ATLANTIC GOLD

Appendix F.2

Hydrogeological Investigation
Beaver Dam Mine

Beaver Dam Mine Project - Revised Environmental Impact Statement Marinette, Nova Scotia

SEABRIGHT RESOURCES INC.

HYDROGEOLOGICAL INVESTIGATION
BEAVER DAM MINE

PROJECT NO. M1289

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Site Investigations,
Blasting Control,
Materials, Mining,
Hydrogeology,
Earthworks,
Foundations,
Environmental

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Moncton, N.B.
St. John's, Nfld.

July 30, 1986
Project No. M1289

Seabright Resources Inc.
Suite 301, 6100 Young Street
Halifax, Nova Scotia

Attention: Mr. P. Keohane, P.Eng.

Dear Sir:

Re: Hydrogeological Study Report - Beaver Dam Mine

Please find enclosed four copies of the above report. This report outlines the results of three separate hydrogeologic studies at the Beaver Dam site:

- Packer Injection Study
- Austin Shaft Dewatering Program
- Groundwater Exploration Program

Please contact either myself or Suther A. Yuill, P.Eng. at this office should you have any questions regarding the enclosed.

Sincerely yours,

JACQUES, WHITFORD & ASSOCIATES LTD.

<Original signed by>

for David S. MacFarlane, M.Sc.

DSM/sd

Consulting Engineers

PROJECT NO. M1289

HYDROGEOLOGICAL INVESTIGATION

PREPARED FOR

SEABRIGHT RESOURCES INC.
BEAVER DAM MINE
HALIFAX COUNTY, N.S.

BY

JACQUES, WHITFORD & ASSOCIATES LTD.

Halifax, Nova Scotia

July 22, 1986

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION 1-1

- 1.1 Purpose 1-1
- 1.2 Location 1-1
- 1.3 Report Organization 1-1
- 1.4 Previous Studies 1-2

2.0 PACKER TESTING PROGRAM 2-1

- 2.1 Purpose 2-1
- 2.2 Method 2-2
- 2.3 Discussion of Results 2-3
- 2.4 Calculation of Mine Inflow 2-5
- 2.5 Summary 2-5

3.0 AUSTIN SHAFT DEWATERING PROGRAM 3-1

- 3.1 Purpose 3-1
- 3.2 Method 3-2
- 3.3 Discussion of Results 3-3
- 3.4 Summary 3-8

4.0 GROUNDWATER SUPPLY EXPLORATION PROGRAM 4-1

- 4.1 Purpose 4-1
- 4.2 Method 4-1
- 4.3 Pump Test Evaluation 4-3
- 4.4 Summary 4-4

5.0 CONCLUSIONS 5-1

6.0 RECOMMENDATIONS 6-1

APPENDIX 1: Regional Hydrogeology
APPENDIX 2: Pumping Test Data, Austin Shaft
APPENDIX 3: Sieve Analysis Results
Test Pit Records

LIST OF FIGURES

Figure 1.1 General Site Location

Figure 1.2 Site Plan

Figure 2.1 Typical Geological Cross-Section (0 + 75W) Illustrating the Location of Packer Injection Zones

Figure 3.1 Distribution of Major Ions Water Quality Samples

Figure 4.1 Seismic Profile Line 2 + 00 W

LIST OF TABLES

Table 2.1 Packer Testing Intervals

Table 2.2 Hydraulic Conductivities

Table 2.3 Inflow Rates

Table 3.1 Austin Shaft Pumping Test # 1 Water Quality Data, June 18-19, 1986

Table 3.2 Austin Shaft Pumping Test # 2 Water Quality Data, July 8-12, 1986

Table 3.3 Field Chemistry Data, Austin Shaft Dewatering Test

Table 3.4 Water Quality Analysis for Groundwater Samples, Beaver Dam Mine, 1986

Table 3.5 Hydraulic Head Monitored at Selected Diamond Drill Holes During the Austin Shaft Dewatering Program

Table 3.6 Caribou Gold Mine, August 26, 1983 Water Quality Analysis

1.0 INTRODUCTION

1.1 Purpose

At the request of Seabright Resource Inc., Jacques, Whitford and Associates Limited has undertaken a series of field studies at the site of the proposed Beaver Dam Gold Mine. The primary purpose of the work was to obtain site-specific hydrogeologic information sufficient to provide a preliminary prediction of groundwater inflows and mine water quality prior to the construction of the new mine portal. Secondary objectives were to evaluate the feasibility of developing groundwater resources for both mine process and potable uses.

1.2 Location

The Beaver Dam gold mine is located approximately 80 km northeast of the City of Halifax, 55 km southeast of Truro, and 70 km from the Gays River milling facility (Figure 1.1). Access to the site is via a 6 km Nova Scotia Department of Transportation haulage road (Beaver Dam Road), off of Route 224 which connects the Villages of Sheet Harbour and Upper Musquodoboit (Figure 1.1). Upgrading of the mine access road is currently underway. The mine site is located adjacent to the Killag River which lies within the watershed of the West Branch Sheet Harbour River which has a total drainage area of about 300 km^2.

1.3 Report Organization

The field investigations were carried out in three phases between May 6, 1986 and July 12, 1986. Section 2.0 outlines the results of a packer injection program conducted on selected exploration boreholes for the Beaver Dam site. The packer testing program was designed to determine the range of hydraulic conductivity values associated with the various rock types and structures comprising the Beaver Dam ore zones. An estimation of mine inflow rates for sizing of pumps is made based on the range of hydraulic conductivity observed.

Section 3.0 outlines the results of a comprehensive pump test and water quality monitoring program conducted on the existing Austin Mine workings. Analysis of time-drawdown data provide an assessment of the bulk hydraulic properties of the shallow (0-22 m) bedrock zones. The continuous, on-site monitoring of water quality provides on assessment of the expected mine effluent quality from the new mine. Monitoring of water level elevations in diamond drill holes distributed across the proposed mine site was carried out during the shaft dewatering to determine the extent of hydraulic response across the Beaver Dam Mine Site.

Section 4.0 outlines a groundwater exploration program conducted on behalf of Seabright Resources Inc. Test pitting was carried out to determine the feasibility of infiltration gallery construction at Crusher Lake, and pipeline construction from Crusher Lake to the mine. One test well was constructed and pump tested to determine the hydraulic properties of the glacial till overburden, and the feasibility of dug well water supplies.

Section 5.0 is a summary of the findings of the various studies, and their implications on the proposed new mine.

Section 6.0 includes recommendations for monitoring of groundwater quantity and quality during mine construction.

1.4 Previous Studies

Very little previous information regarding groundwater flows in the Beaver Dam area is available. A discussion of the regional hydrogeology of the area is presented in Jacques, Whitford and Associates Limited (1986) Environmental Assessment of the Beaver Dam Mine Site, and is included in Appendix 1 for reference purposes.

2.0 PACKER TESTING PROGRAM

2.1 Purpose

Due to the remote location of the Beaver Dam mine site, and the lack of any previous hydrogeological evaluation in the mine area, there were some concerns regarding the volumes of groundwater which may be generated by a mine in the area. Of particular concern was the possibility of groundwater inflows to the mine excavation from the major fault zones in the area such as Mud Lake Fault, from thick deposits of saturated sand and gravel overlying portions of the area, and from existing mine workings such as the Austin Shaft.

The flow of water into the proposed Beaver Dam Mine workings will be dependant on the degree of secondary permeability of the quartzite bedrock. Groundwater transmission in crystalline bedrock in Nova Scotia is governed by the frequency, orientation and aperture of the fracture joints and faults developed in the bedrock. Two methods of evaluating the hydraulic characteristics of fractured rock are commonly used; large scale pumping tests, and packer injection testing. Pumping tests provide the best assessment of the bulk hydraulic characteristics of the overall rock mass surrounding a mine site, however, such investigations are generally extremely expensive and time consuming, requiring several deep vertical drilled wells and observation wells to render reliable results. Packer testing can provide a good statistical determination of the range and variation of hydraulic conductivity provided sufficient measurements are made.

At the Beaver Dam Mine site, the presence of more than 90 exploration diamond drill holes at various attitudes, and the resultant good understanding of the structural geology of the area provided by the geologic logs, allowed the design of a packer injection testing program sufficient in scope to evaluate the hydraulic properties of the various structures and rock types associated with the new mine.

Preliminary discussions with Seabright Resources geologic personnel, and examination of diamond drill geologic logs and vertical cross-sections, led to the selection of 16 diamond drill holes that should yield good, representative packer test results. The criteria used to choose the holes include:

(i) the holes should be as vertical as possible to minimize possible equipment problems, and to allow closer correlation between measured groundwater levels and acting hydraulic head at each packer test location.

(ii) the holes should intersect the primary zones of interest, i.e. the Mud Lake Fault Zone; the ore zone, both deep and shallow; the axis of the Beaverdam anticline; and representative zones of the three main rock types, grey-wacke, argillite and quartzite.

2.2 Method

Field work was carried out during the period of June 5 to June 15, 1986. Of the sixteen holes chosen, packer tests were carried out in nine holes. Five holes were found to be blocked at various depths and no tests were done. In total, 56 packer tests were performed over a period of 8 days.

The packer test equipment consisted of two, one metre-long inflatable packers, connected by a 4.5 m perforated pipe. A small diameter line connected the packers to a source of nitrogen gas at the surface, which was used to inflate the packers and seal the zone between them. The perforated pipe was connected to a high pressure hose line which also ran to the surface. The hose line was connected, through a flow meter and pressure gauge, to a pump. The entire packer apparatus was raised and lowered by a wireline winch system.

The wireline cable was marked in order to determine testing depths. The hose line underwent a certain amount of stretching and thus, would not have been reliable for depth measurements. All hose line connections were pressure tested to ensure that leakage was not taking place. The use of the high pressure hose resulted in superior packer testing results, than would have been the case with the usual E-Rod methods.

The following testing procedure was employed: The packer apparatus was lowered to the required testing depth, and a nitrogen pressure of 300 psi was applied to the packer. After a short wait of approximately 2 minutes, to ensure that the packers had inflated and there were no leaks in the nitrogen line, the pump was started, and water was allowed to flow into the packered zone, at an initial pressure of 25 psi above hydraulic head at that point. This pressure was maintained and the amount of flow recorded every minute until a steady state condition was reached. The water pressure was then sequentially increased to 50 psi and 90 psi, and similar measurements were taken at those pressures. On completion of the testing, the nitrogen pressure was released. When the packers had deflated, the apparatus could be located at the next testing depth. The wireline-winch packer apparatus devised for this study provided an efficient and cost-effective method of testing inclined boreholes.

The tested intervals for each hole are listed on Table 2.1. Hydraulic conductivities (K) were calculated at each pressure level, and the geometric means of the results at each testing interval are given in Table 2.2. Geometric means are considered most appropriate for log-normally distributed hydraulic conductivity data. Figure 2.1 illustrates a typical cross-section through the Beaver Dam Anticline in the vicinity of the portal area and also shows the distribution of packered zones.

2.3 Discussion of Results

Hydraulic conductivities ranged from 1.0×10^{-6} m/sec to 3.7×10^{-10} m/sec, with an overall geometric mean of 2.7×10^{-8} m/sec. The three different rock types had the following geometric mean hydraulic conductivities: argillite, 8.2×10^{-9} m/sec; greywacke, 4.8×10^{-8} m/sec.; quartzite, 2.0×10^{-7} m/sec. Tests conducted in the Mud Lake Fault Zone indicated a mean K of 2.3×10^{-8} m/sec. The mean hydraulic conductivity along the Beaver Dam Anticlinal axis was 9.1×10^{-7} m/sec.

FIGURE 2.1 Typical Geologic Cross - Section (0 + 75 W) Illustrating the Location of Packer Injection Zones. Hydraulic Conductivity Values in m/sec.

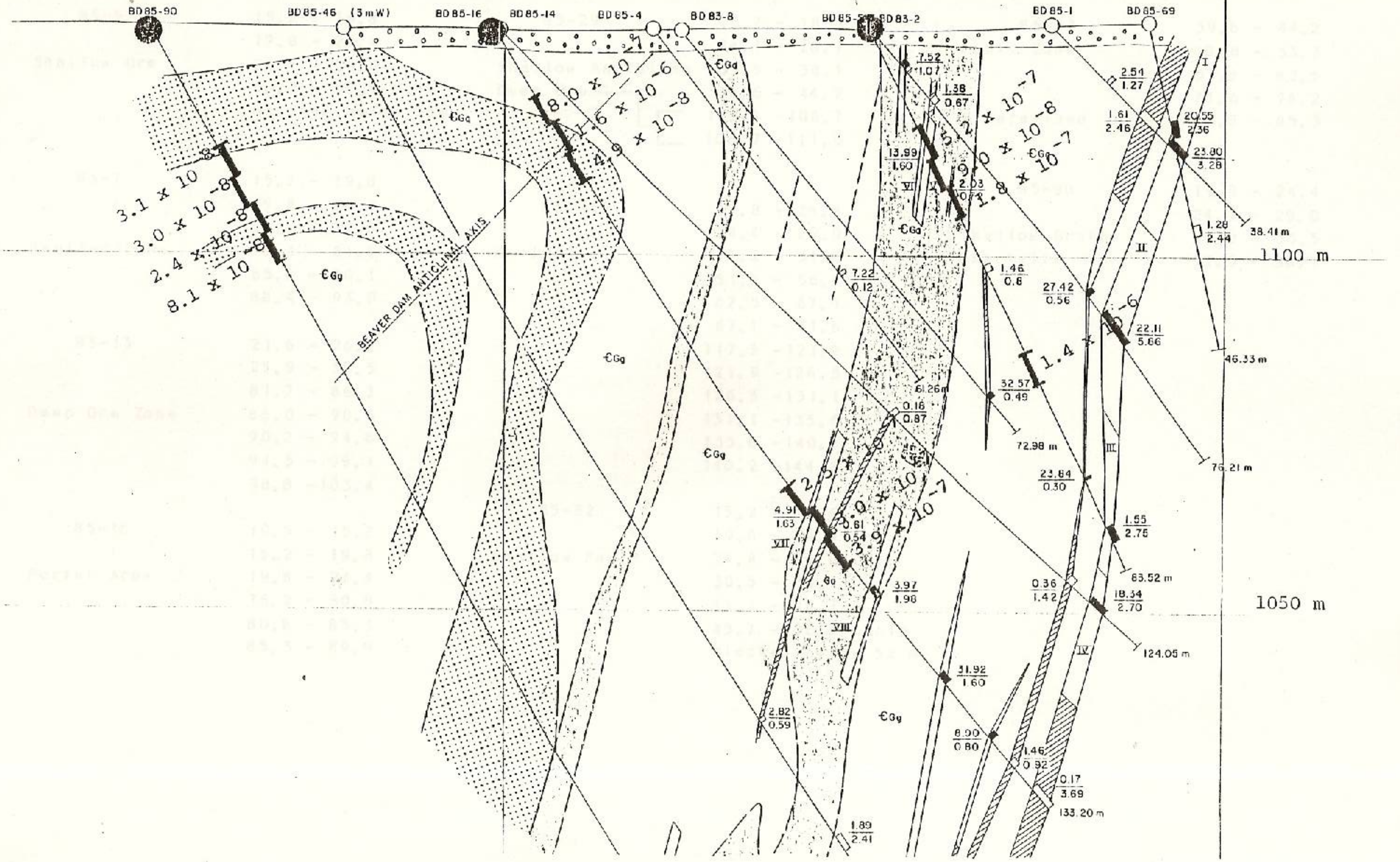


TABLE 2.1: PACKER TESTING INTERVALS

Diamond Drill Hole	Tested Interval (m)	Diamond Drill Hole	Tested Inverval (m)	Diamond Drill Hole	Tested Interval (m)
85-5	15.2 - 19.8	85-29	13.7 - 18.3	85-83	39.6 - 44.2
	19.8 - 24.4		24.1 - 28.7	Fault Zone	48.8 - 53.3
Shallow Ore	24.4 - 29.0	Shallow Anticline	33.5 - 38.1		57.9 - 62.5
	50.3 - 54.9 hole	Deep Ore	39.6 - 44.2		71.6 - 76.2
	blocked below 55m		102.1 -106.7	Mineralized	80.8 - 85.3
			106.7 -111.3		
85-7	15.2 - 19.8			85-90	19.8 - 24.4
	19.8 - 24.4	85 -43	19.8 - 24.4		24.4 - 29.0
	24.4 - 29.0		24.4 - 29.0	Shallow Broken	29.0 - 33.5
Faulted Zone	56.4 - 61.0	Anticline	47.2 - 51.8	Quartzite	33.5 - 38.1
	65.5 - 70.1		51.8 - 56.4		
	88.4 - 93.0		62.5 - 67.1		
			67.1 - 71.6		
85-13	21.6 - 26.2		117.3 -121.9		
	25.9 - 30.5		121.9 -126.5		
	81.7 - 86.3		126.5 -131.1		
Deep Ore Zone	86.0 - 90.6		131.1 -135.6		
	90.2 - 94.8		135.6 -140.2		
	94.5 - 99.1		140.2 -144.8		
	98.8 -103.4				
		85-82	15.2 - 19.8		
85-16	10.6 - 15.2		19.8 - 24.4		
	15.2 - 19.8	Shallow Fault	24.4 - 29.0		
Portal Area	19.8 - 24.4		30.5 - 35.1		
	76.2 - 80.8		41.1 - 45.7		
	80.8 - 85.3		45.7 - 50.3* hole		
	85.3 - 89.9		blocked below 52 m		

TABLE 2.2: HYDRAULIC CONDUCTIVITIES

Diamond Drill Hole	Depth (m)	K (m/sec)	D.D.H	Depth (m)	K (m/sec)	D.D.H.	Depth (mm)	K (m/sec)
85-5	15.2 - 19.8	5.2×10^{-7}	85-29	13.7 - 18.3	4.7×10^{-7}	85-83	39.6 - 44.2	1.5×10^{-8}
	19.8 - 24.4	9.0×10^{-8}		24.1 - 28.7	9.9×10^{-8}		48.3 - 53.3	1.0×10^{-8}
	24.4 - 29.0	1.8×10^{-7}		33.5 - 38.1	9.4×10^{-7}		57.9 - 62.5	1.2×10^{-9}
	50.3 - 54.9	1.4×10^{-6}		39.6 - 44.2	9.0×10^{-8}		71.6 - 76.2	7.1×10^{-9}
				102.1 -106.7	4.9×10^{-8}		80.8 - 85.3	2.7×10^{-8}
85-7	15.2 - 19.8	4.7×10^{-8}		106.7 -111.3	1.6×10^{-8}			
	19.8 - 24.4	1.1×10^{-8}				85-90	19.8 - 24.4	3.1×10^{-8}
	24.4 - 29.0	8.4×10^{-7}	85-43	19.8 - 24.4	8.3×10^{-9}		24.4 - 29.0	3.0×10^{-8}
	56.4 - 61.0	2.0×10^{-9}		24.4 - 29.0	2.6×10^{-8}		29.0 - 33.5	2.4×10^{-8}
	65.5 - 70.1	5.4×10^{-7}		47.2 - 51.8	1.0×10^{-6}		33.5 - 38.1	8.1×10^{-8}
	88.4 - 93.0	3.0×10^{-8}		51.8 - 56.4	2.3×10^{-7}			
				62.5 - 67.1	2.7×10^{-9}			
	21.6 - 26.2	2.0×10^{-8}		67.1 - 71.6	3.4×10^{-9}			
	25.9 - 30.5	2.4×10^{-8}		117.3 -121.9	1.0×10^{-9}			
	81.7 - 86.3	5.8×10^{-8}		121.9 -126.5	7.6×10^{-10}			
	86.0 - 90.6	4.1×10^{-8}		126.5 -131.1	2.6×10^{-9}			
	90.2 - 94.8	2.8×10^{-8}		131.1 -135.6	1.6×10^{-9}			
	94.5 - 99.1	2.5×10^{-8}		135.6 -140.2	5.5×10^{-10}			
	98.8 -103.4	4.3×10^{-8}		140.2 -144.8	3.7×10^{-10}			
85-16	10.6 - 15.2	8.0×10^{-7}	85-82	15.2 - 19.8	3.6×10^{-8}			
	15.2 - 19.8	1.6×10^{-6}		19.8 - 24.4	1.1×10^{-6}			
	19.8 - 24.4	4.9×10^{-8}		24.4 - 29.6	1.9×10^{-6}			
	76.2 - 80.8	2.5×10^{-7}		30.5 - 35.1	8.0×10^{-7}			
	80.8 - 85.3	3.0×10^{-7}		41.1 - 45.7	6.1×10^{-7}			
	85.3 - 89.9	3.9×10^{-7}		45.7 - 50.3	4.6×10^{-7}			

TABLE 2.3: INFLOW RATES

Level	Tunnel Length (m)	Hydraulic Conductivity (m/sec)	Inflow Rate (l/s [igpm])
1125	615	5.0×10^{-7}	4.9 [65.0]
1100	590	1.0×10^{-7}	0.9 [12.5]
1075	595	1.0×10^{-8}	0.1 [1.5]
1050	555	5.0×10^{-8}	0.4 [6.0]
		TOTAL	6.3 [85.0]

The testing program has demonstrated that, with the exception of shallow bedrock zones and the anticline axis, the bedrock at Beaver Dam Mine is considered to be relatively tight. This likely accounts for the poor water well yields reported for the Guysborough county area southeast of the site. Hydraulic conductivity generally decrease with depth, as would be expected, and tends to be lower in the mineralized argillite and quartzite zones then in the quartzite host rock. The higher bedrock permeabilities associated with the anticline axis (range 1.1 x 10^{-6} m/s to 4.7 x 10^{-7} m/s) are associated with the increased fracturing and deformation in the core of the overturned anticline fold. Hydraulic conductivity can be expected to be higher on the southern limb where bedding is more or less vertical.

Testing has shown that the hydraulic conductivity of the Mud Lake Fault zone is relatively low (mean 2 x 10^{-8} m/s) ranging from 1.1 x 10^{-6} m/s near ground surface at borehole 85-82 to 1.2 x 10^{-9} m/s) at 60 m depth at borehole 85-83. This is likely due to the presence of clay-like gouge materials which would tend to fill fractures and block groundwater flow. The Seabright Resources Geologist's log's describe the material as highly brecciated, very broken quartzite containing black graphite gouge material with poor core recoveries. The boreholes, as a result, were often unstable and tended to deform or cave in the fault areas. Several of the holes originally selected for packer testing (62, 5, 82) were found to be blocked at various depths.

It is concluded from the above, that the Mud Lake Fault zone will not likely be a major source of groundwater inflow to the mine. It should be noted, however, that the fault zones are saturated, and could be very unstable and would require special consideration should mining penetrate such rock materials.

The ore zones tend to exhibit the lowest values of hydraulic conductivity (geometric mean 1.5 x 10^{-8} m/s, range 5 x 10^{-7} m/s to 3.7 x 10^{-10} m/s). This is likely due to the presence of abundant quartzite veins and mineralized fill material in the rock fractures. Permeability appears to decrease with depth (K 10^{-10} m/s, borehole 85-43, 85-16). This suggests that the mine zones should be relatively "dry", with the majority of groundwater inflows occurring at shallower levels and via major joints in the bedrock.

Borehole 85-16 is located on the baseline at 0 + 75 m west, and penetrates the shallow bedrock zone where the mine portal will be constructed. Bedrock permeability inferred from the packer testing (Table 2) ranges from 1.6 x 10^{-6} m for a fractured quarzite zone about 13 to 14 meters in depth, to 5.0 x 10^{-10} m/s, averaging 3.5 x 10^{-7} m/s for the upper 78 m of bedrock at the portal location. This suggests that no large groundwater flow would be expected from bedrock in the immediate area of the portal. The most likely source of inflow would be from the overlying glacial tills (estimated K = 2 x 10^{-5} m/s from pump test of test hole # 1) and possibly from an old mine shaft found during portal preparation work approximately 50 meters to the north. The shaft was pumped out by Seabright personnel to a depth of 4.6 m (5.5 m to bottom) and exhibited a very slow recovery, confirming the above predictions. The dewatering of Austin Shaft 100 m to the east, (Section 3.0) with an estimated k of 9 x 10^{-7} m/s exhurted a low flow rate in the order of 3 L/S (40 igpm).

2.4 Calculation of Mine Inflow

In order to calculate the quantity of water inflow that might be expected into the mine workings, several assumptions were made. It was assumed that the hydraulic gradient at every point was equal to one. This is the worst case, and in practice the gradient will likely be somewhat less than one, especially after long time period when dewatering of the overlying rock mass has been achieved.

Actual gradients, however, could not be determined with the existing inclined borehole setups. It was also assumed that seepage would be occurring through all faces of the tunnels, (i.e. roof, floor and walls). Although it is acknowledged that most flow will be via individual fractures, the scale of the mine is large enough that sufficient fracture interconnectivity should occur to result in a hydraulic continuity around the mined area.

Plans of initial workings at four levels, 1125, 1100, 1075 and 1050 were measured to estimate exposed tunnel surface areas, assuming 4 m square tunnels. The average hydraulic conductivities at each level were used. Table 3 gives the measured tunnel lengths, hydraulic conductivities used, and calculated inflow rates.

The total calculated inflow into the tunnels at four levels, 6.3 l/s (85 igpm), may be affected by ore seam workings, fractures not encountered in the packer testing program and fluctuations in groundwater levels, but the calculated value should be representative of average conditions.

A projected mine inflow rate in the order of 100 igpm is considered reasonable for this area. Pump testing of the existing Austin Shaft supports this conclusion with an average inflow of 40 igpm at the 22 m level. Mine discharge rates of 50 igpm and 230 igpm were estimated for the Lake and Holman shafts respectively at nearby Caribou mine (NSDOE Files). During initial portal construction, flow rates may reach or exceed this projection due to inflow from the shallow overburden aquifer or surface water, but rates should decline once the incline portal has been stabilized. During mining, it is possible to encounter sudden groundwater flows from individual fractures, however, such flows should be short term as the fracture is dewatered.

2.5 Summary

A total of 56 determinations of bedrock permeability from 9 inclined exploration boreholes represent the range of hydraulic conductivity variation expected for the various rock types and structures associated with the Beaver Dam Mine. Bedrock hydraulic conductivity averaged 3×10^{-8} m/s for the site, ranging from 1×10^{-6} m/s to 4×10^{-10} m/s. The highest values were found to be associated with the anticline axis and the lowest values were associated with the deep ore zones. The Mud Lake Fault zone was found to have a low K, and the portal area was also found to be relatively tight.

In conclusion, no anomalous water-bearing fracture zones were detected by this packer program. For the exploration portal, an estimated mine inflow rate in the order of 6.3 L/S (85 igpm) is calculated. Full scale mining should be less than 15 L/S (200 ipgm). Dewatering testing conducted on the nearby Austin Shaft suport these predictions.

Pump sizing should therefore be capable of handling both the inflow water and process water used for drilling (est. 3-8 L/S (50 igpm). Some recycling of process water may be feasible within the mine.

3.0 AUSTIN SHAFT PUMP TEST AND GEOCHEMICAL EVALUATION

3.1 Purpose

A comprehensive geochemical monitoring program was conducted concurrent with a dewatering test of the existing Austin Mine workings located approximately 150 meters east of the proposed new mine portal. The primary purpose of the dewatering program was to provide additional site-specific hydrogeologic and groundwater quality information for the prediction and assessment of mine pumping requirements and effluent chemical quality for the new gold mine. The specific objectives of the study were to:

- Assess the bulk hydraulic properties of the shallow bedrock zone (0 - 22 m depth) as an aid in predicting mine inflow for the new mine.

- Evaluate water quality characteristics during pumping of the workings, with particular attention to geochemical variations during drawdown.

- To determine the degree of fracture continuity across the Beaver Dam mine site by monitoring drawdown response in available diamond drill holes during pumping of Austin Shaft.

  A secondary purpose, was to allow Seabright geologists an opportunity to examine the old workings.

3.2 Method

A high capacity, 40 hp submersible turbine pump was installed to a depth of 22 m in the Austin Mine shaft by R. Hopper Well Drilling Limited. Discharge was controlled by an orifice plate and discharge water was directed to a waste rock pile adjacent to a large swamp area. Drawdown was monitored with an electric tape in a drop tube strapped to the pump riser pipe. A valve and flow-through cell were connected to the discharge pipe to facilitate water quality monitoring and sample collection.

Pumping began on June 18, 1986 at 1330 hours at a discharge rate of 500 igpm. Drawdown, ph, dissolved oxygen, temperature and electrical conductance were monitored for a total of 16 hours until drawdown reached the top of the pump bowls (20.5 m). Pumping was terminated at 0535 hours June 19, 1986 and recovery was monitored for 7 hours. The pump was again turned on, for approximately 1.5 hours until water level again reached the top of the pump. The mine was then allowed to recover for a period of two weeks.

Because the initial pump could only dewater the mine to within 1.5 meters of the bottom, a second 30 hp centrifugal pump was acquired and installed in the well on July 8, 1986. The larger submersible pump was started on July 8, 1986 at 1350 hours at a pumping rate of 480 ipgm. The pump was shut down for 6 hours to observe recovery trends, and then restarted. Drawdown and water quality were monitored in a similar manner to test #1. When the large pump broke suction on July 9, 1986 at 1440 hours at 20.8 m after a total of 14 hours of pumping, the smaller centrifugal pump was started at a rate of 166 igpm until it broke suction at 1130 hours, July 10, 1986 at about 21.6 m depth. The initial 10 minutes of pumping after start-up of the second pump produced slightly turbid water due to pump turbulance, however, this quickly shifted to a colorless, ordorless discharge throughout the remainder of the test.

Pumping rate dropped to approximately 38 igpm and remained stable for the final 7 hours of the test. A steady-state flow rate of 38 igpm was measured for the Austin shaft at 21.6 m of depth. Time drawdown data and plots are presented in Appendix 2.

During the mine dewatering, continuous monitoring of water quality was maintained, and selected samples were sent to the Environmental chemistry laboratory for analysis of metals and major ions. Field monitoring of ph, temperature, dissolved oxygen and electrical conductance were performed in a flow-through cell specially devised for this project. This device prevented the rapid degassing of the mine water and prevented contact with the atmosphere, resulting in more reliable measurement of these sensitive parameters. Samples subjected to metal analysis were field preserved with nitric acid in test # 1, and unpreserved in test #2.

Appendix 2 contains drawdown and recovery data and time-drawdown plots for the two pump tests. The results of laboratory analysis and field analysis of water quality for the two pumping tests are presented on Tables 3.1 to 3.3. A summary of available groundwater quality data for the Beaver Dam site is presented on Table 3.4. The orientation of Austin Shaft and diamond drill holes monitored during the test are shown on Figure 1.2.

3.3 Discussion of Results

Time drawdown data for the two dewatering tests were very similar (Appendix 1). At a pumping rate of 480 to 500 igpm, an average drawdown of 192 cm/hr (1.5 inches/min) was observed until water level reached the top of the drift where drawdown decreased to approximately 13 cm/hr as the workings were dewatered. In test #2, when the centrigugal pump was in operation at a rate of 167 igpm, drawdown continued from 20.8 m to suction break at approximately 21.8 m at a rate of about 5 cm/hr, accelerating over the last 0.3 m due to depression-dewatering around the pump. In both tests, the Austin shaft exhibited a consistant recovery rate of 2.5 cm/hr (1"/hr) within the workings, accelerating to about 5 cm/hr within the shaft. It took approximately 2 weeks for full recovery to occur after test #1. The faster drawdown rate exhibited during pump test #2 may be due to a combination of distance-dewatering effects (incomplete recovery), low permeability of the bedrock, lack of rainfall, and lower mean static water level (1.2 cm lower than the June 18 test).

When drawdown reached the bottom of the pump at 21.8 m below shaft collar, the discharge decreased to a steady-state pumping rate of 3 L/S (38 igpm) throughout the final 7 hours of testing. The discharge remained clear, and no evidence of excessive turbidity was observed. Minutes prior to the drop in discharge rate, increasing amounts of clean bark chips and wood debris were observed in the flow-through cell, which signalled that drawdown was approaching the intake screen. The water remained clear and odor-free over the last few hours of pumping.

An empirical estimate of mine water volume 2273 m^3 (0.5 MIG) was made based on the assumption of 2300 m^3 (625,000 imp gal) water pumped and 3 L/S (40 igpm) mine inflow rate. Assuming a 40 igpm steady state flow rate, a bulk apparent transmissivity of 18.7 $m^3/d/m$ (1253 igpd/ft) is estimated assuming a tunnel length of 425 m (from mapping supplied by Seabright Inc.) and an average drift size of 2 m square. This suggests a hydraulic conductivity in the order of 9 x 10^{-5} cm/s, for the upper 22 m of bedrock in this area.

The Austin Shaft, containing approximately 2300 m^3 of water, exhibits a steady shaft pumping rate of 3 L/S (38 igpm). This value is lower than estimates of steady state discharge rates reported from the nearby Caribou Gold Mine (NSDOE, 1983). The Holman Shaft containing 45,500 m^3 of water was pumped at a rate of 17.4 LS (230 igpm) and the Lake Shaft containing 25,000 m^3 of water was pumped at 3.8 L/S (50 igpm).

To assess the impact of the Austin Shaft on the proposed portal, and to determine the area affected by the mine dewatering, several of the existing diamond drill holes were monitored periodically during the dewatering operation. (Table 3.5). Drawdown distribution in various boreholes during both tests showed that there is hydraulic continuity over a large area of the mine site. The greatest drawdowns were observed in the area bounded by lines 0 + 25 E and 0 + 75 E, which is underlain by the Austin workings. Drawdowns of greater than 12.2 m (40 ft) were observed at boreholes 52 and 59, which are believed to penetrate the northern extensions of the Austin workings. Running water could be heard at borehole 52. Several of the boreholes immediately adjacent to the Austin workings (83-71, 85-2, 85-3) were dry to depths greater than 7.6 m. Drawdowns of up to 1 m were observed as far west as BD-85-18, and 85-1 in the vicinity of the proposed portal (0 + 75E). It is possible that some of these inclined boreholes may encounter un-mapped workings along the Austin Seam (Figure 1.2). The majority of the boreholes west of line 0 + 50E exhibited minor or no water level response during testing. Because all of the observation holes are inclined at attitudes of 45° to 70°, further assessment of bedrock hydraulic properties is not practical.

It is concluded from the above, that there is a fair to moderate degree of fracture continuity along the Austin Seam, and in shallow bedrock surrounding the Austin Shaft. It is likely that due to the existing natural fracture distribution, and due to blasting of new mine workings, that long term dewatering of mined workings will influence other boreholes at distances exceeding 100 m, and the new mine, in time, would likely dewater the Austin Shaft.

Water Quality

Water quality during the pumping tests remained relatively steady (pH 6.8; D.O. 2.2 ppm; conductance 82 mS; temperature 5.3 °C) until drawdown entered the mine workings. (Tables 3.1 to 3.3). When drawdown reached 1.5 meters from the bottom, the dissolved oxygen content began to rise to about 3.0 ppm (test #1) and 5.0 ppm (test #2) due to uptake of oxygen in the mine shaft. When drawdown broke suction at 21.8 m depth, the dissolved oxygen increased dramatically due to aeration at the pump intake. This was accompanied by a rise in pH as degassing of dissovled CO_2 gas occurred. A laboratory experiment conducted on a presevedwater sample exhibited a similar rise in pH from 6.51 to 7.3 after 2 days of exposure to the air. This suggests that mine effluent waters should be of neutral pH and that mine waters are likely saturated with respect to calcite derived from the bedrock.

Throughout the pumping there was continual increase in major ions, TDS (43 to 83 ppm), hardness (28-45 mg/L), pH (6.4-7.4) alkalinity (24-56 mg/L, silica (5.2-9.5 mg/L), suspended solids (0.3 - 7.3 mg/l) and metals such as arsenic (0.04 - 0.17 mg/L); iron (0.32 - 2.6 mg/L), manganese (0.3 - 0.38 mg/L), and a drop in concentration of nitrate (0.13 to (0.05 ppm).

Water Samples

X	Austin Shaft May 6/86, t = 0
1	Austin Shaft June 18/86, t = 1 hr
2	Austin Shaft June 18/86, t =16 hr
3	Austin Shaft June 19/86, t =23 hr
4	Austin Shaft July 10/86, t =52 hr
L	Crusher Lake June 13/86
B	Borehole 86-47 June 13/86
D	Dug Well June 26/86

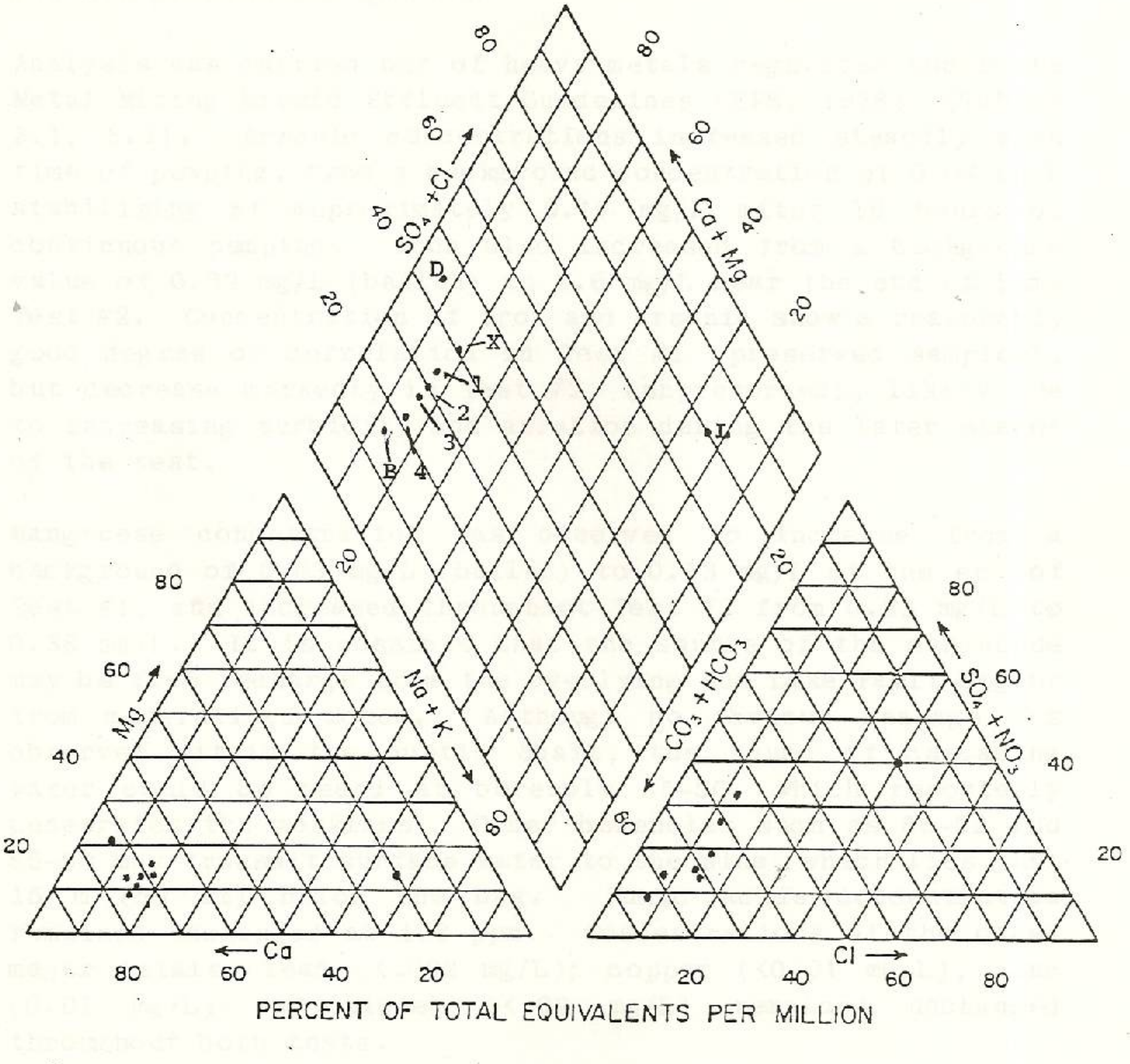


FIGURE 3.1 Distribution of Major Ions, Water Quality Samples Seabright Resources Inc. Beaver Dam Mine, 1986.

It is apparent that, from the unpumped sample bailed from the shaft May 6, 1982, through the two pump tests, the chemistry of the Austin Shaft water is approaching that of natural deep groundwater as exhibited at diamond drill hole 86-47 (Table 3.4). This is illustrated graphically in Figure 3.1 which shows the linear trend in groundwater chemistry towards that of deep groundwater (B). Borehole 86-47 is a flowing artesian well which was pumped several times for drilling water, and is therefore, considered resprentative of the deep bedrock groundwater quality.

Analysis was carried out of heavy metals regulated under the Metal Mining Liquid Effluent Guidelines (EPS, 1978), (Tables 3.1, 3.2). Arsenic concentrations increased steadily with time of pumping, from a background concentration of 0.04 mg/L stabilizing at approximately 0.17 mg/L after 16 hours of continuous pumping. Iron also increased from a background value of 0.32 mg/L (bailed) to 2.6 mg/L near the end of pump Test #2. Concentration of iron and arsenic show a reasonably good degree of correlation in Test #1 (preserved samples), but decrease markedly in Test #2, (unpreserved), likely due to increasing turbidity and aeration during the later stages of the test.

Manganese concentration was observed to increase from a background of 0.03 mg/L (bailed) to 0.13 mg/L at the end of Test #1, and increased throughout Test #2 from 0.23 mg/L to 0.38 mg/L. It is possible that the source of the manganese may be from recharge from the overlying Mud Lake Fault bog or from mineralized zones. Although no obvious leakage was observed within the Austin Shaft, the sound of cascading water could be heard at borehole 85-56, which reportedly penetrates the workings. Other boreholes such as 85-52 and 85-50 may transmit surface water to the mine, which lies just 15 m (50 ft) below the bog. Humic acids concentration remained unchanged at 1.8 ppm. Concentrations of the other major metals, lead (<.002 mg/L); copper (<0.01 mg/L), zinc (0.01 mg/L) and nickel (<.02 mg/L) remained unchanged throughout both tests.

Continuous monitoring of pH was carried out in-situ using a flow-through cell which prevented contact between the sample and the atmosphere. During the May 6, 1986 sampling prior to pumping, pH levels wre measured at 6.8 (Table 3.4). During the first pump tests, ph remained essentially stable at 6.7, but rose to about 7.7 at the beginning of pump Test #2. This increase may be due to oxidation and degassing of groundwater in the mine during the recovery of Test #1. Dissolved oxygen levels increased to 3.0 ppm (Test #1) and 5 ppm (Test #2) after periods of recovery. A similar increase in pH from 6.8 to 7.35 was seen near the end of Test #2 under aeration conditions.

It was noted that after a period of recovery within the workings, there was a large drop in pH from 6.8 to 5.1 (Test #1 after 7 hours of recovery) and from 7.7 to 6.8 after a series of pump stoppages in Test #2. This suggests that there may be some oxidation of sulfide mineralization on the walls and floor of the workings as groundwater recharge occurs. The subsequent rise in pH after 2 1/2 weeks of recovery had occurred and dissolved oxygen had become depleted, suggests buffering of the mine water by such processes as calcite dissolution or sulfate reduction. Acid generation testing conducted on the wasterock from Austin Shaft indicates a mild acid generation capacity (1.2 to 1 ratio). Testing of the non-mineralized quartzite bedrock indicates a significant acid consuming potential (33 to 1 ratio). This could account for the observed variation in pH. It is noted that the drop in pH to 5.1 after 23 hours of pumping in Test #1 resulted in a slight decrease in arsenic concentration to 0.14 mg/L. Arsenic solubility is known to increase with increasing pH.

The chemical analysis and monitoring conducted during the Austin Shaft dewatering indicates that the effluent quality from this mine and the proposed portal should fall within the MMLEG (1978) guidelines. The Beaver Dam metal concentrations are well below those monitored during the Caribou Mine dewatering, carried out in 1983 (Table 3.6). It is interesting to note that the concentrations of arsenic, iron, aluminum and manganese exhibited a significant decrease after passage through a bog area. It is reasonable to conclude that the large bog separating the mine site and Cameron Flowage will afford adequate attenuation of the low levels of metals released from the new mine.

3.4 Summary

A dewatering program conducted on the existing Austin Mine Shaft at Beaver Dam mine has demonstrated that bedrock permeability in the upper 22 m is relatively low in the order of 9.0 x 10^{-7} m/s, resulting in a steady state discharge rate of only 3 litres/sec (40 ipgm) for the Austin workings. An empirically-derived mine volume of 2273 m^3 (0.5 MIGD) is calculated. The shallow bedrock exhibits a fair to moderate fracture interconnectivity, exhibited by measureable borehole hydraulic head response at distances of up to 100 m from the workings. Approximately one meter of drawdown was observed in boreholes adjacent to the proposed new mine portal, which suggests that there will be some minor hydraulic interaction between the two mines at that point. The majority of the new workings would be located further to the west. The majority of the water pumped from Austin Shaft appears to be derived from deep groundwater, rather than surface sources.

Monitoring of discharge water quality suggests that the effluent from the new mine should meet the requirements of the Metal Mining Liquid Effluent Guidelines. The water is described as a soft slightly oxidized (2 ppm D.O.), calcium bicarbonate water, typical of Meguma-Group groundwater in Nova Scotia. Although there is potential for minor acidic drainage in the mine workings, chemical analysis suggests that there is a reasonable degree of buffering capacity in the groundwater (pH 7.3) and the un-mineralized bedrock. Mine effluent pH should be in the range of 6.0 to 7.5, depending on the pumping rate from the mine, and the relative percentage of sulfide mineralized to non-mineralized wall rock.

Suspended solid loads from undisturbed mine sumpage water should also be within the guideline. Should levels exceed the guideline due to drilling and blasting operations, then measures can be implemented to treat the small flow volumes expected at the discharge point.

TABLE 3.1: AUSTIN SHAFT PUMPING TEST # 1 WATER QUALITY DATA, JUNE 18, 1986

	10 min.	1 hr.	4 hr.	6 hr.	9 hr.	16 hr.	23 hr.*	24 hr.
Metals**								
Arsenic	0.10	0.10	0.14	0.16	0.17	0.17	0.14	0.15
Iron	1.1	0.96	1.5	1.8	1.8	1.4	1.4	1.3
Manganese	0.06	0.05	0.07	0.05	0.09	0.11	0.12	0.13
Lead	<0.002	<.002	<.002	<.002	<.002	<0.002	<.002	<.002
Copper	<0.01	<.01	<.01	<.01	<.01	<0.01	<.01	<.01
Zinc	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nickel	<0.02	<0.02	<.02	<.02	<.02	<0.02	<.02	<.02
Sodium		2.8				3.3	2.3	
Potassium		1.1				1.1	1.0	
Calcium		13.0				16.0	10.0	
Magnesium		1.3				1.2	1.2	
Hardness		37.8				45.0	30.0	
Alkalinity		31.7				30.5	25.4	
Sulfate		7.2				7.0	7.2	
Chloride		3.8				4.6	3.8	
Flouride						<0.1		
Silicate						6.1		
Phosphate						0.01		
Nitrate						0.07		
Ammonia						<0.05		
TDS						57.0		
Susp. Solids						6.8		
Colour (TCU)						25.0		
Turbidity (JTU)						8.9		
Conductance (uS)						85.0		
pH						6.6		
Field Parameters								
Dissolved O_2 (ppm)	1.6	1.8	2.15	2.20	2.35	2.50	3.0	3.2
pH	6.73	6.67	6.74	6.72	6.31	6.81	5.46	6.92
Temp (°C)	5.9	5.5	5.5	5.5	5.2	5.5	5.8	5.8
Cond.(uS)	56.0	55.0	55.0	54.0	59.0	60.0	63.0	62.0
Drawdown(m)	.25	3.83	10.41	12.74	15.29	16.74	16.58	16.81

* 7 hours of recovery between t = 16 hr. and t = 23 hr.

** metals were field preserved with nitric acid

All parameters in mg/L unless otherwise noted.

TABLE 3.2: AUSTIN SHAFT PUMPING TEST # 2 WATER QUALITY DATA, JULY 8-12, 1986.

Sample No. Time	1 2 hr.	2 22 hr.	3* 25 hr.	4 44 hr.	5 46 hr.	6 49.5 hr.	7 52.5 hr.
Metals							
Arsenic	.06	.08	.26	.11	.14	.14	.11
Iron	1.1	1.3	8.9	1.9	2.6	1.3	2.6
Manganese	.23	.27	.40	.32	.35	.33	.38
Lead	<.002	<.002	.009	<.002	<.002	<.002	<.002
Copper	<.01	<.01	.02	<.01	<.01	<.01	<.01
Zinc	.01	.01	.02	<.01	<.01	<.01	<.01
Nickel	<.02	<.02	<.02	<.02	<.02	<.02	<.02
Sodium							4.4
Potassium							1.4
Calcium							21.0
Magnesium							2.0
Hardness							60.5
Alkalinity							56.5
Sulfate							9.4
Chloride							4.4
Flouride							<.1
Silicate							9.5
Phosphate							<.01
Nitrate							<.05
Ammonia							<.05
TDS							83.0
Sup. Solids							7.3
Colour (TCU)							7.5
Turbidity (JTU)							19.0
Conductance (uS)							153.1
pH							7.4
Humic Acid							1.8
Aluminum							0.06
Boron							0.02
Barium							0.007
Beryllium							<0.005
Chromium							<0.01
Cadium							<0.01
Cobalt							0.01
Antimony							<0.02
Selenium							<0.10
Tin							<0.03
Vanadium							<0.01
Field Parameter							
Dissolved O_2	1.59	1.8	-	4.8	15.4**	13.2	13.4
pH	7.78	-	6.98	6.78	7.29	7.29	7.20
Temp (°C)	6.7	-	-	6.3	6.3	6.3	6.3
Cond. (uS)	81.0	-	-	85.0	88.0	89.0	75.0
Drawdown (m)	9.4	16.9	16.9	17.82	17.7	17.7	17.7

* Start-up of centrifugal pump caused a short period of turbidity

** Pump breaking suction, t = 45 hr. All parameters in mg/L unless otherwise noted.

TABLE 3.3: FIELD CHEMISTRY DATA, AUSTIN SHAFT DEWATERING TEST

TEST NO. 1, JUNE 18 - 19, 1986

Time (min)	Drawdown (m)	Temp.(°C)		pH	Cond.(uS)	D.O.(mg/L)	Sample
June 18/86							
13:30	0			6.73	54	2.3	
13:35							
13:39							
13:45	0.25	5.9	4.6	6.7	56	1.60	#1
13:55	0.80	5.5	4.6	6.71	56	1.65	
14:05	1.52	5.5	4.5	6.72	56	1.75	
14:15	2.69	5.8	4.7	6.72	56	1.65	faint H_2S odor
14:25	3.29	5.5	4.5	6.70	55	1.75	from other shaft
14:35	3.83	5.5	4.5	6.67	55	1.80	#2
15:03	5.64	5.9	4.8	6.61	52	2.05	Turbidity Increase
15:35	7.72	5.7	4.7	6.59	50	2.00	
16:35	9.14	5.5	4.7	6.72	52	2.00	
17:35	10.41	5.5	4.6	6.74	55	2.15	#3
18:35	11.43	5.5	4.4	6.65	50	2.20	
19:35	12.74	5.5	4.2	6.72	54	2.20	#4
21:35	14.63	5.50	3.8	6.78	59	2.30	
22:35	15.29	5.2	3.6	6.31	59	2.35	#5
23:35	15.87	5.1	3.5	6.48	60	2.32	
June 19/86							
00:35	15.97	5.3	3.5	6.15	60	1.70	
02:45	16.22	5.5	3.5	6.51	60	7.40	MS
04:35	16.58	5.3	3.5	6.4-6.8*	60	2.40	*Shifting
05:35	16.74	5.5	3.5	6.5-6.86*	60	2.50	MS #6
PUMP OFF (SHORT RECOVERY 7 1/2 HOURS) 12:52							
12:52	16.58	5.8	4.0	5.12	64	3.35	#7
13:01	16.62	5.8	4.2	5.46	63	3.0	
13:11	16.65	5.8	4.4	5.95	63	3.0	
13:21	16.70	5.8	4.4	6.71	63	3.0	
13:31	16.72	5.8	4.6	6.72	62	3.0	
13:41	16.76	5.8	4.6	6.90	62	3.05	
14:01	16.81	5.8	4.6	6.92	62	3.2	#8
14:17	16.86	5.8	4.6	6.92	62	3.0	

TEST NO. 2, JULY 8 - 11, 1986 July 8/86

Time (min)	Drawdown (m)	Temp.(°C)		pH	Cond.(uS)	D.O.(mg/L)	Sample
July 8/86							
14:07		6.9	7.0	7.96	33	1.31	
15:00	7.28	6.9	6.6	7.80	84	1.40	
16:00	9.39	6.9	6.7	7.78	81	1.59	#1
17:00	11.08	6.9	6.5	7.69	78	1.98	
18:00	12.45	6.8	6.6	7.69	76	2.25	
July 9/86	PUMP OFF 00:01 to 06:00 (6 hr. recovery)						
12:00	16.89						#2
14:53	16.88	9.2		6.98			#3
July 10/86							
09:00	17.66	6.8	6.5	6.78	87	5.5	
10:00	17.82	5.3	6.3	6.78	85	4.8	#4
11:00	17.96	5.3	6.3	7.10	88	4.8	
12:00	18.00	5.3	6.3	7.29	88	15.4	#5
13:00	18.00	5.3	6.3	7.33	89	10.6	
13:30	18.00	5.6	6.3	7.35	89	12.4	
15:30	18.00	5.6	6.3	7.29	89	13.2	#6
18:30	18.00	5.3	6.3	7.20	75	13.4	#7

TABLE 3.4: Water Quality Analysis for Groundwater Samples, Beaver Dam Mine (1986)

		AUSTIN MINE SHAFT					
	Depth Below Water	May 6/86 7 metres (Bailed)	May 6/86 17 metres (Bailed)	June 19/86 16 hr. pumping#1	July 10/86 52 hr. pumping#2	June 13/86 Flowing DDH 86-47	June/86 Dug Well pumped
Sodium	mg/L	2.1	2.3	3.3	4.4	4.4	2.0
Potassium	mg/L	0.9	0.8	1.1	1.4	1.3	0.3
Calcium	mg/L	8.3	9.5	16.0	21.0	24.3	21.0
Magnesium	mg/L	1.0	1.1	1.2	2.0	2.0	3.5
Hardness ($CaCO_3$)	mg/L	25.0	28.34	45.0	65.0	69.0	67.0
Alkalinity ($CaCO_3$)	mg/L	20.3	23.5	30.5	56.5	69.0	40.7
Sulfate	mg/L	8.0	8.0	7.0	9.4	7.5	22.0
Chloride	mg/L	3.3	3.1	4.6	4.4	4.6	6.4
Fluoride	mg/L	<0.1	<0.1	<0.1	<.1	0.2	<.1
Silica	mg/L	4.8	5.2	6.1	9.5	12.0	3.9
Orthophosphate	mg/L	0.02	<0.01	.01	<.01	.01	<.01
Nitrate + Nitrite	mg/L	0.18	0.13	.07	<.05	<.05	0.12
Ammonia	mg/L	<0.05	<0.05	<.05	<.05	<.05	<.05
Arsenic	mg/L	0.04	0.04	0.12	0.11	.04	.04
Iron	mg/L	0.3	0.32	1.2	2.6	.50	2.3
Manganese	mg/L	<0.01	0.03	0.15	0.38	.31	.25
Lead (HGA)	mg/L	<0.002	<0.002	.003	<.002	<.002	.009
Copper	mg/L	<0.01	<0.01	.01	<.01	<.01	.01
Zinc	mg/L	<0.01	<0.01	.02	<.01	<.01	.03
Total Dissolved Solids	mg/L	35.0	43.0	57.0	83.0	94.0	84.0
Suspended Solids	mg/L	<0.3	<0.3	6.8	7.3	0.8	382.0
Color	T.C.U.	5.0	5.0	25.0	7.5	20.0	12.5
Turbidity	J.T.U.	1.5	2.3	8.9	19.0	0.4	87.0
Conductivity (umho/cm)	umHo/cm	69.0	76.0	85.0	153.0	161.0	149.0
pH	units	6.30	6.40	6.6	7.3	7.4	6.8
Humic Acid	mg/L	2.0	2.0		1.8		
Aluminum	mg/L	<0.05	<0.05		0.06		
Boron	mg/L	<0.02	<0.02		0.02		
Barium	mg/L	<0.005	<0.005		0.007		
Beryllium	mg/L	<0.005	<0.005		<0.005		
Chromium	mg/L	<0.01	<0.01		<0.01		
Cobalt	mg/L	<0.01	<0.01		0.10		
Nickel	mg/L	<0.02	<0.02	<.02	<.02		
Antimony	mg/L	<0.05	<0.05		<0.02		
Selenium	mg/L	<0.1	<0.1		<0.10		
Tin	mg/L	<0.03	<0.03		<0.03		
Vanadium	mg/L	<0.01	<0.01		<0.01		
Mercury	ug/L	<0.05	<0.05		-		
Cadmium-ICP	mg/L	<0.01	<0.01		<0.01		
Field Measurements							
pH	units	6.77	6.80 (downward drift)	6.81	7.20		
Conductivity	umho/cm	47.0	50.0	60.0	75.0		
Temperature	(°C)	5.0	4.2	5.5	6.3		
Dissolved Oxygen	ppm	2.0	2.0 (June 18, 1986)	2.5	13.4		
Odor	TCC	NONE	NONE	NONE	NONE		

TABLE 3.5: HYDRAULIC HEAD MONITORED AT SELECTED DIAMOND DRILL HOLES DURING THE AUSTIN SHAFT DEWATERING PROGRAM

Beaver Dam Mine
Depth in Meters Below Ground Surface

Borehole No.	Test #1	Test #2
85-8	0.889	2.20
85-18	0.31	1.10
85-4	0.52	--
85-5	0.749	1.51
85-1	0.711	2.18
85-64	0.673	1.91
85-67	0.616	1.32
85-6	0.502	4.81
85-10	0.0	--
85-13	0.013	--
85-31	1.42	4.25
85-34	2.55	3.61
85-82	2.74	2.79
85-52	7.67	12.38
85-50	0.940	--
85-56	6.22	12.35
85-9	0.254	--

TABLE 3.6: CARIBOU GOLD MINE, AUGUST 26, 1983 WATER QUALITY ANALYSIS

Parameter (mg/L)	Discharge Pipe	Surface @ Culvert	Bog Area
Arsenic	1.3	1.3	.25
Iron	3.4	3.0	.22
Manganese	1.5	1.5	.22
Lead	<.002	.002	<.002
Copper	<.01	<.01	<.01
Zinc	0.02	.01	<.01
TDS	204.0	203.0	179.0
Conductivity(umho/cm)	340.0	340.0	300.0
pH	7.1	7.2	7.5
Aluminum	.17	.17	<.05
Boron	<.02	<.02	<.02
Barium	.04	.04	.02
Beryllium	<.005	<.005	<.005
Cadmium	<.002	<.002	<.002
Chromium	<.01	<.01	<.01
Cobalt	<.01	<.01	<.01
Nickel	<.02	<.02	<.02
Antimony	<.05	<.05	<.05
Selenium	<.10	<.10	<.10
Tin	<.03	<.03	<.03
Vanadium	<.01	<.01	<.01

Source: NSDOE Environmental Assessment Records

4.0 WATER SUPPLY EXPLORATION PROGRAM

4.1 Purpose

A program of groundwater exploration was carried out by Jacques, Whitford & Associates Ltd. on behalf of Seabright Resources Inc. to evaluate the feasibility of developing a groundwater supply for potable and mine uses. A groundwater source was preferred over a surface water source for a number of reasons, including possible closer proximity to the mine site, thus reducing capital expenditures for piped service; better overall water quality, which would reduce or eliminate water quality treatment requirements; and long term security of supply, since little is known about the hydrology of the available surface water sources. Projected water demand for both potable and mine supply uses was in the order of 3 liters/second, which, with the appropriate storage capacity, would require a well or wells capable of at least 3 L/S (40 igpm) sustained yield.

4.2 Method

Previous drilling attempts in the area of the temporary construction camp failed to develop a viable bedrock well. A 91 meter test well at the construction camp yielded no water after stimulation by blasting. The low hydraulic conductivity values determined by packer injection testing on selected diamond drill holes (Section 2.0) further suggest a low probability of developing bedrock wells in excess of 0.07 to 0.4 L/S (1 to 5 igpm). An average hydraulic conductivity of 2.7×10^{-8} m/s suggests a bulk transmissivity of 0.21 m^2/d (14.3 igpd/ft) for a 91 m (300 ft) drilled well, which would be expected to yield about 0.1 L/S (1.5 igpm). This is within the range and somewhat lower than values determined for pump testing of wells completed in quartzite bedrock in Halifax County (mean yield 0.2 L/S) and Guysborough County (mean yield 0.23 L/S) (Appendix 1). A further indication of low bedrock transmissivity is the very slow recovery of Austin Shaft after dewatering of 0.6 m/day (see Section 3.0).

Because of the low probability of developing the required 3 L/S from bedrock wells, exploration then focused on the silty sand and gravel glacial till overburden which mantles the mine site. Diamond drilling north of the centre line indicates overburden thickness varying between 1.5 metres to over 22 metres in a bedrock depression developed over Mud Lake Fault, and averaging 3.5 to 4.5 metres in the vicinity of the mine site and portal. Significant volumes of groundwater may be associated with the sand and gravel deposits reported in the Mud Lake Fault Trench, however, this area is designated for future exploration. The flat lying area of the mine site may have some potential for dug well development, but potential for contamination or dewatering due to mine activities is present.

With consideration of the topography, drainage, bedrock structure and available information on overburden thickness, it was reasoned that the best location for dug well exploration may be the base of the slope between the mine site and Crusher Lake. A seismic refraction profile (Figure 4.1) was run normal to the slope at 2 + 00 W adjacent to the waste rock storage area. This profile inferred an undulating bedrock topography and an apparent depth of 5 to 8 m (25 ft). A second possible exploration area was identified near Crusher Lake.

A test pit program was conducted on June 26, 1986 to locate sites for dug wells or lateral screen collectors. Based on the seismic data, Test Pit # 1 was excavated across the apparent bedrock depression from Station 1 + 75 S to 1 + 65 S on line 2 + 00 W. Bedrock was encountered at a depth of 4.9 m, and not the 7.0 m inferred from the seismic profile. Four additional test pits constructed within a 50 m radius of Test Pit # 1 varied in depth from 3.3 m to 4.0 m, with similar stratigraphy.

Four soil samples were collected from Test Pit # 1 for grain size analysis at Jacques, Whitford & Associates Ltd. laboratory (Appendix 3). Overburden is described as a 0.6 m layer of orange-brown silty sand and gravel overlying olive brown sandy gravel with some silt containing angular

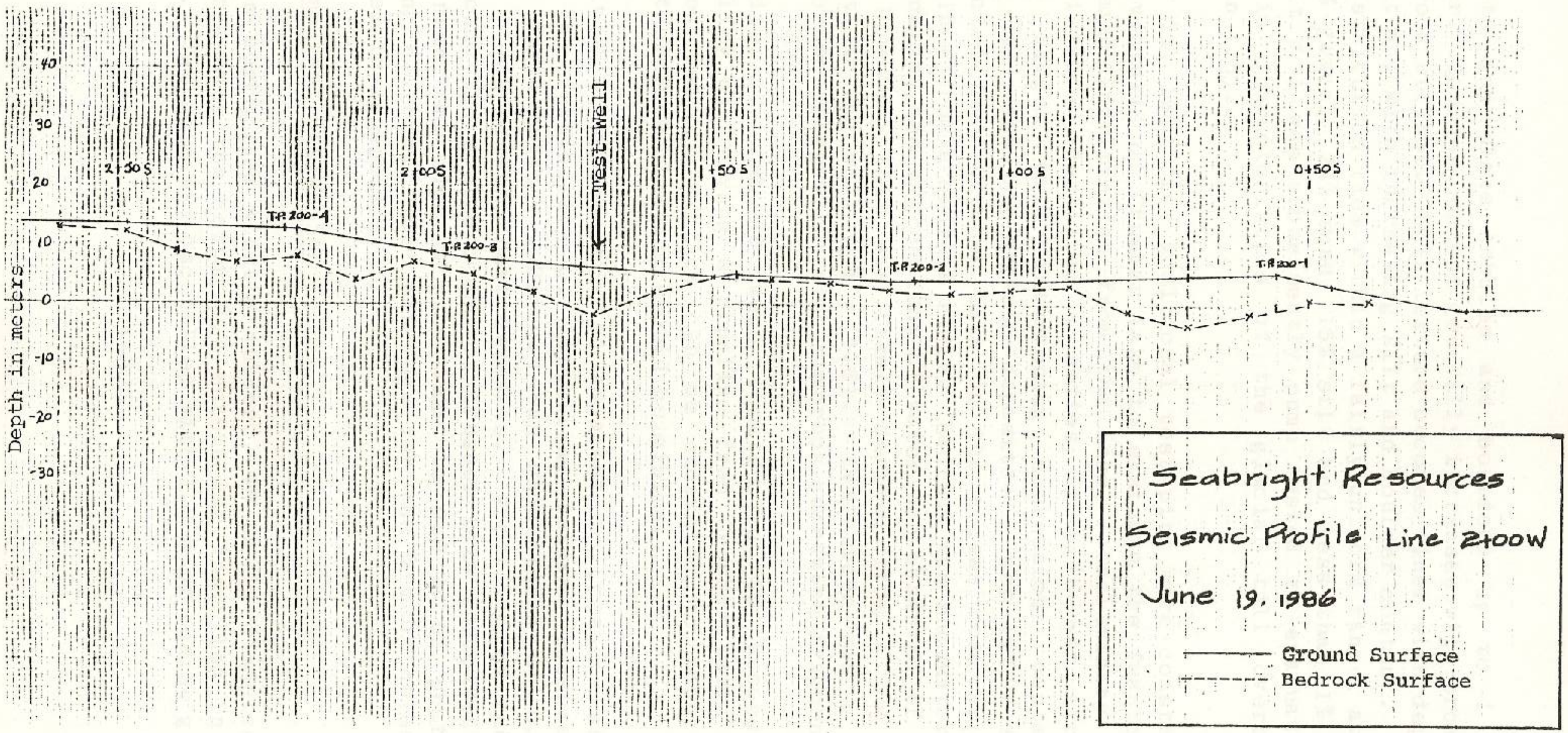


FIGURE 4.1 SEISMIC PROFILE LINE 2 + 00 W. SEABRIGHT RESOURCES INC.
BEAVER DAM MINE, HALIFAX COUNTY, N.S.

Scale: 1:1000		Fig. No: 4.1	JACQUES WHITFORD & ASSOC. LTD.
Date: July 25'86	Dwn. By: D.D.H.	Appd.	

quartzite and slate cobbles and boulders up to 1 m in diameter. Boulder content generally increases with proximity to bedrock surface. Soil texture becomes finer with depth in Test Pit # 1 with increasing silt and boulder content. Grain size distribution lies within a fairly uniform range, averaging 61% gravel, 24% sand, 15% silt and less than 1% clay. Test Pit # 1 was subsequently pump tested to evaluate the hydraulic characteristics of the glacial till overburden (Section 4.3).

On July 11, 1986 five additional test pits were constructed in the vicintiy of Crusher Lake to evaluate the feasibility of induced infiltration from the lake. Preliminary field reconnaissance identified a series of east-west striking bedrock ridges with intervening depressions containing glacial till and bog-organic deposits. Test Pit # 6 was constructed near Crusher Lake on the access road approximately 15 m from a bedrock ridge. Bedrock was encountered at 1.83 m depth, and a good flow of water was observed at 0.6 m depth, however, this was likely derived from a bog area adjacent to the well (pH = 4.6). Overburden was a dense yellow brown silty till, with numerous quartzite fragments.

Test Pits #7 and #9 were constructed to assess the feasibility of burying a pipeline from Crusher Lake. The weathered bedrock surface can be excavated to about 1 m depth, therefore blasting should be minimal.

Test Pit # 8 was constructed adjacent to Crusher Lake to assess the feasibility of installing lateral screens for induced infiltration. Bedrock was encountered at 0.75 m beneath black organic peat deposits. Profiling of the bog area around the southern end of Crusher Lake indicated from 4.3 m near the edge of the lake to 0.6 m of peat bog overlying bedrock. Test pit logs for the 9 test holes are presented in Appendix 3.

4.3 Pump Test Evaluation

A 5.77 m corrugated plastic culvert, 46 cm in diameter was perforated over the bottom 1.8 meters and installed in Test Pit # 1. The hole was backfilled with 1.2 m of coarse gravel followed by 2.4 m of waste rock to above the water table. Glacial till was used to cap the test pit to ground surface. A 3-hp electric submersible pump was installed for pump testing the well.

A series of step drawdown test (1.5 igpm, 12 ipgm, 20 igpm) were carried out and recovery measurements were then made. Analysis of the time-drawdown data infer an apparent transmissivity of 4.85 m^2/d (325 igpd/ft) and a long term continuous safe yield of 1.5 igpm. The hydraulic conductivity of the overburden is estimated at 2×10^{-5} cm/s from the pump test data. This is typical of sandy silt glacial tills in Nova Scotia.

A water quality sample was collected at the end of the pumping test and submitted to the Environmental Chemistry laboratory at the Victoria General Hospital for analysis (Table 3.4). The water chemistry is typical of shallow glacial till aquifer in Nova Scotia, exhibiting higher pH (6.8), alkalinity (51 ppm) and less corrosiveness than the lake water. Elevated iron, manganese and turbidity are a consequence of the well construction method, and turbulence caused by overpumping. The detectable arsenic may be derived from the mine waste rock used in the construction of this test well. Final groundwater quality from a properly constructed dug well would be expected to be lower in these parameters. Iron and manganese would be the most likely water quality problems, and these aesthetic concerns can be effectively treated.

4.4 Summary

It is apparent from the testing carried out to date that a large yield of groundwater will not be available from a single well in the immediate vicinity of the mine site. The test well, when properly constructed and developed, may be capable of about 0.2 L/S (2 igpm) continuous yield, and up to 5 igpm short term yield. Although this well could be developed to supply the majority of potable needs, it may be more cost effective to derive water from the surface water supply line which will be required to supply the mining needs.

Testing in the vicinity of Crusher Lake indicates a poor chance of locating an infiltration gallery along the lake shores which are bedrock controlled. The end closest to the mine site is overlain by thick peat bog deposits, which could result in very poor water quality to underlying screened collectors.

The most feasible water supply alternative for the Beaver Dam Mine is therefore surface water from either Cameron Flowage, or Crusher Lake. Work is currently underway to develop a water supply from Cameron Flowage upstream of the bog outfall. (Jacques, Whitford and Associates Limited, 1986, Job No. M1292).

5.0 CONCLUSIONS

The results of packer injection testing and mine dewatering operations conducted at the Beaver Dam Mine site indicate that the proposed new gold mine workings should encounter relatively low groundwater inflows. An estimated mine water discharge rate of 6.4 L/S (85 igpm) is predicted for the exploration portal, based on packer testing results and the location of the mine tunnels. All hydrogeologic evidence currently available for the site (test drilling, packer testing, shaft dewatering) suggests a steady-state mine effluent discharge rate in the order of 7.5 to 15 L/S (100 to 200 igpm) for a full scale mine. The majority of the flow will be expected from the shallowest mine horizon. Once this zone has been dewatered and appropriately grouted, long term discharge rates from the remaining deeper horizons should be less than 7 to 10 L/S (90 - 130 igpm).

It is anticipated that there should be no problem in the handling of natural groundwater inflow and process waters used for drilling purposes in this mine. There may be some opportunity to employ recirculation of waters within the mine, thereby reducing the total pumping requirements.

Packer injection testing of existing inclined diamond drill holes penetrating the proposed mine workings indicate an overall geometric mean hydraulic conductivity of 2.7×10^{-8} m/s, ranging from 1×10^{-6} m/s to 3.7×10^{-10} m/s. Bedrock permeability was found to decrease with depth and with bedrock type from quartzite to greywacke to argillite, and was lowest for the deep mineralized ore zones. The Mud Lake Fault zone was found to be of low hydraulic conductivity (2.3×10^{-8} m/s), although somewhat unstable. The highest bedrock K values were associated with the crest and axis of the overturned anticline and shallow bedrock (0-20 m).

The shallow bedrock adjacent to the proposed portal has an apparent hydraulic conductivity of 3.5×10^{-7} m/s, which correlates with the estimated K of 9×10^{-7} m/s for shallow bedrock around Austin Shaft. A pumping test conducted in 4.9 m of silty sand glacial till overburden 150 m from the portal area indicated a K of 2 x 10^{-7} m/s. This suggests that inflows to the portal area during construction should be controllable. Pumping of an old mine shaft discovered adjacent to the portal should aid in the control of shallow groundwater flows.

A dewatering test performed on the Austin Mine workings indicated a steady-state mine discharge rate of 3 L/S (40 igpm). Analysis of the time drawdown data suggests that the majority of this inflow was derived from the shallow zones, and that the deeper portion of the abandoned mine workings below 22 m depth was contributing only small amounts of water. Increasing manganese concentration and a shift in water chemistry towards deeper groundwater characteristics suggest that flow is derived from both surface bog sources overlying the working, but primarily from deeper groundwater. This dewatering test indicates that flow rates from the new mine which will be situated in simular geology and structures should also be low, and results confirm the predictions generated by the packer test data.

Continuous, in-situ monitoring of effluent water quality during the dewatering test has demonstrated that the quality of effluent from the new mine should meet the Metal Mining Liquid Effluent Guidlines with minimal or no treatment required. With the exception of arsenic (0.4 -0.17 mg/L), iron (0.3 - 2.6 mg/L) and manganese (0.3 - 0.38 mg/L), all parameters fall within the Canadian Drinking Water Guidelines. Monitoring has shown that there is a small tendency for acidic drainage within the mine after periods of non-pumping, due to contact with mineralized wall rock however, the buffering capacity of the natural groundwater and the quartzite bedrock tend to neutralize this tendency. Under continuous pumping, the effluent would be expected to be a neutral pH (7.4), moderately alkaline groundwater with up to 3 ppm iron and minor arsenic concentration (0.10 - 0.20 mg/L).

Although suspended solids loads under undisturbed conditions are expected to be low, drilling and blasting would be expected to contribute to suspended solids loading. Given the volumes of water expected, it should be feasible to treat the effluent (if necessary) both in the mine sump and at the surface, prior to its release to the bog area. Monitoring of mine effluent quality will determine treatment requirements. The large bog area will afford significant natural attenuation of suspended material and dissolved metals.

Monitoring of the existing diamond drill holes during dewatering of Austin shaft indicates that some hydraulic interconnection likely occurs between the existing workings and the proposed mine. A total drawdown of 1 m was observed near the portal area during the testing. This interconnection may be due in some part to past mining activity along the Austin lead. It is likely that the Austin workings would eventually be dewatered by the new mine, although flow rates would be expected to be small.

Exploration for groundwater resources in the Beaverdam Mine area indicates a poor probability of development of groundwater resources for mine use. Bedrock aquifers exhibit low transmissivity in the order of 0.5 to 1.0 m^2/d, and drilled wells would be capable of less than 3 igpm. Overburden within 200 m of the mine building is generally too thin to develop reliable dug or screened wells. One test well located on line 2 + 00 west may be capable of 2 igpm. The most promising groundwater development possibility lies in the deep bedrock trench (22 m) developed over Mud Lake Fault, west of the site, however, the area is designated for future exploration activities.

As a result of the above, it was decided to develop surface water supplies from Crusher Lake or Cameron Flowage. It is concluded, based on work done to date, that the proposed Beaver Dam Mine will be relatively "dry" after the shallow drifts have been stabilized, and steady state drawdown has been achieved. Mine discharge waters are not expected to pose a serious threat to the environment and should remain within the Metal Mining Liquid Effluent Guidlines with minimal or no treatment required. The naturally occurring iron, manganese, arsenic and aluminum discharged with the effluent should be effectively removed through passage through the swamp prior to release to Cameron Flowage.

6.0 RECOMMENDATIONS

1. Mine water discharge rates and water chemistry should be monitored on a regular basis to ensure that parameters remain within the MMLEG requirements.

2. Although low steady state flow rates in the order of 7.6 L/S (100 igpm) are anticipated for this mine, water pressures ahead of the stope workings should be measured to ensure that all instantaneous flows of groundwater from undetected fractures are anticipated. Such flows should rapidly decrease to steady state rates after fracture dewatering has occurred.

3. A long term groundwater monitoring program should be established to monitor groundwater levels in the Austin Shaft, and bedrock zones above and around the mine workings during mine development. Such monitoring would provide an assessment of the source of flow into the mine, and the degree of fracture dewatering. To accomplish this, it would be necessary to construct a series of observation wells around the site, or to develop some of the existing diamond drill holes.

4. The existing overburden test well should be retained to monitor overburden hydraulic head variation over the summer season. If head does not drop significantly, it may be feasible to develop this as a dug well for auxiliary uses.

5. The geologic and hydrogeologic nature of the Mud Lake Fault Zone suggests that caution should be exercised during mine excavation in these areas. Although the highly brecciated material exhibits a low hydraulic conductivity, the material is saturated and could collapse into the workings. Standard procedures for mine wall stabilization should be implemented in this area.

6. Consideration should be given to recycling of water within the mine for drilling activities and dust control. This would reduce the volume of sump water requiring disposal, and reduce make-up water requirements.

7. Although initial work suggests that discharge water would not be hazardous, over the life of a mine the discharge quality could vary depending on mining activity and zones encountered. Contingency plans should be prepared for treatment of acidic waters with lime addition or to reduce suspended sediment loads by floccuation should such be found to be needed.

APPENDIX 1

TAKEN FROM REPORT NO. M1285

Hydrogeology

Because of the remoteness of the Beaver Dam site, very few site-specific data regarding groundwater quality or flow are currently available. The nearest residential areas are located along route 224 from Upper Musquodoboit 19 km to the northeast and the Village of Marinette 10 km to the south. No impacts on existing groundwater supplies are anticipated in relation to the proposed mining operation.

The following discussion of regional hydrogeology is based on general knowledge of the hydrogeology of the Meguma Bedrock in the eastern portions of Nova Scotia, for example, Halifax and Guysborough counties. The Beaver Dam mine site is underlain by highly resistate crystalline bedrock comprised of Goldenville Quartzite intruded by Devonian-aged granites.

In Nova Scotia, the predominance of steeply-dipping subvertical fracturing, and bedrock strike perpendicular to regional topographic gradient favors the development of short groundwater flow regimes and vertical permeability greater than horizontal permeability. This results in relatively short distances of flow from areas of recharge to areas of discharge, in the order of 1 to 5 km (Lin, 1975). This suggests that groundwater recharging in the highland region to the south of the area (elevation 170 m) flows across the mine site to discharge into Cameron Flowage on the Killag River at an average gradient of about 2.5 percent.

Groundwater Flow

Groundwater flow in fractured crystalline rock is controlled by secondary permeability and fracturing. Locally, bedrock groundwater flows can be expected to be predominantly south-eastward along the dominant fault trends, with smaller flows in the northeast and east directions (Figure 3.3.) Groundwater flow in the sandy silt glacial till overburden is expected to mirror the topographic surface, with recharge occurring on the basin boundaries and uplands, and discharge to the Killag River watershed.

Drilled wells (45-61 m deep) in quartzite bedrock generally yield from 0.04 to 0.4 L/S (0.5-5 IGPM) (N.S. Strait of Canso Environment Comm. 1975). Yields vary greatly depending on the degree of fracturing of the bedrock. Table 3.5 illustrates the range of transmissivity (T) and safe yield (Q_{20}) for 37 wells drilled in quartzite bedrock in Halifax and Guysborough counties (NSDOE pump test inventory). Geometric mean T is low (0.8 m^2/d) compared to an average of 4.1 m^2/d for Meguma Bedrock in Nova Scotia. Well yields in Guysborough County range from 0.05 to 2.4 L/s (0.7-32 IGPM), averaging 0.22 L/s. Specific capacity averages 0.1 L/s per meter of drawdown, compared to 0.04 L/S/m for Halifax County. Pump test data for Nova Scotia indicate that T generally decreases from Yarmouth to Canso, likely because of decreasing degree of metamophorism and less overall fracturing.

ABLE 3.5: Summary of Pump Test Data for Wells Completed in Goldenville Quartzite, Halifax and Guysborough Counties, Nova Scotia

	Range	Mean X	(G)	SD (X)	N
HALIFAX COUNTY					
Well Depth (m)	15.2 - 137.2	67.1	(68.6)	33.2	31
Transmissivity (m^2/d)	.02 - 14.0	2.1	(0.86)	3.1	31
20-yr-safe yield (L/S)	.015 - 4.2	.53	(0.20)	0.9	31
Specific Capacity (L/S/m)	.001 - .16	.04	(0.035)	0.05	31
GUYSBOROUGH COUNTY					
Well Depth (m)	44.8 - 155.4	99.1	(89.0)	46.6	6
Transmissivity (m^2/d)	0.08 - 11.2	2.5	(0.75)	4.3	6
20 yr-safe yield (L/S)	0.05 - 0.46	0.27	(0.23)	0.89	6
Specific Capacity (L/S/m)	0.001 - 0.06	0.11	(0.01)	0.25	6

x = Arithmetic Mean

G = Geometric Mean

SOURCE: N.S. Department of the Environment, Pump Test Inventory

The presence of a dry (91 meter) well near the mine site, and low well yields for Guysborough County wells tend to support this conclusion.

Preliminary results of a packer testing program conducted on the site also support the low transmissivity of the non-mineralized quartzite bedrock (Jacques, Whitford and Associates Ltd., 1986 in preparation). Packer permeability measurements were carried out in June of 1986 for 56 zones 4.6 m in length, which is representative of the various structural rock features identified in the geologists logs (for example, fault zones, fractures, Anticline axis, ore zones, etc.). Hydraulic conductivity averages 2.7×10^{-8} m/s (geometric mean) and ranges from a high of 1×10^{-6} m/s in the shallow zones of Mud Lake Fault and the anticline axis, to less then 4×10^{-11} m/s in the deep ore zone and unfractured rock. Hydraulic conductivity generally decreases with depth, and is low in the ore zone, likely because of fracture filling by quartz veins. Results of bedrock permeability testing will be reported at a later date.

Notwithstanding the above, experience in other mineralized areas of the province has shown that bedrock T and permeability can be greater for Meguma bedrock intruded by Devonian granites and near fault zones. In the Beaver Dam area, the highest bedrock permeabilities would therefore be expected to occur near the granite contact southwest of the site, and adjacent to the major fault zones.

Measurements of hydraulic head in the various mine shafts around the property indicate bedrock water levels varying from 3 to 4 m below ground surface, and dominant groundwater flow direction to the west and northwest, along the strike of bedrock and topographic gradient. Mine shafts, where groundwater levels approach ground surface, appear to be influenced by surface water drainage into the workings. The 3 m depth to water in the Austin and Whip leads may be indicative of actual piezometric surface for shafts penetrating to about 22 m. The majority of the diamond drill holes exhibited static water levels averaging 0.3 meters below ground surface in the vicinity of the cleared area. In the swamp area, most boreholes penetrating Mud Lake Fault were flowing at ground surface, usually at rates of less than 0.1 L/S. Borehole BD-86-47 was measured at a flow rate of 0.1 L/S (1.3 IGPM). The presence of water in most trenches indicates high water table conditions over most of the site which appears to be a net regional groundwater discharge area.

Conversations with the geologists regarding drilling conditions on site indicated that most of the deep boreholes were making enough water to sustain drilling. Some boreholes exhibited loss of drilling fluid to adjacent holes (BD-85-24, 31, 27) which indicates some cross connection, at least in the shallow zones. Boreholes in the Mud Lake Fault Zone were full of gouge material and highly unstable, and generally exhibited low flows due to clogging, and also resulted in low packer permeability values. The degree of bedrock fracturing appears to increase towards the Austin Shaft end of the baseline; likely a result of tectonic movements associated with the fault zones. The drillers stated that negligible movement of water levels was observed in Austin Shaft during pumpage (0.4 - 4.0 L/S) for drilling purposes. A water well 91 m deep constructed for the temporary mining camp on the hill south of the mine was dry, even after stimulation by blasting.

The above discussions suggest that the bulk bedrock hydraulic conductivity in the vicinity of the mine site is relatively low and that the greatest flows will be expected in the southeast end of the site towards Mud Lake Fault. The variability of fracture permeability and hydraulic characteristics of the shallow zone around the Austin Shaft will be assessed in greater detail upon completion of current field work.

In this region of Nova Scotia, most domestic water supplies are obtained from dug or drilled wells. Dug wells developed in the glacial till overburden appear to be the most common domestic supply, yielding large volumes of good quality water from stratified sands and gravels such as are found at the west side of Sheet Harbour, and 0.08 to 0.8 L/S from quartzite tills such as underlie the area. Higher yields may be encountered if sufficient thicknesses of saturated sand and gravel are encountered on the site. A program of overburden exploration is currently being conducted to evaluate the water-bearing characteristics of thick overburden deposits identified by seismic profiling.

Groundwater Quality

Quality of groundwater from Goldenville quartzite aquifers is generally good (NSDOE Well Water Quality Inventory). The most common domestic water quality complaint is that iron and manganese levels are in excess of the respective drinking water limits of 0.30 mg/L and 0.05 mg/L set for aesthetic reasons (Health and Welfare Canada, 1978). In gold mining districts, arsenic concentrations in excess of the 0.05 mg/L health standard commonly occurs, and is generally believed to be derived from arsenopyrite mineralization associated with vein deposits in the bedrock (Grantham & Jones, 1976; McCurdy 1980, Bottomley 1984). Shallow overburden wells generally exhibit similar trends, without arsenic problems.

To date, groundwater samples from the Beaver Dam area are limited to samples from Austin Shaft collected at depths of 10 m and 21 m below the water surface (Table 3.6). Water is a typical calcium carbonate groundwater of good chemical quality. All parameters are within tolerable limits. Arsenic levels at 0.04 mg/L and iron at 0.3 mg/L are typical of groundwaters in mine areas. The downward drift of pH and upward drift in conductivity suggest a slightly reducing condition, confirmed by later dissolved oxygen measurements of 2.0 ppm. A flowing deep borehole (86-41) and several other deep boreholes also exhibited reducing trends (H_2S odors). Detectable nitrate concentrations are likely to caused by vegetation and timbers in the shaft. Profiles of temperature, electrical conductance and dissolved oxygen were also made for the Austin Shaft (Table 3.7) and shows a slight increase in conductivity (TDS) and decrease in temperature with depth, as would be expected. Groundwater from these mine shafts are remarkably clear and are not expected to be an environmental problem.

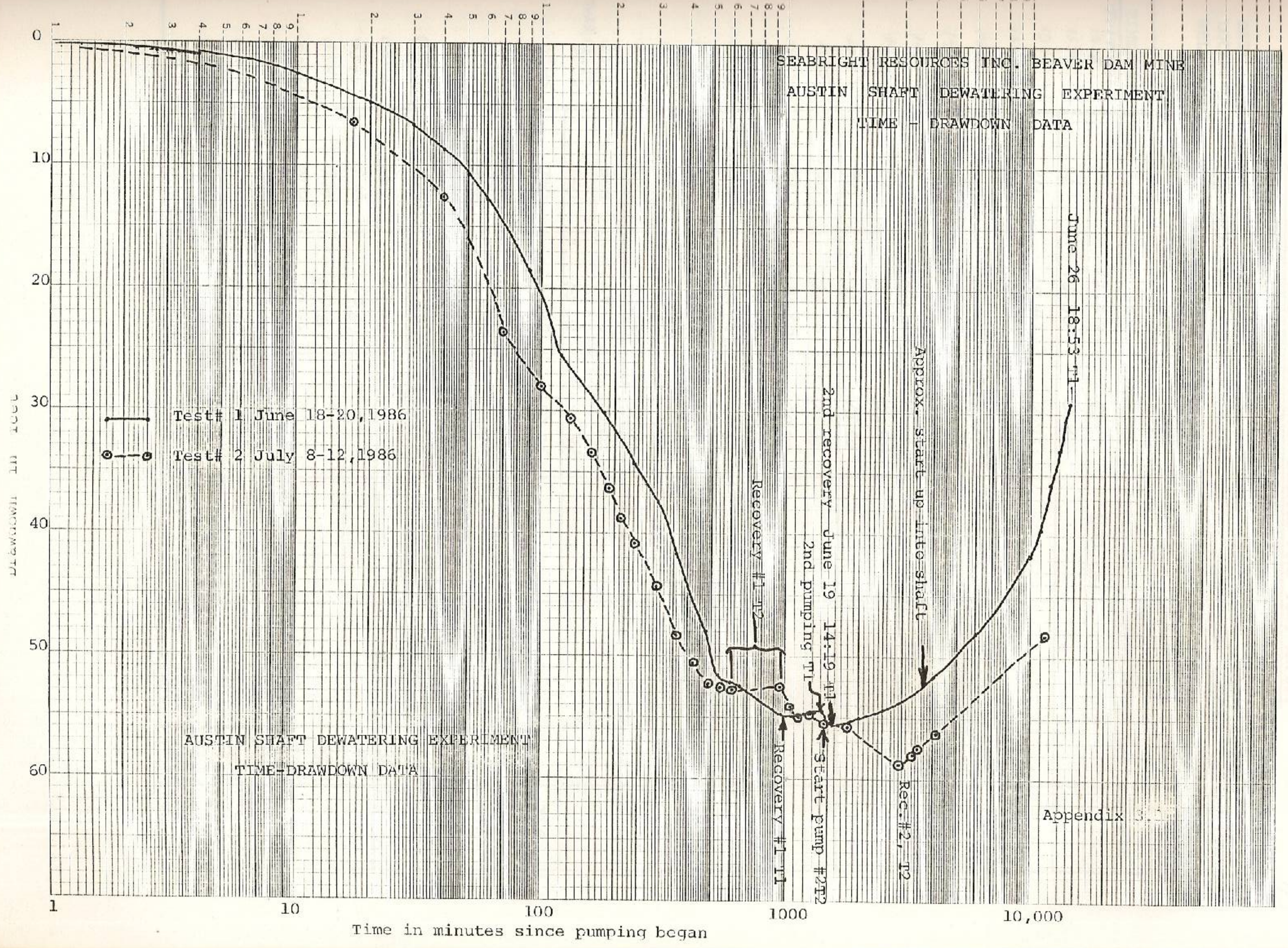
TABLE 3.6: Water Quality Analysis for Austin Shaft,
Beaver Dam Mine (May 6,1986)

Depth Below Water Surface		7 metres AU-1	17 metres AU-2
Sodium	mg/L	2.1	2.3
Potassium	mg/L	0.9	0.8
Calcium	mg/L	8.3	9.5
Magnesium	mg/L	1.0	1.1
Hardness ($CaCO_3$)	mg/L	25.0	28.3
Alkalinity ($CaCO_3$)	mg/L	20.3	23.5
Sulfate	mg/L	8.0	8.0
Chloride	mg/L	3.3	3.1
Fluoride	mg/L	<0.1	<0.1
Silica	mg/L	4.8	5.2
Orthophosphate	mg/L	0.02	<0.01
Nitrate + Nitrite	mg/L	0.18	0.13
Ammonia	mg/L	<0.05	<0.05
Arsenic	mg/L	0.04	0.04
Iron	mg/L	0.3	0.32
Manganese	mg/L	<0.01	0.03
Lead (HGA)	mg/L	<0.002	<0.002
Copper	mg/L	<0.01	<0.01
Zinc	mg/L	<0.01	<0.01
Total Dissolved Solids	mg/L	35.0	43.0
Suspended Solids	mg/L	<0.3	<0.3
Color	T.C.U.	5.0	5.0
Turbidity	J.T.U.	1.5	2.3
Conductivity (umho/cm)	umHo/cm	69.0	76.0
pH	units	6.30	6.40
Humic Acid	mg/L	2.0	2.0
Aluminum	mg/L	<0.05	<0.05
Boron	mg/L	<0.02	<0.02
Barium	mg/L	<0.005	<0.005
Beryllium	mg/L	<0.005	<0.005
Chromium	mg/L	<0.01	<0.01
Cobalt	mg/L	<0.01	<0.01
Nickel	mg/L	<0.02	<0.02
Antimony	mg/L	<0.05	<0.05
Selenium	mg/L	<0.1	<0.1
Tin	mg/L	<0.03	<0.03
Vanadium	mg/L	<0.01	<0.01
Mercury	ug/L	<0.05	<0.05
Cadmium-ICP	mg/L	<0.01	<0.01
Field Measurements			
pH	units	6.77	6.80 (downward drift)
Conductivity	umho/cm	47.0	50.0
Temperature	(°C)	5.0	4.2
Dissolved Oxygen	ppm	2.0	2.0 (June 18, 1986)
Odor	TCC	NONE	NONE

TABLE 3.7: Electrical Conductance and Temperature Profile for Austin Shaft, Beaver Dam (May 6, 1986)

Depth Below Reference(m)	Depth Below Water Level(m)	Temperature (°C)	Conductivity uS/cm	Salinity 0/00
3	0	5.9	45	0.0
5	2	5.5	45	0.0
7	4	5.5	47	0.0
9	6	5.4	47	0.0
11	8	5.4	49	0.0
13	10	5.4	49	0.0
15	12	5.4	50	0.0
22	19	4.7	50	0.0

Measurements by YSI Model 33 STC Meter.



SEABRIGHT RESOURCES INC. BEAVER DAM MINE
AUSTIN SHAFT DEWATERING EXPERIMENT
TIME - DRAWDOWN DATA

Appendix 3

JACQUES WHITFORD AND ASSOCIATES LIMITED PUMP TEST REPORT

DATE JUNE
LOCATION BEAVERDAM MINE
WELL AUSTIN SHAFT

HYDRO. DDH
WEATHER CLEAR

	DRAWDOWN TEST				RECOVERY TEST		
TIME/DATE	TIME (min.)	FEET BTOC	DRAWDOWN	YIELD (gpm)	RESIDUAL DRAWDOWN	t/t'	SAMPLE
JUNE 18/86 1335	0	12.67	0	500 igpm			
1339	4	13.50	0.83				
1345	10	15.42	2.75				#1
1355	20	17.67	5.00				
1405	30	19.58	6.91				
1415	40	21.50	8.83				
1425	50	23.42	10.75				#2
1435	60	25.25	12.58				
1505	90	31.17	18.50				
1535	120	38.00	25.33				
1635	180	42.67	30.00				
1735	240	46.83	34.16				#3
1835	300	50.17	37.50				
1935	360	54.42	41.75				#4
2135	480	60.67	48.00				
2235	540	62.83	50.16				#5
2335	600	64.75	52.08				
JUNE 19/86 0035	660	65.08	52.41				
0245	780	65.92	53.25				#6
0435	900	67.08	54.41				
0535	960	67.58	54.91				#7
	TURN OFF PUMP		7 hour Recovery (#1)				
0540	965	67.61			54.94	193	
0542	967	67.61			"	138	
0545	970	67.61			"	97	
0549	974	67.61			"	69.5	
0554	979	67.60			54.93	51.5	
0600	985	67.59			54.92	39.4	
0610	995	67.58			54.91	28.4	
0620	1005	67.55			54.88	22.3	
0630	1015	67.53			54.86	18.5	

JACQUES WHITFORD AND ASSOCIATES LIMITED PUMP TEST REPORT

2/3

DATE

LOCATION

WELL

HYDRO.

WEATHER

	DRAWDOWN TEST				RECOVERY TEST		
TIME/DATE	TIME (min.)	FEET BTOC	DRAWDOWN	YIELD (gpm)	RESIDUAL DRAWDOWN	t/t'	SAMPLE
JUNE 14/86	1025	67.52			54.85	15.8	
0700	1045	67.47			54.80	12.3	
0720	1065	67.45			54.78	10.1	
0740	1085	67.43			54.76	8.7	
0800	1105	67.39			54.72	7.6	
0830	1135	67.34			54.67	6.5	
0900	1165	67.30			54.63	5.7	
0930	1195	67.26			54.59	5.1	
1000	1225	67.22			54.55	4.6	
1030	1255	67.18			54.51	4.3	
1100	1285	67.14			54.47	4.0	
1130	1315	67.11			54.44	3.7	
1200	1345	67.09			54.42	3.5	
1235	1380	67.07			54.40	3.3	
		START PUMPING		500 IGPM			
1247	1392	67.07	54.40				
1249	1994	67.07	54.40				
1252	1397	–	–				
1254	1399	67.13	54.46				
1257	1402	67.15	54.48				
1301	1406	67.19	54.52				#8
1311	1416	67.32	54.65				
1321	1418	67.44	54.77				
1331	1428	67.52	54.85				
1341	1438	67.65	54.98				
1401	1498	67.83	55.16				#9
1417	1513	68.00	55.33				
1417		TURN OFF PUMP	RECOVERY #2				
1417	0 1513	68.05			55.38	1	
1418	1 1514	68.05			55.38	1485	
1419	2 1515	68.05			11	743	

Appendix 3

3/3

JACQUES WHITFORD AND ASSOCIATES LIMITED PUMP TEST REPORT

DATE ____________
LOCATION ____________
WELL ____________

HYDRO. ____________
WEATHER ____________

	DRAWDOWN TEST				RECOVERY TEST		
TIME/DATE	TIME (min.)	FEET BTOC	DRAWDOWN	YIELD (gpm)	RESIDUAL DRAWDOWN	t/t'	SAMPLE
	3 1516	68.05			55.38	495	
	4 1517	"			"	372	
	5 1518	"			"	298	
	6 1519	"			"	248	
1433	16 1529	68.02			55.35	94	
1443	26 1539	68.02			55.35	58	
1453	36 1549	67.99			55.32	42	
1503	46 1559	67.99			55.32	33	
1523	66 1579	67.93			55.26	23	
1553	94 1609	67.91			55.24	17	
1615	116 1631	67.85			55.18	14	
1645	146 1661	67.81			55.14	11	
JUNE20/86 1010	1190 2705	66.76			54.09	2.3	
14:23	1443 2958	66.55			53.88	2.0	
JUNE26/86	9543 11,058	52.14			39.47	1.16	
	9843 11,358	51.16			38.49	1.15	
JUNE27/86	10,799 12,314	47.65			34.98	1.14	
JUNE 28/86	12,243 13,758	43.09			30.42	1.12	
	12,596 14,111	41.84			29.17	1.11	

Appendix 3

JACQUES WHITFORD AND ASSOCIATES LIMITED PUMP TEST REPORT

DATE JULY 8-10, 1986
LOCATION BEAVER DAM MINE
WELL AUSTIN SHAFT

HYDRO. DSM, DAC
WEATHER CLEAR, WARM
YIELD 200 USgpm

	DRAWDOWN TEST			RECOVERY TEST			
TIME/DATE	TIME (min.)	FEET BTOC	DRAWDOWN (~~m~~ ft)	FEET BTOC	RESIDUAL DRAWDOWN (m)	t/t'	SAMPLE
JULY 8/86 13:50	0	12.91"					
13:07	17	19.46	6.55				
1430	40	25.71	12.8				
1500	70	36.79	23.88				
1530	100	40.96	28.05				
1600	130	43.71	30.8				#1
1630	160	46.50	33.59				
1700	190	49.25	36.34				
1730	210	51.83	38.92				
1800	240	53.75	40.84				
1900	300	57.38	44.47				
2000	360	61.29	48.38				
2100	420	63.58	50.67				
2200	480	65.17	52.26				
2300	540	65.58	52.67				
2400 JULY 9, 1986	600	65.79	52.88 PUMP	SHUT OFF	TILL 0600		
0600	960	65.21	52.30 START PUMP (Recovery 0.58 ft in 6 hr (1"/hr)				
0700	1020	66.19	53.28				
0800	1080	67.12	54.21				
0830	1110	67.50	54.59				
0900	1140	67.79	54.88	PUMP OFF			
1000	1200	67.69	54.78	--			
1100	1260	67.56	54.65	START PUMP (Recovery .19 ft/2 hr or 1"/hr)			
1200	1320	68.33	55.42	STOP PUMP: change pumps			#2
1443	1440	68.27	55.36	START CENTRIFUGAL PUMP			
1500	1500	68.29	55.38	(INITIAL RISE in h when pump started)			#3
1600	1560	"	"				
1700	1620	"	"				
1800	1680	68.29	"				
1900	1740	68.54	55.63				
2000	1800	68.67	55.76				

DRILLER/YEAR HOPPER
WELL DEPTH 72.'
CASING LENGTH MINE SHAFT

PUMP SETTING 71' 10"
PUMP TYPE Centrifugal
SPECIFIC CAPACITY (Q/S)

JACQUES WHITFORD AND ASSOCIATES LIMITED PUMP TEST REPORT

DATE ______
LOCATION ______
WELL ______

HYDRO. ______
WEATHER ______

	DRAWDOWN TEST				RECOVERY TEST		
TIME/DATE	TIME (min.)	FEET BTOC	DRAWDOWN	YIELD (gpm)	RESIDUAL DRAWDOWN	t/t'	SAMPLE
JULY 9/86 → 2100	1860	68.88	55.97				
2200	1920	69.08	56.17				
2300	1980	69.29	56.38				
2400	2040	69.58	56.67				
JULY 10/86 0100	2100	69.67	56.76				
0200	2160	69.75	56.84				
0300	2220	69.92	57.01				
0400	2280	70.08	57.17				
0500	2340	70.25	57.34				
0600	2400	70.42	57.51				
0700	2460	70.58	57.67				
0800	2520	70.79	57.88				
0900	2580	70.85	57.94	Reached bottom of drop pipe			
1000	2640	"					#4
1100	2700	"		Pump clogging with debris			
1200	2760	"		$\boxed{\text{60 igpm}}$ Broke suction @ t = 1130 hrs.			#5
1300	2820	"		$\boxed{\text{38 igpm}}$			
1330	2850	"					
1530	2970	"					#6
1630	3030	"					
1830	3150	"		$\boxed{\text{38 igpm}}$ Pump off; Start recovery			#7

JACQUES WHITFORD AND ASSOCIATES LIMITED PUMP TEST REPORT

DATE JULY 10, 11. 1986
LOCATION BEAVERDAM MINE
WELL AUSTIN SHAFT

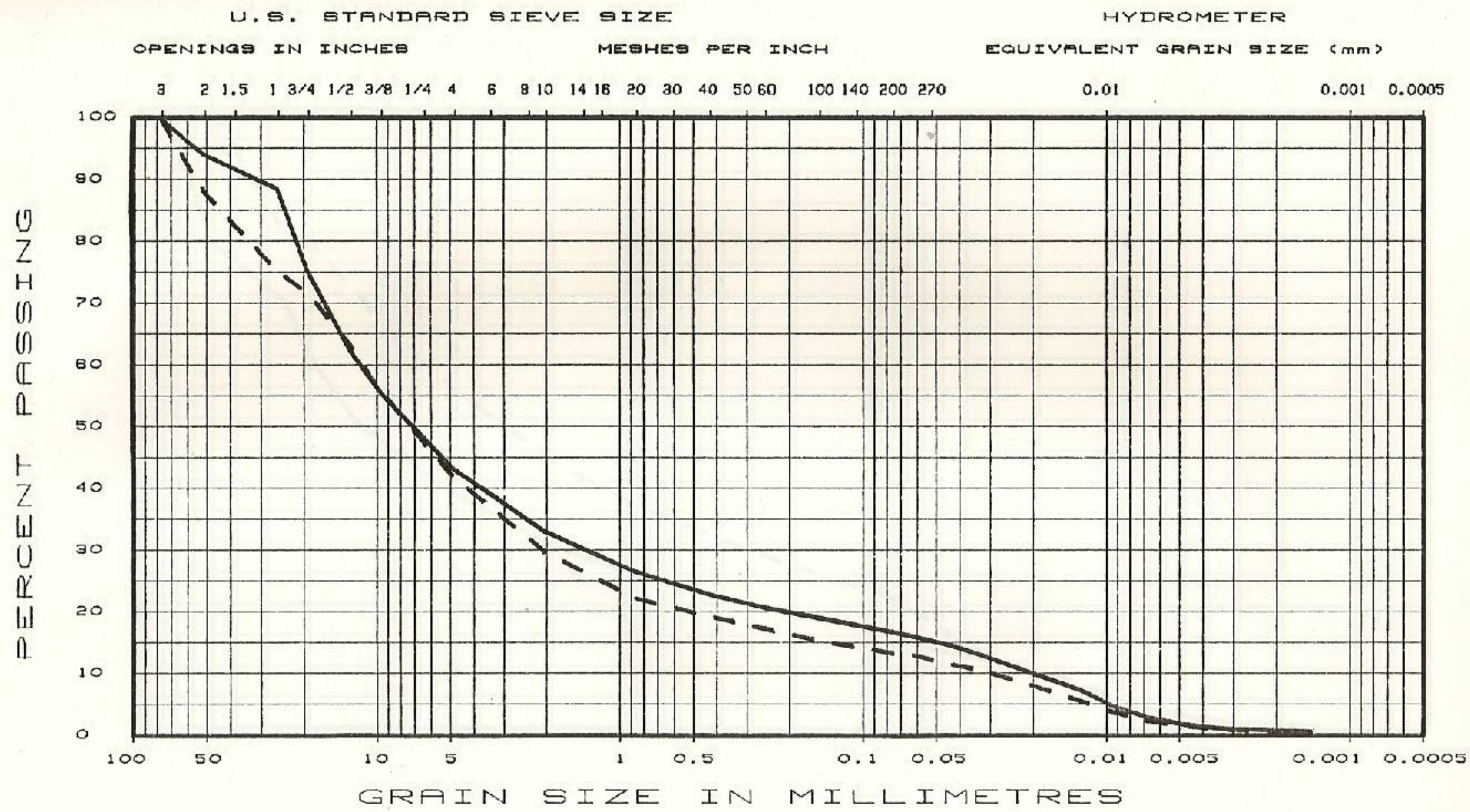
HYDRO.
WEATHER

	DRAWDOWN TEST				RECOVERY TEST		
TIME/DATE	TIME (min.)	FEET BTOC	DRAWDOWN +1.9	YIELD (gpm)	RESIDUAL DRAWDOWN	t/t'	SAMPLE
JULY 10, 1986 1830	0	69.83	56.92		58.92		
20:00	30	69.54	56.63		58.63		
21:00	90	69.31	56.40	est. (40)	58.40		
22:00	150	69.08	56.17		58.17		
24:00	270	68.88	55.97		57.97		
JULY 11, 1986 0200	390	68.71	55.80		57.80		
0400	510	68.54	55.63		57.63		
0600	630	68.38	55.47		57.47		
0700	690	68.29	55.38		57.38		
0800	750	68.21	55.30		57.30		
0900	910	68.12	55.21		57.21		
1020	890	68.04	55.13		57.13		
1400	1110	67.75	54.84	(1"/hour)	56.84		
1700	1290	67.54	54.63		56.63		
JULY 12/86							
J							
July 16 @ 1350	8360	59.58	46.67				
1510	8440	59.25	46.34			1.4 min	

* WATER LEVEL MEASURED FROM NOTCH IN FLOOR

* MEASURING POINT ~ 2.0 Ft lower than top of drop tube

* NOTE: RECOVERY MEAS. DATUM 1.5 Ft lower than for drawdown.

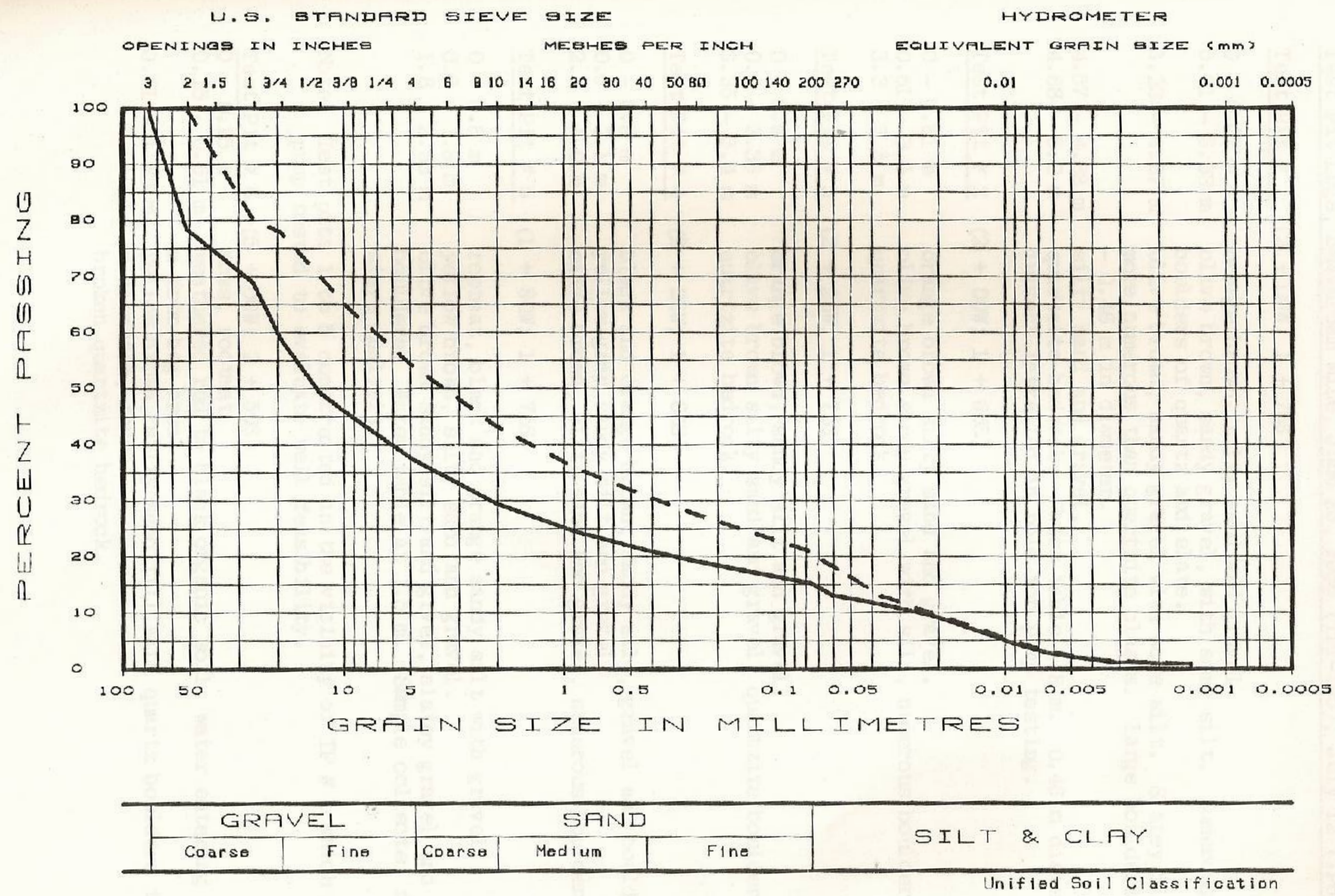


GRAVEL		SAND			SILT & CLAY
Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification

	TEST PIT	SAMPLE	DEPTH	DESCRIPTION
——	1	1	0'–5'	Sandy GRAVEL, some silt
– – –	1	2	5'–10'	Sandy GRAVEL, some silt

M1289



	TEST PIT	SAMPLE	DEPTH	DESCRIPTION
———	1	3	10'-15'	Sandy GRAVEL, some silt
— — —	1	4	15'-16'	Sandy GRAVEL, some silt

M1289

APPENDIX 3

Test Pit Logs, Beaverdam Mine, June 25, 1986 (TP1-TP5); July 12 (TP6-TP9)

Test Pit # 1 (2 + 00W; 1 + 75S)

0 - 0.61 m	orange brown, silty sand and gravel
0.61 - 3.33 m	olive brown, sandy gravel, with some silt. Numerous boulders of quartz and slate.
3.33 - 4.57 m	olive brown, sandy gravel with some silt. Slatey clasts more numerous than quartzite clasts. Large boulders 0.15 - 0.46 m in diameter.
4.57 - 4.88 m	silty sand and gravel.
4.88 - 5.0 m	quartzite bedrock. Water table 1.8 m. 0.46 m diameter culvert installed in hole for pump testing.

Test Pit # 2 (2 + 00W; 1 + 65S)

0 - 0.61 m	orange brown silty sand and gravel.
0.61 - 3.3 m	olive brown sandy gravel with silt, numerous boulders.
3.3 - 3.5 m	quartzite bedrock.

Test Pit # 3 (2 + 25W; 1 + 75S)

0 - 0.9 m	orange brown, sandy silt and gravel.
0.9 - 3.35 m	olive brown silty sand and gravel, quartzite boulders.
3.35 - 3.4 m	quartzite bedrock.

Test Pit # 4 (2 + 25W; 1 + 65S)

0 - 0.6 m	black and orange brown, sandy silt, gravel and boulders.
0.6 - 2.1 m	yellow-gray sandy silt and gravel.
2.1 - 4.0 m	olive brown, silty sand and gravel, numerous boulders.

Test Pit # 5 (1 + 80W; 1 + 75S)

0 - 0.6 m	rootmat, black and orange sandy silt with gravel.
0.6 - 1.8 m	yellow brown, silty sand and gravel.
1.8 - 3.35 m	olive brown sandy silt and grvel, slatey gravel and boulders. Water table at 1.5 m. Sample collected for sieve analysis.

Note: Test pits 1 to 5 constructed in the vicinity of TP # 1 which was pump tested to evaluate well feasibility.

Test Pit # 6 (5 + 00W; 2 + 50S)

0 - 0.15 m	moss, rootmat
0.15 - 0.61 m	weathered red to black organic soil, water entering @ 0.61 m from bog area.
0.61 - 1.83 m	yellow brown, silty sand till with quartz boulders to 0.3 m diameter, dense.
	broken quartzite bedrock.

APPENDIX 3
(continued)

Test Pit # 7 (5 + 20W; 2 + 50S)

0 - .15 m	moss, rootmat
.15 - .61 m	reddish brown, silty sand loam, minor quartzite clasts.
.61 - 1.0 m	broken quartzite bedrock, no water.

Test Pit # 8 (5 + 00W; 2 + 75S)

0 - 0.76 m	black, organic peat and muck, strong H_2S odor
0.76 - 1.0 m	black organic silt
1.0 - 1.22 m	broken quartzite bedrock, some water.

Test Pit # 9 (5 + 15 W; 2 + 00S)

0 - 0.15 m	moss, rootmat
0.15 - 1.5 m	yellow brown silty sand loam, becoming more gravelly with depth. Numerous large quartzite boulders indicate proximity to bedrock.
1.5 - 2.0 m	hard quartzite bedrock. No water. Test pit indicates that bedrock ridge can be ripped to about 1.2 m depth by excavator.