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ROCK CREEK MINE
PLAN OF OPERATIONS
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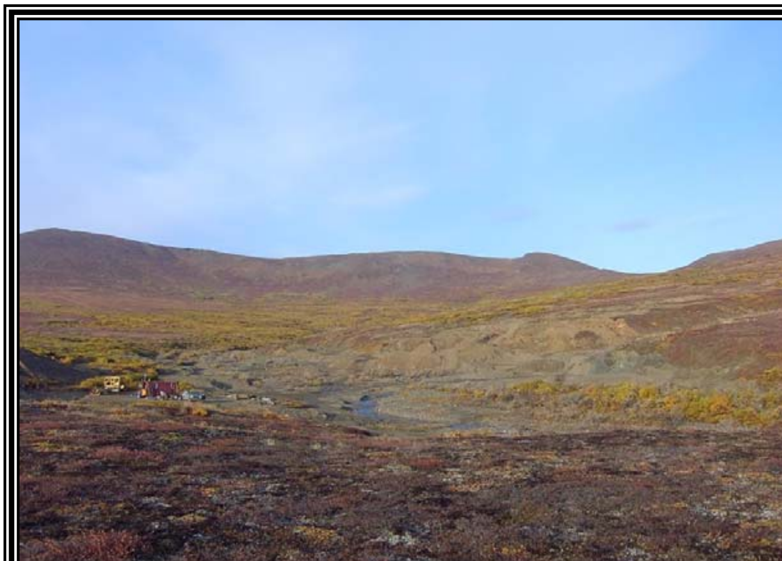

NovaGold

ROCK CREEK MINE PROJECT
WATER MANAGEMENT REPORT

April 2006

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1 INTRODUCTION

The proposed Rock Creek project encompasses two mine sites, the Rock Creek Mine site and the Big Hurrah Mine site. This report will reference the Rock Creek Mine site only which lies within the Snake River catchment approximately 10 km north of Nome Alaska. The Big Hurrah Mine site is addressed in a separate report. The facilities for the operation of a mine in the Rock Creek basin involve the construction of a tailings area, development rock dump areas, a plant site and a pit. These mine elements are almost entirely located within the surface water catchment boundaries of Rock Creek.

The mine facilities require a water management plan to describe the water aspects of the project and to develop an operating and closed mine with acceptable environmental impacts. Water Management Consultants has provided consulting services to Alaska Gold and assisted with development of the water management plan. The activities have included:

- Review of available climate data for the region and the site.
- Review of local stream flow data and determination of likely variation of climatic information that the stream flow data indicates.
- Development of watershed models for Snake River, Glacier Creek, Lindblom Creek and Rock Creek to provide an indication of the range of local stream flows.
- Development of a groundwater model based on available subsurface information and development of a design for interception well field for the pit area.
- Conceptual design of a Class V underground injection system for discharge of water.
- Development of a site wide water balance that considered losses and gains of water from the mill and tailings circuit and quantified probable quantities of water that would be shed from the site as a result of the water management plan.

The water balance for the proposed Rock Creek mine site that was developed incorporates topography, geology, physical hydrogeologic conditions as well as climate and flow data. The water balance was completed using a spreadsheet that addressed the possible recharge sources by catchment area and potential recharge rates. Calculations were completed on a month by month basis, and were reported on an annual basis, with an aim to determine all water interactions between mine elements.

2 PROJECT SETTING

2.1 General

The proposed Rock Creek project site lies within the Snake River catchment (see Figure 1.1). The Snake River, which flows about 11 miles south from the Rock Creek confluence to Norton Sound near Nome Alaska, has a 85 mi^2 (220 km^2) catchment area. The Rock Creek project site is situated on the eastern side of the Snake River valley. Three creeks, all tributary to Snake River, are in the immediate vicinity of the proposed project, Lindblom Creek to the north, Rock Creek in the middle, and Glacier Creek to the south.

The Rock Creek catchment has an elevation gain of 1300 ft from the valley floor which lies at 100 ft. The N-S trending foothills in which the catchment lies have elevations that range up to 2000 ft. The catchment area for Rock Creek is approximately 2 square miles. Glacial, alluvial and tectonic processes shaped the eastern wall of the Snake River Valley, upon which this catchment lies. The hydrogeology of the Rock Creek basin is controlled by the surficial and bedrock geology, the topographic setting as well as the climate and hydrology. Steep slopes of local bedrock dominate the higher elevations on site. The surface topography quickly shallows over the 2.5 mile (4 km) creek path which ends on the alluvial plain of the Snake River.

Within the Rock Creek drainage the dominant bedrock is a well foliated, “wavy” banded, quartz-muscovite schist containing varying proportions of carbonate graphite/carbon and chlorite. Outcrops and near surface bedrock are highly weathered and fractured. Drilling with an RC air rotary rig results in significant water return in many of the drillholes to the full depth, indicating at least moderate bedrock permeability over a significant portion of the site. Overburden materials include silts formed as a weathering profile overlying the schist, as well as glacial, alluvial and colluvial materials. Sands and gravels have been observed at some locations on the lower slopes. The bottom of Rock Creek valley is infilled with sand and gravel. This material has been reworked with a dredge for some distance upstream. West of the Rock Creek site, the Snake River valley has been infilled, primarily with alluvium. The remnants of abandoned and infilled channels are apparent on the valley floor. Silt infill, as well as channel and bar sands are expected. Sand and gravel deposits are codepositional and overlie the Snake River alluvium as fans from Lindblom Creek, Rock Creek and Glacier Creek.

The climate and physiography create typical high latitude vegetation. Tundra, consisting of low lying shrubs and grasses, cover a majority of the region. Higher regions have areas of bedrock outcrop. Discontinuous permafrost has been documented in the planned development area.

2.2 Hydrometeorology

2.2.1 General

Regional climate data has been evaluated to estimate an extended monthly precipitation and temperature dataset for the Rock Creek site. Precipitation frequency analysis has been completed on the precipitation dataset to estimate average, and wet and dry values for various return periods.

The regional data utilized for this task were as follows:

- Daily precipitation and temperature data from the Nome Airport weather station in Nome, AK from 1907 through 2003 (National Climatic Data Center);
- Daily precipitation data for 2005 from an on site meteorological station;
- Stream gage data from the Snake River for the years 1965 through 1991 (Hydraulic Unit Code: 19010504, USGS); and
- Stream gage data for a few recent dates for Rock Creek, Lindblom Creek, Snake River and Glacier Creek.

Precipitation reaches a maximum in late summer and drops to a minimum in April and May. The moderating influence of open water of Norton Sound is effective from early June to about the middle of November. Overcast conditions are common during July and August. Temperatures generally remain well below freezing from the middle of November to the latter part of April. Snow begins to fall in September, but usually does not accumulate on the ground until the first part of November. The snow cover decreases rapidly in April and May, and normally disappears by the middle of June. Severe wind storms are common.

2.2.2 Temperature

The average monthly temperatures for the Nome Airport are presented on Table 2.1. The site temperatures at lower elevations are expected to be similar to Nome, as the site is fairly close to Norton Sound. To develop an understanding of historical climate trends, a graph displaying the five year running average for the Nome airport temperature was developed and is shown on Figure 2.1. Based on Figure 2.1, a cooler period (about -4^{o}C) was present from about 1950 to 1975. The most striking feature of the Nome record and other records in Alaska is the sudden warming in the late 1970's (see Papineau).

2.2.3 Precipitation

Precipitation has been measured at Nome since 1906, an excellent historical record for mine design. The average monthly precipitations are presented in Table 2.1.

As illustrated on Figure 2.1, the precipitation record indicates wet periods from 1920 to 1925 (average of about 550 mm/year) and 1942 to 1952 (average of about 500 mm/year) and a dry period from 1960 to 1980 (average of about 320 mm/year). Average Nome Airport precipitation from 1985 through 2005 was 441 mm.

Table 2.1 Average Monthly Temperature and Precipitation at Nome Airport

Month	Temperature (°C)	Precipitation (mm)
	Nome	Nome
Jan	-13.1	24.4
Feb	-13.0	20.7
Mar	-11.9	18.5
Apr	-6.5	17.9
May	1.8	17.6
June	7.9	27.0
July	10.3	59.2
Aug	9.8	84.0
Sept	5.6	64.3
Oct	-1.8	38.2
Nov	-8.3	27.2
Dec	-12.7	24.3
Annual		423.3

Benning and Yang (2005) describe an evaluation of the Nome airport precipitation data based on studies comparing the catch of precipitation using various gage types. They describe the results of applying an algorithm developed for comparing the gage used at Nome with a gage with extensive wind shielding. The findings of the study indicate that the Nome gage has significant undercatch as there is no wind shield at all on the Nome gage, and the gage is on top of a building where it is exposed to high wind. They report that the actual precipitation at Nome was 1.3 to 4.8 times the measured precipitation, with the larger factors for winter months. The calculated average adjustment is about 4.1 in winter and 1.5 in summer. In summary, the published paper implies a potential for measured snowfall at Nome to be much less than the actual snowfall. Flow data from the Snake River catchment, which may be subject to orographic effects, generally supports the papers results. However, such a high winter multiplier is not supported by measured Snake River Flows (see Section 2.4.10). The paper provides a reminder that snow control may be important. The pit could provide an excellent snow trap if snow fences are not installed. Snow load, particularly in the plant site area might be evaluated at the end of winter and snow removed if required to help with the overall water balance.

There is more than one year of precipitation data collected at the Rock Creek site climate station. That information, reported as monthly precipitation on Table 2.2, indicates that monthly site precipitation is 0.6 to 2.5 times Nome, with an average of 1.7 times Nome. A plot illustrating the monthly rainfall at the two sites, presented as Figure 2.2, illustrates that the multiplication factor increases with precipitation depth. The wet months were September, August, October, and July.

Table 2.2: Comparison of 2005 Nome and Rock Creek Recorded Precipitation (mm)

Month	Nome Airport	Rock Creek	Ratio
Sept/04	16	20	1.3
Oct/04	70	109	1.6
Jan/05	5	11	2.2
Feb/05	21	22	1.0
Mar/05	12	8	0.7
Apr/05	8	4	0.5
May/05	27	47	1.7
June/05	22	21	1.0
July/05	41	68	1.7
Aug/05	74	133	1.8
Sept/05	123	302	2.5
Oct/05	41	69	1.7
Nov/05	10	9	0.9
Dec/05	11	13	1.2
Annual	394	708	1.7

A precipitation frequency analysis was completed for the wet and dry distribution of the Nome airport annual precipitation over the 96-year period of record from 1907 through 2003. Listed in Table 2.3 are the average, 5, 10, 50, 100, and 200-year return period annual wet and drought precipitation levels for the Nome Airport. For comparison, the Nome Airport minimum annual precipitation recorded was 188 mm and the maximum annual precipitation recorded was 749 mm. The site return precipitation predictions were derived by multiplying the wet airport data by 1.7.

Table 2.3: Nome Airport and Estimated Rock Creek Annual Precipitation Distribution

Return Period (yr)	**Wet Annual Precipitation (mm)**		**Dry Annual Precipitation (mm)**	
	Airport	**Site***	**Airport**	**Site***
Average	425	722	425	722
5	520	884	322	547
10	574	976	280	476
20	620	1054	250	425
100	709	1205	202	343
200	743	1263	187	318

* Site precipitation at 1.7 times Nome Airport

2.2.4 Evapotranspiration and Evaporation

There is no evaporation data available for the site or the airport. Evapotranspiration in the area has not been studied in detail. Munter et al. (1991) quoting Patric and Black (1968) calculated the actual evapotranspiration in the Nome area to be 14 inches/yr based on Thornthwaite's classification. A study by Fraver (2003) of thermokarst ponds in the Council area, about 75 miles northeast of Nome, included evaluation of evapotranspiration. Extrapolation of the results from that study indicated an annual evapotranspiration of about 14 inches (356 mm) for ponds, 10 inches (254 mm) for wetlands and 7 inches (178 mm) for uplands. This precipitation and evaporation information indicates there is a significant quantity of water available for runoff and groundwater recharge in the area. The average monthly potential evapotranspiration (PET) and estimated actual evapotranspiration (AET) for this study is illustrated on Table 2.4.

Table 2.4: Calculated Average Evapotranspiration (mm)

	PET		Natural AET	
Month	<1,000'	>1,000'	<1,000'	>1,000'
Jan				
Feb				
Mar				
Apr				
May	32	26	13	13
June	109	108	41	43
July	127	127	52	53
Aug	101	101	46	46
Sept	52	56	25	24
Oct				
Nov				
Dec				
Annual	423	412	181	179

Note: Ponded water evaporated at PET

2.3 Hydrogeologic Setting

2.3.1 General

In the proposed project area there are three creeks that potentially have hydrologic influence. Rock Creek runs down the center of the site, Lindblom Creek borders the site on the north and Glacier Creek borders the site to the south. Lindblom Creek has a smaller catchment than Rock Creek while Glacier Creek is larger, encompassing the entire east and south side of Mount Brynteson (see Figure 1.1). All of these creeks are tributary to the Snake River.

Potential sources of groundwater recharge include snowmelt, rainfall, and sites where streams or other surface water features are perched above the water table.

Groundwater recharge initiates as surface infiltration. The infiltrated water may be transmitted downslope as interflow (or very shallow groundwater) or percolate to the groundwater table. There is a significant quantity of water that transmits down the slope as interflow, with visible discharge from the banks of Rock Creek. This flow path results in a significant retention of storm water, probably reducing the peaks from rainfall events. Some of this retention is within the tundra grasses and some is within the overburden and near surface fractured rock. This interflow may be within the active area, where permafrost is present.

Water entering the groundwater system travels to local discharge within the creeks or further to discharge into the Snake River alluvium. The local discharge of deeper groundwater into Rock

Creek is apparent from the presence of winter base flow, artesian flow from open drill holes and from the chemistry of Rock Creek water. The estimated annual infiltration in the Rock Creek basin is approximately 8 inches (200 mm), based on rainfall, estimated evapotranspiration, and limited runoff measurements. The presence of permafrost over the catchment could significantly reduce groundwater recharge.

There is a significant quantity of groundwater moving downstream in the alluvium within Rock Creek Valley. The permeability of this alluvium was probably enhanced by dredging operations. Groundwater within this alluvium includes direct precipitation, interflow from upper slopes and groundwater discharged from depth. The water character is expected to be similar to the character of the creek water although there may be a higher percentage of deep groundwater.

Recharge of groundwater in the Snake River alluvium occurs as direct precipitation, as discharge of deep groundwater into the alluvium and as stream recharge of alluvial fans. The sand and gravel fans (Rock Creek, Lindblom Creek, and Glacier Creek) transmit considerable water as a result of higher hydraulic conductivity and gradients than the underlying Snake River alluvium. As a result, groundwater discharge is expected into the alluvium, as well as into channels and ponds surrounding the fans.

2.3.2 Hydrogeologic Investigations

A groundwater monitoring program was planned and initiated in October 2003. The objective of the monitoring program was to document the existing, natural groundwater chemistry and flow regime within the areas in which mine development is proposed. The open pit, development rock storage and tailings storage are the three mine facilities that will have the greatest effect on groundwater. Hydraulic testing was also conducted to determine aquifer properties.

Seven monitoring wells, summarized on Table 2.5, and seven additional test holes were completed between 2003 and 2004. Their locations, shown on Figure 2.3, are up gradient and down gradient of the proposed mine facilities. All monitoring wells were installed with 12 m of 0.020 inch factory slotted 4 inch diameter PVC screen. T&J Drilling constructed the wells in 8 inch holes using an exploration air rotary rig.

Bedrock was intercepted in all of the test holes and was screened in all of the monitoring wells except MW03-06. The bedrock consists primarily of fractured carbonate rich schist which is highly weathered at the surface.

Two wells were installed to document groundwater quantity and quality within the shallow bedrock and alluvium of Rock Creek and the Snake River. The down gradient tailing facility well (MW03-05) documents the groundwater quality in the bedrock just before it reaches alluvium and MW03-06 documents the groundwater in the alluvium closer to the Snake River. MW03-06, drilled through the Rock Creek Fan, penetrated 35 ft of sand and gravel overlying silt and clay, finally encountering bedrock at a depth of 61 ft.

To refine expected groundwater inflow estimates, Alaska Gold drilled a number of additional test holes and pump wells and carried out three pump tests in 2004 and 2005. Three sites were initially selected for pump testing. Two pilot holes (A and B) were drilled at each of these three sites in 2004. Following an iteration of the mine layout, the test sites were moved to reflect the expected layout of the open pit and pump wells. Two additional test wells (C and D) and a pump well (E) were drilled were drilled at each of the three sites in 2005. Inflow rates during airlifting from some of these holes are provided on Table 2.6.

Following is a summary of the 2005 drilling for the pump testing program.

- One pumping well (E) and two monitoring wells (C, D) were installed at each test site with a depth from 86 to 116 m, and a diameter of 200 mm.
- Monitoring wells C and D are 15 to 25 m distant from the pumping wells (E). Wells C and D were installed about 100-300 m from monitoring wells drilled the previous year (1A, 1B, 2A, 2B, 3A and 3B). Locations of all wells are shown in Figure 2.3.
- During drilling, groundwater inflow into boreholes was frequently measured. Table 2.6 summarizes depth and major inflow zones as documented by an Alaska Gold employee.
- Inflow rates were similar to rates from the A and B wells and in the MW series wells.

Trends in the groundwater flow regime were identified in the data from observations made during drilling of the monitoring wells and test wells. Air lift flows up to 200 gpm were measured during air rotary drilling of wells around the pit area. Inflows generally reached significant rates in the lower portion of each hole. This did not occur in 2D, although it was within 15 to 20 m of holes (2C and 2E) that did have that response. Lower inflows were also observed in MW03-07. Lower values in MW03-02 and MW03-01 may have been related to the limited depth of these holes. Figure 2.4 shows an E-W profile through the pit with air lift returns labelled for drill holes. The flow rate distribution indicates that most of the groundwater flow is from discrete fractures and faults.

Water return was generally low in the shallow portions of the drillholes. That is expected as air lift return will be less with less submergence of the drill pipe. However, the low return from shallow portions of some of the holes may be due to permafrost. Permafrost distribution has been described in more detail by Smith Williams Consulting Inc.

Water quality samples were collected and analyzed from each of the monitoring wells on a quarter annual basis to document natural groundwater quality conditions in sufficient detail to identify seasonal fluctuations. Field measurements of pH, electrical conductivity, temperature, oxidation reduction potential, ferrous iron, and depth to water were made at the time of, or before, sample collection. Samples are continuing to be collected from the wells for water quality analysis.

Investigations were also carried out in surficial materials to identify areas where Class V injection systems could be constructed. As part of this program, 20 borings were drilled into the alluvial fans of Rock Creek and Lindblom Creek and the Snake River alluvium. Soil samples were collected from these borings and grain size distributions and moisture contents measured. Slotted PVC pipe was installed so that water levels could be measured. Silty sands, silty sand and gravel, and sand and gravel were logged in the holes. Lindblom Creek fan is overlain by a significant thickness of silty soils so that near surface Class V systems are not applicable. There is an adequate area of the Rock Creek fan covered with relatively permeable materials that a near surface Class V system might be feasible.

To further define the surficial soils of the Rock Creek Fan, percolation testing was completed at four sites on the fan. Slug tests were then carried out in four of the observation wells installed into Rock Creek fan material. The location of the 20 borings and 4 test pits are presented on Figure 2.3.

Table 2.5: Monitoring Well Summary

Well ID	Location (UTM)		Total Drilled Depth	Elevation	Depth to Water	Date Sampled	Potentiometric Elevation	Conductivity Estimates (K)
				Measuring Porch				
	Easting	Northing	(m)	(m amsl)	(m)	(d-m-y)	(m amsl)	(m/s)
MW03-01	480011	7164903	24.4	86.5	10.2	22-1-04	76.3	1.3E-06
MW03-02	479855	7165284	45.7	75.2	9.9	29-1-04	65.3	2.5E-07
MW03-03	480751	7166260	36.6	162.3	3.6	30-1-04	158.7	5.0E-07
MW03-04	479994	7166135	21.3	133.1	3.9	21-1-04	129.2	2.0E-05
MW03-05	479178	7164306	27.0	30.9	2.9	15-1-04	28.0	2.5E-06
MW03-06	478802	7164190	9.1	22.4	2.7	22-1-04	19.7	1.0E-05*[1]
					2.7	26-1-04	19.7	
MW03-07	479620	7165330	33.5	70.0	3.1	21-1-04	66.9	4.0E-07
					2.1	28-1-04	67.9	

Table 2.6: Groundwater Inflow from Air Lifting Monitoring Results

Well	Interval (feet)		Air-lift data
	From:	To:	Q = gpm
1C	70	75	10
	80	85	50
	90	95	70
	95	100	100
	115	120	125
	140	145	200
	375	378	200
1D	75	80	1
	80	85	30
	100	105	43
	120	125	60
	140	145	100
	160	165	150
	200	205	150
	205	210	180
	275	277	180
1E	85	90	< 5
	90	95	20
	115	120	60
	160	165	75
	190	195	85
	200	205	100
	220	225	100
	225	230	150
	320	325	150
	340	345	180
	350	353	180
2C	80	85	6
	85	90	10
	100	105	20
	105	110	30
	125	130	50
	165	170	60
	185	190	75
	225	230	85
	265	270	95
	305	310	100
	310	315	110
	360	362	110
2D	115	120	< 3
	120	125	6
	180	185	6
	185	190	8
	205	210	8
	210	215	12
	355	360	12
2E	95	100	5
	100	105	50
	115	120	50
	120	125	70
	135	140	150
	215	220	150
	230	235	175
	375	382	175
3E	90	95	5
	95	100	10
	100	105	10
	105	110	50
	110	115	60
	140	145	80
	150	155	100
	160	165	110
	180	185	120
	210	215	130
	215	220	150
	250	255	170
	265	270	180
3C	40	45	1
	45	50	20
	65	70	40
	110	115	50
	130	135	80
	155	160	100
	200	205	120
	215	220	135
	255	260	135
3D	85	90	5
	110	115	35
	115	120	60
	135	140	80
	145	150	120
	170	175	135
	235	240	180
	260	265	180

2.3.3 Hydraulic Conductivity:

To estimate hydraulic conductivity recovery data obtained during response testing of the monitoring wells were placed on Hvorslev plots. The hydraulic conductivity results range over two orders of magnitude from 10^{-7} m/s to 10^{-5} m/s. Table 2.7 includes the results of the Hvorslev analysis. Typically, the monitoring wells were installed to sample the more permeable horizons intersected by the drillhole. Monitoring well MW03-06, within the alluvium of the Snake River valley, recovered too quickly to run a recovery test. The hydraulic conductivity is expected to be on the order of 10^{-4} m/s due to the nature of the alluvial material.

Pumping tests were carried out in test wells drilled in 2005. All pumping and monitoring wells tested in 2005 were installed in fractured bedrock with a thin overburden cover. The pumping and monitoring was carried out in open holes. Total hole depths are presented on Table 2.6 as are water return rates. A summary of the interpreted hydrogeologic parameters derived from the pump test data is presented on Table 2.7.

Table 2.7: Summary of Pump Test Results

Test Site	Average well depths (m)	Assumed aquifer width (m)	Assumed Storativity	Transmissivity (m2/s)	Hydraulic Conductivity (m/s)
1	100	30	0.02	2.5×10^{-4}	2.5×10^{-6}
	100	60	0.03	1.5×10^{-4}	1.5×10^{-6}
2	110	>200	0.0008	5.9×10^{-5}	5.4×10^{-7}
	110	>200	0.0008	6.5×10^{-5}	5.9×10^{-7}
3	80	>65	0.0009	5.5×10^{-4}	6.9×10^{-6}

Of significance is the presence of no flow boundaries at Test Site 1, and the potential for similar boundaries at Test Site 2. A constant head boundary was present at a distance of about 65 m at Test Site 3. Test site 3 is adjacent to Rock Creek.

Percolation testing was carried out on the Rock Creek fan in four machine excavated test pits. The percolation testing results were consistent with the mix of clean and silty material mapped within the pits. Slug tests were carried out in four observation wells on Rock Creek fan, RKIG-TB1, RKIG-TB12, RKIG-TB13 and RKIG-TB15. Results of the tests ranged from 1×10^{-5} to 5×10^{-5} m/s, with the lower hydraulic conductivity from the zones with 12% passing the 200 sieve, and the higher hydraulic conductivity with less than 10% passing the 200 sieve. The results of percolation and slug tests are presented on Table 2.8

Table 2.8: Summary of Percolation and Slug Tests

Test Site	Percolation results (m/s)	Materials
TP-1	$5x10^{-5}$	Silty sand, gravel and silt
TP-12	$8x10^{-5}$	Silty sand, gravel and clay
TP-13	$2x10^{-4}$	Gravel in wall during fast response
TP-15	$<5x10^{-6}$	Silty peat, silty clay

Obs well	Slug Test result (m/s)	
RKIG-TB1	$3x10^{-5}$	<10 % passing 200 sieve
RKIG-TB12	$3x10^{-5}$	<10 % passing 200 sieve
RKIG-TB13	$1x10^{-5}$	Approx 12 % passing 200 sieve
RKIG-TB15	$1x10^{-5}$	Approx 12 % passing 200 sieve

2.3.4 Recharge:

Recharge rates for the site were estimated by first comparing recorded base flows from the Snake River with the watershed model described in Section 2.4. Base flows are the sustained flows of a river or creek between storm or seasonal runoff events, due to groundwater discharge where lakes are not present. Base flow can easily be converted to apparent recharge rate for a watershed by multiplying the flow by the catchment surface area. In this manner a single base flow measurement taken in January, 2004 on Rock Creek resulted in a rate of 110 mm/yr. However this is only one measurement, when ice would make precise measurement difficult and does not consider the expected decay in base flows over the winter. In order for the watershed model (Section 2.4) to output this base flow an annual recharge rate of 250 mm/yr was input. Based on the above findings, an average annual recharge of 200 mm was selected for the Rock Creek catchment.

2.3.5 Groundwater Levels

The groundwater table is expected to be a muted image of the ground topography. This is the case throughout most of the Rock Creek basin. Piezometric surface contours derived from a groundwater modelling calibration are presented on Figure 2.3. Some groundwater level data is presented in Table 2.5. Given the locally moderate permeability of the bedrock, the groundwater levels exhibit more variation than expected. This is probably the result of compartmentalization of the groundwater by low permeability faults in the proposed mine area. The Boulder Creek Fault strikes northwest directly above the pit area, the Rock Creek Fault underlies the creek bed which runs through the pit and Sophies Gulch Fault, a low angle normal fault, can be seen in the surface topography at the southeast corner of the pit. Three other high angle strike slip faults, all of which strike north, are the Anvil Fault, Brynteson Fault and the Upper Albion Creek fault. These faults and probably additional unmapped discontinuities all have the ability to compartmentalize groundwater through low permeability gouge zones and high permeability fractures.

2.4 Site Wide Water Balance

2.4.1 Introduction:

The water balance modelling strategy used for this study was to first develop a model that balanced the recorded flows on Snake River for the 26 years of discharge data with the Nome Airport Precipitation Data. Once the model was calibrated for this time period, it was adjusted to the area of mine operations, more specifically the Rock Creek, Lindblom Creek and Glacier Creek Catchments. The methodology is widely used for consideration of surface water and groundwater conditions in basins (see Alley, 1984 and Steenhuis and Van der Molen, 1986).

2.4.2 Input Areas

The catchment areas input for each of the creeks is presented on Table 2.9

Table 2.9: Areas used for Watershed Models (km^2)

		Elevation Bands		Total
		Under	Above	
Item	Name	1,000 ft	1,000 ft	
1	Snake River	176.82	43.51	220.33
2	Lindblom Creek	1.28	0.03	1.31
3	Rock Creek	3.61	0.77	4.38
4	Glacier Creek	16.60	2.24	18.84

2.4.3 Temperature and Precipitation

The temperature was adjusted for elevation using:

$$T = T_s - \frac{(E-E_s)}{360}$$

where
- T = required temperature (deg C);
- T_s = temperature at Nome Airport (deg C);
- E = elevation of site (m); and
- E_s = elevation at Nome Airport (m)

The precipitation record was constructed by multiplying Nome Airport precipitation by 1.7.

$$P = P_s * K$$

where
- P = required precipitation;
- P_s = precipitation at Nome Airport; and
- K = factor selected through calibration and precipitation data (1.7).

The distribution of precipitation to snow and rainfall assumed that all precipitation fell as rain if the average monthly temperature was greater than 2^{o}C and all as snow if the average monthly temperature was below -2^{o}C. In between the ratio of precipitation as snow was varied linearly with the temperature between -2^{o}C and 2^{o}C.

The elevation gain of the site was too small to require any further linear extrapolation of precipitation data with elevation gain.

2.4.4 Sublimation

Sublimation is complex and requires tabulation of a number of variables for a rigorous determination. In this analysis, we have assumed that maximum sublimation is 0.3 mm/day. Sublimation was allowed in the months November through April. Although sublimation rates may be high during snowmelt, the sublimation is often countered by night time condensation into the snow pack. Sublimation therefore was not considered for May and June. The snow was assumed to sublimate at the set rate until none remained on the ground.

2.4.5 Snowmelt

Although snowmelt can be estimated, the required meteorological parameters are not available for this site. The snowmelt was estimated using a temperature index method. A first order estimate of the apparent losses were:

Snow melt (mm) = 150(T+2).

Where T is the average monthly temperature in ^{o}C.

The values (150 and 2) were defined in matching the precipitation record with Snake River Flows. This equation was used to estimate the potential snowmelt for each month. The actual snowmelt was up to the potential after considering the available snow after sublimation. The water available each month was calculated as the sum of snowmelt and rainfall.

2.4.6 Evapotranspiration

Evapotranspiration was calculated with a methodology after Thornthwaite (1948). First, the potential evapotranspiration (PET) was estimated based on the average monthly temperature and modified by the site latitude and the number of days in the month. The monthly water balance was calculated assuming the soil profile could retain some moisture from month to month. A maximum soil moisture retention was defined. The balance considered losses and gains to soil moisture, rainfall and snowmelt, evapotranspiration and surplus water (available for infiltration and runoff). Evapotranspiration was limited by the soil moisture condition. Below the soil moisture capacity of the soil, the PET was reduced linearly with soil moisture.

During snowmelt, the ground may be frozen, preventing contribution of snowmelt to soil moisture, and thereby contributing more water to runoff. This was addressed by preventing any contribution to soil moisture below a set temperature and ramping the water available to soil moisture up linearly to a second temperature. Finally, based on calibration to Snake River flows, a portion of the PET (0.7) was selected to provide an analogue for runoff and recharge speeds that limited the evapotranspiration over the month.

Open water was assumed to evaporate at the full PET.

2.4.7 Infiltration

Infiltration was modelled at an adjustable rate that is dependent on surface conditions, soil permeability and available storage capacity. The infiltration was set equal to available water up to a volume equal to the product of an infiltration rate and the subcatchment area. For wetter months, a fraction of the remaining available water was infiltrated.

2.4.8 Groundwater Discharge

Water was infiltrated into storage in each subcatchment. The infiltration accumulated within the groundwater compartment was released at a rate determined by the product of the volume of water in storage and a discharge factor. In this way, month to month storage was allowed within each subcatchment, with increasing discharge rate with increasing groundwater in storage. Lower discharge factors resulted in larger accumulated storage with the same recharge. The effect of decreasing the factor was to cause a more uniform discharge rate.

2.4.9 Model Structure

For each subcatchment, the water available for runoff and infiltration was calculated based on the Thornthwaite calculation and the subcatchment area. The water that was not infiltrated was passed on to the next subcatchment downstream as immediate runoff. Groundwater was stored and released at a rate proportional to the volume in storage. The groundwater released was passed on to the next subcatchment downstream up to an amount defined by estimated transmissivity, width and gradient in the groundwater system. The remainder of the released water was discharged within the subcatchment and was passed on to the next subcatchment downstream with the surface water.

2.4.10 Snake River Watershed Results

There are no long-term flow records of precipitation or flow for Rock Creek. Flow records from the neighboring Snake River and precipitation data from Nome Airport were used for the water balance modelling (rainfall-runoff analysis). The goal of this analysis was to determine the factor by which Nome Airport precipitation data would need to be changed to estimate average precipitation over the Snake River Basin. The gage station on the Snake River includes a catchment area of 85 km^2 (220 km^2) and is located at a bridge 3.7 miles (6 km) inland from Norton Sound at an elevation of 8.6 feet above sea level. Rock Creek, whose catchment covers 1.8 mi^2 (4.7 km^2), is a tributary to the Snake River located 3 miles (5 km) North Northeast of the Snake River gauging station.

The watershed model inputs long-term precipitation and temperature data and outputs flow volumes. The calibrated output and the measured flows are illustrated for the years 1982 to 1992 on Figure 2.5 and the cumulative flow over the period 1983 to 1992 on Figure 2.6. The illustrated match was obtained by multiplying the Nome Airport winter precipitation by 3.0 and the Nome Airport summer precipitation 2.5. The general fit is good over the last years of record. The annual average multiplier of Nome Airport precipitation to generate the Snake River flow volumes was 2.7. As the measured Nome airport precipitation over the 1983 to 1992 period was16.5 in (418 mm), the average Snake River Basin precipitation over that same period was expected to be 44.5 inches (1130 mm). As Rock Creek is not near the headwaters, Rock Creek is most probably less than 40 inches (1000 mm) per year.

2.4.11 Local Watersheds

A few flow measurements were completed on Rock Creek, Glacier Creek and Lindblom Creek for this study. Models similar to the Snake River Watershed model were set up for these three creeks. Calculated flow rates for all four watersheds are presented on Figure 2.7 along with recent flow measurements. The precipitation input to these models used a factor of 2 times the Nome Airport precipitation.

3 OPERATING MINE WATER MANAGEMENT

3.1 Introduction

To minimize fresh surface water runoff from passing through the mine site, surface water from upslope will be diverted through a ditch to Lindblom Creek. Interception ditches will be constructed downstream of the development rock dumps to route this water to Lindblom Creek or Rock Creek. Water will not be diverted to Glacier Creek. A layout of mine facilities including ditches is presented on Figure 3.1

Groundwater moving towards the pit will be intercepted with perimeter pumping wells as shown on Figure 3.2. Well water required to meet process needs (low flow periods) will be pumped to the mill and the remainder will be treated and reintroduced to the groundwater through a Class V injection system.

Water used in process will be recycled except for process losses. Much of the water will be recovered from the slurry at the mill in a thickener. The tailings will be transported to the tailings area as a paste in a pipeline. Supernatant will be recovered from the tailings pond with a reclaim pump. Temporary excess water from snowmelt and rainfall will be stored in the tailings area. This stored water will be used as process water during dry periods.
Process losses will be made up from sources of water on site. Site wide and tailings water management is conceptualized on Figure 3.4.

The losses within the mill and tailings circuit will include:

- water in the tailings pores;
- evaporation from the tailings pond and from moisture on exposed tailings sand;
- seepage from the tailings area;
- minor losses within the mill; and
- minor losses to the foundation pore spaces.

The losses will be made up from:

- direct precipitation and snowmelt within the tailings area during the ice free period;
- moisture content of ore;
- runoff collected from the plant site area;
- mine water pumped from sumps in the open pit;
- seepage recovery from the toe of the tailings dam;
- when required, water from the open pit groundwater interceptor wells will be used in processing. The remainder of the open pit well water will be treated and reinjected to the groundwater.

- When additional make up water is required, water supply wells will be used.

3.2 Open Pit Groundwater Interception wells

3.2.1 Pit Hydrogeology

Recharge areas on the slopes of the upper watershed provide water for creeks, alluvium and deeper groundwater. Shallow groundwater travels down the valley across an alluvial fan and discharges to surface water and alluvium of the Snake River. Excavation of the pit will intersect these groundwaters.

As the pit depth increases, groundwater will be pumped to keep the groundwater level below the bottom of the pit. Storage properties of the aquifer will determine how much water is released from an area by gravity drainage due to a decline in the water table. The pumping will also cause a cone of depression so that the groundwater catchment area of the pit will increase. As a result some areas that were initially not in hydraulic communication with the pit will become sources of pit inflows.

The surface geology and vegetation effect groundwater recharge rates. The site is similar to that of most high latitude regions with low lying shrubs and grass (tundra) cover over most of the area except for some bedrock outcrop on the high steeper slopes. Vegetation can store precipitation allowing a longer time period for evaporation and recharge.

The primary bedrock geologic units in the pit area are calcareous schists and marbles from the Nome Group. Fractures in the bedrock are the primary matrix for the transportation of groundwater towards the pit. Hydraulic heterogeneities, low permeable gouge zones and high permeability fractures through bedrock, will cause compartmentalization of groundwater.

Another control on groundwater movement and recharge is permafrost. Groundwater flow is impeded by permafrost. Test pits and boreholes to the west of the pit have intersected permafrost that reaches depths of up to 100 ft. Groundwater was observed in some permafrost areas to concentrate flow above the frozen surface or just below the tundra. This concentration of near surface flow above frozen ground (observed near the top of Rock Creek) was also observed in non permafrost areas. Pit inflows may be influenced if the excavation passes through frozen ground.

Permafrost was not considered when estimating pit inflows but is recognized as a potential factor in controlling groundwater movement.

3.2.2 Groundwater Model

A 2D (single layer) finite difference groundwater model was produced using MODFLOW and Vistas 4 which is a user interface for MODFLOW. The groundwater model includes watershed catchments of Rock Creek, Lindblom Creek, Prospect Creek and some of Glacier Creek. The top elevation is 1480 ft (450) m at Brynteson Mountain and a bottom elevation of -300 ft (–100 m), significantly below the depth of the proposed pit. This single layer model does not consider vertical movement of groundwater. As a result all mine elements are assumed to completely penetrate the aquifer.

Hydraulic heads and regional discharges were the two calibration targets for modelling. Hydraulic head elevations were available at spring locations and at monitoring wells. Regional flow rates have been recorded historically for the Snake River and have been recently measured for Rock Creek, Lindblom Creek and Glacier Creek. Low flow (base flow) measurements are the result of groundwater discharges in the absence of major lakes in the system.

The recharge rates required to produce the target hydraulic heads were estimated with a range of hydraulic conductivities. As hydraulic conductivity is lowered less recharge is required to produce the target potentiometric surface. The results of this investigation are shown in Table 3.1. The values that were tested are within the appropriate boundaries for both conductivity and recharge. The highlighted values were used in the calculations, as they are considered to be a reasonable value given the information available. The piezometric surface illustrated on Figure 2.3 is output from the calibrated groundwater model.

Table 3.1: Relationship Between Hydraulic Conductivity and Recharge

K (m/s)	Recharge (mm/yr)
1.9×10^{-7}	95
3.0×10^{-7}	158
3.8×10^{-7}	200
6.3×10^{-7}	300

3.2.3 Dewatering Calculations

Mining will continue for a period of up to four years, with the ultimate pit floor at an elevation of about 10 m below sea level. The pit outline and depths were input to the groundwater model described above and the groundwater flows to dewatering wells calculated to keep the pit floor dry. The dewatering rate calculated using the groundwater model is presented on Table 3.2.

Table 3.2: Estimate of Groundwater Dewatering Rate from Pit Wells

End of Year	Elevation of pit bottom (m)	Pit Well Field Pumping Rate (gpm)	Number of Perimeter wells
2006	Phase I = 85 Phase II = 95		5
2007	Phase I = 60 Phase II = 80	600	11
2008	Phase I = 50 Phase II = 45	600	11
2009	Phase I = 50 Phase II = 0 Phase III = 115	635	11
2010	Phase I = 50 Phase II = -10 Phase III = 70	635	11

The expected maximum required pumping rate from the open pit perimeter interception wells will be 635 gpm (Table 3.2). Pumping will need to begin at 600 gpm early in mine life to meet planned mine depth. Installation of three wells (together with operation of two existing wells) is recommended in 2006 so that excavation below the water table will be possible early in 2007.

The dewatering rate estimate is based on an assumption of average groundwater recharge (200 mm/year) and that the single layer model will provide a reasonable estimate of inflows. If permafrost cover is extensive, then recharge over the remaining ground would need to be higher (for example, if permafrost covers 50% of the ground, the average recharge rate over the remaining ground would need to be 400 mm, which is about 50 % of precipitation). From this standpoint, an average annual recharge of 200 mm is conservative.

The calculations also allow complete penetration of the aquifer by the pumping wells, which will not be true. Incomplete penetration of the wells will result in more drawdown near the wells with a vertical component of groundwater flow to the well screens. This provides an additional component of conservatism to the perimeter well design.

Based on air lift production testing, pumping rates from producing wells will vary from 50 to 150 gpm. About 11 such production wells are anticipated to be required around the perimeter of the pit. Possible locations for the wells are illustrated on Figure 3.2 A static head of 300 to 500 ft is expected. This should be possible with submersible pumps of 5 to 15 horsepower if head loss in installed piping is low.

The submersible pumps will be connected to a header that will transfer the pumped water to process or to the Class V injection area via the treatment system (section 3.5.5). Also included in the perimeter well system will be hour meters, flow measurement devices, well water level meters and piezometers for measuring system effectiveness.

3.3 Class V Underground Injection System

3.3.1 Background

The objective is to reinject water from the pit pumping wells that is not required in the process. The reinjection would be using Class V wells, relatively shallow and simply constructed devices which inject under the force of gravity. In wet weather, all of the water from the perimeter wells may need to be treated and injected. In dry weather and particularly in the winter, much of the water from the perimeter wells will be used in process. Injection methods considered were:

- Injection wells or dry wells
- Seepage pits
- Drainfields
- Surface discharge
- Infiltration gallery

Based on site investigation work, limited injection using a drainfield is possible on the Rock Creek fan. The remainder of the water will be injected into bedrock wells.

3.3.2 Rock Creek Fan Injection Site

This Class V reinjection system will be located on the Rock Creek fan. The fan toe is adjacent to side channels of the Snake River. Water injected into this fan would migrate through the fan deposits towards the toe of the fan where it would discharge into alluvium and into the side channels at the toe of the fan.

During operations, water from the upper reaches of the Rock Creek basin will be diverted to Lindblom Creek, reducing the quantity of water reaching this fan. Following treatment, the water from the pit pumping wells will be reinjected to the fan to make up for this reduction.

Drilling and testing indicated that the upper half of the fan is underlain by suitably permeable material. The injection system will consist of a network of perforated pipes buried within the Rock Creek alluvial fan. The installation of the system will require trench excavation, pipe installation within the trenches and encapsulation of the pipes with imported gravel materials. The trenches will then be backfilled with the native alluvial materials to the natural ground elevation. The injection system will cross the upper part of the fan in a north south direction, about 200 m downslope of the fan apex.

The capacity of this system was estimated to be about 100 gpm. The velocity from the injection system to discharge points downstream was calculated as follows:

v = Ki/n, where

K (hydraulic conductivity) =	$5x10^{-5}$ m/s and
i (gradient) =	0.02 and
n (porosity) =	0.25; so
v (velocity) =	4x10-6 m/s or 0.35 m/day

The distance to the toe of the fan is approximately 700 m, so the travel time to the fan toe is approximately 2,000 days or 5.5 years.

3.3.3 Bedrock Injection Well Field

All of the perimeter well water not used in process, except the 100 gpm injected into the fan, will be injected into the bedrock injection wells. The preliminary locations for these wells are illustrated on Figure 3.2. Pumping test results and water returns during drilling indicate fracture sets are permeable enough to receive the remaining water. Injection pumping may be required.

Each well will inject into a relatively permeable environment that is bounded by lower permeability materials. This will result in considerable dispersion of the injected water along a variety of discontinuous fractures and fault. The dispersed water will enter alluvium at depth under the local surface water, and travel downstream in the alluvium prior to discharging along a considerable length of Snake River.

Each well will be about 120 m deep. The top 50 m will be sealed to prevent annular flow to the ground surface. The lower 70 m will be screened for injection. Actual dimensions will be adjusted during construction. The injection capacity of the wells should exceed 50 gpm.

A total of 15 injection wells are anticipated to be adequate for injecting the required volume of water. The injection program will include resting of wells to allow dissipation of groundwater mounding.

Travel time of groundwater flowing into the injection wells to the Snake River alluvium was calculated with the same numerical model used to estimate perimeter well pumping rates. Travel path lines with travel times (in years) are shown of Figure 3.2. Calculated travel times are in excess of two years. Typically, about 10 wells will be in operation during the summer months, and about four wells injecting through the winter. Figure 3.3 presents a schematic cross section through the injection wells with estimated pre-mine flows as well as flow direction of injected water.

3.4 Mill and Tailings Circuit Water Losses

3.4.1 Tailings Voids

The majority of the losses in the mill and tailings circuit are to tailings voids. In this project, these losses have been reduced by adopting a paste tailings placement system rather than a conventional tailings pond system. This results in a higher density tailings and lower void volume. The tailings assumptions are:

- Solids specific gravity of 2.75 tonnes/m^3;
- A dry unit weight of the paste tailings of 1.52 tonnes/m^3;
- A milling rate of 7,000 tonnes/day of ore; and
- A tailings saturation of 85%.

The resulting void ratio is 0.447 and water lost to voids is 2,750 m^3/day (320 gpm).

3.4.2 Evaporation

Evaporation losses occur from tailings area open water and from moisture on exposed tailings deposits. Evaporation was estimated using the Thornthwaite (1948) procedure. The full PET was used for open water. Some of the tailings area will be a natural ground surface. The water balance on this natural ground was calculated with the same parameters as used for the pre-mine condition (see Section 2.4). Evaporation from the pond requires an assumption of the pond area. The relationship between pond area and water volume used was:

Volume (m3)	Area (m^2)
1,000	13,600
10,000	15,700
50,000	24,800
100,000	35,900
200,000	57,000
500,000	112,800

The evaporation losses from the surface of the pond were based on the PET values listed on Table 2.4.

Evaporation from the tailings deposit was a product of the tailings area and the expected evaporation rate. The tailings area was estimated by subtracting the pond area from the total expected area. The total expected area used was:

End of year	Total Area (m^2)
1	271,140
2	360,171
3	441,108
4	497,764

The evaporation rate used was the PET on Table 2.5, but only 50% of the result was taken to account for the likely dry areas on the tailings surface.

Sublimation was accounted for on natural surfaces, but was not included in the tailings pond balance.

3.4.3 Seepage

Seepage from the tailings area will be minimized by keeping the stored volume of water low, and by appropriate design of the tailings dam. Seepage from the pond was estimated as a function of the stored water volume. The seepage rate used was:

Volume (m3)	Seepage (m^3/day)
20,000	1.1
50,000	1.6
100,000	2.6
200,000	4.9
500,000	13.5

3.4.4 Minor Losses

Other minor losses considered were net losses in the mill area such as loss to evaporation and product and gain from moisture in the ore and losses to the foundation pore spaces as the tailings elevation increased. The assumptions were:

- Approximately 3.3 m^3/day (0.6 gpm) lost in the mill area; and
- Approximately 50 m^3/day (9 gpm) lost to pore spaces in the tailings foundation.

3.5 Mill and Tailings Circuit Water Makeup

3.5.1 Rainfall and Snowmelt in Tailings Area

Diversion ditches upslope of the tailings facility will reduce the quantity of water entering the mine area from precipitation and snowmelt. The surface area used to estimate the quantity flowing into the tailings area was 651,667 m^2. The quantity of water from this source was modified to account for sublimation and evapotranspiration, both on natural ground and tailings surface. Water will also accompany the underflow from the tailings thickener (2460 m^3/day). The pond area accepted the total water volume and the full evaporation rate (in losses) was applied to the pond area. The pond area did not include sublimation. Other pond losses were seepage (Section 3.4.3), water lost to voids (Section 3.4.1) and water pumped to the reclaim tank.

3.5.2 Plant Site Runoff

Rainfall and snowmelt within the plant site collection ditches will be routed directly to the mill recycle water pond where it will be used as make up water to the mill circuit. The plant site area used was 194,249 m^2.

3.5.3 Open Pit Surface Water Inflows

The surface water runoff component of inflow to the pit will be minimized by the construction of ditches upslope of the pit (see Section 3.1) to divert water to Lindblom Creek. The inflow will be further reduced by construction of temporary diversion ditches to direct most of the area below the diversion ditch into Rock Creek. Inflow from surface water will be derived primarily from direct snowmelt and precipitation. Although some snow will be removed from the pit during operations this component has not been included in the estimate due to the small proportion.

The catchment area reporting to the pit sumps was estimated to be:

year	Area (m^2)
1	225,000
2	225,000
3	285,000
4	285,000

The proposed open pit dewatering system will require sumps which will manage surface water inflows and residual groundwater inflows not captured by the groundwater interception wells. Water collected will be routed to the mill recycle pond if required. Excess pit water will be treated and injected. As much of the runoff will be snowmelt, there may be a period in the spring when there may be some ponding on the pit floor, until it can be removed with installed treatment and injection capacity.

3.5.4 Seepage Recovery

Seepage will be recovered from the toe of the tailings dam to isolate the tailings from the downstream environment. Water collected from this facility will be pumped directly to the reclaim water tank where it will feed the mill recycle water pond. The quantity of water to be collected from this facility includes runoff from the small area that this facility will capture, and a groundwater component that is a function of the calculated volume of groundwater that is in storage. Seepage from the tailings area and local recharge contribute to volume of groundwater in storage. Typical recovery rates are expected to range up to 500 m^3/day (90 gpm) with an average annual rate of up to 150 m^3/day (25 gpm).

3.5.5 Open Pit Perimeter Wells

Water from the open pit perimeter wells will be treated and discharged to a Class V underground injection system. Water in excess of the treatment plant capacity will be routed to the mill circuit or the tailings pond. In dry periods (when the tailings pond is dry or frozen), water from the perimeter wells will be used for make up water.

3.6 Operating Site Wide Water Balance

3.6.1 General

The site wide water balance for operating conditions was developed with the same calculation procedure as described in Section 2.4. The conceptual surface and mill water flow diagram is presented as Figure 3.4. Subcatchment areas were established to reflect natural and operations barrier to flows. The watersheds were divided into subcatchments to facilitate suitable inflows for mine operation planning. The subcatchments are illustrated on Figure 3.5 and are listed along with their respective surface area in Table 3.3. The model was run over the life of the mine with average climate conditions (1978 precipitation distribution).

Table 3.3: Site Wide Water Balance Subcatchment Areas

		Elevation Bands		
		Lower	Upper	Total
Area	Name	<1000’	>1000’	(m^2)
1	Lindblom Creek	1,335,484	29,060	1,364,544
2	North Development Rock Dump Catchment	246,783		246,783
3	North Development Rock Dump	793,251		793,251
4	Plant Site	194,249		194,249
5	Snake River and Rock Ck Wetlands	3,757,560		3,757,560
6	Snake River u/s of Glacier Creek	125,199,654	40,575,369	165,775,023
7	Open Pit Catchment	1,564,202	807,389	2,353,681
8	Open Pit	824,013		824,,013
9	South Development Rock Dump Catchment	124,247		124,247
10	Tailings Impoundment	651,667		651,667
11	Seepage Collection	27,082		27,082
12	Glacier Creek Catchment	19,602,219	2,096,697	21,698,916
13	South Development Rock Dump	503,591		503,591

Table 3.4 presents the climatic (precipitation and temperature) conditions that were used in the calculations.

Most of the water demand is from tailings operations. This includes water retained in tailings and foundation materials as well as seepage and evaporation. Evaporation will occur both from the tailings solid surface and from the retained pond. A total of 47 months of operations was assumed.

The tailings area is designed to retain excess water from snowmelt or rainfall events. This will result in some ponding. The storage available for water should retain the wet year pond volume and the design storm.

Table 3.4: Life of Mine Assumed Climatic Inputs

	Temperature (°C)			Precipitation (mm)	
Month	Nome	<1,000'	>1,000'	Nome	Site
Jan	-5.8	-6.2	-7.0	10.9	18.6
Feb	-11.2	-11.6	-12.5	10.2	17.3
Mar	-11.9	-12.3	-13.1	5.6	9.5
Apr	-3.9	4.4	-5.2	27.7	47.1
May	5.6	5.2	4.4	9.9	16.8
June	7.1	6.6	5.8	105.4	179.2
July	12.5	12.1	11.2	42.4	72.1
Aug	12.4	12.0	11.1	63.2	107.5
Sept	8.1	7.7	6.9	89.9	152.9
Oct	-2.8	-3.2	-4.0	19.1	32.4
Nov	-4.5	-4.9	-5.8	43.9	74.7
Dec	-9.8	-10.2	-11.1	30.5	51.8
Annual				458.7	779.8

Site precipitation 1.7 times Nome Airport precipitation

3.6.2 Life of Mine Water Balance

A site wide water balance was prepared that combined all the site water including estimates of seepage loss from the tailings area, pit inflows, development rock dump storage, and site discharge requirements. The methodology followed the general procedures defined in Section 2.4. The life of mine water balance was calculated using the average climatic conditions presented on Table 3.4. Water losses were primarily tailings pore water lock-up, tailings seepage, evaporation from the tailings area and net losses within the mill. Mill circuit water is derived from the mill recycle water pond. Mill recycle water pond sources are in order of need:

- Thickener water.
- Plant site precipitation/runoff. All of this water would be used.
- Water from the reclaim tank, which is derived from water from the seepage collection system and the tailings pond. As there is little storage associated with the seepage collection sump, it is assumed that this source is used in preference to the tailings water which could pond.
- Open pit precipitation/runoff if required. When not required, this water would be treated and injected in a Class V injection system.
- Pit interception wells, if required. When not required, this water would be treated and injected in a Class V injection system.

Table 3.5 lists the expected water balance items for the 4 year mine life while pumping the pit interception wells at the rate listed in Table 3.2. Treatment plant and injection well capacity was assumed to be adequate to meet the needs of operations. Following are comments regarding the information on Table 3.5.

- All of the water from the plant site will report directly to the mill recycle pond with water from the thickener. In addition all of the water from the seepage collection sump will report to the mill recycle pond, through the reclaim water tank.
- Table 3.5 indicates that the mill recycle storage will contain 20,000 m^3 through most of the year. In practise, this volume will be drawn down to provide some storage for wet periods.

- Table 3.5 indicates that essentially none of the open pit runoff will be used in the process, and this water will be treated and injected to ground in a Class V system. Nonetheless, whenever possible during operations, open pit runoff should be pumped to the mill recycle water pond for use as process water.
- During dry periods, and particularly during the winter, some of the pit interception well water will be pumped to the mill recycle water pond. The remainder of the interception well water will be treated and injected in a Class V Injection System.
- Table 3.5 indicated that the most significant contributors of water to the TSF are thickener underflow and runoff within the TSF area.
- The water from the tailings pond will report to the mill recycle pond through the reclaim water tank in ice free months (May through November). Through the winter, water will accumulate in the pond, predominantly as snow and ice. During snowmelt, and perhaps in wet summer/fall months, there will be excess water that will pond in the tailings storage facility. The calculated volume of water stored in the pond over the mine life is illustrated on Figure 3.6.
- Significant volumes of water will be diverted to Lindblom and Rock creeks, thereby reducing the volume of water that must be managed on site.

3.6.3 Wet and Dry Water Balance

To illustrate the impact of operating in wet or dry years, the water balance was run in a repeating mode rather than a life of mine mode. The water balance was computed for year 1 using the climate data from 1907 to 2004. Ten year return period wet and dry conditions were selected by computing statistics on the annual runoff rather than the precipitation, as runoff is more important to mine operations. The selected climate years to represent expected operating conditions were:

- 1978 for the average year;
- 1933 for the 10 year return period dry year; and
- 1932 for the ten year return period wet year.

Table 3.6 provides a summary of the average, wet and dry year site responses for the first year of operations with twice Nome precipitation and a pit interception well pumping rate of 600 to 635 gpm.

With the dry year (1933), water from the interception wells is required for process make up (to the Mill Recycle Water Pond) over most of the year. The tailings pond is expected to dry for five months. Although pit runoff would be treated, very little runoff is predicted from the pit in these dry conditions.

With the wet year (1932), water from the interception wells is mostly treated and released through the year as is the pit runoff. The tailings pond fluid volume exceeds 280,000 m^3 in June of the wet year.

Under the range of conditions examined, the annual treatment volume in year one would range from 562,000 to 866,000 m^3.

Table 3.5: Water Balance Calculation Summary (m^3) for 1978 Climate Year

Year	Month	Water Sources					Mill Recycle Water Pond								Tailings Pond								Treated and Injected			Diverted Water			
							from					to			from		To												
		pit runoff	interception wells	seepage recovery	plant site runoff	tailings runoff	plant site	seepage recovery	tailings pond	pit runoff	interception wells	net mill losses	thickener underflow	Pond Volume	tailings runoff	thickener underflow	Seepage	Bank Storage	Evaporation	Pore water lock up	Recycle Pond	Pond Volume	from interception wells	from pit runoff	total	Upper Channel to Lindblom	North Rk Dump to Lindblom	Pit Catchment to Rock Ck	South Rk Dump to Rock Ck
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	385	7,400	6,437
	2	979	94,962	0	213	1,119	213	0	0	979	67,788	100	68,880	0	1,119	68,880	0	1,500	0	49,023	0	19,476	27,175	0	27,175	0	22	2,607	2,771
	3	0	101,511	0	0	0	0	0	0	0	96,285	100	76,260	19,925	0	76,260	34	1,500	0	54,276	0	39,925	5,226	0	5,226	0	11	0	4
	4	0	98,237	0	0	0	0	0	0	0	73,975	100	73,800	20,000	0	73,800	44	1,500	0	52,525	0	59,656	24,262	0	24,262	0	5	0	2
	5	25,264	101,511	3,288	26,275	82,139	26,275	3,288	46,796	0	0	100	76,260	20,000	82,139	76,260	2,163	1,500	5,343	54,276	46,796	107,977	101,511	25,264	126,776	308,052	84,570	67,261	57,984
	6	16,451	98,237	2,898	17,907	63,867	17,907	2,898	53,095	0	0	100	73,800	20,000	63,867	73,800	2,383	1,500	9,264	52,525	53,095	126,877	98,237	16,451	114,688	186,874	53,533	43,798	35,917
	7	1,180	101,511	1,337	0	21,875	0	1,337	75,023	0	0	100	76,260	20,000	21,875	76,260	1,257	1,500	16,287	54,276	75,023	76,668	101,511	1,180	102,691	0	3,830	3,141	1,356
	8	417	101,511	1,426	2,011	28,920	2,011	1,426	72,923	0	0	100	76,260	20,000	28,920	76,260	2,129	1,500	13,880	54,276	72,923	37,140	101,511	417	101,929	0	4,777	1,111	1,691
	9	15,421	98,237	3,639	16,972	60,835	16,972	3,639	53,288	0	0	100	73,800	20,000	60,835	73,800	3,296	1,500	7,861	52,525	53,288	53,304	98,237	15,421	113,657	172,506	47,833	41,054	32,662
	10	1,225	101,511	1,944	0	7,178	0	1,944	74,416	0	0	100	76,260	20,000	7,178	76,260	53	1,500	0	54,276	74,416	6,498	101,511	1,225	102,737	0	3,527	3,263	1,249
	11	0	98,237	1,373	0	3,888	0	1,373	30,161	0	32,527	100	73,800	10,161	3,888	73,800	0	1,500	0	52,525	30,161	0	65,709	0	65,709	0	1,698	0	601
	12	0	101,511	926	0	1,109	0	926	0	0	66,866	100	76,260	1,593	1,109	76,260	0	1,500	0	54,276	0	21,593	34,646	0	34,646	0	818	0	290
2	1	0	101,993	608	0	0	0	608	0	0	94,159	100	76,260	20,000	0	76,260	36	1,500	0	54,276	0	42,041	7,835	0	7,835	0	394	0	139
	2	0	92,559	409	0	0	0	409	0	0	71,031	100	71,340	20,000	0	71,340	42	1,500	0	50,774	0	61,065	21,528	0	21,528	0	190	0	67
	3	0	102,958	212	0	0	0	212	0	0	76,148	100	76,260	20,000	0	76,260	57	1,500	0	54,276	0	81,492	26,810	0	26,810	0	91	0	32
	4	0	100,103	102	0	0	0	102	0	0	73,798	100	73,800	20,000	0	73,800	67	1,500	0	52,525	0	101,200	26,305	0	26,305	0	44	0	16
	5	25,264	103,922	3,990	26,275	93,337	26,275	3,990	46,095	0	0	100	76,260	20,000	93,337	76,260	5,886	1,500	12,050	54,276	46,095	150,991	103,922	25,264	129,186	308,052	79,185	67,261	56,078
	6	15,283	101,036	4,225	17,907	73,092	17,907	4,225	51,768	0	0	100	73,800	20,000	73,092	73,800	4,856	1,500	16,314	52,525	51,768	170,918	101,036	15,283	116,319	186,874	53,457	40,688	35,890
	7	0	104,886	2,746	0	28,831	0	2,746	73,614	0	0	100	76,260	20,000	28,831	76,260	2,067	1,500	24,743	54,276	73,614	119,810	104,886	0	104,886	0	8,129	0	2,878
	8	0	105,368	2,711	2,011	38,820	2,011	2,711	71,638	0	0	100	76,260	20,000	38,820	76,260	3,186	1,500	20,161	54,276	71,638	84,127	105,368	0	105,368	0	9,551	0	3,382
	9	14,169	102,436	4,903	16,972	64,585	16,972	4,903	52,025	0	0	100	73,800	20,000	64,585	73,800	4,646	1,500	11,158	52,525	52,025	100,658	102,436	14,169	116,604	172,506	46,320	37,721	32,126
	10	0	106,332	3,058	0	5,942	0	3,058	73,302	0	0	100	76,260	20,000	5,942	76,260	81	1,500	0	54,276	73,302	53,701	106,332	0	106,332	0	6,696	0	2,371
	11	0	103,369	2,207	0	2,975	0	2,207	71,693	0	0	100	73,800	20,000	2,975	73,800	51	1,500	0	52,525	71,693	4,706	103,369	0	103,369	0	3,224	0	1,142
	12	0	107,297	1,549	0	433	0	1,549	0	0	60,434	100	76,260	5,623	433	76,260	0	1,500	0	54,276	0	25,623	46,863	0	46,863	0	1,552	0	550
3	1	0	107,297	1,069	0	0	0	1,069	0	0	89,667	100	76,260	20,000	0	76,260	38	1,500	0	54,276	0	46,070	17,629	0	17,629	0	747	0	265
	2	0	96,913	750	0	0	0	750	0	0	68,230	100	68,880	20,000	0	68,880	44	1,500	0	49,023	0	64,383	28,683	0	28,683	0	360	0	127
	3	0	107,297	465	0	0	0	465	0	0	75,895	100	76,260	20,000	0	76,260	59	1,500	0	54,276	0	84,807	31,401	0	31,401	0	173	0	61
	4	0	103,836	289	0	0	0	289	0	0	73,611	100	73,800	20,000	0	73,800	69	1,500	0	52,525	0	104,513	30,225	0	30,225	0	83	0	30
	5	32,002	107,297	4,375	26,275	99,174	26,275	4,375	45,709	0	0	100	76,260	20,000	99,174	76,260	7,777	1,500	15,197	54,276	45,709	155,489	107,297	32,002	139,298	308,052	73,799	60,524	54,171
	6	19,359	103,836	4,972	17,907	79,515	17,907	4,972	51,021	0	0	100	73,800	20,000	79,515	73,800	6,510	1,500	20,594	52,525	51,021	176,653	103,836	19,359	123,194	186,874	53,381	36,613	35,863
	7	0	107,297	3,597	0	34,680	0	3,597	72,763	0	0	100	76,260	20,000	34,680	76,260	2,704	1,500	30,765	54,276	72,763	125,585	107,297	0	107,297	0	12,428	0	4,400
	8	0	107,297	3,541	2,011	47,293	2,011	3,541	70,808	0	0	100	76,260	20,000	47,293	76,260	4,090	1,500	24,886	54,276	70,808	93,577	107,297	0	107,297	0	14,326	0	5,072
	9	17,947	103,836	5,801	16,972	68,499	16,972	5,801	51,127	0	0	100	73,800	20,000	68,499	73,800	5,919	1,500	13,825	52,525	51,127	110,979	103,836	17,947	121,782	172,506	44,806	33,942	31,590
	10	0	107,297	3,888	0	5,139	0	3,888	72,472	0	0	100	76,260	20,000	5,139	76,260	88	1,500	0	54,276	72,472	64,042	107,297	0	107,297	0	9,865	0	3,493
	11	0	103,836	2,822	0	2,381	0	2,822	71,078	0	0	100	73,800	20,000	2,381	73,800	57	1,500	0	52,525	71,078	15,063	103,836	0	103,836	0	4,750	0	1,682
	12	0	107,297	2,009	0	0	0	2,009	0	0	69,866	100	76,260	15,515	0	76,260	32	1,500	0	54,276	0	35,515	37,431	0	37,431	0	2,287	0	810
4	1	0	107,297	1,414	0	0	0	1,414	0	0	79,431	100	76,260	20,000	0	76,260	43	1,500	0	54,276	0	55,956	27,865	0	27,865	0	1,101	0	390
	2	0	96,913	1,006	0	0	0	1,006	0	0	67,974	100	68,880	20,000	0	68,880	49	1,500	0	49,023	0	74,263	28,939	0	28,939	0	530	0	188
	3	0	107,297	655	0	0	0	655	0	0	75,705	100	76,260	20,000	0	76,260	65	1,500	0	54,276	0	94,683	31,592	0	31,592	0	255	0	90
	4	0	103,836	432	0	0	0	432	0	0	73,468	100	73,800	20,000	0	73,800	75	1,500	0	52,525	0	114,383	30,367	0	30,367	0	123	0	44
	5	32,002	107,297	4,691	26,275	104,215	26,275	4,691	45,394	0	0	100	76,260	20,000	104,215	76,260	9,382	1,500	17,968	54,276	45,394	166,339	107,297	32,002	139,298	308,052	68,414	60,524	52,264
	6	19,359	103,836	5,580	17,907	89,192	17,907	5,580	50,413	0	0	100	73,800	20,000	89,192	73,800	7,782	1,500	24,014	52,525	50,413	193,098	103,836	19,359	123,194	186,874	53,306	36,613	35,837
	7	0	107,297	4,279	0	38,260	0	4,279	72,081	0	0	100	76,260	20,000	38,260	76,260	3,217	1,500	35,855	54,276	72,081	140,689	107,297	0	107,297	0	16,727	0	5,922
	8	0	107,297	4,211	2,011	53,681	2,011	4,211	70,138	0	0	100	76,260	20,000	53,681	76,260	4,849	1,500	29,054	54,276	70,138	110,813	107,297	0	107,297	0	19,100	0	6,763
	9	17,947	103,836	6,534	16,972	77,314	16,972	6,534	50,393	0	0	100	73,800	20,000	77,314	73,800	6,986	1,500	16,172	52,525	50,393	134,350	103,836	17,947	121,782	172,506	43,292	33,942	31,054
	10	0	107,297	4,571	0	2,380	0	4,571	71,789	0	0	100	76,260	20,000	2,380	76,260	103	1,500	0	54,276	71,789	85,322	107,297	0	107,297	0	13,034	0	4,615
	11	0	103,836	3,331	0	341	0	3,331	70,569	0	0	100	73,800	20,000	341	73,800	69	1,500	0	52,525	70,569	34,800	103,836	0	103,836	0	6,276	0	2,222
	12	0	107,297	2,388	0	0	0	2,388	0	0	73,972	100	76,260	20,000	0	76,260	42	1,500	0	54,276	0	55,241	33,325	0	33,325	0	3,022	0	1,070

Table 3.6: Year One Water Balance (m3) Calculation Summary for Dry, Average and Wet Years

Year	Month	Water Sources					Mill Recycle Water Pond								Tailings Pond									Treated and Injected			Diverted Water			
							from					to			from			To												
		pit runoff	interception wells	seepage recovery	plant site runoff	tailings runoff	plant site	seepage recovery	tailings pond	pit runoff	interception wells	net mill losses	thickener underflow	Pond Volume	tailings runoff	tailings moisture	thickener underflow	Seepage	Bank Storage	Evaporation	Pore water lock up	Recycle Pond	Pond Volume	from interception wells	from pit runoff	total	Upper Channel to Lindblom	North Rk Dump to Lindblom	Pit Catchment to Rock Ck	South Rk Dump to Rock Ck
Dry 1933	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,400	6,412
	2	997	91,688	0	243	3,361	243	0	0	997	69,458	100	68,880	1,718	3,361	0	68,880	0	1,500	0	49,023	0	21,718	22,230	0	22,230	0	0	2,653	2,847
	3	0	101,511	0	0	794	0	0	0	0	94,642	100	76,260	20,000	794	0	76,260	36	1,500	0	54,276	0	42,960	6,869	0	6,869	0	0	0	5
	4	0	98,237	0	0	0	0	0	0	0	73,900	100	73,800	20,000	0	0	73,800	45	1,500	0	52,525	0	62,689	24,337	0	24,337	0	0	0	2
	5	11,721	101,511	1,534	18,824	55,084	18,824	1,534	56,003	0	0	100	76,260	20,000	55,084	0	76,260	1,113	1,500	0	54,276	56,003	81,141	101,511	11,721	113,233	105,916	14	31,206	49,949
	6	0	98,237	450	0	7,809	0	450	73,450	0	0	100	73,800	20,000	7,809	0	73,800	676	1,500	9,652	52,525	73,450	24,946	98,237	0	98,237	81,374	1	0	582
	7	0	101,511	387	0	4,194	0	387	35,000	0	35,973	100	76,260	15,000	4,194	0	76,260	417	1,500	14,208	54,276	35,000	0	65,539	0	65,539	0	0	0	280
	8	0	101,511	551	0	22,297	0	551	28,286	0	40,810	100	76,260	8,286	22,297	0	76,260	2,230	1,500	12,265	54,276	28,286	0	60,702	0	60,702	0	2	0	1,384
	9	0	98,237	744	0	8,513	0	744	22,279	0	44,870	100	73,800	2,279	8,513	0	73,800	851	1,500	5,158	52,525	22,279	0	53,367	0	53,367	0	1	0	811
	10	0	101,511	579	0	0	0	579	20,484	0	53,502	100	76,260	484	0	0	76,260	0	1,500	0	54,276	20,484	0	48,009	0	48,009	0	0	0	351
	11	0	98,237	357	0	0	0	357	19,775	0	53,284	100	73,800	0	0	0	73,800	0	1,500	0	52,525	19,775	0	44,952	0	44,952	0	0	0	169
	12	0	101,511	175	0	0	0	175	0	0	76,669	100	76,260	484	0	0	76,260	0	1,500	0	54,276	0	20,484	24,843	0	24,843	0	0	0	68
																0														
Average 1978	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7,400	6,412
	2	997	91,688	0	246	3,567	246	0	0	997	69,660	100	68,880	1,923	3,567	0	68,880	0	1,500	0	49,023	0	21,923	22,028	0	22,028	0	0	2,653	2,847
	3	0	101,511	0	0	945	0	0	0	0	94,437	100	76,260	20,000	945	0	76,260	36	1,500	0	54,276	0	43,317	7,074	0	7,074	0	0	0	5
	4	0	98,237	0	0	0	0	0	0	0	73,900	100	73,800	20,000	0	0	73,800	46	1,500	0	52,525	0	63,046	24,337	0	24,337	0	0	0	2
	5	12,922	101,511	1,750	19,963	64,948	19,963	1,750	54,646	0	0	100	76,260	20,000	64,948	0	76,260	1,651	1,500	5,370	54,276	54,646	86,811	101,511	12,922	114,433	200,948	16	34,401	53,196
	6	14,912	98,237	2,603	20,283	72,991	20,283	2,603	51,014	0	0	100	73,800	20,000	72,991	0	73,800	2,453	1,500	9,053	52,525	51,014	117,057	98,237	14,912	113,149	204,718	18	39,701	54,671
	7	1,803	101,511	1,341	0	16,547	0	1,341	75,019	0	0	100	76,260	20,000	16,547	0	76,260	1,266	1,500	16,146	54,276	75,019	61,657	101,511	1,803	103,314	0	2	4,800	1,224
	8	878	101,511	1,434	2,278	24,982	2,278	1,434	72,649	0	0	100	76,260	20,000	24,982	0	76,260	2,156	1,500	13,697	54,276	72,649	18,622	101,511	878	102,389	0	2	2,338	7,027
	9	14,000	98,237	3,444	19,224	69,551	19,224	3,444	51,232	0	0	100	73,800	20,000	69,551	0	73,800	3,351	1,500	7,732	52,525	51,232	45,633	98,237	14,000	112,237	190,350	16	37,272	51,326
	10	1,937	101,511	2,018	0	1,993	0	2,018	68,062	1,937	4,344	100	76,260	20,000	1,993	0	76,260	48	1,500	0	54,276	68,062	0	97,168	0	97,168	0	2	5,156	1,234
	11	0	98,237	1,427	0	56	0	1,427	19,831	0	32,642	100	73,800	0	56	0	73,800	0	1,500	0	52,525	19,831	0	65,595	0	65,595	0	1	0	594
	12	0	101,511	966	0	0	0	966	0	0	75,878	100	76,260	484	0	0	76,260	0	1,500	0	54,276	0	20,484	25,634	0	25,634	0	1	0	207
																0														
Wet 1932	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,400	6,412
	2	995	91,688	0	96	3,254	96	0	0	995	74,419	100	71,340	4,070	3,254	0	71,340	0	1,500	0	49,023	0	24,070	17,268	0	17,268	0	0	2,650	2,847
	3	0	101,511	0	0	862	0	0	0	0	92,290	100	76,260	20,000	862	0	76,260	37	1,500	0	54,276	0	45,379	9,222	0	9,222	0	0	0	5
	4	0	98,237	0	0	0	0	0	0	0	73,900	100	73,800	20,000	0	0	73,800	47	1,500	0	52,525	0	65,108	24,337	0	24,337	0	0	0	2
	5	48,105	101,511	6,204	53,375	167,702	53,375	6,204	16,780	0	0	100	76,260	20,000	167,702	0	76,260	2,857	1,500	0	54,276	16,780	233,656	101,511	48,105	149,616	527,838	60	128,068	141,881
	6	21,346	98,237	3,646	25,475	93,266	25,475	3,646	44,778	0	0	100	73,800	20,000	93,266	0	73,800	2,414	1,500	12,683	52,525	44,778	286,822	98,237	21,346	119,583	364,628	26	56,828	69,375
	7	2,596	101,511	1,611	0	17,087	0	1,611	74,749	0	0	100	76,260	20,000	17,087	0	76,260	1,121	1,500	17,909	54,276	74,749	230,615	101,511	2,596	104,108	0	2	6,912	1,827
	8	823	101,511	1,427	0	16,344	0	1,427	74,933	0	0	100	76,260	20,000	16,344	0	76,260	1,310	1,500	14,807	54,276	74,933	176,394	101,511	823	102,335	0	1	2,192	1,254
	9	12,292	98,237	3,045	18,263	63,283	18,263	3,045	52,592	0	0	100	73,800	20,000	63,283	0	73,800	2,715	1,500	6,217	52,525	52,592	197,928	98,237	12,292	110,529	179,217	14	32,725	48,761
	10	1,967	101,511	1,856	1,743	6,470	1,743	1,856	72,761	0	0	100	76,260	20,000	6,470	0	76,260	512	1,500	0	54,276	72,761	151,609	101,511	1,967	103,478	0	2	5,236	5,543
	11	936	98,237	1,450	0	893	0	1,450	72,450	0	0	100	73,800	20,000	893	0	73,800	112	1,500	0	52,525	72,450	99,715	98,237	936	99,173	0	1	2,493	718
	12	0	101,511	1,008	0	0	0	1,008	0	0	75,352	100	76,260	20,000	0	0	76,260	81	1,500	0	54,276	0	120,119	26,160	0	26,160	0	0	0	247

3.6.4 Design Capacity for Water in Tailings Area

A memorandum prepared by Ecological Resource Consultants, Inc (ERC) and dated April 12, 2006 regarding the tailings storage facility process solution requirements is attached as Appendix I. As the objective of defining fluid retention for input to the tailings facility design is different from the needs of a water balance, the calculation procedures used are different in the calculations reported in the memorandum than described in this study. For example:

1. Climate data used by ERC to define average conditions was average monthly values whereas this study used 1978 precipitation to illustrate a year with average precipitation.
2. To define wet conditions, ERC used the wettest four year period and inserted a 100 return period wet year to model mine operations during a significant wet period. This study used the 1932 rainfall to illustrate the impact of a wet year with a return period of about 10 years on year one of operations. ERC also used a 100 year return period fro Drought conditions while this study used the 1933 climate record to approximate a 10 year return period dry condition.
3. ERC used runoff coefficients to define expected runoff from natural ground. This study calculated evapotranspiration based on precipitation and temperature data and included groundwater recharge and discharge to define runoff.
4. Seepage from the tailings was calculated for the ERC report based on the design of the tailings facility. Seepage was assumed in this study as a function of solution volume.
5. ERC assumed water would arrive in the process stream as moisture in the ore. This study does not consider this source of moisture except as a small contribution to net process loss.

Given the above, the fluid balance derive by ERC is very similar to the site wide water balance developed in this study.

4 CLOSURE MINE WATER MANAGEMENT

4.1 Introduction

Following mine operations, the mine will be closed. This will include the following to the water management systems at the site.

- The diversion ditch upslope of the North Development Rock Dump from Rock Creek to Lindblom Creek will be removed and the area graded to discourage flow concentration.
- A new diversion ditch will be installed upslope of the North Development Rock Dump to direct water from this catchment towards the pit lake.
- The diversion ditch from upslope of the South Development Rock Dump to upper Rock Creek will be left intact, diverting flow to Rock Creek and the pit lake.
- Development rock dump surfaces will be graded to discourage flow concentration and potential erosion.
- The interception ditch downslope of the North Development Rock Dump and the South Development Rock Dump will be removed and the area graded to discourage flow concentration.
- The tailings area will be capped and graded to shed water without erosion.
- The seepage collection system will be removed, assuming that groundwater concentrations meet regulatory requirements.
- The plant site structures and related surface features will be removed. The site will be graded to discourage flow concentration.
- The pit perimeter wells will be turned off and pumps and piping removed. Surface expressions will be removed and the well bores capped.
- The Class V underground injection system will be left in place, but with all surface features removed.
- The Rock Creek Fan wells will be turned off and pumps and piping removed. Surface expressions will be removed and the well bores capped.
- The open pit will be allowed to flood from groundwater and surface water inflow. The low crest on the pit is at about 68 m. The high point on the pit wall will be about 150 m. The pit floor will be at an elevation of about –10 m. The pit lake water level after flooding is expected to reach an elevation of about 68 m. Following flooding, water will discharge from the pit lake, possibly throughout the year. This water will discharge into Rock Creek.

Most of the mine elements will therefore be removed on closure as shown on Figure 4.1. Topographic changes will remain at the tailings area and the Development Rock Dumps. A pit lake will form at the pit site. Only one ditch will be retained, and it will be along a hillside that already has ditches training water towards Rock Creek. The following sections address the timing of pit lake filling and the expected water balance for the pit lake.

4.2 Pit Lake Filling

Pit lake filling time was estimated assuming an elevation volume relationship within the pit, and with water flow criteria established in the water balance. The water surface was considered to determine the pit lake evaporation. The elevation volume assumed is presented on Table 4.1. The filling curve for average conditions at 2 times Nome Airport precipitation is illustrated on Figure 4.2. The filling time is expected to take from 1.5 to 3 years.

Table 4.1: Pit Lake Elevation, Area and Volume Relationships

Elevation (m)	Area (m2)	Volume (m3)
-10	2,655	0
-5	2,656	13,278
0	4,892	34,673
5	9,050	76,308
10	13,099	136,575
15	18,490	223,343
20	22,388	328,911
25	28,344	462,161
30	33,076	620,229
35	43,000	832,232
40	52,923	1,094,044
45	62,847	1,397,595
50	70,053	1,736,892
55	80,000	2,133,970
60	91,421	2,579,769
65	105,147	3,092,953
68	110,000	3,421,313

4.3 Pit Lake Water Balance

The pit will be filled and the spill elevation of the pit lake will be 68 masl. Contributions to the pit lake water balance will be direct precipitation on the lake surface, surface water inflow and groundwater inflow. Discharge from the lake will include spillage and evaporation. The long term average water balance for the pit lake is presented on Tables 4.2 and 4.3 for 1.5 and 2 times the Nome precipitation, to provide a range of potential inflows.

From Tables 4.2 and 4.3, the range of average annual pit inflows will be 1 to 2 million m^3 with about 69% from the catchment and from diversion ditches to the pit lake, 6% from snowmelt and rainfall on the pit lake surface and 25% as groundwater inflow. Approximately 96% of the water spills from the pit lake and 4% evaporates.

The spill from the pit lake will flow down the original Rock Creek channel to the confluence with Snake River. The most significant change to the closure Rock Creek Flows from the pre-mine condition is attenuation of peak flows from storage in the pit lake and the increase in expected winter groundwater discharge and therefore base flows.

Table 4.2: Pit Lake Water Balance Estimate (Precipitation 1.5 times Nome)

Month	Surface water into pit (m^3)				GW to pit (m^3)	total to pit (m^3)	evaporation from pond	volume spilled (m^3)
	from pit catchment	from pit walls	snowmelt and rain on lake	total to pit lake				
Jan	0	0	0	0	21,427	21,427	0	21,427
Feb	0	0	0	0	20,045	20,045	0	20,045
Mar	0	0	0	0	21,427	21,427	0	21,427
Apr	0	0	0	0	20,736	20,736	7,713	20,736
May	271,973	12,609	16,877	301,458	21,427	322,886	10,014	315,172
Jun	223,753	11,994	17,393	253,140	20,736	273,876	14,684	263,862
Jul	0	0	6,999	6,999	21,427	28,426	12,055	13,742
Aug	8,047	4,402	10,436	22,884	21,427	44,312	6,740	32,257
Sep	211,063	11,104	14,836	237,003	20,736	257,739	0	251,000
Oct	0	0	0	0	21,427	21,427	0	21,427
Nov	0	0	0	0	20,736	20,736	0	20,736
Dec	0	0	0	0	21,427	21,427	0	21,427
Annual	714,836	40,109	66,540	821,485	252,979	1,074,464	51,206	1,023,258

Table 4.3: Pit Lake Water Balance Estimate (Precipitation 2 times Nome)

Month	Surface water into pit (m^3)				GW to pit (m^3)	total to pit (m^3)	evaporation from pond	volume spilled (m^3)
	runoff to pit	from pit walls	snowmelt and rain on lake	total to pit lake				
Jan	0	0	0	0	42,854	42,854	0	42,854
Feb	0	0	0	0	40,090	40,090	0	40,090
Mar	0	0	0	0	42,854	42,854	0	42,854
Apr	0	0	0	0	41,472	41,472	7,713	41,472
May	490,485	19,995	24,504	534,984	42,854	577,839	10,014	570,125
Jun	384,577	17,609	23,190	425,376	41,472	466,848	14,684	456,834
Jul	0	1,927	9,332	11,259	42,854	54,113	12,055	39,429
Aug	87,178	7,638	13,914	108,729	42,854	151,584	6,740	139,529
Sep	348,249	15,893	19,782	383,923	41,472	425,395	0	418,655
Oct	0	0	0	0	42,854	42,854	0	42,854
Nov	0	0	0	0	41,472	41,472	0	41,472
Dec	0	0	0	0	42,854	42,854	0	42,854
Annual	1,310,488	63,061	90,722	1,464,272	505,958	1,970,230	51,206	1,919,025

5 CONCLUSIONS

Hydrometeorology

A long term climate record is available for Nome, only 10 km south of the Rock Creek gold mine prospect. Stream flow data and limited site precipitation data indicates that the annual site precipitation at the site is approximately 1.7 times the precipitation at Nome, possibly due to orographic effects. The annual site precipitation may therefore be approximately 720 mm (28 in.). On average, the highest precipitation months are July, August and September when about 50% of precipitation occurs. Site evaporation is expected to be approximately 420 mm (16 in.) per year, almost all from May to September. Evapotranspiration on natural slopes is expected to be approximately 180 mm (7 in.) The average monthly temperatures range from -13.1^{o}C in January to 10.3^{o}C in July.

Mine Water Management

Diversion Ditches
To minimize fresh surface water runoff from passing through the mine site, surface water from upslope will be diverted through a ditch to Lindblom Creek. Interception ditches will be constructed downstream of the development rock dumps to route this water to Lindblom Creek or Rock Creek. Water will not be diverted to Glacier Creek.

Pit Dewatering Wells
Groundwater moving towards the pit will be intercepted with pumping wells. This water will either be used as process water or will be treated and reintroduced to the groundwater through a Class V injection system.

Process Water
Process water will come from the following sources:

- Plant site runoff;
- Water from the seepage collection system
- Recycled tailings transport water and precipitation from the tailings pond;
- Open pit runoff derived from precipitation; and
- Pit interception wells

If additional process make up water is required in addition to the above sources, water supply wells can be installed in the Rock Creek Alluvium or additional wells can be pumped from the pit area.

Water Balance

Process Water Supply

The water balance indicates that there will be water at the mine site in excess of that required for processing. Thus, no external sources of makeup water are expected to be required through the life of the mine. Excess water at the mine will need to be treated and reintroduced to groundwater in a Class V injection system on the Rock Creek alluvial fan and in bedrock injection wells. Excess water on the site means that the mine needs to allow for the capability to store excess water during wet periods. Storage capacity considerations are addressed in Appendix I.

Water treatment capacity for Class V injection

Excess water from the pit dewatering wells will require treatment prior to reintroduction to the groundwater. The expected pit well field pumping rate is expected to be on the order of 635 GPM. The water treatment capacity for the pit dewatering wells will need to be on the order of 110,000 m^3 per month over a five month period of the year. In addition there can be up to 44,000 m^3 of runoff water in the pit during spring break up.

The Class V injection system must be capable of accepting a maximum flow rate of on the order of 150,000 m^3 per month. The proposed Class V system can be expanded as necessary, based on the actual monitored performance.

The expected travel time at the Rock Creek Injection site for the injected treated water to reach the Snake River alluvium is on the order of 5 years. The expected travel time for water injected into the bedrock Injection Wells to reach the Snake River Alluvium is in excess of 2 years.

Pit Filling

The annual average pit inflows are expected to be 1 to 2 million m^3 with about 69% from the catchment and from diversion ditches to the pit lake, 6% from snowmelt and rainfall on the pit lake surface and 25% as groundwater inflow. The open pit filling time is expected to take from 1.5 to 3 years.

Recommendations

1. Due to the predicted excess water at site, water supply wells to provide make up water should only be installed if and when they are needed. The need for these water supply wells will be evident upon analysis and consideration of water balance information collected upon start up of the mining operation.

2. Take steps to decrease the excess water on site as follows:
    - Snow fencing can be installed around the tailings area and open pit to minimize the potential for snow accumulation within the pit.
    - Snow removal equipment and capability can be considered to enable snow removal from the catchment of the mine workings and plant site.

REFERENCES:

Alley, William M. (1984). On the Treatment of Evapotranspiration, Soil Moisture Accounting, and Aquifer Recharge in Monthly Water Balance Models. Water Resources Research, Vol 20, pages 1137 – 1149.

Benning, Jennifer and Daging Yang (2005). Adjustment of Daily Precipitation Data at Barrow and Nome Alaska for 1995 – 2001. Arctic, Antarctic, and Alpine Research, Volume 37, No.3 pp. 276 – 283.

Ecological Resource Consultants, Inc (2006) Technical Memorandum re tailings storage facility process solution system analysis, prepared for the Rock Creek Project.

Fraver Matthew R. (2003). Hydrology of Thermokarst Ponds near Council Alaska. Thesis presented for MSC, University of Alaska Fairbanks

Hann C., Barfield B., Hayes J. (1994). *Design Hydrology and Sedimentology for Small Catchments*. Boston: Academic Press

Hvorslev, M.J. 1951, Time lag and soil permeability in groundwater observations. US Army Corps. Engrs. Waterways Exp. Sta. Bull. 36, Vicksburg, Miss.

Munter James A. , M.A. Maurer, M.G. Ingram and W.A. Petrik (1992). Recharge Area Evaluation for Moonlight Springs, Nome, Alaska. Report of Investigations 92-2, Division of Water, Department of Natural Resources, Division of Geological and Geophysical Surveys, in cooperation with the City of Nome.

National Climatic Data Center (2004). *Climatological Record for Nome Municipal Airport*. http://www.ncdc.noaa.gov

National Oceanic and Atmospheric Administration 'NOAA' (2004). *Precipitation Intensity Duration Frequency Maps*. http://aprfc.arh.noaa.gov/data/probmax

Odden John (2005) personal communication regarding drill fluid return from resource drilling at Rock Creek site.

Papineau John. Understanding Alaska's Climate Variation
http://pafc.arh.noaa.gov/climvar/climate-paper.html

Steenhuis T.S. and W.H. Van der Molen (1986) The Thornthwaite – Mather Procedure as a Simple Engineering Method to Predict Recharge. Journal of Hydrology, 84, Pages 221 – 229.

Thornthwaite C.W. (1948) An approach toward a Rational Classification of Climate. American Geophysical Review. Vol 38

United States Geological Survey: Water Resources Division (1979). *Flood Characteristics of Alaskan Streams.* USGS Water Resources Investigation 78-129.

United States Geological Survey: Water Resources Division (2004). *Mean monthly stream flows of the Snake River.* http://nwis.waterdata.usgs.gov

World Meteorological Organization. (1986). *Manual for estimation of Probable Maximum Precipitation (second edition) No. 232.* Geneva: Secretariat of the WMO

FIGURES

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Figure 1.1 Site Location Plan

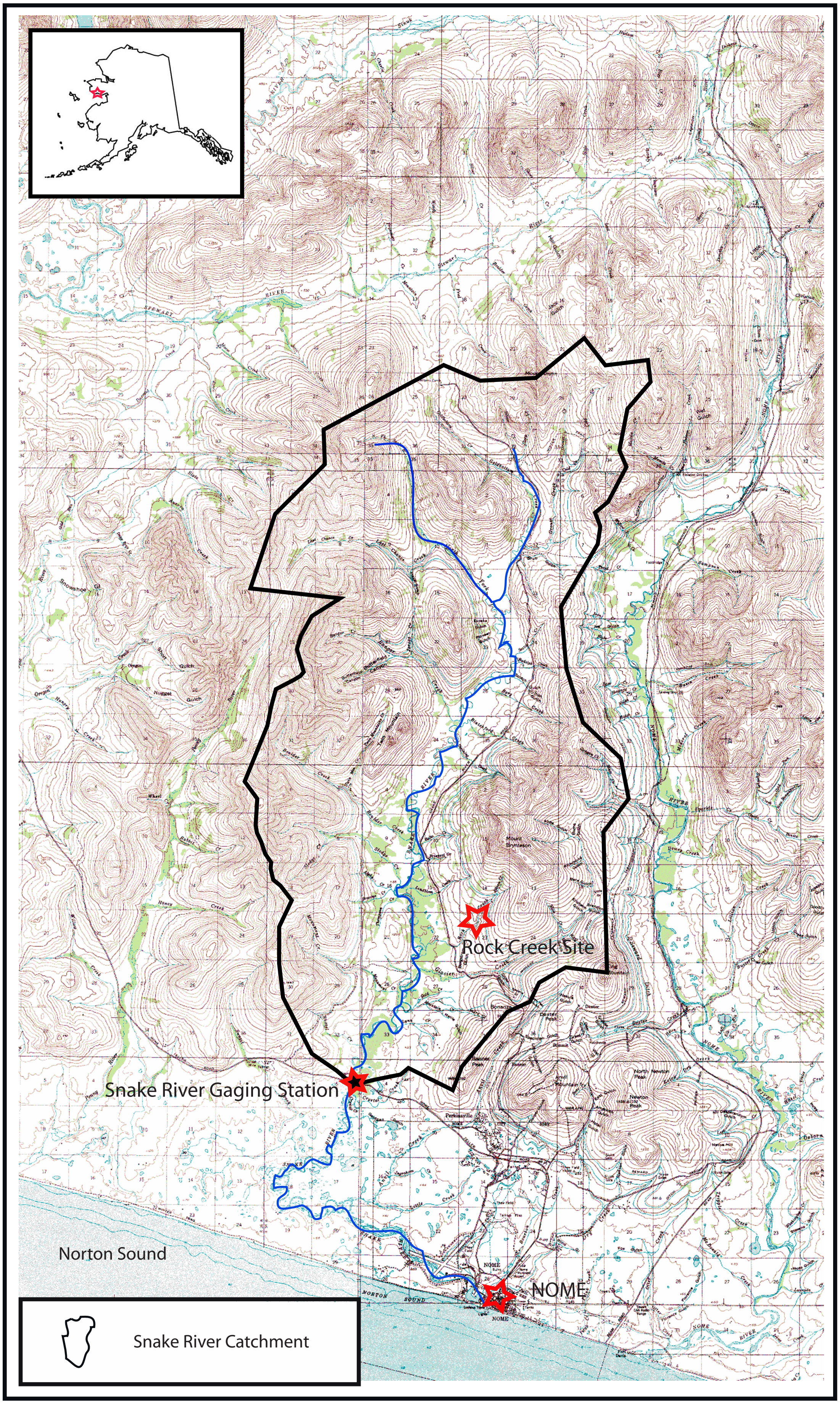

Figure 2.1: Five Year Running Average of Nome Precipitation and Temperature

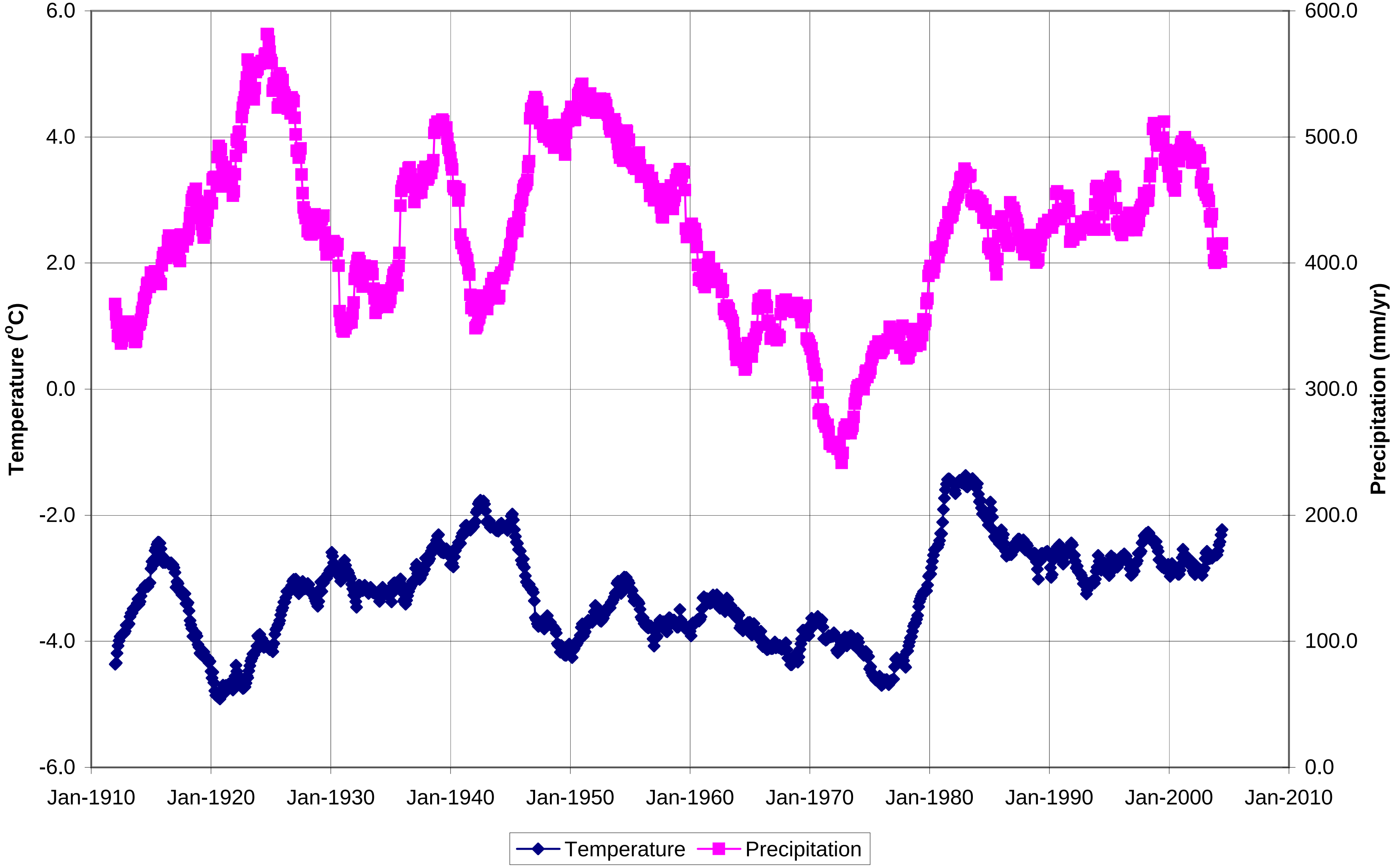

Figure 2.2: Comparison of 2005 Monthly Precipitation for Nome Airport and Rock Creek

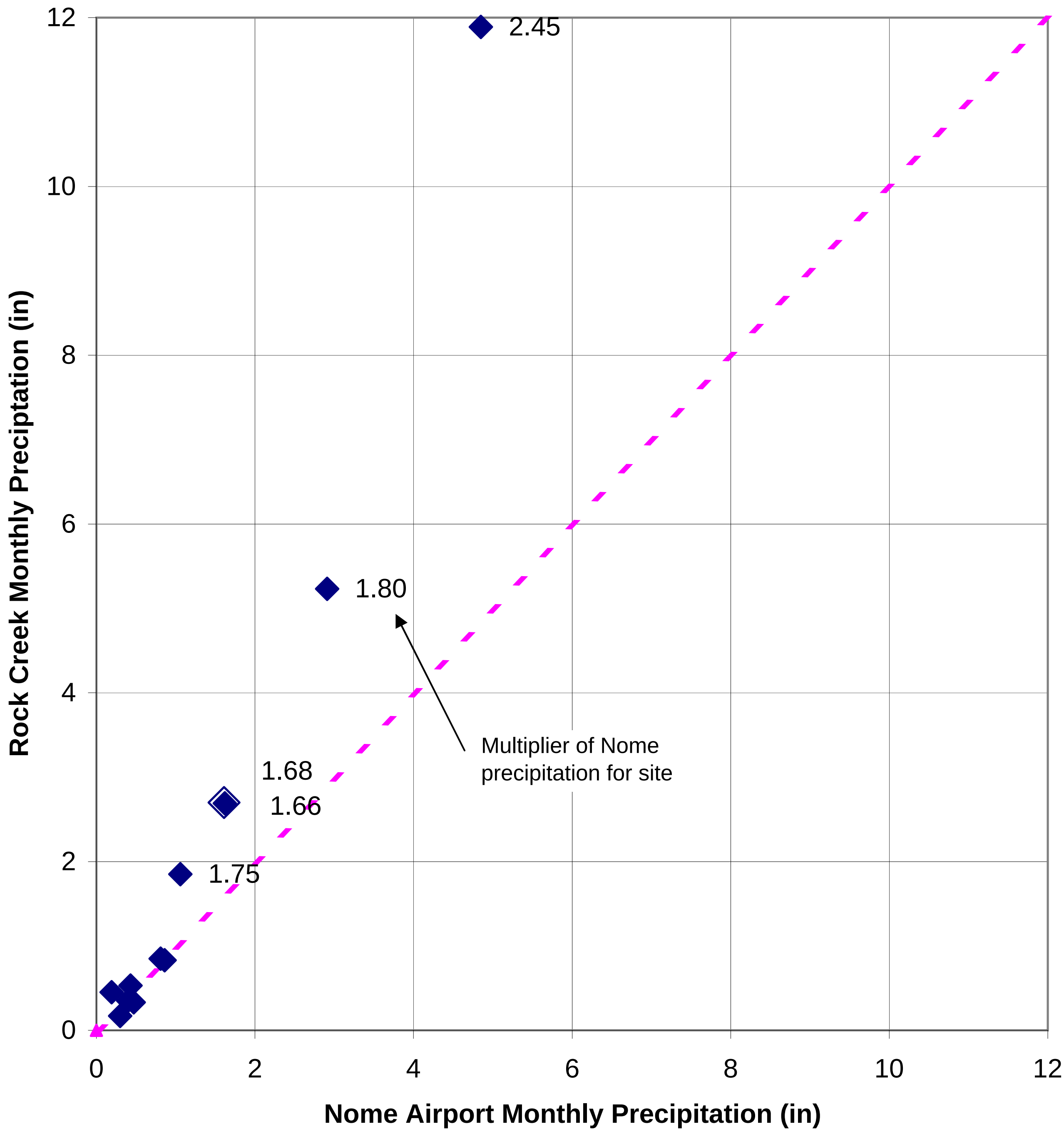

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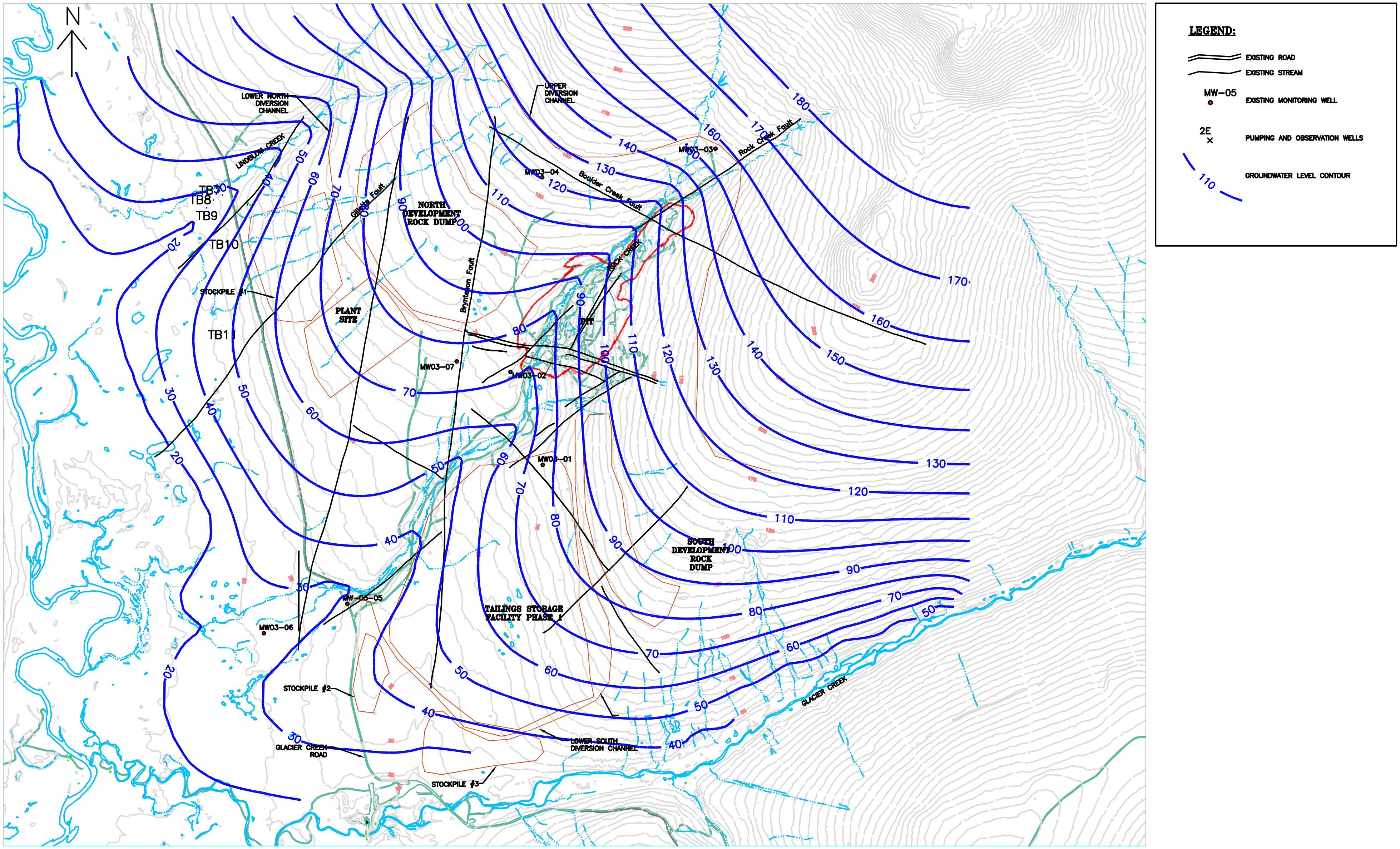
Figure 2.3 Borehole Locations and Piezometric Surface



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150 0 150 300 METERS
SCALE = 1:15000

Original drawing (1011F35 – Preliminary Permafrost Frozen/Thawed Zone Delineation) provided by Smith Williams Consultants, Inc.

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Figure 2.4 Profile with Airlift Returns

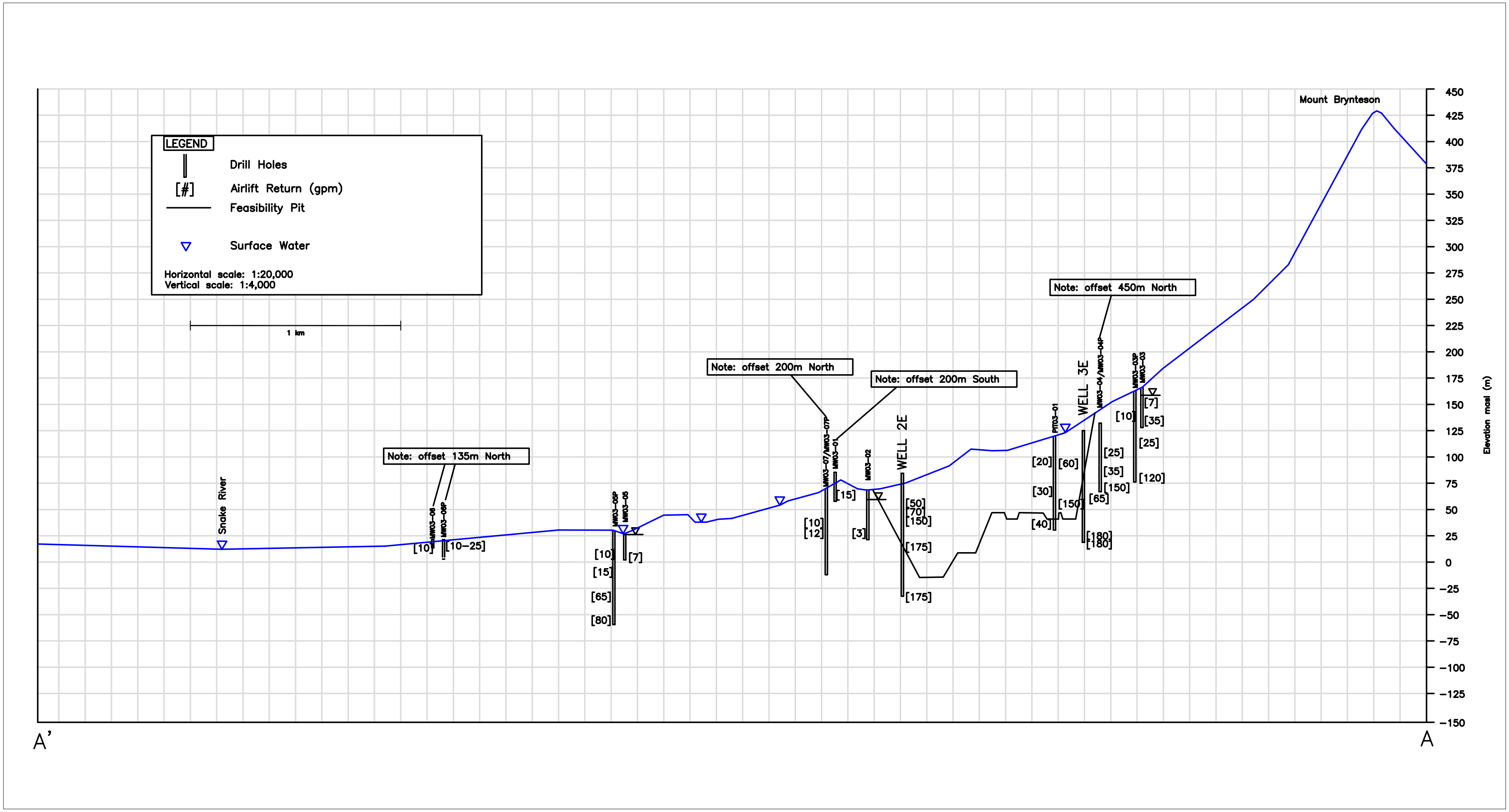


Figure 2.5: Measured and Calculated Monthly Flows for Snake River (1982 to 1992)

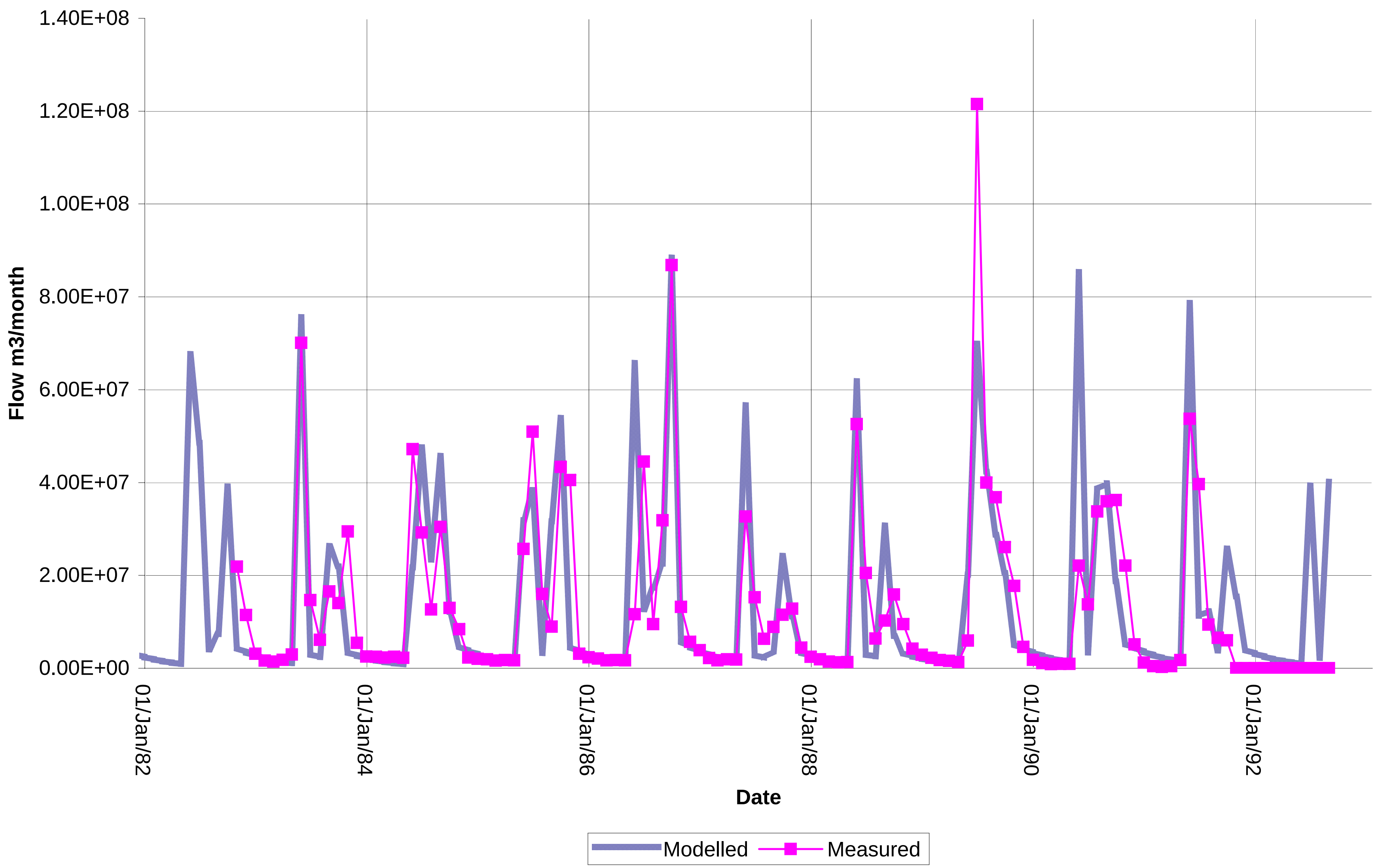


Figure 2.6 Measured and Calculated Cumulative Volume for Snake River (1983 to 1992)

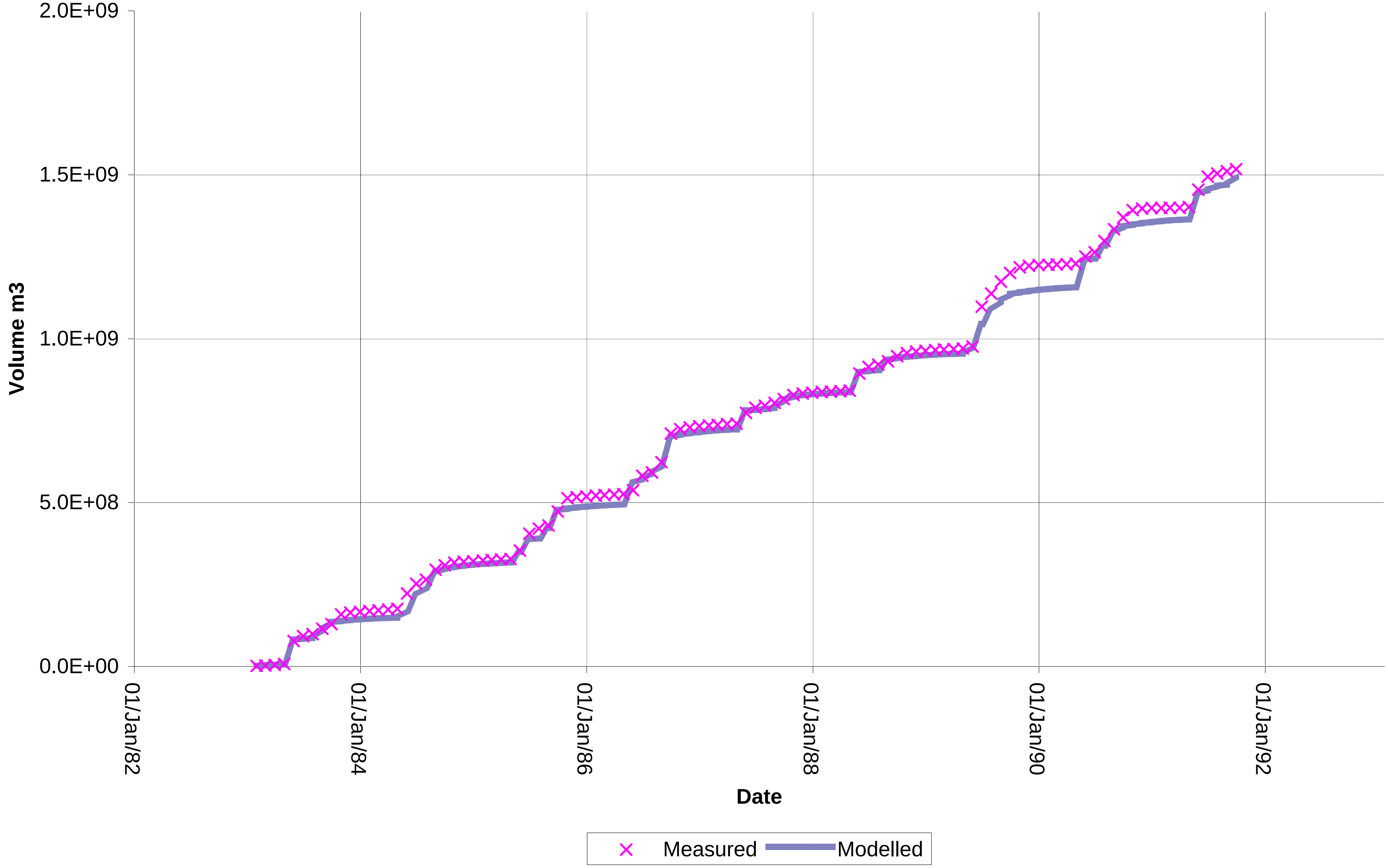
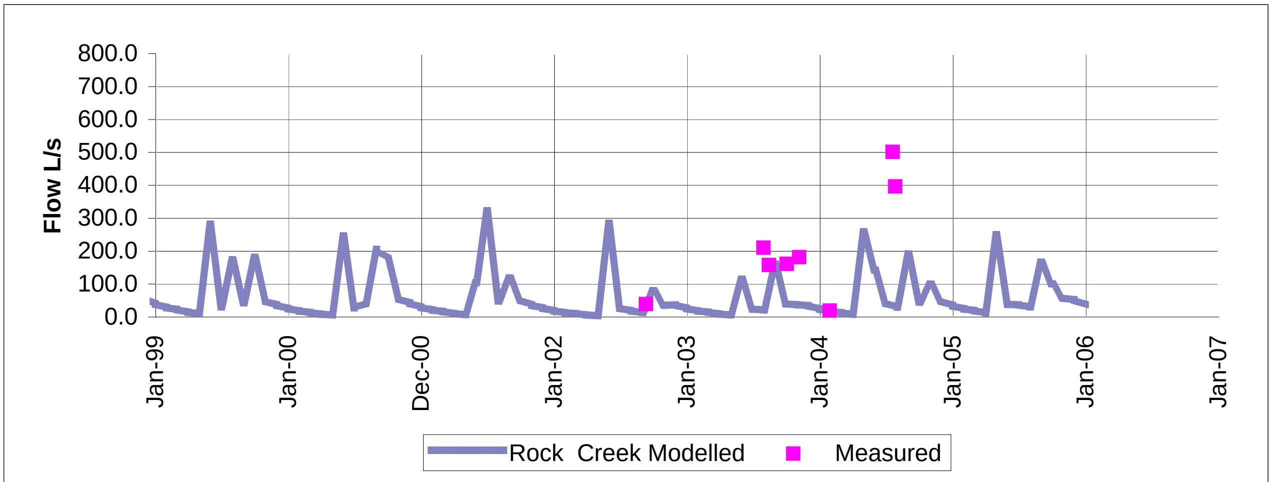
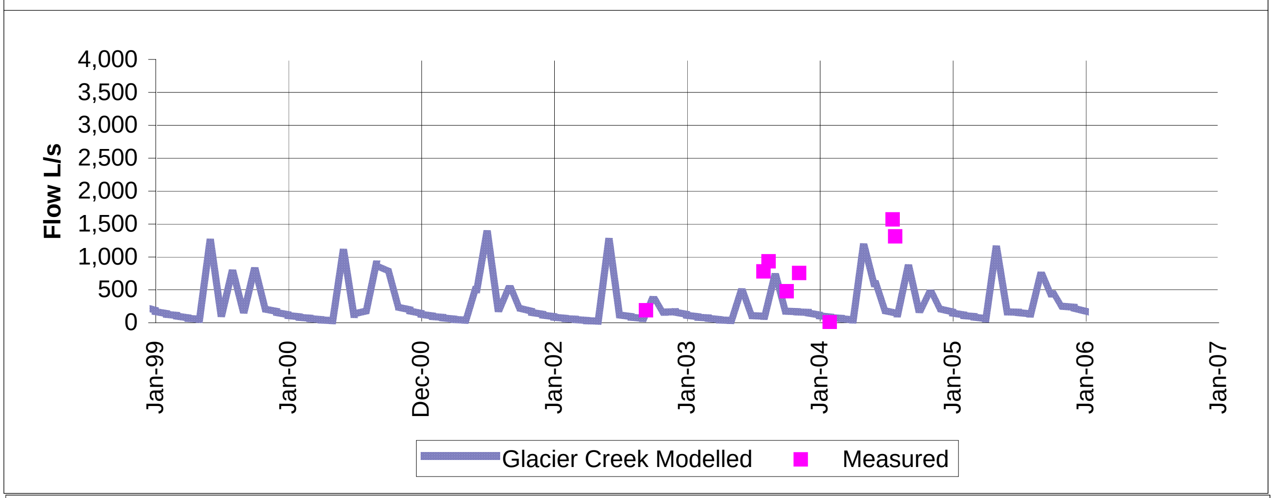


Figure 2.7: Measured and Modelled Creek Flows





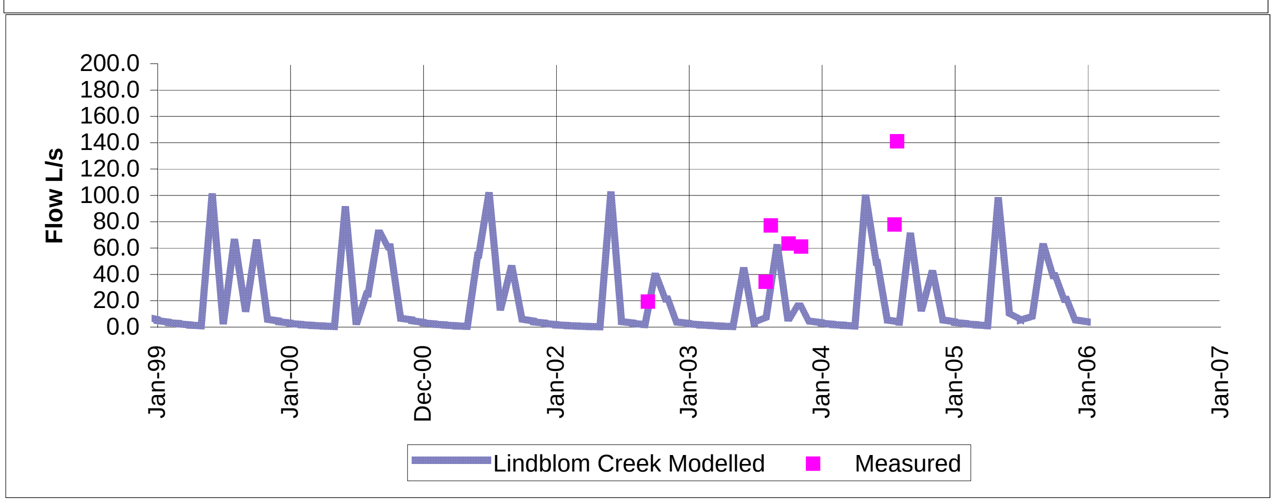


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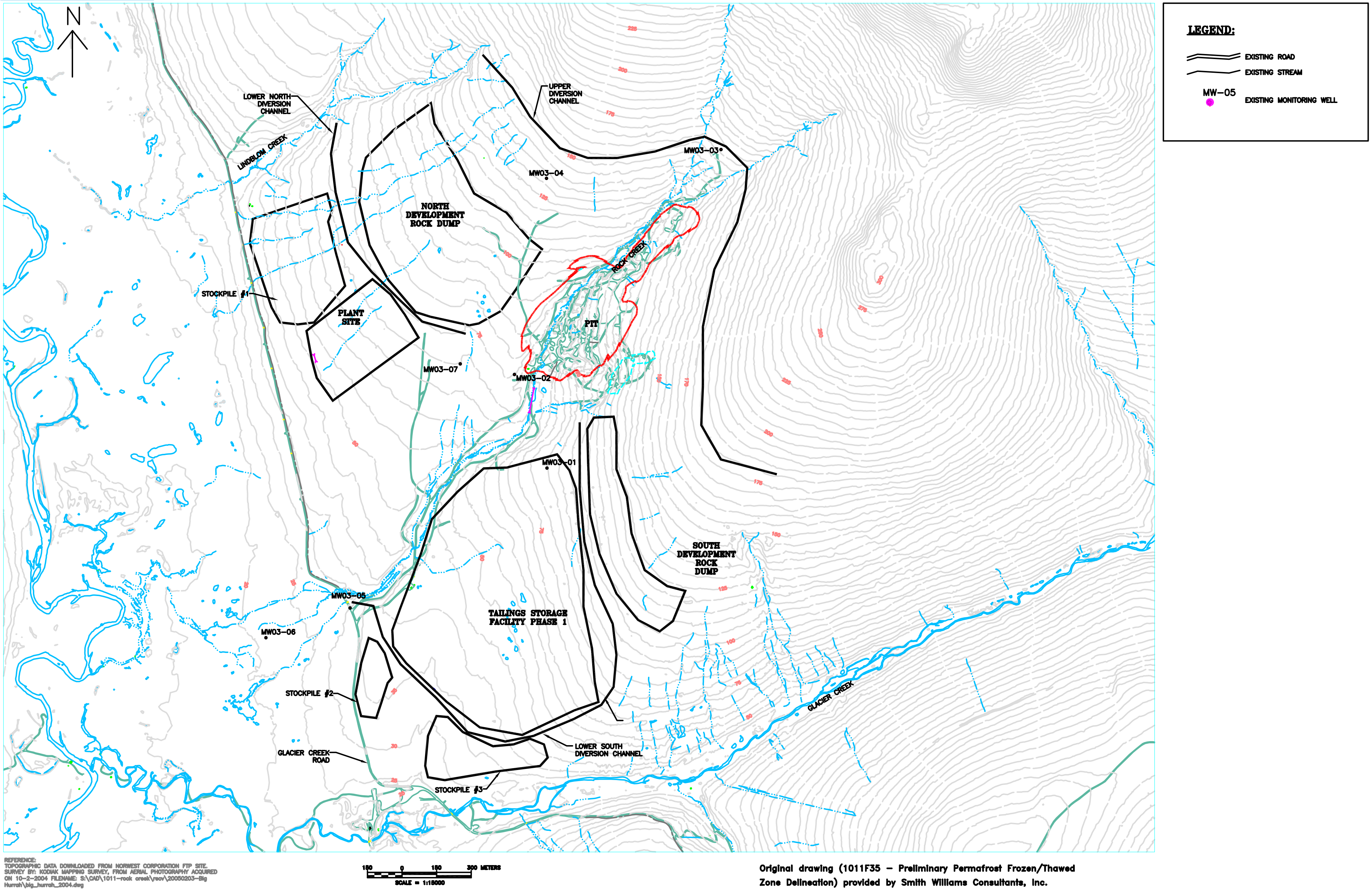
Figure 3.1Mine Layout



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Original drawing (1011F35 – Preliminary Permafrost Frozen/Thawed Zone Delineation) provided by Smith Williams Consultants, Inc.

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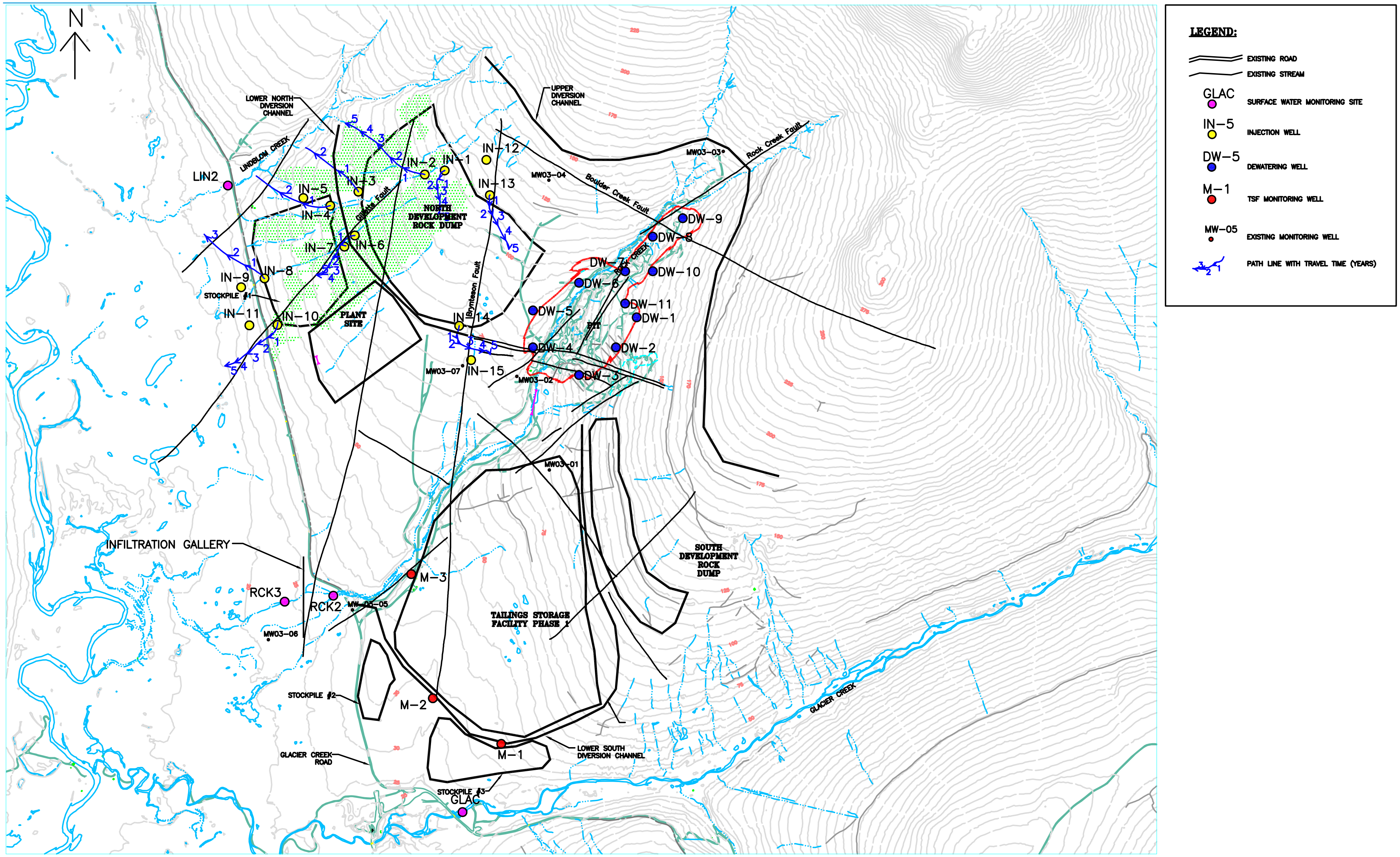
Figure 3.2 Dewatering Well and Injection Well Layout



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150 0 150 300 METERS
SCALE = 1:15000

Original drawing (1011F35 – Preliminary Permafrost Frozen/Thawed Zone Delineation) provided by Smith Williams Consultants, Inc.

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Figure 3.3 Schematic Section Through Injection Wells

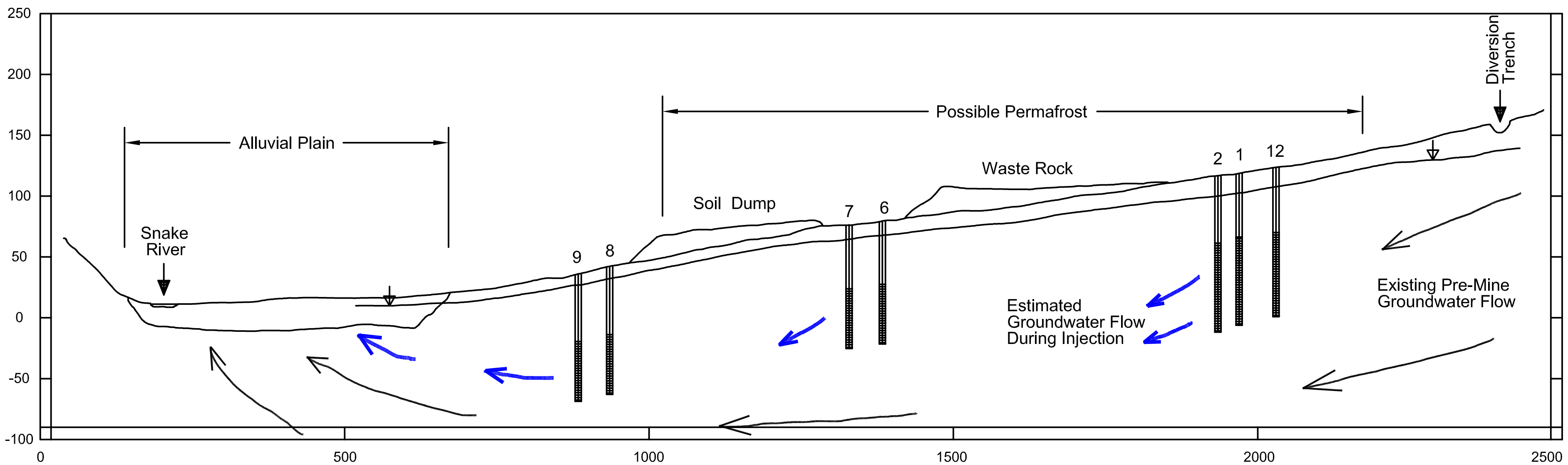
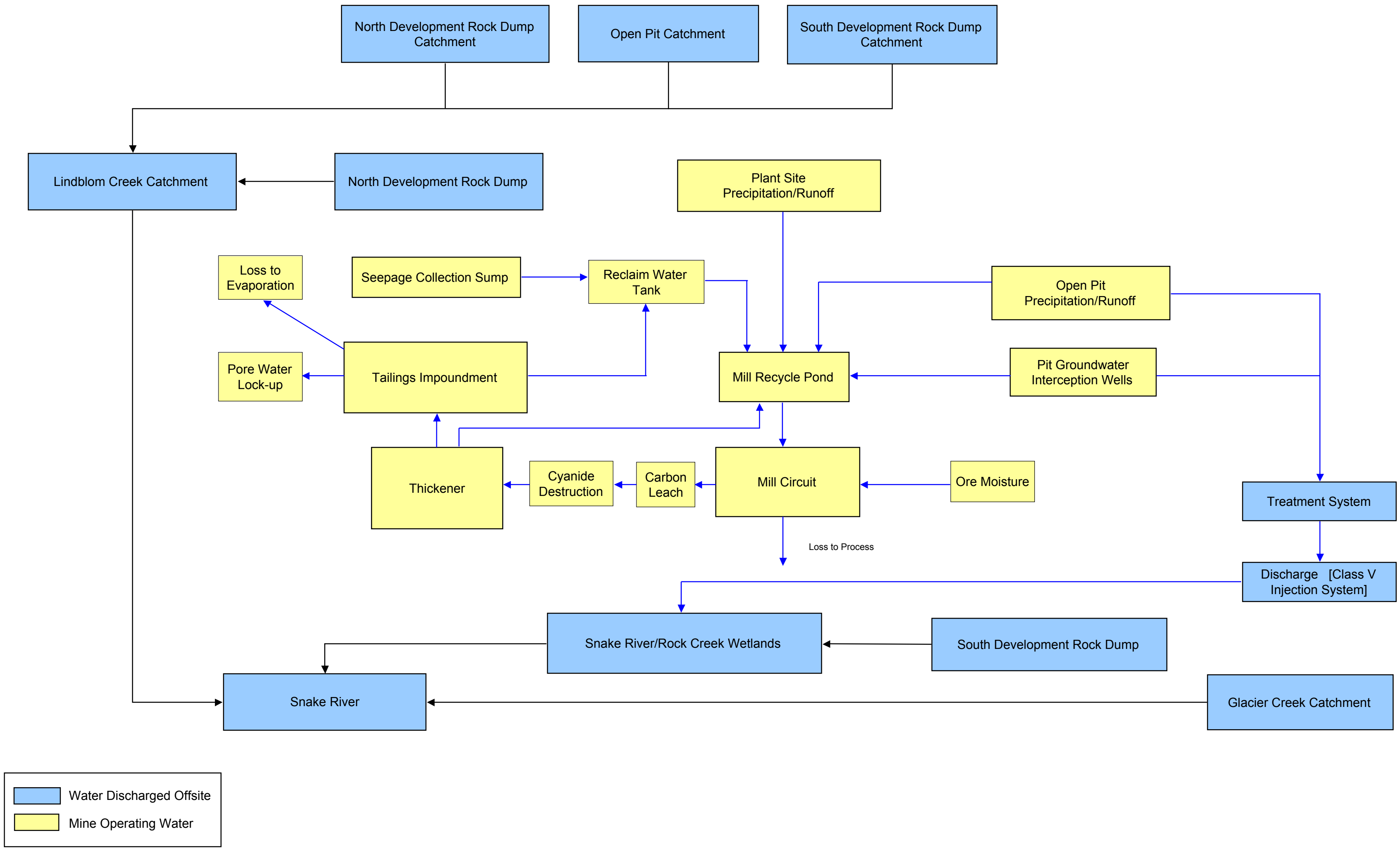


Figure 3.4: Conceptual Surface and Mill Water Flow Diagram



Note: Precipitation and snowmelt contribute to all areas

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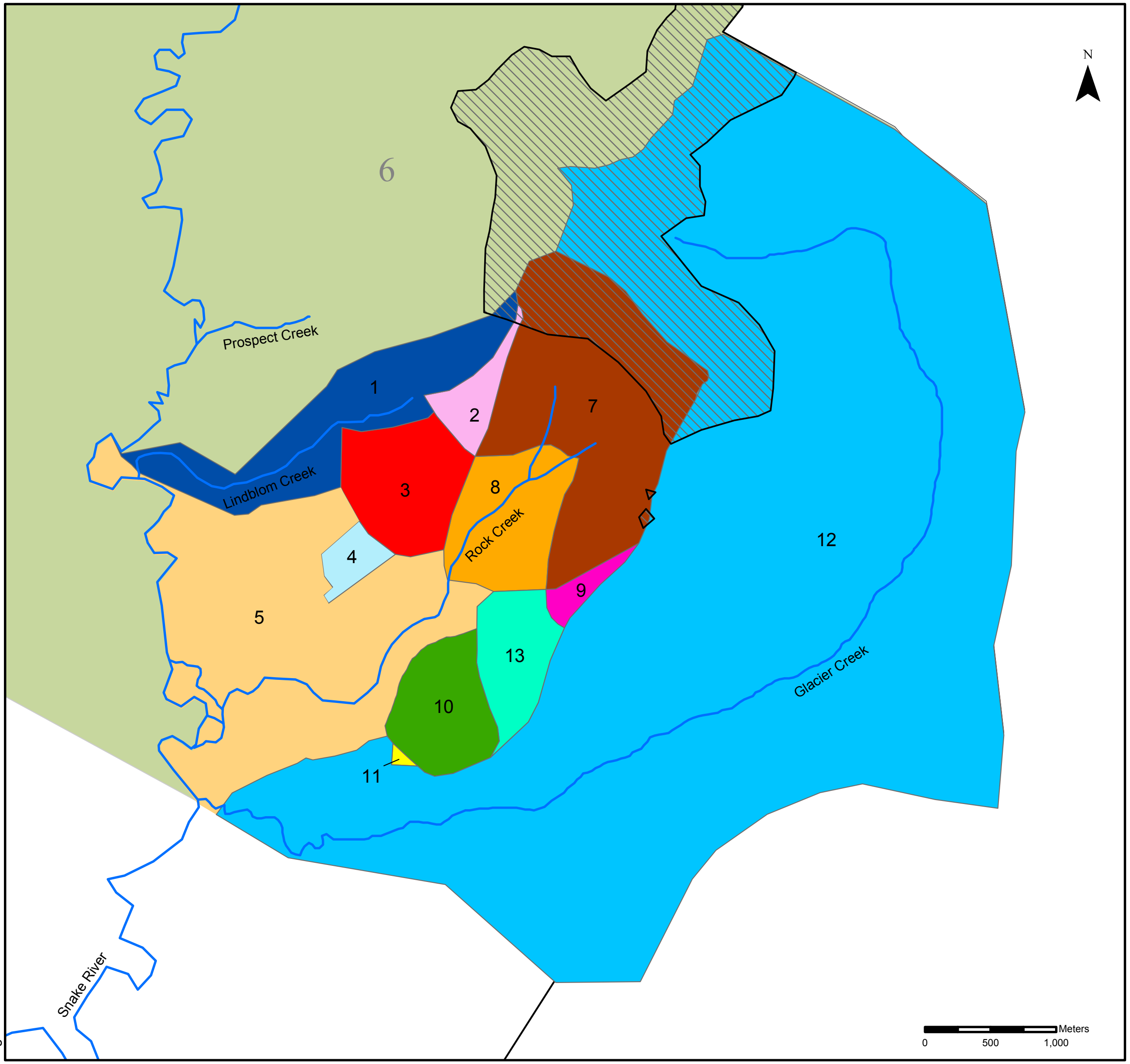
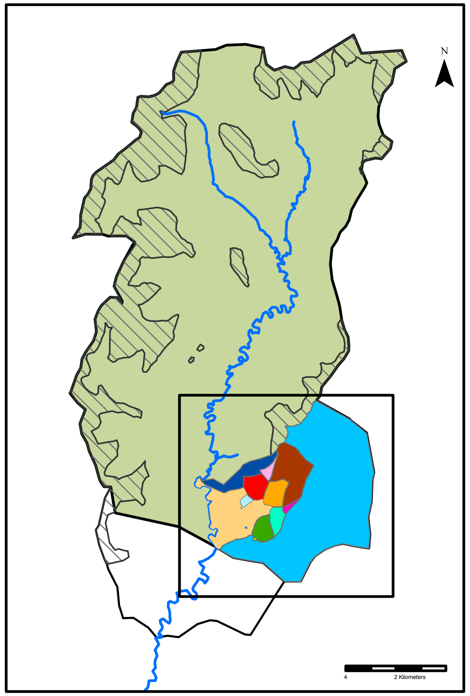
Figure 3.5: Subcatchment Areas





Watershed Model Units

- Snake River Watershed Unit (0)
- Snake River Catchment
- Area with Elevation > 1000 ft

Units

- Glacier Creek (12)
- Lindblom Creek Catchment (1)
- North Development Rock Dump (3)
- North Development Rock Dump Catchment (2)
- Open Pit (8)
- Open Pit Catchment (7)
- Plant Site (4)
- Seepage Recovery (11)
- Snake R/Rock Cr Wetlands (5)
- South Development Rock Dump (13)
- South Development Rock Dump Catchment (9)
- Tailings Impoundment (10)

Figure 3.2 Subcatchment Areas.mxd

Figure 3.6: Calculated Volume of Water Stored in Tailings Pond with Average Precipitation

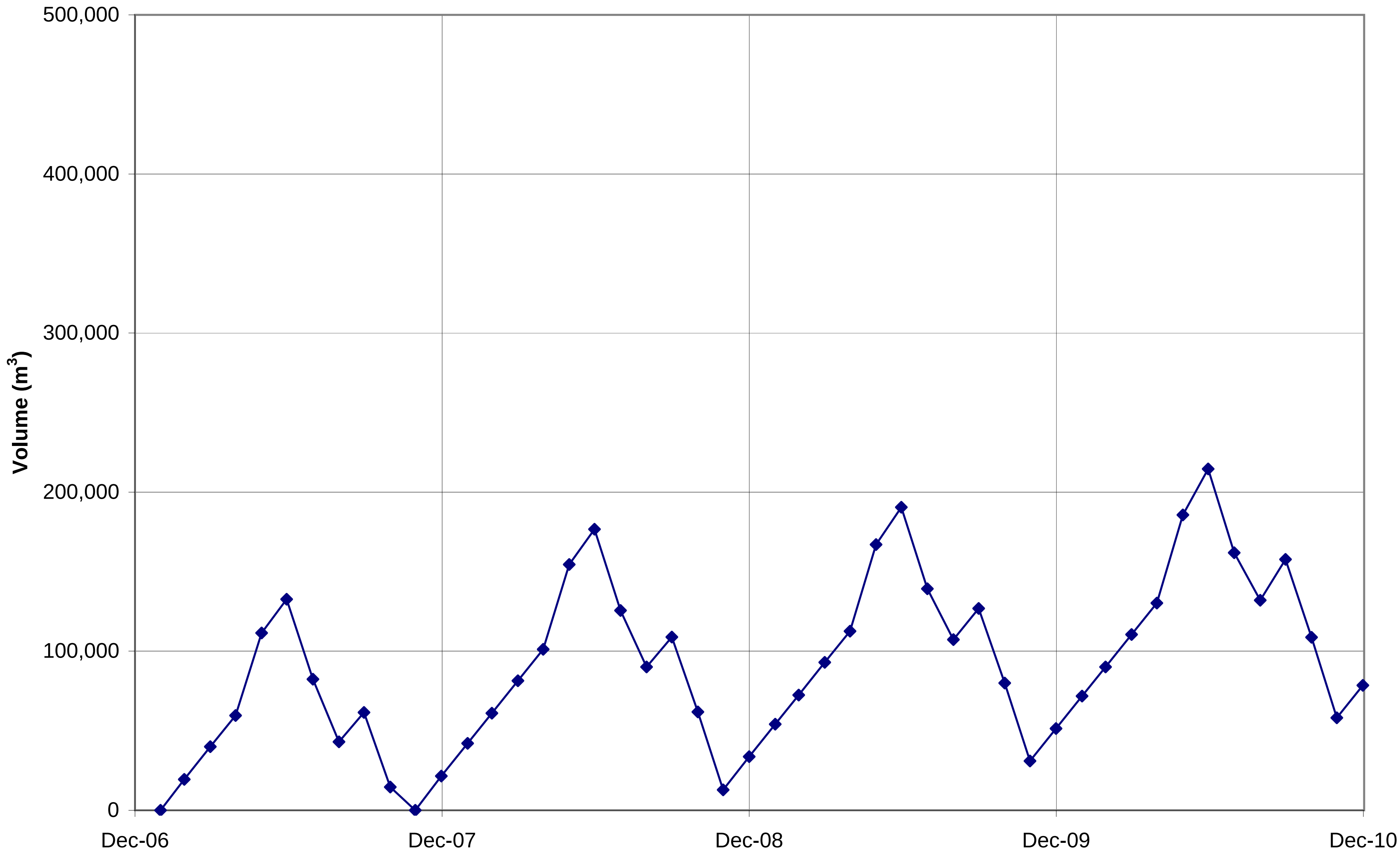


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Figure 4.1 Closure Plan Layout

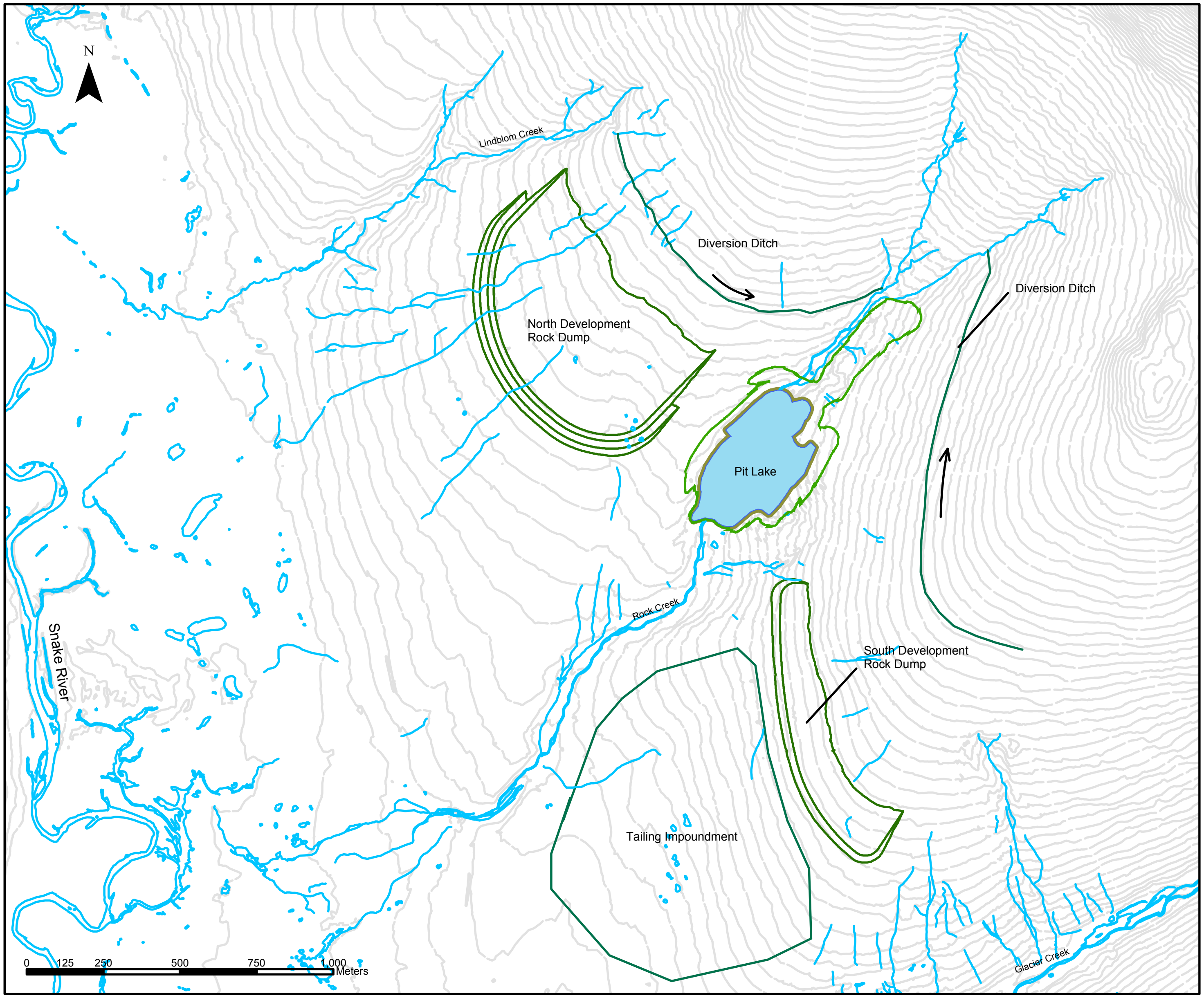
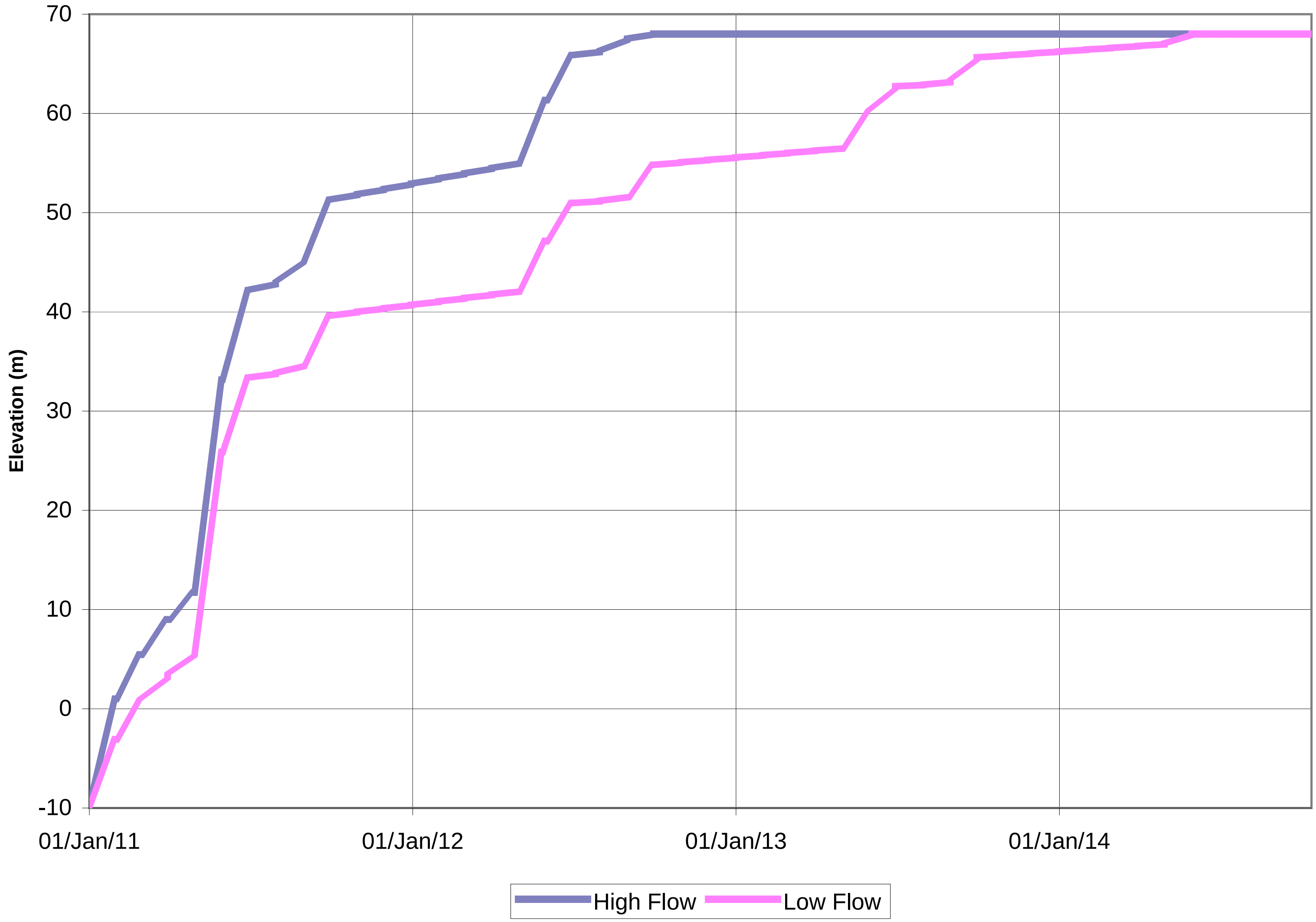


Figure 4.1 Closure Plan Layout

Figure 4.2: Pit Water Level Following Closure



APPENDICES

Ecological Resource Consultants, Inc.

35715 US Hwy. 40, Suite D204 ~ Evergreen, CO 80439 ~ 303.679.4820

Technical Memorandum

Date: April 12, 2006

To: Ryan Baker, Smith Williams Consultants, Inc.

From: Troy Thompson

Project: Rock Creek Mine

Re: Water Balance Analysis

Ecological Resource Consultants, Inc. (ERC) has completed a water balance model for the proposed Rock Creek mine site at the request of Smith Williams Consultants, Inc. (SWC). The purpose of this model is to predict monthly fluctuations in solution volumes and water flow rates within the mine system. Assumptions used in the model, modeling techniques and results obtained are presented herein.

1.0 WATER BALANCE COMPONENTS

This water balance incorporates water inputs into the system including pit dewatering wells, ore water and meteorological water. It also specifically tracks free water/solution within the tailings storage facility (TSF) and average monthly flow rates within the system. **Figure 1** shows a schematic of the overall flow diagram as modeled in the water balance.

2.0 MODEL ASSUMPTIONS/INPUTS

2.1 Production

<u>Mine Plan</u>
The current mine plan, which has a duration of 47 months, was used for the water balance model. Operations were modeled as commencing in February of 2007 (Year 1) and continuing through the end of December 2010 (Year 4).

<u>Monthly Production Rates</u> – Production rates were assumed to remain at a constant level of 7,716 short tons per day (dry) for the 47 month life of the mine.

2.2 Climatologic & Hydrologic

Climatologic Data

Background climatologic data used in the water balance models is presented in the Technical Memo "Rock Creek and Big Hurrah Mine Sites – Climate Data" by ERC dated September 23, 2005. Precipitation values presented in the September 2005 technical memo were revised in ERC's Updated Precipitation Analysis memo dated January 5, 2006. Precipitation data used in the model is based on the January update. Site precipitation was modeled as 170% of precipitation recorded at the Nome Station.

Rain verses Snow Season

As presented in the climate evaluation, average temperatures are above freezing for the months of May through September. Any precipitation during this season is assumed to occur in the form of rain. Temperatures are below freezing for the months of November through March and all precipitation during this time is anticipated to be in the form of snow. For the months of April and October approximately half of the days are above freezing and half are below freezing given normal conditions. As a result, half of the precipitation in these months is modeled in the form of snow and half in the form of rain.

Reclaim Solution Season

The model assumes that solution can be reclaimed from the TSF impoundment beginning in April and continuing through December (9 months) of each year during operations, as needed. During the remainder of the year, free water in the impoundment is assumed to be in an ice form and reclaim is not available.

Snow and Ice Melt

Based on results of the climate evaluation (ERC, 2005), the model assumes that half of the winter snow/ice accumulation melts in the month of April and the remaining half melts in the month of May. This assumption includes ice and snow within the TSF impoundment in addition to snowpack from the tributary drainage areas.

Evaporation Coefficients

The modeled evaporation coefficient for the tailings pond surface is assumed to be 50% of pond evaporation. This accounts for a portion of the surface being tailings and a portion being free water.

Runoff Coefficient

A runoff coefficient of 1 was used to model direct runoff from the tailings. This assumes that rainfall on the tailings remains in the system to contribute to the free water pond, evaporate or be lost as seepage.

Monthly Rainfall Runoff Coefficients
Modeled monthly runoff coefficients during the warmer months for undisturbed ground tributary to the impoundment are:

- April 0.5
- May 0.3
- June 0.3
- July 0.35
- August 0.35
- September 0.4
- October 0.5

Monthly Snowmelt Runoff Coefficients
Modeled runoff from snowpack is assumed to be 95% for snow on the tailings surface, 100% for snow on the lined face of the embankment and 65% for snow on the undisturbed ground tributary to the impoundment.

2.3 TSF Embankment and Impoundment

Embankment Staging
Embankment staging was provided by SWC. Three stages of construction are anticipated. Stage 1 will be completed for the February 2007 start up date. The initial embankment will be constructed to a crest elevation of 160 feet. The second phase, constructed to a crest elevation of 176 feet, will be operational starting in August of 2007 and the final embankment phase will come on line in July of 2008 with a crest elevation of 197 feet. Tributary drainage areas at the three different phases are 5,586,735 square feet (0.20 square miles) for Stage 1, 5,802,249 square feet (2.1 square miles) for Stage 2 and 6,137,739 square feet (0.22 square miles) for Stage 3.

Embankment Freeboard
The TSF design criteria require that a minimum of 3.3 feet of freeboard be maintained at all times in the impoundment. This equates to 90 acre-feet of storage within the freeboard limits.

Tailings and Available Water Storage
Tailings and water storage capacity of the impoundment was provided by SWC and used in the water balance model. ERC interpolated values for months when data was not calculated. Storage at different times during the life of the facility along with planned embankment phasing is provided on the following table. Highlighted cells indicate values interpolated by ERC.

Date	Tailings Surface Area (acres)	Exposed Liner (acres)	Max. Water Storage Vol. (ac-ft)
2/1/2007	0	8	577
2/10/2007	5	8	545
2/23/2007	11	7	493
3/20/2007	19	7	411
4/6/2007	26	6	373
5/3/2007	31	6	281
6/11/2007	41	6	270
7/10/2007	46	5	270
7/29/2007	50	5	240
8/26/2007	55	10	678
9/25/2007	58	9	638
10/25/2007	61	9	597
11/24/2007	64	9	557
12/23/2007	67	8	517
1/26/2008	70	8	450
2/28/2008	73	7	384
3/28/2008	74	7	349
4/25/2008	75	7	315
5/24/2008	76	7	281
6/22/2008	77	7	247
7/21/2008	79	9	401
8/20/2008	81	11	555
9/18/2008	82	13	709
10/18/2008	84	14	863
11/10/2008	87	14	858
12/4/2008	89	13	852
1/11/2009	92	12	805
2/18/2009	95	11	758
3/18/2009	96	11	718
4/16/2009	97	11	678
5/14/2009	98	11	638
6/12/2009	100	11	598
7/10/2009	101	11	558
8/8/2009	102	10	518
9/5/2009	103	10	478
10/6/2009	105	10	460
11/7/2009	107	9	442
12/8/2009	109	9	424
1/8/2010	111	9	406
2/9/2010	113	8	389
3/12/2010	115	8	371
4/12/2010	116	7	353
5/3/2010	117	7	341
5/23/2010	118	7	329
6/12/2010	119	7	317
7/3/2010	120	7	305

7/23/2010	121	7	292
8/12/2010	122	7	280
9/2/2010	123	7	268

Initial Impoundment Water Storage

The Stage 1 embankment is scheduled for completion prior to production commencing in February of 2007. For the water balance model it was assumed that no water/ice will be stored in the impoundment at startup.

2.4 Tailings Properties

Tailings Moisture Contents

The following tailings moisture contents have been used in the water balance model.

- Tailings Slurry Percent Solids (by weight) 74%
- Tailings Slurry Moisture Content 35.1%
- Tailings Specific Gravity 2.75
- Consolidated Tailings Density (dry) 1.52
- Consolidated Tailings Moisture Content 25%
- Consolidated Tailings Saturation (%) 85%

Consolidated tailings moisture content is assumed to be “locked” in the tailings and not available to be reclaimed.

2.5 Other Water Sources

Pit Water

Pit dewatering requirements were developed based on pit interception estimates presented in the report “Rock Creek Mine Project, Water Management Report” prepared by Water Management Consultants (WMC). Dewatering rates were estimated for the end of year conditions based on pit development. The dewatering rates at the end of each year of operation used in the model are presented below.

End of Year	Pit Dewatering Rate (gpm)
2007	600
2008	600
2009	635
2010	635

Dewatering rates were assumed to be constant at 600 gpm throughout the first year of operations and were linearly interpolated based on these year-end values during 2009.

This water is available as raw water that can be used to supplement reclaim from the impoundment to meet the demands of the ore processing. Any pit water that is not used as reclaim will be discharged into the infiltration gallery. The pit dewatering system is assumed to be operational year-round beginning at the start of production.

Seepage

SWC provided estimated seepage losses from the TSF. Seepage lost will be collected by the seepage collection system within the TSF and reclaimed as process water separate from the impoundment reclaim system. Estimates for annual seepage given the three embankment stages were generated and monthly distributions developed by others.

Average annual seepage rates for the three embankment stages are:

- Stage 1 6.0 gpm
- Stage 2 22.6 gpm
- Stage 3 60.8 gpm

Seepage over the three stages was distributed monthly according to the following percentages:

Month	Stage 1	Stage 2	Stage 3
January	0%	0%	7%
February	0%	0%	2%
March	0%	0%	0%
April	0%	0%	0%
May	4%	2%	1%
June	6%	2%	1%
July	8%	4%	2%
August	17%	32%	39%
September	37%	24%	19%
October	27%	18%	10%
November	1%	12%	10%
December	0%	6%	9%
Total	100%	100%	100%

The seepage collection systems will be designed so that seepage water is pumped back to the plant to satisfy a portion of the reclaim water required by the plant operations.

The model limits seepage to available water in the pond within the TSF impoundment. Seepage was not allowed to reduce water in the pond below 16 acre-feet.

Process Plant Stormwater

Stormwater runoff from the process plant site is collected by the diversion channels around the perimeter of the plant site and routed to the mill recycle water pond. This water is accounted for in the water balance model. The area within the process plant diversion ditches that contributes meteorological water to the system was modeled as 2,090,880 square feet.

2.6 Reclaim System, Makeup and Infiltration

Maximum Reclaim Rate

A maximum reclaim rate of 412.1 gpm is used in the model. This value includes a 96% production utilization factor. Reclaim water needs are met by seepage water, stormwater collecting in the mill recycle water pond, reclaim from the TSF impoundment and pit dewatering water. The model assumes that seepage and stormwater collected in the process pond are the first waters reclaimed and brought into the process. Whenever available, water from the impoundment will then be used to meet remaining water demands. When reclaim from the impoundment is not be available and other sources is not available (between December and March) or available in limited supply, pit dewatering will act as the makeup water source for the process.

Infiltration Gallery

Pit water that is not used in the process is to be pumped to the Class V injection system and released. This value is computed by the model on a monthly basis.

3.0 MODEL RUNS

Three different meteorological scenarios were modeled: average conditions, a wet cycle and drought (dry) conditions. Wet and drought conditions each have an approximately 1% annual chance of occurrence. Results provide information on storage volumes, reclaim, makeup and treatment requirements that can be anticipated throughout the mine life.

3.1 Precipitation Values

Dry, average and wet year monthly precipitation totals used in the model are shown below.

Monthly Precipitation Totals (inches – water equivalents)

Mon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dry	0.70	0.54	0.48	0.55	0.57	0.83	1.71	2.62	1.89	1.15	0.87	0.69	12.61
Avg.	1.51	1.18	1.04	1.20	1.23	1.81	3.70	5.68	4.10	2.49	1.90	1.50	27.33
Wet	2.54	1.97	1.74	2.01	2.05	3.03	6.19	9.51	6.87	4.17	3.17	2.51	45.77

Wet cycle model runs were generated assuming that the extreme wet year could occur during any of the four years of operations. Based on the available precipitation records from Nome, ERC determined the wettest consecutive four (4) years of record and used this data in the model. These four years were modeled so that the highest annual precipitation years were adjacent to the single wet year. Precipitation was distributed between the 12 months following the average annual distribution above.

Modeled Annual Wet Cycle Precipitation (inches)

Model Year	Wet Year 1	Wet Year 2	Wet Year 3	Wet Year 4
1	45.8	34.8	29.5	29.5
2	34.8	45.8	34.8	31.2
3	31.2	31.2	45.8	34.8
4	25.9	29.5	31.2	45.8

4.0 MODEL RESULTS

Water/solution storage, reclaim from the impoundment and discharge/reclaim requirements for pit dewatering water were calculated by the model on a monthly basis for each of the three separate meteorological scenarios (Dry, Average and Wet). Results are summarized below.

4.1 Total Inflows and Losses

Total annual water inputs to and “losses” from the system are tabulated below based on year 4 modeling results. For the wet year, these results assume that the one percent wet year occurs in year 4. All values are given in acre-feet.

Summary of Year 4 Model Results

	Dry Year	Average Year	Wet Year
System Inputs			
TSF Impoundment Area Precipitation	120	281	464
Plant Site Precipitation	19	46	75
Tailings Water	728	728	728
Pit Dewatering Water	1,024	1,024	1,024
Total Inputs	**1,890**	**2,079**	**2,290**
System "Losses"			
Evaporation	142	142	142
Seepage	30	71	89
Tailings Lockup	519	519	519
TSF Impoundment Reclaim	157	278	335
Pit Area and Plant Site Precipitation Reclaim	19	46	75
Pit Dewatering Reclaim	459	271	166
Pit Dewatering Treatment	564	753	857
Total "Losses"	**1,890**	**2,079**	**2,183**

A number of conclusions can be drawn from these general results.

1. Pit dewatering and tailings water are the largest contributors to water in the system.
2. During dry and average years, seepage losses will be limited by available water in the impoundment.
3. Given dry and average conditions, inflows match losses indicating that the impoundment can be dewatered prior to the winter season.
4. Given extreme wet conditions (1% annual chance), it is anticipated that the TSF impoundment will not be fully dewatered.

4.2 Storage Requirements

Anticipated average water/solution storage requirements in the TSF impoundment were determined on a monthly basis. These values were then compared with available storage to ensure sufficient capacity existed at all times during the proposed project. A summary of the maximum water/solution stored during different years of operation along with the minimum additional available storage volume is shown on the table below. Detailed monthly results are shown graphically on **Figures 2-4**. Note that available storage listed below is calculated as the capacity up to an elevation of 3.3 feet below the embankment crest to ensure freeboard requirements are met.

Calculated Maximum Water/Solution Storage Verses Minimum Remaining Storage (acre-feet)

Year	Dry		Average		Wet Years	
	Maximum Storage Required	Minimum Storage Remaining	Maximum Storage Required	Minimum Storage Remaining	Maximum Storage Required	Minimum Storage Remaining
1 (2007)	16	224	19	224	53	224
2 (2008)	52	229	120	161	227	98
3 (2009)	50	408	124	408	252	226
4 (2010)	46	252	123	206	258	10

Results indicate that for all conditions, sufficient capacity exists in the TSF impoundment to contain all water/solution predicted to enter the system.

As **Figures 2 and 3** indicate, for dry and average conditions, planned reclaim facilitates full evacuation of free water in the impoundment prior to winter in all years of operations. If an extreme wet cycle were to occur during operations (**Figure 4**), free water may be held over in the impoundment during the winter, but sufficient capacity exists for this water.

In the event an extreme wet cycle occurs during operations and solution accumulates from year to year, the volume of free water stored can be further decreased from the values presented in this report by extending the reclaim period beyond the typical April – December window.

4.3 Short Duration Storm

The tributary area to the impoundment is approximately 6,158,000 square feet and the 100-year, 24-hour rainfall value is 5.1 inches. Assuming 100% runoff from the 100-year storm, a total volume of 60 acre-feet of water would enter the impoundment. Actual runoff would be below 100%, so this is a conservatively high estimate. Results above indicate that during normal operating conditions and dry or average climate conditions, storage capacity within the TSF impoundment will always be available for the 100-year storm event. In all but a couple of months towards the end of operations, the TSF would have capacity for the 100-year, 24-hour storm in addition to the 100-year wet cycle. It is overly conservative to design for the 100-year, 24-hour storm in addition to the wet cycle as each separate event has a 1% annual chance of occurring.

4.4 TSF Impoundment Reclaim

Reclaim water is taken from the TSF impoundment between April and December, when available. **Figure 5** shows the monthly reclaim volume for each of the three meteorological scenarios.

Results indicate that in most months calculated reclaim given average and wet conditions are similar indicating that reclaim taken from the TSF will be maximized for these precipitation scenarios. Given dry conditions, calculated reclaim from the TSF is significantly less indicating that the TSF is drained of water during dry years well before the winter. Monthly TSF impoundment reclaim rates peak between 375 gpm and 400 gpm, mainly between the months of April and June. Reclaim rates from the TSF impoundment are anticipated to decrease notably during the months of August and September. This is attributable to higher seepage losses requiring reclaim at these times (see Section 2.5 – Seepage)

4.5 Pit Dewatering Treatment

Pit dewatering water will be used as a water source if needed. Any pit water not required for use in the processing of the ore will be treated and pumped to the infiltration gallery for discharge. **Figure 6** shows anticipated discharge for the pit dewatering water.

Peak treatment/discharge rates are dictated by dewatering rates and are up to 600 gpm in years 1 and 2 and 635 gpm in years 3 and 4.

4.6 Pit Makeup Water

During the months of January through March the model assumes TSF impoundment water will not be reclaimed. During these months and in conditions where TSF impoundment water is not available to meet process needs, pit dewatering water will be used to meet the demands of the process. Monthly makeup requirements for the pit and additional water are shown on **Figure 7**.

During times when pit water is the sole source of makeup water, it will be used as process water at a peak rate of 413 gpm. In dry conditions, pit water will likely be used at this rate consistently from November through March.

5.0 REFERENCES

Ecological Resource Consultants, Technical Memo on Rock Creek Climate Data, September 23, 2005.

Ecological Resource Consultants Updated Rock Creek Precipitation Analysis, January 5, 2006.

Water Management Consultants, Rock Creek Mine Project Water Management Report, March, 2006.

Attachments

Figure 1 – Rock Creek Flow Diagram
Figure 2 – Impoundment Solution Storage and Remaining Capacity – Dry Cycle
Figure 3 – Impoundment Solution Storage and Remaining Capacity – Avg. Cycle
Figure 4 – Impoundment Solution Storage and Remaining Capacity – Wet Cycle
Figure 5 – Impoundment Reclaim Rates
Figure 6 – Pit Dewatering Discharge
Figure 7 – Pit Water and Additional Makeup Requirements

Figure 1-- Rock Creek Flow Diagram

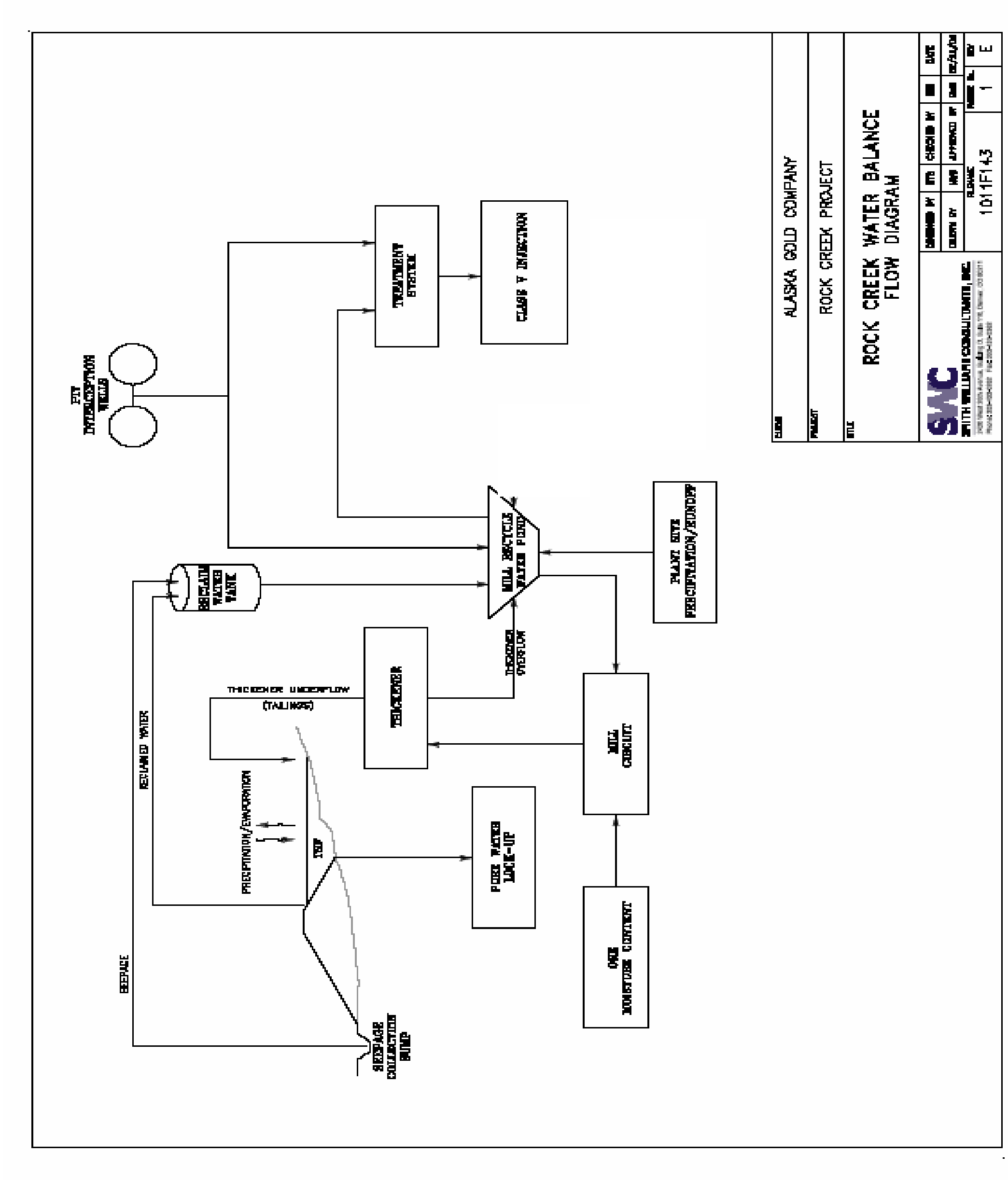


Figure 2 – Impoundment Solution Storage and Remaining Capacity – Dry Cycle

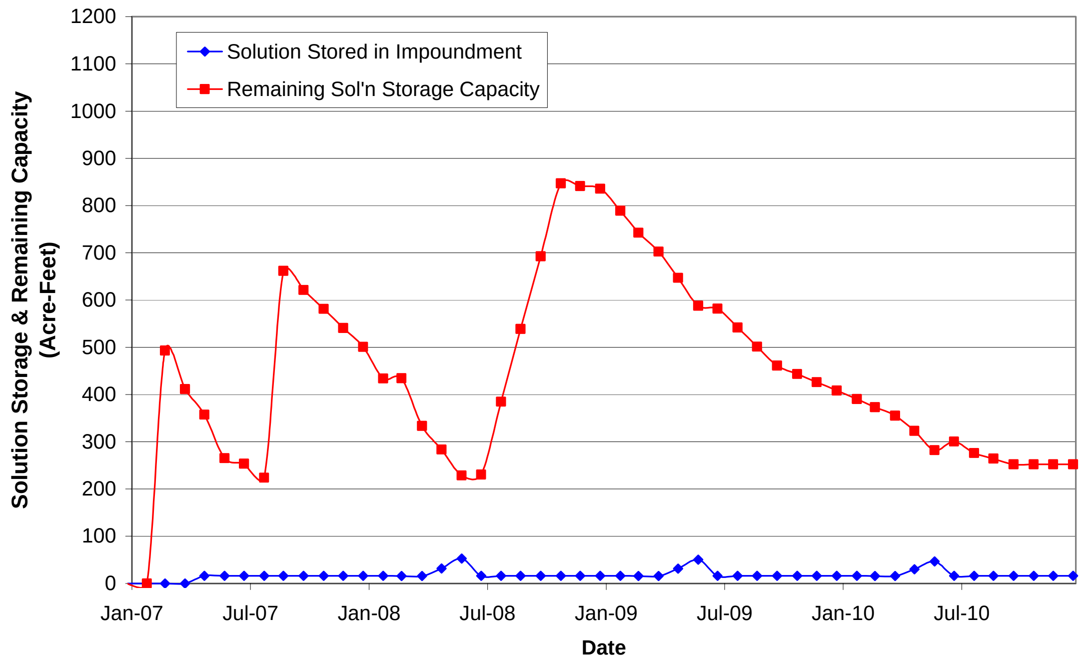


Figure 3 – Impoundment Solution Storage and Remaining Capacity – Avg. Cycle

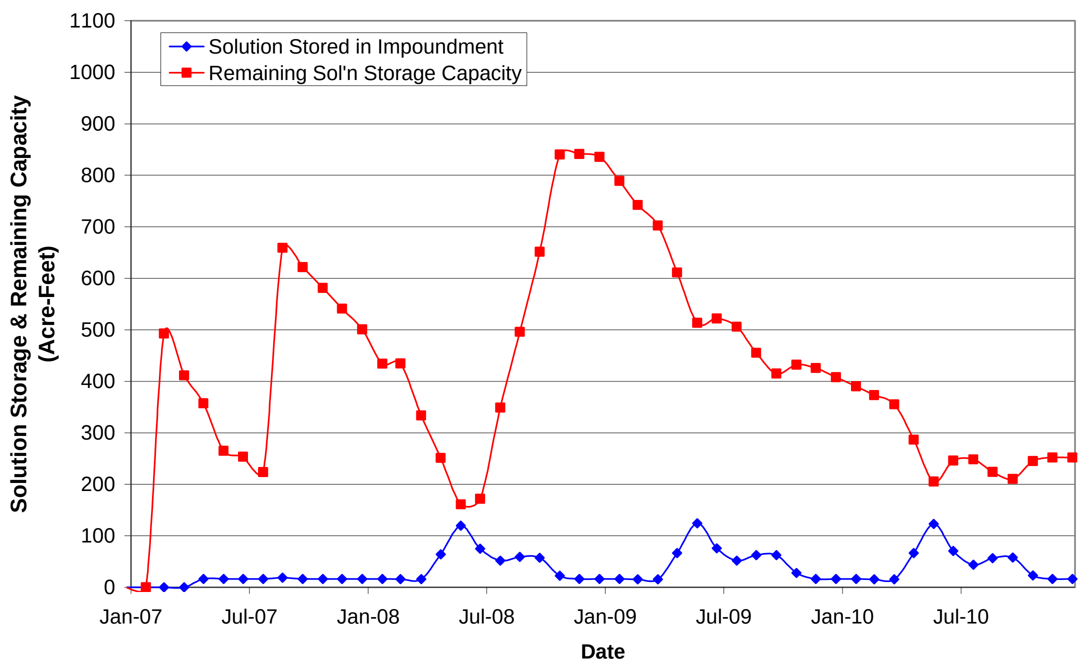


Figure 4 – Impoundment Solution Storage and Remaining Capacity – Wet Cycle

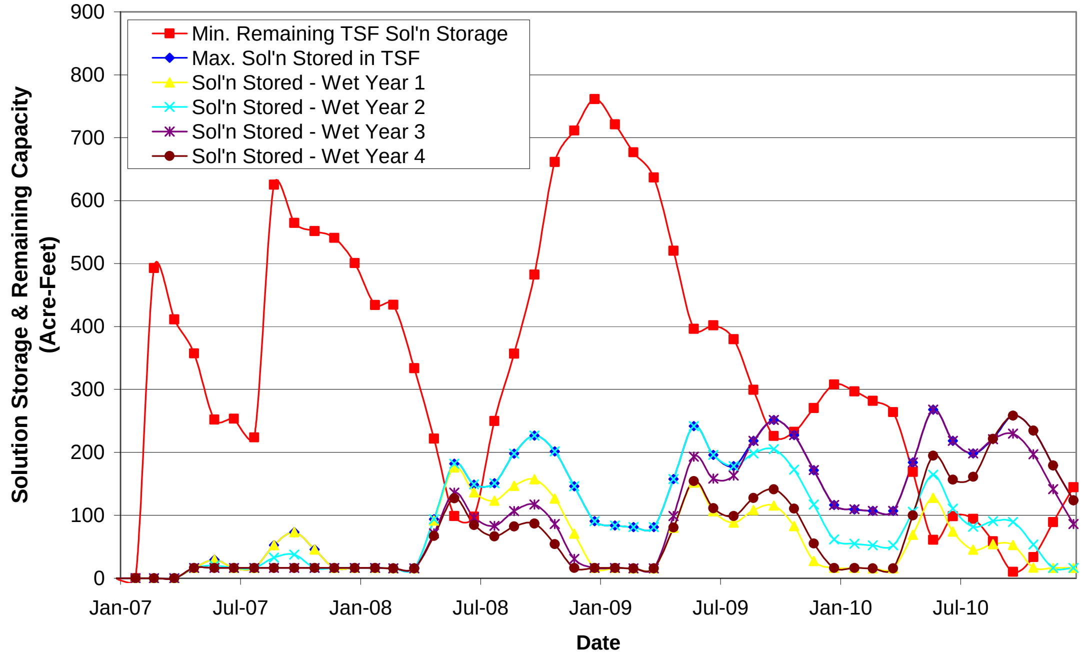


Figure 5 – Impoundment Reclaim Rates

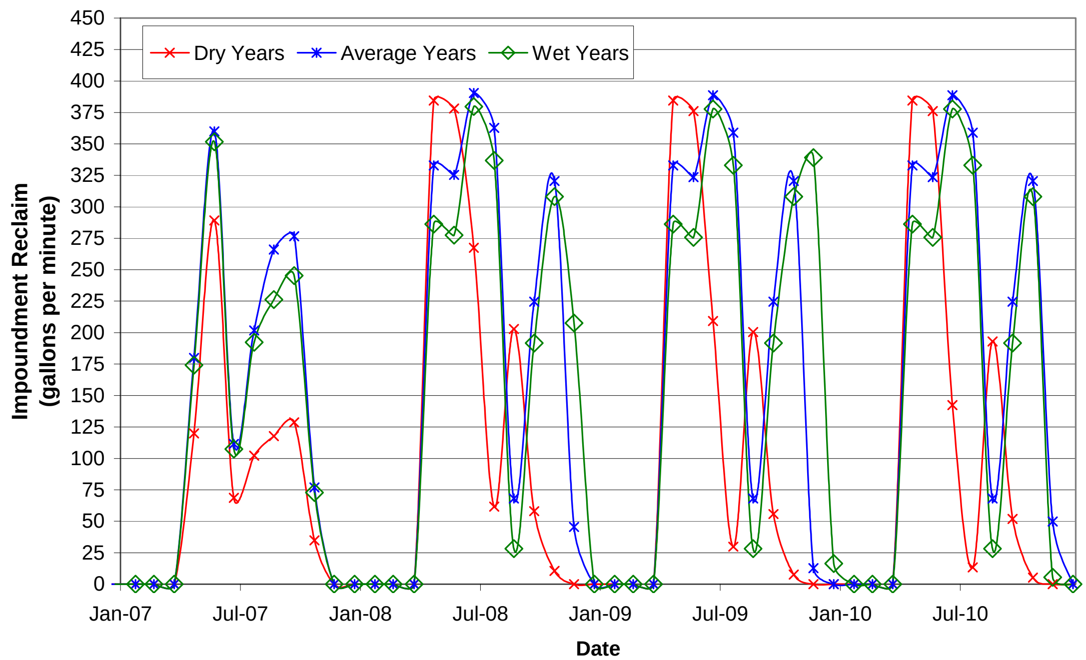


Figure 6 – Pit Dewatering Discharge

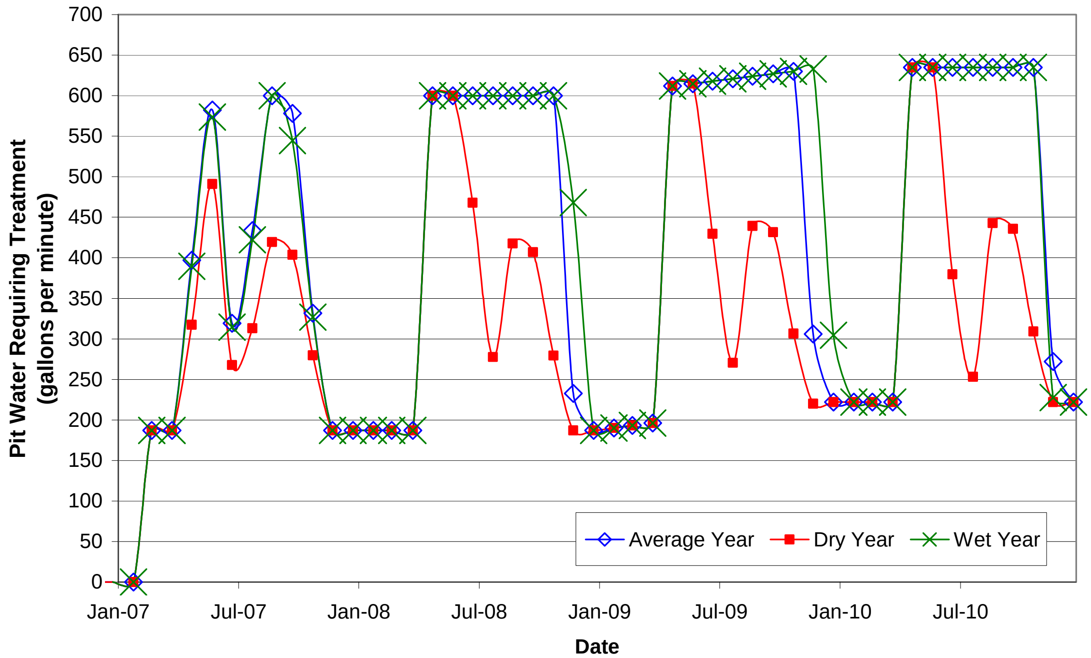
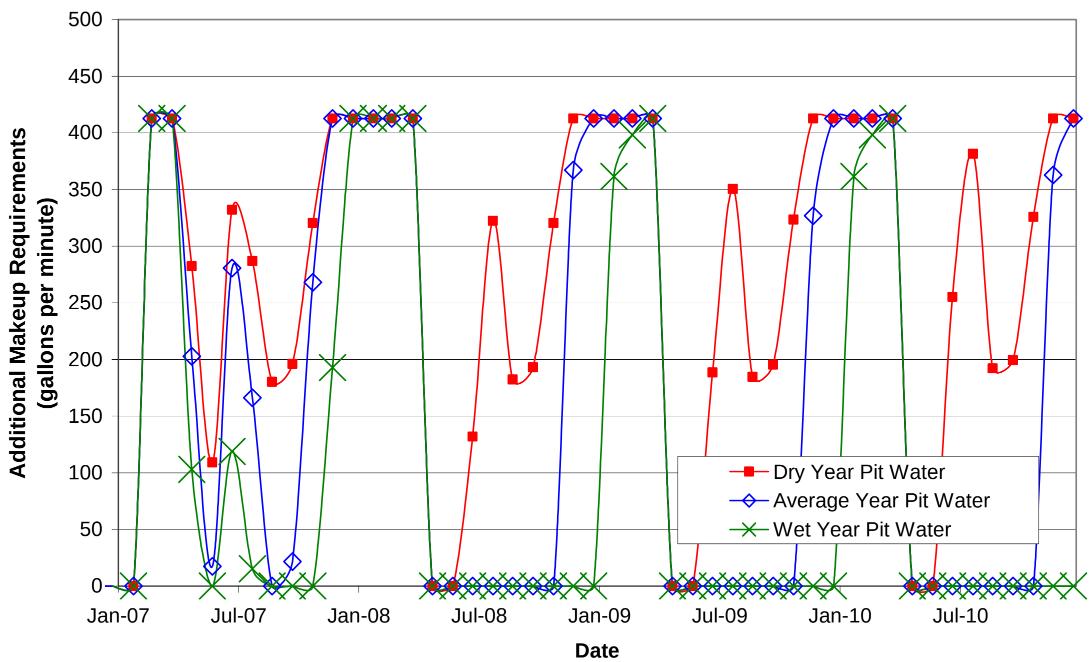


Figure 7 – Pit Water Makeup Requirements



WATER MANAGEMENT CONSULTANTS

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Doug Nicholson
Alaska Gold Company
P.O. Box 82430
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USA

April 4, 2006

Dear Mr. Nicholson:

Big Hurrah Mine Project, Water Management Plan

Site Description

General

The Big Hurrah site is located about 40 miles east of Nome Alaska, at the confluence of the Little Hurrah and Big Hurrah Creeks (see Figure 1). Historic placer mining works, underground works, and mill building are present, as are historic waste rock and tailings deposits. There are significant historic mine workings in the area. Big Hurrah Creek flows west to the Solomon River which flows south to Norton Sound.

Precipitation and Temperature

There is not enough site data to define the climatic conditions at the site. Therefore, the plan (Figure 2), from the publication "Flood Characteristics of Alaskan Streams" Water Resources Investigation 78-129, prepared by the US Department of the Interior Geological Survey et al. was used to define rainfall. That plan indicates the Big Hurrah annual precipitation may be about 25 inches, compared to 16 inches for Nome Airport. We have therefore selected a multiplication factor of 1.5 times the Nome precipitation for the Big Hurrah site. We have used the Nome temperature data directly in this assessment. Table 1 provides the average monthly temperature and precipitation.

Table 1 Average Monthly Temperature and Precipitation

Month	Temperature (^oC)	Precipitation (mm)	
	Nome	Nome	Big Hurrah (1.5 x Nome)
Jan	-13.1	24.4	36.6
Feb	-13.0	20.7	31.1
Mar	-11.9	18.5	27.8
Apr	-6.5	17.9	26.9
May	1.8	17.6	26.4
June	7.9	27.0	40.5
July	10.3	59.2	88.8
Aug	9.8	84.0	126
Sept	5.6	64.3	96.4
Oct	-1.8	38.2	57.3
Nov	-8.3	27.2	40.8
Dec	-12.7	24.3	36.4
Annual		423.3	635

A precipitation frequency analyses was completed for 96 years of record at Nome Airport and adapted to the Big Hurrah site by multiplying by 1.5. The results are presented on Table 2.

Table 2: Nome Airport and Estimated Big Hurrah Annual Precipitation Distribution

Return Period	Wet Annual Precipitation (mm)		Dry Annual Precipitation (mm)	
	Airport	Site	Airport	Site
Average	425	637.5	425	637.5
5	520	780	322	483
10	574	861	280	420
20	620	930	250	375
100	709	1063.5	202	303
200	743	1114.5	187	280

Evapotranspiration

There is no evaporation data available for the site or the airport. Evapotranspiration in the area has not been studied in detail. Munter et al. (1991) quoting Patric and Black (1968) calculated the actual evapotranspiration in the Nome area to be 14 inches/yr based on Thornthwaite's classification. A study of thermokarst ponds by Fraver (2003) in the Council area, about 75 miles northeast of Nome, included evaluation of evapotranspiration. Extrapolation of the results from that study indicated an annual evapotranspiration of about 14 inches (356 mm) for ponds, 10 inches (254 mm) for wetlands and 7 inches (178 mm) for uplands. This precipitation and evaporation information indicates there is significant quantity of water available for runoff and groundwater recharge in the area.

Site Geology

The host rock at the Big Hurrah Mine site is a graphitic shale. The mineralization is primarily within silica veins filling fractures within the host rock. The veins typically trend northwest. The slopes are mantled with colluvial materials and the creek valley floors are infilled with sand and gravel alluvium. The alluvium has been dredged for gold, and dredge piles are visible on the valley floor. Mill tailings are evident near the confluence on Big Hurrah and Little Hurrah Creek from the historic Big Hurrah Mine.

Historic Big Hurrah Mine

The Big Hurrah historic underground mine was described by Orr (1954). The mine operated from 1903 to 1908 and for two months in 1952. The underground workings extend to the 250' level. The headframe was on the slope to the east of Little Hurrah Creek (near the 80' elevation). Information provided by Orr indicates that the water level in the flooded workings was at about the 72' level. The pumping rate to dewater the workings was reported to be between 150 and 200 gpm. The development on the 150' level was terminated just short of Little Hurrah Creek due to increased inflows along a vein and concern regarding the proximity of the alluvium in Little Hurrah Creek.

Operating Mine Water Management

Figure 3 shows the site catchment and subcatchments.

The mine facilities will include the following water management works:

- an open pit interception well system. This will include water from the historic underground workings.
- a water treatment and Class V injection system
- open pit diversion ditches
- open pit dewatering system
- Little Hurrah Creek diversion works
- development rock dump and ore stock pile diversion ditches
- development rock dump
- ore stock pile
- overburden stock piles

Open Pit Groundwater Interception

Air lift pumping rates were monitored during exploration drilling with air rotary drill equipment. The drillholes are located on Figure 4. The air lift rates are plotted versus depth on Figure 5. Typically air lift rates were low at elevations above the Little Hurrah Creek bed elevation, but were significant in many of the holes at depth. Groundwater levels measured in drillholes are at or slightly above the Little Hurrah Creek elevation.

Groundwater interception wells are planned so the groundwater does not contact the mine workings. The intercepted water will be treated, if necessary, and reinjected in a Class V underground injection system. The required drawdown is expected to be achievable by pumping from four wells. The system will also include piezometers, flow meters for monitoring flow rates, a method for controlling well flow rates, and normal well operating system level controls.

Open Pit Sumps

Sumps and sump pumps will be required in the pit to collect runoff and groundwater not intercepted by the open pit groundwater interception system. The system will not require high pumping capacity, as the pit will provide the primary storage for mine water on the site.

Water collected in the sumps will be mixed with groundwater interception well water for discharge using a Class V underground injection system.

Class V Injection System

As the ore will be trucked to the Rock Creek site, there is no mill facility in need of process water at this location. Excess water will therefore be treated, if necessary, and injected into the groundwater system using a Class V underground injection system. The water from the open pit interception wells will be discharged using this method. Several alternative discharge methods have been considered. We have assumed that the discharge will be 200 to 250 gpm based on historical data.

Retention time of injected water before it reaches a body of surface water and the capacity of an area to accept the required amount of water are of greatest importance when considering different sites for injection.

The water will be injected into fracture systems at depth below the mine workings. These wells might be located as indicated on Figure 1. Injection well depths of about 400 ft are anticipated. The injection wells would include 200 ft or more of cemented casing to prevent short circuiting to the ground surface. Seven wells are planned to accept the anticipated flow. Test wells will be required to identify and test fracture zones (or transmissive veins). The injected water would radiate out from the well along the fracture with losses to intersection fractures along the travel path, and the remainder discharging into the alluvium of Big Hurrah Creek. Modeled travel paths and times (in years) in bedrock are illustrated on Figure 1. Discharge into the base of the alluvium would result in a downstream migration of the injected water and slow discharge to the creek downstream. Any anisotropy of the alluvium would tend to move the discharge further away from the source well, and increase the travel time.

Groundwater Inflow

Groundwater inflow to the underground workings and probably into the proposed pit is expected to be along veins, as the quartz filled veins will probably stay open, whereas the graphitic shale is not expected to carry significant quantities of water. Dewatering for pit operations will include removal of water from the historic underground workings. The pumping rate to dewater the workings was reported to be between 150 and 200 gpm.

Little Hurrah Creek Diversion System

The mine plan includes excavation into the slopes of Little Hurrah Creek and retaining the creek in the natural channel for as long as possible. When excavation below the creek bed is required, the creek will be routed along a mine bench constructed for that purpose. The diversion will include a small diversion structure with a cutoff to bedrock, with flow into the channel. Flows greater than the annual average instantaneous peak will be routed over an overflow spillway along the bench and allowed to flow into the pit. The diversion structure will provide adequate protection against sedimentation and loss of capacity of the diversion ditch on the bench.

Open Pit Diversion Ditches

Diversion ditches will be constructed around the perimeter of the pit to discharge water that has not been in contact with mining activities directly into the local surface water. This will significantly reduce the quantity of water coming into contact with open pit walls. Diversion ditch locations are illustrated on Figure 1. As shown in Figure 1, discharge will be to Little Hurrah Creek from the south side of the pit, which then flows to Big Hurrah Creek.

Development Rock Dump and Ore Stock Pile Diversion Ditches

Diversion ditches will be constructed around the perimeter of the Development Rock dump and Ore Stockpile to discharge water that has not been in contact with mining activities directly into the local surface water. Diversion ditch locations are illustrated on Figure 1. As shown in Figure 1 discharge from upslope of the development rock dump will be to the small creek to the east which then flows north to Big Hurrah Creek, and directly to Big Hurrah Creek from upslope of the ore stockpile.

Development Rock Dump and Overburden Stock Piles

Run off from the development rock dumps and overburden stock piles will be managed to control sediment loading to the surface water bodies. Best management practices will be used to prevent concentration of flows that could lead to erosion and to prevent migration of fines away from the development rock dumps.

Ore Stock Pile

Run off from the ore stock pile will be combined with pit water and discharged in the Class V injection system.

Site Wide Water Balance

The site wide water balance for operating conditions was developed with subcatchments to reflect natural and operations barriers to flows. The subcatchments are illustrated on Figure 3 and are listed along with their respective surface area in Table 3. The model was run over the life of the mine with average climate conditions and run for year 1 to examine wet and dry conditions.

Table 3: Site Wide Water Balance Subcatchment Areas

		Elevation Bands		
		Lower	Upper	Total
Area	Name	<1000'	>1000'	(m^2)
1	Upper Little Hurrah Creek	2,852,458		2,852,458
2	Development Rock Dump	269,209		269,209
3	Stockpile and Pitlet	22,976		22,976
4	Development Rock Dump Catchment	185,819		185,819
5	Pit	115,028		115,028

Table 4 presents the climatic (precipitation and temperature) conditions that were used in the calculations. Conservative estimates indicate that the site will have precipitation that is approximately 1.5 times the Nome Airport recorded precipitation. Based on these inputs, values were estimated for evapotranspiration, runoff, groundwater recharge, snowpack accumulation and snowmelt.

Table 4: Life of Mine Assumed Climatic Inputs

	Temperature (^{o}C)			Precipitation (mm)	
Month	Nome	<1,000’	>1,000’	Nome	Site
Jan	-5.8	-6.2	-7.0	10.9	16.4
Feb	-11.2	-11.6	-12.5	10.2	15.3
Mar	-11.9	-12.3	-13.1	5.6	8.4
Apr	-3.9	4.4	-5.2	27.7	41.6
May	5.6	5.2	4.4	9.9	14.9
June	7.1	6.6	5.8	105.4	158.1
July	12.5	12.1	11.2	42.4	63.6
Aug	12.4	12.0	11.1	63.2	94.8
Sept	8.1	7.7	6.9	89.9	134.9
Oct	-2.8	-3.2	-4.0	19.1	28.7
Nov	-4.5	-4.9	-5.8	43.9	65.9
Dec	-9.8	-10.2	-11.1	30.5	45.8

The small pit will retain some open pit and ore stockpile excess water from snowmelt or rainfall. The water balance provides a means to determine the required discharge rate from the small pit under average and wet conditions.

Table 5 lists the expected water balance items for the 4 year mine life with 1.5 times the Nome precipitation while pumping 200 gpm from the pit groundwater interception wells. Following are comments regarding the expected surface water monthly flows presented on Table 5.

- In the early mine life, flow along Little Hurrah Creek through the pit area will be maintained in the natural channel. In later mine life, this flow will be routed along a mine bench through the pit area. The highest flow with the precipitation distribution illustrated is during snowmelt. Dry season and winter flows are relatively low.
- Flows diverted around the Development Rock Dump will be relatively low.
- Precipitation and snowmelt onto natural ground or development rock will both result in runoff, although the development rock may result in more detention, which will reduce the peaks and spread the flow out over a longer time period.
- Runoff from the open pit and the stockpile will be stored temporarily in the small open pit. The water in the small pit will be pumped to treatment if

required and injected in a Class V system.

Table 5 also indicates the following expected groundwater flows:

- Minimal seepage is expected from Little Hurrah Creek alluvium to the pit as a cutoff will be constructed when the creek is diverted onto the bench.
- Groundwater from the Development Rock Dump to Big Hurrah Creek will be similar to pre-mine conditions, although infiltration to the groundwater system may be a little enhanced once the development rock is in place.
- A relatively small volume of seepage is expected from the small pit to Big Hurrah Creek alluvium.
- Groundwater will be pumped to intercept flow towards the pit once the pit is excavated to below the invert of Little Hurrah Creek. The groundwater will be pumped from the underground workings at about 200 gpm. This water will be reinjected after undergoing suitable treatment.

Table 6 provides an indication of the expected range of surface water and groundwater flows that will be accommodated by the mining operation. This range represents approximately the 10 year return period wet and dry years.

- The 10 year wet month within the Little Hurrah Creek channel would be about 640,000 m^3/month.
- A groundwater interception system is assumed to pump 200 gpm for wet dry and average conditions.

Closure Mine Water Management

After closure, all diversion ditches and water management facilities will be removed. Surfaces will be regraded and reclaimed to reduce the potential for concentration of flows. Little Hurrah Creek will flow through the completed pit. Following is a description of the expected pit lake flooding and the expected water balance of the flooded pit lake.

Pit Lake Flooding

The pit lake will flood when pumping from the pit and interception wells is stopped and the diversion of Little Hurrah Creek along the bench is removed so that Little Hurrah Creek flows through the pit. Filling the pit, assuming that the mine closure is in the winter, will require two spring freshets, assuming 1981 conditions. The pit filling curve is presented on Figure 6. Spill will be into the original Little Hurrah Creek channel. An engineered spill channel is therefore not required.

Table 5: Big Hurrah Expected Site Wide Water Balance for 4 Year Mine Life (m^3/month)

Year	Month ending	Surface Water				Groundwater			
		Little Hurrah Creek to	Development Dump Catchment to	Development Dump to	Little Open pit to	Little Hurrah Creek to	Development Rock Dump to	Small pit	Intercepted groundwater
		Pit area channel	Diversion Ditch	Big Hurrah Creek	Class V Injection	Open pit	Big Hurrah Creek Alluvium	Big Hurrah Creek Alluvium	Class V Injection
1	31/Jan/07	7,031	0	0	0	48	976	942	0
	28/Feb/07	5,894	0	0	0	45	671	665	0
	31/Mar/07	4,933	0	0	0	48	461	540	0
	30/Apr/07	4,132	0	0	1,544	47	317	224	0
	31/May/07	464,093	29,819	39,274	21,700	48	1,459	148	0
	30/Jun/07	7,806	0	6	1,606	47	2,400	143	0
	31/Jul/07	65,139	3,657	4,817	3,932	48	2,471	0	0
	31/Aug/07	68,488	3,667	5,478	4,084	48	2,480	0	0
	30/Sep/07	13,707	0	970	1,113	47	2,400	0	0
	31/Oct/07	12,681	0	387	272	48	2,480	0	0
	30/Nov/07	10,631	0	0	135	47	2,095	0	0
	31/Dec/07	8,909	0	0	83	48	1,463	0	0
2	31/Jan/08	7,465	0	0	62	48	1,010	0	0
	29/Feb/08	6,259	0	0	49	44	694	0	0
	31/Mar/08	5,239	0	0	51	48	477	0	0
	30/Apr/08	4,388	0	0	48	47	328	0	0
	31/May/08	465,155	29,874	39,346	21,700	48	1,468	153	0
	30/Jun/08	7,987	0	13	1,641	47	2,400	149	0
	31/Jul/08	65,291	3,657	4,817	3,932	48	2,476	0	0
	31/Aug/08	68,616	3,667	5,481	4,084	48	2,480	0	0
	30/Sep/08	13,814	0	972	1,113	47	2,400	0	32,659
	31/Oct/08	12,771	0	389	272	48	2,480	0	33,748
	30/Nov/08	10,707	0	0	135	47	2,096	0	32,659
	31/Dec/08	8,972	0	0	83	48	1,464	0	33,748
3	31/Jan/09	7,518	0	0	62	48	1,010	0	33,748
	28/Feb/09	6,303	0	0	49	44	695	0	30,482
	31/Mar/09	5,276	0	0	51	48	477	0	33,748
	30/Apr/09	4,419	0	0	48	47	328	0	32,659
	31/May/09	465,182	29,874	39,346	21,700	48	1,468	153	33,748
	30/Jun/09	8,009	0	13	1,641	47	2,400	149	32,659
	31/Jul/09	65,310	3,657	4,817	3,932	48	2,477	0	33,748
	31/Aug/09	68,631	3,667	5,481	4,084	48	2,480	0	33,748
	30/Sep/09	13,827	0	972	1,113	47	2,400	0	32,659
	31/Oct/09	12,782	0	389	272	48	2,480	0	33,748
	30/Nov/09	10,716	0	0	135	47	2,096	0	32,659
	31/Dec/09	8,980	0	0	83	48	1,464	0	33,748
4	31/Jan/10	7,525	0	0	62	48	1,010	0	33,748
	28/Feb/10	6,309	0	0	49	44	695	0	30,482
	31/Mar/10	5,280	0	0	51	48	477	0	33,748
	30/Apr/10	4,423	0	0	48	47	328	0	32,659
	31/May/10	465,185	29,874	39,346	21,700	48	1,468	153	33,748
	30/Jun/10	8,012	0	13	1,641	47	2,400	149	32,659
	31/Jul/10	65,312	3,657	4,817	3,932	48	2,477	0	33,748
	31/Aug/10	68,633	3,667	5,481	4,084	48	2,480	0	33,748
	30/Sep/10	13,829	0	972	1,113	47	2,400	0	32,659
	31/Oct/10	12,783	0	389	272	48	2,480	0	33,748
	30/Nov/10	10,717	0	0	135	47	2,096	0	32,659
	31/Dec/10	8,981	0	0	83	48	1,464	0	33,748

Table 6: Range of Possible Monthly Flows for Big Hurrah (m^3/month)

Big Hurrah Water Balance Calculation

Dry Year (1932)

Month ending	Surface Water				Groundwater			
	Little Hurrah Creek to	Development Dump Catchment to	Development Dump to	Little Open pit to	Little Hurrah Creek to	Development Rock Dump to	Small pit	Intercepted groundwater
	Pit area channel	Diversion Ditch	Big Hurrah Creek	Class V Injection	Open pit	Big Hurrah Creek	Big Hurrah Creek	Class V Injection
31/Jan/33	8,182	0	0	107	48	1,659	0	33,748
28/Feb/33	6,860	0	0	67	44	1,147	0	30,482
31/Mar/33	5,743	0	0	57	48	789	0	33,748
30/Apr/33	4,811	0	0	50	47	542	0	32,659
31/May/33	310,616	19,833	26,121	15,399	48	1,378	0	33,748
30/Jun/33	8,053	0	0	599	47	2,108	0	32,659
31/Jul/33	6,746	0	0	266	48	1,633	0	33,748
31/Aug/33	5,651	0	0	134	48	1,158	0	33,748
30/Sep/33	4,734	0	0	80	47	802	0	32,659
31/Oct/33	3,962	0	0	62	48	552	0	33,748
30/Nov/33	3,317	0	0	52	47	379	0	32,659
31/Dec/33	2,773	0	0	50	48	261	0	33,748

Big Hurrah Water Balance Calculation

Average Year (1981)

Month ending	Surface Water				Groundwater			
	Little Hurrah Creek to	Development Dump Catchment to	Development Dump to	Little Open pit to	Little Hurrah Creek to	Development Rock Dump to	Small pit	Intercepted groundwater
	Pit area channel	Diversion Ditch	Big Hurrah Creek	Class V Injection	Open pit	Big Hurrah Creek	Big Hurrah Creek	Class V Injection
31/Jan/81	11,001	0	0	92	48	1,677	0	33,748
28/Feb/81	9,225	0	0	61	44	1,159	0	30,482
31/Mar/81	7,726	0	0	55	48	797	0	33,748
30/Apr/81	6,475	0	0	50	47	548	0	32,659
31/May/81	417,373	26,650	35,100	20,454	48	1,543	0	33,748
30/Jun/81	9,381	0	0	635	47	2,386	0	32,659
31/Jul/81	66,461	3,657	4,817	3,925	48	2,455	0	33,748
31/Aug/81	69,597	3,667	5,466	4,081	48	2,480	0	33,748
30/Sep/81	14,637	0	962	1,112	47	2,400	0	32,659
31/Oct/81	13,461	0	382	272	48	2,480	0	33,748
30/Nov/81	11,286	0	0	135	47	2,091	0	32,659
31/Dec/81	9,458	0	0	83	48	1,461	0	33,748

Big Hurrah Water Balance Calculation

Wet Year (1954)

Month ending	Surface Water				Groundwater			
	Little Hurrah Creek to	Development Dump Catchment to	Development Dump to	Little Open pit to	Little Hurrah Creek to	Development Rock Dump to	Small pit	Intercepted groundwater
	Pit area channel	Diversion Ditch	Big Hurrah Creek	Class V Injection	Open pit	Big Hurrah Creek	Big Hurrah Creek	Class V Injection
31/Jan/54	9,949	0	0	86	48	1,386	0	33,748
28/Feb/54	8,342	0	0	59	44	954	0	30,482
31/Mar/54	6,986	0	0	54	48	655	0	33,748
30/Apr/54	5,854	0	0	49	47	450	0	32,659
31/May/54	138,482	8,528	11,231	7,016	48	1,049	0	33,748
30/Jun/54	8,528	0	0	539	47	1,606	0	32,659
31/Jul/54	172,461	10,607	13,970	8,750	48	2,067	0	33,748
31/Aug/54	639,300	40,814	55,115	21,700	48	2,480	1,316	33,748
30/Sep/54	322,822	20,260	29,349	21,000	47	2,400	1,612	32,659
31/Oct/54	16,496	0	2,669	3,276	48	2,480	349	33,748
30/Nov/54	13,968	0	1,409	408	47	2,400	0	32,659
31/Dec/54	11,707	0	192	190	48	2,480	0	33,748

Pit Lake Water Balance

After flooding the pit lake water will include runoff from the surrounding hills, direct precipitation and snowmelt on the pond and surrounding pit slopes, evaporation, seepage in and out, and spill from the pit lake. Table 7 provides a summary of the pit lake water balance.

Table 7: Summary Pit Lake Water Balance after Pit Flooding

Month	Pit Lake Volume (m^3)	Pit Lake Inflows (m^3)				Pit Lake Outflows (m^3)	
		Rain and snowmelt		Surface water	Ground water	Spill	Pond evaporation
		On pit lake	On pit slopes				
Jan	828,222	0	0	8,173	50	8,222	0
Feb	828,222	0	0	6,928	46	6,974	0
Mar	828,222	0	0	5,866	50	5,915	0
Apr	828,222	0	0	4,969	48	5,017	0
May	828,222	9,530	6,126	495,473	50	518,880	0
Jun	828,222	1,304	838	8,523	48	10,713	3,335
Jul	828,222	5,493	3,531	69,588	50	79,999	5,312
Aug	828,222	4,107	2,640	72,949	50	81,086	5,028
Sep	828,222	1,500	964	14,428	48	17,168	4,349
Oct	828,222	0	0	13,426	50	13,475	1,970
Nov	828,222	0	0	11,381	48	11,429	0
Dec	828,222	0	0	9,644	50	9,694	0

Sincerely,

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H.R.(Rod) Smith

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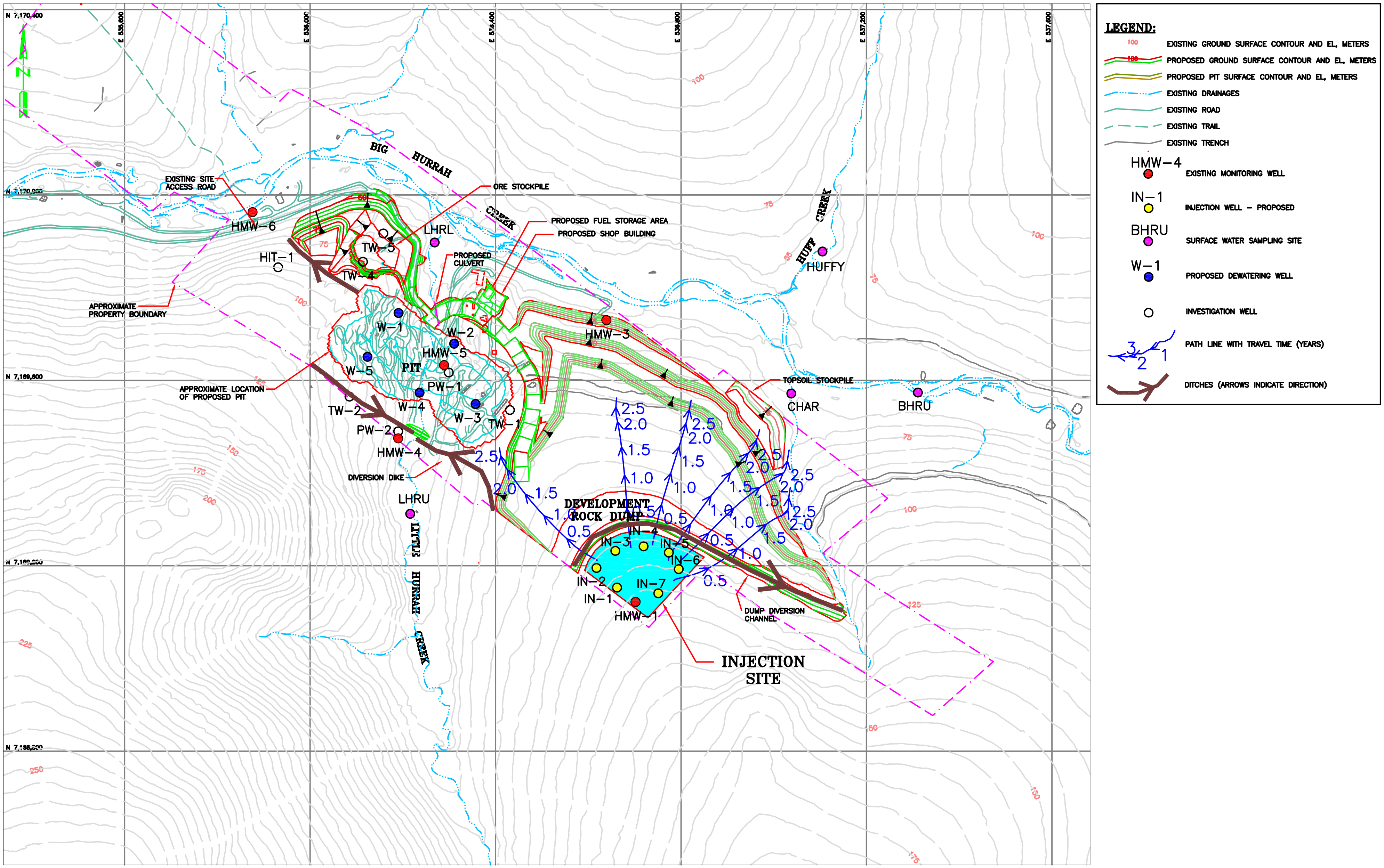
Figure 1 Big Hurrah Site Plan



REFERENCE:
TOPOGRAPHIC DATA DOWNLOADED FROM NORWEST CORPORATION FTP SITE.
SURVEY BY: KODIAK MAPPING SURVEY, FROM AERIAL PHOTOGRAPHY ACQUIRED ON 10-2-2004 FILENAME: S:\CAD\1011-rock creek\recv\20050203-Big Hurrah\big_hurrah_2004.dwg

80 0 80 160 METERS

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Figure 2 Annual Precipitation Contours

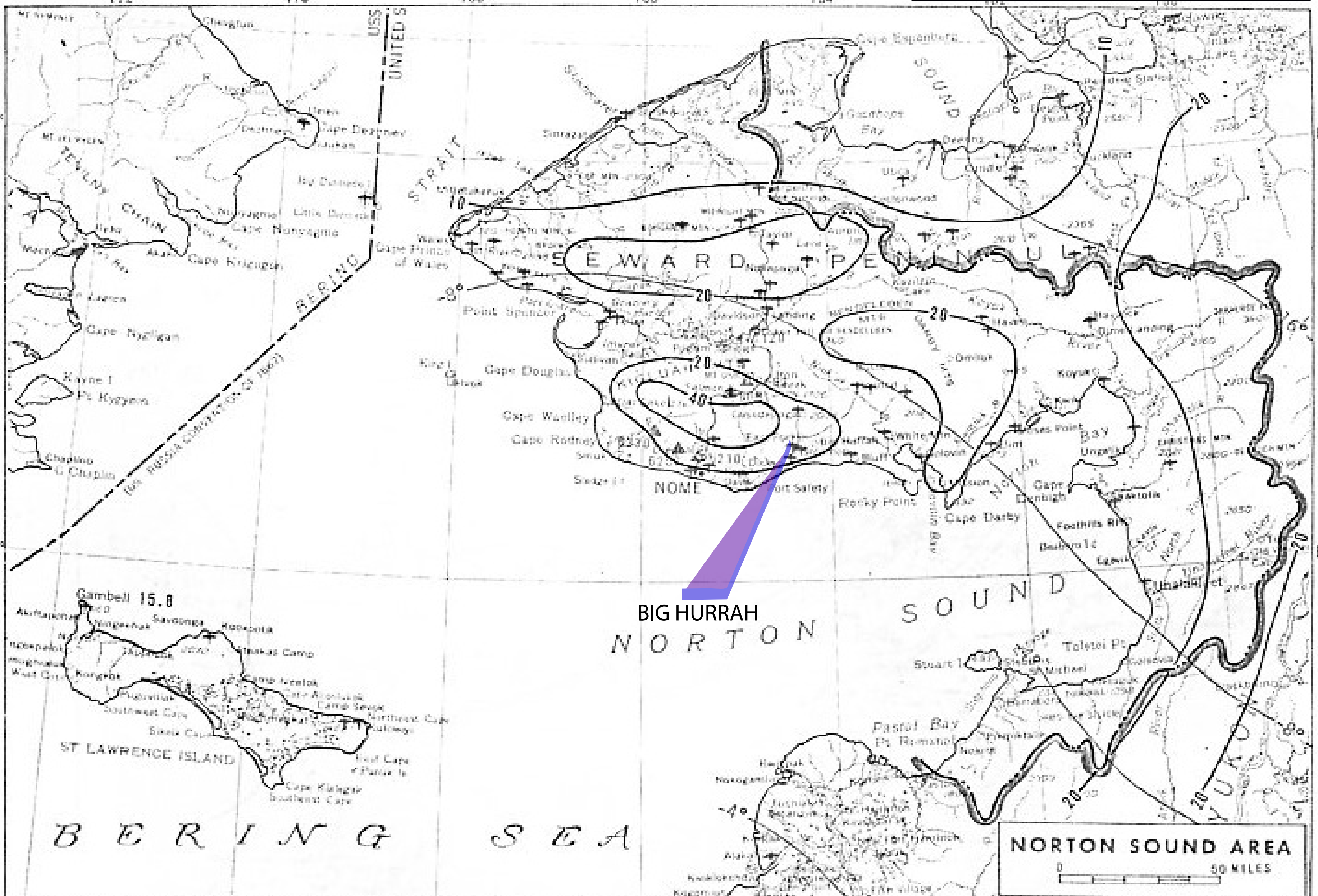

Figure 4-5.--Mean annual precipitation and mean minimum January temperatures in Norton Sound area.

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Figure 3 Catchments and Subcatchments

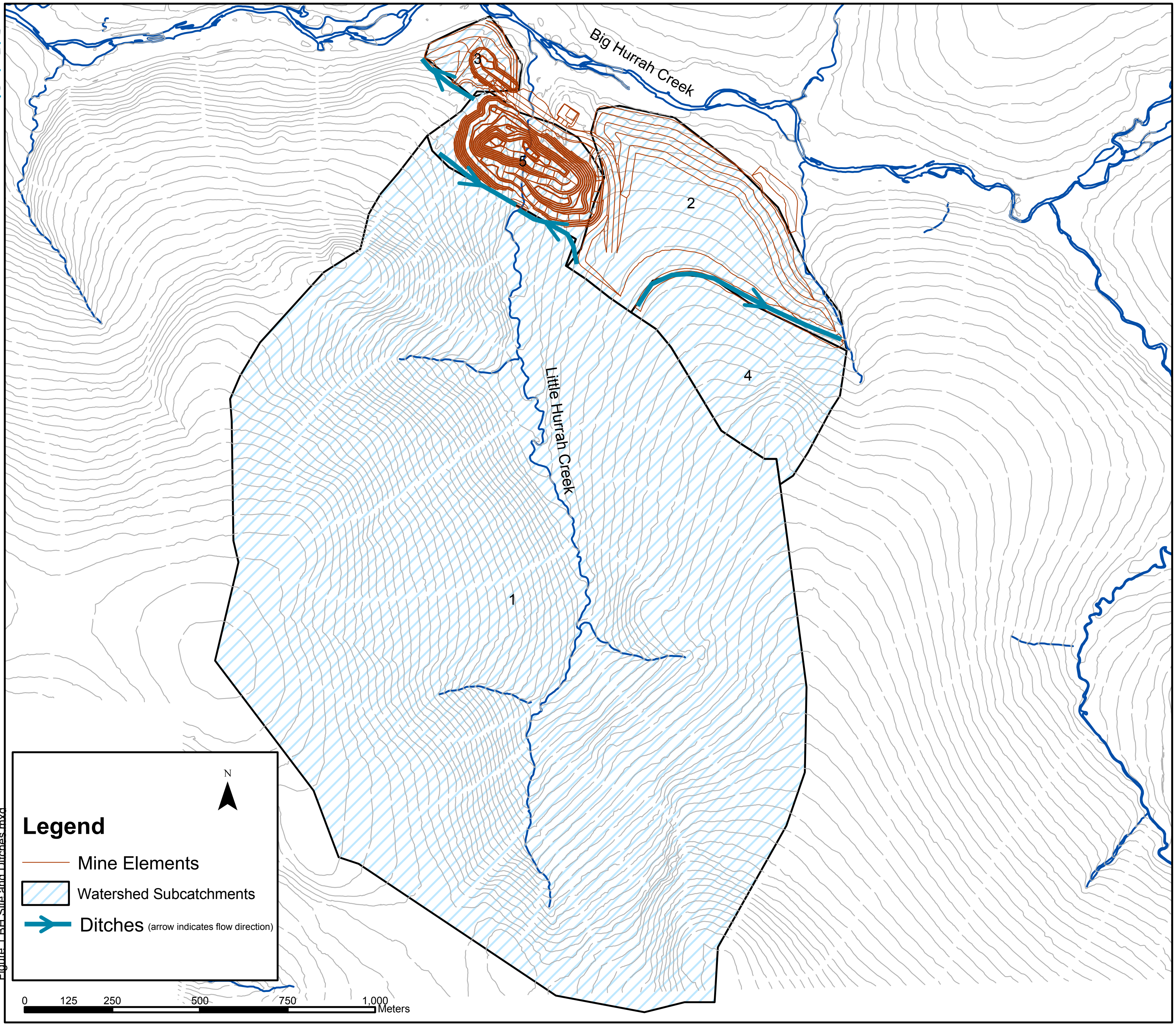

Figure 4 Big Hurrah Exploration Drill Holes

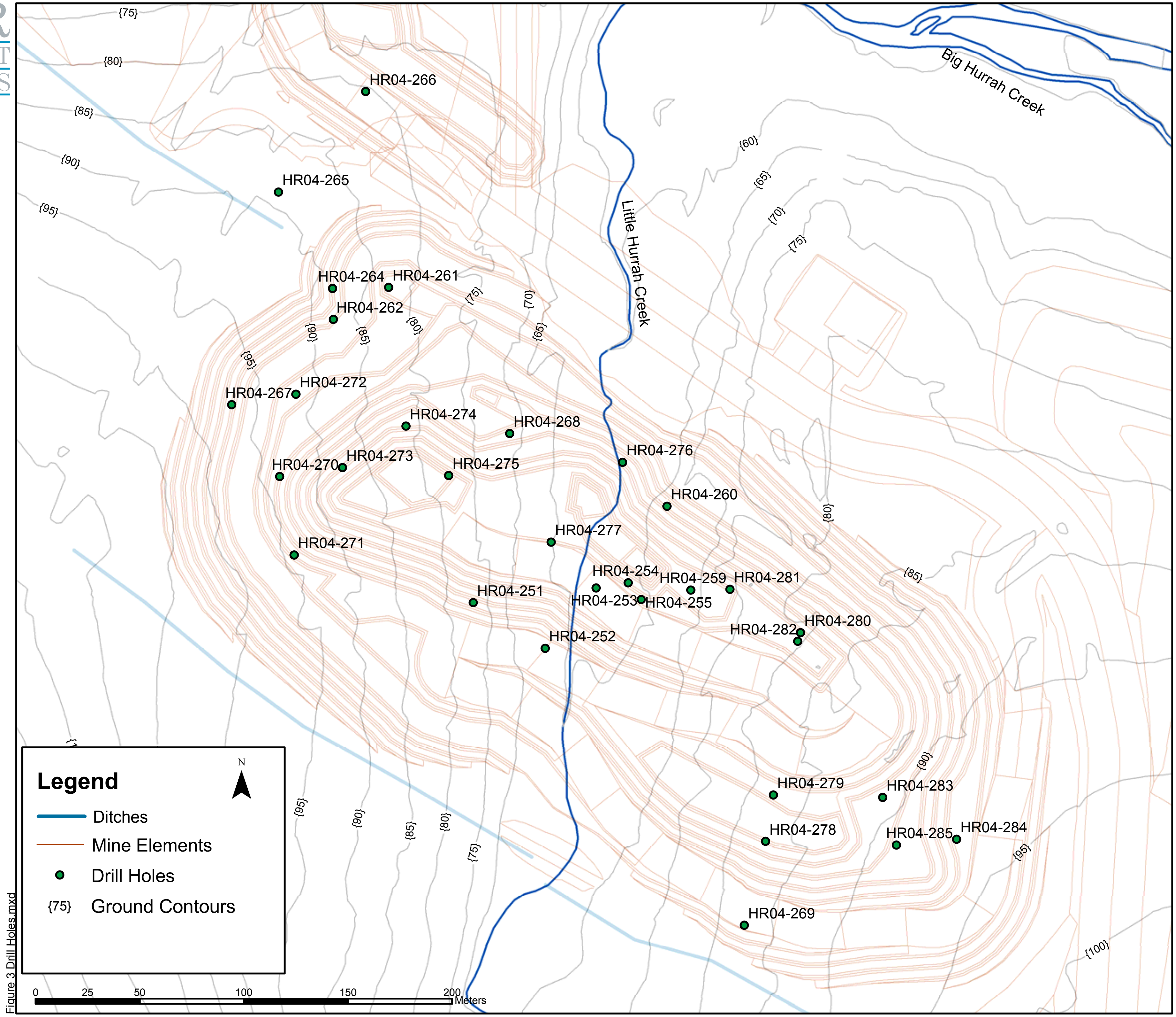

Figure 5: Big Hurrah Exploration Drill Holes Air Lift Rates with Depth

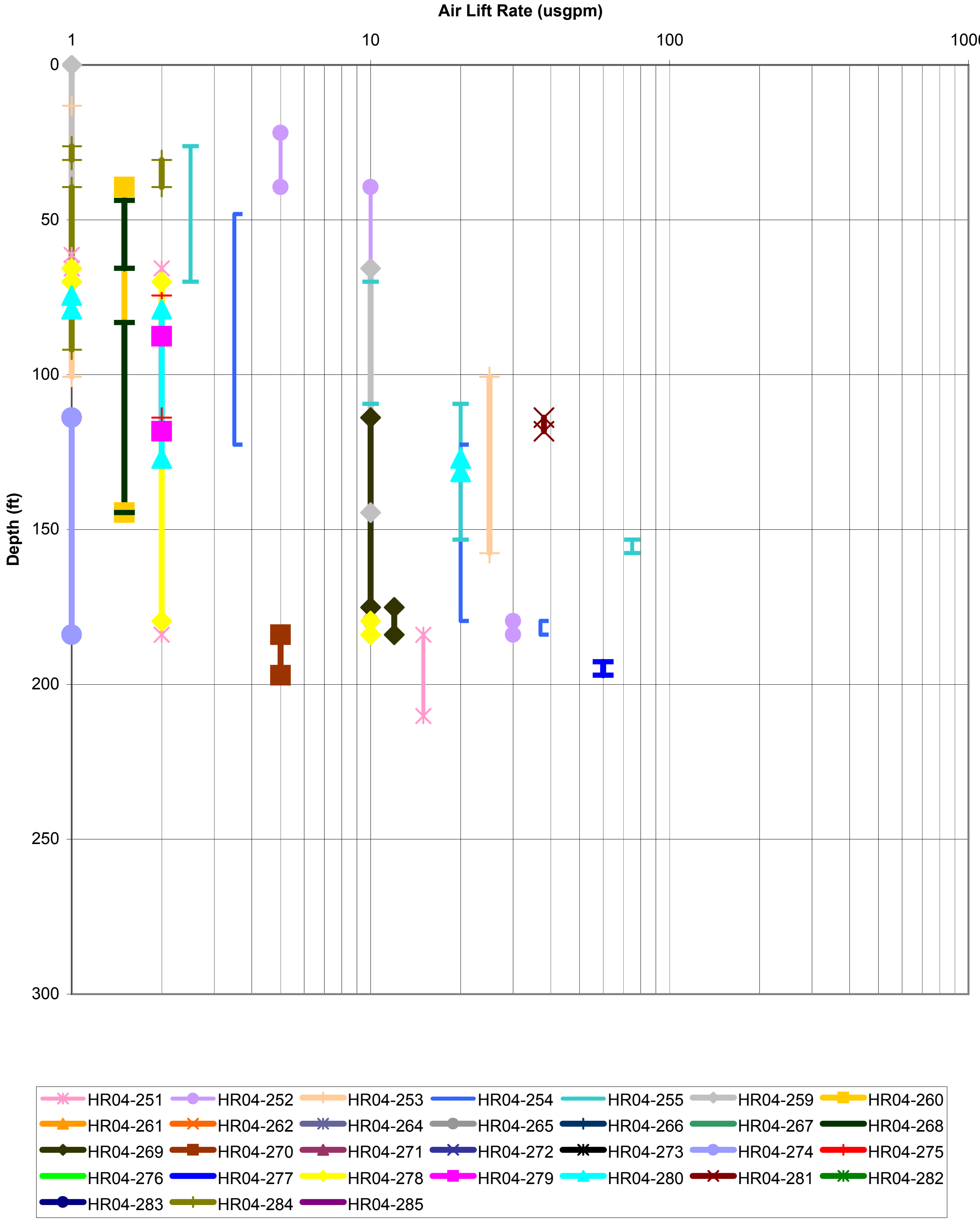

Figure 6: Big Hurrah Pit Lake Filling Curve