.67
	13	0.07	0.01	0.00	0.00	0.04	0.11	0.49	0.39	0.00	0.42	0.00	0.67
	14	0.00	0.28	0.00	0.12	0.08	0.20	0.43	0.00	0.00	0.52	0.00	0.05
	15	0.00	0.29	0.00	0.36	0.03	0.04	0.00	0.00	0.00	0.43	0.00	0.11
	16	0.03	0.41	0.20	0.24	0.01	0.00	0.01	0.00	0.04	0.27	0.00	0.00
	17	0.13	0.11	0.16	0.28	0.00	0.08	0.13	0.00	0.00	0.01	0.00	1.00
	18	0.12	0.02	0.08	0.00	0.02	0.27	0.30	0.07	1.49	0.01	0.00	0.01
	19	0.01	0.02	0.19	0.00	0.00	0.03	0.31	0.71	0.94	0.42	0.00	0.11
	20	0.00	0.06	0.05	0.03	0.00	0.00	0.06	0.00	0.25	0.07	0.01	0.00
	21	0.29	0.11	0.51	0.23	0.00	0.00	0.12	0.00	0.15	0.10	0.09	0.11
	22	0.01	0.48	0.10	0.01	0.00	0.00	0.18	1.02	0.28	0.07	0.07	0.62
	23	0.00	1.77	0.04	0.00	0.00	0.00	0.32	0.48	0.43	0.05	1.17	0.10
	24	0.00	0.10	0.64	0.00	0.00	0.03	0.84	0.05	0.30	0.23	0.05	0.16
	25	0.00	0.27	0.44	0.01	0.00	0.00	0.09	0.07	0.76	0.69	0.12	0.23
	26	0.02	0.00	0.01	0.44	0.00	0.00	0.00	0.00	0.09	0.18	0.09	0.17
	27	0.30	0.18	0.02	0.17	0.06	0.00	0.04	0.00	0.22	0.01	0.06	0.36
	28	0.06	0.13	0.12	0.01	0.14	0.02	0.25	0.04	0.00	0.05	0.08	0.72
	29	0.03		0.13	0.12	0.04	0.00	0.06	0.00	0.00	0.01	0.03	0.08
	30	0.00		0.09	0.00	0.00	0.00	0.51	0.00	0.00	0.13	0.07	0.41
	31	0.16		0.02		0.12		0.23	0.00		0.43		0.00
	Totals	1.55	5.34	3.16	3.74	1.87	2.24	6.40	4.06	5.62	4.56	3.01	8.81

Total Annual **50.36**

1998	Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1	0.00	0.00	0.01	0.20	0.01	0.00	0.00	0.00	0.17	0.01		0.00
	2	0.00	0.01	0.00	0.07	0.04	0.00	0.00	0.00	1.03	0.00	0.00	0.00
	3	0.07	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.01
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.07	0.08	0.10
	5	0.00	0.00	0.00	0.02	0.06	0.00	0.33	0.00	0.00	0.52	0.00	0.23
	6	0.00	0.00	0.00	0.17	0.61	0.00	0.05	0.17	0.20	0.03	0.00	0.01
	7	0.00	0.00	0.00	0.02	0.08	0.00	0.63	0.66	0.17	0.31	0.00	0.07
	8	0.00	0.00	0.00	0.30	0.05	0.37	0.03	0.66	0.41	0.04	0.00	0.41
	9	0.00	0.10	0.00	0.06	0.00	0.04	0.08	0.10	0.00	0.00	0.00	0.79
	10	0.00	0.02	0.04	0.00	0.30	0.08	0.30	0.34	0.49	0.00	0.00	0.85
	11	0.00	0.03	0.13	0.00	0.08	0.05	0.63	0.00	0.38	0.00	0.49	0.19
	12	0.00	0.33	0.11	0.00	0.00	0.08	0.03	0.00	0.32	0.01	0.12	0.33
	13	0.04	0.21	0.06	0.01	0.00	0.25	0.24	0.01	0.20	0.45	0.02	0.02
	14	0.01	0.07	0.19	0.01	0.00	0.54	0.19	0.09	0.00	0.01	0.05	0.10
	15	0.00	0.02	0.24	0.14	0.00	0.08	0.26	0.04	0.01	0.16	0.00	0.35
	16	0.01	0.03	0.00	0.03	0.00	0.00	0.10	0.05	0.00	0.13	0.00	0.05
	17	0.04	0.00	0.09	0.14	0.00	0.00	0.02	0.29	0.00	0.18	0.00	0.05
	18	0.00	0.00	0.11	0.29	0.01	0.00	0.00	0.02	0.00	0.15	0.03	0.00
	19	0.00	0.03	0.00	0.12	0.22	0.00	0.25	0.00	0.00	2.46	0.49	0.00
	20	0.07	0.01	0.00	0.00	0.29	0.00	0.00	0.00	0.00	2.89	0.07	0.00
	21	0.00	0.00	0.00	0.11	0.16	0.64	0.85	0.08	0.01	0.49	0.08	0.00
	22	0.00	0.02	0.00	0.00	0.23	0.01	0.01	0.37	0.00	0.38	0.17	0.00
	23	0.18	0.02	0.00	0.01	0.00	0.20	0.02	0.02	0.14	0.20	0.05	0.00
	24	0.01	0.17	0.01	0.11	0.01	0.00	0.25	0.25	0.36	0.44	0.00	0.00
	25	0.01	0.02	0.15	0.27	0.00	0.00	0.04	0.05	0.02	0.35	0.01	0.00
	26	0.30	0.20	0.01	0.07	0.00	0.00	0.00	0.22	0.04	0.00	0.23	0.00
	27	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.14	0.05	0.09	0.00
	28	0.07	0.00	0.10	0.00	0.00	0.00	0.00	0.69	0.02	0.00	0.00	0.16
	29	0.54		0.82	0.02	0.00	0.00	0.00	0.09	0.40	0.00	0.00	0.33
	30	0.09		0.36	0.04	0.01	0.00	0.00	0.04	0.71		0.00	0.13
	31	0.00		0.17		0.00		0.07	1.23				0.22
	Totals	1.48	1.29	2.60	2.23	2.16	2.34	4.38	5.78	5.75	9.33	1.98	4.40

Total Annual **43.72**

1999	DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	1	0.09	0.00	0.03	0.75	0.52	0.00	0.00	0.00	0.00	0.21	1.62	0.15
	2	0.24	0.03	0.12	0.16	0.11	0.12	0.00	0.00	0.03	0.18	0.00	0.03
	3	0.60	0.11	0.00	0.02	0.06	0.10	0.00	0.00	0.14	0.19		0.21
	4	0.80	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.03	0.07		0.04
	5	0.00	0.99	0.02	0.08	0.02	0.03	0.00	0.00	0.00	0.03		0.14
	6	0.15	0.16	0.07	0.15	0.11	0.00	0.00	0.00	0.26	0.27		0.03
	7	0.31	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.64	0.48		0.07
	8	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.46	0.18	0.57		0.00
	9	0.00	0.02	0.01	0.01	0.00	0.00	0.22	0.41	0.46	0.11		0.06
	10	0.67	0.03	0.01	0.47	0.00	0.00	0.18	0.23	0.09	0.21		0.34
	11	0.07	1.40	0.08	0.12	0.02	0.00	0.36	0.01	0.07	0.22	0.02	0.08
	12	0.23	4.09	0.02	0.12	0.10	0.00	0.52	0.00	0.18	0.44	0.03	0.00
	13	0.32	0.20	0.05	0.01	0.00	0.04	0.00	2.09	0.03	0.41	0.07	0.11
	14	0.11	0.01	0.15	0.22	0.00	0.00	0.00	0.08	0.11	0.03	0.01	0.20
	15	0.02	0.00	0.13	0.79	0.00	0.00	0.00	0.19	0.46	0.25	1.03	0.45
	16	0.01	0.00	0.09	0.01	0.00	0.69	0.00	0.07	0.05	0.60	0.46	0.22
	17	0.09	0.03	0.00	0.00	0.02	0.04	0.01	0.53	0.57	0.00	0.00	0.06
	18	0.00	0.09	0.00	0.00	0.20	0.11	0.00	0.00	1.10	0.66	0.15	0.01
	19	0.00	0.21	0.00	0.00	0.14	0.18	0.77	0.19	0.10	0.39	0.35	0.34
	20	0.00	0.02	0.06	0.46	0.42	0.19	0.02	0.02	0.58	0.00	0.04	0.42
	21	0.00	0.00	0.11	0.00	0.14	0.10	0.27	0.39	0.17	0.98	0.16	0.03
	22	0.00	0.23	0.32	0.53	0.28	0.34	0.05	0.15	1.13	0.14	0.09	0.00
	23	0.02	0.04	0.02	0.25	0.52	0.00	0.00	0.05	0.90	0.87	0.10	0.04
	24	0.32	0.00	0.01	1.21	0.22	0.00	0.00	0.33	0.04	0.07	0.72	0.55
	25	0.00	0.00	0.02	0.11	0.15	0.04	0.18	0.03	0.23	0.23	0.18	1.12
	26	0.09	0.00	0.22	0.04	0.09	0.10	0.91	0.36	0.11	0.16	0.11	0.09
	27	0.28	0.01	0.09	0.00	0.15	0.14	0.60	0.28	0.03	0.18	0.00	3.02
	28	0.09	0.03	0.00	0.00	0.39	0.13	0.24	0.32	0.00	0.44	0.12	0.72
	29	0.00		0.00	0.02	0.48	0.03	0.00	0.02	0.06	0.12	0.16	0.00
	30	0.05		0.00	0.03	0.59	0.03	0.00	0.34	0.11	0.07	0.00	0.12
	31	0.39		0.00		0.04		0.00	0.00		0.16		0.04
	TOTALS	5.10	7.77	1.66	5.56	4.78	2.41	4.33	6.56	7.86	8.74	5.42	8.69

Total Annual **68.88**

ANGOON, ALASKA (500310)

Period of Record Monthly Climate Summary

Period of Record : 9/ 1/1949 to 4/30/1989

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	31.8	36.7	40.8	47.0	53.4	58.8	62.0	61.5	56.5	48.4	39.8	34.1	47.6
Average Min. Temperature (F)	23.4	27.1	29.8	33.9	39.8	45.6	49.8	49.7	45.4	39.2	32.3	27.1	36.9
Average Total Precipitation (in.)	3.51	2.86	2.48	2.22	1.91	1.90	2.31	3.78	4.84	7.72	4.54	4.13	42.19
Average Total SnowFall (in.)	17.3	13.8	8.8	2.1	0.0	0.0	0.0	0.0	0.0	0.4	6.5	16.4	65.3
Average Snow Depth (in.)	7	9	4	1	0	0	0	0	0	0	1	4	2

Percent of possible observations for period of record.
Max. Temp.: 81% Min. Temp.: 80.9% Precipitation: 83.7% Snowfall: 85.2% Snow Depth: 85.3%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

AUKE BAY, ALASKA (500464)

Period of Record Monthly Climate Summary

Period of Record : 2/ 1/1963 to 12/31/2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	29.8	35.4	40.4	49.0	57.0	63.1	65.3	64.2	56.8	47.2	37.0	32.4	48.1
Average Min. Temperature (F)	21.0	24.9	28.2	33.2	40.1	46.5	49.9	49.2	44.9	38.3	29.3	24.8	35.9
Average Total Precipitation (in.)	4.73	3.86	3.37	2.96	3.96	4.17	5.37	6.51	8.67	8.59	5.29	4.87	62.36
Average Total SnowFall (in.)	28.0	17.5	11.3	1.9	0.0	0.0	0.0	0.0	0.0	0.6	11.8	20.2	91.4
Average Snow Depth (in.)	11	12	9	2	0	0	0	0	0	0	2	6	3

Percent of possible observations for period of record.
Max. Temp.: 97.7% Min. Temp.: 97.9% Precipitation: 98.1% Snowfall: 98.2% Snow Depth: 97.8%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

JUNEAU 2, ALASKA (504094)

Period of Record Monthly Climate Summary

Period of Record : 7/ 6/1965 to 12/31/1998

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.2	37.2	41.2	48.9	56.1	62.4	63.8	63.2	56.8	48.6	39.8	35.5	48.9
Average Min. Temperature (F)	24.2	27.3	30.5	34.9	41.5	47.7	50.8	49.6	45.1	38.8	30.6	26.5	37.3
Average Total Precipitation (in.)	6.84	6.40	6.04	4.88	5.56	4.12	5.55	7.58	11.72	13.16	8.76	7.64	88.26
Average Total SnowFall (in.)	24.2	13.4	7.8	0.9	0.0	0.0	0.0	0.0	0.0	0.3	7.9	16.7	71.4
Average Snow Depth (in.)	5	4	2	0	0	0	0	0	0	0	1	2	1

Percent of possible observations for period of record.
Max. Temp.: 76.5% Min. Temp.: 76.2% Precipitation: 77.8% Snowfall: 75.8% Snow Depth: 75.9%
Check Station Metadata or Metadata graphics for more detail about data completeness.

JUNEAU 9 NW, ALASKA (504110)

Period of Record Monthly Climate Summary

Period of Record : 7/ 8/1965 to 6/30/1980

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	29.9	35.2	40.0	47.0	53.7	57.0	58.7	58.8	54.7	47.4	37.2	34.5	46.2
Average Min. Temperature (F)	15.6	19.9	24.8	30.6	36.2	41.6	43.7	42.7	39.8	35.6	26.0	21.9	31.5
Average Total Precipitation (in.)	5.15	4.10	4.50	3.80	4.73	4.72	5.64	7.42	10.81	11.51	7.40	4.99	74.77
Average Total SnowFall (in.)	26.5	19.1	12.1	0.7	0.0	0.0	0.0	0.0	0.0	1.3	13.1	19.9	92.8
Average Snow Depth (in.)	11	13	11	3	0	0	0	0	0	0	3	8	4

Percent of possible observations for period of record.
Max. Temp.: 71.3% Min. Temp.: 71.5% Precipitation: 83.3% Snowfall: 82.3% Snow Depth: 79.8%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

JUNEAU AP, ALASKA (504100)

Period of Record Monthly Climate Summary

Period of Record : 9/ 1/1949 to 12/31/2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	29.0	34.2	38.7	47.5	55.3	61.6	64.0	62.7	56.0	47.0	37.7	32.5	47.2
Average Min. Temperature (F)	18.2	23.0	26.6	32.4	39.2	45.3	48.4	47.6	43.2	36.9	28.5	23.4	34.4
Average Total Precipitation (in.)	4.26	3.92	3.48	2.93	3.53	3.13	4.29	5.34	7.21	7.86	5.43	5.09	56.47
Average Total SnowFall (in.)	26.8	19.6	14.4	2.8	0.0	0.0	0.0	0.0	0.0	1.1	11.7	21.8	98.4
Average Snow Depth (in.)	6	6	3	0	0	0	0	0	0	0	1	4	2

Percent of possible observations for period of record.
Max. Temp.: 97.8% Min. Temp.: 97.8% Precipitation: 97.8% Snowfall: 96.4% Snow Depth: 95.4%
Check Station Metadata or Metadata graphics for more detail about data completeness.

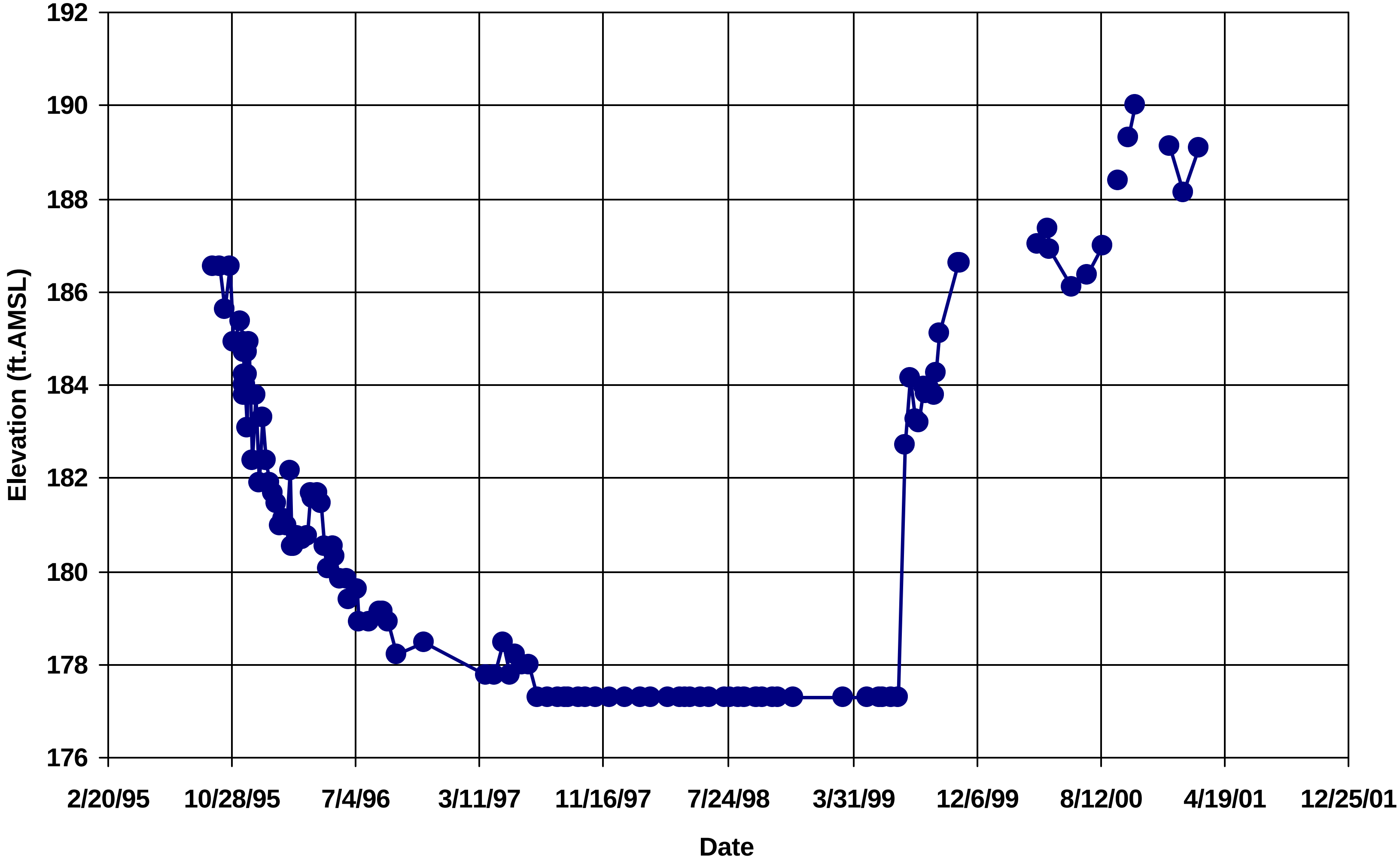
Western Regional Climate Center, wrcc@dri.edu

Appendix B

Tailings Piezometer Hydrographs

KENNECOTT GREENS CREEK MINE

PZ-44 Hydrograph



Bottom of Nitrogen Tube (ft. AMSL): 177.3

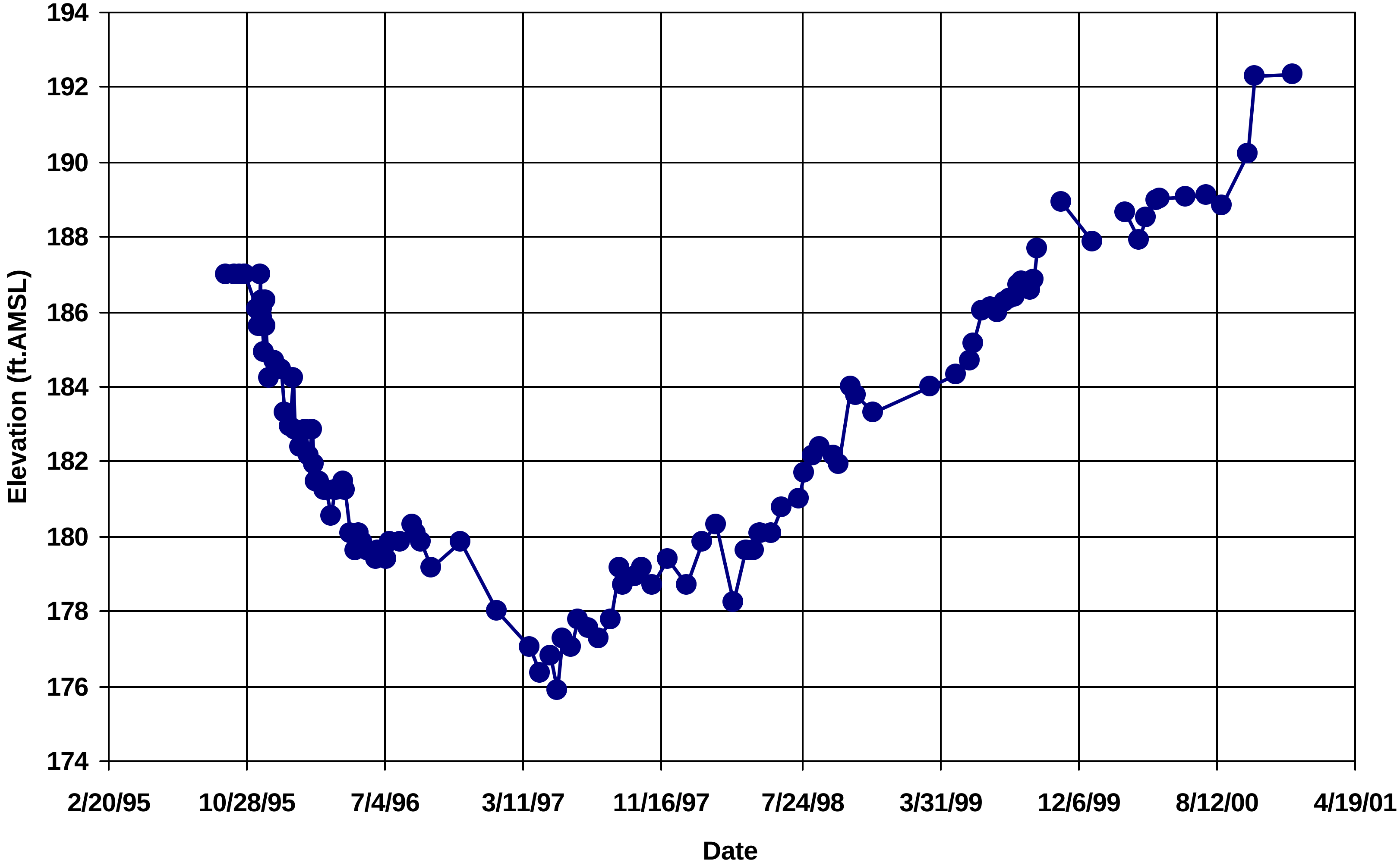
Land Surface Elevation (ft. AMSL): 208.59

Completion Zone: TAILINGS

Notes:

KENNECOTT GREENS CREEK MINE

PZ-50 Hydrograph



Bottom of Nitrogen Tube (ft. AMSL) 164.37

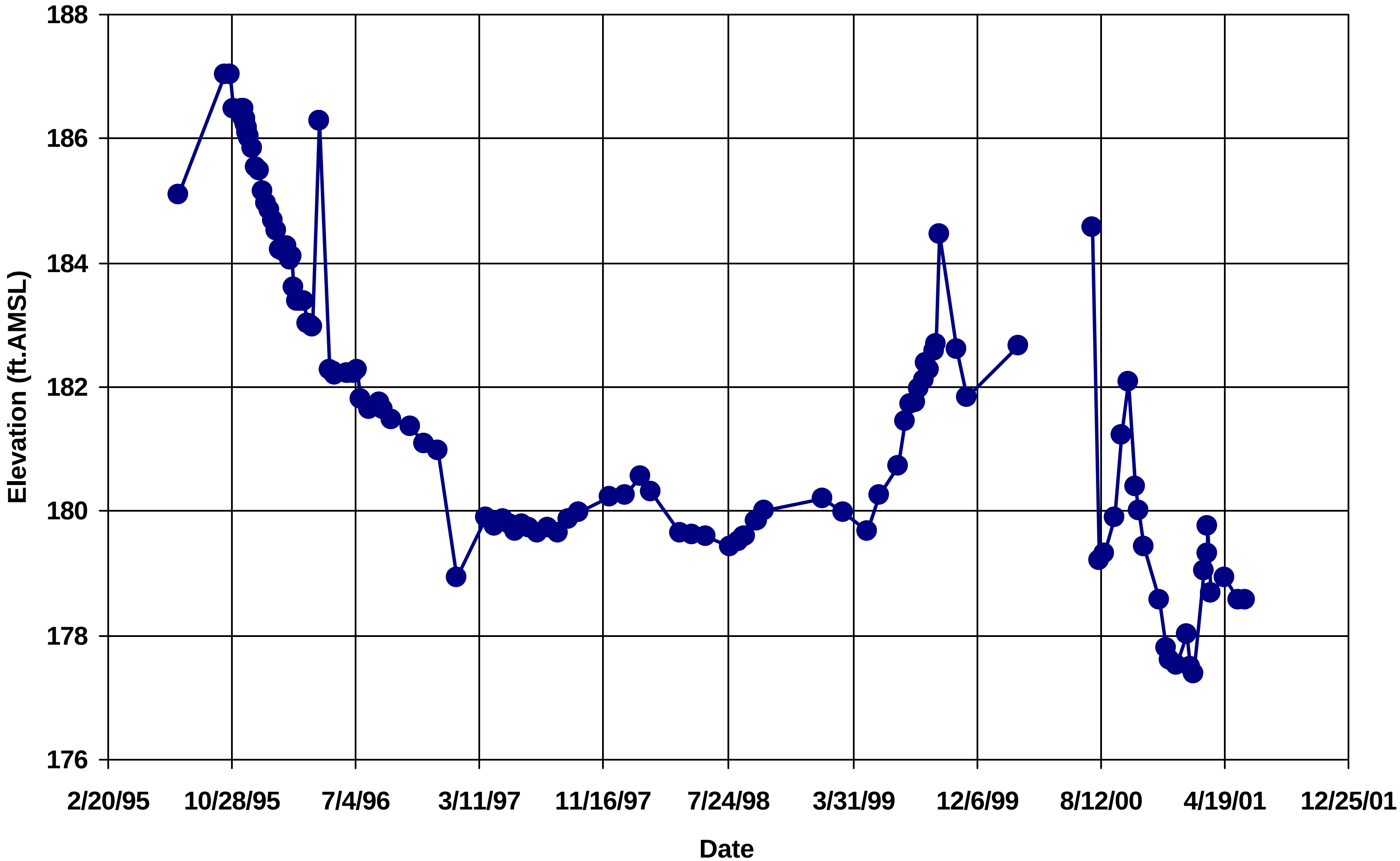
Land Surface Elevation (ft. AMSL): 215.45

Completion Zone: TAILINGS

Notes:

KENNECOTT GREENS CREEK MINE

TA-3 Hydrograph



Total Depth (ft. BLS): 60.5

Screen Top (ft BLS): 47.5

Land Surface Elevation (ft. AMSL): 201

Completion Zone: TILL

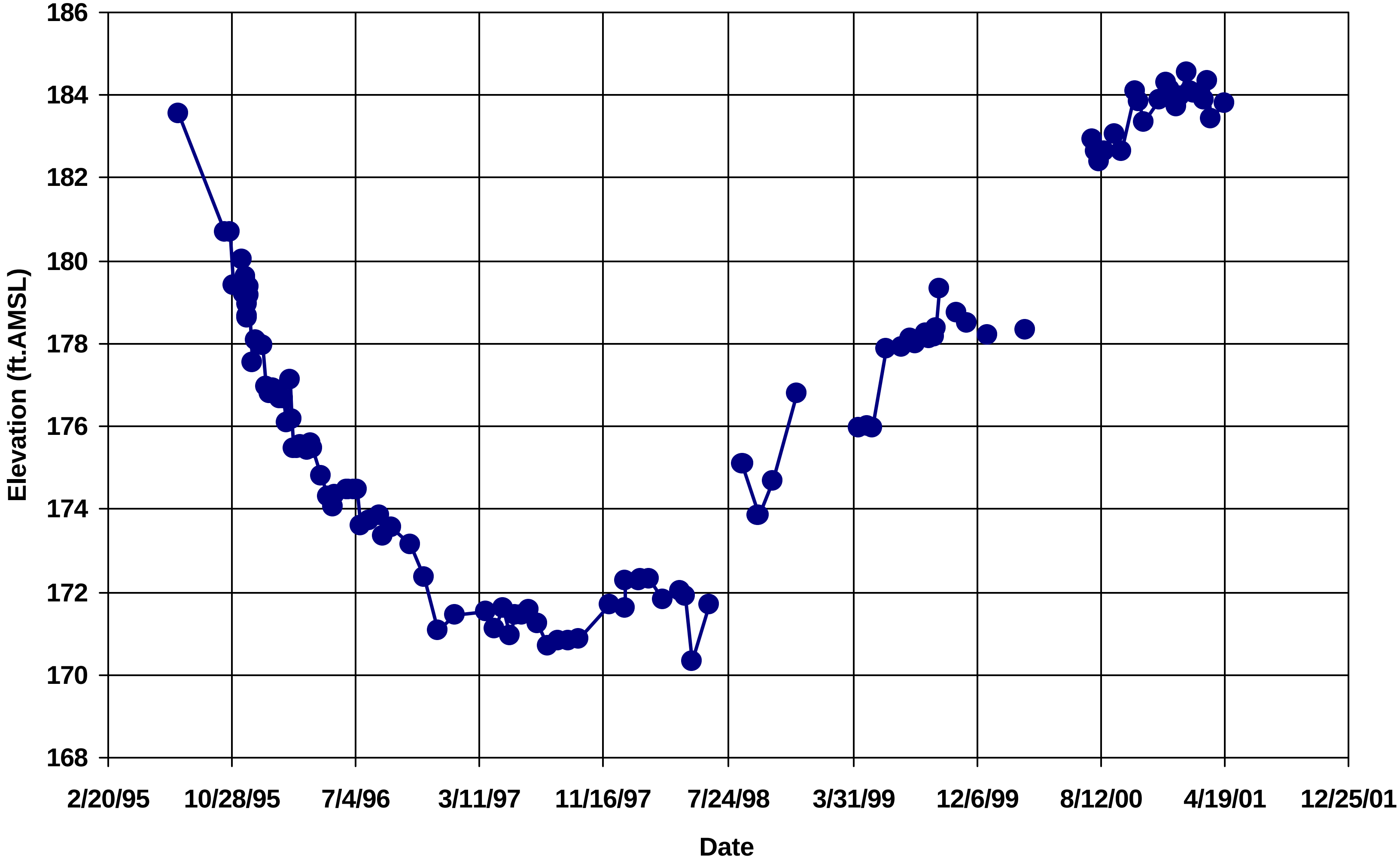
Screen Bottom (ft BLS): 52.5

Top of Casing Elevation (ft AMSL): 203.2

Notes: Partial Penetration

KENNECOTT GREENS CREEK MINE

TB-2 Hydrograph



Total Depth (ft. BLS): 59

Completion Zone: TAILINGS

Screen Top (ft BLS): 48.5

Screen Bottom (ft BLS): 59

Land Surface Elevation (ft. AMSL): 206.21

Top of Casing Elevation (ft AMSL): 208.71

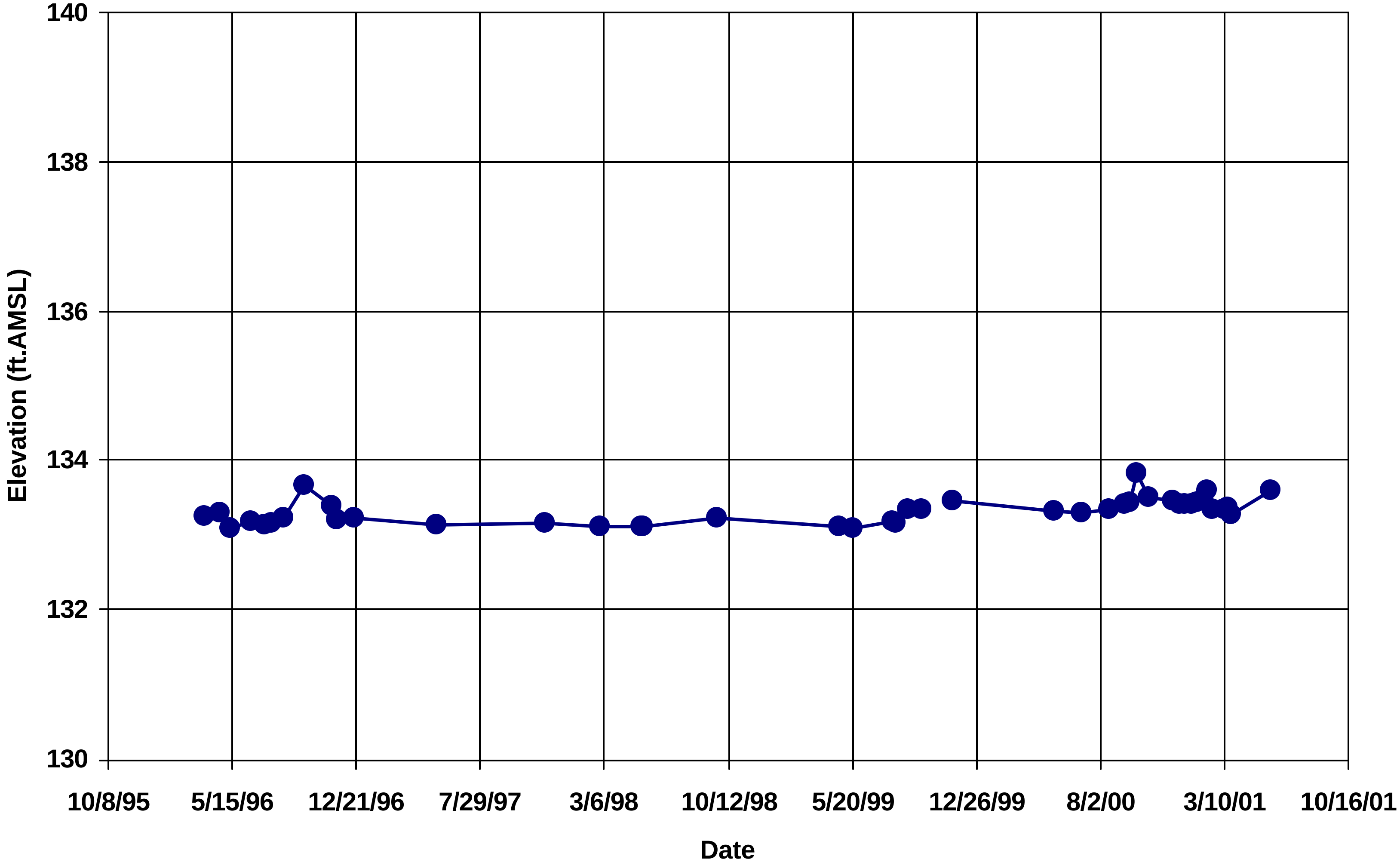
Notes: Partial Penetration

Appendix C

Peat, Sand, Till, and Bedrock Hydrographs

KENNECOTT GREENS CREEK MINE

MW-3S Hydrograph



Total Depth (ft. BLS): 14.66

Screen Top (ft BLS): 9

Land Surface Elevation (ft. AMSL): 134.3

Completion Zone: PEAT

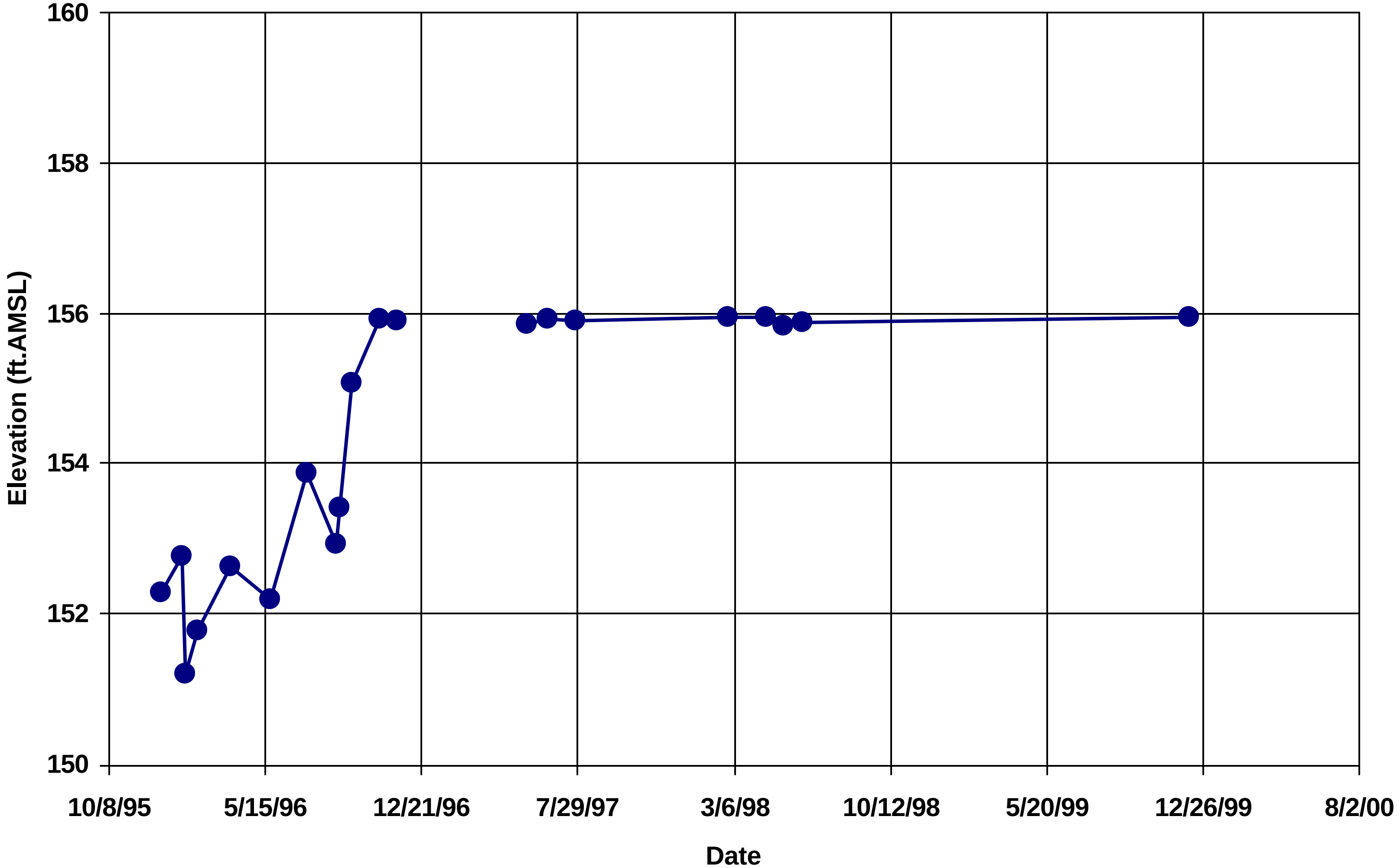
Screen Bottom (ft BLS): 14

Top of Casing Elevation (ft AMSL): 135.26

Notes:

KENNECOTT GREENS CREEK MINE

MW95-2 Hydrograph



Total Depth (ft. BLS): 7.05

Completion Zone: TILL

Screen Top (ft BLS): 6.75

Screen Bottom (ft BLS): 11.75

Land Surface Elevation (ft. AMSL): 153.07

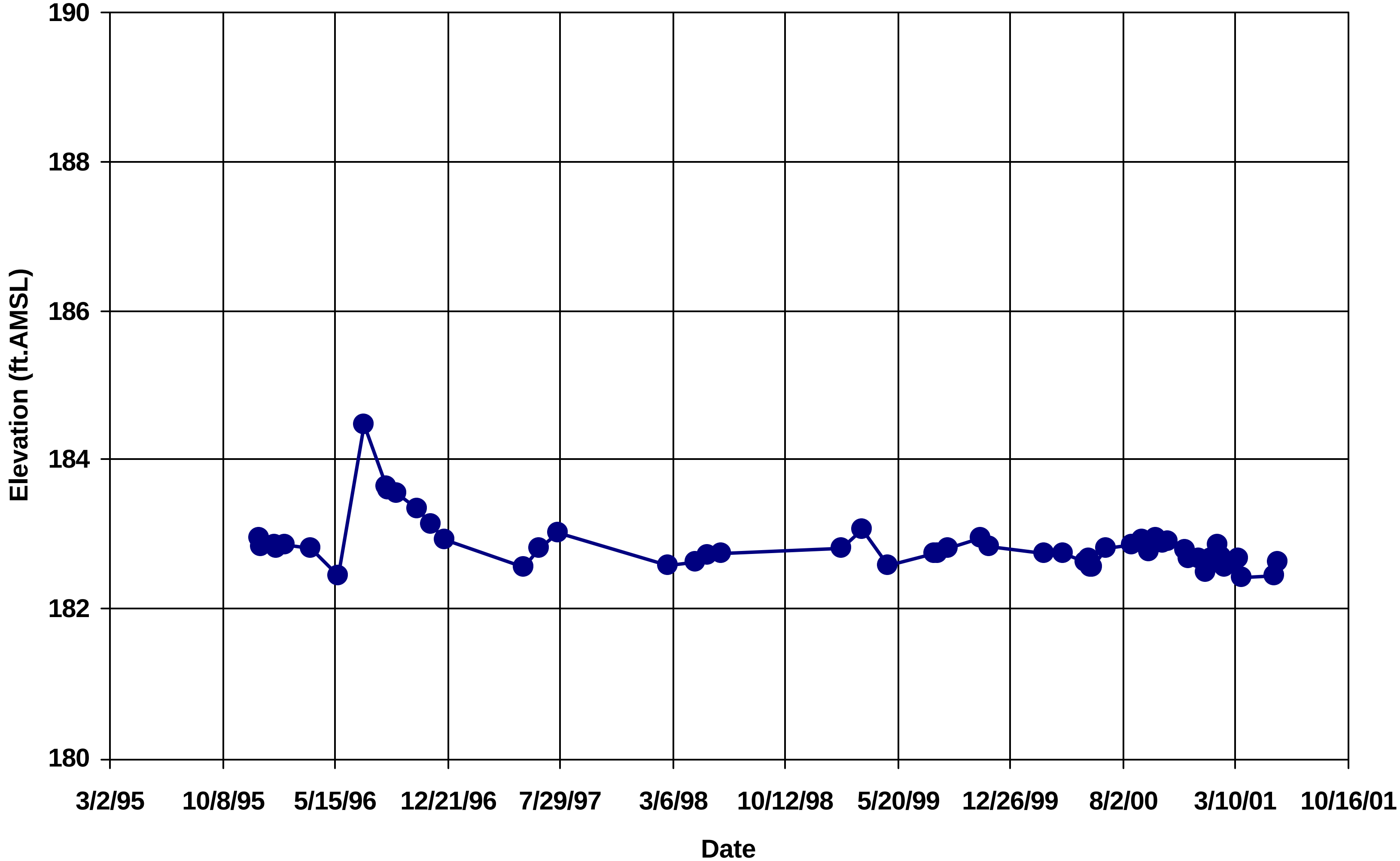
Top of Casing Elevation (ft AMSL): 155.94

Notes: Poor Seal Due to Sloughing

Top of casing measurements may indicate flowing well.

KENNECOTT GREENS CREEK MINE

MW95-5C Hydrograph



Total Depth (ft. BLS): 9.9

Completion Zone: PEAT

Screen Top (ft BLS): 5

Screen Bottom (ft BLS): 10

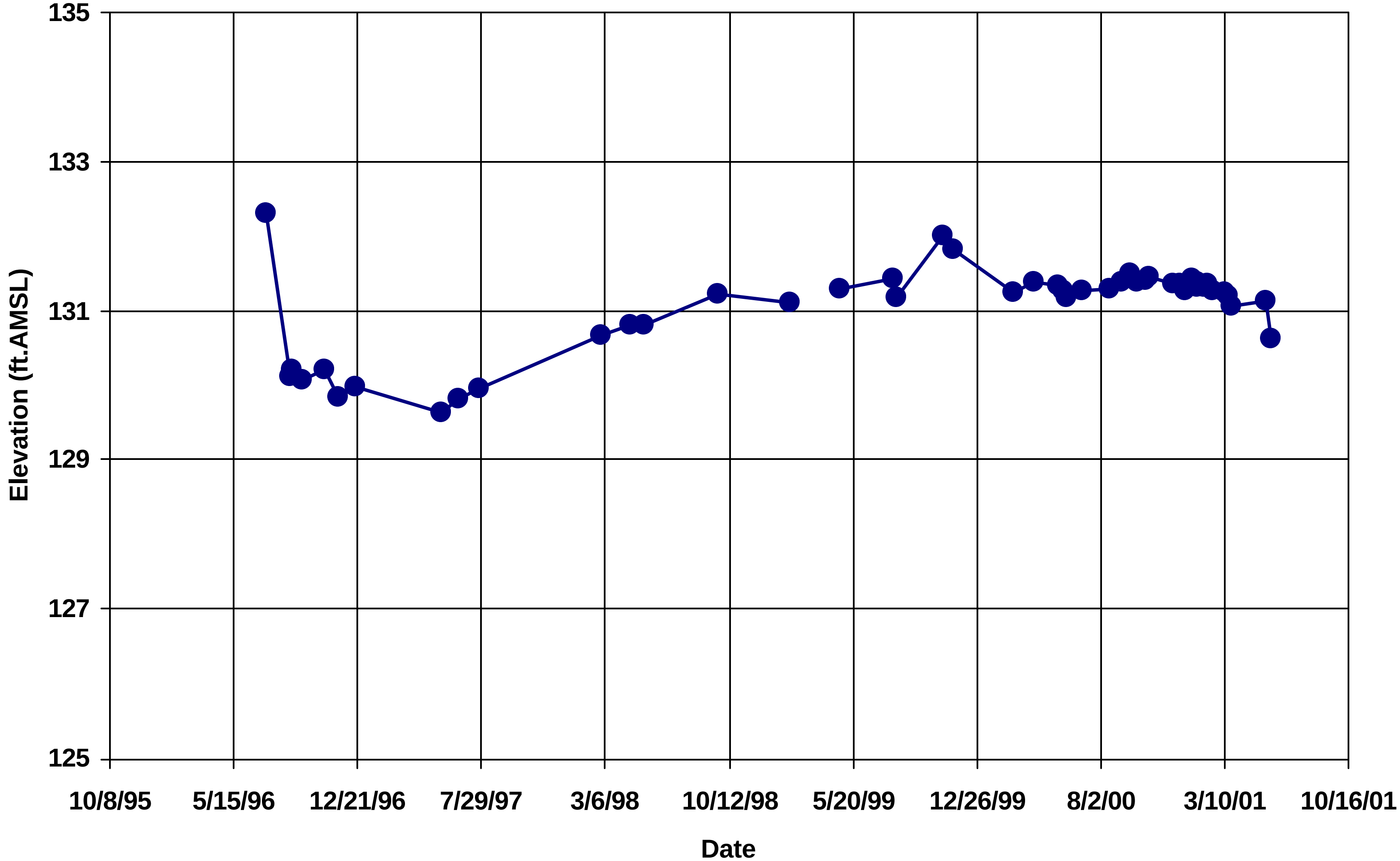
Land Surface Elevation (ft. AMSL): 184.4

Top of Casing Elevation (ft AMSL): 187.25

Notes: Partial Penetration

KENNECOTT GREENS CREEK MINE

MW96-2 Hydrograph



Total Depth (ft. BLS): 65

Screen Top (ft BLS): 45

Land Surface Elevation (ft. AMSL): 139.25

Completion Zone: BEDROCK

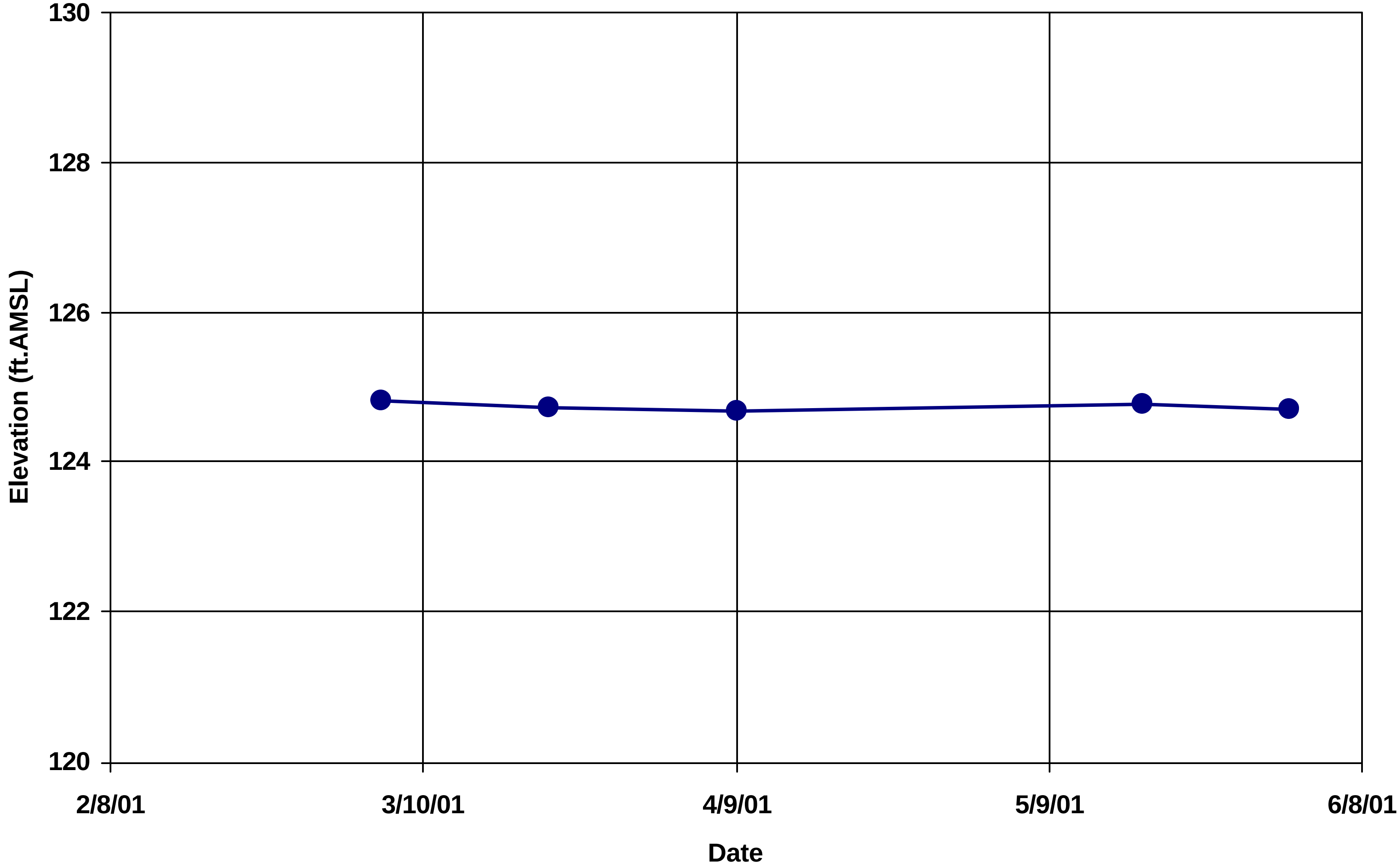
Screen Bottom (ft BLS): 65

Top of Casing Elevation (ft AMSL): 142.12

Notes: artesian

KENNECOTT GREENS CREEK MINE

MWT01-03A Hydrograph



Total Depth (ft. BLS): 21.3

Completion Zone: BEDROCK

Screen Top (ft BLS): 16.3

Screen Bottom (ft BLS): 21.3

Land Surface Elevation (ft. AMSL): 134.1

Top of Casing Elevation (ft AMSL): 135.8

Notes:

Appendix D

Update of Information and Action Plan on Seeps West of the Current Tailings Disposal Facility

KENNECOTT GREENS CREEK MINING COMPANY

Update of Information and Action Plan on Seeps West of the Current Tailings Disposal Facility

Prepared by
Kennecott Greens Creek Mining Company

January 2002

Table of Contents

1.0 Introduction

This report is an assessment of the geochemical characteristics of surface water and groundwater at the Kennecott Greens Creek Mine tailings facility. It is intended to supplement ongoing environmental monitoring reports, present an update on actions taken to define anomalous water compositions identified at the site and provide baseline information for proposed expansion of the tailings facility. A summary of the report findings and an updated action plan are provided in Sections 5.0 and 6.0, respectively.

1.1 Background

In the spring of 2001, surface water sampling results indicated pH values below 6.5 and anomalous metal concentrations in two small drainages west of the Greens Creek Mine tailings facility (Figure 1). Site topography and the lack of other geochemical indicators such as sulfate and zinc suggested that metal concentrations observed in one of these drainages, C.C. Creek, were natural occurrences and not an influence from the tailings facility. The other drainage, Further Creek, had somewhat elevated sulfate concentrations relative to some surface waters in the area. The surface water sulfate and metal concentrations were, however, comparable with concentrations from some of the background groundwater samples collected at the facility. A small area (~100' wide) in the Further Creek drainage area produced intermittent seepage (Further Seep) which had a pH of less than 4.0. While some of the anomalies were attributable to natural conditions, others suggested a possible influence from the tailings facility.

Kennecott Greens Creek Mining Company (KGCMC) notified regulatory agencies (USFS, ADEC, ADNR) of its findings and proposed further characterization of the area as the first step of an action plan to address these preliminary findings. Regulatory personnel inspected the site on July 31, 2001. On September 6, 2001 KGCMC proposed additional actions and monitoring to determine the sources for the anomalous waters compositions. The proposal discussed natural sources of acidity in muskeg environments and described how the composition of Further Seep suggested a mineral source for the acidity in the drainage. The proposal discussed possible scenarios to explain the occurrence.

This report presents information obtained during the ongoing investigation and provides a discussion of geochemical and hydrological processes that appear to be controlling water compositions in the vicinity of the tailings area. Section 5.0 contains an executive summary of the report findings.

1.2 Data Presentation

The figures accompanying this text allow comparison of aqueous components and enable interpretation of the geochemical and hydrological processes that are occurring at the tailings facility. Because of the large variation in concentrations of individual components, most of the data are plotted on logarithmic axes. The logarithmic plots improve presentation of the data for interpretation but impart distortion with respect to the concentrations that are displayed. Therefore, caution should be exercised while interpreting the figures. Figures and tables are presented in appendix form to facilitate easy access to information. A list of abbreviations and acronyms used in the text, figures and tables is presented in the appendix.

Compositional data for sites discussed in this report are presented in Table 1. Samples were grouped by general water type or completion zone (lithology and depth) prior to data interpretation. There are cases, with respect to the peat, sand and marine/glacial sediments, where the data suggest that a given sample was not assigned to the most appropriate group. For example, a sample assigned to the peat group may have geochemical signature of the alluvial/marine sands. In order to remain consistent with other documents (e.g. field logs and hydrology reports) the samples were not reassigned to a new group. To facilitate black and white printing of the figures, different icon sizes, shapes and shades represent different groups. Larger icons represent background samples and smaller icons represent down-gradient samples. Background sites are sites that are located hydrologically up-gradient of the tailings basin site, are geographically distal or were sampled prior to commencement of tailings placement in 1989. Analyses that are below the detection limit are conservatively plotted at the detection limit value. Bold value text indicates total rather than dissolved analyses and shaded cells indicate that the result was taken from a different sample analysis at the same site (Table 1).

1.3 Geochemical Overview

The purpose of this report is to utilize available geochemical data to describe a relatively diverse suite of site waters. For example, Figure 2 shows the comparison between sulfate and combined calcium and magnesium. Tailings contact waters plot in the upper right portion of the graph and reflect the products of sulfide oxidation and carbonate dissolution. Background samples plot in the lower left portion of the graph, reflecting the relatively minimal ambient sulfate, calcium and magnesium loading from geologic materials with which the waters are in contact. Most of the down-gradient samples plot inside an ellipse that incorporates the background samples. However, some of the down-gradient sites plot outside that ellipse, suggesting communication between the contact waters and background waters.

Contact waters are waters that have been in direct communication with tailings or production rock and result from a dynamic system of naturally-occurring geochemical processes. These processes include but are not limited to oxidation, reduction, evaporation, dilution, mixing, precipitation, dissolution, sorption and ion exchange. It is beyond the scope of this report to describe the genesis of the diverse suite of contact waters represented at the tailing facility. However, the composition of these waters is consistent with the mineral content of the of the tailings and/or production rock with which they have been in contact (e.g. iron and base metal sulfides, carbonates and sheet silicates). Weathering of these minerals contributes sulfate, calcium, magnesium, sodium, iron, manganese, zinc and other trace metals to the contact waters.

Pyritic rock from quarries, road cuts and underground development has been used at the tailings facility. There are cases where such pyritic rock, not the tailings, is controlling drainage compositions. Therefore, analyses from production rock sites, which are not associated with the tailings facility, are included on most plots. These analyses represent the range of drainage compositions produced from pyritic rock sources.

Sample results from wells completed in similar geologic units three miles from the existing tailings site augment the background water sample suites. Inclusion of this information is necessary because some of the water compositions encountered down-gradient of the tailings facility do not have up-gradient analogues. For example, there are uplifted terraces at the tailings site that differ in age, elevation, stratigraphy and water composition. Therefore, lateral comparisons with the same terrace at a distal site are more appropriate than proximal vertical comparisons between terraces that differ in age.

The pH values of several site waters are shown on Figure 3 (see Section 2.2 for descriptions of acronyms used in the figure). Background muskeg waters are acidic – a result of acids produced by decomposition of organic compounds in the peat. Waters from uplifted marine sediments are alkaline – a result of residual seawater entrained in the sediments (the pH of seawater is 8.5). Tailings contact waters have pH values between 6.5 and 8.5. The alkaline character of the tailings waters shows that acidity formed by sulfide oxidation is effectively neutralized in-situ by tailings carbonate dissolution. The relationship between Further Seep and other site waters, as illustrated on the figure, is explained in Section 2.1

Sodium versus potassium concentrations, shown in Figure 4, show that residual marine sediments are enriched in sodium and that both sodium and potassium are depleted rapidly as tailings, production rock and quarry rock weather. Since tailings and production rock are also derived from marine sediments, comparison of sodium and chloride concentrations, shown in Figure 5, does not allow differentiation between background and contact waters. Comparison of sodium and sulfate, however, does show separation of contact and background waters (see Figure 6 and Section 2.2 for descriptions of acronyms used in the figure). Figure 6 also shows differences between contact waters and illustrates the similarities in the range of water compositions derived from production rock, tailings and pyritic quarry rock.

2.0 Surface Water Compositions

2.1 Further Seep

Further Seep originates at the toe of the West Buttress access road and attains intermittent flow (0 to ~1 gpm) where it reaches a terrace slope approximately 200 feet west of the road (see Figure 1). The seep has a pH of approximately 3.5. As discussed in Section 1.3, occurrences of pH values less than 6.5 but greater than 4.0 (as observed in Althea Creek and C.C. Creek) are common in muskeg environments. Since several of the small streams west of the tailings area drain muskeg, such pH values are expected and clearly do not represent an influence from the tailings facility. However, occurrence of pH values less than 4.0 (as observed in Further Seep) are not typical of muskeg environments. It is recognized that drainage from undisturbed sulfide-bearing outcrop or drainage from mine tailings and production rock can produce waters with pH less than 4.0. The term for such water is "acid rock drainage" (ARD). Four possible scenarios for the low pH in Further Seep were discussed in the September 6, 2001 proposal. These scenarios are as follows:

<u>Scenario A (Residual Effects/Non-Tailings Source)</u>

Acidic drainage from a non-tailings source may have occurred prior to installation of the slurry wall/french drain systems in 1996, and the depressed pH in the drainage reflects residual effects outside of the slurry wall. With more than five years since the drain system was installed, one might expect to see signs of improvement, such as encroachment of plants and shrinkage of seep area. Localized signs of improvement are evident. Also, a road containing pyritic rock was present along a portion of the perimeter of the area prior to construction of the slurry wall. The trace of the old road is directly under the current perimeter road in the area of the acidic seep. Even though the majority of the pyritic rock was removed during West Buttress construction, its effects may still remain (see pH increase relative to ARD source in Figure 3 and decrease in sulfate in Figure 6).

<u>Scenario B (Hydrogen Ion Exchange/Thiosalt Oxidation)</u>

Alkaline drainage from the tailings facility could be migrating beyond the french drain and slurry wall system and could be exchanging divalent and trivalent cations (Ca, Mg, Fe, etc.) for monovalent hydrogen ion (H^+). The exchanged H^+ would lower the pH of the drainage. It is also possible that mill process-related thiosalts, such as thiosulfate or trithionate, could oxidize to sulfate, thus increasing the acidity of the seepage. This scenario could also include ion exchange or oxidation of residual, initially alkaline seepage that occurred prior to installation of the slurry wall and french drain.

Thiosalt and ion exchange-induced pH reduction in the peat has not been observed elsewhere at the facility. The effects of thiosalts have only been observed in mill process water and in residual tailings filterpress water collected from suction lysimeters placed in relatively fresh tailings. Thiosalts from the residual process water do not appear to persist in the tailings facility waters.

<u>Scenario C (Natural Occurrence)</u>

ARD could be occurring in the pyrite-bearing outcrop northwest of the tailings pile and daylighting at the seep location. Although the surrounding rock does contain pyrite, the outcrops are fairly weathered and do not contain large amounts of the potentially acid forming mineral. Wells completed in similar lithologies in the area do not produce acidic water. The minimal buildup of iron hydroxide precipitates downstream suggests that the seep has been present for several years but not necessarily hundreds to thousands of years, which would be expected for a natural occurrence.

<u>Scenario D (Current Tailings Source)</u>

ARD could be occurring in the tailings pile, migrating beyond the french drain and slurry wall systems and daylighting at the seep location. Extensive sampling of many water types inside the tailings facility has produced nothing but alkaline water. The tailings do have the long-term potential to generate ARD. However, even tailings that have been exposed for approximately ten years remain alkaline and still have available carbonate for further neutralization of acids caused by pyrite oxidation. Water that is in contact with tailings is buffered at neutral pH. No other pH anomalies have been observed along the slurry wall.

Site observations and laboratory data indicate that rock from the old access road, discussed in Scenario A, was the most probable source of the acidity in Further Seep. The pyritic rock was placed during construction of the site in 1988 (see Figure 7 for road location). Construction photos (Figures 8 through 10) indicate that the old road was removed when the West Buttress slurry wall was installed in 1996. The physical characteristics of the muskeg precluded removal of 100% of the pyritic rock, but field observations indicate only a minor residual component exists. Peat and sand were excavated from the West Buttress area in 1999 prior to installation of the basal drainage system. Samples of the residual pyritic rock taken during excavation for the West Buttress indicated the rock was potentially acid generating. Drainage from the pyritic rock flowed to the west.

Figures 3 and 11 compare pH and alkalinity to combined calcium and magnesium and indicate the mixing relationship between a surrogate ARD source and background surface water to produce the seep composition. A surrogate was required for comparison because the actual source appears to have been removed during West Buttress construction. The surrogate drainage sample was collected from pyritic rock that outcrops south of the site. Further Seep has combined calcium and magnesium, sulfate and acidity concentrations that are 6, 8 and 19 times less, respectively, than the surrogate ARD source. The lack of a significant surface water contribution that would dilute the drainage and observations of reduced impacts to vegetation in the seep area suggest that the source of acidity has been removed and that the quality of the water is improving. Continued monitoring of the seep will help verify this conclusion.

The concentration of metals, such as arsenic, lead and zinc, in the seep water are equal to or above background surface water concentrations but below maximum background concentrations observed in the peat, sand, silt and bedrock near the site (see Table 1 and

Figures 12 through 14). Although the pH of the seep (3.3) is lower than that of the muskeg nearby (generally 4.5 to 6.0), its acidity (32 mg/l $CaCO_3$) is not significantly higher than the acidity of typical muskeg water (up to 25 mg/l $CaCO_3$). Samples of peat that show no sign of contact with tailings water have a paste pH range of 3.3 to 5.4 (value average 4.2).

Sample results of peat and other materials encountered during excavation of the West Buttress area are presented in Table 2. The data show that some of the peat came in contact with tailings water prior to construction of the West Buttress. This is consistent with the topographic relationship between the low-lying area that is now occupied by the West Buttress area and location of the original tailings pile. The component of contact water drainage that used to flow through the peat to the west is now captured by the West Buttress slurry wall/french drain system. Relative to background values, increases in paste pH, conductivity, iron, manganese and most other trace metals in the peat are observed. The acidic, reduced conditions which typify background muskeg environments promote iron and manganese mobility. A comparison of the iron and manganese concentrations in the background peat solids (Table 2) relative to background concentrations in peat waters (Figure 15) illustrates partitioning of iron and manganese to the fluid phase. Interaction with alkaline tailings water caused the pH of the peat to increase and, along with oxidation, promoted precipitation of iron and manganese in the peat.

Paste conductivity values from several of the peat samples collected during West Buttress construction in 1999 (see Table 2) are generally higher than the current conductivity values in drainages west of the bentonite slurry wall (see Table 1). The apparent improvement in water quality is likely the result of the removal of the pyritic road rock and installation of the slurry wall.

2.2 Further Creek

Several small drainages convey water from the muskeg bogs west of the tailings area (Figure 1). Three of the drainages (Further Creek, Proffett Creek and Franklins Creek) have sulfate concentrations higher than apparent background in two drainages southwest (Althea Creek and C.C. Creek) and one east of the tailings pile (G.R. Creek). See Figure 1 for drainage locations and Figures 6 and 11 for differences in drainage compositions. Further Creek has several tributary branches, one of which contains Further Seep (discussed in Section 2.1). Water compositions (e.g. alkalinity, sulfate and zinc concentrations) and field observations (e.g. location of sample sites and flow measurements) indicate that Further Seep is not the only source of sulfate and metals in Further Creek.

In addition to the two original sampling locations labeled Further Creek Lower Reach (FCLR) and Further Creek Upper Reach (FCUR), two tributary branches were sampled. They are Further Creek South Fork (FCSF) and Further Creek North Fork South Spur (NFSS). FCSF plots close to the composition of Further Seep on several figures (e.g. Figures 6, 11, 12 and 16). The old access road, which likely created the acidity observed in Further Seep, terminated at the head of the FCSF branch. The location of the two drainages relative to the previously discussed pyritic access road segment is a reasonable explanation for why they have similar compositions.

The NFSS branch has higher dissolved constituent loading than the other branch samples (see Table 1 and Figures 6, 11, 14 and 16). The head of this branch of the Further Creek drainage is located at the toe of the West Buttress and coincides with the location of the temporary culvert that conveyed water off the PVC cover that existed from 1995 to 1999. The PVC cover was placed over the tailings pile during cessation of operations to shed rainwater and facilitate reducing water levels in the pile. A thin (millimeter-scale) veneer of tailings residue has been identified in the immediate area of the removed culvert noted on Figure 1. During sequential removal of the cover, a storm apparently washed tailings into the cover drainage system. Field conductivity measurements (see Figure 1) suggest that the tailings in that small area are contributing to the dissolved load.

A small exposure of tailings has also been identified in the bank of the Northwest Diversion Ditch located at the northwest corner of the West Buttress area. Sample analyses and field conductivity readings indicate that the exposed tailings are contributing to the Further Creek load. The tailings are part of a wedge of fill built to allow access to the bedrock ridge at the northwest corner of the site.

2.3 Proffett and Franklins Creeks

Analyses from Proffett Creek and Franklins Creek indicate a different source for dissolved constituents than observed in Further Creek (Figures 6, 11 and 16). Surface flow from Proffett Creek diminishes just northwest of the MW-01-02 monitoring well nest and appears to resurface in the Franklins Creek drainage. Similarities in their water compositions support the apparent link between these two drainages.

An access road and bedding materials for the NPDES outfall pipe and other utilities provide a preferential flow path for water along a portion the western perimeter of the facility. This water, which is represented by the sample labeled "Duck Blind Drain" appears to be influencing the composition of Proffett Creek and Further Creek. On several figures (e.g. Figures 3, 4, 6, 12 and 15) the Duck Blind Drain plots closer to samples of drainage from older pyritic rock (production rock sites) than samples of tailings contact waters. Sulfate concentrations imply a pyritic source. However the zinc concentration in the Duck Blind Drain sample is very low, relative to production rock sites, contact surface water and contact underdrains. High manganese and iron in conjunction with low arsenic and sodium preclude contact saturated zone water from being a source of the Duck Blind Drain water. Based on these observations, pyritic quarry rock containing carbonate mineralization but lacking zinc mineralization appears to be controlling the composition of the Duck Blind Drain and ultimately, Proffett Creek and Franklins Creek. The difference in mineral content between rock used to bed the NPDES outfall line and rock used in the access road near Further Seep indicates they were derived from different sources.

3.0 Monitoring Well Water Compositions

3.1 West Zone

Of the 13 wells west of the facility from which quality samples were obtained, three produced anomalous sulfate concentrations. Two of the wells are completed in shallow sand in the Further Creek drainage. The wells, MW-T-01-15C and MW-T-01-03B, had average sulfate concentrations of 90 mg/l and 186 mg/l, respectively. Although above background levels, the sulfate concentrations are approximately 10 times lower than those of tailings contact waters. These data are consistent with the concept that water from Further Seep, pyritic rock and/or the tailings pile (likely prior to slurry wall construction) has been in contact with the shallow sands in the area of those wells.

Zinc concentrations in water from these wells are low (less than .008 ppb) relative to tailings underdrain and runoff concentrations (1 to 16 mg/l). Either tailings water is not a significant contributor to the waters in the shallow sands, or sulfate reduction and/or ion exchange have reduced zinc concentrations by at least two orders of magnitude. Installation of the slurry wall likely stopped the direct communication between tailings contact water and water in the shallow sand unit. Approximately equal water elevations on both sides of the slurry wall indicate that there is not a significant gradient through the structure. However, the slurry wall is not totally impermeable and transport of small amounts of sulfate through it is possible.

The sulfate concentration measured in the first sampling of MW-T-01-03A, a bedrock completion, was low (11.9 mg/l). Subsequent sampling of the well yielded a sulfate concentration of 149 mg/l. The low initial value may have been influenced by water introduced into the formation during drilling, although the well was purged several times prior to sampling. Additional sampling will be performed to verify the sulfate concentrations in the formation water. The lack of significant chloride in the 01-03A bedrock well (6 mg/l) suggests that water from the 01-03B sand unit, which is high in chloride (~130 mg/l), is not the source for water in the bedrock (see Figure 5). Two plausible source areas for sulfate loading to the bedrock are the knob near the northwest corner of the tailings pile and the northern terminus of West Buttress slurry wall where it keys into bedrock. As observed with samples of the shallow sand, the zinc concentration in the bedrock is low (less than 0.01 mg/l). The low concentrations of zinc and sulfate relative to tailings contact waters suggest that either contact water is not the source or that its contribution is small (more than 10 parts background water to 1 part contact water). If contact water were a significant source of the sulfate, then considerable zinc attenuation via sulfate reduction or ion exchange is required to explain the observed water compositions. In any case, the low permeability of the bedrock (2E-5 to 1E-6 cm/s) would preclude all but a low overall water flux.

3.2 North Zone

Analysis of monitoring well data in the vicinity of Pit 5 suggests a source of sulfate loading in bedrock waters either in Pit 5 or near the northwest corner of the tailing facility. Sulfate loading (149 to 888 mg/l) was identified in bedrock wells MW-T-01-07, 08, 09, 03A and 96-4 (see Figure 6). However zinc concentrations are low (less than 10 ppb for all wells except MW-T-01-08, 40 ppb (see Figure 14)). The low zinc concentrations are not consistent with sources such as oxidized production rock and tailings surface waters. The abundance of iron and manganese in 96-4 and MW-T-01-09 (Figure 15) suggest that the tailings saturated zone, which has low concentrations of those elements, is not the source of the sulfate loading. In order for the saturated zone to be the source, significant mixing with an iron and manganese-rich, sulfate-deficient water would be required.

While drill core stored at Pit 5 likely contributes to the dissolved load, field conductivity measurements indicate that drainage from the core is not the dominant sulfate source in the area. At this point, the bedrock knob in the northwestern portion of the facility cannot be ruled out as a potential recharge area for down-gradient bedrock zones. However, disturbed, unmineralized, pyritic rock in the Pit 5 area alone could be the sulfate source. Low sodium and potassium concentrations suggest the contributing source rock has had time to weather (Figures 4 and 6). A mixture of two or more of these sources could also account for the observed water compositions.

Conductivity measurements in the muskeg area just north of the Pit 5 access road suggest that artesian flow of water from MW-T-96-4 is contributing sulfate to surface water in that area. Wells completed in the peat and marine/glacial units (MW-T-95-5A, -5B, -5C) directly above the MW-T-96-4 bedrock screen interval have low sulfate concentrations (less than 12 mg/l). This implies the marine/glacial units are an effective barrier to vertical flow between aquifers and suggests that flow through the slurry wall, if it occurs at all, does not have a negative influence on down-gradient water quality. The slurry wall is located along the axis of the Pit 5 entrance road (see Figure 1). KGCMC will continue to characterize this area, including verifying that contact surface water conveyed in the ditch on the south side of the Pit 5 entrance road does not have the opportunity to migrate beyond the slurry wall.

3.3 South Zone

Well MW-T-00-04A, which is completed in shallow sand south of Tank 6 in the southeast corner of the facility, shows sulfate loading (78.6 mg/l) that appears to be about two to four times background levels (Figure 6). However, metal concentrations are very low (Cu < 0.5 ppb, Pb < 0.2 ppb, Zn 5.9 ppb). Other than sulfate, major ion and trace element concentrations are consistent with those of background water. MW-A-01-11B is completed in a similar unit at the distal site used for comparison where suitable proximal analogues do not exist. The sulfate concentration in MW-A-01-11B is 63.1 mg/l and demonstrates that background sulfate levels of that magnitude do occur. See section 4.0 for an expanded discussion of background sites. Rock exposed at the Wide Corner area east of Tank 6 contains pyritic zones that could produce the minor sulfate loading observed in MW-T-00-04A and quarry bedrock wells MW-T-01-06A, MW-T-01-6B, MW-T-01-05. Surface or sub-surface contributions from the tailings have not been identified, and the lack of zinc, calcium and magnesium loading suggests such contributions do not exist.

Samples taken from the muskeg area south of the Main Embankment and north of the small access road below the embankment also show sulfate loading (labeled “S Return” on Figure 6). Samples taken prior to tailings placement in 1989 also showed sulfate loading, but the current concentrations are somewhat higher. The rock used to construct approximately two thirds of this access road in 1988 contains abundant pyrite and lacks carbonate mineralization. Drainage from this road is the apparent source of the sulfate observed in the samples. The increase in sulfate concentrations is consistent with the concept of increased sulfide oxidation rates that often accompany depletion of carbonate buffering capacity. The road and the area it encompasses were named "Seepage Return" in 1988 because they were designed to allow pumping of water from the toe of the Main Embankment if seepage though the embankment occurred, and if it was of unacceptable quality. Such waters have not been found at this site. KGCMC plans to remove this access road and will continue to monitor the area. The five wells completed south of the main embankment have low sulfate concentrations. See for example data for MW-T-88-1S, MW-T-88-1D, MW-T-88-2S, MW-T-88-2D, MW-T-96-1. These findings suggest that the sulfate loading is confined to a small area and does not reflect large-scale influences, whether natural or from the tailings facility.

The fact that the almost all of the down-gradient wells do not show a contact water component indicates that the bentonite slurry walls and clay/silt sedimentary units are performing well with respect to capturing site waters. The cases where anomalous sulfate concentrations have been identified appear to be isolated sites where pyritic material (quarry rock, production rock or tailings) lies (or once lay) outside the capture area of the slurry walls and clay/silt units.

4.0 Background Sites

Background sites were discussed briefly in Section 1.0 and have been referred to repeatedly throughout the report. Discussions presented in Sections 1, 2 and 3 provide information necessary to explain the diverse suite of site waters However, an expanded discussion of the data obtained from background sites is warranted. Background sites are sites that are located hydrologically up-gradient of the tailings basin site, are geographically distal or were sampled prior to commencement of tailings placement in 1989. As explained in Section 1.3, the rationale for using data from distal sites is based on the concept of geomorphically comparable aquifer material. This approach is necessary due to the lack of up-gradient comparison sites for the tailings basin because of the occurrence of stepped terraces that rise hydrologically up-gradient to the east. These uplifted terraces differ in age, elevation, stratigraphy and water composition. Therefore, lateral comparisons with the same terrace at a distal site are more appropriate than proximal vertical comparisons between terraces that differ in age and geochemistry.

Samples taken from down-gradient wells prior to 1989 are considered background. Samples from the same wells taken since 1989 are reported as down-gradient wells. Figure 17 shows that sulfate concentrations in the eight background wells were low in 1988 (less than 25 mg/l) and have remained low.

The presence of background waters that do not have pH values between the values of 6.5 and 8.5 was discussed in Section 1 (see Figure 3). Muskeg waters tend to have pH values less than 6.5 and waters from marine sediments can have pH values greater than 8.5. In addition to pH, there are cases where some metal concentrations from background sites are higher than Alaska water quality standards. Figures 18, 19 and 20 show the relationship of copper, lead and zinc, respectively, to hardness and the Alaska water quality standards (chronic, freshwater). Figure 12 shows that several of the wells completed in marine units produce water with arsenic concentrations that are also above the water quality standard.

5.0 Summary and Conclusions

Comparison of sulfate versus combined calcium and magnesium for site waters indicates that many of the down-gradient samples have compositions consistent with background waters. However, some down-gradient samples suggest localized communication (either ongoing or past) with contact waters or other sulfate sources.

Background pH values of site waters range from acidic to alkaline. Waters with pH values as low as 4.0 are not unusual for background muskeg areas. The low pH of muskeg waters is a result of acids produced by decomposition of organic compounds in the peat. Alkaline waters derived from uplifted marine sediments yield pH values in excess of 8.5. The pH of tailings contact waters is between 6.5 and 8.5, which indicates any acidity produced by sulfide oxidation is effectively neutralized in-situ by carbonate dissolution.

Acidic drainage observed in a small area west of the tailings pile (Further Seep) was likely caused by weathering of pyritic rock in an access road on the western perimeter of the site. The road was removed during construction of the West Buttress and observations of water compositions suggest that the quality of the water is improving. The acidity of the seep (32 mg/l $CaCO_3$) is not significantly higher than the acidity of typical muskeg water (up to 25 mg/l $CaCO_3$). The maximum concentration of some metals, such as copper, lead and zinc in the seep water are equal to or above background surface water concentrations but below maximum background concentrations observed in the peat, sand, silt and bedrock near the site.

Water compositions and field observations in the area west of the pile indicate that there are other sources of dissolved loading in surface waters than those that produced Further Seep. These sources include residual contact water that existed in the area prior to slurry wall installation in 1996, pyritic construction rock and small amounts of tailings that reside inside the facility boundary but outside of primary containment structures. Water compositions suggest that contact water up-gradient of the slurry wall is not a significant contributor to dissolved loading in the western drainages.

Of the 13 wells west of the facility from which quality samples were obtained, three produced anomalous sulfate concentrations. Data from two of the three wells (both completed in shallow sand in the Further Creek drainage) are consistent with the suspected sources of dissolved loading to surface drainages (Section 2.2). The composition of water from MW-T-01-03A, a bedrock completion, suggests two possible sources of loading. Potential sources include the knob near the northwest corner of the tailings pile and the northern terminus of West Buttress slurry wall where it keys into bedrock. The low concentrations of zinc and sulfate relative to tailings contact waters suggest that either contact water is not the source or that its contribution is small. If contact water were a significant source of the sulfate, then considerable zinc attenuation via sulfate reduction or ion exchange is required to explain the observed water compositions. In any case, the low permeability of the bedrock would preclude all but a low overall water flux.

Analysis of monitoring well data in the vicinity of Pit 5 suggests a source of sulfate loading in bedrock waters either in Pit 5 or near the northwest corner of the tailings facility. Low zinc concentrations in the well waters are not consistent with sources such as oxidized production rock and tailings surface waters. The abundance of iron and manganese in MW-T-96-4 and MW-T-01-09 suggest that the tailings saturated zone, which has low concentrations of those elements, is not the source of the sulfate loading. In order for the saturated zone to be the source, significant mixing with an iron and manganese-rich, sulfate-deficient water would be required. The bedrock knob in the northwestern corner of the facility cannot be ruled out as a potential recharge area for down-gradient bedrock zones. However, unmineralized, pyritic rock fill in the Pit 5 area alone could also be the sulfate source. Low sodium and potassium concentrations suggest the contributing source rock has had time to weather. A mixture of two or more of these sources could also account for the observed water compositions.

Conductivity measurements in the muskeg area just north of the Pit 5 access road suggest that artesian flow of water from MW-T-96-4 is contributing sulfate to surface water in that area. The lack of sulfate in wells completed in the peat and marine/glacial units above the MW-T-96-4 bedrock well screen implies the marine/glacial units are an effective barrier to vertical flow. Observations from these shallower wells also suggest that the slurry wall is an effective barrier to flow.

There are two areas of sulfate loading south of the tailings pile. The sulfate concentration of 78.6 mg/l observed in MW-T-00-04A is above typical background concentrations; however, all other major and trace element concentrations are consistent with background sources. Rock exposed at the Wide Corner area east of Tank 6 contains pyritic zones that could produce sulfate loading observed in MW-T-00-04A and bedrock wells MW-T-01-

06A, MW-T-01-6B, MW-T-01-05. Surface or sub-surface contributions from the tailings have not been identified, and the lack of zinc, calcium and magnesium loading suggests such contributions do not exist.

Sulfate loading occurred in the muskeg area south of the Main Embankment prior to the start of tailings placement in 1989. Rock used to construct a portion of the access road below the Main Embankment contains abundant pyrite and lacks carbonate mineralization. Drainage from these road materials appears to be the source of sulfate observed in the samples.

The fact that most down-gradient waters do not show a contact water component indicates that the slurry walls and clay/silt sedimentary “natural liner” units are performing well with respect to capturing site waters. The cases where anomalous sulfate concentrations occur appear to be places where pyritic material (quarry rock, production rock or tailings) lies (or once lay) outside the capture area of the slurry walls and clay/silt “natural liner” units.

6.0 Proposed Actions

The interpretations presented above are based on field observations and analysis of data collected to date. The data indicate that there are multiple, localized sources of sulfate loading in down-gradient waters at the tailings facility. KGCMC will continue to monitor these sites to verify that the effects from the identified sources are consistent with the magnitude of the observed loading and that mitigation efforts are effective. The following actions are proposed to verify initial interpretations and to minimize influences from confirmed sources:

- Monitoring and Analysis
    - Continue sampling and interpretation of site waters
    - Define extent of Duck Blind Drain sulfate source (standpipes and test pits)
    - Confirm removal of acidity source in Further Seep (standpipes, test pits)
    - Identify source for Pit 5 sulfate loading (test pits)

    - Collect additional water elevation data on either side of slurry walls (standpipes)
    - Cap MW-T-96-4 to determine its influence on surface waters
- Route NW Diversion Ditch into West Buttress Ditch
- Remove accessible tailings residue from the toe of the West Buttress berm
- Remove access road below Main Embankment
- Install pump in Duck Blind Drain and route water to Wet Well 1
- Lower inlet to North Retention Pond to improve drainage to pond
- Evaluate water control systems, and evaluate need to improve containment structures along the western and northern perimeters of the facility.

KGCMC will continue monitoring and analysis and plans to utilize the 2002 construction season to complete the proposed actions. Information obtained from the proposed actions will be summarized in future progress reports.

Appendices

List of abbreviations and acronyms

Data Tables

Figures

List of Abbreviations and Acronyms

ARD	acid rock drainage
AWQS	Alaska Water Quality Standard (chronic freshwater)
bicarb	bicarbonate
bkg, bg, bkgrnd	background
C Toe	Site C toe drainage
carb	carbonate
CCLR	C.C. Creek Lower Reach
CCUR	C.C. Creek Upper Reach
cond	conductivity
CPP	corrugated plastic pipe
DBD	Duck Blind Drain
dg	down-gradient
DOC	dissolved organic carbon
E	east
E CCP	Site E corrugated plastic pipe east drainage
E Toe	Site E south toe drainage
FCLR	Further Creek Lower Reach
FCSF	Further Creek South Fork
FCUR	Further Creek Upper Reach
FrC	Franklins Creek
FS	Further Seep
gpm	gallons per minute
GRC	G.R. Creek
mar/glac	marine/glacial sediment
MDL	minimum detection level
mg/l	milligrams per liter (~ parts per million, ppm)
mg/kg	milligrams per kilogram (parts per million, ppm)
N	north
NE	northeast

NFSS	North Fork South Spur (Further Creek)
NW	northwest
NW Div Ditch	northwest diversion ditch
PC	Proffett Creek
S	south
S Return	seepage return structure (south of Main Embankment)
Seds	sediments
s.u.	standard units (pH)
SW	southwest
TDS	total dissolved solids
TSS	total suspended solids
uS/cm	micro-Siemens per centimeter (conductivity)
umhos/cm	micro-mhos per centimeter (conductivity, equals uS/cm)
01-6B	MW-T-01-6B (well identification, same convention all wells)
23-F#	Site 23 Finger Drain Number 2, 3, 5, 7, etc.
960	Site 960 Seep #2 sample
1350	Site 1350 east lobe drainage sample

Table 1 Water Compositions (Page 1 of 8)

		Background Surface Water					Downgradient Surface Water									Duck Blind Drain
		Althea Creek	C.C. Creek			G.R. Creek	Proffett Creek	Franklins Creek	Further Creek							Duck Blind Drain
			Upper Reach	Lower Reach					N Fork S Spur	S Fork	Upper Reach	Lower Reach		Further Seep		
		surface (bkg)	surface (bkg)	surface (bkg)	surface (bkg)	surface (bkg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)	surface (dg)
		9/6/2001	5/9/2001	5/9/2001	9/6/2001	5/9/2001	9/6/2001	9/6/2001	8/29/2001	8/29/2001	5/9/2001	5/9/2001	8/29/2001	5/24/2001	8/29/2001	9/4/2001
Aluminum	mg/l, dissolved	0.535	<0.1	0.49	0.407	0.168	0.124	0.209	0.324	0.338	0.21	0.438	0.915	1.11	1.23	0.25
Boron	mg/l, dissolved	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.106	0.11	<0.1	<0.1
Barium	mg/l, dissolved	0.0132	0.00746	0.00715	0.0124	0.00922	0.0259	0.0155	0.0814	0.0377	0.0338	0.0305	0.0432	0.0346	0.0424	0.059
Calcium	mg/l, dissolved	2.19	4.16	4.65	4.99	3.99	65	31.7	41.4	26.5	17.5	16.6	19.4	20.9	19.5	218
Iron	mg/l, dissolved	1.33	0.186	0.333	0.804	<0.1	0.311	0.551	0.26	0.732	0.508	0.67	1.48	2.35	1.59	0.465
Magnesium	mg/l, dissolved	0.964	0.755	0.801	0.96	0.908	10.7	5.46	14.6	7.06	6.91	6.43	7.6	6.31	7.4	31.2
Sodium	mg/l, dissolved	2.27	1.3	1.47	1.55	2.17	2.23	2.01	4.32	2.98	2.91	2.69	3.32	3.28	3.29	3.41
Arsenic	mg/l, dissolved	0.00146	0.00061	<0.0005	<0.001	<0.0005	<0.001	<0.001	0.00097	0.00119	<0.0005	0.00057	0.00208	<0.0005	0.00108	0.001
Antimony	mg/l, dissolved	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00377	<0.001	<0.001	<0.001	0.00125	<0.001	<0.001	<0.001
Cadmium	mg/l, dissolved	<0.001	<0.0001	<0.0001	<0.001	<0.0001	<0.001	<0.001	0.00061	<0.0001	0.00032	0.00016	0.00016	0.00021	0.00028	<0.001
Chromium	mg/l, dissolved	0.00253	0.0156	0.0195	0.00162	0.0155	<0.001	0.0011	0.00125	<0.001	0.00145	0.0198	0.00308	0.00194	0.0011	<0.001
Copper	mg/l, dissolved	<0.002	0.00139	0.00724	<0.002	0.00466	<0.002	<0.002	0.00402	0.0015	0.00259	0.0071	0.00447	0.00492	0.00428	<0.002
Lead	mg/l, dissolved	<0.001	0.00028	0.00087	<0.001	<0.0002	<0.001	<0.001	0.00427	0.00072	0.00196	0.00172	0.00198	0.00363	0.00182	<0.001
Manganese	mg/l, dissolved	0.0394	<0.002	<0.002	0.0102	0.00483	0.0329	0.00523	0.0341	0.12	0.0313	0.0344	0.0856	0.577	0.31	4.08
Molybdenum	mg/l, dissolved	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.00573	<0.005	<0.005	<0.005	<0.005	<0.005
Mercury	mg/l, dissolved	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Nickel	mg/l, dissolved	<0.002	0.00124	0.00234	<0.002	0.00215	<0.002	<0.002	0.00263	0.00257	0.00228	0.00741	0.00306	0.00783	0.00684	0.0659
Selenium	mg/l, dissolved	<0.001	<0.0005	0.00184	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0005	<0.0005	0.00144	<0.0005	<0.001	0.00128
Silver	mg/l, dissolved	<0.001	0.00025	0.00074	<0.001	0.00019	<0.001	<0.001	0.00027	0.00018	0.00015	0.0002	0.00049	<0.0001	0.00016	<0.001
Zinc	mg/l, dissolved	0.00649	0.00433	0.00387	0.005	0.00477	<0.005	<0.005	0.209	0.0293	0.0838	0.0508	0.0508	0.0718	0.0654	0.0973
Potassium	mg/l, dissolved	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1	1.87	<1.0	<1.0	<1.0	1.03	<1.0	<1.0	4.08
Lab pH	s.u.	4.53	7.06	7.28	5.62	7.67	6.89	7.24	6.57	5.21	6.88	6.85	6.45	3.27	3.4	7.09
Field pH	s.u.	4.66	5.91	6.16	5.72	6.51	6.99	7.41	6.23	5.07	6.5	6.29	6.03	3.32	3.25	6.64
Acidity	mg/l $CaCO_3$	23.4	<10.0	<10.0	17.4	<10.0	<10.0	<10.0	<10.0	13.2	<10.0	<10.0	10.2	26	38.8	<10.0
Phosphorus	mg/l	0.0283	0.00768	0.00994	0.0227	<0.005	0.021	0.0241	0.0459	0.0402	0.0153	0.0148	0.0289	0.0218	0.00994	0.0224
Orthophosphate	mg/l	0.00748	0.00455	0.00562	0.00828	0.00216	0.00615	0.00934	0.0179	0.0157	0.00615	0.00615	0.0144	0.00296	0.00322	0.00801
DOC	mg/l	36.1	18.4	17.9	38	7.99	17.4	29.4	17.6	31.6	16.5	16.9	24.6	5.1	5.42	<5.0
Bicarb Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	8.0	71.2	29.4	13	<5.0	11.0	7.2	5.2	<5.0	<5.0	234
Carb Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide Alk.	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	8.0	71.2	29.4	13	<5.0	11.0	7.2	5.2	<5.0	<5.0	234
Silica	mg/l	2.76	3.9	5.3	1.06	4.23	4.39	2.98	7.73	4.6	5.65	5.95	5.11	49	13.5	11
Chloride	mg/l	2.3	1.38	1.48	1.48	2.09	1.7	1.56	4.25	1.84	2.94	2.61	2.86	3.3	3.48	1.92
Fluoride	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate-N	mg/l as N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite-N	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/l	3.08	0.873	0.833	1.46	2.64	140	63	149	87.8	47.4	43.4	65.3	97.5	118	496
Sulfide	mg/l		<0.05	<0.05		<0.05					<0.05	<0.05		<0.05		
Lab Spec. Cond.	uS/cm	37.4	21.7	20.8	28.7	33.8	382	198	303	178	146	131	145	377	342	1150
Field Spec. Cond.	uS/cm	42.3	26.5	30.9	28.5	33.3	441	177.5	371	197	147	133.3	157.8	406	455	1205
TDS	mg/l	120	51	110	120	37	330	210	303	230	130	130	180	160	210	920
TSS	mg/l	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	11	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	11
Hardness	mg/l	9.4	13.5	14.9	16.4	13.7	206	101	164	95.2	72.2	67.9	79.7	78.2	79.2	673
Cat/Anion Bal	% Difference	67.7	70.75	73.87	130.63	23.66	11.44	22.52	0.12	5.27	19.69	25.38	17.44	54.21	39.66	11.01
Field Temp	C	11	5.9	5.9	11.6	5.4	11.5	10.4	11.1	10.9	5.5	5.3	11.4		10.9	14.5
Flow (approximate)	gpm		5	8		10		10			5	15		7.2		2

See first page of appendix for
abbreviations and acronyms list

Table 1 Water Compositions (Page 2 of 8)

		NW Div Ditch	S Return		Contact Surface Water		Background Peat								Downgradient Peat	
		NW Div Ditch	S Return	S Return	W. Buttress Ditch	South Toe Ditch	MW-T-00-1C	MW-A-01-11C	MW-A-01-12C	MW-A-01-13C	MW-1S	MW-2S	MW-3S	MW-5	MW-1S	MW-2S
			34	34				Distal Site	Distal Site	Distal Site	25	27	29	32	25	27
		surface (dg)	surface (dg)	surface (dg)	runoff	runoff	peat (bkg)	peat (bkg)	peat (bkg)	peat (bkg)	peat (bkg)	peat (bkg)	peat (bkg)	peat (bkg)	peat (dg)	peat (dg)
		8/29/2001	12/21/1988	11/7/1996	9/7/2001	9/7/2001	4/18/2001	4/10/2001	4/11/2001	4/10/2001	10/20/1988	12/28/1988	10/20/1988	11/11/1988	8/15/1996	11/7/1996
Aluminum	mg/l, dissolved	0.506		<0.5	0.29	0.388	0.146	0.541	0.313	0.259					<0.5	<0.5
Boron	mg/l, dissolved	<0.1	0.07	**0.092**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**0.16**	**0.09**	**0.14**	**0.12**	**0.2**	**0.13**
Barium	mg/l, dissolved	0.0628	0.12	0.0503	0.0176	0.018	0.00709	0.00887	0.0141	0.00855	0.16	0.11	<0.02	0.11	<0.05	<0.05
Calcium	mg/l, dissolved	51.2	35	81.9	382	427	7.76	3.73	1.8	1.7	19	34	12	5	26	10.9
Iron	mg/l, dissolved	0.307	1.7	0.43	<0.1	<0.1	0.352	1.36	1.33	0.411	2.8	0.75	4.9	2.1	3.4	2.6
Magnesium	mg/l, dissolved	20.8	5.1	17.6	89.5	185	1.98	1.2	0.613	0.567	5.4	4.4	10	2.1	5.44	2.02
Sodium	mg/l, dissolved	4.81	25	7.41	11.2	9.77	3.71	6.74	10.4	7.15	25	33	16	36	21.6	13.4
Arsenic	mg/l, dissolved	0.00166	<0.005	<0.005	0.0063	0.00275	0.00067	0.00075	0.00162	0.00228	<0.005	<0.005	0.008	<0.005	<0.005	<0.005
Antimony	mg/l, dissolved	0.00242			0.0263	0.0124		<0.001	<0.001	<0.001						
Cadmium	mg/l, dissolved	<0.0001	<0.002	<0.000066	0.0398	0.0365	<0.0001	<0.0001	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.000066	0.0000688
Chromium	mg/l, dissolved	0.00165		<0.012	0.00119	0.00158	<0.0005	0.00109	<0.0005	0.00096					<0.012	<0.012
Copper	mg/l, dissolved	0.00373	0.006	<0.00065	0.0063	0.0122	0.00057	<0.0005	<0.0005	<0.0005	0.007	<0.002	0.006	0.01	0.00207	0.00388
Lead	mg/l, dissolved	0.00131	0.01	0.000178	0.351	0.0772	<0.0002	0.00056	0.00035	0.0018	0.01	<0.01	<0.01	<0.002	0.000275	0.0011
Manganese	mg/l, dissolved	0.51	0.71	0.71	1.92	3.18	0.0216	0.128	0.0499	0.0628	0.23	0.36	0.17	0.052	0.33	0.21
Molybdenum	mg/l, dissolved	<0.005		<0.5	0.00585	0.00591	<0.005	<0.005	<0.005	<0.005					<0.5	<0.5
Mercury	mg/l, dissolved	<0.00001		0.00000251	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001					0.00000343	0.00000131
Nickel	mg/l, dissolved	0.00298		<0.0056	0.318	0.204	<0.0005	0.0018	0.00066	0.00188					<0.0056	<0.0056
Selenium	mg/l, dissolved	0.00128	<0.005	<0.002	0.0252	0.00427	<0.0005	0.0008	0.00088	0.00377	<0.005	<0.005	<0.005	<0.005	<0.002	<0.002
Silver	mg/l, dissolved	0.00033	<0.002	<0.000012	0.00442	<0.001	<0.0001	0.00054	0.00037	0.00061	<0.002	<0.002	<0.002	<0.002	0.0000213	0.0000931
Zinc	mg/l, dissolved	0.107	0.039	0.0178	16.4	11.9	0.00218	0.00561	0.0337	0.0206	0.068	0.056	0.064	0.12	0.023	0.0097
Potassium	mg/l, dissolved	1.24	4.6	1.98	8.27	10.5	<1.0	<1.0	1.94	<1.0	2.9	2.4	2.4	2.3	1.61	<1.0
Lab pH	s.u.	7.28	6.6	6.71	7.35	7.55	6.41	5.01	5.04	5.34	6.5	6.4	5.9	5.8	6.38	6.04
Field pH	s.u.	6.63	6.4	6.55	6.94	7.6	5.7	4.94	5.47	5.13	6.4	6.4	5.9	6.4	6.63	6.02
Acidity	mg/l $CaCO_3$	<10.0			<10.0	<10.0	<10.0	15.4	21.6	12						
Phosphorus	mg/l	0.0331			0.159	0.19	0.019	0.179	0.254	0.311						
Orthophosphate	mg/l	0.00588			0.0524	0.028	0.00269	0.0932	0.148	0.152						
DOC	mg/l	21.8			1.24	<2.0	4.28	29.8	32.1	26.3						
Bicarb Alkalinity	mg/l $CaCO_3$	71.6			49	110	26.6	12.6	6	10						
Carb Alkalinity	mg/l $CaCO_3$	<5.0			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0						
Hydroxide Alk.	mg/l $CaCO_3$	<5.0			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0						
Total Alkalinity	mg/l $CaCO_3$	71.6	102.69	61.9	49	110	26.6	12.6	6	10	136	153.9	136.8	136.8	128	58.8
Silica	mg/l	4.24			2.82	2.57	11	4.16	4.7	11.3						
Chloride	mg/l	3.56	6		4.75	10.2	3.61	4	8.02	3	4	4	3	2		
Fluoride	mg/l	<0.1			0.29	0.304	<0.1	<0.1	<0.1	<0.1						
Nitrate-N	mg/l as N	<0.1			3.43	0.218	<0.1	<0.1	<0.1	<0.1	0.3		0.4			
Nitrite-N	mg/l	<0.1			0.206	<0.1	<0.1	<0.1	<0.1	<0.1						
Sulfate	mg/l	145	49	167	1330	1800	3.7	6.54	4.98	5.31	3	5	2	14	6.22	<2.0
Sulfide	mg/l															
Lab Spec. Cond.	uS/cm	344	280	398	1960	2490	70	65.6	63	54.4	260	280	250	210	305	115
Field Spec. Cond.	uS/cm	451	290	321	2150	2730	61.3	72.3	81.7	57.7	338	283	250	140	324	106
TDS	mg/l	330	210		1900	2600	59	100	110	120	300	240	240	230		
TSS	mg/l	9	6		67	29	13	6	<4.0	44	140	850	20	46		
Hardness	mg/l	214		149	1320	1830	27.5	14.3	29.7	6.6	96	150	70	45	85.5	23.6
Cat/Anion Bal	% Difference	15.29			3.31	3.15	1.32	36.9	35.99	18.44						
Field Temp	C	13	1	11.7	14.8	14.8	4.2	6.7	6	6.7	7.9	3.5		7	14.3	11.3
Flow (approximate)	gpm				2.5	0.5										

See first page of appendix for
abbreviations and acronyms list

Table 1 Water Compositions (Page 3 of 8)

		MW-3S	MW-5	Background Alluv./Marine Sand												
				MW-4	MW-4	MW-T-00-2A	MW-T-00-1B	MW-T-00-3A	MW-T-98-3	MW-T-98-5	MW-T-98-6	MW-A-01-12B	MW-A-01-14B	MW-A-01-14C	MW-A-01-11B	MW-A-01-13B
		29	32	31	31							Distal Site	Distal Site	Distal Site	Distal Site	Distal Site
		peat (dg)	peat (dg)	peat/sand (bg)	peat/sand (bg)	sand (bkg)	sand (bkg)	sand (bkg)	sand (bkg)	sand (bkg)	sand (bkg)	sand (bkg)	sand (bkg)	peat/sand (bg)	sand (bkg)	sand (bkg)
		11/7/1996	11/7/1996	10/18/1988	11/7/1996	4/18/2001	4/18/2001	4/18/2001	4/26/2001	4/26/2001	4/26/2001	4/11/2001	4/11/2001	4/11/2001	4/10/2001	4/10/2001
Aluminum	mg/l, dissolved	<0.5	0.7		<0.5	0.119	<0.1	<0.1	<0.1	<0.1	0.119	0.212	0.184	0.458	0.161	0.177
Boron	mg/l, dissolved	**0.072**	**0.094**	**0.1**	**0.072**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.105	1.07	0.108	<0.1	<0.1
Barium	mg/l, dissolved	<0.05	<0.05	<0.02	<0.05	0.0363	0.00796	0.0349	0.0253	0.0328	0.0132	0.176	0.0424	0.0759	0.154	0.0996
Calcium	mg/l, dissolved	11.4	3.19	15	27.9	36.2	12.5	25.6	14.1	23.2	2.44	85.8	17.1	78.2	37.9	83.5
Iron	mg/l, dissolved	4.3	2.1	<0.01	<0.1	<0.1	0.254	0.66	1.91	<0.1	0.135	17.6	0.115	21.8	10.2	9.12
Magnesium	mg/l, dissolved	6.55	<1.0	5.1	4.22	3.91	3.21	3.68	1.49	2.31	0.779	16.6	9.92	4.71	7.17	8.47
Sodium	mg/l, dissolved	5.93	7	5	4.03	4.87	5.22	4.26	2.79	2.67	2.48	25.9	194	15.3	75.4	19.8
Arsenic	mg/l, dissolved	0.0126	<0.005	<0.005	<0.005	0.00369	<0.0005	0.00138	<0.0005	<0.0005	<0.0005	0.00158	0.00407	0.00613	0.00335	0.00723
Antimony	mg/l, dissolved								<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/l, dissolved	<0.000066	<0.000066	<0.002	<0.000066	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/l, dissolved	<0.012	<0.012		<0.012	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.00263	0.00066	0.00153	0.00303	0.00118
Copper	mg/l, dissolved	0.00143	0.00116	<0.002	<0.00065	0.00072	<0.0005	<0.0005	0.00107	0.00191	0.00148	<0.0005	0.00105	0.00135	0.00051	<0.0005
Lead	mg/l, dissolved	0.000698	0.00206	<0.01	<0.00013	<0.0002	<0.0002	<0.0002	0.0004	<0.0002	0.00357	<0.0002	0.00033	0.00032	<0.0002	<0.0002
Manganese	mg/l, dissolved	0.14	0.027	0.033	0.071	0.0847	0.0472	1.55	0.792	0.341	0.0102	0.663	0.111	0.43	0.355	0.719
Molybdenum	mg/l, dissolved	<0.5	<0.5		<0.5	<.0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0199	<0.005	0.0105	<0.005
Mercury	mg/l, dissolved	<0.0000012	<0.0000012		<0.0000012	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Nickel	mg/l, dissolved	<0.0056	<0.0056		<0.0056	<0.0005	0.00841	0.00066	0.00162	0.00683	<0.0005	0.00128	0.00102	0.00113	0.00243	<0.0005
Selenium	mg/l, dissolved	<0.002	<0.002	<0.005	<0.002	0.00222	0.00071	0.0007	<0.0005	<0.0005	<0.0005	0.00212	0.00133	0.00128	0.0054	0.0009
Silver	mg/l, dissolved	0.0000265	<0.000012	<0.002	<0.000012	<0.0001	0.00012	<0.0001	<0.001	<0.001	<0.001	0.00112	0.00012	0.00036	0.00122	0.00044
Zinc	mg/l, dissolved	0.0191	0.0181	0.015	0.00499	0.00385	<0.001	0.00311	0.00524	0.0159	0.123	0.0396	0.0129	0.00864	0.00708	<0.005
Potassium	mg/l, dissolved	1.24	<1.0	2	1.06	1.04	<1.0	<1.0	<1.0	<1.0	<1.0	2.84	3.42	1.12	1.17	2.41
Lab pH	s.u.	6.13	5.6	7.5	7.8	7.79	6.64	7.03	6.76	7	5.94	6.68	7.96	6.56	6.27	7.08
Field pH	s.u.	5.89	5.51	7.5	7.53	7.79	5.78	7.03	5.9	6.62	5.02	6.87	8.1	6.79	6.4	7.17
Acidity	mg/l $CaCO_3$					<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Phosphorus	mg/l					0.0108	0.0105	0.017	0.021	0.0179	0.142	0.166	1.64	0.0575	0.0688	0.214
Orthophosphate	mg/l					0.00482	0.00322	0.00269	0.00216	<0.002	<0.002	<0.002	1.16	<0.002	0.00828	<0.002
DOC	mg/l					3.85	2.81	3.16	5.73	2.02	1.8	18	14.4	18.9	19.6	14.1
Bicarb Alkalinity	mg/l $CaCO_3$					99.2	49	78	34.4	85.6	7.6	336	482	237	197	273
Carb Alkalinity	mg/l $CaCO_3$					<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide Alk.	mg/l $CaCO_3$					<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity	mg/l $CaCO_3$	102	30.2	85.5	95.4	99.2	49	78	34.4	85.6	7.6	336	482	237	197	273
Silica	mg/l					12.2	15.4	18.4	3.75	5.6	4.35	46	36.4	12.4	34	21.4
Chloride	mg/l			4		3.85	4.22	5.35	2.93	2.95	2.74	10.2	25.4	1.76	9.76	11.4
Fluoride	mg/l					<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.222	0.699	<0.1	<0.1	<0.1
Nitrate-N	mg/l as N			<0.02		0.151	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.613	<0.1
Nitrite-N	mg/l					<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/l	<2.0	2	4	3.96	10.7	2.81	3.16	7.26	14	2.67	7.07	9.16	8.5	63.1	3.88
Sulfide	mg/l								<0.05	<0.05	<0.05					
Lab Spec. Cond.	uS/cm	181	85	190	165	215	107	161	84.1	196	30.5	628	930	449	522	519
Field Spec. Cond.	uS/cm	168	75.7	190	158	220	158		100	224	30.2	715	944	516	638	570
TDS	mg/l			120		140	84	120	64	130	44	380	600	260	350	310
TSS	mg/l			34		4	<4.0	<4.0	93	<4.0	57	48	29	48	25	61
Hardness	mg/l	60.9	5.2	80	58.3	106	44.4	79.1	41.3	67.4	9.3	283	83.5	194	124	243
Cat/Anion Bal	% Difference					36.02	4.98	32.79	44.35	6.91	1.94	41.99	41.3	69.36	33.06	51.19
Field Temp	C	14.3	12.3		12.5	6	5.3	6.4	5	5.5	4.5	6.3	6.4	6.3	7.5	8.2
Flow (approximate)	gpm															

See first page of appendix for
abbreviations and acronyms list

Table 1 Water Compositions (Page 4 of 8)

		Downgradient Alluv./Marine Sand							Background Marine/Glacial Seds								
		MW-T-01-02D	MW-T-01-15C	MW-T-01-15C	MW-T-00-4A	MW-T-01-01C	MW-T-95-1B	MW-T-95-1B	MW-T-00-1A	MW-T-00-3B	MW-T-98-2	MW-A-01-12A	MW-A-01-14A	MW-A-01-11A	MW-A-01-13A	MW-1D
												Distal Site	Distal Site	Distal Site	Distal Site	26
		sand (dg)	sand (dg)	sand (dg)	sand (dg)	sand (dg)	sand (dg)	sand (dg)	Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (bkg)
		4/4/2001	6/7/2001	9/6/2001	5/24/2001	4/4/2001	5/31/2001	9/4/2001	4/18/2001	4/18/2001	4/26/2001	4/11/2001	4/11/2001	4/10/2001	4/10/2001	10/20/1988
Aluminum	mg/l, dissolved	0.169	0.193	0.106	0.1	0.176	<0.1	0.123	<0.1	<0.1	0.217	0.111	0.11	<0.1	<0.1	
Boron	mg/l, dissolved	<0.1	<0.1	<0.1	<0.1	<0.1	0.236	<0.1	<0.1	<0.1	<0.1	0.133	0.562	1.31	0.498	**0.64**
Barium	mg/l, dissolved	0.0562	0.0481	0.0412	0.0546	0.126	0.0798	0.0703	0.00738	0.0454	0.0582	0.0541	0.0249	0.01	0.0703	0.15
Calcium	mg/l, dissolved	59.5	55	59.1	70.4	100	78.9	74.4	14.1	22.4	25.2	26.6	6.53	5.89	19.5	2
Iron	mg/l, dissolved	0.476	0.14	0.105	5.79	5.29	15.8	15.6	<0.1	0.687	6.31	0.1	0.191	<0.1	<0.1	<0.01
Magnesium	mg/l, dissolved	13.9	11.5	10.9	9.83	12.9	24.9	21.8	3.62	3.42	2.57	14.1	3.67	4.47	7.76	1.4
Sodium	mg/l, dissolved	11	48.8	51.1	20.7	8.62	26.3	24.2	4	4.18	3.41	30	135	212	106	210
Arsenic	mg/l, dissolved	0.00332	0.0306	0.0262	0.00459	0.00127	0.0511	0.0615	<0.0005	0.00076	0.0126	0.0127	0.00839	0.0596	0.00337	0.078
Antimony	mg/l, dissolved	<0.0005	0.00346	<0.001	<0.001	<0.001	<0.001	<0.001			0.00268	<0.001	<0.001	<0.001	<0.001	
Cadmium	mg/l, dissolved	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.002
Chromium	mg/l, dissolved	0.00129	0.00115	0.00116	0.00133	0.00322	0.00156	0.00159	0.00327	<0.0005	0.00097	<0.0005	0.0005	<0.0005	<0.0005	
Copper	mg/l, dissolved	0.00161	0.00338	<0.002	<0.0005	0.00101	0.00053	<0.002	<0.0005	<0.0005	0.0102	<0.0005	0.0232	0.00133	<0.0005	0.008
Lead	mg/l, dissolved	0.00078	0.0003	<0.001	<0.0002	0.00044	<0.0002	<0.001	<0.0002	<0.0002	0.00655	<0.0002	<0.0002	<0.0002	<0.0002	<0.01
Manganese	mg/l, dissolved	0.597	0.725	0.455	0.0432	0.112	1.2	1.81	<0.002	0.841	0.281	0.188	0.14	0.00925	0.0439	<0.002
Molybdenum	mg/l, dissolved	<0.005	0.0154	0.013	<0.005	0.00586	<0.005	<0.005	<0.005	<0.005	<0.005	0.0114	0.0148	0.0995	0.0137	
Mercury	mg/l, dissolved	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Nickel	mg/l, dissolved	0.00365	0.00735	0.00696	0.0012	0.00297	0.00268	0.00305	0.00076	0.00051	0.00208	0.0005	0.00134	0.00944	<0.0005	
Selenium	mg/l, dissolved	<0.001	0.00239	<0.001	<0.0005	<0.001	0.00089	<0.001	0.00086	<0.0005	0.00144	0.00238	0.00126	0.00159	0.00051	<0.005
Silver	mg/l, dissolved	0.0007	0.0002	<0.001	<0.0001	0.00143	<0.0001	<0.001	0.00011	<0.0001	<0.001	0.00026	<0.0001	0.00011	0.0002	<0.002
Zinc	mg/l, dissolved	0.0105	0.004	<0.005	0.00593	0.00589	<0.005	<0.005	0.00208	0.0018	0.0127	<0.005	<0.005	<0.005	0.00739	0.007
Potassium	mg/l, dissolved	4.35	9.66	8.35	1.89	2.46	1.96	1.94	<1.0	<1.0	1.08	5.72	6.6	8.45	5.62	3.7
Lab pH	s.u.	6.54	7.72	7.24	6.79	6.84	7.05	7.15	7.07	7	7.11	7.68	8.11	8.53	8.27	8.7
Field pH	s.u.	6.58	7.12	7.05	6.91	6.98	6.95	7.04	6.04	6.82	6.35	7.98	8.34	8.88	8.5	8.7
Acidity	mg/l $CaCO_3$	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	
Phosphorus	mg/l	0.0365	0.514	2.3	0.0317	0.0303	0.101	0.118	0.00655	0.0145	0.0164	0.149	10.7	1.59	0.884	
Orthophosphate	mg/l	0.00961	1.49	13	0.0176	0.00482	0.00481	0.0623	0.00375	0.00269	0.00642	0.102	1.88	1.12	0.434	
DOC	mg/l	16.7	10.2	6.96	8.86	21.7	22.4	<6.0	1.78	4.19	5.14	5.64	9.51	17.5	9.12	
Bicarb Alkalinity	mg/l $CaCO_3$	198	211	219	179	278	333	335	47.6	70	62.8	165	243	437	304	
Carb Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	18.8	<5.0	
Hydroxide Alk.	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
Total Alkalinity	mg/l $CaCO_3$	198	211	219	179	278	333	335	47.6	70	62.8	165	243	456	308	307.8
Silica	mg/l	17.2	21.1	21.9	81.8	38.2	20.6	20.8	15.9	17.8	5.3	17.2	9.35	9.4	16.2	
Chloride	mg/l	6	4.91	5.16	5.82	3.06	1.53	1.14	4.1	5.21	3.38	14.9	86.3	23.1	12.1	66
Fluoride	mg/l	<0.1	0.237	0.292	0.252	0.171	0.285	0.173	<0.1	<0.1	<0.1	0.297	0.871	1.21	0.506	
Nitrate-N	mg/l as N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.186	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.02
Nitrite-N	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Sulfate	mg/l	6.03	84.2	96.2	78.6	0.713	<0.2	<0.2	5.25	2.93	11.2	9	7.76	19.8	1.78	25
Sulfide	mg/l		0.0805		<0.05		<0.05				<0.05					
Lab Spec. Cond.	uS/cm	398	565	648	511	524	620	583	109	143	146	355	689	942	571	910
Field Spec. Cond.	uS/cm	403	593	880	518	516	621	648	122		215	385	720	893	568	70
TDS	mg/l	230	440	480	320	320	360	360	82	110	92	200	1300	660	360	1100
TSS	mg/l	7	5	<4.0	12	11	49	28	<4.0	<4.0	100	10	670	46	79	560
Hardness	mg/l	206	47.4	192	216	303	300	276	50.1	70	73.5	124	31.4	33.1	80.6	20
Cat/Anion Bal	% Difference	54.37	28.92	24.62	3.8	50.76	67.46	60.89	5.22	17.62	56.66	36.95	22.83	49.01	48.73	
Field Temp	C	6.3	7.9	9.9	8.5	5.5	7.8	10.8	5.6	6.7	4.8	6.7	6.4	7.6	9.7	7
Flow (approximate)	gpm															

See first page of appendix for
abbreviations and acronyms list

Table 1 Water Compositions (Page 5 of 8)

				Downgradient Marine/Glacial Seds												Background
		MW-2D	MW-3D	MW-T-96-1	MW-T-01-3B	MW-T-01-10	MW-T-95-5A	MW-T-95-5B	MW-T-00-4B	MW-2D	MW-1D	MW-3D	MW-T-95-1A	MW-T-95-1A	MW-T-01-3B	MW-T-98-1
		28	30							28	26	30				
		Mar/Glac (bkg)	Mar/Glac (bkg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	Mar/Glac (dg)	bedrock (bkg)
		12/21/1988	11/14/1988	5/24/2001	6/14/2001	4/4/2001	5/24/2001	5/24/2001	5/24/2001	11/7/1996	8/15/1996	11/7/1996	5/31/2001	9/4/2001	9/4/2001	4/26/2001
Aluminum	mg/l, dissolved			0.363	0.135	<0.1	0.482	<0.1	<0.1	<0.5	0.56	<0.5	<0.1	<0.1	<0.1	0.103
Boron	mg/l, dissolved	**0.12**	**0.78**	0.632	0.208	0.307	0.799	<0.1	<0.1	**0.14**	**0.96**	**0.69**	0.444	0.407	0.183	<0.1
Barium	mg/l, dissolved	<0.02	0.09	0.129	0.225	0.082	0.0416	0.0397	0.05	<0.05	<0.05	<0.05	0.0421	0.043	0.191	0.051
Calcium	mg/l, dissolved	19	3	9.78	55.7	52.5	17	26	23.3	12.1	3.24	7.4	10.9	10.3	58.8	39
Iron	mg/l, dissolved	0.01	0.22	0.281	<0.1	<0.1	0.455	3.88	<0.1	0.39	<0.1	0.83	<0.1	<0.1	0.227	0.64
Magnesium	mg/l, dissolved	5.3	2.7	5.61	31.1	56	10.4	5.04	13.2	6.79	2.06	3.83	7.72	7.66	33.3	4.26
Sodium	mg/l, dissolved	17	110	242	99.9	70.5	86.4	9.08	12.1	16.3	179	107	58.3	60.1	83.4	4.43
Arsenic	mg/l, dissolved	0.068	0.035	0.0027	0.00278	0.0215	0.0218	0.00069	0.0118	0.0756	0.075	0.0328	0.0158	0.0173	0.00156	0.0041
Antimony	mg/l, dissolved			<0.001	0.00419	0.00148	0.00117	<0.001	<0.001				<0.001	<0.001	0.00276	<0.002
Cadmium	mg/l, dissolved	<0.002	<0.002	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.000066	<0.000066	<0.000066	<0.0001	<0.001	<0.001	<0.0002
Chromium	mg/l, dissolved			0.00145	<0.001	0.00077	0.00142	0.00193	0.00098	<0.012	<0.012	<0.012	0.00126	0.00135	<0.001	<0.001
Copper	mg/l, dissolved	<0.002	0.003	0.0006	0.00224	0.00156	0.00161	0.00128	<0.0005	0.000964	0.00446	0.00204	0.00233	<0.002	<0.002	<0.001
Lead	mg/l, dissolved	<0.01	<0.01	0.00025	<0.001	0.00173	0.00101	0.0011	0.00046	<0.00013	<0.00013	<0.00013	<0.0002	<0.001	<0.001	0.00064
Manganese	mg/l, dissolved	0.022	0.004	0.255	0.551	0.253	0.154	0.15	0.289	0.039	<0.02	<0.02	0.00487	0.0512	1.1	0.274
Molybdenum	mg/l, dissolved			<0.005	0.0174	0.016	0.0465	<0.005	<0.005	<0.5	<0.5	<0.5	0.0215	0.0242	0.0146	<0.01
Mercury	mg/l, dissolved			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.0000012	<0.0000012	<0.0000012	<0.00001	<0.00001	<0.00001	<0.00001
Nickel	mg/l, dissolved			0.00072	<0.002	0.00203	0.00141	<0.0005	<0.0005	<0.0056	<0.0056	<0.0056	0.00055	<0.002	<0.002	0.00882
Selenium	mg/l, dissolved	<0.005	<0.005	<0.0005	0.00588	<0.001	0.00062	<0.0005	<0.0005	<0.002	<0.002	<0.002	0.00123	<0.001	0.00305	<0.001
Silver	mg/l, dissolved	<0.002	<0.002	<0.0001	<0.001	0.00026	<0.0001	<0.0001	<0.0001	0.0000536	<0.000012	<0.000012	<0.0001	<0.001	<0.001	<0.002
Zinc	mg/l, dissolved	<0.002	0.01	<0.005	0.00835	0.013	<0.005	0.0529	<0.005	0.0047	<0.0047	<0.0047	<0.005	0.00503	0.00585	0.0379
Potassium	mg/l, dissolved	4.2	5	6.28	12.9	13.3	5.99	1.84	4.53	4.97	3.85	4.09	5.49	5.38	10.7	1.54
Lab pH	s.u.	8.1	8.7	8.19	7.44	7.53	7.85	6.57	7.89	8.93	8.79	8.52	7.92	8.27	7.89	7.67
Field pH	s.u.	8	8.5	8.49	7.8	7.62	8.02	7.01	8.3	8.73	8.71	8.54	7.89	8.07	7.68	6.82
Acidity	mg/l $CaCO_3$			<10.0	<10.0	<10.0	<10.0	<10.0	<10.0				<10.0	<10.0	<10.0	<10.0
Phosphorus	mg/l			0.0575	0.0422	0.0207	0.221	0.0422	0.0648				0.184	0.134	0.0377	0.0241
Orthophosphate	mg/l			0.0461	0.0149	0.00508	0.196	0.0211	0.0559				0.158	0.123	0.0107	0.00296
DOC	mg/l			6.3	4.18	13.3	6.96	5.03	2.4				4.8	<3.0	<4.0	4.5
Bicarb Alkalinity	mg/l $CaCO_3$			345	122	437	217	80	111				169	177	148	103
Carb Alkalinity	mg/l $CaCO_3$			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0				<5.0	<5.0	<5.0	<5.0
Hydroxide Alk.	mg/l $CaCO_3$			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0				<5.0	<5.0	<5.0	<5.0
Total Alkalinity	mg/l $CaCO_3$	102.6	307.8	345	122	437	217	80	111	361	397	353	169	177	148	103
Silica	mg/l			15	9.4	20.9	64.2	86.5	70				9.66	9.84	8.33	7.15
Chloride	mg/l	5	8	92.7	173	32.5	5.55	5.01	5.68				3.84	3.48	143	3.79
Fluoride	mg/l			1.11	0.409	0.379	0.787	0.284	0.289				0.45	0.349	0.352	0.174
Nitrate-N	mg/l as N			<0.1	0.193	<0.1	<0.1	<0.1	<0.1				<0.1	<0.1	0.35	<0.1
Nitrite-N	mg/l			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1
Sulfate	mg/l	11	2	20.6	170	5.1	11.1	11.9	17.6	15.3	20.8	<4.0	10.9	10.5	201	16
Sulfide	mg/l			0.18			0.126	<0.05	<0.05				<0.05			<0.05
Lab Spec. Cond.	uS/cm	200	490	956	1090	888	433	196	247	240	845	576	355	354	1020	232
Field Spec. Cond.	uS/cm	138	418	969	880	928	388	194	252	186	864	428	355	359	1044	246
TDS	mg/l	110	1800	550	680	480	260	130	150				210	230	630	150
TSS	mg/l	<2.0	54	<4.0	<4.0	5	<4.0	9	4				23	<4.0	<4.0	6
Hardness	mg/l			47.5	267	362	82.8	85.7	112	59.6	9.5	30.7	59	57.3	284	115
Cat/Anion Bal	% Difference			50.75	1.19	56.35	27.87	39.5	18.52				50.4	48.93	3.46	42.93
Field Temp	C	5.1		8.4	8.4	7	9.7	8.2	8.3	11.1	12.9	13.2	8.8	10.9	11.1	5.7
Flow (approximate)	gpm															

See first page of appendix for
abbreviations and acronyms list

Table 1 Water Compositions (Page 6 of 8)

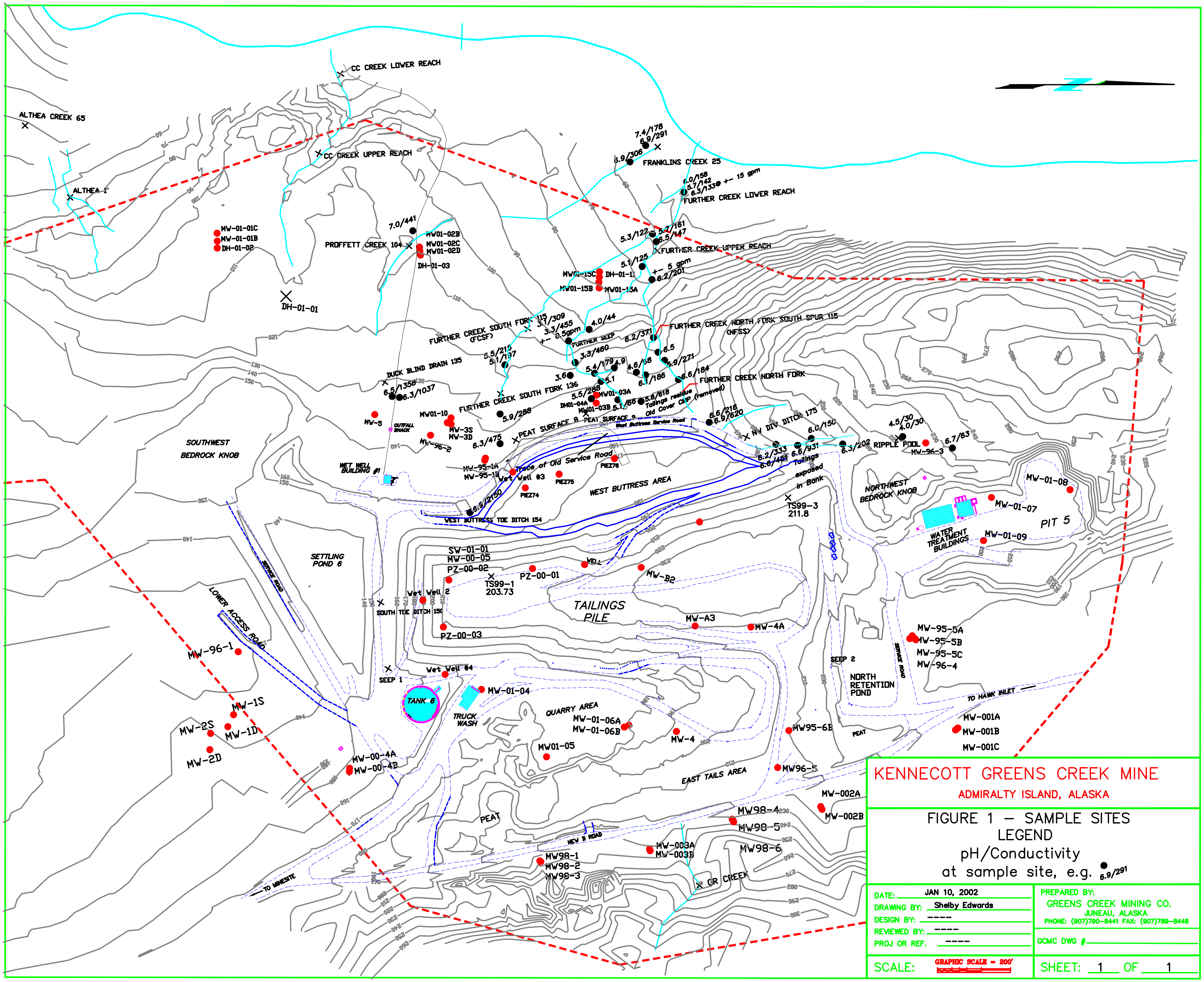
		Bedrock				Downgradient Bedrock										
		MW-T-98-4	MW-T-00-2B	MW-T-96-3	MW-T-01-05	MW-T-96-5	MW-T-96-4	MW-T-01-01A	MW-T-96-2	MW-T-01-06A	MW-T-01-06B	MW-T-01-07	MW-T-01-08	MW-T-01-09	MW-T-01-03A	MW-T-01-3A
		bedrock (bkg) 4/26/2001	bedrock (bkg) 4/18/2001	bedrock (bkg) 6/7/2001	bedrock (bkg) 4/4/2001	bedrock (dg) 6/14/2001	bedrock (dg) 5/24/2001	bedrock (dg) 4/9/2001	bedrock (dg) 5/24/2001	bedrock (dg) 4/4/2001	bedrock (dg) 4/4/2001	bedrock (dg) 5/31/2001	bedrock (dg) 4/4/2001	bedrock (dg) 5/31/2001	bedrock (dg) 4/9/2001	bedrock (dg) 9/4/2001
Aluminum	mg/l, dissolved	<0.1	<0.1	0.831	0.247	0.196	0.298	<0.1	0.155	0.111	0.148	0.422	0.233	0.271	0.125	0.169
Boron	mg/l, dissolved	<0.1	<0.1	<0.1	<0.1	<0.1	0.122	0.35	0.105	<0.1	<0.1	0.146	<0.1	<0.1	<0.1	<0.1
Barium	mg/l, dissolved	0.069	0.0694	0.0992	0.138	0.343	0.049	0.105	0.0193	0.102	0.111	0.0475	0.14	0.0832	0.128	0.166
Calcium	mg/l, dissolved	34.4	37.6	6.23	35.6	8.54	104	7.22	4.9	51.8	52.1	326	120	123	48.1	35.2
Iron	mg/l, dissolved	0.587	<0.1	1.98	0.291	<0.1	1.66	<0.1	<0.1	0.812	<0.1	0.123	<0.1	2.39	1.46	3.46
Magnesium	mg/l, dissolved	3.6	5.5	1.53	7.12	2.44	28.8	4.85	2.39	13.2	12.2	38.2	18	20.1	16.7	15
Sodium	mg/l, dissolved	5.81	25.3	1.38	5.27	7.76	26.8	122	31.7	9.7	23.5	36.6	12.6	7.2	29	61.3
Arsenic	mg/l, dissolved	0.00134	0.00121	0.0224	0.00331	<0.001	0.0518	0.0368	<0.0005	0.00597	0.00388	0.00102	0.00183	0.00143	0.00722	0.0212
Antimony	mg/l, dissolved	<0.001		0.00355	0.00453	<0.001	<0.001	0.00095	<0.001	0.00073	0.0043	<0.001	0.00424	<0.001	0.00092	<0.001
Cadmium	mg/l, dissolved	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	0.00079	0.00021	0.00013	0.00015	<0.0001	<0.001
Chromium	mg/l, dissolved	<0.0005	<0.0005	0.00143	0.00078	<0.001	0.00129	<0.0005	0.00106	0.00056	0.00065	0.00267	0.00051	0.00253	0.00058	0.00126
Copper	mg/l, dissolved	<0.0005	0.00197	0.0718	0.00126	<0.002	0.00762	<0.0005	0.00052	0.00068	0.00207	0.00114	0.123	0.00051	0.00135	<0.002
Lead	mg/l, dissolved	<0.0002	0.00051	0.00314	0.00026	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	0.00074	<0.0002	0.00078	<0.0002	0.00032	<0.001
Manganese	mg/l, dissolved	0.051	0.0493	2.08	0.162	0.025	0.871	0.0297	0.016	0.871	0.607	2.7	0.141	1.89	0.266	0.481
Molybdenum	mg/l, dissolved	<0.005	0.00925	<0.005	0.007	0.0219	0.0408	0.00642	0.00605	<0.005	0.00546	0.0151	0.044	0.00607	0.00534	<0.005
Mercury	mg/l, dissolved	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Nickel	mg/l, dissolved	<0.0005	0.00266	0.0462	0.00069	<0.002	0.00176	0.00086	<0.0005	0.00117	0.00312	0.0171	0.00783	0.0108	0.00261	<0.002
Selenium	mg/l, dissolved	<0.0005	0.00186	0.00182	<0.001	0.00151	0.0016	<0.0005	<0.0005	<0.001	0.00229	0.00214	0.00252	0.00134	0.00221	<0.001
Silver	mg/l, dissolved	<0.001	<0.0001	0.00061	0.0004	<0.001	<0.0001	<0.0001	<0.0001	0.00041	0.00031	<0.0001	0.00028	<0.0001	0.0011	<0.001
Zinc	mg/l, dissolved	<0.005	0.00675	0.0682	<0.001	<0.005	<0.005	0.00273	<0.005	0.0102	0.0176	0.00909	0.0405	<0.005	0.00957	<0.005
Potassium	mg/l, dissolved	1.16	2.26	<1.0	1.67	1.86	5.37	7.33	7.91	5.47	11.5	8.07	9.75	6.8	4.18	5.24
Lab pH	s.u.	7.22	7.73	6.9	7.82	9.37	7.66	8.14	9.72	7.39	7.44	7.24	7.52	7.21	7.47	7.81
Field pH	s.u.	5.79	7.73	6.37	7.9	9.9	7.68	8.34	10.18	7.53	7.6	7.3	7.71	7.14	7.25	7.48
Acidity	mg/l $CaCO_3$	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Phosphorus	mg/l	0.00994	0.0198	0.0535	0.0263	0.0529	0.0645	0.178	0.088	0.0148	<0.005	0.0198	<0.005	0.0164	0.0249	0.0674
Orthophosphate	mg/l	<0.002	<0.002	0.0245	0.0149	0.0237	0.0224	0.117	0.0368	0.00242	0.00242	0.00215	0.00296	0.00614	0.00216	0.0282
DOC	mg/l	16	2.34	17.8	2.3	31.4	3.51	5.22	4.75	4.3	3.58	4.14	4.12	4.86	7.06	29
Bicarb Alkalinity	mg/l $CaCO_3$	75.6	111	16.6	80.4	27	164	255	57.4	147	159	182	189	161	140	239
Carb Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	5.6	<5.0	<5.0	22	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide Alk.	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity	mg/l $CaCO_3$	75.6	111	16.6	80.4	32.6	164	255	79.4	147	159	182	189	161	140	239
Silica	mg/l	5.3	10.3	0.738	11	0.271	56.5	13.6	<0.2	13	12.6	9.74	10.2	6.46	9.95	5.84
Chloride	mg/l	7.33	5.17	1.7	2.95	4.97	5.47	22.1	5.4	4.79	64	33.8	7.35	5.6	2.78	6.08
Fluoride	mg/l	<0.1	0.242	<0.1	<0.1	0.316	0.257	0.357	0.324	<0.1	0.175	0.264	0.233	0.28	0.208	0.181
Nitrate-N	mg/l as N	<0.1	0.404	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite-N	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/l	8.39	32.5	6.22	29.3	0.844	247	22.2	0.781	40	93.2	888	174	210	11.9	149
Sulfide	mg/l	0.496		<0.05			<0.05		<0.05			<0.05		<0.05		
Lab Spec. Cond.	uS/cm	181	285	51.3	226	77.7	790	587	192	382	704	1750	740	709	289	725
Field Spec. Cond.	uS/cm	82	483	98.6	234	89	784	620	179.3	403	484	1641	798	694	452	623
TDS	mg/l	100	190	100	130	55	550	350	110	210	330	1400	490	470	160	540
TSS	mg/l	<4.0	9	5	5	27	7	6	26	4	5	10	<4.0	9	12	<4.0
Hardness	mg/l	101	116	21.9	118	31.4	378	38	22.1	184	180	971	374	390	189	150
Cat/Anion Bal	% Difference	55.92	43.38	69.58	40.07	58.81	6.48	47.18	51.85	43.25	13.52	0.81	32.15	29.17	89.34	2.66
Field Temp	C	5.6	6.5	8.7	4.8	8.9	9.7	7	9	5.1	4.3	7.5	5.4	7.9	7	9.8
Flow (approximate)	gpm															

See first page of appendix for
abbreviations and acronyms list

Table 1 Water Compositions (Page 7 of 8)

		Roadcut ARD	Contact Underdrains				Contact Saturated Zone			Contact Unsaturated Zone			Tls Filterpress	Production Rock Sites		
		1.8 Mile Distal Site surface 7/12/1995	Wetwell 2 underdrain 4/25/2001	Wetwell 2 underdrain 9/7/2001	Wetwell 3 underdrain 4/25/2001	Wetwell 3 underdrain 9/7/2001	PZ-T-00-1 tailings 5/9/2001	PZ-T-00-3 tailings 5/9/2001	MW-TB2 tailings 4/25/2001	SW01-01 New Tails 7/5/2001	TSS99-01 New Tails Suction Lysimeters (tailings) 12/7/1999	TSS99-03 Old Under PVC 11/17/1999	Tails Filterpress Distal Site Process Water 6/14/2001	23-F7 Distal Site Prod. Rock 10/21/1999	23-F5 Distal Site Prod. Rock 10/21/1999	23-F3 Distal Site Prod. Rock 10/21/1999
Aluminum	mg/l, dissolved	12	0.316	0.288	0.307	0.33	0.364	0.263	0.287	1.69			0.492			
Boron	mg/l, dissolved	0.074	0.123	<0.1	0.118	<0.1	0.224	0.166	0.11	0.48			0.25			
Barium	mg/l, dissolved	<0.5	0.0252	0.0319	0.021	0.0235	0.0129	0.0136	0.0117	0.0386			0.0453			
Calcium	mg/l, dissolved	136	272	343	443	467	358	225	182	837	**1720**	**489**	386	**350**	**115**	**150**
Iron	mg/l, dissolved	190	15.5	19.3	15.8	2.35	<0.1	0.15	<0.1	<0.1	0.192	0.195	<0.1	<0.15	<0.15	<0.15
Magnesium	mg/l, dissolved	27.3	105	121	273	132	373	355	316	349	**453**	**4620**	8.52	**236**	**24**	**43.6**
Sodium	mg/l, dissolved	4.19	25.1	23	49.6	21.9	133	188	129	61.7	**89.4**	**15.5**	50.3	**256**	**22.1**	**40.1**
Arsenic	mg/l, dissolved	0.015	0.0191	0.0212	0.00426	0.00506	0.0108	0.0114	0.0168	0.0341	<0.01	<0.005	0.0477	0.00207	<0.001	<0.001
Antimony	mg/l, dissolved		<0.001	0.00196	<0.001	0.00498	0.00385	0.0129	0.00391	0.0204			0.0148			
Cadmium	mg/l, dissolved	0.0081	<0.0001	<0.001	0.00084	0.00743	<0.0001	<0.0001	<0.0001	0.0017	0.00376	<0.005	<0.001	0.00715	<0.001	0.00121
Chromium	mg/l, dissolved	<0.05	<0.0005	0.00137	0.00092	0.00147	<0.0005	<0.0005	0.00097	0.00134			<0.001			
Copper	mg/l, dissolved	0.44	0.00104	0.00216	0.00292	0.00374	0.00578	0.00576	0.00309	0.274	1.32	0.0482	<0.002	0.00767	0.00199	0.0029
Lead	mg/l, dissolved	0.019	<0.0002	0.00143	<0.0002	0.005	<0.0002	<0.0002	<0.0002	0.00216	16.9	<0.005	0.123	0.0085	<0.001	<0.001
Manganese	mg/l, dissolved	3.7	3.24	4.82	9.66	4.17	0.453	0.899	0.335	0.0676	1.81	0.269	0.00777	3.66	0.00284	0.00503
Molybdenum	mg/l, dissolved	<0.5	<0.005	<0.005	<0.005	<0.005	0.00828	0.872	<0.005	0.109			0.15			
Mercury	mg/l, dissolved	<0.0002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.000055			<0.00002			
Nickel	mg/l, dissolved	0.9	0.054	0.122	0.0591	0.2	0.00159	0.00185	0.00151	0.00712	0.048	0.00749	0.00309	0.795	0.00669	0.0133
Selenium	mg/l, dissolved	0.0051	0.00188	0.00244	0.00335	0.00747	0.00362	0.00253	0.00134	0.145	**0.244**	**0.0137**	0.274	0.0221	0.00633	0.00816
Silver	mg/l, dissolved	<0.05	<0.0001	<0.001	<0.0001	<0.001	0.00013	0.00015	<0.0001	0.353			0.00464			
Zinc	mg/l, dissolved	0.86	1.2	2.11	1.45	3.71	0.0132	0.0123	0.0109	0.0552	3.57	1.29	0.0727	3.25	0.108	0.189
Potassium	mg/l, dissolved	<1.0	9.47	10.5	18.9	10.2	45.5	53.5	43.8	60.2	**66.3**	**29**	10.9	**48.2**	**2.49**	**4.79**
Lab pH	s.u.	2.8	6.77	6.5	6.62	6.43	8.02	7.79	7.79	5.75	6.56	7.53	7.86	6.62	7.01	6.82
Field pH	s.u.	1.46	6.68	6.67	6.56	6.48	8.14	8.15	7.71	7.96	7.12	7.52	7.86	6.51	7.01	6.83
Acidity	mg/l $CaCO_3$	604	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	1100	91.7	<10.0	507	<5.0	<5.0	<5.0
Phosphorus	mg/l	<0.05	0.0719	0.0739	0.0759	0.036	0.238	0.159	0.589	0.193	2.44	<2.0	0.224			
Orthophosphate	mg/l	1.4	<0.002	0.0288	<0.002	0.00375	0.0487	0.0354	0.00216	<0.002			0.0333	<0.2	<0.2	<0.2
DOC	mg/l	6.3	14.1	<5.0	19.4	<5.0	44	20	33.4	107			23	19.1	6.97	6.93
Bicarb Alkalinity	mg/l $CaCO_3$		262	252	404	227	290	340	357	<5.0	38	491	<5.0			
Carb Alkalinity	mg/l $CaCO_3$		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0			
Hydroxide Alk.	mg/l $CaCO_3$		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0			
Total Alkalinity	mg/l $CaCO_3$	<5.0	262	252	404	227	290	340	357	<5.0	38	491	<5.0	380	158	156
Silica	mg/l	38	10.4	9.78	17.8	7.22	10.1	9.15	10.1	<4.0	6.31	5.71	1.14	7.6	6.53	7.21
Chloride	mg/l	22	9.71	7.47	22.5	7.19	22	35.9	15.8	15.5	13.6	15	19.6	33	4.27	5.64
Fluoride	mg/l	1	0.21	0.272	0.184	0.233	0.375	0.563	0.46	0.317			0.328			
Nitrate-N	mg/l as N	<1.0	<0.1	0.261	<0.1	1.45	<0.1	0.833	0.25	0.599	21	<1.0	13.9	77.5	12.7	24.8
Nitrite-N	mg/l	1.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1			0.196			
Sulfate	mg/l	930	840	1130	2070	1580	1980	1790	1820	2410	2290	17000	660	1840	200	349
Sulfide	mg/l		<0.05		<0.05		13	0.0625	7	<0.05			<0.05			
Lab Spec. Cond.	uS/cm	1800	1790	2050	3350	2570	3380	3240	3240	5290	7560	14000	1860	3710	757	1060
Field Spec. Cond.	uS/cm	1818	1691	2220	3090	2160	3660	3510	2950	5020	8363	14310		4230	902	1355
TDS	mg/l	1500	1500	1900	3200	2600	3100	2800	2700	5400			1500			
TSS	mg/l	24	25	22	34	<4.0	<4.0	<4.0	80	<4.0			16			
Hardness	mg/l	452	1110	1350	2230	1710	2750	2320	1760	3530			999			
Cat/Anion Bal	% Difference	2.16	16.7	10.47	0.22	0.32	19.2	17.49	1.84	38.6			37.7			
Field Temp	C	10.5	7.1	12.2	7.8	13	8.1	6.3	7	12	8.6	13.5		8	7.9	8.5
Flow (approximate)	gpm													<.25	13.5	4

See first page of appendix for
abbreviations and acronyms list


KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
FIGURE 1 – SAMPLE SITES
LEGEND
pH/Conductivity
at sample site, e.g. 6.9/291
DATE: JAN 10, 2002
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----
PREPARED BY:
GREENS CREEK MINING CO.
JUNEAU, ALASKA
GCMC DWG #
SCALE:
SHEET: 1 OF 1
ALTHEA CREEK 65
ALTHEA 1
CC CREEK LOWER REACH
CC CREEK UPPER REACH
FRANKLINS CREEK 25
7.4/178
6.9/291
5.9/306
FURTHER CREEK LOWER REACH
FURTHER CREEK UPPER REACH
PROFFETT CREEK 104
7.0/441
MW-01-01C
MW-01-01B
DH-01-02
MW01-02B
MW01-02C
MW01-02D
DH-01-03
DH-01-01
FURTHER CREEK SOUTH FORK 115
(FCSF)
FURTHER CREEK NORTH FORK SOUTH SPUR 115
(NFSS)
DUCK BLIND DRAIN 135
FURTHER CREEK SOUTH FORK 136
FURTHER CREEK NORTH FORK
NW DIV DITCH 175
RIPPLE POOL
MW-96-3
MW-5
MW01-10
MW-3S
MW-3D
MW-96-2
WET WELL BUILDING #1
SOUTHWEST BEDROCK KNOB
PEAT SURFACE 8
PEAT SURFACE 9
Trace of Old Service Road
Wet Well #3
PIEZ74
PIEZ75
PIEZ76
WEST BUTTRESS AREA
WEST BUTTRESS TOE DITCH 154
TS99-3
211.8
NORTHWEST BEDROCK KNOB
WATER TREATMENT BUILDINGS
PIT 5
MW-01-08
MW-01-07
MW-01-09
SETTLING POND 6
SW-01-01
MW-00-05
PZ-00-02
TS99-1
203.73
PZ-00-01
MW-B2
TAILINGS PILE
Wet Well 2
SOUTH TOE DITCH 150
PZ-00-03
MW-A3
MW-4A
MW-95-5A
MW-95-5B
MW-95-5C
MW-96-4
SEEP 2
NORTH RETENTION POND
LOWER ACCESS ROAD
MW-96-1
SEEP 1
Wet Well #4
TANK 6
TRUCK WASH
MW-01-04
QUARRY AREA
MW-01-06A
MW-01-06B
MW-4
MW95-6B
MW-1S
MW-1D
MW-2S
MW-2D
MW-00-4A
MW-00-4B
MW01-05
TO HAWK INLET
MW-001A
MW-001B
MW-001C
EAST TAILS AREA
MW96-5
MW-002A
MW-002B
PEAT
MW98-4
MW98-5
MW98-6
MW-003A
MW-003B
MW98-1
MW98-2
MW98-3
GR CREEK
TO MINESITE

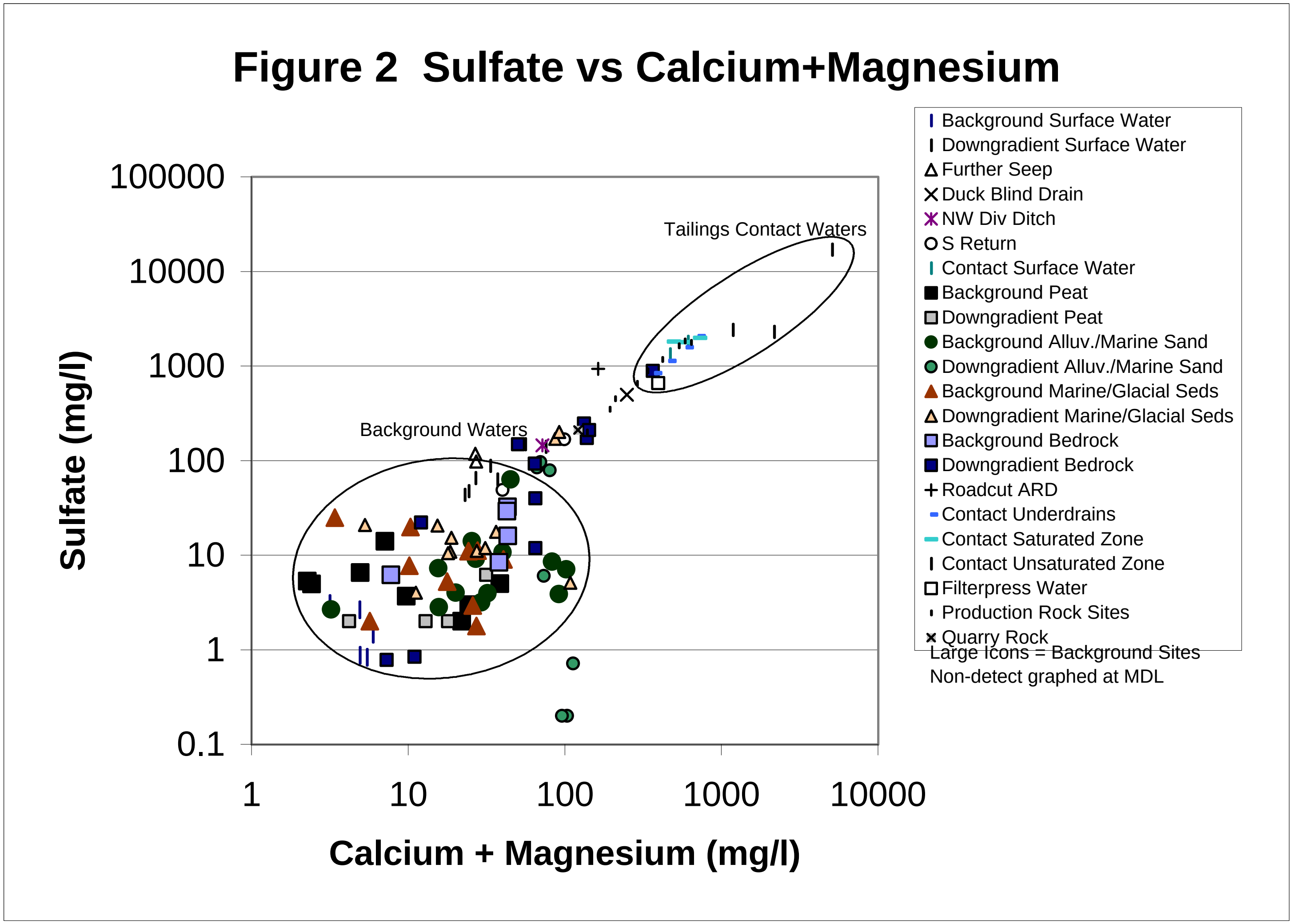


Figure 2 Sulfate vs Calcium+Magnesium
Sulfate (mg/l)
100000
10000
1000
100
10
1
0.1
1
10
100
1000
10000
Calcium + Magnesium (mg/l)
Tailings Contact Waters
Background Waters
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

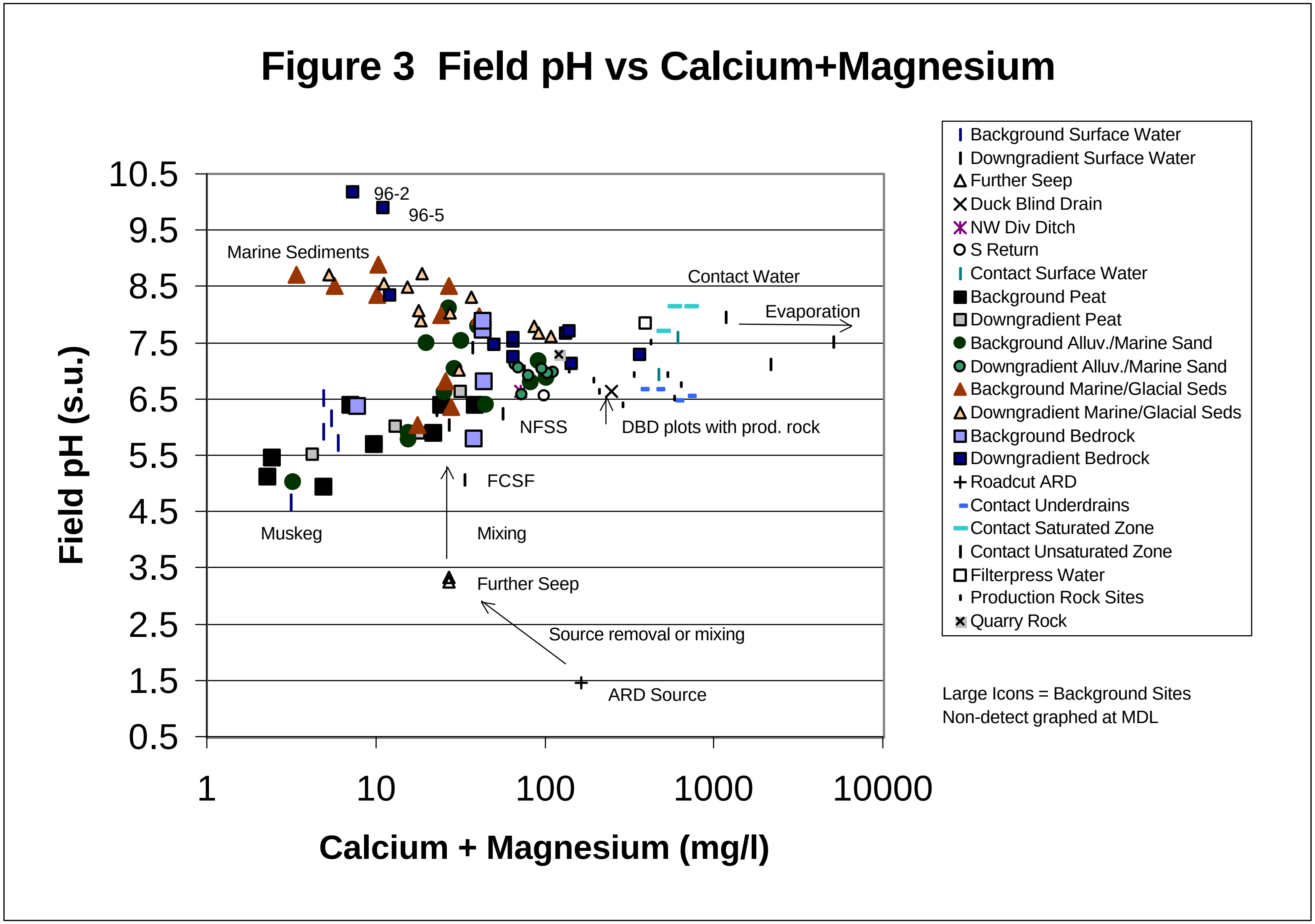


Figure 3 Field pH vs Calcium+Magnesium
Field pH (s.u.)
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
1
10
100
1000
10000
Calcium + Magnesium (mg/l)
96-2
96-5
Marine Sediments
Contact Water
Evaporation
NFSS
DBD plots with prod. rock
FCSF
Muskeg
Mixing
Further Seep
Source removal or mixing
ARD Source
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

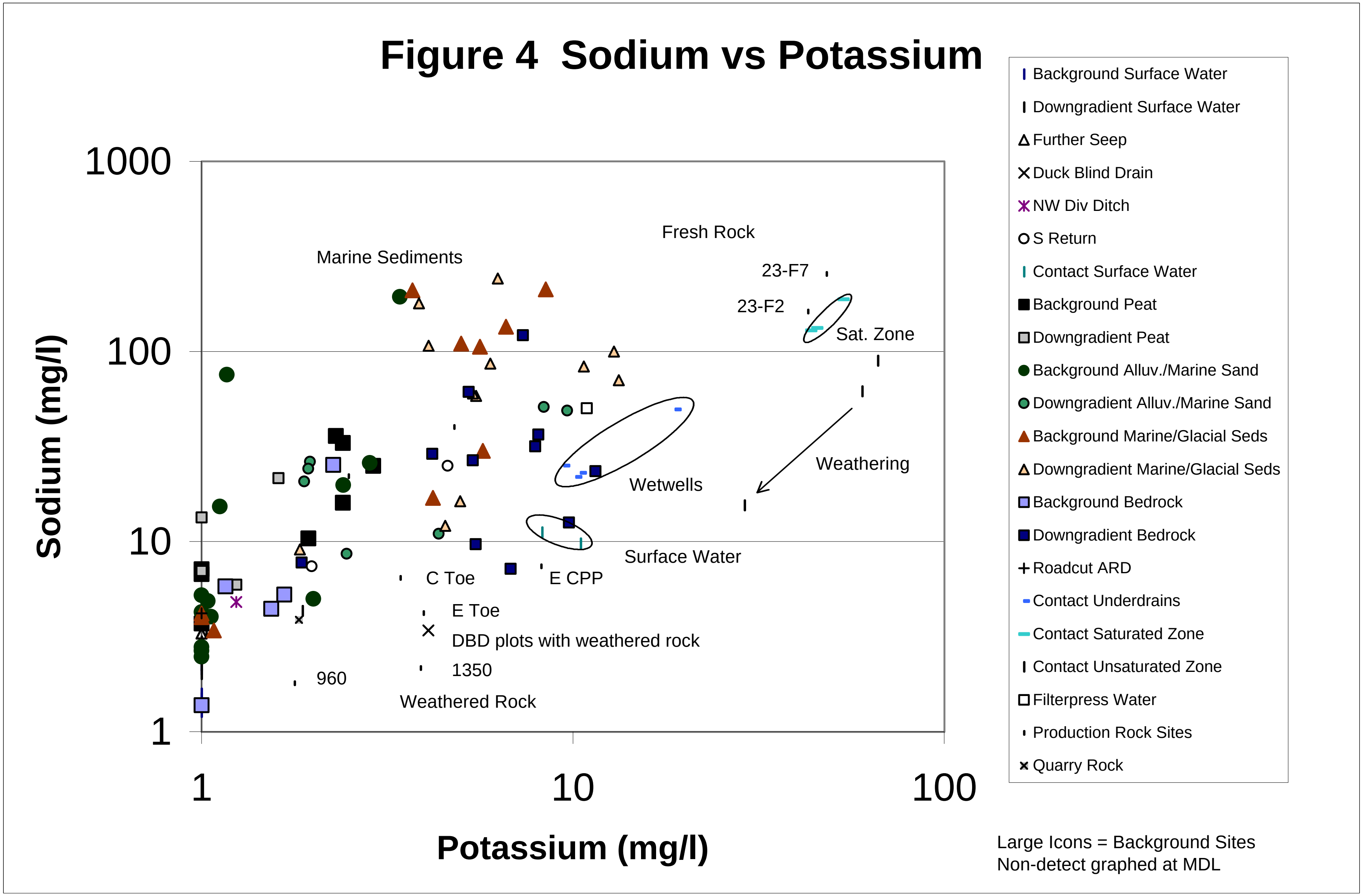


Figure 4 Sodium vs Potassium
Sodium (mg/l)
Potassium (mg/l)
1000
100
10
1
1
10
100
Fresh Rock
Marine Sediments
23-F7
23-F2
Sat. Zone
Wetwells
Weathering
Surface Water
C Toe
E CPP
E Toe
DBD plots with weathered rock
1350
960
Weathered Rock
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

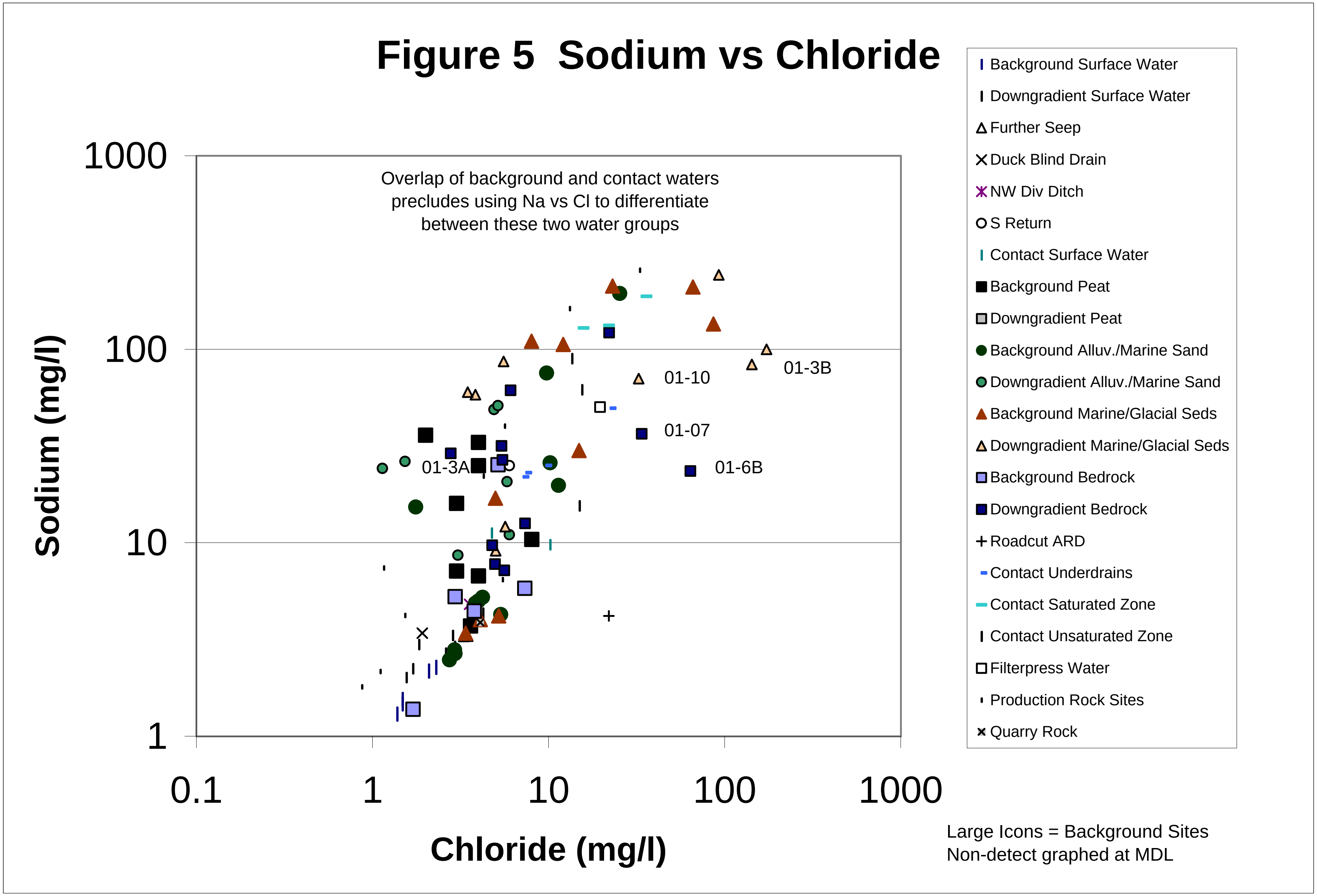


Figure 5 Sodium vs Chloride
Overlap of background and contact waters precludes using Na vs Cl to differentiate between these two water groups
Sodium (mg/l)
Chloride (mg/l)
1000
100
10
1
0.1
1
10
100
1000
01-3A
01-10
01-3B
01-07
01-6B
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

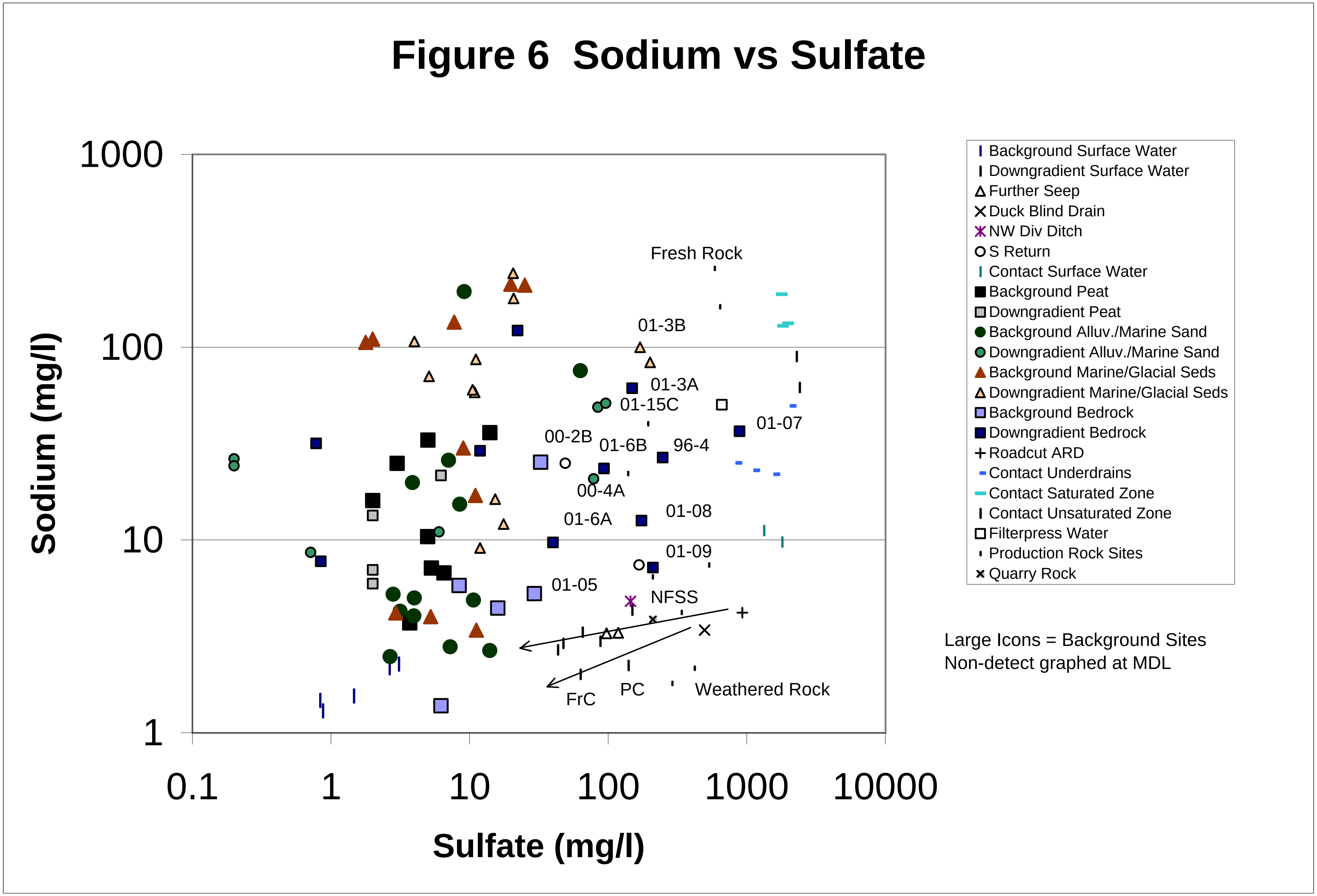


Figure 6 Sodium vs Sulfate
Sodium (mg/l)
1000
100
10
1
0.1
1
10
100
1000
10000
Sulfate (mg/l)
Fresh Rock
01-3B
01-3A
01-15C
01-07
00-2B
01-6B
96-4
00-4A
01-6A
01-08
01-09
01-05
NFSS
FrC
PC
Weathered Rock
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

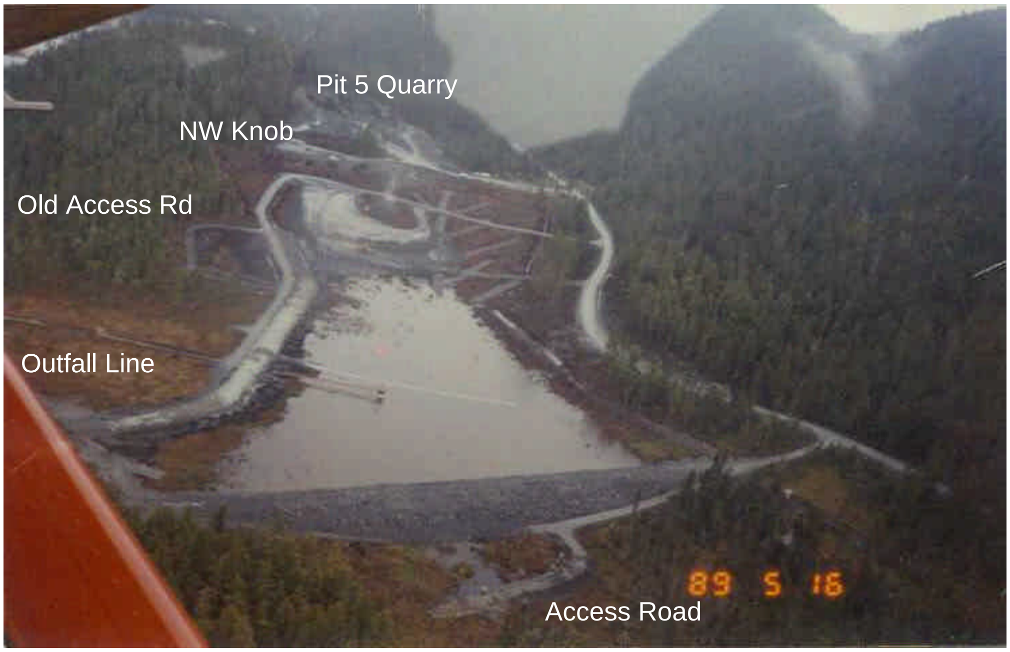


Figure 7 1989 View of Tailings Facility (Looking North)

Main Embankment and lower access road are in the foreground.
Saddle Embankment and NPDES Outfall Line are to the left.
Old access road is left about mid picture.
The Northwest Knob is between Pit 5 (background) and the tailings pile (center).

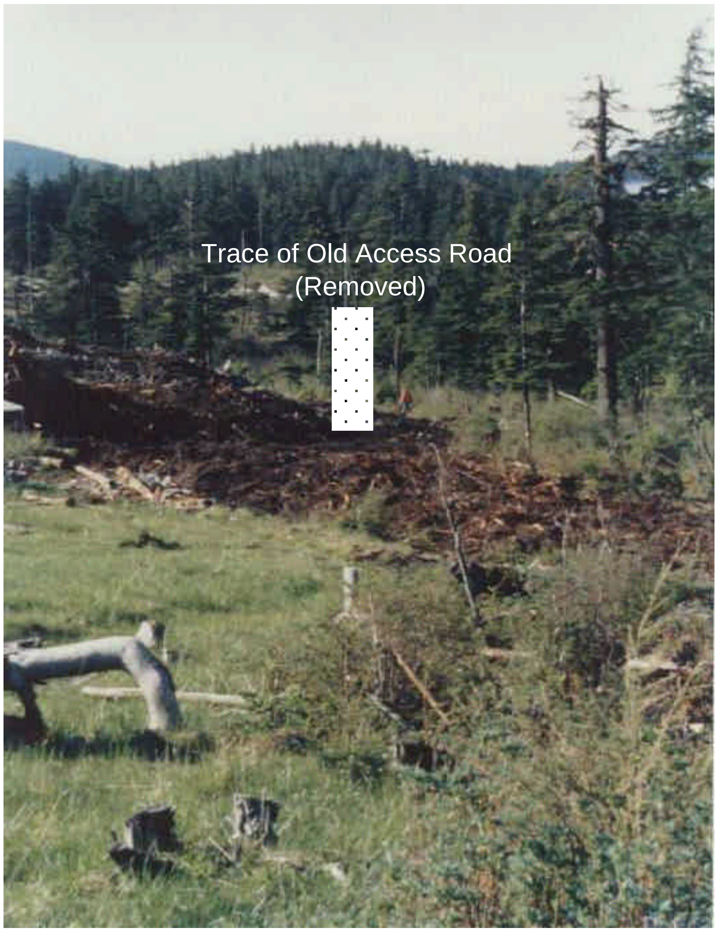


Figure 8 1996 View of West Buttress Area (Looking South)

The trace of the old access road is in the center of the photograph.
Note disturbed peat and absence of road rock.

Figure 9 1996 View of West Buttress Road Construction (Looking North)

Figure 10 1996 View of West Buttress Road Construction (Looking South)

New road base was advanced over the trace of the old access road.
Note disturbed peat where the old road was removed.

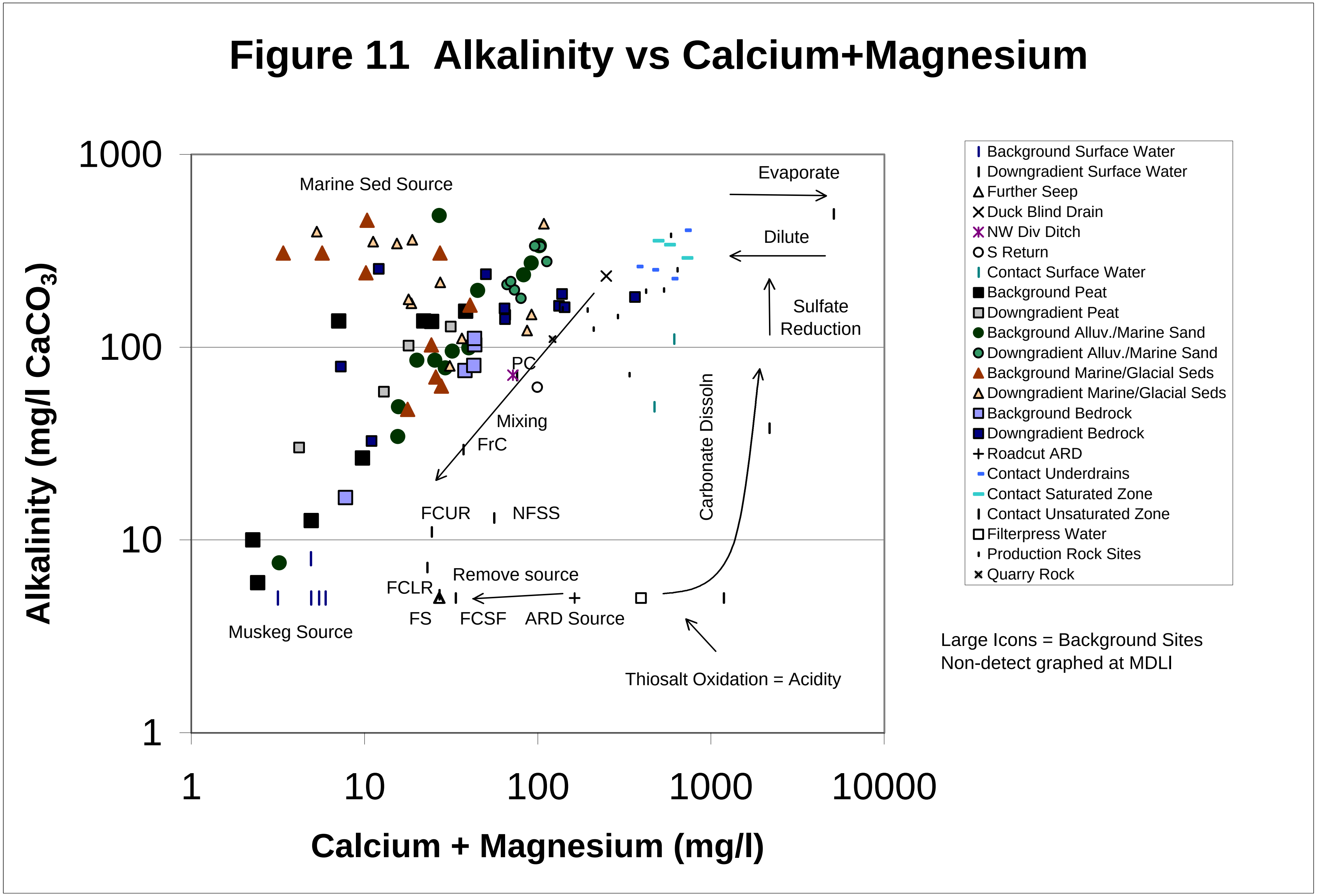


Figure 11 Alkalinity vs Calcium+Magnesium
Alkalinity (mg/l CaCO3)
Calcium + Magnesium (mg/l)
1000
100
10
1
1
10
100
1000
10000
Marine Sed Source
Evaporate
Dilute
Sulfate Reduction
Carbonate Dissoln
PC
Mixing
FrC
FCUR
NFSS
FCLR
Remove source
FS
FCSF
ARD Source
Muskeg Source
Thiosalt Oxidation = Acidity
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDLI

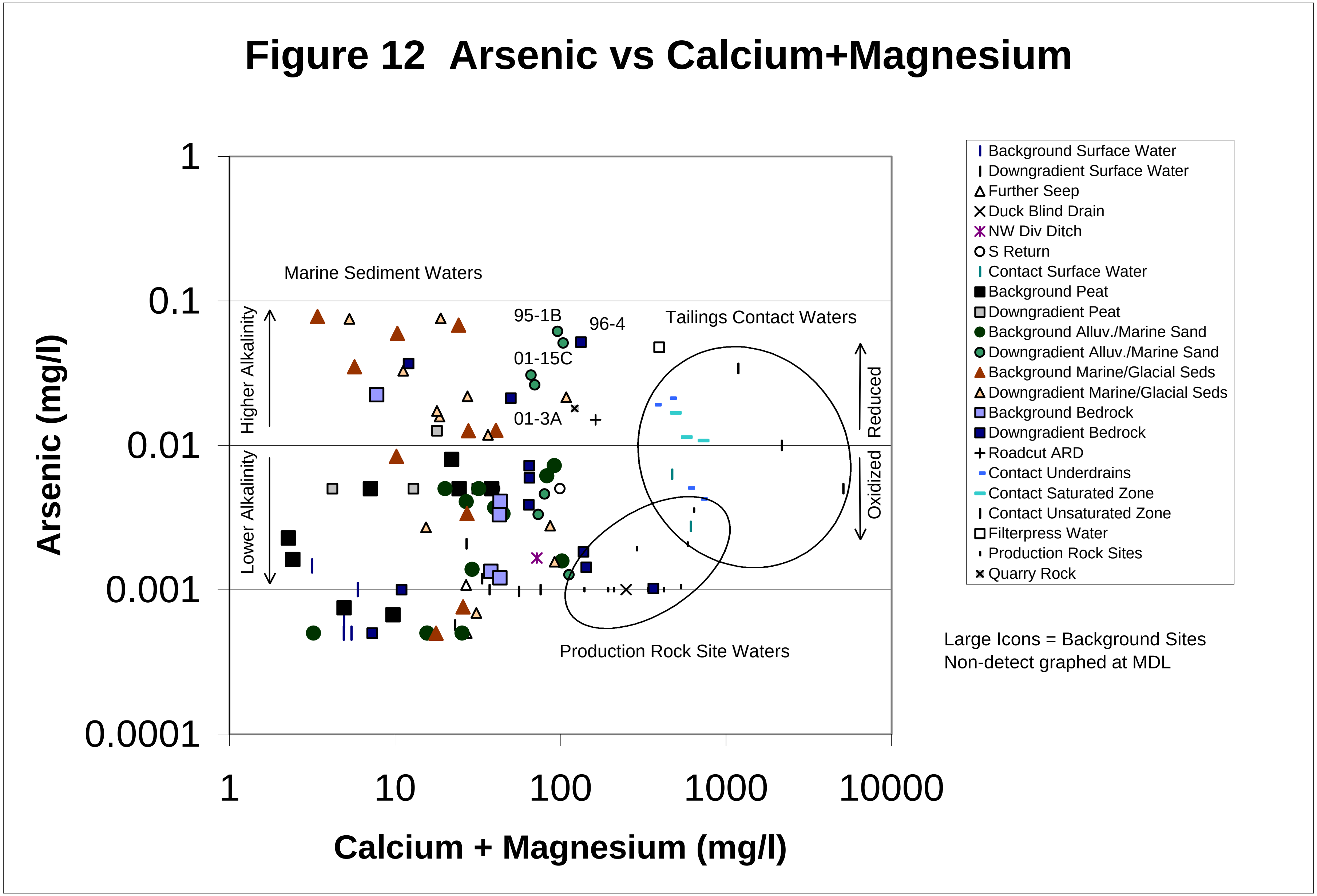


Figure 12 Arsenic vs Calcium+Magnesium
1
0.1
0.01
0.001
0.0001
Arsenic (mg/l)
1
10
100
1000
10000
Calcium + Magnesium (mg/l)
Marine Sediment Waters
Tailings Contact Waters
Production Rock Site Waters
95-1B
96-4
01-15C
01-3A
Higher Alkalinity
Lower Alkalinity
Reduced
Oxidized
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

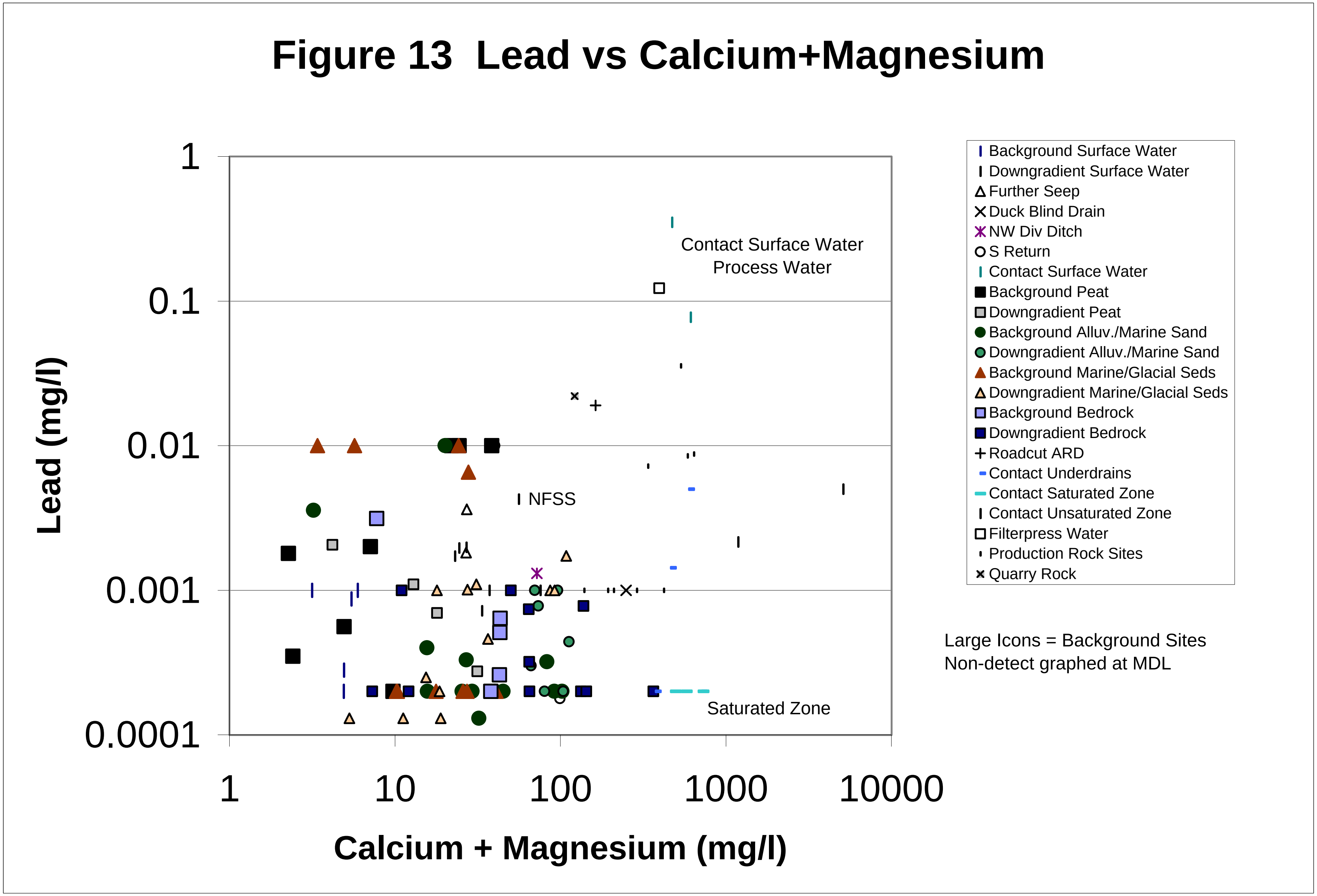


Figure 13 Lead vs Calcium+Magnesium
Lead (mg/l)
Calcium + Magnesium (mg/l)
1
0.1
0.01
0.001
0.0001
1
10
100
1000
10000
Contact Surface Water
Process Water
NFSS
Saturated Zone
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

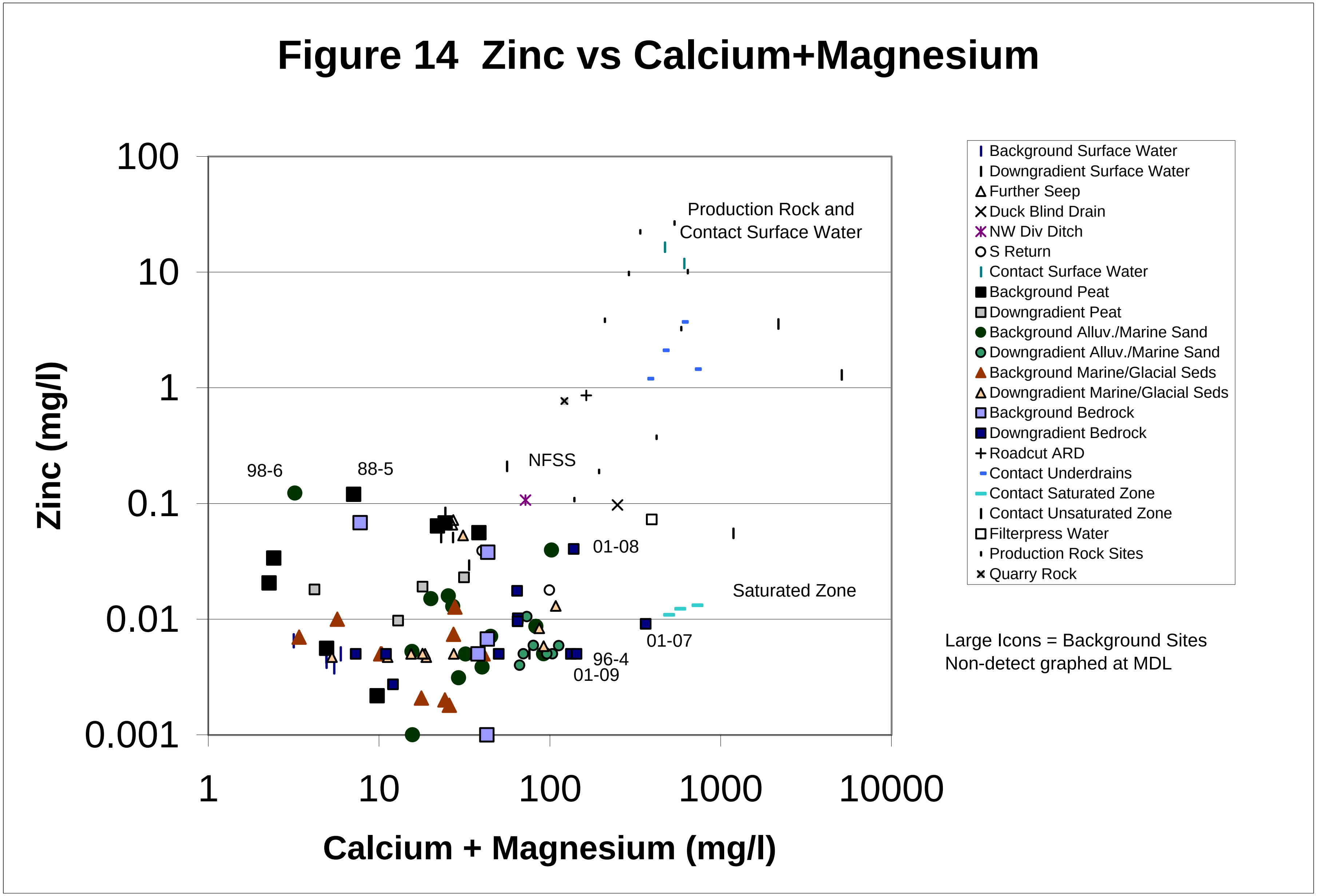


Figure 14 Zinc vs Calcium+Magnesium
Zinc (mg/l)
100
10
1
0.1
0.01
0.001
Calcium + Magnesium (mg/l)
1
10
100
1000
10000
Production Rock and Contact Surface Water
NFSS
98-6
88-5
01-08
Saturated Zone
01-07
96-4
01-09
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

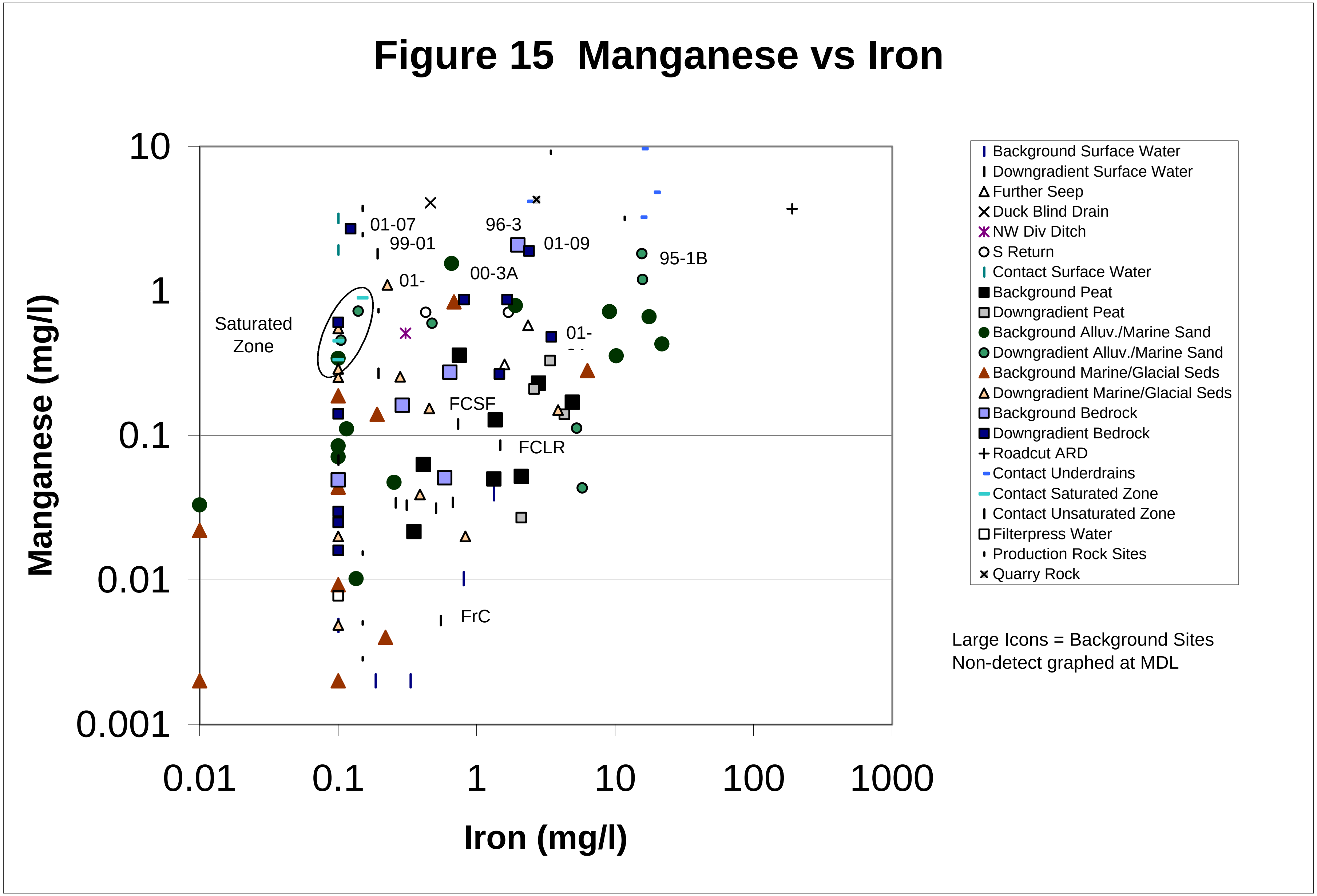


Figure 15 Manganese vs Iron
Manganese (mg/l)
Iron (mg/l)
10
1
0.1
0.01
0.001
0.01
0.1
1
10
100
1000
Saturated Zone
01-07
99-01
96-3
01-09
95-1B
01-
00-3A
01-
FCSF
FCLR
FrC
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

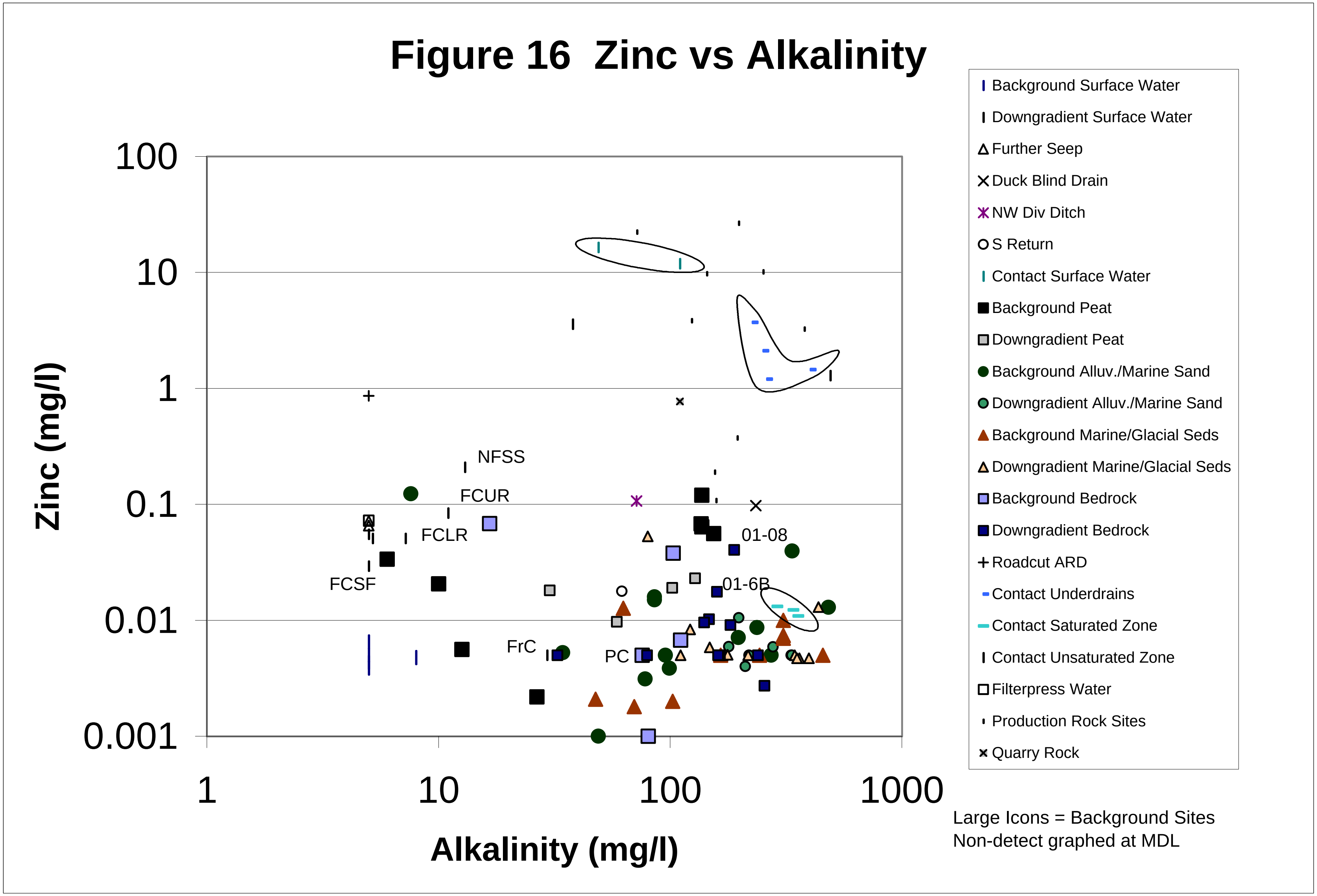


Figure 16 Zinc vs Alkalinity
Zinc (mg/l)
Alkalinity (mg/l)
100
10
1
0.1
0.01
0.001
1
10
100
1000
NFSS
FCUR
FCLR
FCSF
FrC
PC
01-08
01-6B
Background Surface Water
Downgradient Surface Water
Further Seep
Duck Blind Drain
NW Div Ditch
S Return
Contact Surface Water
Background Peat
Downgradient Peat
Background Alluv./Marine Sand
Downgradient Alluv./Marine Sand
Background Marine/Glacial Seds
Downgradient Marine/Glacial Seds
Background Bedrock
Downgradient Bedrock
Roadcut ARD
Contact Underdrains
Contact Saturated Zone
Contact Unsaturated Zone
Filterpress Water
Production Rock Sites
Quarry Rock
Large Icons = Background Sites
Non-detect graphed at MDL

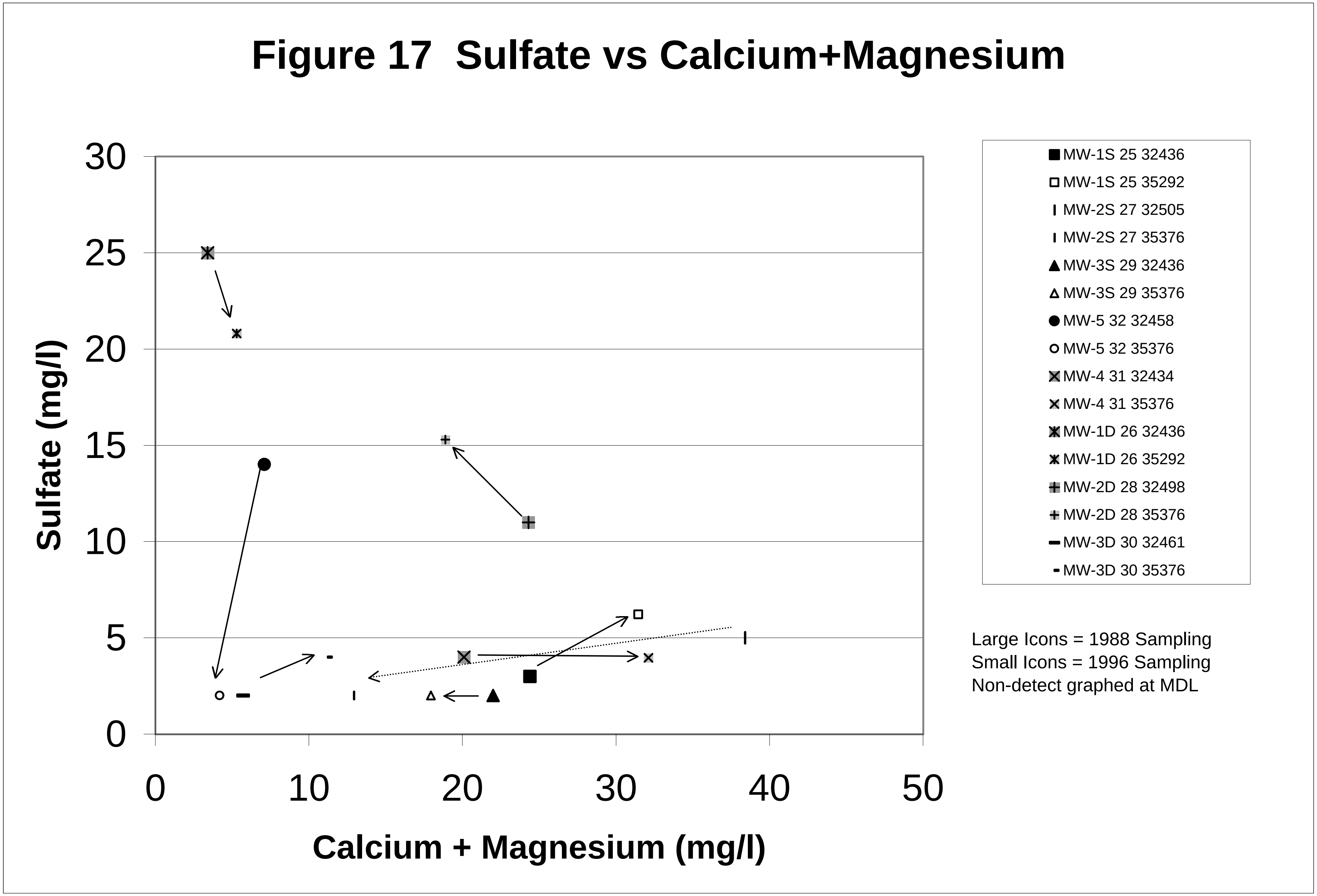


Figure 17 Sulfate vs Calcium+Magnesium
Sulfate (mg/l)
Calcium + Magnesium (mg/l)
0
5
10
15
20
25
30
0
10
20
30
40
50
MW-1S 25 32436
MW-1S 25 35292
MW-2S 27 32505
MW-2S 27 35376
MW-3S 29 32436
MW-3S 29 35376
MW-5 32 32458
MW-5 32 35376
MW-4 31 32434
MW-4 31 35376
MW-1D 26 32436
MW-1D 26 35292
MW-2D 28 32498
MW-2D 28 35376
MW-3D 30 32461
MW-3D 30 35376
Large Icons = 1988 Sampling
Small Icons = 1996 Sampling
Non-detect graphed at MDL

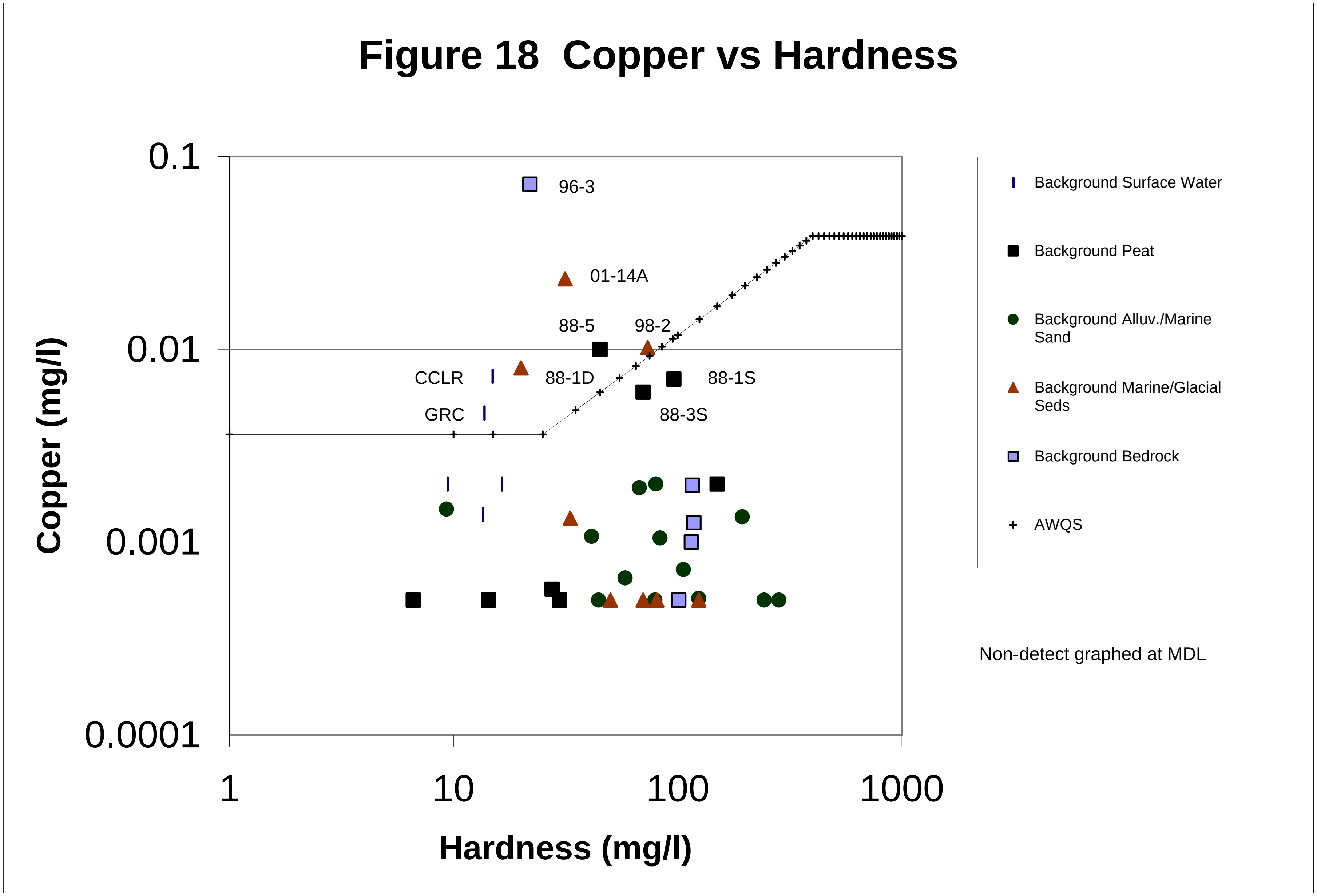


Figure 18 Copper vs Hardness
Copper (mg/l)
0.1
0.01
0.001
0.0001
Hardness (mg/l)
1
10
100
1000
96-3
01-14A
88-5
98-2
CCLR
88-1D
88-1S
GRC
88-3S
Background Surface Water
Background Peat
Background Alluv./Marine Sand
Background Marine/Glacial Seds
Background Bedrock
AWQS
Non-detect graphed at MDL

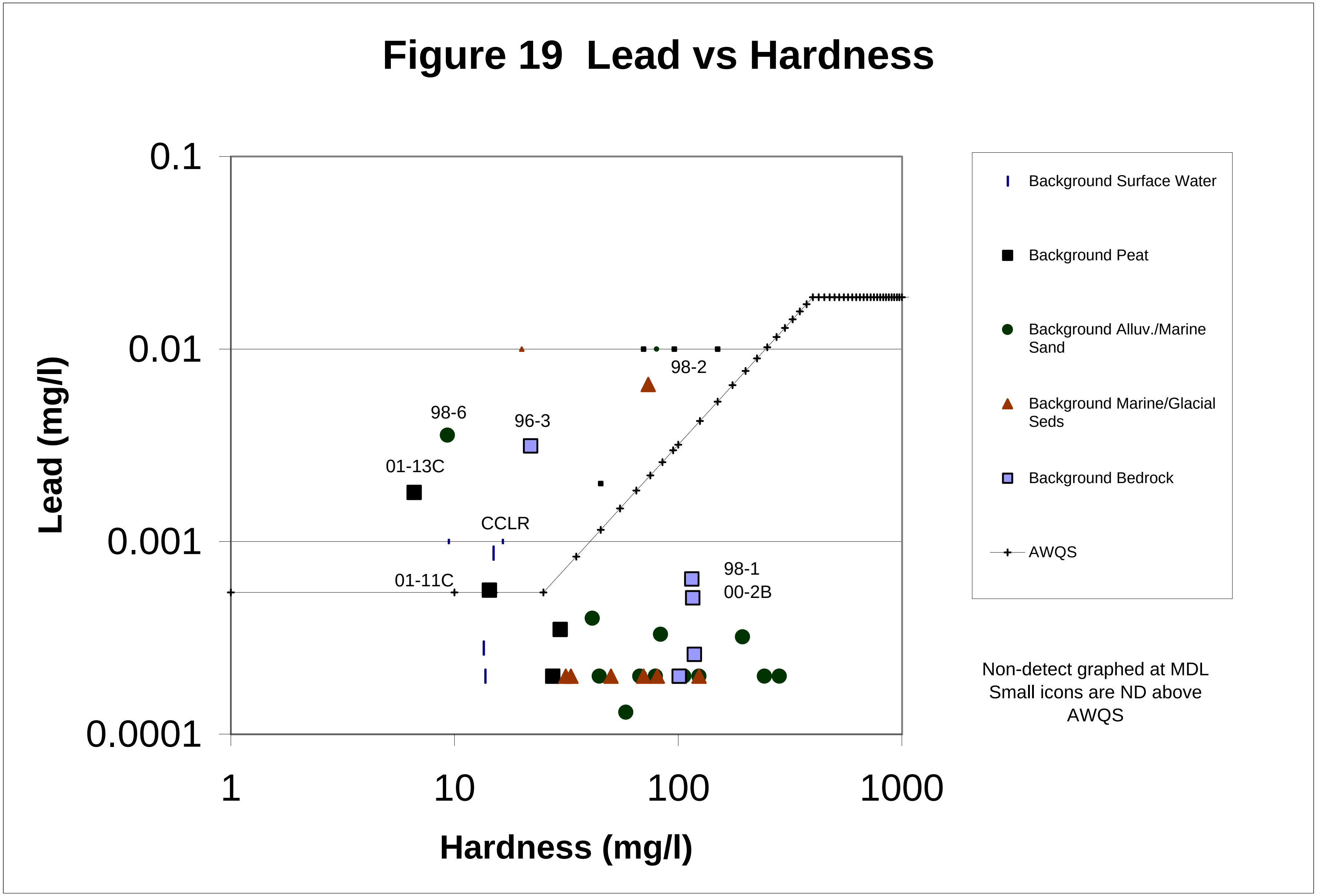


Figure 19 Lead vs Hardness
Lead (mg/l)
0.1
0.01
0.001
0.0001
1
10
100
1000
Hardness (mg/l)
98-6
96-3
01-13C
CCLR
01-11C
98-2
98-1
00-2B
Background Surface Water
Background Peat
Background Alluv./Marine Sand
Background Marine/Glacial Seds
Background Bedrock
AWQS
Non-detect graphed at MDL
Small icons are ND above AWQS

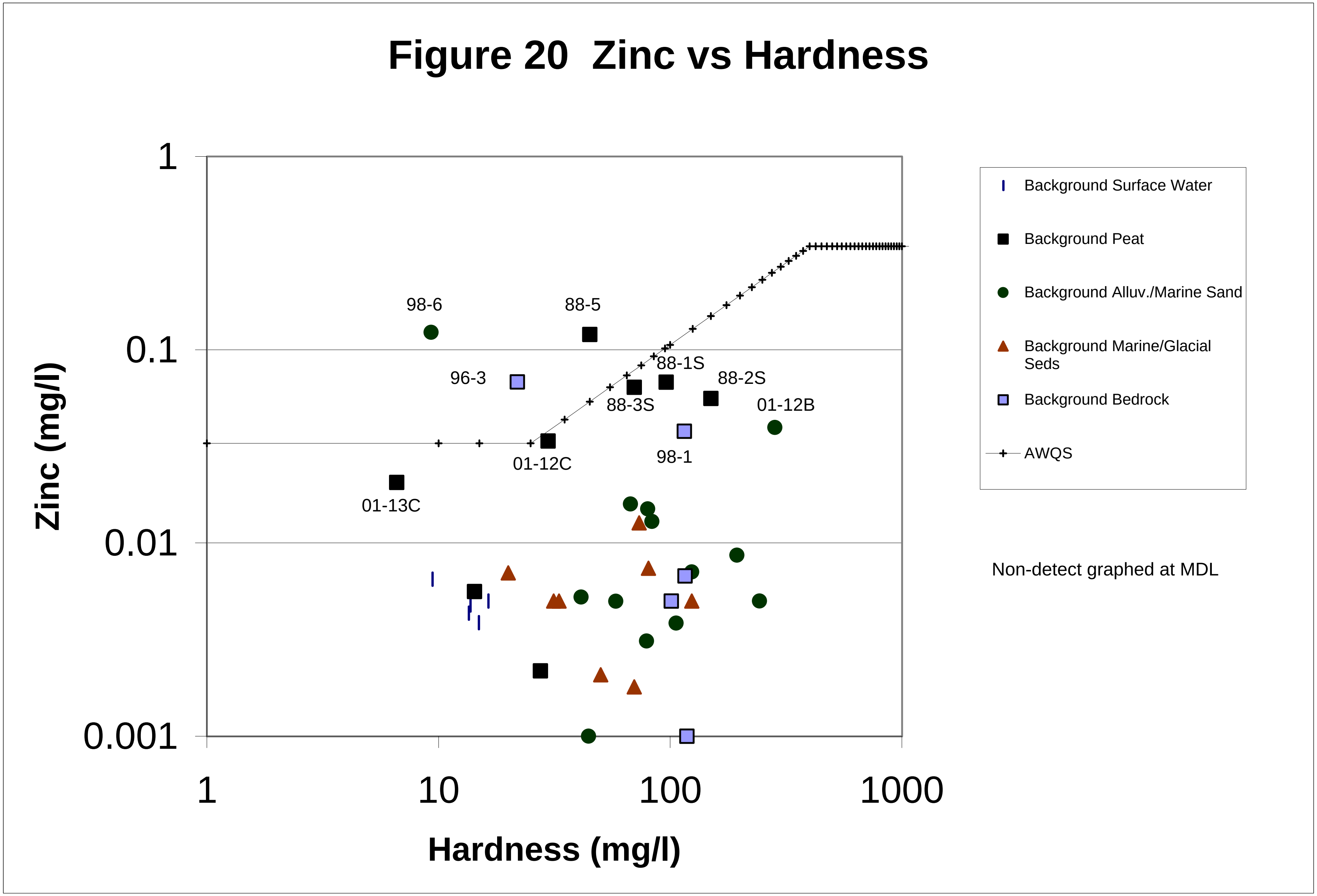


Figure 20 Zinc vs Hardness
1
0.1
0.01
0.001
Zinc (mg/l)
1
10
100
1000
Hardness (mg/l)
98-6
88-5
96-3
88-1S
88-2S
88-3S
01-12B
98-1
01-12C
01-13C
Background Surface Water
Background Peat
Background Alluv./Marine Sand
Background Marine/Glacial Seds
Background Bedrock
AWQS
Non-detect graphed at MDL

Appendix E

Wet Well Flow Meter Records

wet well 2

date	flow
01/01/00	62.08
01/03/00	48.06
01/04/00	38.75
01/05/00	34.79
01/06/00	31.46
01/07/00	35.14
01/08/00	41.53
01/09/00	42.71
01/10/00	36.53
01/11/00	34.38
01/12/00	29.65
01/14/00	23.61
01/15/00	21.94
01/16/00	20.76
01/18/00	17.78
01/19/00	20.97
01/20/00	20.90
01/22/00	19.31
01/23/00	20.83
01/24/00	20.63
01/25/00	19.93
01/26/00	20.14
01/27/00	22.57
01/28/00	58.61
01/29/00	72.01
01/30/00	88.82
01/31/00	91.53
02/01/00	70.21
02/02/00	59.10
02/04/00	47.01
02/05/00	39.03
02/06/00	32.99
02/07/00	29.31
02/08/00	26.94
02/10/00	36.32
02/12/00	28.19
02/13/00	25.49
02/14/00	24.24
02/15/00	22.29
02/16/00	21.94
02/17/00	20.83
02/18/00	20.83
02/19/00	23.13
02/20/00	30.42
02/21/00	39.79
02/22/00	43.19
02/24/00	44.72
02/26/00	53.13
02/27/00	54.58

wet well 2

date	flow
02/28/00	52.57
02/29/00	47.22
03/01/00	41.67
03/02/00	44.93
03/03/00	57.15
03/04/00	50.76
03/05/00	61.18
03/06/00	56.04
03/07/00	48.96
03/08/00	42.71
03/09/00	37.64
03/10/00	33.89
03/11/00	30.07
03/12/00	28.68
03/13/00	26.25
03/14/00	25.21
03/15/00	24.72
03/16/00	24.38
03/17/00	25.63
03/18/00	36.53
03/19/00	46.46
03/20/00	48.82
03/21/00	91.88
03/22/00	115.07
03/23/00	94.86
03/24/00	86.04
03/25/00	93.19
03/26/00	102.43
03/27/00	124.86
03/28/00	107.92
03/30/00	90.00
03/31/00	146.88
04/01/00	187.57
04/02/00	117.64
04/03/00	105.49
04/04/00	111.60
04/05/00	112.57
04/06/00	148.96
04/07/00	124.44
04/08/00	155.63
04/09/00	156.81
04/10/00	102.92
04/11/00	80.49
04/12/00	68.75
04/13/00	63.75
04/15/00	49.24
04/16/00	42.99
04/17/00	38.82
04/18/00	35.63

wet well 2

date	flow
04/18/00	43.96
04/20/00	52.08
04/21/00	60.21
04/22/00	68.54
04/23/00	69.79
04/24/00	55.42
04/25/00	49.72
04/26/00	39.65
04/27/00	75.90
04/29/00	62.43
04/30/00	70.42
05/01/00	81.81
05/02/00	125.83
05/03/00	94.31
05/04/00	67.71
05/05/00	55.76
05/06/00	48.26
05/07/00	42.08
05/10/00	31.32
05/11/00	28.89
05/12/00	27.15
05/15/00	24.58
05/18/00	22.01
07/02/00	26.53
07/03/00	26.04
07/04/00	25.00
07/05/00	26.25
07/07/00	26.74
07/08/00	26.32
07/09/00	24.86
07/10/00	23.61
07/11/00	22.57
07/12/00	20.63
07/13/00	19.44
07/14/00	18.61
07/15/00	18.26
07/16/00	17.78
07/17/00	17.22
07/18/00	17.01
07/19/00	21.04
07/20/00	46.46
07/22/00	35.00
07/24/00	111.32
07/25/00	93.82
07/26/00	65.90
07/27/00	50.21
07/28/00	41.32
07/29/00	36.94
07/30/00	34.03

wet well 2

date	flow
07/31/00	32.15
08/01/00	32.15
08/02/00	31.18
08/03/00	26.18
08/04/00	21.11
08/05/00	23.54
08/06/00	22.64
08/07/00	21.81
08/08/00	27.64
08/09/00	38.82
08/10/00	32.78
08/11/00	28.19
08/12/00	26.04
08/13/00	23.96
08/14/00	24.65
08/15/00	37.29
08/16/00	34.65
08/17/00	31.39
08/18/00	29.93
08/19/00	28.47
08/20/00	61.25
08/21/00	76.04
08/22/00	108.26
08/23/00	70.07
08/24/00	52.01
08/25/00	25.35
08/26/00	
08/27/00	
08/28/00	
08/29/00	16.74
08/30/00	35.00
08/31/00	31.94
09/01/00	28.54
09/02/00	27.29
09/03/00	24.93
09/04/00	52.50
09/05/00	46.81
09/06/00	77.64
09/09/00	53.96
09/11/00	38.40
09/12/00	28.13
09/14/00	52.22
09/15/00	69.72
09/16/00	122.08
09/17/00	165.14
09/18/00	132.78
09/19/00	76.18
09/21/00	216.74
09/22/00	204.17

wet well 2

date	flow
09/23/00	250.83
09/24/00	230.56
09/25/00	144.24
09/26/00	59.65
09/27/00	27.43
02/28/01	25.42
09/29/00	33.54
09/30/00	46.39
10/01/00	38.54
10/02/00	32.36
10/03/00	29.38
10/04/00	25.90
10/05/00	22.92
10/06/00	33.75
10/07/00	35.97
10/08/00	39.93
10/09/00	32.08
10/10/00	29.51
10/11/00	32.50
10/12/00	38.68
10/13/00	47.01
10/14/00	34.93
10/15/00	30.42
10/16/00	22.01
10/19/00	25.90
10/20/00	29.65
10/21/00	31.67
10/22/00	36.81
10/23/00	46.67
10/24/00	45.49
10/25/00	36.60
10/26/00	32.57
10/28/00	27.08
10/29/00	24.03
10/30/00	22.01
10/31/00	21.74
11/02/00	37.78
11/03/00	25.49
11/05/00	26.74
11/06/00	24.17
11/07/00	20.56
11/09/00	19.86
11/10/00	23.33
11/11/00	21.74
11/12/00	21.18
11/13/00	24.51
11/14/00	22.01
11/15/00	20.07
11/16/00	21.53

wet well 2

date	flow
11/17/00	21.46
11/18/00	25.76
11/19/00	24.38
11/20/00	20.83
11/21/00	19.51
11/22/00	25.07
11/23/00	46.32
11/25/00	35.07
11/26/00	30.07
11/27/00	28.13
11/28/00	25.69
11/29/00	26.81
11/30/00	37.29
12/02/00	20.00
12/03/00	20.90
12/04/00	36.04
12/05/00	52.64
12/06/00	38.89
12/08/00	54.58
12/09/00	
12/10/00	
12/11/00	
12/12/00	
12/13/00	
12/14/00	
12/15/00	
12/16/00	
12/17/00	
12/18/00	
12/19/00	27.36
12/20/00	
12/23/00	
12/24/00	
12/25/00	
12/26/00	
12/27/00	
12/28/00	105.76
12/30/00	54.03
01/01/01	39.24
01/02/01	42.36
01/03/01	49.03
01/04/01	72.64
01/05/01	85.07
01/07/01	43.82
01/08/01	36.39
01/09/01	41.11
01/11/01	80.69
01/13/01	90.28
01/15/01	50.56

wet well 2

date	flow
01/17/01	48.96
01/18/01	36.81
01/20/01	45.90
01/22/01	31.53
01/23/01	45.69
01/26/01	39.72
01/28/01	42.15
01/31/01	36.18
02/02/01	47.01
02/03/01	52.64
02/04/01	42.43
02/05/01	36.67
02/12/01	127.15
02/19/01	59.93
02/26/01	159.31
03/05/01	254.86
03/12/01	266.67
03/19/01	122.43
03/26/01	204.65
04/02/01	
04/09/01	
04/16/01	
04/01/01	27.57
04/02/01	27.85
04/03/01	26.67
04/04/01	25.69
04/05/01	26.67
04/06/01	30.69
04/07/01	34.58
04/08/01	32.71
04/09/01	30.56
04/10/01	28.96
04/11/01	26.53
04/12/01	25.83
04/13/01	26.18
04/14/01	25.49
04/15/01	25.56
04/16/01	25.90
04/17/01	24.44
04/18/01	23.54
04/19/01	21.88
04/20/01	22.71
04/21/01	22.57
04/22/01	22.57
04/23/01	21.18
04/24/01	21.74
04/25/01	21.18
04/26/01	20.76
04/27/01	21.25

wet well 2

date	flow
04/28/01	26.67
04/29/01	29.65
04/30/01	30.49
05/01/01	28.33
05/02/01	25.63
05/03/01	26.32
05/04/01	28.54
05/05/01	36.39
05/06/01	37.57
05/07/01	33.68
05/08/01	31.88
05/09/01	30.35
05/10/01	29.93
05/11/01	29.44
05/12/01	29.03
05/13/01	29.93
05/14/01	29.17
05/15/01	29.03
05/16/01	27.50
05/17/01	26.81
05/18/01	25.56
05/19/01	23.96
05/20/01	24.44
05/21/01	23.33
05/22/01	22.08
05/23/01	22.92
05/24/01	22.57
05/25/01	21.88
05/26/01	22.01
05/27/01	21.04
05/28/01	21.88
05/29/01	20.76
05/30/01	19.58
05/31/01	20.76
06/01/01	19.31
06/02/01	18.89
06/03/01	19.72
06/04/01	18.06
06/05/01	18.82
06/06/01	18.82
06/07/01	18.54
06/08/01	16.74
06/09/01	18.13
06/10/01	18.96
06/11/01	17.85
06/12/01	19.24
06/13/01	18.96
06/14/01	17.78
06/15/01	19.10

wet well 2

date	flow
06/16/01	18.13
06/17/01	18.33
06/18/01	18.26
06/19/01	18.19
06/20/01	18.33
06/21/01	17.71
06/22/01	16.88
06/23/01	17.78
06/24/01	17.50
06/25/01	18.13
06/26/01	17.43
06/27/01	17.50
06/28/01	17.50
06/29/01	16.46
06/30/01	16.18
07/01/01	16.46
07/02/01	15.28
07/03/01	15.21
07/04/01	14.17
07/05/01	15.35
07/06/01	14.86
07/07/01	15.69
07/08/01	18.61
07/09/01	21.94
07/10/01	27.36
07/11/01	29.10
07/12/01	27.29
07/13/01	26.39
07/14/01	25.69
07/15/01	27.15
07/16/01	26.53
07/17/01	25.83
07/18/01	25.14
07/19/01	23.96
07/20/01	23.19
07/21/01	21.25
07/22/01	22.22
07/23/01	20.83
07/24/01	20.49
07/25/01	20.63
07/26/01	21.81
07/27/01	21.67
07/28/01	22.36
07/29/01	21.67
07/30/01	21.32
07/31/01	21.11
08/01/01	20.97
08/02/01	20.21
08/03/01	19.31

wet well 2

date	flow
08/04/01	19.51
08/05/01	18.75
08/06/01	17.99
08/07/01	17.29
08/08/01	16.94
08/09/01	16.39
08/10/01	16.39
08/11/01	15.42
08/12/01	16.04
08/13/01	15.56
08/14/01	14.86
08/15/01	14.51
08/16/01	13.75
08/17/01	14.86
08/18/01	13.89
08/19/01	13.82
08/20/01	13.40
08/21/01	13.61
08/22/01	13.13
08/23/01	13.06
08/24/01	12.78
08/25/01	12.78
08/26/01	12.31
08/27/01	39.72
08/28/01	36.53
08/29/01	30.63
08/30/01	29.44
08/31/01	25.83
09/01/01	24.86
09/02/01	43.19
09/03/01	37.36
09/04/01	33.40
09/05/01	29.93
09/06/01	33.13
09/07/01	43.26
09/08/01	44.03
09/09/01	39.86
09/10/01	32.43
09/11/01	18.06
09/12/01	
09/13/01	104.72
09/14/01	103.19
09/15/01	72.15
09/16/01	96.32
09/17/01	
09/18/01	160.69
09/19/01	68.54
09/20/01	74.58
09/21/01	61.32

wet well 2

date	flow
09/22/01	58.82
09/23/01	47.99
09/24/01	40.28
09/25/01	33.68
09/26/01	30.00
09/27/01	27.99
09/28/01	26.25
09/29/01	25.07
09/30/01	44.31
10/01/01	72.15
10/02/01	59.24
10/03/01	45.76
10/04/01	37.71
10/05/01	32.15
10/06/01	29.38
10/07/01	28.89
10/08/01	29.38
10/09/01	31.25
10/10/01	32.78
10/11/01	34.44
10/12/01	40.63
10/13/01	46.88
10/14/01	39.79
10/15/01	35.42
10/16/01	37.78
10/17/01	50.90
10/18/01	53.75
10/19/01	71.94
10/20/01	64.79
10/21/01	52.08
10/22/01	46.81
10/23/01	42.36

average gpm **42.20**

minimum gpm **12.31**

wet well 3

date	flow
10/28/00	8.61
10/29/00	7.57
10/30/00	7.36
10/31/00	9.10
11/02/00	10.69
11/05/00	10.49
11/06/00	9.24
11/07/00	8.78
11/09/00	7.99
11/10/00	8.40
11/11/00	9.24
11/12/00	14.79
11/13/00	10.97
11/14/00	9.38
11/15/00	9.10
11/16/00	10.28
11/17/00	16.67
11/18/00	13.96
11/19/00	12.01
11/20/00	11.39
11/21/00	11.94
11/22/00	26.18
11/23/00	45.21
11/25/00	18.26
11/26/00	14.24
11/27/00	12.22
11/28/00	10.63
11/29/00	10.35
11/30/00	8.96
12/02/00	11.88
12/04/00	8.61
12/05/00	50.69
12/06/00	26.25
12/08/00	13.06
12/09/00	10.69
12/10/00	9.10
12/11/00	8.19
12/12/00	7.71
12/13/00	7.50
12/14/00	7.78
12/15/00	7.36
12/16/00	7.57
12/17/00	7.15
12/18/00	6.94
12/19/00	6.74
12/20/00	6.11
12/23/00	6.11
12/24/00	5.69
12/25/00	5.90

wet well 3

date	flow
12/26/00	5.90
12/27/00	5.49
12/28/00	3.68
12/30/00	8.19
01/03/01	45.42
01/04/01	31.18
01/05/01	42.43
01/07/01	21.39
01/08/01	17.08
01/09/01	16.11
01/11/01	10.07
01/13/01	7.71
01/15/01	13.68
01/17/01	22.50
01/18/01	21.11
01/20/01	12.99
01/22/01	11.67
01/23/01	20.90
01/26/01	13.06
01/28/01	22.85
01/31/01	17.22
02/02/01	25.42
02/03/01	26.11
02/04/01	19.86
02/05/01	13.68
02/12/01	7.15
02/19/01	6.81
02/26/01	10.69
03/05/01	9.79
03/12/01	20.14
03/19/01	11.94
03/26/01	4.10
04/02/01	
04/09/01	
04/16/01	
04/01/01	7.64
04/02/01	6.81
04/03/01	6.04
04/04/01	5.49
04/05/01	8.68
04/06/01	11.46
04/07/01	8.61
04/08/01	7.29
04/09/01	6.39
04/10/01	6.39
04/11/01	6.11
04/12/01	7.01
04/13/01	7.50
04/14/01	6.39

wet well 3

date	flow
04/15/01	6.32
04/16/01	6.31
04/17/01	6.39
04/18/01	6.32
04/19/01	6.18
04/20/01	5.69
04/21/01	5.63
04/22/01	5.56
04/23/01	5.56
04/24/01	5.69
04/25/01	5.69
04/26/01	6.04
04/27/01	9.51
04/28/01	10.83
04/29/01	8.54
04/30/01	7.01
05/01/01	5.97
05/02/01	5.69
05/03/01	9.03
05/04/01	15.14
05/05/01	13.82
05/06/01	9.03
05/07/01	7.57
05/08/01	8.40
05/09/01	8.33
05/10/01	7.85
05/11/01	7.99
05/12/01	8.89
05/13/01	9.03
05/14/01	8.40
05/15/01	7.43
05/16/01	6.88
05/17/01	6.60
05/18/01	6.39
05/19/01	6.04
05/20/01	5.83
05/21/01	5.83
05/22/01	6.18
05/23/01	6.04
05/24/01	5.63
05/25/01	5.21
05/26/01	5.83
05/27/01	5.97
05/28/01	5.97
05/29/01	5.83
05/30/01	5.42
05/31/01	5.42
06/01/01	5.42
06/02/01	5.42

wet well 3

date	flow
06/03/01	5.00
06/04/01	5.00
06/05/01	5.00
06/06/01	4.86
06/07/01	4.86
06/08/01	4.44
06/09/01	5.00
06/10/01	5.42
06/11/01	5.21
06/12/01	5.21
06/13/01	5.21
06/14/01	4.79
06/15/01	4.86
06/16/01	4.44
06/17/01	4.44
06/18/01	4.44
06/19/01	4.44
06/20/01	4.65
06/21/01	4.24
06/22/01	4.44
06/23/01	4.44
06/24/01	4.38
06/25/01	4.38
06/26/01	4.31
06/27/01	4.31
06/28/01	4.10
06/29/01	4.10
06/30/01	4.10
07/01/01	3.89
07/02/01	40.97
07/03/01	3.96
07/04/01	4.10
07/05/01	4.51
07/06/01	5.69
07/07/01	7.15
07/08/01	7.36
07/09/01	7.50
07/10/01	8.13
07/11/01	6.53
07/12/01	5.69
07/13/01	6.11
07/14/01	8.33
07/15/01	6.94
07/16/01	5.90
07/17/01	5.49
07/18/01	5.00
07/19/01	49.37
07/20/01	4.93
07/21/01	4.79

wet well 3

date	flow
07/22/01	5.14
07/23/01	5.00
07/24/01	5.00
07/25/01	5.00
07/26/01	5.00
07/27/01	5.00
07/28/01	4.79
07/29/01	4.58
07/30/01	4.79
07/31/01	4.58
08/01/01	4.58
08/02/01	4.44
08/03/01	4.58
08/04/01	4.44
08/05/01	4.44
08/06/01	4.44
08/07/01	4.03
08/08/01	3.82
08/09/01	4.03
08/10/01	4.24
08/11/01	4.03
08/12/01	4.03
08/13/01	4.10
08/14/01	4.10
08/15/01	3.89
08/16/01	3.89
08/17/01	3.89
08/18/01	3.89
08/19/01	3.89
08/20/01	4.17
08/21/01	4.38
08/22/01	4.17
08/23/01	4.17
08/24/01	4.17
08/25/01	3.75
08/26/01	4.65
08/27/01	47.99
08/28/01	10.00
08/29/01	8.61
08/30/01	7.50
08/31/01	6.39
09/01/01	6.11
09/02/01	22.92
09/03/01	10.83
09/04/01	9.03
09/05/01	10.69
09/06/01	10.14
09/07/01	20.42
09/08/01	16.04

wet well 3

date	flow
09/09/01	10.00
09/10/01	6.81
09/11/01	5.56
09/12/01	7.71
09/13/01	61.94
09/14/01	20.28
09/15/01	11.60
09/16/01	24.31
09/17/01	
09/18/01	31.18
09/19/01	10.42
09/20/01	15.49
09/21/01	11.39
09/22/01	14.51
09/23/01	13.06
09/24/01	10.07
09/25/01	8.33
09/26/01	7.29
09/27/01	6.81
09/28/01	6.39
09/29/01	6.39
09/30/01	18.06
10/01/01	25.14
10/02/01	14.58
10/03/01	10.07
10/04/01	8.33
10/05/01	7.64
10/06/01	7.85
10/07/01	8.47
10/08/01	10.14
10/09/01	11.11
10/10/01	12.08
10/11/01	12.22
10/12/01	18.54
10/13/01	12.36
10/14/01	9.24
10/15/01	10.21
10/16/01	17.71
10/17/01	4.17
10/18/01	3.68
10/19/01	16.04
10/20/01	13.06
10/21/01	12.43
10/22/01	12.50
10/23/01	10.76

average gpm **9.90**

minimum gpm **3.68**

wet well 4

date	Flow (gpm)
01/22/01	8.89
01/23/01	40.35
01/26/01	6.39
01/28/01	16.18
01/31/01	19.38
02/02/01	
02/03/01	14.72
02/04/01	11.18
02/05/01	5.90
03/05/01	
03/12/01	10.63
03/19/01	1.32
04/01/01	2.64
04/02/01	1.32
04/03/01	1.11
04/04/01	0.56
04/05/01	18.54
04/06/01	18.06
04/07/01	4.65
04/08/01	2.64
04/09/01	0.83
04/10/01	0.35
04/11/01	2.64
04/12/01	6.60
04/13/01	3.26
04/14/01	1.32
04/15/01	
04/16/01	
04/17/01	
04/18/01	0.56
04/19/01	0.76
04/20/01	
04/21/01	
04/22/01	0.21
04/23/01	
04/24/01	
04/25/01	3.89
04/26/01	2.22
04/27/01	22.85
04/28/01	12.92
04/29/01	6.18
04/30/01	4.38
05/01/01	2.50
05/02/01	3.13
05/03/01	21.32
05/04/01	36.94
05/05/01	17.36
05/06/01	8.61
05/07/01	8.40

wet well 4 date	Flow (gpm)
05/08/01	13.82
05/09/01	7.50
05/10/01	3.68
05/11/01	15.90
05/12/01	8.89
05/13/01	9.79
05/14/01	4.24
05/15/01	2.50
05/16/01	1.94
05/17/01	0.63
05/18/01	1.39
05/19/01	0.63
05/20/01	0.28
05/21/01	
05/22/01	6.81
05/23/01	1.25
05/24/01	0.63
05/25/01	
05/26/01	
05/27/01	0.14
05/28/01	0.21
05/29/01	
05/30/01	
05/31/01	
06/01/01	
06/02/01	
06/03/01	
06/04/01	
06/05/01	
06/06/01	
06/07/01	
06/08/01	
06/09/01	
06/10/01	1.32
06/11/01	1.18
06/12/01	0.90
06/13/01	
06/14/01	
06/15/01	
06/16/01	
06/17/01	0.07
06/18/01	
06/19/01	
06/20/01	
06/21/01	
06/22/01	
06/23/01	
06/24/01	0.42
06/25/01	

wet well 4

date	Flow (gpm)
06/26/01	
06/27/01	
06/28/01	
06/29/01	
06/30/01	
07/01/01	
07/02/01	0.42
07/03/01	
07/04/01	
07/05/01	
07/06/01	0.07
07/07/01	5.42
07/08/01	0.14
07/09/01	
07/10/01	8.26
07/11/01	4.65
07/12/01	3.47
07/13/01	8.89
07/14/01	11.94
07/15/01	5.83
07/16/01	2.99
07/17/01	1.18
07/18/01	
07/19/01	
07/20/01	
07/21/01	
07/22/01	
07/23/01	0.56
07/24/01	1.18
07/25/01	1.74
07/26/01	1.74
07/27/01	1.18
07/28/01	0.63
07/29/01	0.56
07/30/01	0.14
07/31/01	
08/01/01	
08/02/01	0.56
08/03/01	
08/04/01	0.56
08/05/01	
08/06/01	0.69
08/07/01	
08/08/01	
08/09/01	
08/10/01	
08/11/01	
08/12/01	
08/13/01	

wet well 4 date	Flow (gpm)
08/14/01	
08/15/01	
08/16/01	
08/17/01	
08/18/01	
08/19/01	
08/20/01	
08/21/01	
08/22/01	
08/23/01	
08/24/01	
08/25/01	0.56
08/26/01	0.76
08/27/01	77.22
08/28/01	12.01
08/29/01	19.24
08/30/01	12.08
08/31/01	8.61
09/01/01	12.22
09/02/01	58.26
09/03/01	25.28
09/04/01	17.43
09/05/01	29.51
09/06/01	19.17
09/07/01	67.36
09/08/01	34.79
09/09/01	18.68
09/10/01	12.29
09/11/01	8.06
09/12/01	34.51
09/13/01	268.54
09/14/01	52.64
09/15/01	47.43
09/16/01	93.19
09/17/01	
09/18/01	82.78
09/19/01	31.53
09/20/01	47.01
09/21/01	25.76
09/22/01	44.79
09/23/01	27.43
09/24/01	16.04
09/25/01	13.61
09/26/01	9.38
09/27/01	6.46
09/28/01	7.64
09/29/01	9.44
09/30/01	104.58
10/01/01	97.08

wet well 4

date	Flow (gpm)
10/02/01	32.99
10/03/01	21.32
10/04/01	14.93
10/05/01	11.25
10/06/01	23.96
10/07/01	18.40
10/08/01	29.44
10/09/01	31.67
10/10/01	29.65
10/11/01	35.49
10/12/01	62.50
10/13/01	22.29
10/14/01	14.79
10/15/01	43.68
10/16/01	64.38

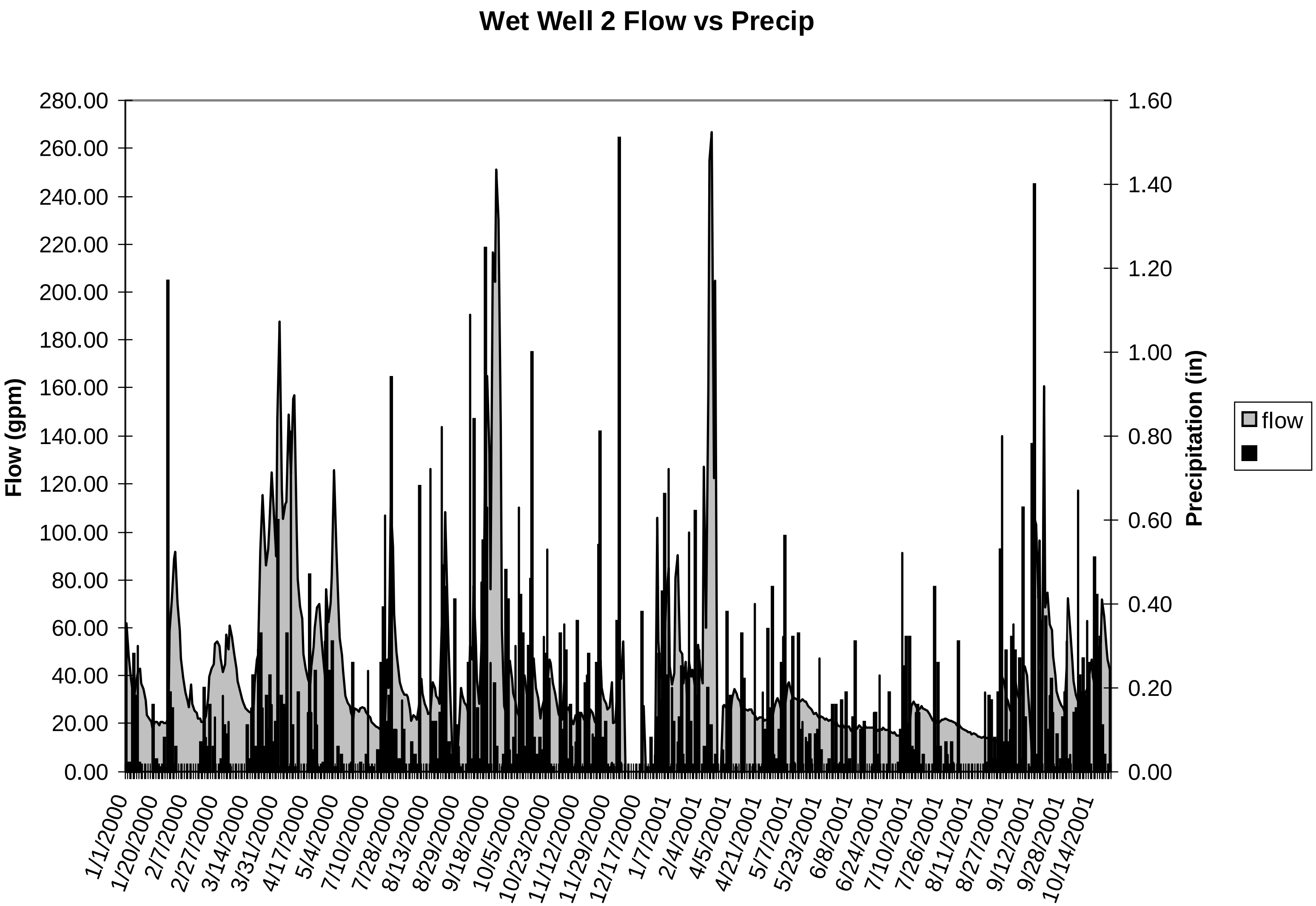
average gpm **34.20**

minimum gpm **6.46**

based on 8/25/01 thru 10/16/01

Appendix F

Wet Well Flow Computations and Graphs


Wet Well 2 Flow vs Precip
Flow (gpm)
280.00
260.00
240.00
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Precipitation (in)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
flow
1/1/2000
1/20/2000
2/7/2000
2/27/2000
3/14/2000
3/31/2000
4/17/2000
5/4/2000
7/10/2000
7/28/2000
8/13/2000
8/29/2000
9/18/2000
10/5/2000
10/23/2000
11/12/2000
11/29/2000
12/17/2000
1/7/2001
2/4/2001
4/5/2001
4/21/2001
5/7/2001
5/23/2001
6/8/2001
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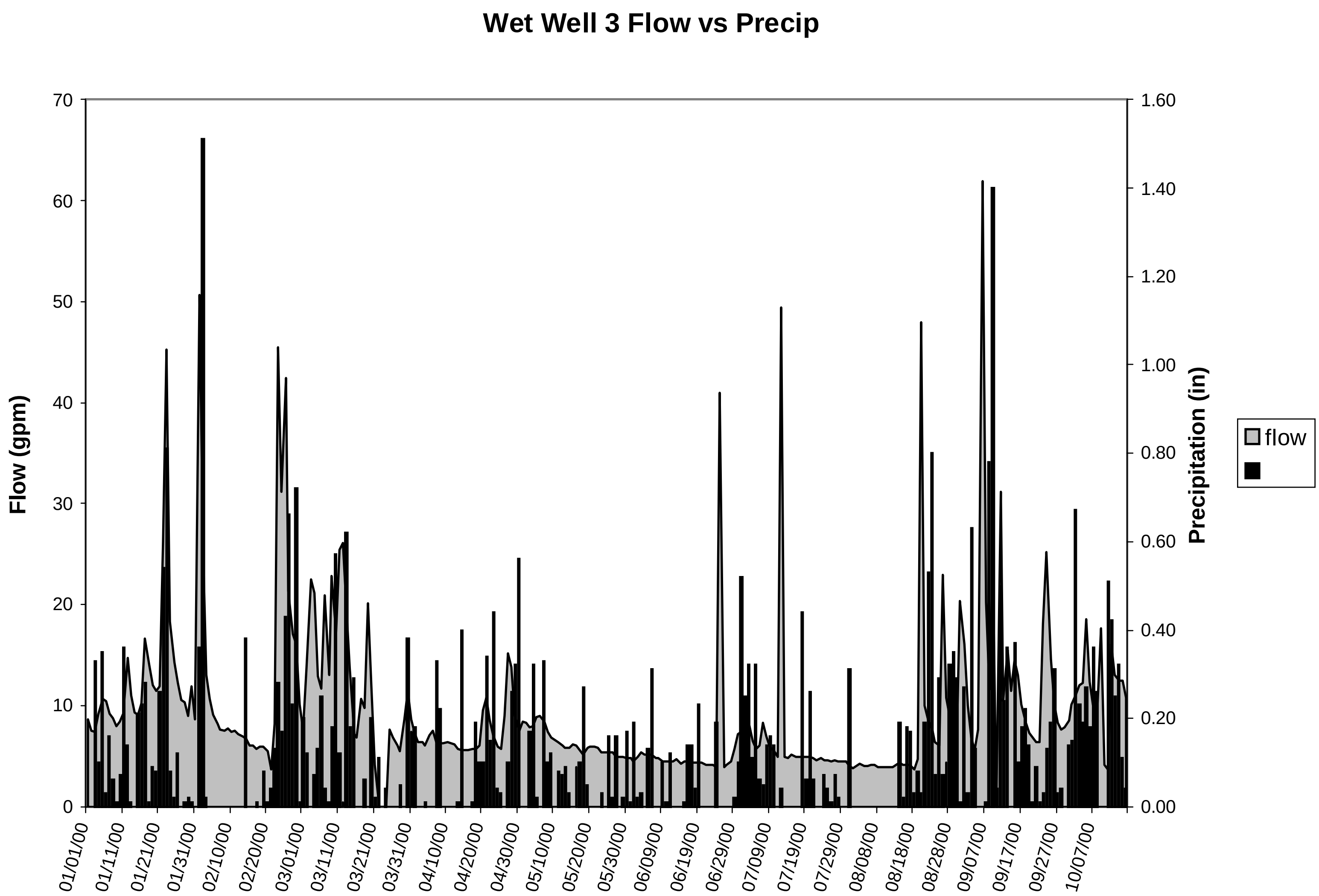
7/10/2001
7/26/2001
8/11/2001
8/27/2001
9/12/2001
9/28/2001
10/14/2001


Wet Well 3 Flow vs Precip
Flow (gpm)
Precipitation (in)
70
60
50
40
30
20
10
0
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/01/00
01/11/00
01/21/00
01/31/00
02/10/00
02/20/00
03/01/00
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07/19/00
07/29/00
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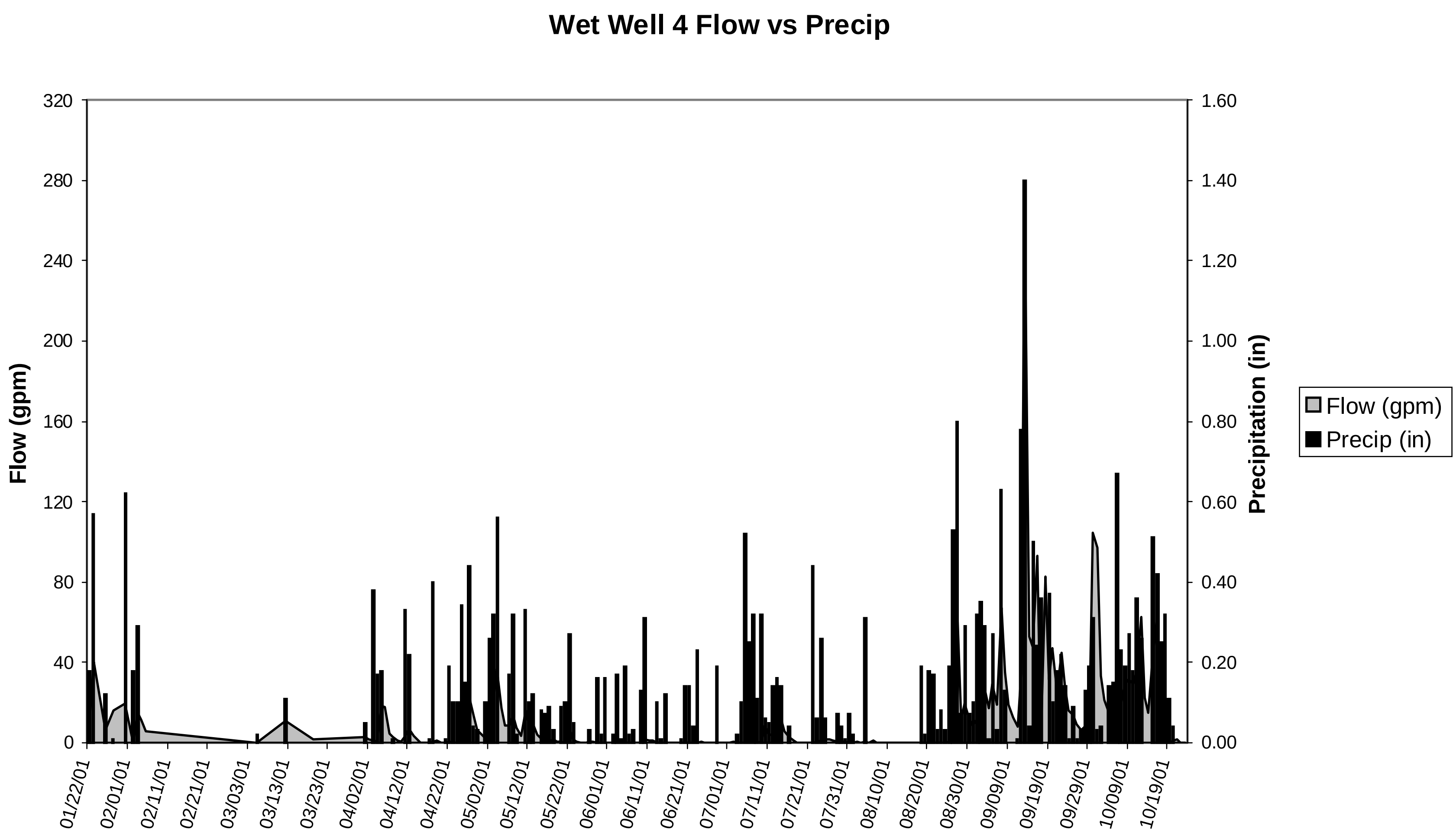
08/28/00
09/07/00
09/17/00
09/27/00
10/07/00
flow


Wet Well 4 Flow vs Precip
Flow (gpm)
Precipitation (in)
Flow (gpm)
Precip (in)
320
280
240
200
160
120
80
40
0
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
01/22/01
02/01/01
02/11/01
02/21/01
03/03/01
03/13/01
03/23/01
04/02/01
04/12/01
04/22/01
05/02/01
05/12/01
05/22/01
06/01/01
06/11/01
06/21/01
07/01/01
07/11/01
07/21/01
07/31/01
08/10/01
08/20/01
08/30/01
09/09/01
09/19/01
09/29/01
10/09/01
10/19/01

Appendix F

Calculations for Tailings Area Surface Runoff and Impoundment Infiltration Rates

Calculations of the amount of average stormwater runoff resulting from precipitation at the surface tailings site, were made to estimate the average runoff flows at the tailings wet wells. These estimates were made by using the average annual rainfall in the surface tailings impoundment area of 52.9 inches/year (4.41 feet /year) at KGCM, breaking that down to a yearly volume over a known surface area (for example the known surface area associated with up-gradient drainage to Wet Well 2), and then converting that volume per year to an average gpm. For instance, the approximate size of the up-gradient stormwater drainage area associated with Wet Well 2 is 12.2 acres. 12.2 acres multiplied by 43,560 square feet per acre, multiplied by 4.41 feet per year, gives 2,343,615 cubic feet per year, or 33.4 gpm on average.

A portion of the stormwater from precipitation on tailings runs off and is collected at wet wells or basins, and a portion infiltrates into the tailings pile. Methodology is outlined in the "KGCMC Stage II Tailings Expansion Hydrology Baseline Characterization Study" report prepared for KGCM by EDE Consultants, 01/31/02, to evaluate the infiltration rate of water within the tailings pile. That report details the process for arriving at a conservative infiltration rate of $7.7x10^{-6}$ gpm/ft^2 for the tailings pile material based on observations of surface tailings water levels during capped and uncapped pile conditions. Using this infiltration rate, and areas associated with the underdrains reporting to Wet Wells 2, 3, and 4, of 14.6 acres, 3.7 acres, and 4.3 acres respectively, average infiltration flow rates entering the wet wells were calculated. The average infiltration flow rates are calculated at 4.9 gpm, 1.2 gpm, and 1.4 gpm for Wet Wells 2, 3, and 4 respectively. Note that the stormwater runoff drainage area up-gradient of Wet Well 2 (12.2 acres), is not the same as the surface area of the tailings pile from which infiltration impinges on the Wet Well 2 collection drains (14.6 acres). This is because the surface topography of the tailings pile directs some stormwater runoff, having a related infiltration component that reaches Wet Well 2, away from Wet Well 2. This stormwater runs north to the North Retention Pond, while the associated infiltration is carried south to Wet Well 2 by the underdrain. Likewise, the up-gradient stormwater runoff area for Wet Well 3 is 3.5 acres, while the infiltration area is 3.7 acres.

Average infiltration loss from stormwater runoff for surface tailings drainage areas up-gradient of the wet wells was attained in the same manner as the infiltration rates calculated above. For instance, as calculated above, average precipitation flow reporting to the stormwater drainage area up-gradient of Wet Well 2, is 33.4 gpm. Subtracting an average infiltration rate of 4.2 gpm, associated with the 12.2 acres of the Wet Well 2 stormwater runoff area, from the 33.4 gpm, gives an average of 29.2 gpm of drainage area stormwater runoff. Completing the same calculation for Wet Well 3 gives an average of 8.4 gpm of drainage area stormwater runoff. Again note, that the precipitation that forms stormwater runoff reaching Wet Wells 2 and 3, is not the only precipitation contributing to infiltration arriving at the wet wells via the underdrains, hence the difference seen in the associated runoff and infiltration areas.

To attain the amount of average flow at Wet Wells 2 and 3 attributable to groundwater, base flow conditions at the wet wells were observed from the preceding figures. These base flows are representative of the flow at the wet wells without any contribution from precipitation induced runoff. Therefore, the graphed base flow is the sum of the average infiltration flow and the average groundwater flow at the wet well. For Wet Wells 2 and 3 the base flows are 12.3 gpm and 3.7 gpm respectively (the portions of the figures showing no flow at the wet wells at all, are reflective of no data collected for that time frame). These base flows result in average groundwater flows of 7.4 gpm and 2.5 gpm for Wet Wells 2 and 3 respectively, when the infiltration flows reporting to the wet wells, as calculated above, are subtracted from the base flows.

Flowmeter readings for Wet Wells 2 and 3 show average flow at these wells of 42.2 gpm and 9.9 gpm respectively. Subtracting the infiltration and groundwater flow rates, from the average flow recorded by the flowmeters at the wet wells, gives the average stormwater runoff contribution to the wet well flow. Average stormwater runoff contribution calculated in this manner for Wet Well 2 is 29.9 gpm and for Wet Well 3 is 6.2 gpm. Appendix E shows Wet Well 2 and 3 flowmeter readings, average flow, and minimum flow (base flow) in gpm.

Comparison of the average stormwater runoff contribution calculated from wet well base flow (Wet Well 2 = 29.9 gpm, Wet Well 3 = 6.2 gpm), to the drainage area average stormwater runoff calculated from the average precipitation and infiltration (Wet Well 2 = 29.2 gpm, Wet Well 3 = 8.4 gpm) reveals that the numbers are very similar. Slight variation in the areas used to calculate runoff and infiltration, could account for the differences between the methods. It appears that all average stormwater runoff flow associated with the drainage areas up-gradient from Wet Wells 2 and 3, reports to the wet wells. The conveyance of this stormwater runoff to the wet wells is thought to be through unlined tailings stormwater collection toe ditches around the tailings pile, that overlay underdrain collection piping to the wet wells. There appears to be direct communication between the toe ditches and the underdrain collection system. Since the values for stormwater runoff contribution derived from the base flow method are tailored to the average flowmeter readings, these values are used for average flow estimations at Wet Wells 2 and 3.

Estimation of average flow contribution at Wet Well 4 was done similarly to that for Wet Wells 2 and 3, but with the inclusion of a fourth water source at the wet well: average effluent from the North Retention Pond. The base flow for Wet Well 4 from, the preceding figure, is 6.5 gpm. Average infiltration contribution to the Wet Well 4 flow, using the same method described above, is 1.4 gpm. Average groundwater flow at Wet Well 4 is therefore 5.1 gpm. The flowmeter at Wet Well 4 has malfunctioned through much of 2001. From 8/25/01 until the present, the Wet Well 4 flowmeter has provided a more accurate reading. Using this most recent, most accurate, data, the average flow recorded at the Wet Well 4 flowmeter is found to be 34.2 gpm. Given the short time frame of accurate recorded data this average may not be representative of a true average flow at Wet Well 4. Subtracting average infiltration and groundwater flows from the 34.2 gpm, leaves 27.7 gpm of flow to be accounted for as average stormwater runoff. Average precipitation flow over the 17 acres draining to the North Retention Pond is calculated at 46.4 gpm based on average rainfall. The North Retention Pond discharges directly to Wet Well 4. The North Retention Pond drainage area includes some tailings at the northern edge of the pile, some disturbed areas and roadways, and native areas of peat and forest. A portion of the precipitation over the North Retention Pond drainage area can, therefore, be expected to be lost to abstractions including interceptions, infiltration, evaporation, surface storage, surface detention, etc. The least possible abstraction rate for the North Retention Pond runoff would be 40% or (1 - 27.7 gpm/46.4 gpm)*100. Given the large portion of native lands and the potential drainage interceptions within the drainage area, 40% abstraction is possible. A greater abstraction rate, however, seems unlikely, and is not justified within this area. Using this abstraction rate, an average effluent rate of 27.7 gpm from the North Retention Pond to Wet Well 4 is derived. This accounts for all of the average stormwater runoff flow reporting to Wet Well 4 and leaves no room for stormwater runoff to the well from the Wet Well 4 up-gradient surface drainage area. All stormwater runoff from the up-gradient drainage area of Wet Well 4 is assumed to report to Pond 6 as direct stormwater runoff collected in toe ditches and trenches.

Precipitation falling in the surface tailings area that reports directly to Pond 6 via collection ditches, falls mainly on compacted soil types and roadways. Total precipitation induced average flow from the 4.1 acres draining directly to Pond 6 is 11.2 gpm. Additionally the surface area of Pond 6 (1.5 acres) receives 4.1 gpm on average from direct precipitation influent.

Calculations for Expansion Tailings Area Wastewater Flow Rates

Calculations for average stormwater runoff from precipitation for the proposed expansion surface tailings impoundment area were made to estimate the average flows for the various tailings areas. These estimations were made using the same procedure outlined above. That is, by taking the average annual rainfall on a daily basis over a known stormwater runoff drainage area, and converting it to gpm. For the runoff areas draining over tailings materials, a proportion of the rainfall induced flow equal to the infiltration flow was subtracted from the overall average precipitation flow, to attain the average amount of stormwater flow leaving the area as runoff. The procedure presented in the “KGCMC Stage II Tailings Expansion Hydrology Baseline Characterization

Study" report prepared for KGCM by EDE Consultants, 01/31/02, was used to calculate infiltration flow within the runoff areas.

Because the design and construction of the proposed expansion area wet well underdrain systems and collection ditches should alleviate the current problem of runoff waters in toe ditches being directed to drain systems, no surface stormwater runoff is expected to report directly to the wet wells after the proposed Stage II Expansion. Stormwater runoff collected on the north end of the tailings pile and routed to the North Retention Pond will be subsequently routed to Wet Well 4 from the pond discharge.

Average direct runoff from the area immediately south of the expansion tailings pile was modeled as in the previous section above with no infiltration loss assumed. This stormwater runoff is mainly collected at the southwest corner of the proposed expanded surface tailings pile, from compacted areas and roadways and is routed directly to proposed Pond 7. Stormwater runoff falling directly over the proposed Pond 7 surface area of 5.6 acres was considered as direct stormwater runoff to proposed Pond 7 with no loss to abstractions.

Calculations for average infiltration flow rates reporting to the wet wells from the infiltration areas associated with the wet wells were made, again using the procedure from the "KGCMC Stage II Tailings Expansion Hydrology Baseline Characterization Study" report prepared for KGCM by EDE Consultants, 01/31/02. The tailings filling the proposed expansion footprint are expected to be placed on and engineered low permeability liner. Under-drains to the wet well locations will be placed atop this engineered liner necessary. This engineered liner will curtail groundwater flow to the underdrain systems, consequently, no attributable groundwater flow component is expected to be seen at any additionally necessary wet wells (conceptual as Wet Wells 5 and 6) which drain tailings placed on this material. Groundwater flow contribution at Wet Wells 2, 3, and 4 will remain the same as current conditions because the expanded infiltration areas at these wells will be underlain by liner material. However, the infiltration collection area at Wet Wells 2, 3, and 4 will be expanded so infiltration flow rates will increase.

The calculations and values presented for the proposed surface tailings expansion area water management should be considered estimates. In particular, the predicted average flow rates from any new wet wells (proposed Wet Wells 5 and 6) are subject to actual as-built pile and underdrain configurations. Wet Wells 5 and 6 would be installed, if necessary, to provide a means to address all of the areas encompassed by the proposed surface tailings expansion footprint. The exact location and actual number of additional wet wells needed is subject to change during build out. However, the amount of water to be dealt with is proportional to the area of the pile footprint, and therefore, will not change regardless of the addition, deletion, or movement of proposed wet wells.

If an engineered liner is not placed underneath all of the proposed tailings expansion or does not seal completely, there will be an additional amount of flow reporting to the affected wet wells from groundwater. Based on the current groundwater contribution of 15 gpm under 22.6 acres of surface tailings, a prediction of potential groundwater flow contribution (unlined tailings), under the 67.6 acre proposed expanded surface tailings footprint, of 44.9 gpm can be made. This indicates 29.9 gpm of additional groundwater flow could possibly be added to the proposed surface tailings expansion collection at the wet wells. It should be noted that this prediction assumes potential groundwater flow contribution beneath the pile to be uniform within the average flow seen at Wet Wells 2, 3, and 4. This may not be the case, some areas may produce more or less flow than has been seen to date at the three locations under the existing tailings pile.