Deloitte
& Touche

Anvil Range Mining Complex
2005 Seepage Investigation at the S-Cluster Area Below the Faro Waste Rock Dump

2005/06 - Task 20e

Prepared for

Deloitte & Touche Inc.

on behalf of

The Faro Mine Closure Planning Office

Prepared by

SRK Consulting
Engineers and Scientists

Project Reference Number
SRK 1CD003.073

November 2006

2005 Seepage Investigation at the S-cluster Area Below the Faro Waste Rock Dump

Deloitte & Touche Inc.

On behalf of

The Faro Mine Closure Planning Office

SRK Consulting (Canada) Inc.
Suite 800, 1066 West Hastings Street
Vancouver, B.C. V6E 3X2

Tel: 604.681.4196 Fax: 604.687.5532
E-mail: vancouver@srk.com Web site: www.srk.com

In association with Robertson GeoConsultants, Inc.

SRK Project Number 1CD003.73

November 2006

Authors

Dan Mackie, M.Sc.
Dr. Christoph Wels, Ph. D., M.Sc.

Reviewed by

Cam Scott, P.Eng.

Executive Summary

Results of the 2005 field program suggest the presence of multiple aquifers and a laterally constrained contaminant plume, which is currently discharging into the NFRC. Geology data indicates separate shallow and deep porous media aquifers, constrained to the west by a bedrock high. At least the shallow aquifer may be oriented along a pre-mining creek alignment. Bedrock was intersected in all drillholes, drillholes generally extending to the interpreted base of the weathered bedrock profile. A single drillhole (SP-6) was drilled further into bedrock (>5m); overburden at this location was frozen and the monitoring well, which is completed in bedrock, has been dry since installation. Hydraulic testing was completed in most monitoring wells with results varying from approximately 1 x 10-4 to 4 x 10-7 m/s. The porous media aquifers are believed to be the primary zones of concern in this area.

Groundwater zinc concentrations range from a low of approximately 0.1mg/L at locations close to the eastern extent of the S-cluster area, to a high of 277 mg/L in the area of the pre-mining creek alignment. Surveys of the NFRC indicate discharge increased by 0.146 m^3/s (9%) in reaches passing through the S-cluster area. Based on these data, loading estimates to the NFRC indicate that contaminated groundwater in the S-cluster area is discharging to the NFRC. Incremental zinc load in the NFRC as it passes through the S-cluster area is estimated at approximately 0.4 to 0.9 tonnes/yr under current conditions. Based on observed groundwater concentrations, zinc load could reach a maximum of 14 tonnes/yr.

An adaptive management plan approach consisting of a multi-phase seepage interception system is recommended for the S-cluster area, focused initially on groundwater with high contaminant concentrations. The initial system would be composed of a cut-off wall and permeable trench with pumping wells, all located along the alignment of the 2005 drilling program. An extensive monitoring system with both groundwater and surface water components, as well as specific contingency remedial actions, would be implemented to provide a flexible, responsive approach to contaminant interception. Additional pumping wells could be installed down gradient of the cut-off wall, in the vicinity of the original S-cluster wells, if monitoring results indicated that this specific area remained of concern.

* * *

Report Title: 2005 Seeapge Investigation at the S-cluster Area Below the Faro Waste Rock Dump - Task 20e 2005/06
Prepared by: SRK Consulting Project 1CD003.073
Date Submitted: November 8, 2006
Number of Pages: 61/138 (Body & Figures / Total report)
Number of Appendices: 4

Table of Contents

List of Tables

List of Photographs

List of Figures

List of Appendices

1 Introduction and Scope of Work

This report presents results of the 2005/2006 hydrogeology program for the North Fork Rose Creek (NFRC) S-cluster area as part of Task 20e – Continued Seepage Investigations. Seepage from the Intermediate waste rock dump has been identified as a potential source of contamination to the North Fork Rose Creek. As a result, impacts and potential mitigation measures have been investigated. Figure 1 shows the location of the study area.

Task 20e includes investigations for four areas: the Emergency Tailings Area (ETA), Zone 2 Pit area, the S-cluster area, and the Grum area. The scope of work of this report covers the NFRC S-cluster component, the primary objectives of which are:

- Development of a hydrogeological model for the S-cluster area
- Delineation of the contaminant plume in the S-cluster area
- Assessment of contaminant loading to groundwater & surface water
- Development of a conceptual design for seepage interception

Initially, the final objective of this study was to update the conclusions of the 2004 field program described in: ***Preliminary Seepage Collection Options – Faro and Grum Waste Rock Dumps (SRK, 2006)*** and present a one-step collection option for the area. While reviewing the assessment of data collected during the 2005 program, consideration should be given to timing of other, more significant components of the overall mine closure plan (e.g. the ETA and tailings impoundments) and, subsequently, the concept of a phased collection system as a method to reduce uncertainty and improve long-term performance.

In the report, a description of methodologies and work completed during the 2005/06 field program are included in Section 2. Results of the field program and analysis of data collected are described in Section 3, including a hydrogeological conceptual model for flow. A description of contaminant sources as well as loading estimates to groundwater and the NFRC are presented in Section 4. Section 5 describes options for conceptual seepage collection systems.

2 Background

In July 2004, Robertson GeoConsultants, Inc. (RGC) presented a review of historical water quality data at the S-cluster area. This review indicated sulphate and zinc "breakthrough" times at the S-cluster observation wells in 1999 and 2003, respectively. RGC recommended additional field work to further assess contamination in the S-cluster area.

In August 2004, a short field program was completed in the S-cluster area consisting of limited drilling and monitoring well installation, hydraulic testing of the existing S-cluster monitoring wells, sampling for water quality and test pitting. A seismic survey was also conducted in this area. Details of this investigation can be found in the report: ***Preliminary Seepage Collection Options-Faro and Grum Waste Rock Dumps (SRK, 2006)***.

Results of the 2004 program suggested that contaminant migration was dominated by a shallow pre-mining drainage that extended upgradient from the S-cluster area to under the footprint of the Intermediate waste rock dump. Water quality, measured at the S-cluster groundwater monitoring wells, was consistent with findings of the 2004 RGC water quality review, indicating that sulphate and zinc contamination from the waste rocks dumps was present. A conceptual seepage collection design was presented, consisting of a combination of groundwater and surface water collection elements. At the time this option was presented, significant uncertainty remained regarding the geologic and hydrogeologic conditions in this area.

As a result, recommendations in the 2004 report included:

- Additional drilling to constrain the spatial distribution of contamination
- Additional hydraulic testing to improve the groundwater collection system design
- Monitoring of contaminant loading to NFRC and installation of staff gauges to improve our understanding of stream-aquifer interaction

In August, 2005, SRK presented a proposal (***Task 20e proposal – Continued seepage investigations at Faro Mine***) for additional field work at multiple areas of the Anvil Range Mining Complex, including the S-cluster area. Additional field work was based on the recommendations presented in the 2004 report.

3 Field Investigation

The 2005 field program consisted of both groundwater and surface water investigations. Groundwater investigations included installation, testing and sampling of monitoring wells, plus the installation of shallow drivepoints along the banks of the NFRC. Surface water investigations included discharge surveys along the NFRC in the vicinity of the S-cluster on three occasions. Groundwater sampling was conducted once by Gartner Lee Limited (GLL) as part of the quarterly monitoring program, and surface water sampling was completed as part of two of the three stream surveys.

3.1 Monitoring Well Drilling & Installation

Monitoring wells were installed at six locations in the S-cluster area below the rock drain: SRK05-SP1 to SRK05-SP6 (Figure 1).

Monitoring wells were drilled by Sonic Drilling Services, a division of Boart Longyear of Alberta, using a Nodwell-mounted sonic drill. The sonic rig was equipped with a 4 x 6 system (4”/10cm core barrel and 6”/15cm casing) that allowed for continuous sampling in 3 meter runs (1 core barrel = 10ft; approximately 3 metres) by advancing the core barrel using ultra-sonic vibrations. Casing is advanced over the core barrel to below the bit to keep the hole open during barrel retrieval. Water is only used during casing advancement to prevent heave between barrel and casing. Water use was kept to the minimum required to advance casing.

Core is recovered in the drill tube and “extruded” into plastic bags, preserving most, if not all, of the natural stratigraphy. Plastic bags were laid out and the core samples logged as they were recovered. On some occasions, some or all of the core was lost from the core barrel or otherwise not recovered. Photograph 1 shows the core recovered at SRK05-SP4.

Photograph 1: SRK05-SP4 Drill Core (sonic drill in background). Core has been "split" to allow better characterisation

During drilling, drillhole water was recovered and electrical conductivity (EC) measured to provide preliminary field determination of the presence of contamination. In general, EC values of contaminated water in this area are greater than 1,000 µS/cm, which are considered high relative to background levels (<500 µS/cm).

Screen zones for each monitoring well were determined based on the stratigraphy encountered at each particular site and field-assessed water quality data. SRK05-SP-6, which was drilled predominantly in bedrock, was dry during construction.

A single monitoring well was installed in each borehole using 50 mm (2-inch) threaded PVC riser pipes and screens (#10 slot size). Filter sand was emplaced around the screen sections to a height of approximately 0.5 to 1.0m above the top of the sreen section. Bentonite chips were emplaced from the top of sand to ground surface and protective steel casings installed over all stick-ups.

Three of the six monitoring locations consist of "nested" shallow and deep monitoring wells, the monitoring wells of each "nest" completed in separate drillholes located within a couple of meters of each other (i.e., SRK05-SP1A & 1B, SRK05-SP3A & 3B and SRK05-SP4A & 4B).

Locations of the monitoring wells are shown on Figure 1. Table 1 summarises completion information for the new monitoring wells installed as part of this 2005 program, as well as information for the existing S-cluster monitoring wells. Field measurements of electrical conductivity (EC) for each screen zone are included.

Table 1: NFRC/S-cluster Area Monitoring Well Summary

2005 SRK Monitoring Wells	Easting	Northing	Total Depth (m)	Stick-up Elevation (m.a.s.l.)	Screen Interval (m.b.g.s.)	Field EC (mS/cm)	Purged Volume (L)
SRK05-SP1A	584,727	6,912,901	19.2	1091.99	13.7 - 19.2	1.40	120
SRK05-SP1B	584,726	6,912,901	12.3	1091.94	9 - 12.3	1.55	80
SRK05-SP2	584,791	6,912,861	11.0	1086.70	7.9 - 11.0	0.36	160
SRK05-SP3A	584,651	6,912,924	22.9	1088.50	17.4 - 21.9	0.88	220
SRK05-SP3B	584,652	6,912,924	12.3	1088.41	8.3 - 11.4	1.15	120
SRK05-SP4A	584,612	6,912,939	21.6	1087.27	16.5 - 21.0	0.80	200
SRK05-SP4B	584,611	6,912,939	4.0	1087.44	0.6 - 3.5	7.94	180
SRK05-SP5	584,576	6,912,956	14.0	1087.53	9.4 - 12.5	7.54	180
SRK05-SP6	584,492	6,912,975	11.0	1097.73	3.1 - 11.0	--	dry
S-cluster Monitoring Wells	**Easting**	**Northing**	**Total Depth (m)**	**Stick-up Elevation (m.a.s.l.)**	**Screen Interval (m.b.g.s.)**	**n/a**	
S1a	584,539	6,912,942	12.2	1085.43	9.2 - 12.2		
S1b				1085.27	1.3 - 4.3		
S2a	584,577	6,912,944	12.2	1086.03	9.2 - 12.2		
S2b				1086.30	3.7 - 6.7		
S3	584,585	6,912,918	5.6	1085.53	2.6 - 5.6		

Drill logs and completion diagrams for all boreholes are included in Appendix A.

3.2 Geology

3.2.1 Bedrock

Bedrock in the S-cluster area is comprised of the Mt Eye schist, and was described in the field as schist or phyllite. Weathered bedrock was characterised as brown to gray and damp, and was considered to be more easily drilled than unweathered bedrock. Iron precipitation on drill chips was frequently used an indicator of weathered bedrock. The thickness of the weathered bedrock varies from 0.6 to 1.5 metres along the studied transect.

Photograph 2 shows the contact between till and weathered bedrock at SRK05-SP6.

Photograph 2: Till-bedrock contact at SRK05-SP6

Figure 2 shows depth to bedrock for the S-cluster area.

Figure 3 is a map showing the location of cross-sections created for the site. Figures 4 and 5 show cross-sections through the S-cluster area with inferred stratigraphic units.

As seen on Figures 2 and 4, depth to bedrock in the 2005 drillholes and S-cluster drillholes is greatest at SRK05-SP4A and - SP3A, with depths to bedrock greater than 20 metres. Observed depth to bedrock is a minimum at SRK05-SP6, 3 metres, located closer to the toe of the waste rock dump and at higher ground elevation than SP4A and SP3A. Depth to bedrock increases further to the west at SRK04-2, where bedrock was not intersected at the total drillhole depth of 19.8 metres during the 2004 field program. Of note is the difference in bedrock elevation (listed in table on Figure 2) between S1A, S2A and SP5, as well as SP4A and SP3A. Bedrock elevation increases by approximately four metres from SP5 to S2A, which is located approximately 15 metres from SP5 in the down gradient direction. S1A, S2A and SP5 all have bedrock elevations eight metres or greater above those of SP4A and SP3A.

Comparison of depth to bedrock and ground elevation for each drillhole indicates that the bedrock surface in this area is undulating with significant variations between drillholes. A possible bedrock low may exist, trending along the alignment of the NFRC below the S-cluster area. A bedrock high extends south-eastwards towards the trough from the area of the western edge of the waste rock dump. Alternatively, bedrock may generally rise from the area of the 2005 SP wells towards the NFRC. Additional drilling near the NFRC would be required to better delineate the bedrock surface.

The seismic survey conducted in 2004 by Aurora Geophysics was completed along a transect close to the 2005 SP wells, but closer to the toe of the waste rock dump. At the time, there were no drillholes available to calibrate interpretations. Two of the 2005 drillholes are located close to the ends of the seismic profile line. Seismic data could be re-analysed using the currently available depth-to-bedrock data to provide improved definition of the bedrock surface.

3.2.2 Overburden

Drillcore indicates that the overburden material at the site generally consists of varying percentages of interbedded silt, sand and gravels, with trace to minor clay.

Coarse sands and gravels are generally located at greater depth, with the exception of a single location. At SRK05-SP4, approximately three metres of gravelly sand were identified relatively close to ground surface.

The sand and gravel units at greater depth are described as ranging from silty - gravelly fine to coarse sand to sandy-gravel with cobbles and trace silt. In general, it appears that the silt content in sandy intervals increases from east to west. The shallow layer of coarser materials in SRK05-SP4B is described as gravelly sand with silt and trace to minor clay. The shallow material is interpreted to represent fluvial deposits of limited lateral extent within the pre-mining drainage identified in earlier reports.

Separating the coarser sand to gravel-dominated units are finer-grained sandy-clayey silts to sandy-gravelly silts. Gravels ranged from angular to rounded and cobbles were identified in many of the drillholes. The finer-grained materials are generally interpreted as glacial till deposits.

The old drill logs of the existing S-cluster wells had indicated predominantly gravelly-sandy silt, interpreted as till. Relatively coarser materials had only been reported at the overburden-bedrock interface. In the drill logs for the deeper S-cluster wells (S2A and S1A) the interface of overburden and bedrock had generally been described as “weathered rock: some sand and gravel…” to “sand and gravel”. No other sand and gravel units were identified. It is possible that relatively coarser grained materials are present on bedrock at these locations. In general, the 2005 drillholes show a larger percentage of sand and gravel materials in the overburden than the S-cluster wells.

3.3 Monitoring Well Hydraulic Testing

Hydraulic testing was completed in all 2005 monitoring wells with the exception of SRK05-SP-6, which was dry. The original S-cluster wells were also tested.

Tests were completed as standard slug tests or as “mini-pumping” tests. Standard slug tests were completed by “instantaneously” introducing a cylindrical slug (25mm x 1-1.5m/0.16-0.23 L) to the monitoring well and recording water level response. Mini-pumping tests were completed using a portable transfer pump with a suction line. Water was pumped for a period of time with discharge measured using a bucket and stopwatch. After the discharge period, the pump was shut off and recovery monitored. The suction line was fitted with a check-valve to keep water from flowing back into the monitoring well during shut-off. The recovery data from these mini pumping tests were interpreted using AquiferTest V4.0 by Waterloo Hydrogeologic. This software uses conversion of recovery data (Agarwal method) to allow the application of standard discharge analysis methods, such as Theis for confined aquifers and Hantush for leaky aquifers.

Water level data was collected by a combination of manual and automated methods. Solinst Leveloggers with resolution of 0.3cm were used for automated water level recording.

Results of hydraulic tests are listed in Table 2. Hydraulic test water level data and analysis sheets are included in Appendix B.

Note that no hydraulic testing was completed at SRK05-SP1A and -1B. In these bores, the depth to water was too great for the suction capacity of the available pump and no slug testing was carried out.

Table 2: Hydraulic Testing Summary

Well ID	Test Type	Aquifer Thickness (m)	2005			2004 re-calculation
			Mini-pumping		Slug Testing	Slug Testing
			T (m^2/s)	K (m/s)	K (m/s)	K (m/s)
SP1a	None	10.2	No Testing			
SP1b	None	3.3				
SP2	Mini-pumping	6.4	3.0x10^{-3}	4.7 x10^{-4}	--	
SP3a	Mini-pumping	13.7	1.2 x10^{-4}	8.8 x10^{-6}		
SP3b	Mini-pumping	3.2	5.0 x10^{-4}	1.6 x10^{-4}		
SP4a	Mini-pumping	6.1	4.0 x10^{-5}	6.6 x10^{-6}		
SP4b	Mini-pumping	3.5	1.1 x10^{-4}	3.1 x10^{-5}		
SP5	Mini-pumping	4.3	4.8 x10^{-4}	1.1 x10^{-4}		
SP6	None	7.9	Dry			
S1a	Mini-pumping	12.2	6.8 x10^{-4}	5.6 x10^{-5}	--	
S1b	Slug	4.5	--		3.9 x10^{-7}	--
S2a	Slug	12.2			1.5 x10^{-6}	--
S2b	Slug	7			2.4 x10^{-6}	2.3 x10^{-6}
S3	Slug	5.6			6.6 x10^{-6}	6.8 x10^{-6}

Slug testing was conducted on most of the original S-cluster wells. In the cases of S2b and S3, data from 2004 slug tests were re-interpreted with improved data filtering, suggested by reviewers of the 2004 Preliminary Seepage Investigations report, and are included in Table 2 for comparison. Data was interpreted using the same analytical methods as in 2004. At these two wells, hydraulic conductivity (K) values calculated from 2004 and 2005 test data are in very good agreement.

As expected, higher K values were generally observed in:

- shallow sand and gravel layers (e.g., SP3b and SP4b)
- areas of thicker sand and gravel sequences at greater depth (e.g., SP2)
- weathered bedrock (e.g., SP5)

Comparison of hydraulic conductivity values derived from mini-pumping vs. slug tests indicates slightly higher hydraulic conductivity values from mini-pumping tests. This may be a result of the geology of the screened zone, which for the S-cluster wells corresponds more closely to the inferred low permeability zones of the 2005 drillholes. Alternatively, differences in hydraulic conductivity values for mini-pumping tests may be a result of uncertainties in the estimation of aquifer thickness (required for back-calculation of K from T).

3.4 Stream Survey

3.4.1 Methods

Three stream surveys were conducted along the NFRC in the S-cluster area by Laberge Environmental Services (LES). River level and discharge (Q) measurements were completed at three to six locations for each survey. Monitoring stations in the North Fork of Rose Creek are shown on Figure 1 (marked with the affix “NFRC”). The four NFRC_SC-x locations were established specifically for this S-cluster area investigation. Two others, NFRC 20/21 and 22/23 were established as part of other investigations or routine monitoring programs. Station NFRC_22/23 corresponds with the routine water quality monitoring station X2.

Methodologies for stream surveys are included in the LES memoranda in Appendix C.

To assess measurement error, multiple measurements were made during each sampling event at a minimum of one station. Table 3 summarises measurement error for each flow survey.

Table 3: NFRC Stream Survey Measurement Error

Date	Repetition Measurements	Q Error Range (m^3/s)	Assumed Q Error (m^3/s)
July 7, 2005	NFRC 20/21 & 22/23	n/a	n/a
August 10, 2005	NFRC 22/23	0.051	0.051
December 19, 2005	NFRC SC-2 to SC-4	0.010 – 0.057	0.057

In cases where multiple flow measurements were taken at an individual station, reported discharge is taken as the average of measurements.

As part of the creek monitoring, water quality was assessed. Samples of creek water were taken for lab analysis from each station for two of the three sampling events. Additionally, surface water seeps along the river banks were measured for field conductivity using a hand-held conductivity meter. Locations of ponded surface water were labelled as “SCS” stations and are shown on Figure 1.

Details of each sampling event are listed in Table 4.

Table 4: NFRC Stream Survey Details

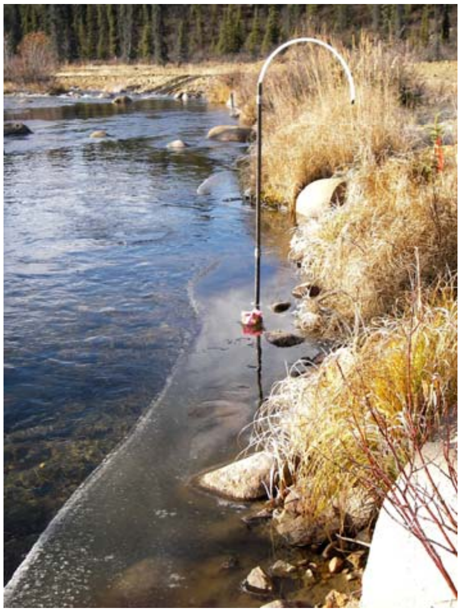
Date	NFRC SC-x Stations	NFRC 20/21 & 22/23 Stations	Q (flow quantity)	Discharge Measurement Type	Water Quality Sampling	Seep Conductivity
July 7, 2005	√	√	√	MF	-	√
August 10, 2005	√	√	√	MF	√	-
December 19, 2005	√ (No SC-1)	-	√	SD	√	-

*MF = Mechanical Flowmeter

*SD = Salt Dilution

3.4.2 Drivepoints

Four shallow drivepoints were installed along the north bank of the North Fork of Rose Creek, immediately down-gradient of the groundwater monitoring wells to improve understanding of stream-aquifer gradients. Drivepoint locations are shown on Figure 1. Drivepoints were constructed of prefabricated 6-inch x 1-inch (15 x 2.5cm) stainless-steel points with screened perforations (purchased from Solinst, Inc. of Ontario, Canada). The stainless-steel points were attached to 1-inch (2.5cm) carbon steel pipe and driven in using a post-driver. In areas where river velocity was high around the drivepoint, a section of PVC was put around the drivepoint to allow measurement of static river head at the drivepoint location. Photograph 3 shows a drivepoint installation in the Zone 2 pit area. The white teflon tubing protruding from the steel casing is sample tubing.



Photograph 3: Typical Drivepoint Installation

Drivepoint completion information are summarised in Table 5. Most drivepoints are angled due to intersecting boulders during installation. As a result, correction factors are required to convert depths to water to true vertical. Correction multipliers for each drivepoint are included in Table 5.

Table 5: NFRC Drivepoint Completion Summary

2005 SRK Drivepoint	Easting	Northing	Angle Correction Multiplier	Total Vertical Depth Below River Bottom (m)	Stick-up Elevation (m.a.s.l.)
SRK05-DP1	584,630	6,912,887	0.99	1.14	1083.97
SRK05-DP2	584,554	6,912,904	0.82	0.53	1082.55
SRK05-DP3	584,514	6,912,901	0.93	0.75	1081.89
SRK05-DP4	584,535	6,912,911	1.0	0.94	1082.19

Drivepoint SRK05-DP4 is a sampling drivepoint. Teflon tubing is directly attached to the stainless-steel drivepoint to allow extraction of water samples without contacting the carbon steel riser pipe (see example in Photograph 3).

3.4.3 Flow Survey Results

Discharge measurements from the three stream surveys are summarised in Table 6. Measurement station locations are shown on Figure 1.

Table 6: NFRC Flow Survey Summary

Flow Station	Q (m^3/s)		
	July 7, 2005	August 10, 2005	December 19, 2005
NFRC 20/21	1.421	1.114	n/a
NFRC SC_1	1.627	1.656	n/a
NFRC SC_2	1.447	1.346	0.385
NFRC SC_3	1.553	1.496	0.505
NFRC SC_4	1.540	1.510	0.553
NFRC 22/23 (X2)	1.593	1.538	n/a

Relative differences in discharge values between each reach provide an indication of the relative direction of water flux between the NFRC and the groundwater system.

Results from the July and August surveys indicate that discharge increases significantly from NFRC 20/21, located upstream of the rock drain, to NFRC SC-1, immediately upstream of the S-cluster area itself. In other words, the NFRC is a gaining stream in the general vicinity of the rock drain with groundwater discharge representing the most likely source (no significant surface inflows were reported along this reach). Note, however the large variations in streamflow gains between the two surveys. At other stations the two summer flow measurements agreed much better suggesting problems with flow measurements at NFRC 20/21 in one of those two surveys.

Between NFRC SC-1 and NFRC SC-2, discharge decreased for both the July and August surveys. In August, reported discharge values indicate a decrease of 310 L/s, or approximately 19% of the flow at NFRC SC-1.

Between NFRC SC-2 and NFRC 22/23, net discharge increases, though discharge values at NFRC 22/23 were not as high as those of NFRC SC-1.

The presence of gaining and losing reaches suggests that surface water and groundwater (at least shallow groundwater) are in good hydraulic connection along much of the length through the S-cluster area.

Comparison with gradients derived from shallow drivepoints located along the banks of the NFRC, shown in Table 7, provides additional insight into creek dynamics. The location of drivepoints is included on Figure 1.

Table 7: Drivepoint Measurements and Gradients

ID		**Vertical Depth to Water (m)**		**Gradient**	
Date	**Drivepoint**	**GW**	**River**	**Differential**	**Direction**
9-Sep-05	DP3	1.04	1.02	**0.02**	**gradient down**
9-Sep-05	DP2	1.25	0.81	**0.44**	**gradient down**
9-Sep-05	DP1	0.69	0.64	**0.05**	**gradient down**
13-Sep-05	DP3	1.03	1.01	**0.02**	**gradient down**
13-Sep-05	DP2	1.20	0.80	**0.39**	**gradient down**
13-Sep-05	DP1	0.66	0.65	***0.00***	***gradient down***
15-Sep-05	DP3	1.05	1.04	**0.01**	**gradient down**
15-Sep-05	DP2	1.21	0.84	**0.37**	**gradient down**
15-Sep-05	DP1	0.66	0.66	***-0.01***	***gradient up***
18-Sep-05	DP4	1.66	1.46	**0.20**	**gradient down**

Attempts to measure water levels in January 2006 were unsuccessful as the drivepoints were frozen.

All drivepoints are located within the reach between NFRC SC-2 and NFRC SC-3, which has a shown a net increase in stream discharge during the three monitoring surveys. The majority of drivepoint gradients, recorded only in September soon after installation, indicate downward gradients from the NFRC to the groundwater system.

The reason for the contradictory evidence is unclear, but may be related to the depth of the drivepoint screen sections. Screen sections are roughly 0.5 to 1 metre below the bed of the NFRC. If shallow groundwater flow is dominantly occurring within the near surface materials (e.g., macropores in organics), inflow to the creek may occur laterally, very close to the ground surface.

The change in river discharge observed between SC-1 and NFRC 22/23, during August, 2005, generally support the concept of a shallow, hyporheic flow system. A loss of approximately 310 L/s occurred from SC-1 to SC-2 during the August monitoring event. Approximately 62% (192 L/s) is gained back to the NFRC between SC-2 and SC-3. Another 17% (42 L/s) is gained between SC-3 and NFRC 22/23. It is feasible that the gains in lower reaches are just water returning to the creek that was lost in upper reaches.

3.5 Hydrogeologic Conceptual Model

3.5.1 Hydrostratigraphy

Based on the geology and results of hydraulic testing, four hydrostratigraphic units are defined for the S-cluster area:

- Unit 1: Shallow aquifer unit
- Unit 2: Low conductivity unit
- Unit 3: Deep aquifer unit
- Unit 4: Bedrock

Unit 1: The shallow aquifer unit is characterised by sand and gravel materials confined to a narrow band trending along the alignment of a pre-mining drainage feature. Hydraulic conductivity is approximately 3 x 10^{-5} m/s. The much higher water levels in this zone (Figure 4) suggest that this shallow aquifer is perched.

Unit 2: The low conductivity unit is defined as predominantly fine-grained materials and represents a confining layer for the shallow (perched) aquifer and the underlying, confined aquifer. The unit appears to be laterally continuous, though likely inter-fingers with coarser grain materials. Direct hydraulic conductivity data is not available for this unit. Grain size analyses completed on samples from surface exposures of these materials, taken from a test pitting program in 2004, suggest maximum hydraulic conductivity values in the range of 2 x10^{-7} to 3x10^{-7} m/s.

Unit 3: The deep aquifer unit includes sand and gravel materials found at depth and/or overlying bedrock, as well as the weathered bedrock profile. Thickness varies across the site from <1 metre to approximately 10 metres. In some areas, such as SRK05-SP5 and –SP6, the deep aquifer unit may consist predominantly of weathered bedrock with only a minor component of unconsolidated material. Hydraulic conductivity ranges from 1 x 10^{-4} to 9 x 10^{-6} m/s.

Unit 4: The bedrock in the S-cluster area consists of schist of the Mt. Mye Formation. Bedrock is defined as a calcareous schist to calc-silicate. In the area of the S-cluster, bedrock has a phyllitic texture and has been called phyllite in the drill logs. No significant fractures or structures have been identified, but drilling generally did not continue far into bedrock and the drilling method precludes recovery of continuous core. Hydraulic testing was not carried out in this unit; however, the hydraulic conductivity of the bedrock is expected to be orders of magnitude lower than the overlying aquifer units 1 and 3.

The distribution of aquifer units 1 and 3 varies across the site. Unit 1 appears to be confined to the pre-mining drainage. To the west of the S-cluster area, unit 3 is the only aquifer unit present and may, in isolated areas, get close to ground surface, depending on bedrock topography. To the east of the S-cluster area, closer to the rock drain, unit 3 increases in thickness and is dominated by sand and gravel deposits.

On the southeast facing slope northwest of the S-cluster, discontinuous (possibly relict) permafrost has been intersected in test pits and drillholes. In SRK05-SP5, ice lenses up to 2mm thickness were identified at depths up to 3.7 meters. Based on exposure, the permafrost may have cracks and fissures in the upper sections that act to increase permeability, but overall the permafrost is considered to be relatively impermeable compared to aquifer materials. Permafrost has only been identified at shallow depths in unit 2.

3.5.2 Groundwater Flow System

Measurements of water level in monitoring wells were taken on numerous occasions during the summer field program. Water levels were taken using a standard water level tape from a marked datum on each monitoring well stickup, if present, or from the top of the PVC monitoring well casing. Total depths of monitoring wells were measured with the water level tape in order to prevent confusion as to which monitoring wells were deep and which were shallow. Table 8 summarises water level data.

A complete set of water level data is not available on any specific date, but comparison of measurements on different dates indicates that water levels were not changing significantly.

Table 8: NFRC Water Level Summary

Drillhole	**Date**	**25-Aug-05**		**12-Sep-05**		**13-Sep-05**		**14-Sep-05**		**15-Sep-05**		**18-Sep-05**	
	Datum Elevation	**Depth to water**	**Water Elevation (m.a.s.l.)**	**Depth to water**	**Water Elevation (m.a.s.l.)**	**Depth to water**	**Water Elevation (m.a.s.l.)**	**Depth to water**	**Water Elevation (m.a.s.l.)**	**Depth to water**	**Water Elevation (m.a.s.l.)**	**Depth to water**	**Water Elevation (m.a.s.l.)**
SRK05-SP-1A	1091.99	7.345	1084.64	7.344	1084.64	7.330	1084.66						
SRK05-SP-1B	1091.94	7.444	1084.50	7.445	1084.50								
SRK05-SP-2	1086.70	2.096	1084.61	2.099	1084.60								
SRK05-SP-3A	1088.50	4.725	1083.78			4.710	1083.79	4.665	1083.84				
SRK05-SP-3B	1088.41	4.015	1084.40			4.000	1084.41	3.959	1084.45				
SRK05-SP-4A	1087.27	4.075	1083.19					4.032	1083.23				
SRK05-SP-4B	1087.44	1.448	1086.00					1.446	1086.00				
SRK05-SP-5	1087.53	6.012	1081.52					5.962	1081.57	5.957	1081.57		
SRK05-SP-6	1097.73	dry											
SRK05-DP1	1083.97					0.665	1083.31			0.656	1083.31		
SRK05-DP2	1082.55					1.463	1081.09			1.207	1081.34		
SRK05-DP3	1081.89					1.100	1080.79			1.048	1080.84		
SRK05-DP4	1082.19											1.660	1080.53
S1A	1085.43							4.042	1081.39	3.587	1081.84		
S1B	1085.27									2.370	1082.90		
S2A	1086.03							2.775	1083.26	2.812	1083.22		
S2B	1086.30							2.662	1083.64	3.580	1083.58		
S3	1085.53									1.870	1083.66		

Interpretation of water table data is included on Figures 12 through 15, which also display water quality data and are discussed in Section 3.6.

The groundwater table at the S-cluster site generally mimics topography, suggesting flow from high elevations to relatively lower elevations. The NFRC alignment itself represents a local low elevation feature at the site and likely affects the overall shape of the water table.

Water level data is currently only available for the north side of the NFRC, between the NFRC and the Intermediate waste rock dump. As shown on Figures 12 and 13, both shallow and deep groundwater flow direction is towards the NFRC from the surrounding higher elevations. On the south side of the creek, where there is no available water level data, groundwater is also assumed to flow towards the creek.

Depth to bedrock will affect the overall groundwater flow direction in the deep aquifer system. Available bedrock depth data supports the concept of flow towards the NFRC on the north side of the creek, but the lack of bedrock depth data the south of the creek precludes an interpretation of groundwater flow in this area. Despite the lack of data to the south of the NFRC, topographic control on groundwater flow directions is a very common feature in mountainous environments and is considered reasonable for both the deep and shallow groundwater systems in this area.

Groundwater flow directions are suggested to be affected by shallow, hyporheic flow system near the NFRC itself. Discharge measurements suggest that the NFRC loses water to the shallow groundwater system in reaches immediately upgradient of the S-cluster wells, and gains water from the shallow groundwater system along reaches at the S-cluster wells and downgradient.

3.6 Water Quality

Groundwater and surface water were sampled as part of the 2005 field program. These data were compared with historical water quality in this area to improve understanding of trends.

3.6.1 Historical Water Quality

As part of the assessment of current and potential future contaminant loading in groundwater and the NFRC in the S-cluster area, records for long-term monitoring locations were updated. Historical data are available for the locations listed below.

Groundwater:

- S-cluster wells: S1A, S1B, S2A, S2B, S3 (Figures 6 and 7)
  Date of record – 1989 to present
- P96-7: located close the toe of the waste rock dump, upgradient from the S-cluster wells (Figures 8 and 9)
  Date of record – 1996 to present

Surface Water:

- X2: NFRC water quality monitoring station located where the NFRC crosses the main access road (Figures 10 and 11)
  Date of record – 1987 to present

Graphical representations of data for each location are included in the figures referred to for each record description. Figures include sulphate and zinc concentrations, as well as alkalinity and pH.

S-cluster

As shown on Figure 6, sulphate and zinc concentrations have shown increasing concentrations over time.

- Sulphate concentrations began to show a gradual increase since start of monitoring in 1989. Average breakthrough of the sulphate contamination occurred around 1999.
- Zinc shows a significant breakthrough in three of the five S-cluster monitoring between 2001 and 2003. Data from 2004 and 2005 suggest zinc concentrations may be levelling off.
- pH, alkalinity and hardness, shown on Figure 7, have remained relatively stable.

Concentrations of both sulphate and zinc are generally highest in S1A, S2A and S3. S1A and S2A are completed in weathered bedrock and overlying materials interpreted to be part of the deep aquifer system. S3, interpreted to be part of the shallow system, also shows higher relative concentrations and may indicate either connection between S3 and SRK05-SP4b or that the deep aquifer is thicker than believed based on available drill logs. Alternatively, upwelling groundwater from the deep to shallow aquifer systems in the vicinity of S3, may be the cause for higher the higher concentrations observed at S3.

Physical parameters for the S-cluster wells (pH, total alkalinity and hardness) are relatively stable for the length of record. pH is generally circum-neutral, tending to be slightly acidic. The pH has not fallen below a value of 5 over the course of record.

Of note at S1B and S2B, during the period May, 2002 to present, are apparent seasonal fluctuations, particularly evident in alkalinity and hardness values, suggestive of the influence of surface runoff or increased groundwater flow during the spring, freshet, period.

All drill logs for the S-cluster wells indicate a predominance of till.

P96-7

Sulphate and zinc concentrations are shown on Figure 8. Sulphate has shown a steady increase since monitoring began in 1996, from concentrations of approximately 500 mg/L in 1998 to close to 2,000 mg/L in 2005. Zinc concentrations have not shown the same trend. With the exception of a spike during 1997, zinc concentrations have generally remained close to 0.01-0.02 mg/L.

- Sulphate concentrations suggest the influence of seepage from the waste rock dumps, possibly indicating breakthrough in late 1998 to early 1999. Sulphate concentrations to do yet appear to be levelling.
- Zinc concentrations have remained relatively low, suggesting either attenuation of zinc upgradient from this monitoring location or that the zinc plume has not reached this area.
- pH, alkalinity and hardness have remained relatively stable for the period of record (Figure 9).

X2

Figures 10 and 11 present data for station X2, a NFRC monitoring station located downstream of the S-cluster monitoring wells. Trends for the NFRC do not show the same "breakthrough" as observed in the groundwater monitoring wells, but do provide insight into possible connection between the NFRC and underlying groundwater system.

- Sulphate (analysis changed from total sulphates to dissolved sulphates in 2002) shows annual variation, with highest concentrations in the fall and winter and lowest concentrations in the late spring.
- This annual sulphate trend suggests year-round loading with increased dilution during freshet conditions.
- Overall, sulphate concentrations suggest a slow increase over time.
- Total zinc concentrations do not suggest an increase over the period of record. The highest concentrations were recorded in 2000, prior to the significant zinc breakthrough at the S-cluster in 2001. Variation in total zinc concentrations may not indicate effects of groundwater, but the effects of particulates in surface waters.
- Dissolved zinc concentrations may suggest an overall increase in early 2002. Prior to 2002, zinc concentrations are typically recorded as "<0.01", presumably representing the limit of detection at the time. After 2002, dissolved zinc concentrations are typically greater than 0.01 mg/L.

3.6.2 Current Water Quality

Groundwater from the 2005 and original S-cluster monitoring wells was sampled by GLL on September 12, 2005, soon after the 2005 monitoring wells were installed. Samples were collected using standard GLL protocols.

Samples of NFRC waters for water quality analyses were obtained during the August and December flow surveys by LES. Samples were collected using standard field techniques, including field filtration and preservation for metal analyses. Samples were submitted to ALS Canada Ltd. in Vancouver for analysis, including: physical tests, major cations and anions, total metals and dissolved metals. Full analytical results from GLL for groundwater samples, and from ALS for surface water samples, are included in Appendix D.

Results

Summary results of September 2005 groundwater quality analyses are listed in Table 9. S-cluster results from May 2005 are included for comparison.

Table 9: Groundwater Quality for May and September, 2005

Monitoring Well		S1A	S1B	S2A	S2B	S3	SP1A	SP1B	SP2	SP3A	SP3B	SP4A	SP4B	SP5
5/5/2005	Conductivity	n/a	n/a	n/a	n/a	n/a	Monitoring wells not installed at this time							
	SO4	4550	403	1860	1760	4610								
	Zn-D	113	0.067	127	8.65	158								
9/12/2005	Conductivity	5600	1430	5440	3660	5850	1130	1170	359	512	537	750	6190	5720
	SO4	4070	703	3910	2510	4360	383	309	45.4	245	261	158	4680	4170
	Zn-D	118	0.051	178	1.19	165	1.63	0.144	0.161	1.04	0.628	1.10	277	153

Sulphate and zinc levels, considered to be indicators of the level of contamination for this study, show significant variation both between shallow and deep aquifer and between individual wells. Sulphate and zinc levels show variations of up to two orders of magnitude:

- Sulphate varies from 45.4 mg/L at SP2 to 4680 mg/L at SP4b. Significant variation can be seen between shallow and deep monitoring locations (e.g. S1B and S1A, respectively) and between shallow monitoring locations, such as S1B and SP4b.
- Zinc varies from 0.051 mg/L in the shallow aquifer (at S1B) to 118 mg/L in the deeper aquifer unit (at S1A), located at the same position. Significant variation is also observed between monitoring wells of the same aquifer unit. Zinc concentration varies, from 0.051 mg/L at S1B to 277 mg/L at SP4b, both considered to be representative of the shallow aquifer.

The interpreted distribution of sulphate and zinc are shown on Figures 12 through 15.

- Figures 12 and 13 show sulphate distribution for the shallow and deep aquifer, respectively.
- Figures 14 and 15 show zinc distribution for the shallow and deep aquifer, respectively.

Based on the interpreted distribution of sulphate and zinc at the S-cluster area from the August 2005 sampling data, contamination in the shallow aquifer is considered to be relatively constrained when compared with the deeper aquifer. Contamination in the deeper aquifer, in particular sulphate, is relatively widespread and has likely travelled much further down gradient compared to zinc.

Contamination in the shallow aquifer is believed to be constrained to the pre-mining drainage alignment. Concentrations decreases rapidly away from this alignment. Hydraulic conductivities of shallow materials are also interpreted to decrease away from the alignment.

Contamination appears to be more dispersed in the deep aquifer unit, which is considered to be more broad an aquifer unit than the shallow system. Bedrock topography likely plays a role in the distribution of contaminants.

Table 10 summarises results of August and December sampling of the NFRC itself. Discharge values are included if available.

Table 10: NFRC Water Quality and Discharge for August & December, 2005

Station	Lab Conductivity (uS/cm)	SO4 (mg/L)	Zn-D (mg/L)	August Discharge (m^3/s)	December Discharge* (m^3/s)
NFRC 20/21 – August	n/a	n/a	n/a	1.114	--
NFRC 20/21 – December	n/a	n/a	n/a	--	n/a
NFRC_SC-1 – August	180	10.8	0.0063	1.656	--
NFRC_SC-1 – December	260	18.0	0.0111	--	n/a
NFRC_SC-2 – August	180	10.8	0.0079	1.346	--
NFRC_SC-2 – December	259	18.3	0.0122	--	0.385
NFRC_SC-3 – August	184	12.7	0.0158	1.496	--
NFRC_SC-3 – December	263	21.8	0.0566	--	0.505
NFRC_SC-4 – August	186	13.5	0.0168	1.510	--
NFRC_SC-4 – December	271	25.4	0.0610	--	0.553
NFRC 22/23 (X2) – August	185	15.1	0.018	1.538	--
NFRC 22/23 (X2) – December	n/a	n/a	n/a	--	n/a

*December discharge values calculated as average of repeat measurements

In the NFRC, sulphate and zinc concentrations generally increase in a downstream direction through the S-cluster area. Between stations NFRC SC-1 and SC-4, sulphate increased by approximately 40% in both August and December. Between the same stations, zinc increased by approximately 166% in August and 450% in December. Two observations can be made:

- Concentrations vary over time
- The relative increase in concentrations through the S-cluster area is greater for zinc than sulphate

Review of the historic record of X2, located downstream of the S-cluster area (Figures 10 and 11), suggests seasonal variation in concentrations in the NFRC. Seasonal variation is much more regular in sulphate concentrations than zinc concentrations, but, in general, both zinc and sulphate concentrations in the NFRC are higher during baseflow periods (winter to early spring), than other times of the year. This suggests that the observed loads include significant contributions from groundwater or re-entry of hyporheic flow, supporting the results of the LES discharge surveys. Loading calculations (following section) will show that this load cannot all be originating from re-entry of NFRC water lost upstream of the S-cluster, but must have a component of external groundwater input.

The August and December data indicate that sulphate and zinc concentrations in the NFRC increase by differing amounts. Zinc concentrations increased three to ten times greater than sulphate concentrations between NFRC SC-1 and SC-4. This may be a result of the distribution of contaminants.

As shown in Figures 12 through 15 (concentration contour maps), the sulphate "plume" is interpreted to have moved further down gradient than the zinc "plume". This interpretation is consistent with historical trends of groundwater quality in the S cluster wells which indicate an earlier breakthrough of sulphate compared to zinc. Sulphate concentrations in groundwater, where it discharges to the creek, may have become relatively "stable" over time in terms of total potential load to the creek.

Zinc concentrations at the S-cluster have not yet "plateaued" as observed for sulphate. While zinc concentrations, in general, do appear to be stabilising, this trend has only been apparent within the past couple of years. At this time, the mechanisms controlling these variable concentrations are uncertain.

4 Assessment of Contaminant Sources & Loading

4.1 Contaminant Sources

The primary contaminant sources to the S-cluster area are the Main East and Intermediate waste dumps (ME and ID WRDs, respectively). In particular, the sulphide cells associated with each dump are expected to be a source of significant metals contamination. In addition to sulphide cells, observations of exposed sulphide and “free-dumped” sulphide materials on the slopes of the Intermediate dump may add to the contaminant load. For additional details regarding the composition of individual WRDs and the potential loads, readers are directed to the ICAP Report (RGC, 1996). A review of potential loadings to the S-clsuter area is currently in progress as part of the overall refinement of the water and load balance for the entire mine site (SRK, in progress).

4.2 Contaminant Loading

4.2.1 Contaminant Loading in Groundwater

Sulphate and zinc loads in groundwater in the S-cluster area were determined based on available geology and hydrogeology data, using water quality data from the September sampling event.

Groundwater flux values were determined based on the current understanding of the area hydrogeology. Flux values were calculated separately for the shallow and deep aquifers along the section defined by the new SP series of wells. In addition, for the deep aquifer separate flux values were calculated for areas of high and low contaminant concentrations. The separation between these areas was defined as the approximate location between monitoring wells where concentrations decreased significantly (e.g. between SRK05-SP-5 and –SP-4A where zinc concentration decreases from 153 mg/L to 1.10 mg/L).

Flux calculations were based on the following information:

- Cross-sectional area along the section line as determined from average aquifer thickness and width (Figure 4)
- Average hydraulic conductivity values for each aquifer unit based on results from the 2004 and 2005 hydraulic testing (Table 2).
- Hydraulic gradients estimated along a straight line extending from the line of the main cross-section (Figure 4) to the NFRC along the trend of the maximum observed concentrations.

Table 11 summarises groundwater flux for the shallow and deep aquifers. Flux for the deep aquifer high concentration and low concentration zones are shown separately.

Table 11: Estimated Groundwater Flux

	Average Area (m2)	Gradient	Min K (m/s)	Ave K (m/s)	Max K (m/s)	Min Flux (L/s)	Ave Flux (L/s)	Max Flux (L/s)
Shallow Aquifer	75	0.05	1.8E-6	1.9E-5	1.1E-4	6.6E-3	0.07	0.41
Deep Aquifer – high concentration	90	0.03	1.8E-5	1.8E-4	6.8E-4	4.9E-2	0.49	1.8
Deep Aquifer – low concentration	595	0.01	4.0E-5	2.9D-4	3.0E-3	2.4E-1	1.7	1.8
TOTAL	760	-	-	-	-	0.30	2.26	4.0

K = Hydraulic Conductivity

Based on these calculations, total flux from the deep aquifer is more than one order of magnitude greater than flux from the shallow aquifer.

Estimates of solute loads in groundwater were determined using the flux values presented in Table 11 and transmissivity-weighted concentration data from the August, 2005 sampling event. The use of transmissivity-weighted average concentrations gives a greater weight to monitoring bores with higher groundwater flow and therefore provides more representative average concentrations for loading calculations. Maximum and minimum loading values were calculated using the maximum and minimum concentration and flux values. Table 12 summarises the results.

Table 12: Estimated Sulphate and Zinc Loads in Groundwater

SO_4	Observed SO_4 Concentrations (mg/L)			SO_4 Load (tonnes/yr)		
	High	T-wtd Average*	Low	High	T-wtd Average*	Low
Shallow Aquifer	4,680	4,346	703	61	9	0.1
Deep Aquifer – high concentration	4,170	4,108	3,910	240	62	6
Deep Aquifer – low concentration	383	83	45	210	5	0.3
Total Loads				511	76	6.4
Zn	**Observed Zn Concentrations (mg/L)**			**Zn Load (tonnes/yr)**		
	High	**T-wtd Average***	**Low**	**High**	**T-wtd Average***	**Low**
Shallow Aquifer	277	111	0.051	3.5	0.2	$1x10^{-5}$
Deep Aquifer – high concentration	178	133	118	10	2.0	0.18
Deep Aquifer – low concentration	1.63	0.264	0.144	0.9	0.01	$1x10^{-3}$
Total Loads				14.4	2.2	~0.18

*T-wtd Average = Transmissivity-weighted average

Based on these analyses, the average annual sulphate loading is estimated to be 76 tonnes/year, with a possible maximum of 511 tonnes/year. Average annual zinc loading is 2.2 tonnes/year with a possible maximum of 14.4 tonnes/yr. According to these loading calculations, the highly contaminated portion of the deep aquifer unit represents the large majority of total contaminant loading in this area (i.e. 81% and 91% of the total sulphate and zinc loading, respectively).

4.2.2 Contaminant Loading to North Fork of Rose Creek

Sulphate and zinc loading to the NFRC was determined for September and December, 2005.
Table 13 lists flows, concentrations and calculated sulphate and zinc loads at each monitoring station for the August and December sampling events. Note that the solute loads listed in Table 13 represent total, cumulative loads calculated for each monitoring point. Table 14 lists the incremental sulphate and zinc load for each reach of the monitored NFRC length.

Table 13: Calculated NFRC Loads

Flow Station	Q (m^3/s)	Change from Upstream Station (m^3/s)	SO4-D (mg/L)	Cumulative SO4 Load (tonnes/yr)	Zn-D (mg/L)	Cumulative Zn Load (tonnes/yr)
NFRC SC-1 – August	1.656	0.542*	10.8	564	0.0063	0.31
NFRC SC-1 – December	n/a	n/a	18.0	n/a	0.0111	n/a
NFRC SC-2 - August	1.346	-0.310	10.8	459	0.0079	0.35
NFRC SC-2 - December	0.385	n/a	18.3	222	0.0122	0.15
NFRC SC-3 - August	1.496	0.150	12.7	600	0.0158	0.76
NFRC SC-3 - December	0.505	0.120	21.8	347	0.0566	0.90
NFRC SC-4 - August	1.510	0.014	13.5	643	0.0168	0.79
NFRC SC-4 - December	0.553	0.048	25.4	443	0.0610	1.06
NFRC 22/23 (X2) - August	1.538	0.018	15.1	733	0.018	0.88
NFRC 22/23 (X2) - December	n/a	n/a	n/a	n/a	n/a	n/a

Change at NFRC SC-1 calculated from NFRC 20/21 located upstream of the rock drain

All August NFRC water quality data from August 10 sampling event, with exception of X2, which is from August 22

Zn-D = Dissolved zinc

SO_4-D = Dissolved sulphate

Table 14: Incremental Load for NFRC Reaches

Flow Station	Discharge (m^3/s)	Change from Upstream Station (m^3/s)	Incremental SO4 Load (tonnes/yr)	Incremental Zn Load (tonnes/yr)
NFRC SC_1 – August	1.656	0.542*	n/a	n/a
NFRC SC_1 – December	n/a	n/a	n/a	n/a
NFRC SC_2 - August	1.346	-0.310	-105	0.04
NFRC SC_2 - December	0.385	n/a	n/a	n/a
NFRC SC_3 - August	1.496	0.150	141	0.41
NFRC SC_3 - December	0.505	0.120	125	0.75
NFRC SC_4 - August	1.510	0.014	43	0.03
NFRC SC_4 - December	0.553	0.048	96	0.16
NFRC 22/23 (X2) - August	1.538	0.018	90	0.09
NFRC 22/23 (X2) - December	n/a	n/a	n/a	n/a
Load increase SC-2 to SC-4 (August)			184	0.44
Load increase SC-2 to SC-4 (December)			221	0.91

Based on the results shown in Tables 13 and 14, an increase in both sulphate and zinc load in the NFRC occurs along reaches passing through the S-cluster area. Discussion of variations in load through the S-cluster area will focus on the August monitoring event as there is a full data set. In December, a sample for station SC-1 could not be taken due to ice conditions, nor was data for station X2 available.

Between stations SC-1 and SC-4, representing the length of the NFRC passing through the direct S-cluster area, discharge decreases by 0.146 m^3/s, or approximately 9%. Through this same reach, zinc load shows a net increase of 0.48 tonnes/yr (155%), while sulphate shows a net increase of 79 tonnes/yr (14%).

Between stations SC-1 and SC-2, NFRC discharge decreases by 0.310 m^3/s (19%). In this reach, sulphate load decreased by 105 tonnes/yr (19%), while zinc load showed a marginal increase of 0.04 tonnes/year (13%).

Finally, between stations SC-2 and SC-4, in which NFRC discharge increases by 0.164 m^3/s (12%), zinc load increased by 0.44 tonnes/yr (126%), while sulphate increased by 184 tonnes/yr (40%).

Comparison of the net change in sulphate and zinc load suggests variable influence of shallow hyporheic and groundwater discharge to the NFRC between different reaches on the loads themselves. The net decrease in sulphate load between SC-1 and SC-2 of 79 tonnes/yr is equivalent to 43% of the net increase observed between SC-2 and SC-4. This suggests that almost half of the total increase in sulphate load observed through downstream reaches of the S-cluster area may be reintroduction of NFRC waters lost in upstream reaches. By comparison, zinc load increases through all reaches. Consequently, there is more confidence that the change in zinc load through the S-cluster is a result of groundwater discharge to the NFRC.

4.3 Loading Scenarios

Simple loading calculations were carried out to assess the possible contribution of contaminated groundwater to the observed increase in the NFRC load.

The four scenarios presented assume a single source of water (i.e. impacted groundwater from the S-cluster area) is mixing with the North Fork Rose Creek water. The following assumptions were made in the different scenarios:

1. Required concentrations to obtain observed loads based on the observed increase in creek discharge between SC-2 and SC-4 (164 L/s during the August monitoring event);
2. Required shallow groundwater concentrations to obtain observed creek load based on shallow groundwater flux alone (0.07 L/s);
3. Calculated creek concentrations assuming all estimated loading from the S-cluster area in reaching the creek (76 tonnes/yr sulphate and 2.2. tonnes/yr zinc);
4. The required flux of “unimpacted” groundwater combined with shallow groundwater flux (0.07 L/s) and concentration to obtain observed creek concentrations.

Table 15 summarises results of these scenarios. Bold numbers are assumed and represent model input.

Table 15: NFRC Loading Scenario Results

Scenario	Description	Groundwater Flux (L/s)	Inferred Seepage Concentrations (mg/L)	
			SO4	Zn
1	Observed increase in discharge (August)	**164**	36	0.09
2	Shallow seepage only	**0.07**	100,358	416
3	Total seepage	**2.29**	3,053	12.6
4	Shallow seepage	**0.07**	**4,346**	**111**
	Plus unimpacted groundwater	67	**100**	**0**

Scenario 1 assumes that the observed increase in NFRC flux and load comes completely from groundwater flowing through the S-cluster area. This scenario indicates that this seepage would have to have an average concentration of 36 mg/L SO4 and 0.09 mg/L zinc.

Results of scenario 2 suggests that if the observed load in the NFRC was from shallow groundwater only, sulphate concentrations in seepage from the S cluster area would have to be significantly greater than observed, and seepage zinc concentrations approximately four times the amount of the transmissivity-weighted average (111 mg/L).

The results of scenario 3, representing a diluted combination of deep and shallow groundwater, indicate that observed combined concentrations in shallow and deep groundwater could lead to the observed creek concentrations.

Results of scenario 4 indicate that only 67 L/s of clean groundwater would be required to mix with S-cluster groundwater under observed concentrations to obtain observed creek concentrations.

The results of scenarios 3 and 4 also suggest that, if the interpreted sulphate concentration distribution for the deep aquifer shown in Figure 13 is reasonable, additional loading from the deep aquifer to the NFRC could be occurring downstream of the S-cluster.

In summary, assessment of the available data indicates that contaminant load in the NFRC increases in the area of the S-cluster, and is likely resulting from a combination of deep and shallow groundwater plus water lost upstream or entering the creek for the first time. While it is not possible to accurately define the exact source, there is a high level of confidence that deep and shallow groundwater must be both contributing to load in the NFRC at the S-cluster area.

Based on observed concentrations in the NFRC during the August and December monitoring events, and calculated maximum groundwater flux, annual loading estimates are provided:

Annual load based on current observed zinc load at NFRC SC-4:

0.8 – 1.0 tonnes/yr

Potential maximum annual zinc load at NFRC SC-4 based on maximum observed concentrations:

14 tonnes/yr

NOTE: These estimates generally coincide with values determined as part of the Faro Mine Water and Load Balance

5 Conceptual Design of Seepage Interception System

Based on the loading calculations presented in the previous section, contaminated groundwater from the S-cluster area currently discharges to the NFRC and likely exists in the groundwater system beneath and around the creek. Remedial actions will be required for the S-cluster area to prevent further contamination of the NFRC.

The primary source of contamination in the S-cluster area is the Intermediate Dump, which will not be removed as part of the mine closure, though options to reduce infiltration through the dump and, subsequently, load from the dump, are being considered. Consequently, collection systems to intercept the main flow of contaminated groundwater emanating from the dumps will be required for an indefinite period of time. This extended period of time will allow any capture system to be refined and upgraded in order to achieve the required capture efficiency.

An adaptive management plan is proposed for the design and implementation of the seepage interception system (SIS) that would ensure that the required capture efficiency is met with a high degree of confidence. The initial design will focus on the relatively well-defined area of high concentrations that currently dominates contaminant load to the NFRC. An extensive monitoring network would be implemented to assess the performance of the initial collection system. If required, the initial design would then be upgraded using contingency measures that are clearly defined in the adaptive management plan.

5.1 Available Technologies

Numerous types and configurations of groundwater interception systems are potentially available for the S-cluster SIS:

Pumping wells – The use of pumping wells is an extensively utilised approach to capture contaminated groundwater. Pumping wells are relatively quick to design and install, and can be adapted somewhat to different geologic conditions. A significant drawback to pumping wells is the inability to accurately predict the influence of geologic heterogeneity on capture zone distribution and, subsequently, the potential for contaminant by-pass.

Cut-off walls – Cut-off walls form a low-permeability, physical barrier to groundwater flow. Cut-off walls require significantly more construction than pumping wells. Cut-off walls can be constructed of slurry materials (e.g., mixtures of bentonite grout and soil) or sheet piles. Cut-off walls can be installed to significant depths (>20m) using either trenching or jet-grouting techniques, depending on local soil conditions. A pumping system is required to remove the blocked groundwater.

Shallow sumps and trenches - In areas of shallow groundwater (within approximately 5 meters of ground surface), sumps or trenches can be used as passive collection systems. If soil material can be excavated to below the water table and designed with stable sidewalls, shallow groundwater will naturally seep into the excavation and can be collected by use of sump pumps or gravity drainage. Passive sump or trench systems are not practical for deeper groundwaters.

Permeable reactive barriers – Permeable reactive barriers (PRBs) have seen significant use in hydrocarbon-contaminated sites and at isolated mine sites for ARD seepage (e.g., Nickel Rim Mine, Ontario). PRBs are a passive technology that acts to treat water *in situ*, as it passes through a reactive media. PRBs are constructed by placing a high permeability medium within a trench. The trench cross-cuts the contaminated area, allowing groundwater to flow through the reactive medium, where the contaminants of concern are geochemically altered to allow precipitation or conversion to a more inert form. While use of a PRB negates the requirement for *ex situ* water treatment, appropriate design of both the reactive material and the system hydraulics requires significant field and laboratory investigation. Furthermore, the reactive material has a fixed lifetime, and the system likely has to be replaced with fresh reactive material, if required for long periods of time. Finally, significant care is required when installing the reactive material to ensure that the system hydraulics are not compromised (e.g., by-pass or pipe flow).

Stream isolation – In certain situations, where the environmental receptor at a contaminated site is a surface water course, it may be possible to physically remove the water course from the system. Removal or protection of the water course could be accomplished by lining a creek channel or re-aligning the water course to an area less susceptible to inflow from contaminated water. While significant construction activity is required, particularly if the water course has high flow rates, isolation or re-alignment of the stream provides more opportunity (space) for installation of other groundwater capture technologies while minimising the hydraulic effects due to surface water leakage.

5.2 Recommended Approach

The S-cluster SIS should utilise a combination of methods installed in phases. The use of a combination of methods is recommended due to two factors:

1. the heterogeneous nature of the overburden geology, and
2. the relatively broad distribution of contamination in the deep aquifer.

Due to these factors, the individual use of any of the collection methods described would not likely provide the required level of confidence for contaminant capture.

The initial installation phase would focus on the high concentration/high load zones. Additional system upgrades would be implemented in other areas, as required. These contingency measures may, for example, be required in lower concentration/load zones, not initially targeted.

Contingency remedial phases would be implemented in a timely manner according to a well-defined adaptive management plan integrated with an extensive monitoring network.

5.2.1 Initial SIS

The initial high concentration zone SIS would consist of a cut-off wall and permeable pumping trench running parallel to the creek, close to the alignment of the 2005 SP monitoring wells. Figure 16 illustrates the layout of the proposed system and Figure 17 illustrates the pumping trench and cut-off wall installations.

The cut-off wall, located downgradient of the permeable trench, would provide a physical barrier to groundwater flow and improve hydraulics of the pumping system. The permeable trench would be comprised of a high permeability material, such as gravel, installed using the same equipment as that for the cut-off wall. The permeable trench would cross all lithologic zones, providing improved hydraulic connection and minimizing the required number of pumping wells. The cut-off wall and trench would be keyed into weathered bedrock along the entire length.

Both the cut-off wall and permeable trench would be constructed using conventional excavation technologies. The cut-off wall would be constructed using a bentonite grout – soil slurry (or equivalent) of low permeability relative to the surrounding overburden materials. The permeable trench would be constructed using a bio-degradable slurry material, such as Revert mud. Multiple pumping wells would be installed in the permeable materials. The Revert mud decomposes to a higher viscosity fluid over time and can be pumped out of the highly permeable material.

The proposed alignment will not capture contaminated groundwater already present down gradient of the cut-off wall. This residual contamination would be addressed by a fence of temporary pumping wells installed into weathered bedrock of the deep aquifer down gradient of the cut-off wall and pumping trench. If necessary, a shallow trench could be installed in this area to capture shallow groundwater. This secondary SIS would only be operated for a limited period of time, i.e. until the residual contamination in this area downgradient of the primary SIS system has been cleaned up.

Water from all pumping wells would be directed to a pipeline leading to a water treatment plant.

The proposed alignment takes advantage of the relatively high level of confidence in geologic conditions from the SP wells and would overlap with the known high concentration zones in the shallow and deep aquifers. The SIS ends extend somewhat into areas of interpreted lower concentrations to provide a margin of safety for capturing the high concentration plume.

5.2.2 Initial Monitoring System

The initial monitoring network would have components installed along the entire length of the NFRC in the S-cluster area. The layout of a preliminary monitoring system is shown on Figure 16.

Monitoring wells would be installed within the permeable trench, downgradient of the cut-off wall/permeable trench alignment, alongside the entire length of the NFRC in the S-cluster area, and along the hillside southwest of the S-cluster area. All monitoring wells will be screened in the overburden soils and weathered bedrock and, at selected locations in the underlying competent bedrock. The majority of monitoring wells focus on areas of known contamination. Monitoring wells located along the southwest hillside would allow early detection of a potential breakthrough of contaminated seepage from the southwest edge of the waste rock dump.

Five surface water discharge and water quality monitoring stations would be located along the NFRC itself, extending from the rock drain to the current X2 water quality monitoring station.

The combined data from the monitoring system would be assessed for three components:

1. Groundwater gradients
2. Groundwater concentrations
3. Creek load

Groundwater levels in targeted monitoring wells both within the pumping trench and around its perimeter would be monitored to assess the hydraulic performance of the capture system, namely, that the induced gradient is towards the trench. Water levels would be monitored continuously using dataloggers to provide detailed information on system performance, at least during initial stages of SIS activation.

Monitoring of groundwater concentrations and creek load would be conducted on a quarterly basis, including baseflow conditions in the winter and high flow conditions during the spring freshet. System performance would be assessed by comparing groundwater concentrations with pre-system-installation levels, and monitoring any changes in contaminant loading in the creek.

Intercepted groundwater would also be monitored. Flow meters would be installed on pumping wells and, combined with samples of pumped water, would be used to determine total load captured.

5.2.3 Adaptive Management Program

Four management zones would be used to identify potential system failures and delineate areas requiring contingency remedial measures (shown on Figure 16):

1. Upstream Zone – Reach 1
2. Capture Zone – Reach 2
3. Downstream Zone – Reach 3
4. NFRC End Zone – Reach 4

Data collected from the monitoring system components in each zone would be used to determine if triggers had been reached and an investigation of causes was required. Triggers would include hydraulic performance of the active collection system, contaminant concentrations in monitoring wells and/or contaminant load in the NFRC itself. Response actions would be defined for each failure type in an adaptive management plan, including contingency remedial measures.

Table 16 summarises a conceptual adaptive management plan for the S-cluster area.

Table 16: S-cluster Adaptive Management Plan Structure

Management Zone	Component	Monitoring Location	Trigger	Response		
				Level 1	Level 2	Level 3
Upstream Zone	Groundwater	SP1, SP2 and along NFRC	Groundwater concentrations	Additional Pumping Wells	Extension of initial SIS	NFRC Isolation and downstream collection system components
	Creek	Reach 1	Creek Load			
Capture Zone	Groundwater	Monitoring wells downgradient of wall, at ends of wall and along NFRC	Hydraulic gradient	Investigate and repair pumping system	Additional pumping wells in permeable trench	
			Groundwater concentrations	Underflow: grout curtain in bedrock Edge bypass: pumping wells at edges	Additional pumping wells immediately down gradient of cut-off wall; extension of initial SIS if required	
	Creek	Reach 2	Creek load			
Downstream Zone	Groundwater	Monitoring wells along NFRC and southwest hillside	Groundwater concentrations	Additional Pumping Wells	Extension of initial SIS or installation of second SIS with additional pumping wells	
	Creek	Reach 3	Creek load			
End Zone	Groundwater	Monitoring wells along NFRC	Groundwater concentrations	Additional Pumping Wells	Installation of second SIS and additional pumping wells	
	Creek	Reach 4 (X2)	Creek load			

Three levels of response action are defined, 1 to 3, the utility of which are two-fold. First, increasing levels of response action recognizes the potentially time-sensitive nature of a response: a Level 1 response can be achieved relatively quickly; Level 3 responses require a more significant lead time. Secondly, if the initial phase is itself not adequate, the increasing response levels provide an iterative approach to attaining overall objectives.

The following paragraphs briefly summarize the proposed monitoring components and response actions for each management zone.

Upstream Zone – NFRC monitoring stations N1 and N2 (Reach 1) and up gradient groundwater monitoring stations. Triggers would include groundwater concentrations and NFRC load.

If an observed increase in groundwater concentrations was believed to be limited to a specific area (“hot spot”), a Level 1 response would be implemented involving installation of one or more pumping wells in this area. Additional monitoring wells would be installed in the area to assess performance of the pumping well(s). If the increase in groundwater concentrations was widespread, or pumping wells could not adequately capture the affected areas, a Level 2 response could be initiated, involving extension of the full SIS system, i.e. cut-off wall and pumping trench system. Level 3, isolation of the NFRC, would be implemented if the initial contingency measures were not successful or if capture with the appropriate confidence could not be accomplished.

Capture Zone –NFRC monitoring stations N2 and N3 (Reach 2) and upgradient groundwater monitoring stations both around and in the permeable trench. Triggers would include groundwater concentrations, NFRC load, and water levels close to the cut-off wall and permeable trench.

If the increase in groundwater concentrations was believed to be related to incomplete capture by the pumping trench due to underflow or edge by-pass, Level 1 response would be implemented: in the case of underflow, a grout curtain would be installed in bedrock under the trench; to stop edge by-pass, pumping wells would be installed at the edges of the cut-off wall. If groundwater concentrations down gradient of the active system continued to increase, Level 2 would be initiated, involving installation of additional pumping wells down gradient of the cut-off wall or extension of the initial SIS if the contaminant plume was interpreted to have spread laterally. Level 3, isolation of the NFRC, would be implemented if initial contingency measures were not successful or if capture with the appropriate confidence could not be accomplished.

If hydraulic gradients in the area of the SIS were determined to indicate poor performance of the SIS, Level 1 would be implemented: pumping wells in the trench would be assessed for operational issues (e.g. pump failure, loss of well efficiency etc). If necessary, Level 2 would be implemented: additional pumping wells would be installed in the trench to improve gradient control.

Downstream Zone – NFRC monitoring stations N3 and N4 (Reach 3) and groundwater monitoring wells up gradient and along the NFRC. Triggers would include groundwater concentrations and NFRC load.

If the increase in groundwater concentrations was believed to be confined to a small area, a Level 1 response would be implemented involving installation of one or more pumping wells in this area. Additional monitoring wells would be installed in the area to assess performance of the pumping well(s). If the increase in groundwater concentrations was widespread or pumping wells could not adequately capture affected areas, Level 2 could be initiated, involving either an extension of the initial SIS cut-off wall and pumping trench, or installation of a second cut-off wall and pumping trench system. Level 3, isolation of the NFRC, would be implemented if initial contingency measures were not successful or if capture with the appropriate confidence could not be accomplished.

End Zone – NFRC monitoring stations N4 and X2 (Reach 4) and groundwater monitoring wells along the NFRC. Triggers would include groundwater concentrations and NFRC load.

If the increase in groundwater concentrations was believed to be limited, a Level 1 response would be implemented involving installation of one or more pumping wells in the “hot” area. Additional monitoring wells could be installed in the area to assess performance of the pumping well(s). If the increase in groundwater concentrations was widespread or pumping wells could not adequately capture affected areas, Level 2 could be initiated, involving installation of a second SIS, or cut-off wall and stand-alone pumping wells. Level 3, isolation of the NFRC, would be implemented if initial contingency measures were not successful or if the contaminant load to the NFRC remained above project requirements.

5.3 Further Work

Additional design work could be completed on two issues regarding the S-cluster area SIS:

1. Location Variants
2. Method Variants

Alignment of the SIS along the SP well alignment could lead to continued, though decreased, loading to NFRC for an interim period, due to the residual contamination present down gradient of the cut-off wall and permeable trench. While temporary pumping wells are proposed to address this issue, an alternative location for the SIS closer to the NFRC would reduce the size of the residual contamination zone and therefore the potential for short to medium-term discharge of contaminated groundwater to the NFRC. At the present time, there is insufficient data available on the hydrostratigraphy close to the NFRC, particularly depth to bedrock, to allow a defensible design in this location. Additional drilling would be required before a SIS system along this alignment could be designed.

Alternative methods exist for installation of the cut-off wall and permeable trench, as well as technology variants for other components of the SIS. A cost analysis of these different options should be completed prior to final design with respect to both system requirements and capture confidence.

6 Conclusions & Recommendations

An assessment of groundwater flow and groundwater quality conditions, combined with loading estimates to the NFRC, indicate that contaminated groundwater in the S-cluster area is discharging to the NFRC. Drilling indicates that highly impacted groundwater occurs in both a shallow (perched) aquifer unit and a deep aquifer unit but is limited to a well-defined zone of limited lateral extent (<100m). Loading calculations suggest that highly impacted groundwater from both aquifer units is currently discharging into the NFRC. Based on observed concentrations, zinc load to the NFRC could reach a maximum of approximately 14 tonnes/yr under current conditions. Therefore, a seepage interception system (SIS) will be required in the S-cluster area, probably for an indefinite period of time. The anticipated long time frame should be incorporated into the overall SIS approach.

A multi-phase SIS is recommended for the S-cluster area, focused initially on groundwater with high contaminant concentrations. The initial system would be composed of a cut-off wall and permeable trench with pumping wells both in the trench and down gradient of the cut-off wall. An extensive monitoring system and an adaptive management plan, including specific contingency remedial actions, would be implemented to provide a flexible, responsive approach to contaminant interception.

Recommendations for future work include the following:

1. Integration of S-cluster area loading calculations with the site-wide water and load balance.
2. Installation of the initial phase SIS as soon as reasonably possible to stop the current discharge to the NFRC and maximise the amount of time for initial system performance monitoring and optimisation,
3. Continue detailed groundwater monitoring in the S-cluster area to evaluate time trends in contaminant concentrations and to develop a baseline for future system performance monitoring:
    i. Monthly water level monitoring in all existing and newly installed monitoring wells and drive points in the area; and
    ii. Quarterly sampling of all existing and newly installed monitoring wells and drive points in the area for water quality analysis.
4. Continue detailed surface water monitoring along the NFRC, including drivepoints, to improve understanding of the interaction between the local groundwater and stream water, including loading to the NFRC:
    i. Monthly water level readings at all existing streamflow stations and drive points in the area; and
    ii. Quarterly monitoring of stream flows and stream water quality at the existing weirs (X2) and newly installed stream monitoring stations (S1 to S4) in the NFRC.

This report, **"2005 Seepage Investigation at the S-cluster Area Below the Faro Waste Rock Dump – 2005/06 Task 20e"**, has been prepared by SRK Consulting (Canada) Inc.

Dan Mackie, M.Sc.

Dr. Christoph Wels, Ph. D., M.Sc.

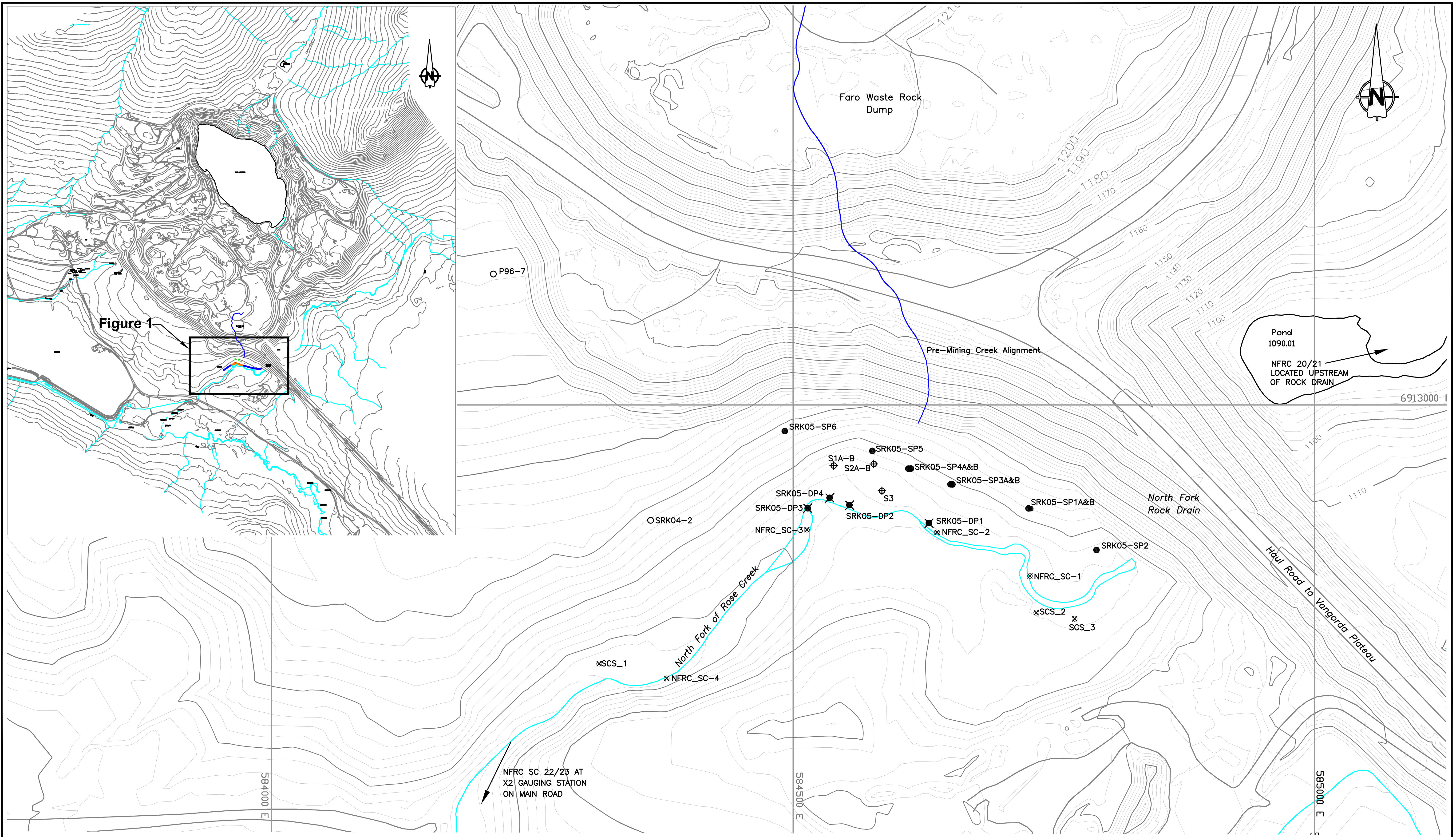
Reviewed by

Cam Scott, P.Eng.

7 References

SRK, 2006 Preliminary Seepage Collection Options – Faro and Grum Waste Rock Dumps; prepared for Deloitte and Touche, Interim Receiver for Anvil Range Mining.

Figures



LEGEND

● 2005 Groundwater Monitoring Well

○ Other Groundwater Monitoring Well

⊠ Shallow Drivepoint

× NFRC Monitoring Station
(NFRC_SC–4 = FLOW/SAMPLING)
(SCS_1 = SURFACE SEEP)

⊕ S–Cluster Monitoring Well

50 0 100 200 300 feet

25 0 50 100 150 Metres

SRK Consulting
Engineers and Scientists

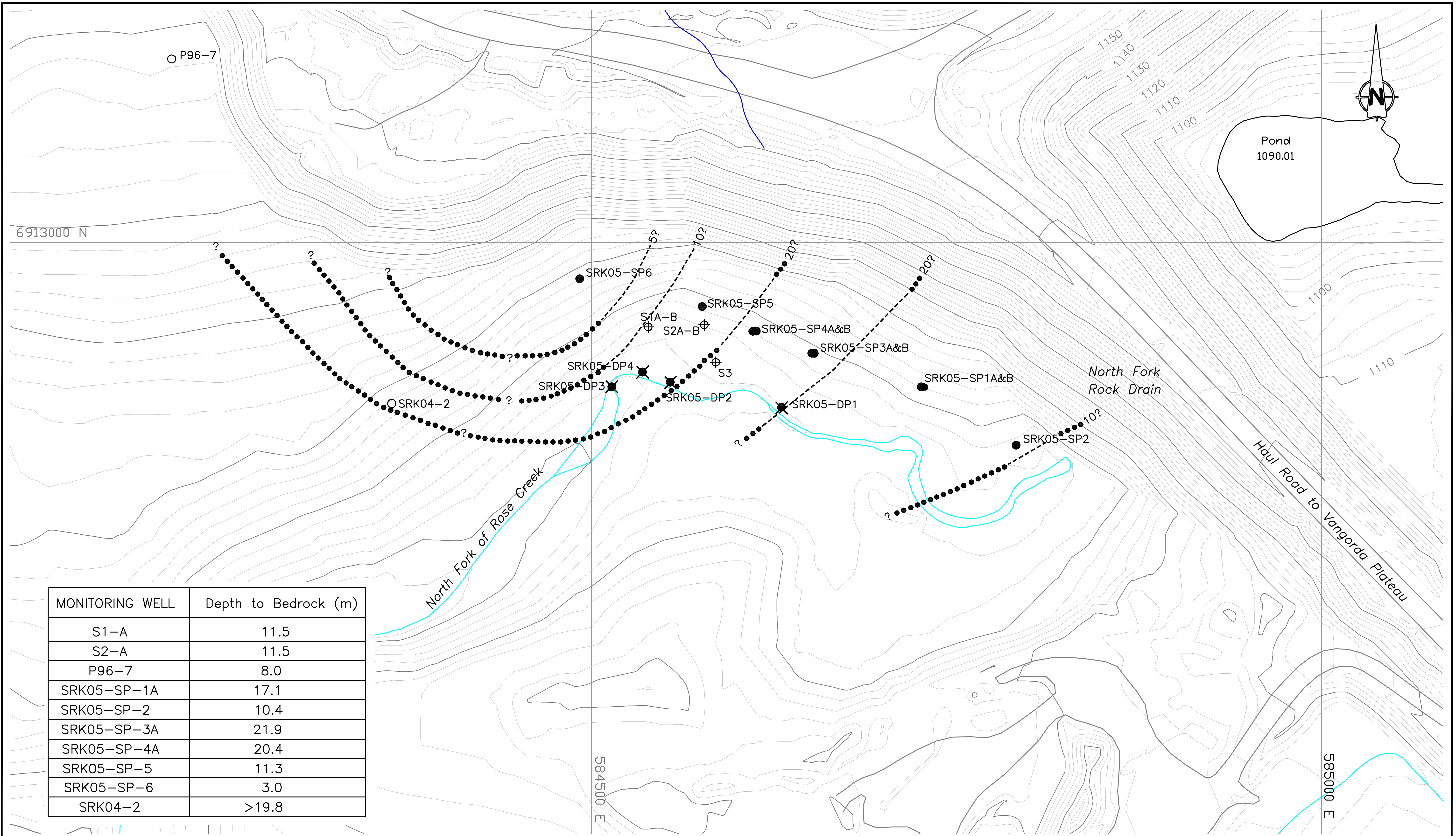
G:\Deloitte_touche\Logo\Logo_new.bmp

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

MONITORING STATION LOCATION MAP

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	1

File Ref: 2006 Acad drawings\ FARO SITE PLAN-updated-DM.dwg



MONITORING WELL	Depth to Bedrock (m)
S1–A	11.5
S2–A	11.5
P96–7	8.0
SRK05–SP–1A	17.1
SRK05–SP–2	10.4
SRK05–SP–3A	21.9
SRK05–SP–4A	20.4
SRK05–SP–5	11.3
SRK05–SP–6	3.0
SRK04–2	>19.8

SRK Consulting
Engineers and Scientists

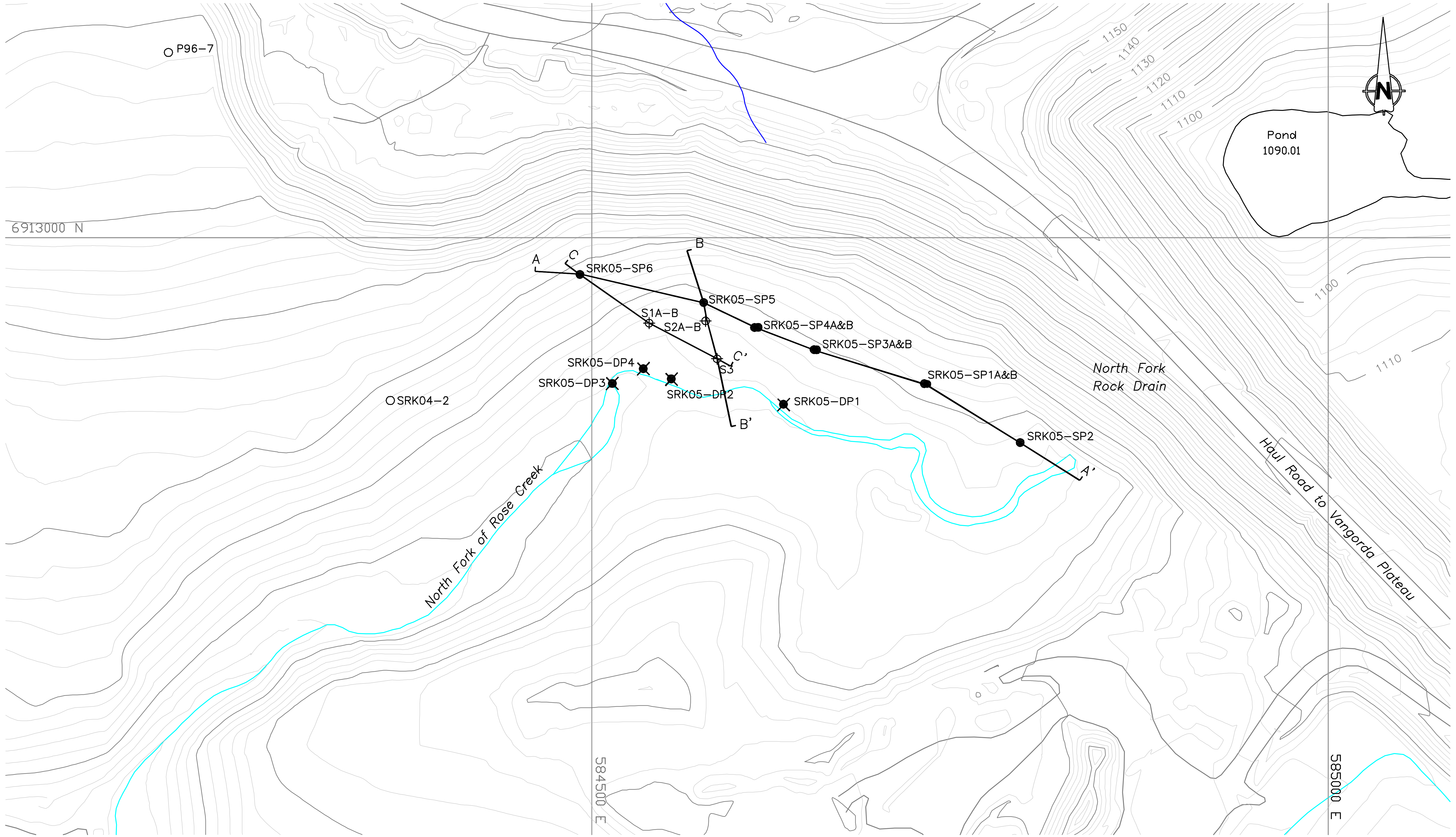
Deloitte & Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

DEPTH TO BEDROCK

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	2

File Ref: 2006 Acad drawings\ FARO SITE PLAN-updated-DM.dwg



LEGEND

- ● 2005 Groundwater Monitoring Well
- ○ Other Groundwater Monitoring Well
- ⌧ Shallow Drivepoint
- × NFRC Monitoring Station
  (NFRC_SC–4 = FLOW/SAMPLING)
  (SCS_1 = SURFACE SEEP)
- ⊕ S–Cluster Monitoring Well

50 0 100 200 300 feet

25 0 50 100 150 Metres

SRK Consulting
Engineers and Scientists

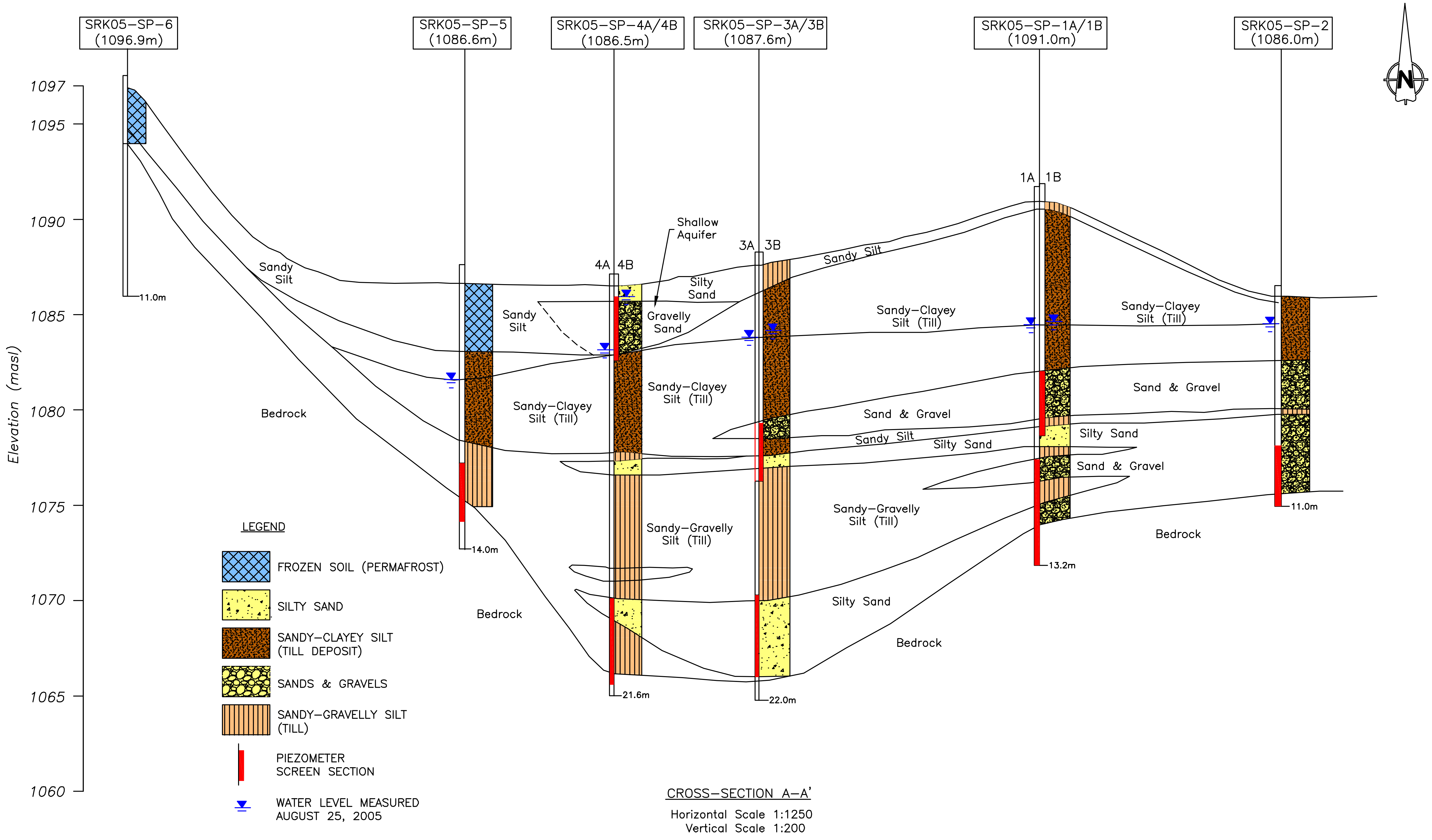
Deloitte
& Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

Cross Section Location Map

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Feb. 2006	DM	3

File Ref: 2006 Acad drawings\ FARO SITE PLAN–updated–DM.dwg



CROSS–SECTION A–A'

Horizontal Scale 1:1250
Vertical Scale 1:200

SRK Consulting
Engineers and Scientists

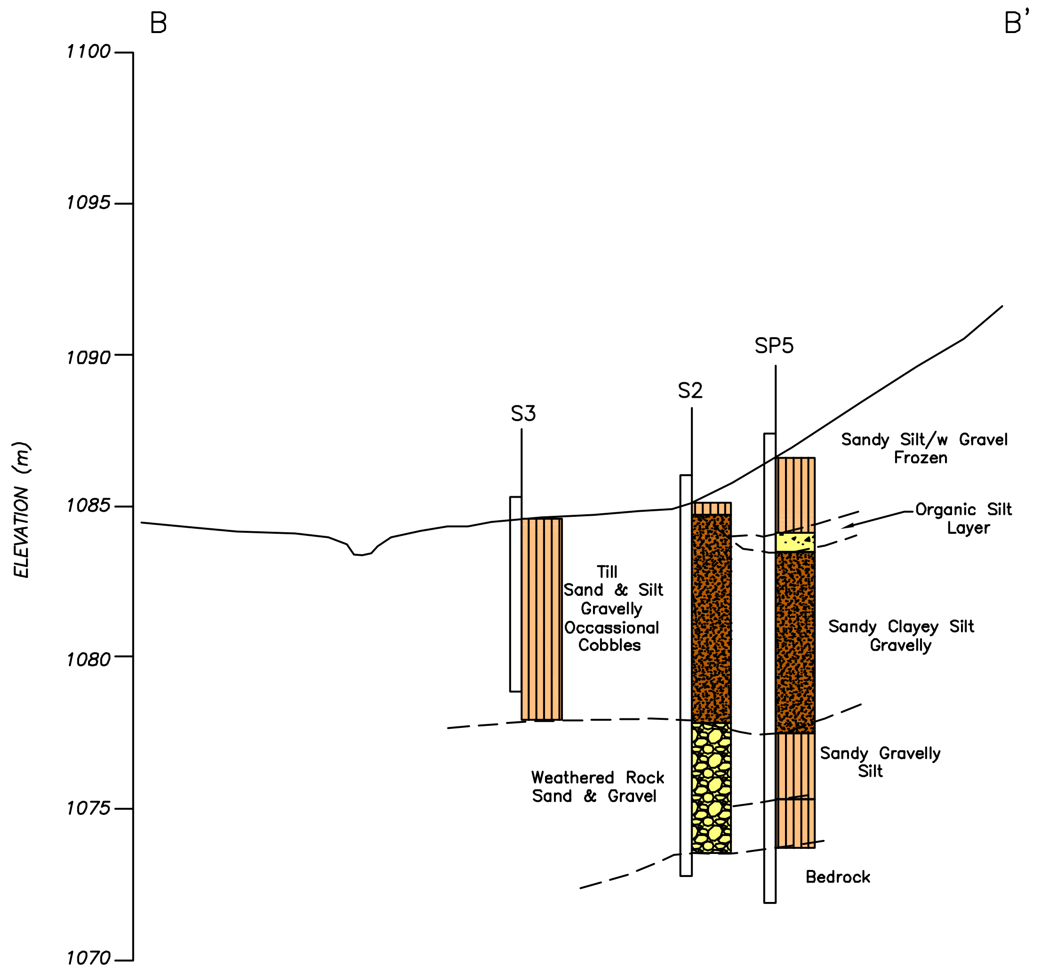
Deloitte & Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

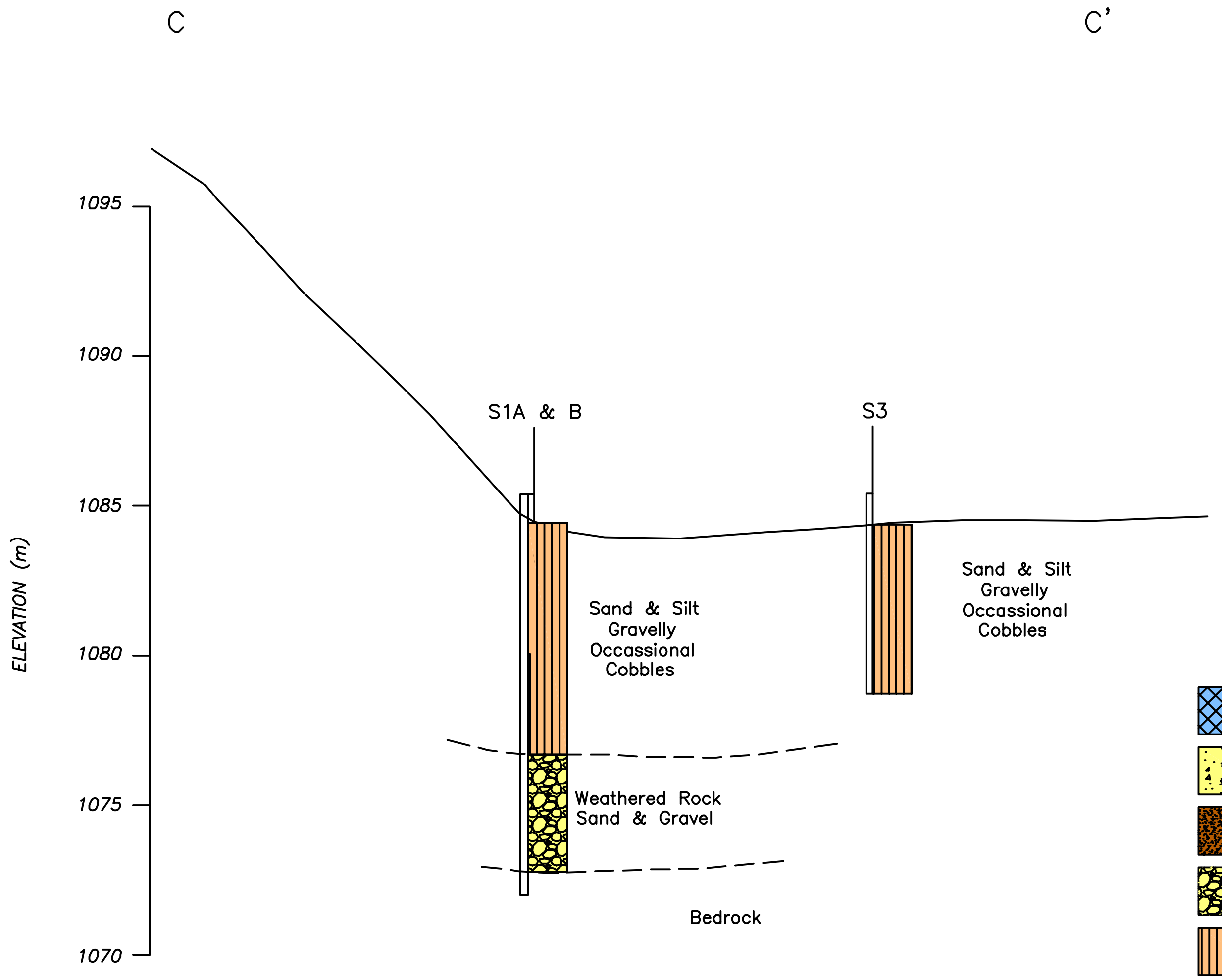
CROSS SECTION A–A'

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	4

File Ref: FARO SITE PLAN-updated-DM.dwg



8a. CROSS-SECTION B-B'



8b. CROSS-SECTION C-C'

LEGEND

▦	FROZEN SOIL (PERMAFROST)
▒	SILTY SAND
▓	SANDY-CLAYEY SILT (TILL DEPOSIT)
▩	SANDS & GRAVELS
▥	SANDY-GRAVELLY SILT (TILL)
▮	PIEZOMETER SCREEN SECTION
▼	WATER LEVEL MEASURED AUGUST 25, 2005

SRK Consulting
Engineers and Scientists

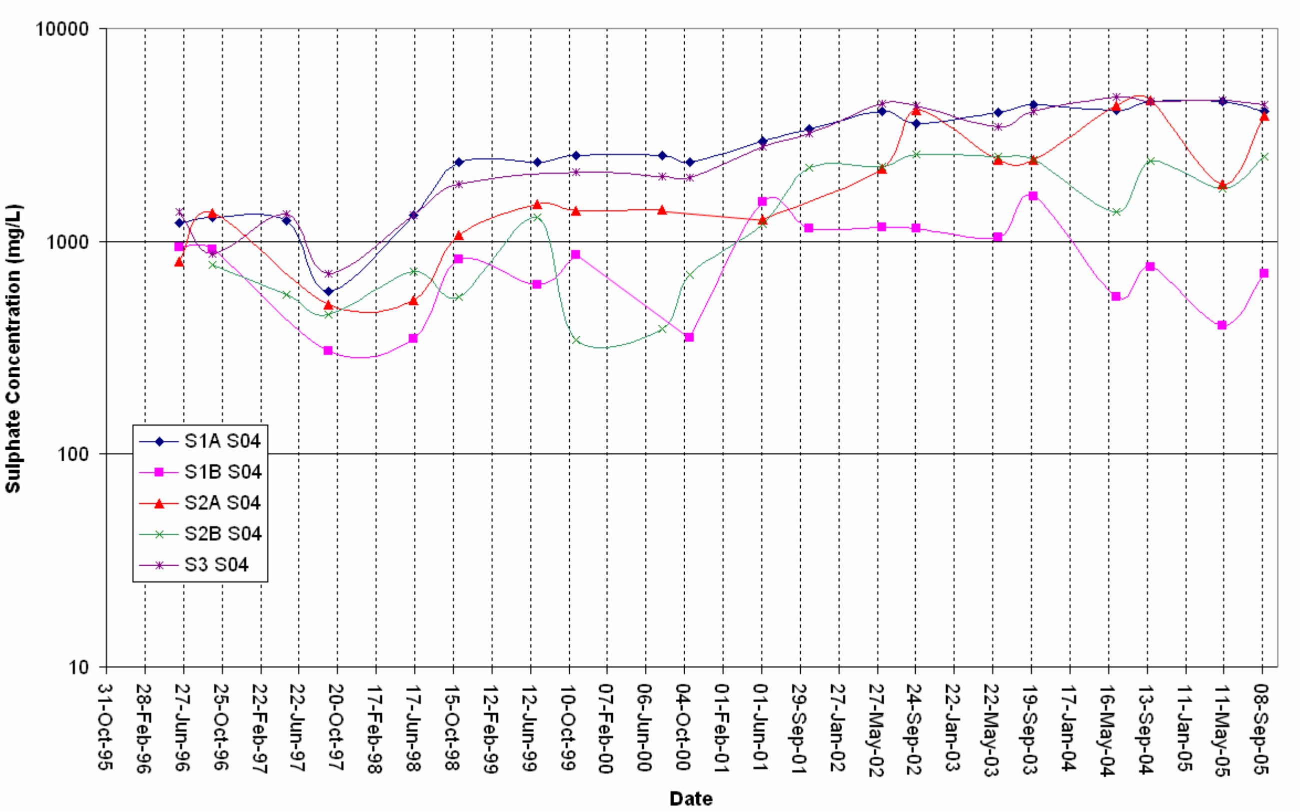
Deloitte & Touche

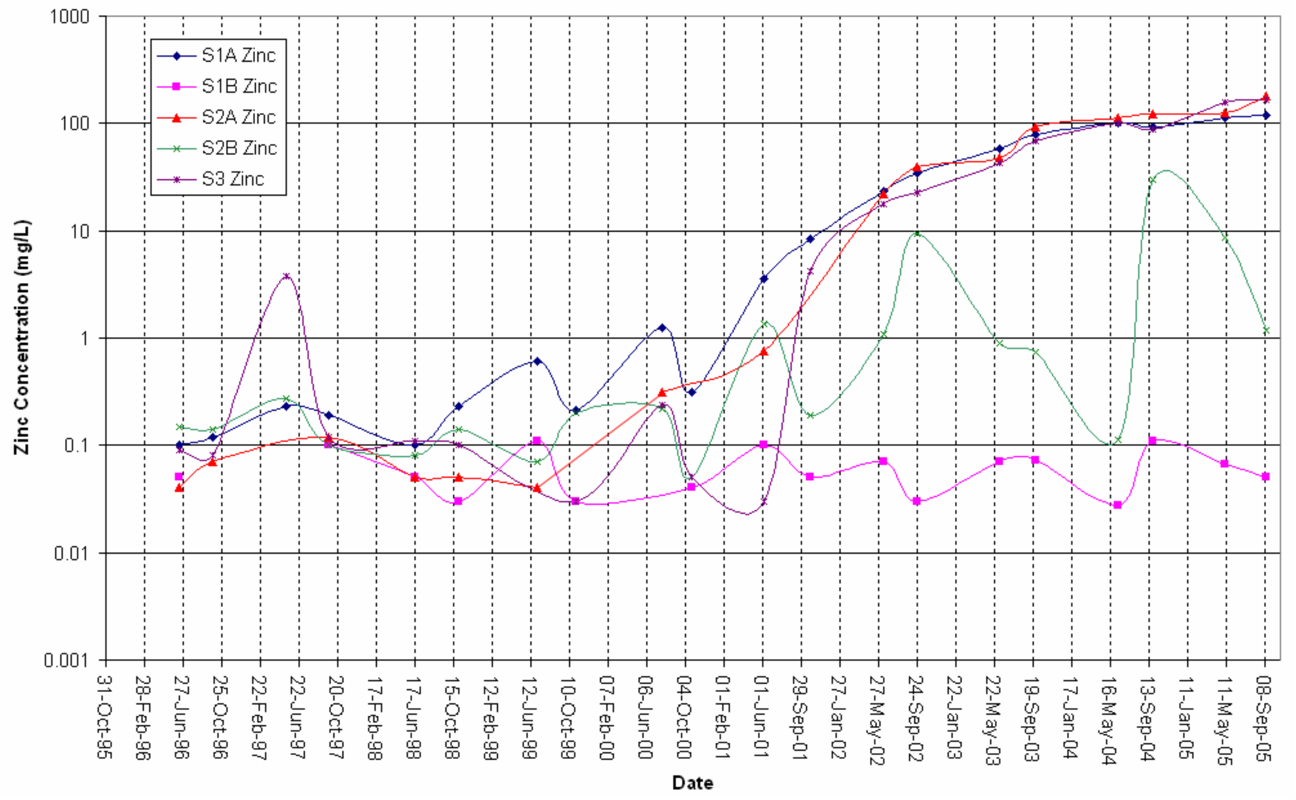
Faro Mine Site – S-Cluster Area
Continued Seepage Investigation

CROSS SECTIONS
B-B' AND C-C'

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.053	Mar. 2006	DM	5

File Ref: Faro Site plan-updated-dn.dwg





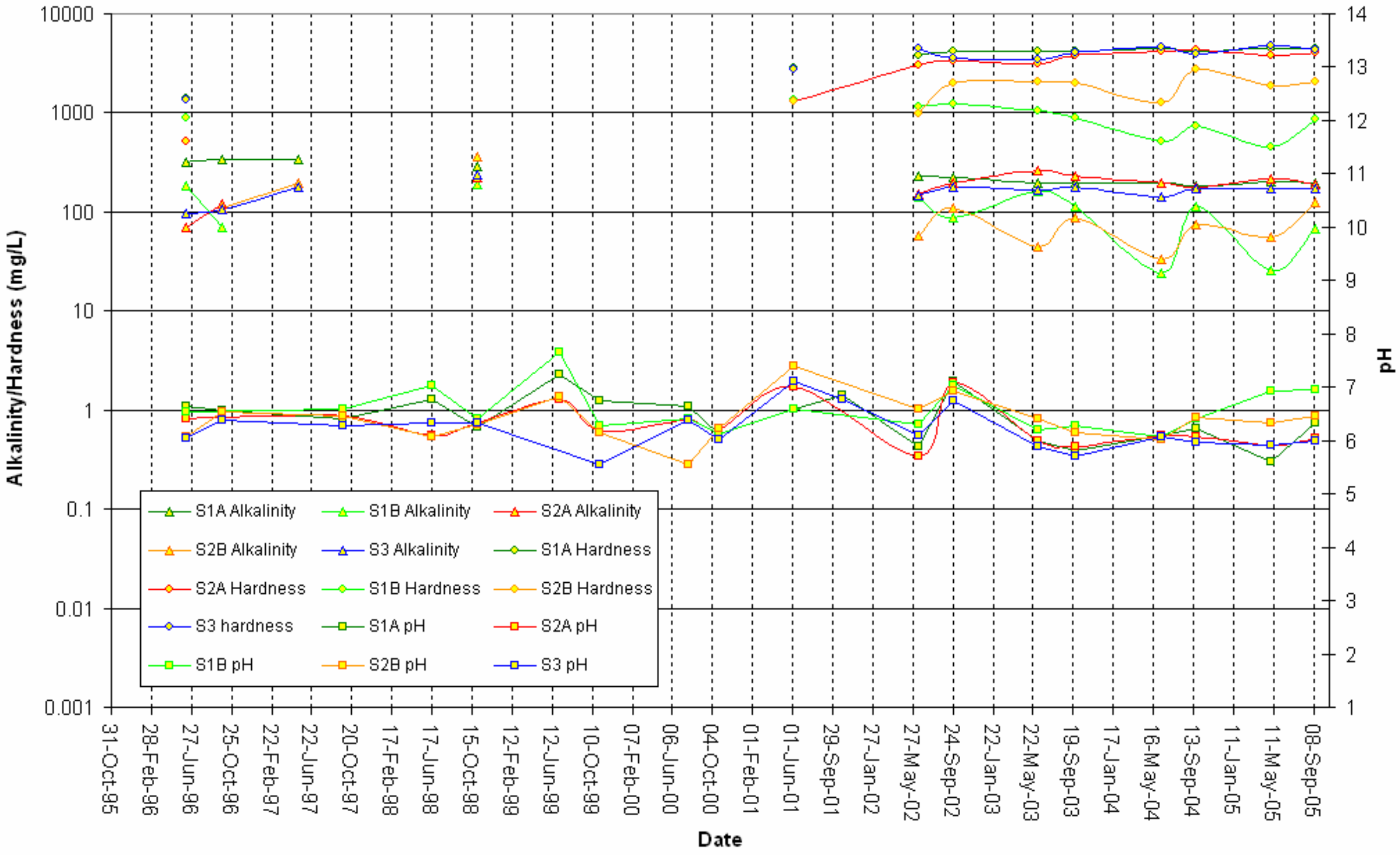
SRK Consulting
Engineers and Scientists

Task 20e – Continue Seepage Investigation

Historical S-cluster Sulphate and Zinc Concentrations

Deloitte and Touche

PROJECT: 1CD003.073	DATE: Feb 2006	APPROVED:	FIGURE: 6



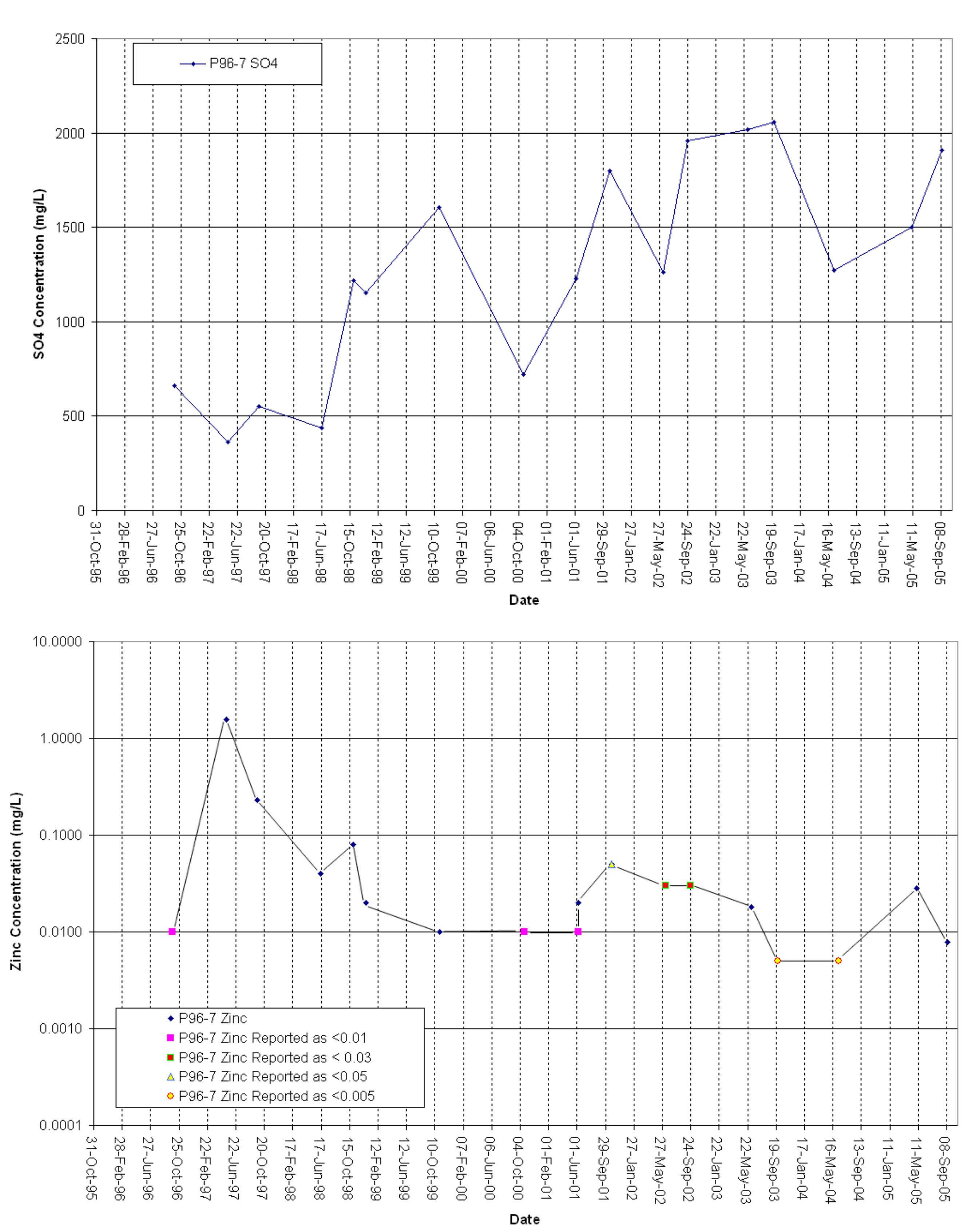
SRK Consulting
Engineers and Scientists

Deloitte and Touche

Task 20e – Continue Seepage Investigation

Historical S-cluster pH, Alkalinity and Hardness

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.073	Feb 2006		7



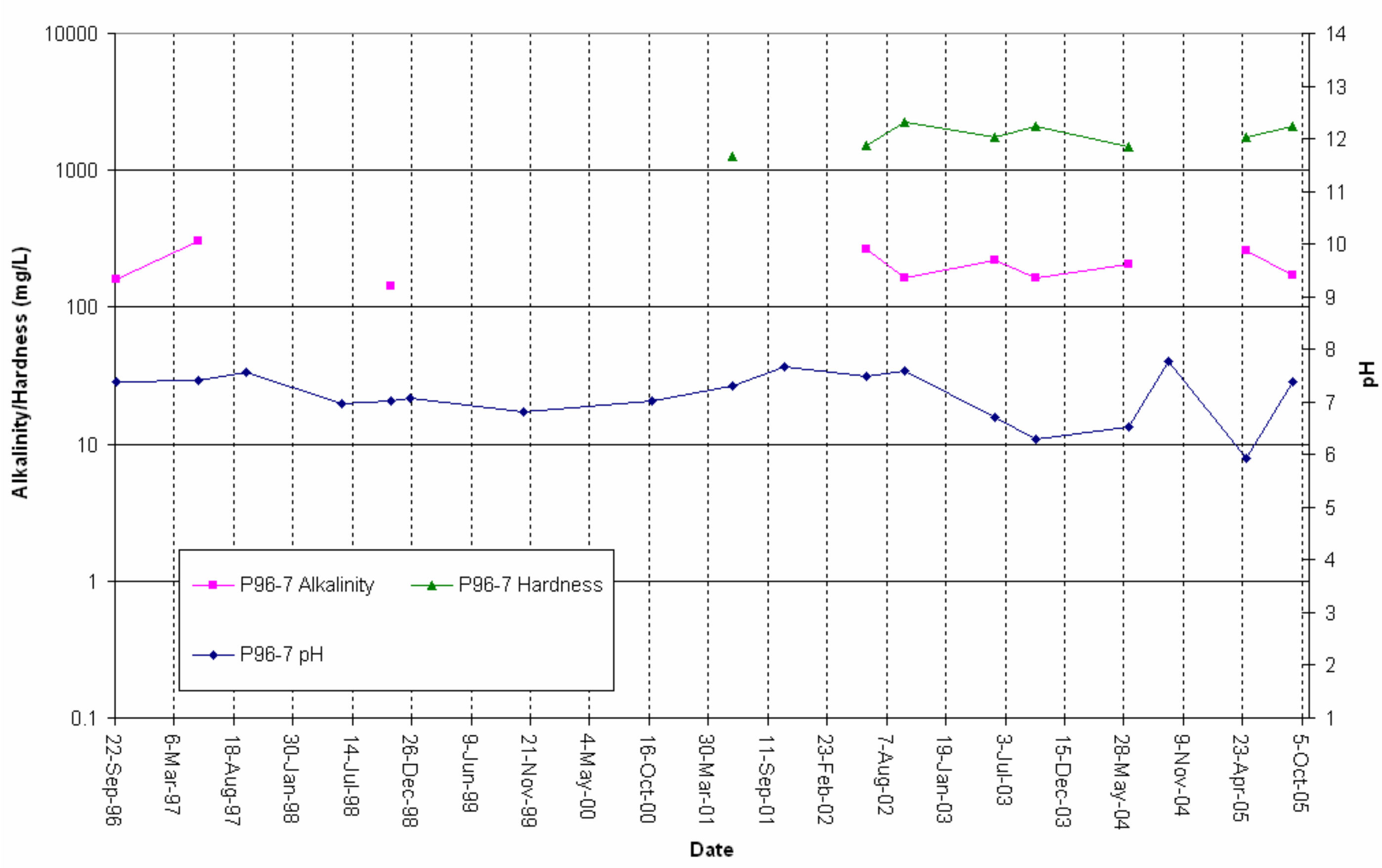
SRK Consulting
Engineers and Scientists

Deloitte and Touche

Task 20e – Continue Seepage Investigation

Historical P96-7 Sulphate and Zinc Concentrations

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.073	Feb 2006		8



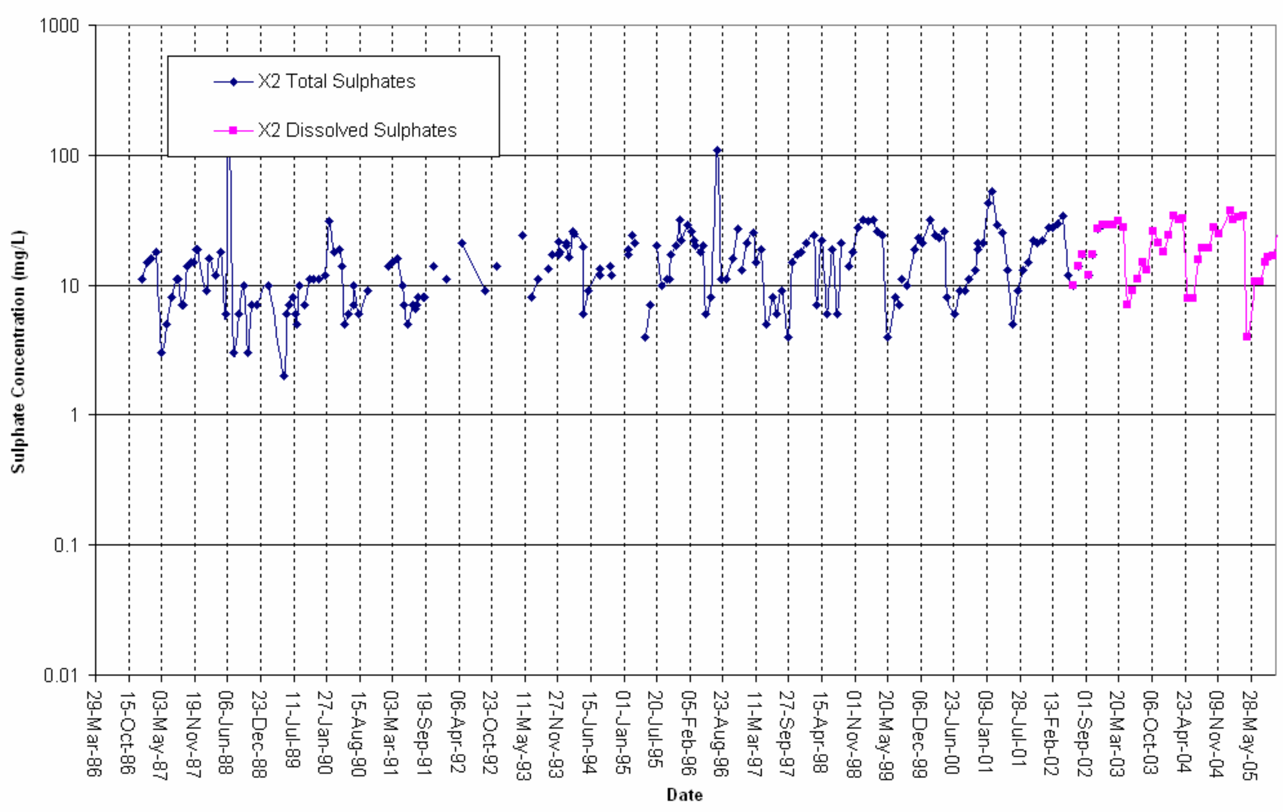
SRK Consulting
Engineers and Scientists

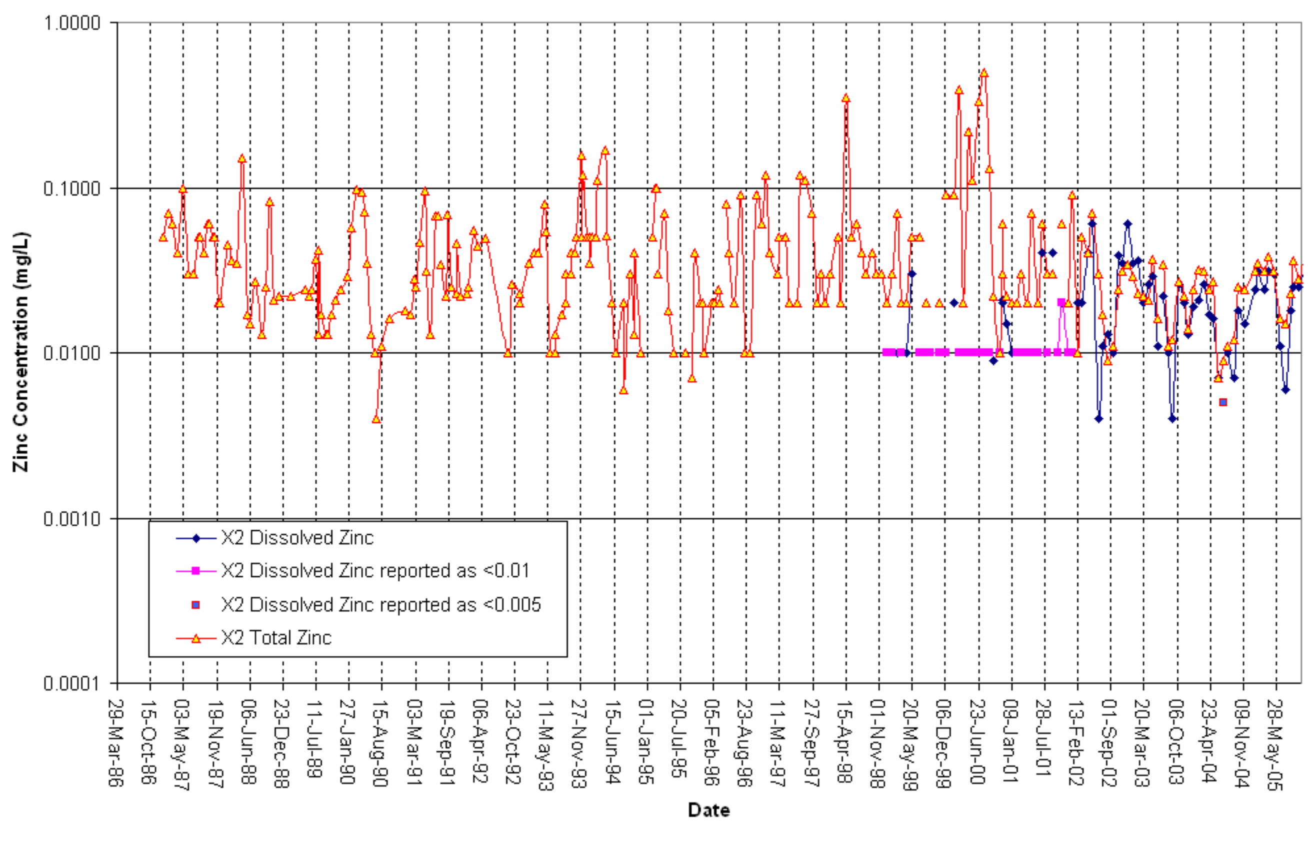
Deloitte and Touche

Task 20e – Continue Seepage Investigation

Historical P96-7 pH, Alkalinity and Hardness

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.073	Feb 2006		9





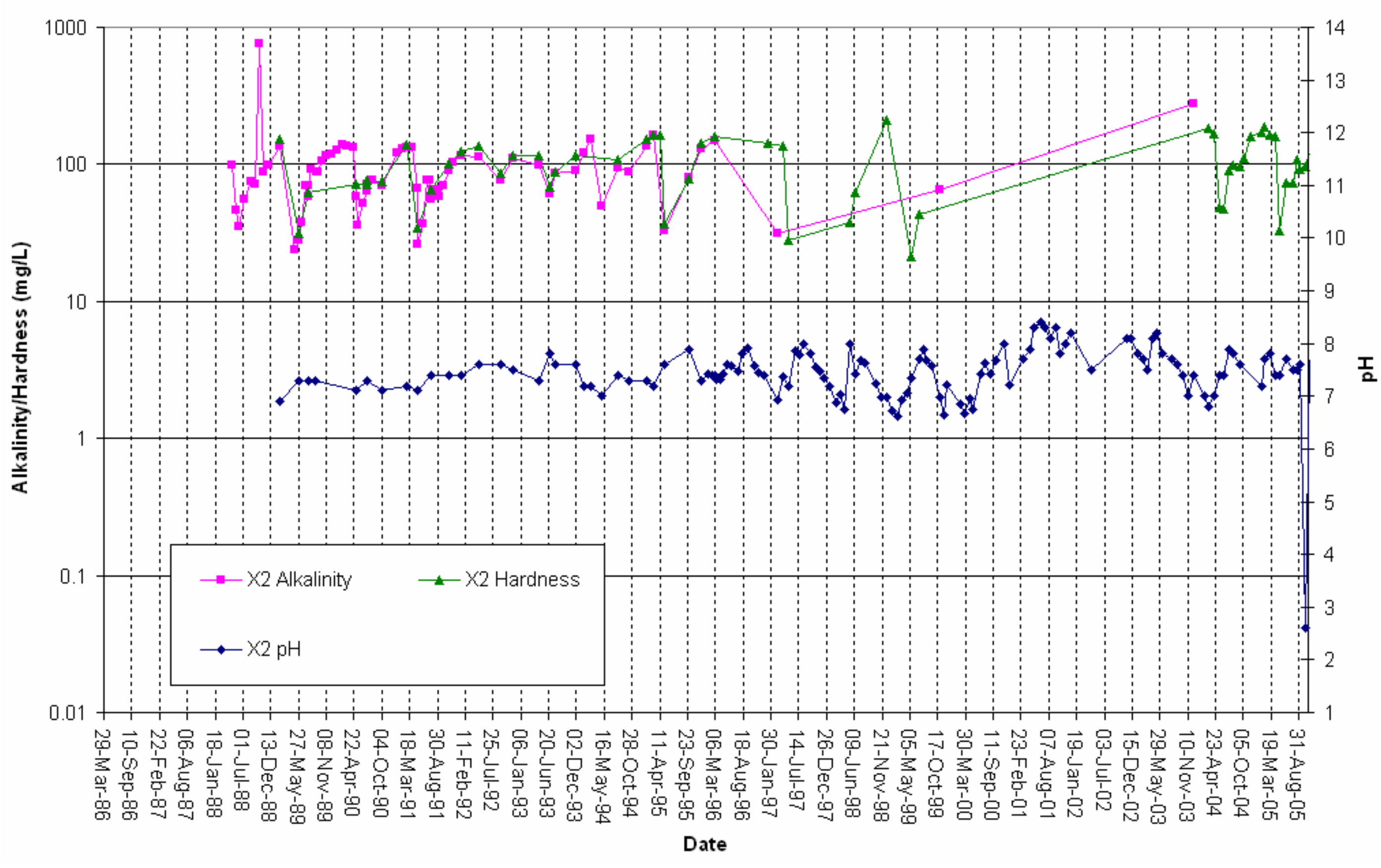
SRK Consulting
Engineers and Scientists

Deloitte and Touche

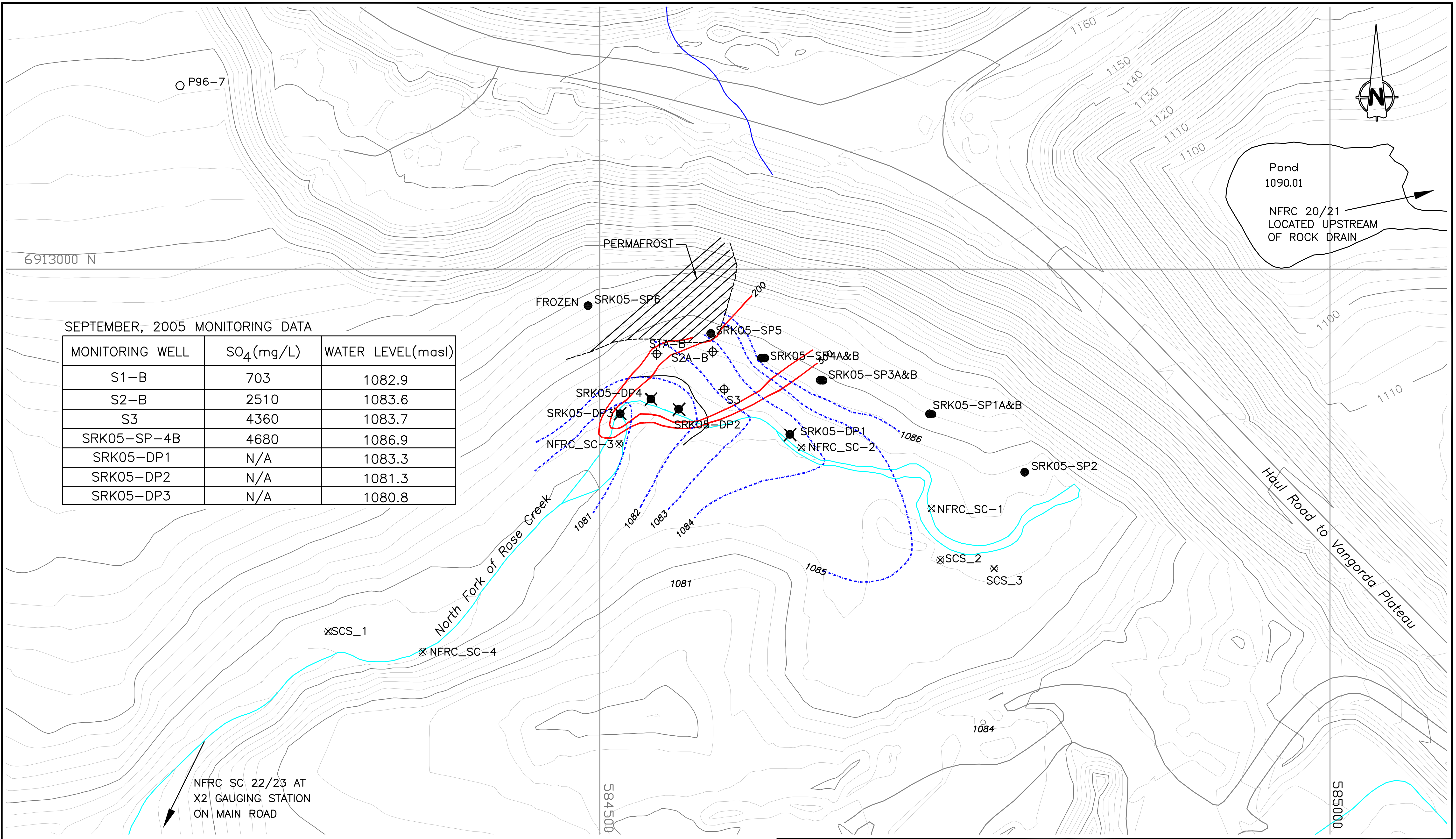
Task 20e – Continue Seepage Investigation

Historical X2 Sulphate and Zinc Concentrations

PROJECT:	DATE:	APPROVED:	FIGURE:
1CD003.073	Feb 2006		10



SRK Consulting Engineers and Scientists	Task 20e – Continue Seepage Investigation
	Historical X2 pH, Alkalinity and Hardness
Deloitte and Touche	PROJECT: 1CD003.073
	DATE: Feb 2006
	APPROVED:
	FIGURE: 11



SEPTEMBER, 2005 MONITORING DATA

MONITORING WELL	SO_4(mg/L)	WATER LEVEL(masl)
S1–B	703	1082.9
S2–B	2510	1083.6
S3	4360	1083.7
SRK05–SP–4B	4680	1086.9
SRK05–DP1	N/A	1083.3
SRK05–DP2	N/A	1081.3
SRK05–DP3	N/A	1080.8

LEGEND

- ● 2005 Groundwater Monitoring Well
- ○ Other Groundwater Monitoring Well
- ✖ Shallow Drivepoint
- ☒ NFRC Monitoring Station
  (NFRC_SC–4 = FLOW/SAMPLING)
  (SCS_1 = SURFACE SEEP)
- ⊕ S–Cluster Monitoring Well
- —— Concentration Contour
- - - - - Hydraulic head Contour

50 0 100 200 300 feet

25 0 50 100 150 Metres

SRK Consulting
Engineers and Scientists

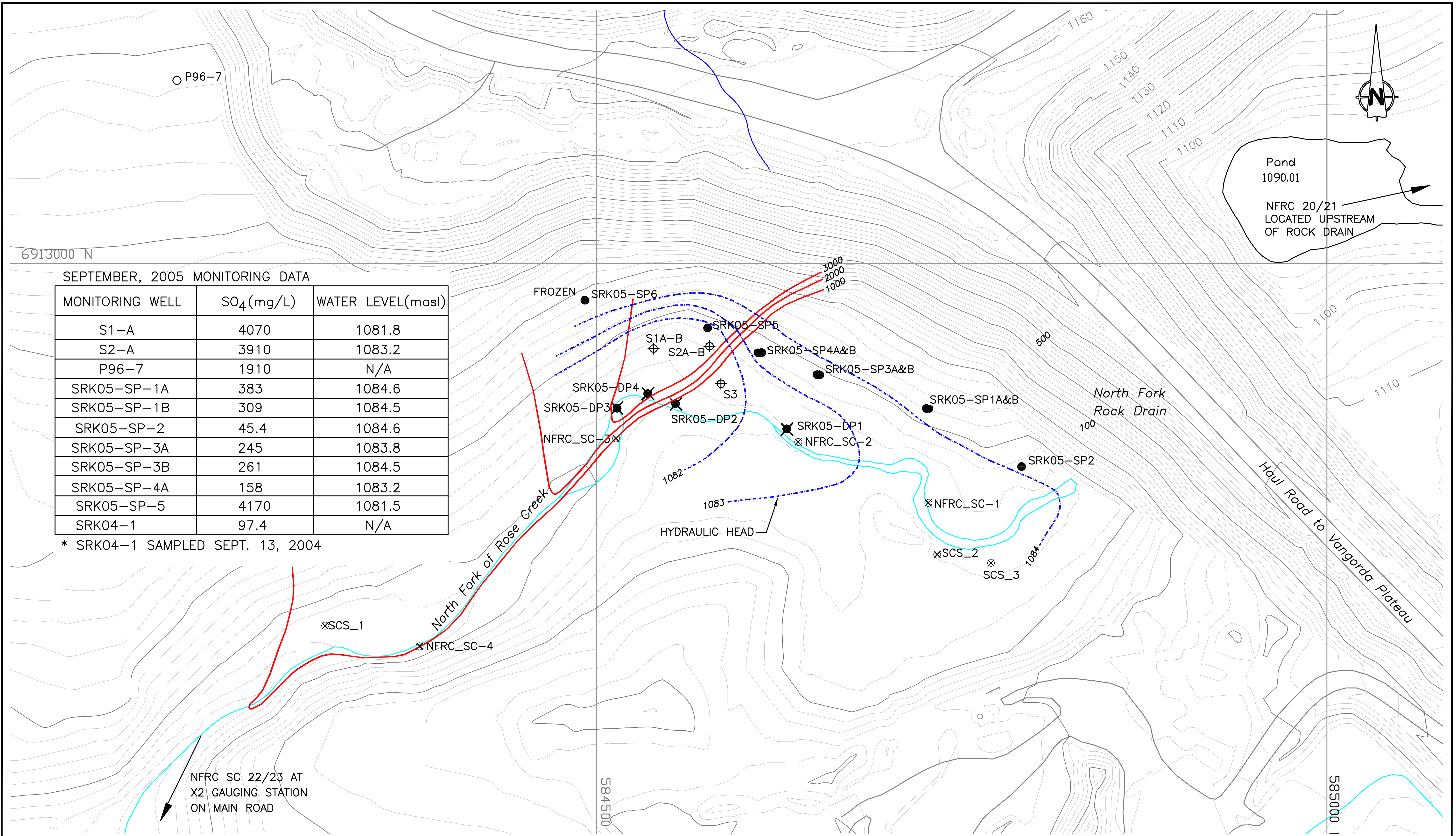
Deloitte & Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

Concentration Contour Map
Shallow Aquifer SO_4

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	12

File Ref: 2006 Acad drawings\ FARO SITE PLAN-updated-DM.dwg



SEPTEMBER, 2005 MONITORING DATA

MONITORING WELL	SO_4 (mg/L)	WATER LEVEL(masl)
S1–A	4070	1081.8
S2–A	3910	1083.2
P96–7	1910	N/A
SRK05–SP–1A	383	1084.6
SRK05–SP–1B	309	1084.5
SRK05–SP–2	45.4	1084.6
SRK05–SP–3A	245	1083.8
SRK05–SP–3B	261	1084.5
SRK05–SP–4A	158	1083.2
SRK05–SP–5	4170	1081.5
SRK04–1	97.4	N/A

* SRK04–1 SAMPLED SEPT. 13, 2004

LEGEND

- ● 2005 Groundwater Monitoring Well
- ○ Other Groundwater Monitoring Well
- ✖ Shallow Drivepoint
- ⊠ NFRC Monitoring Station (NFRC_SC–4 = FLOW/SAMPLING) (SCS_1 = SURFACE SEEP)
- ⊕ S–Cluster Monitoring Well
- Concentration Contour
- Hydraulic head Contour

SRK Consulting
Engineers and Scientists

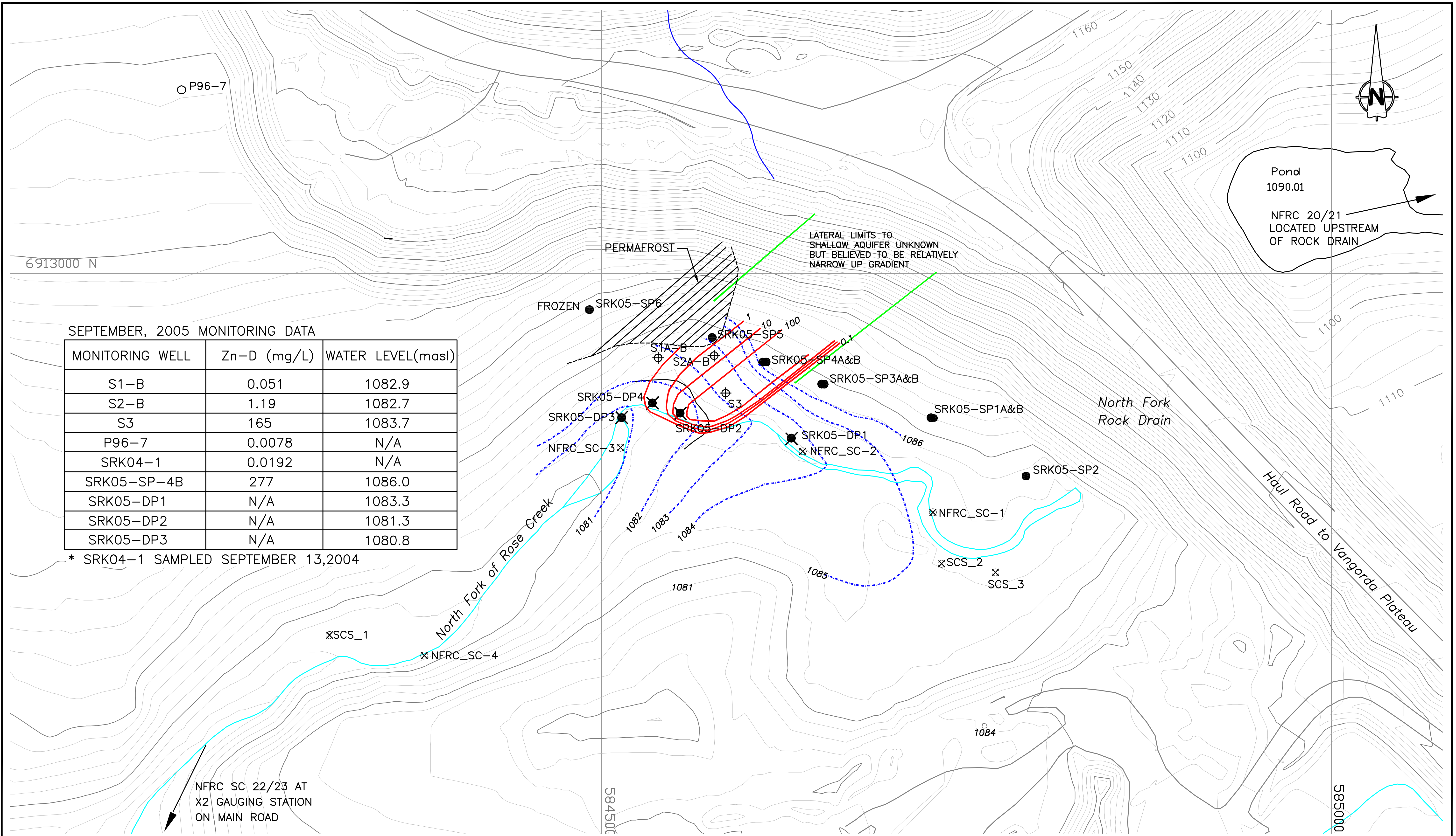
Deloitte & Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

Concentration Contour Map
Deep Aquifer SO_4

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	13

File Ref: 2006 Acad drawings\ FARO SITE PLAN–updated–DM.dwg



SEPTEMBER, 2005 MONITORING DATA

MONITORING WELL	Zn–D (mg/L)	WATER LEVEL(masl)
S1–B	0.051	1082.9
S2–B	1.19	1082.7
S3	165	1083.7
P96–7	0.0078	N/A
SRK04–1	0.0192	N/A
SRK05–SP–4B	277	1086.0
SRK05–DP1	N/A	1083.3
SRK05–DP2	N/A	1081.3
SRK05–DP3	N/A	1080.8

* SRK04–1 SAMPLED SEPTEMBER 13,2004

LEGEND

- ● 2005 Groundwater Monitoring Well
- ○ Other Groundwater Monitoring Well
- ☒ Shallow Drivepoint
- ⊗ NFRC Monitoring Station
  (NFRC_SC–4 = FLOW/SAMPLING)
  (SCS_1 = SURFACE SEEP)
- Concentration Contour
- Hydraulic head Contour

50 0 100 200 300 feet

25 0 50 100 150 Metres

File Ref: 2006 Acad drawings\ FARO SITE PLAN-updated-DM.dwg

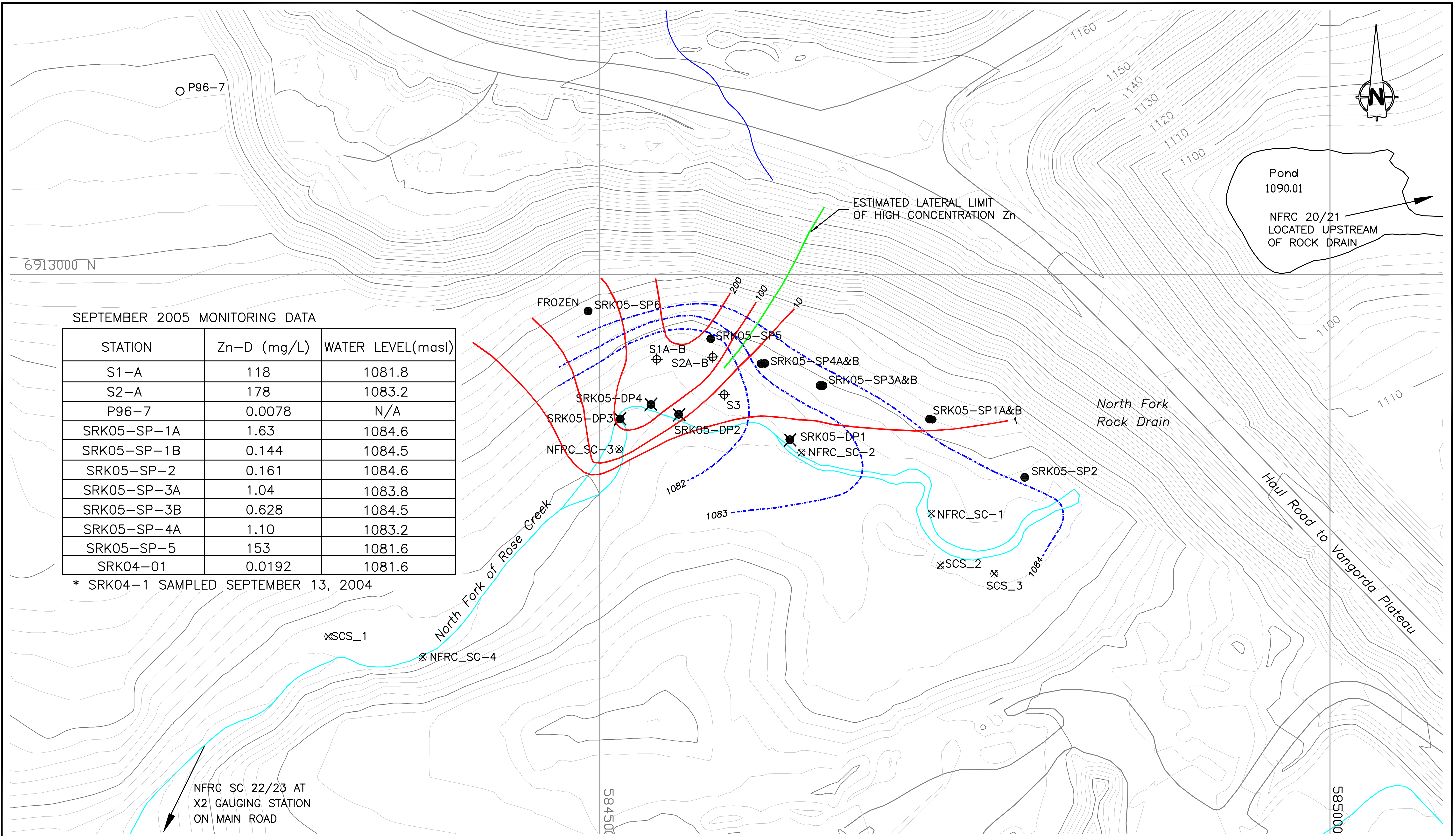
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

Concentration Contour Map
Shallow Aquifer Zinc

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	14



SEPTEMBER 2005 MONITORING DATA

STATION	Zn–D (mg/L)	WATER LEVEL(masl)
S1–A	118	1081.8
S2–A	178	1083.2
P96–7	0.0078	N/A
SRK05–SP–1A	1.63	1084.6
SRK05–SP–1B	0.144	1084.5
SRK05–SP–2	0.161	1084.6
SRK05–SP–3A	1.04	1083.8
SRK05–SP–3B	0.628	1084.5
SRK05–SP–4A	1.10	1083.2
SRK05–SP–5	153	1081.6
SRK04–01	0.0192	1081.6

* SRK04–1 SAMPLED SEPTEMBER 13, 2004

LEGEND

- ● 2005 Groundwater Monitoring Well
- ○ Other Groundwater Monitoring Well
- ✖ Shallow Drivepoint
- ⊠ NFRC Monitoring Station (NFRC_SC–4 = FLOW/SAMPLING) (SCS_1 = SURFACE SEEP)
- ⌖ S–Cluster Monitoring Well

Concentration Contour
Hydraulic head Contour

50 0 100 200 300 feet

25 0 50 100 150 Metres

File Ref: 2006 Acad drawings\ FARO SITE PLAN-updated-DM.dwg

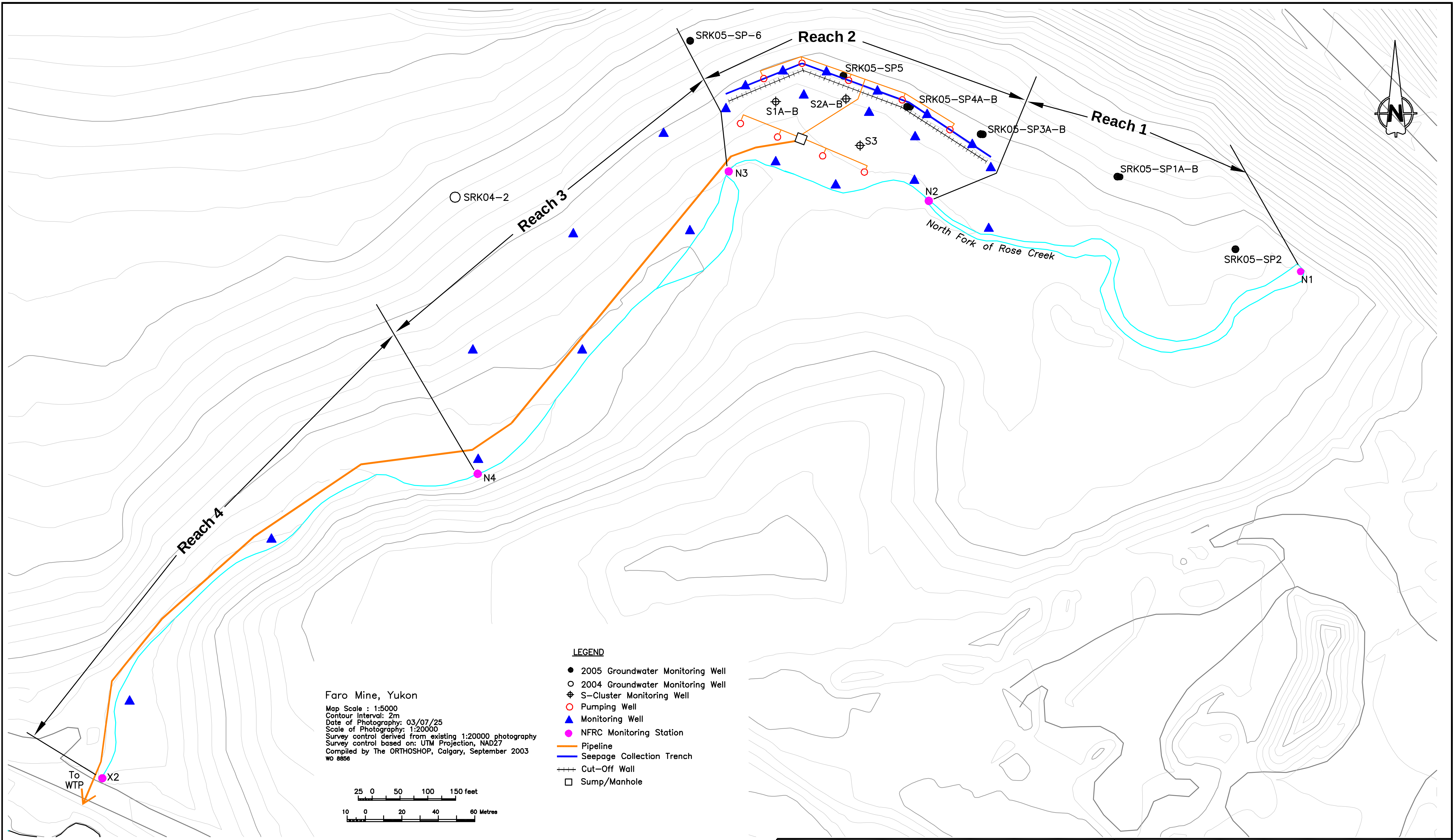
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

Concentration Contour Map
Deep Aquifer Zinc

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	15



Contour Interval: 2m
Date of Photography: 03/07/25
Scale of Photography: 1:20000
Survey control derived from existing 1:20000 photography
Survey control based on: UTM Projection, NAD27
Compiled by The ORTHOSHOP, Calgary, September 2003
WO 8856

File Ref: s-cluster-seepage options.dwg

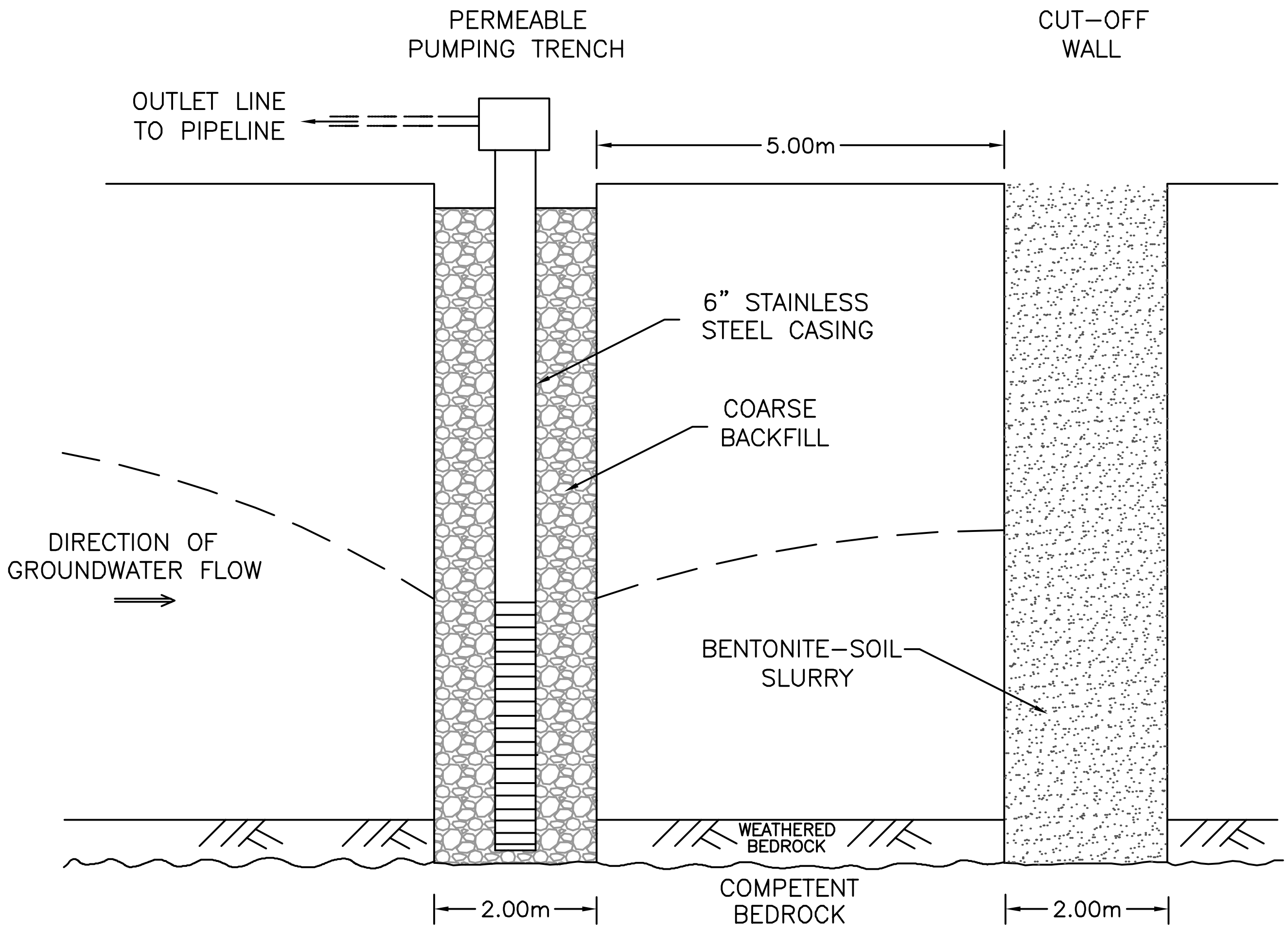
SRK Consulting
Engineers and Scientists

Deloitte & Touche

Faro Mine Site – S-Cluster Area
Continued Seepage Investigation

S-Cluster SIS
Cut-off Wall and Permeable Trench
w/ Monitoring Network

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	16



File Ref: 2006 Acad drawings\ DM FARO SITE seep options.dwg

SRK Consulting
Engineers and Scientists

Deloitte
& Touche

Faro Mine Site – S–Cluster Area
Continued Seepage Investigation

Schematic Cross–Section of Permeable
Trench and Cut–off Wall for S–cluster Area

PROJECT NO.	DATE	APPROVED	FIGURE
1CD003.073	Mar. 2006	DM	17

Appendix A

Drill Logs and Completion Diagrams

2005 SP Monitoring Wells

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-12 **TO** 2005-08-12
DIP: **AZIMUTH:**
COORDINATES: 6912901.00 N 584727.00 E **DATUM:**

BOREHOLE: SRK05-SP1A
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

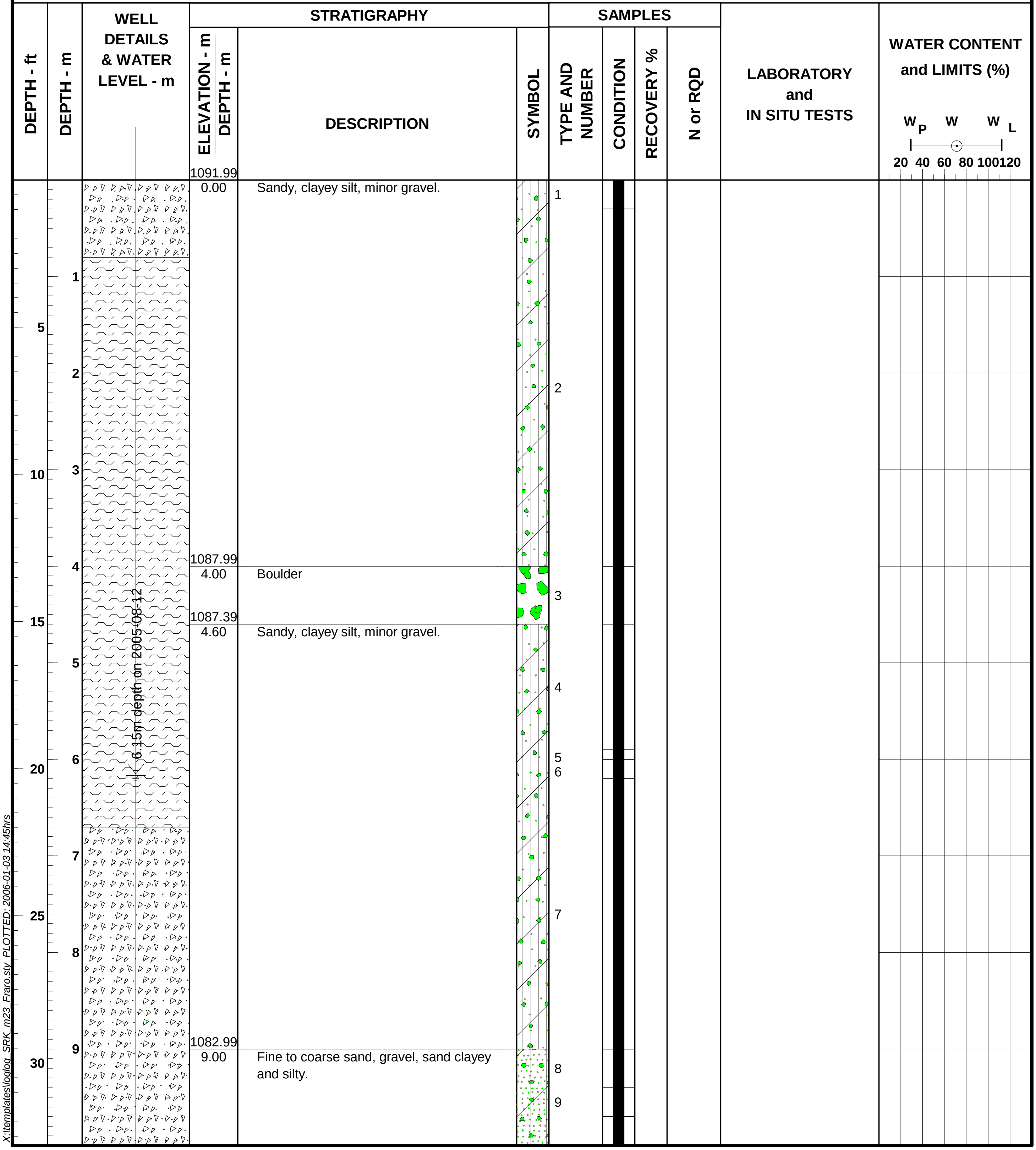
SAMPLE CONDITION
☒ Remoulded
▨ Undisturbed
■ Lost
◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION
1091.99 0.00	Sandy, clayey silt, minor gravel.
1087.99 4.00	Boulder
1087.39 4.60	Sandy, clayey silt, minor gravel.
1082.99 9.00	Fine to coarse sand, gravel, sand clayey and silty.

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-12 **TO** 2005-08-12

DIP: **AZIMUTH:**

COORDINATES: 6912901.00 N 584727.00 E **DATUM:**

BOREHOLE: SRK05-SP1A

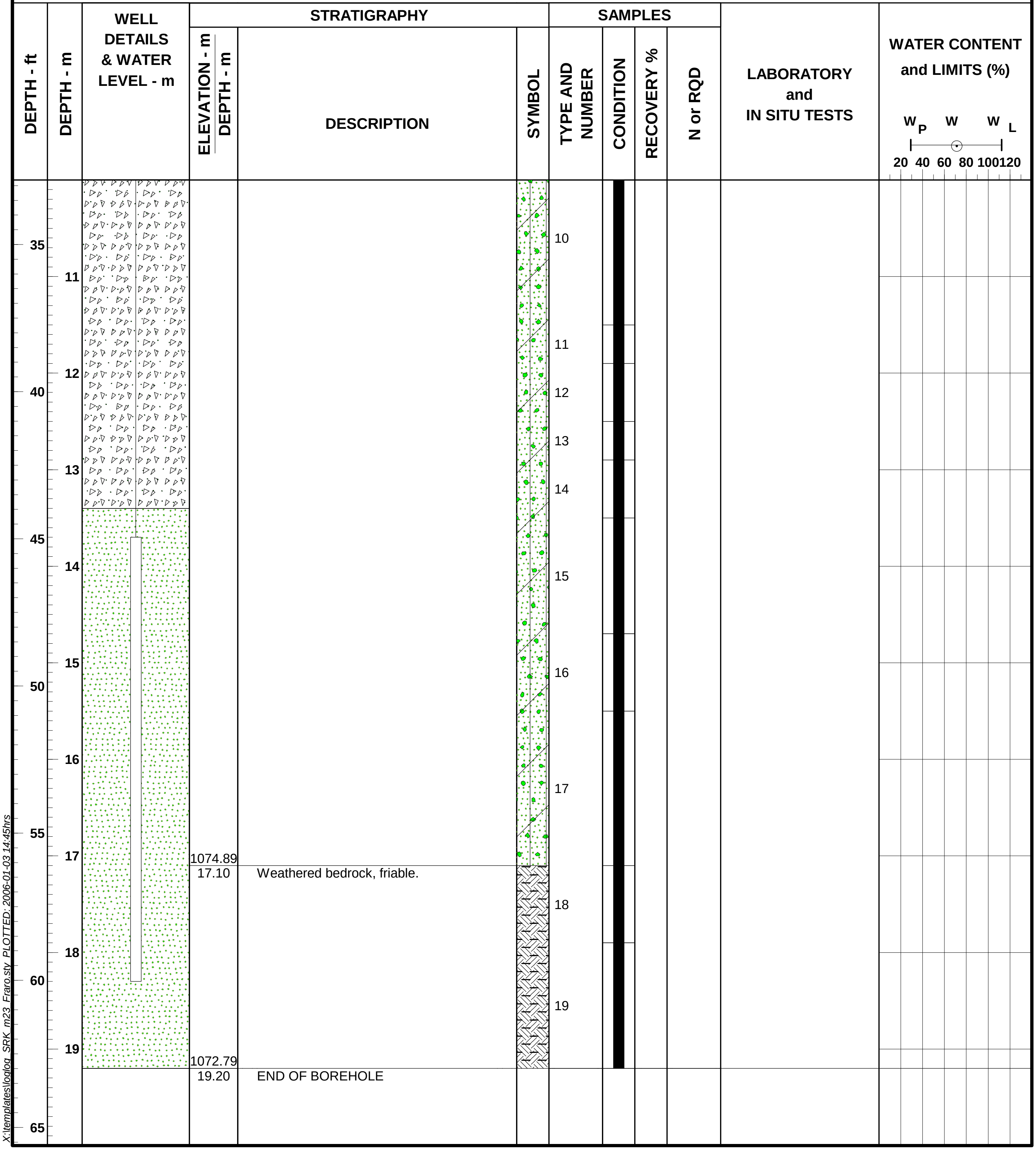
PAGE: 2 **OF** 2

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION
1074.89 17.10	Weathered bedrock, friable.
1072.79 19.20	END OF BOREHOLE

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-12 **TO** 2005-08-12

DIP: **AZIMUTH:**

COORDINATES: 6912901.00 N 584726.00 E **DATUM:**

BOREHOLE: SRK05-SP1B

PAGE: 1 **OF** 2

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION

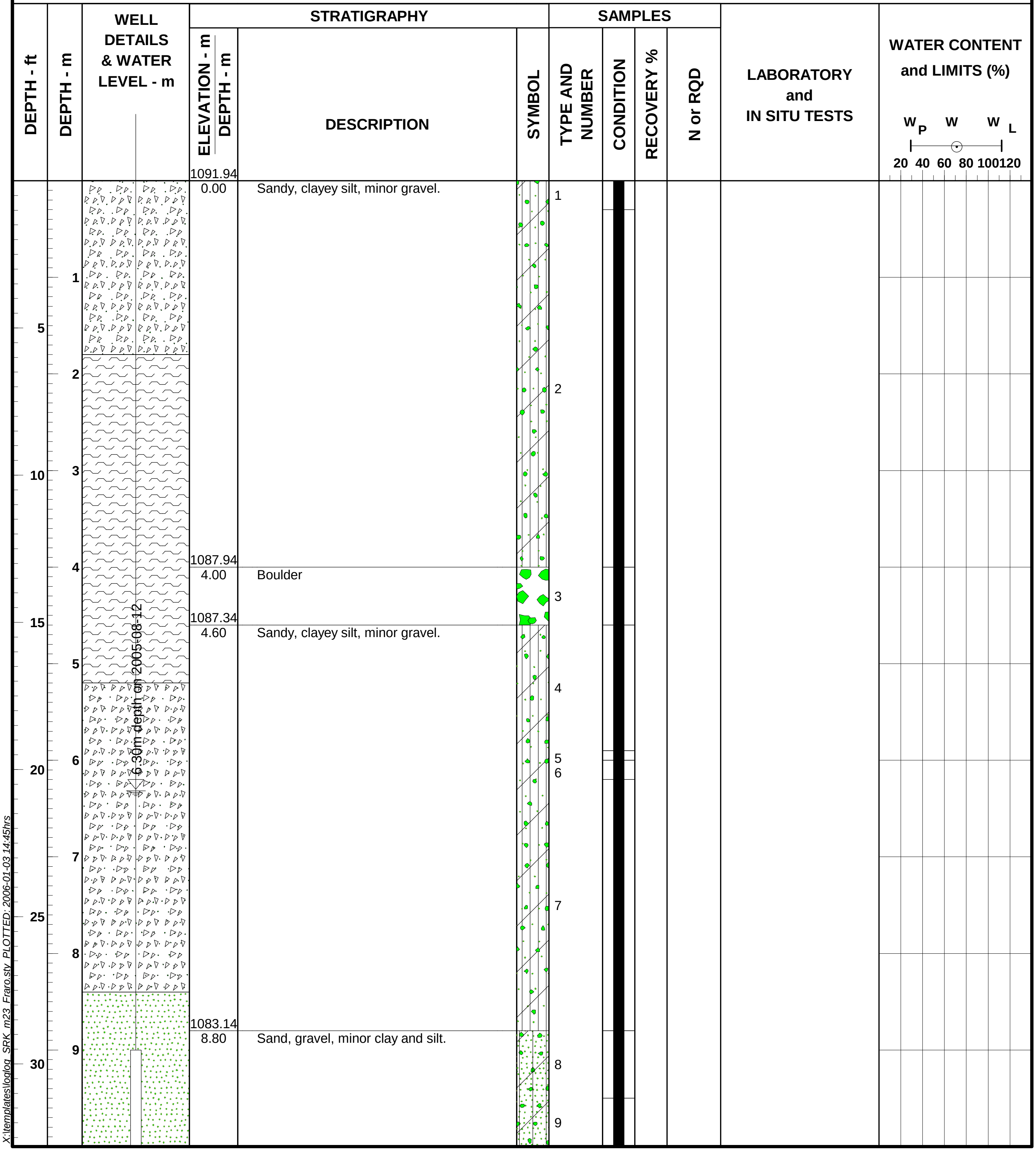
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation
D	Bulk density (kg/m3)
Dr	Specific gravity
Ksat	Saturated hydraulic cond. (cm/s)
Ku	Thermal conductivity Unfrozen (W / m°C)
Kf	Thermal conductivity Frozen (W / m°C)
PS	Particle size analysis



ELEVATION - m / DEPTH - m	DESCRIPTION
1091.94 0.00	Sandy, clayey silt, minor gravel.
1087.94 4.00	Boulder
1087.34 4.60	Sandy, clayey silt, minor gravel.
1083.14 8.80	Sand, gravel, minor clay and silt.

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

BOREHOLE LOG

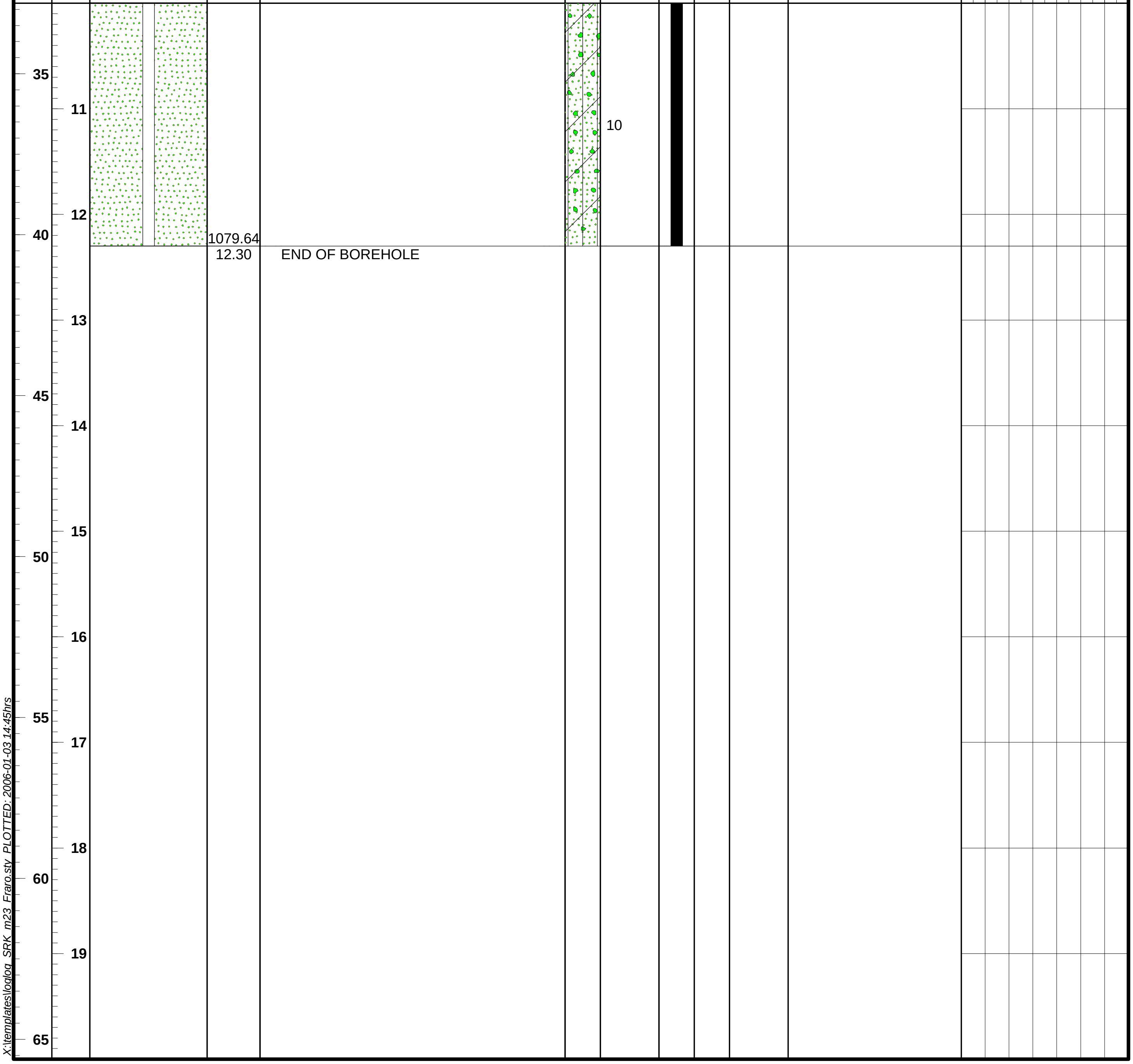
SRK Consulting Engineers and Scientists

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-12 **TO** 2005-08-12
DIP: **AZIMUTH:**
COORDINATES: 6912901.00 N 584726.00 E **DATUM:**

BOREHOLE: SRK05-SP1B
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY: ELEVATION - m / DEPTH - m	STRATIGRAPHY: DESCRIPTION	STRATIGRAPHY: SYMBOL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY %	SAMPLES: N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120
						10	■				
			1079.64 12.30	END OF BOREHOLE							



X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

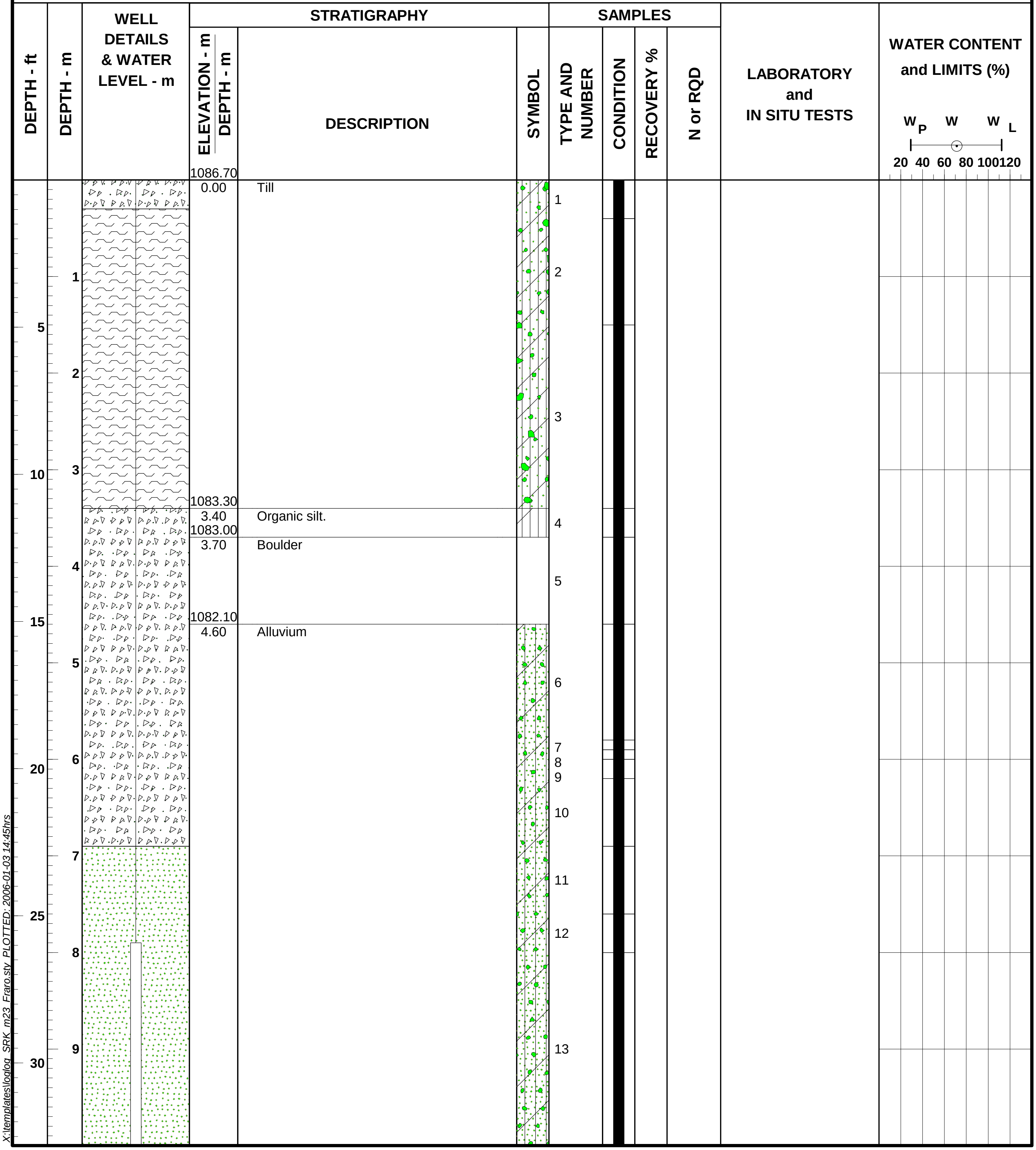
SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-21 **TO** 2005-08-21
DIP: **AZIMUTH:**
COORDINATES: 6912861.00 N 584791.00 E **DATUM:**

BOREHOLE: SRK05-SP2
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION
1086.70 0.00	Till
1083.30 3.40	Organic silt.
1083.00 3.70	Boulder
1082.10 4.60	Alluvium

TYPE AND NUMBER
1
2
3
4
5
6
7
8
9
10
11
12
13

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-21 **TO** 2005-08-21

DIP: **AZIMUTH:**

COORDINATES: 6912861.00 N 584791.00 E **DATUM:**

BOREHOLE: SRK05-SP2

PAGE: 2 **OF** 2

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION

- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120
			1076.30 10.40	Bedrock			■				
35						14	■				
	11		1075.70 11.00	END OF BOREHOLE							
	12										
40											
	13										
45											
	14										
	15										
50											
	16										
55											
	17										
	18										
60											
	19										
65											

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

BOREHOLE LOG

SRK Consulting
Engineers and Scientists

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6912924.00 N 584651.00 E **DATUM:**

BOREHOLE: SRK05-SP3A
PAGE: 1 **OF** 3
DRILL TYPE:
DRILL:
CASING:

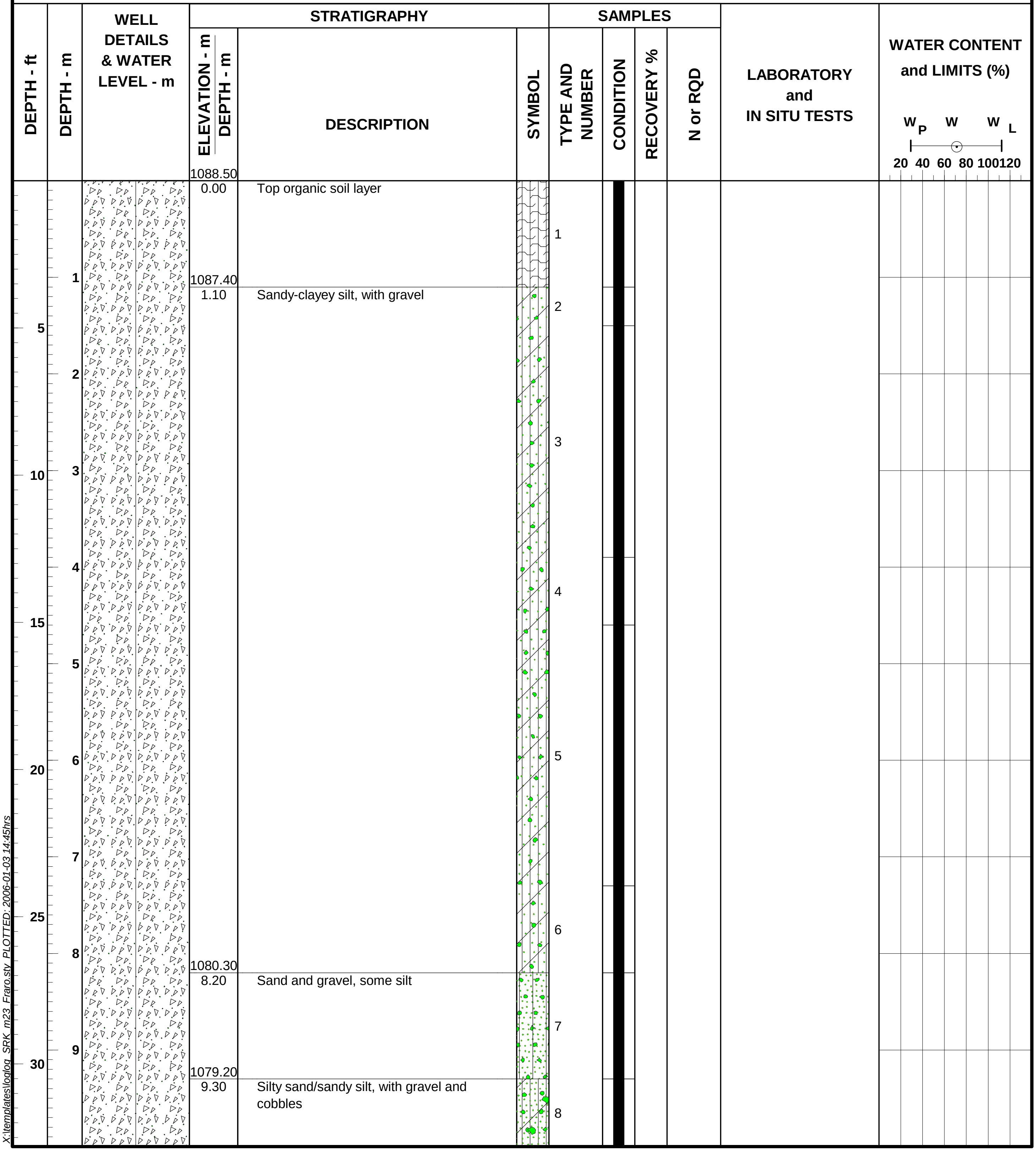
SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m / DEPTH - m	DESCRIPTION
1088.50 0.00	Top organic soil layer
1087.40 1.10	Sandy-clayey silt, with gravel
1080.30 8.20	Sand and gravel, some silt
1079.20 9.30	Silty sand/sandy silt, with gravel and cobbles

X:\templates\loglog SRK m23 Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-13 **TO**

DIP: **AZIMUTH:**

COORDINATES: 6912924.00 N 584651.00 E **DATUM:**

BOREHOLE: SRK05-SP3A

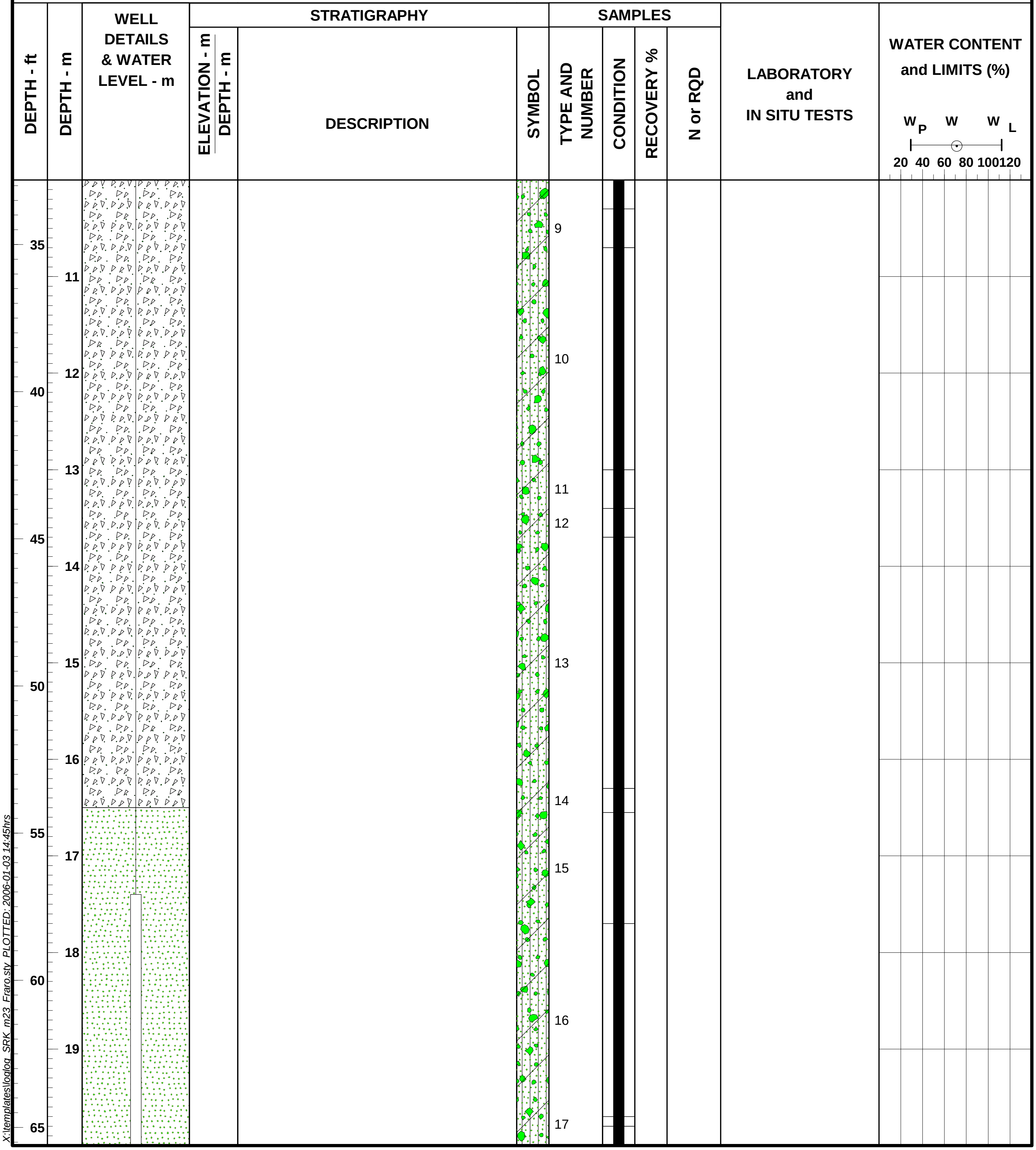
PAGE: 2 **OF** 3

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		



SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6912924.00 N 584651.00 E **DATUM:**

BOREHOLE: SRK05-SP3A
PAGE: 3 **OF** 3
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION

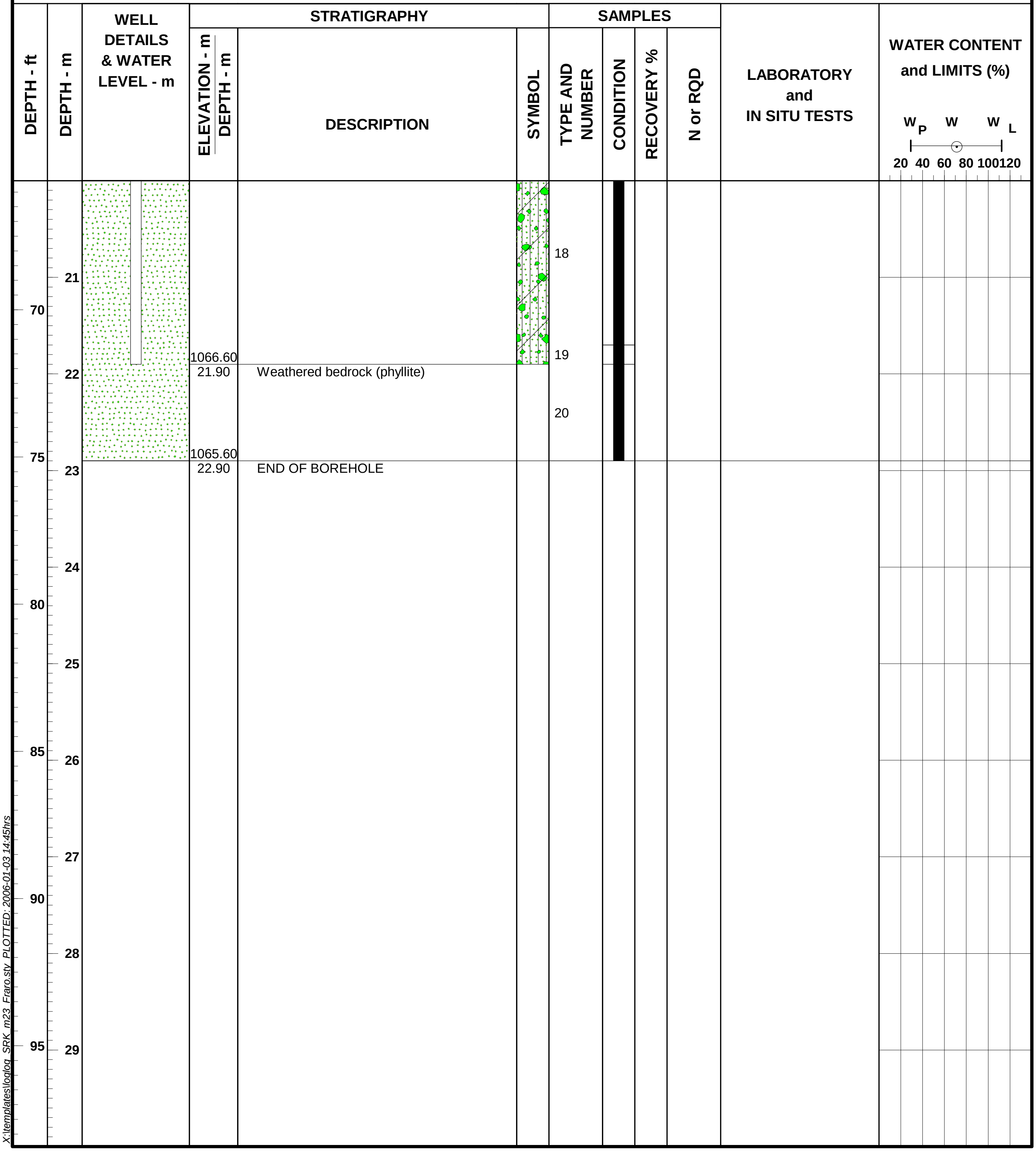
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m / DEPTH - m	DESCRIPTION	TYPE AND NUMBER
		18
1066.60 21.90	Weathered bedrock (phyllite)	19 20
1065.60 22.90	END OF BOREHOLE	

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-13 **TO** 2005-08-13

DIP: **AZIMUTH:**

COORDINATES: 6912924.00 N 584652.00 E **DATUM:**

BOREHOLE: SRK05-SP3B

PAGE: 1 **OF** 2

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION

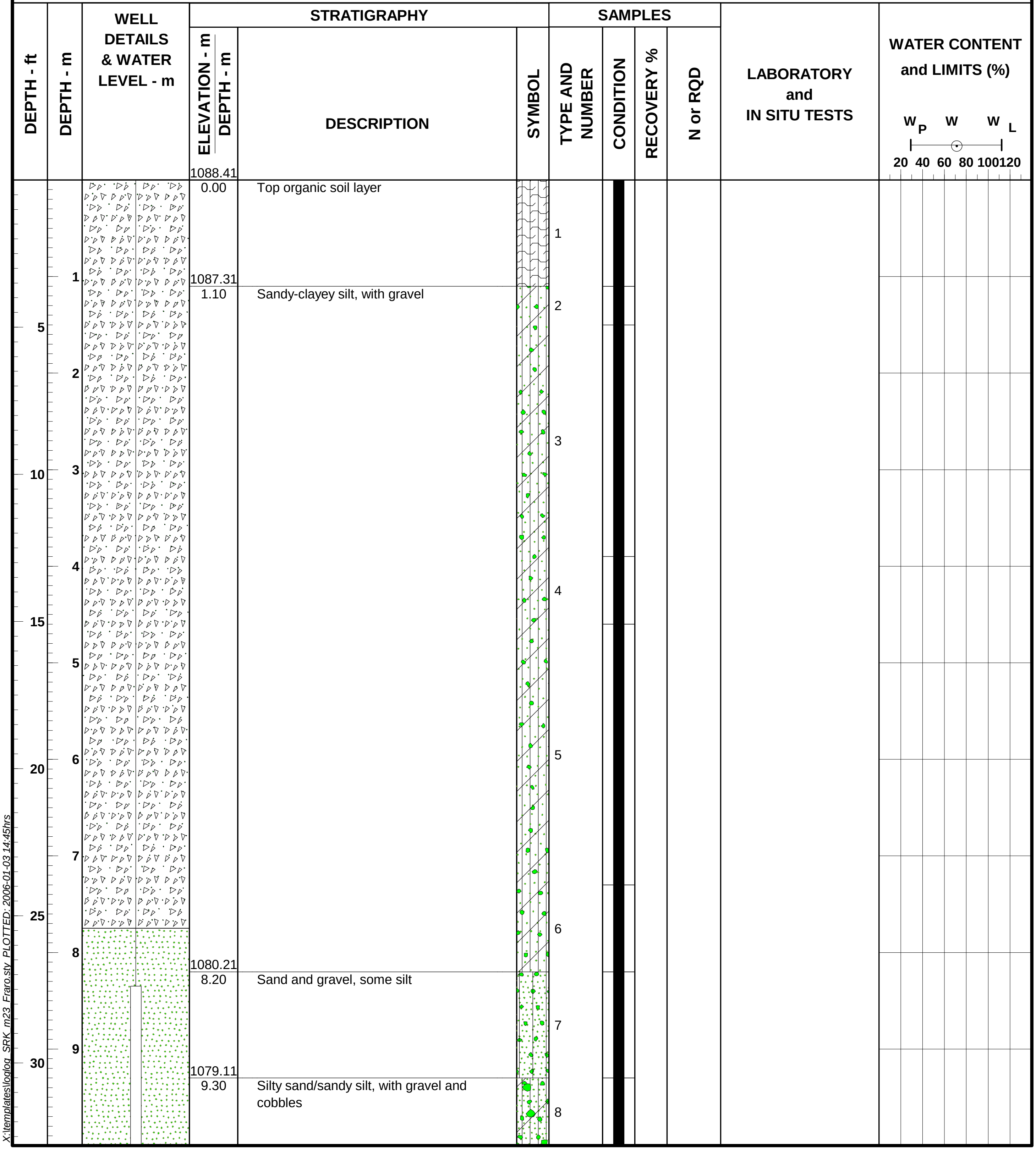
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION
1088.41 0.00	Top organic soil layer
1087.31 1.10	Sandy-clayey silt, with gravel
1080.21 8.20	Sand and gravel, some silt
1079.11 9.30	Silty sand/sandy silt, with gravel and cobbles

SAMPLES TYPE AND NUMBER: 1, 2, 3, 4, 5, 6, 7, 8

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

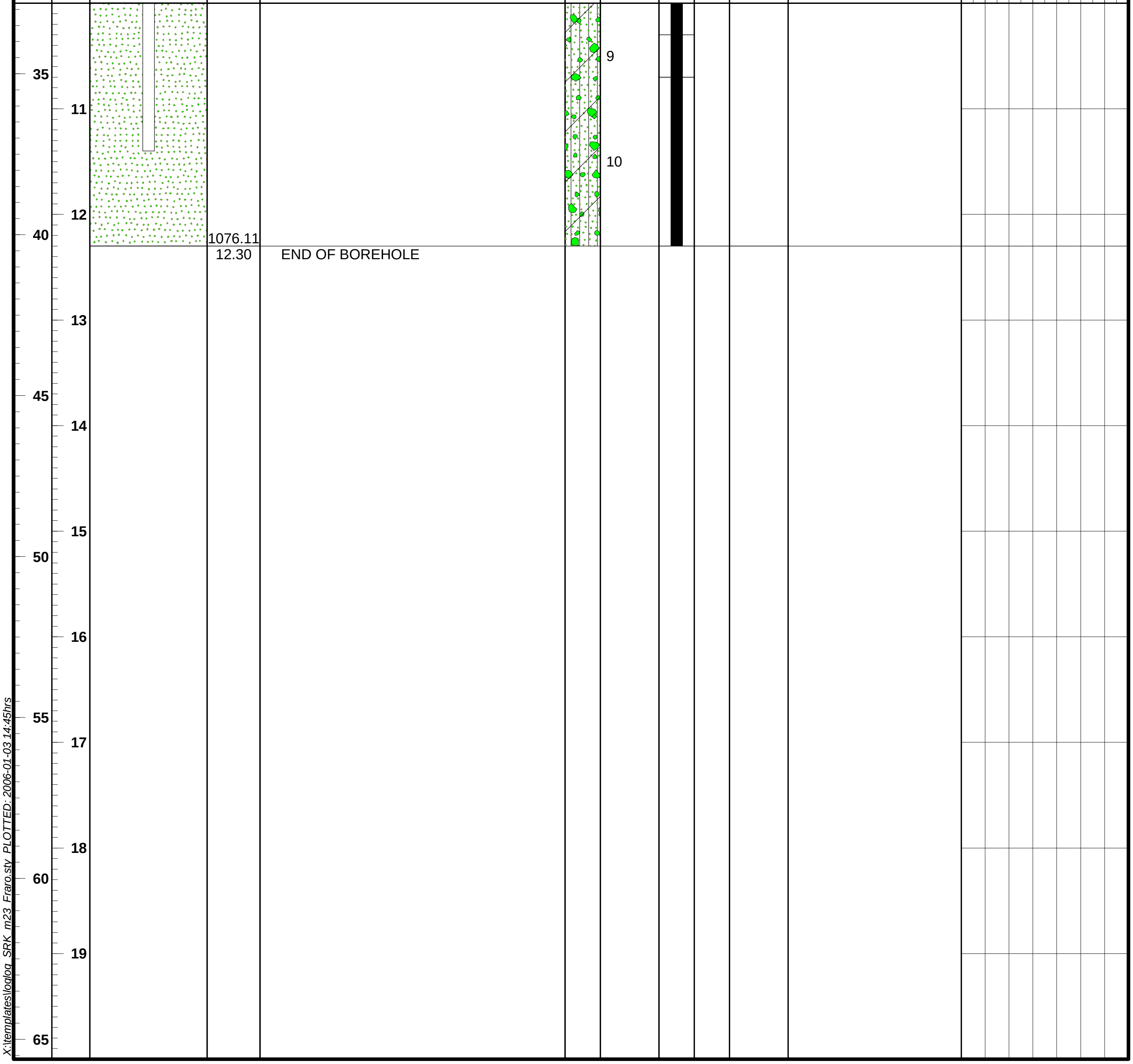
SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO** 2005-08-13
DIP: **AZIMUTH:**
COORDINATES: 6912924.00 N 584652.00 E **DATUM:**

BOREHOLE: SRK05-SP3B
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◨	Core			Ksat	Saturated hydraulic cond. (cm/s)		



DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100120
35	11					9					
						10					
40	12		1076.11 12.30	END OF BOREHOLE							
45	13 14										
50	15 16										
55	17										
60	18 19										
65											

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO** 2005-08-13
DIP: **AZIMUTH:**
COORDINATES: 6912924.00 N 584652.00 E **DATUM:**

BOREHOLE: SRK05-SP3B
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

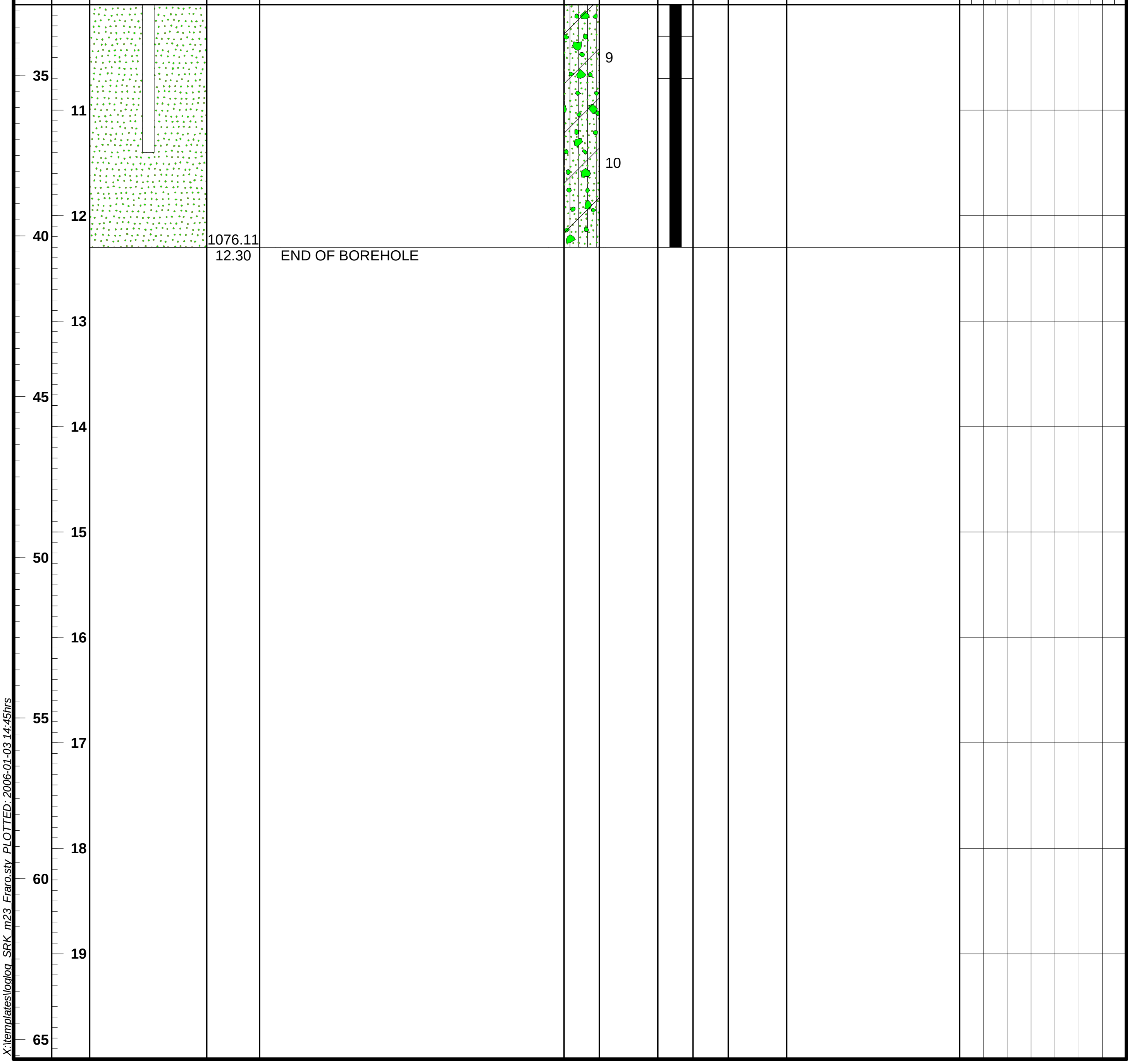
TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation
D	Bulk density (kg/m3)
Dr	Specific gravity
Ksat	Saturated hydraulic cond. (cm/s)
Ku	Thermal conductivity Unfrozen (W / m°C)
Kf	Thermal conductivity Frozen (W / m°C)
PS	Particle size analysis

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY			SAMPLES				LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%)
			ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD		W_P W W_L 20 40 60 80 100120
			1076.11 12.30	END OF BOREHOLE		9 10					



X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO** 2005-08-13
DIP: **AZIMUTH:**
COORDINATES: 6912924.00 N 584652.00 E **DATUM:**

BOREHOLE: SRK05-SP3B-OLD
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION

☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY: ELEVATION - m / DEPTH - m	STRATIGRAPHY: DESCRIPTION	STRATIGRAPHY: SYMBOL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY %	SAMPLES: N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100120
						CT-1	☒				
5	1					CT-2	☒				
	2					CT-3	☒				
10	3					CT-4	☒				
15	4					CT-5	☒				
	5					CT-6	☒				
20	6					CT-7	☒				
25	7					CT-8	☒				
	8					CT-9	☒				
30	9					CT-10	☒				

X:\templates\loglog SRK m23 Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO** 2005-08-13
DIP: **AZIMUTH:**
COORDINATES: 6912924.00 N 584652.00 E **DATUM:**

BOREHOLE: SRK05-SP3B-OLD
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m / DEPTH - m	STRATIGRAPHY DESCRIPTION	STRATIGRAPHY SYMBOL	SAMPLES TYPE AND NUMBER	SAMPLES CONDITION	SAMPLES RECOVERY %	SAMPLES N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100120
						CT-11A	☒				
35											
	11										
						CT-11B	☒				
						CT-11C	☒				
						CT-11D	☒				
	12										
40											
						CT-12A	☒				
						CT-12B	☒				
						CT-12C	☒				
	13										
						CT-13A	☒				
						CT-13B	☒				
						CT-13C	☒				
45											
						CT-13D	☒				
	14										
						CT-14A	☒				
						CT-14B	☒				
						CT-14C	☒				
						CT-14D	☒				
	15										
50						CT-15A	☒				
						CT-15B	☒				
	16										
55											
	17										
	18										
60											
	19										
65											

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:		**BOREHOLE:**	SRK05-SP4A
LOCATION:	NFRC - North Fork Rose Creek	**PAGE:**	1 **OF** 3
FILE No:	FARO (1CD003.73)	**DRILL TYPE:**	
BORING DATE:	2005-08-14 **TO**	**DRILL:**	
DIP:	**AZIMUTH:**	**CASING:**	
COORDINATES:	6912939.00 N 584612.00 E **DATUM:**		

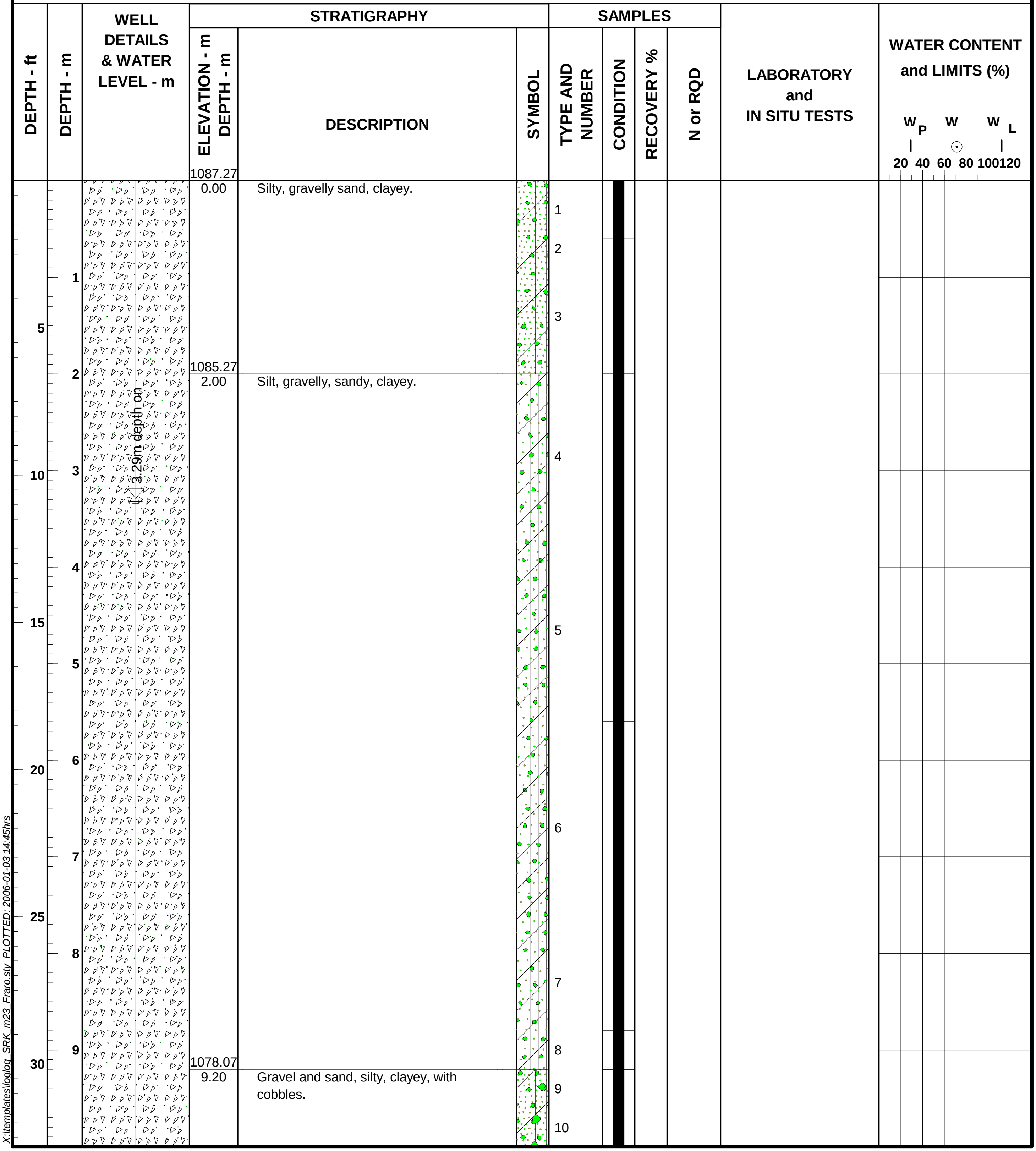
SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m / DEPTH - m	DESCRIPTION	TYPE AND NUMBER
1087.27 0.00	Silty, gravelly sand, clayey.	1 2 3
1085.27 2.00	Silt, gravelly, sandy, clayey.	4 5 6 7 8
1078.07 9.20	Gravel and sand, silty, clayey, with cobbles.	9 10

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

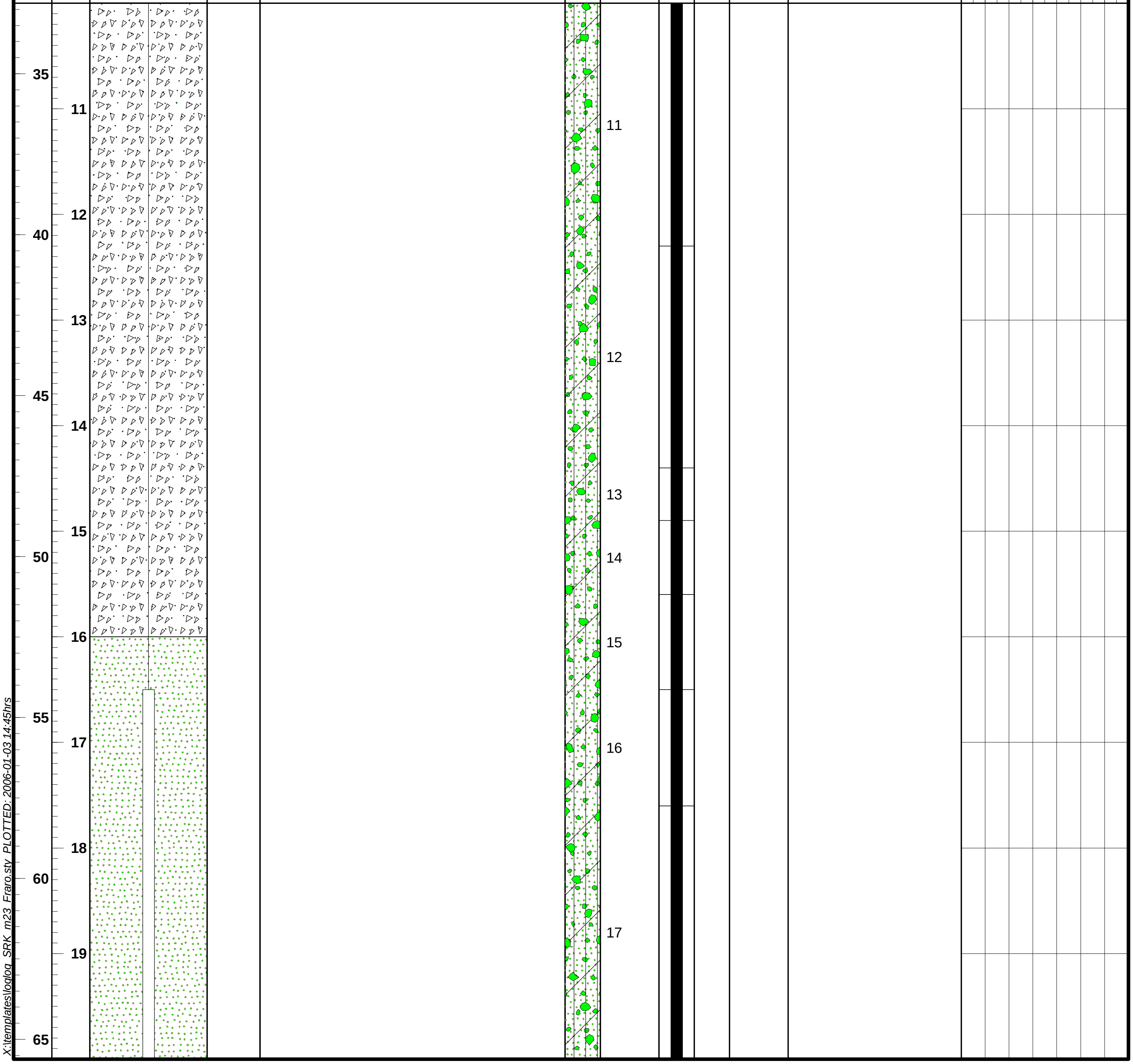
BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-14 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6912939.00 N 584612.00 E **DATUM:**

BOREHOLE: SRK05-SP4A
PAGE: 2 **OF** 3
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		TYPE OF SAMPLER		LABORATORY AND IN SITU TESTS			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY			SAMPLES				LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%)
			ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD		W_P W W_L 20 40 60 80 100 120



X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-14 **TO**
DIP: **AZIMUTH:**
COORDINATES: 6912939.00 N 584612.00 E **DATUM:**

BOREHOLE: SRK05-SP4A
PAGE: 3 **OF** 3
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY ELEVATION - m DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120
			1066.87 20.40	Weathered bedrock, phyllite.							
	21					18	■				
70			1065.67 21.60	END OF BOREHOLE							
	22										
75	23										
	24										
80	25										
85	26										
	27										
90	28										
95	29										

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-21 **TO** 2005-08-21

DIP: **AZIMUTH:**

COORDINATES: 6912939.00 N 584611.00 E **DATUM:**

BOREHOLE: SRK05-SP4B

PAGE: 1 **OF** 1

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION

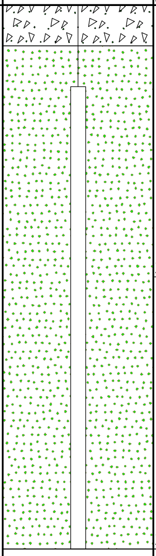
☒	Remoulded
▨	Undisturbed
■	Lost
◨	Core

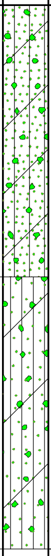
TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		





DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120
			1087.44 0.00	Silty, gravelly sand, clayey		1	■				
						2	■				
	1										
5						3	■				
	2		1085.44 2.00	Silt, gravelly, sandy, clayey							
						4	■				
10	3										
						5	■				
	4		1083.44 4.00	END OF BOREHOLE							
15	5										
20	6										
	7										
25	8										
30	9										

X:\templates\loglog SRK m23 Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

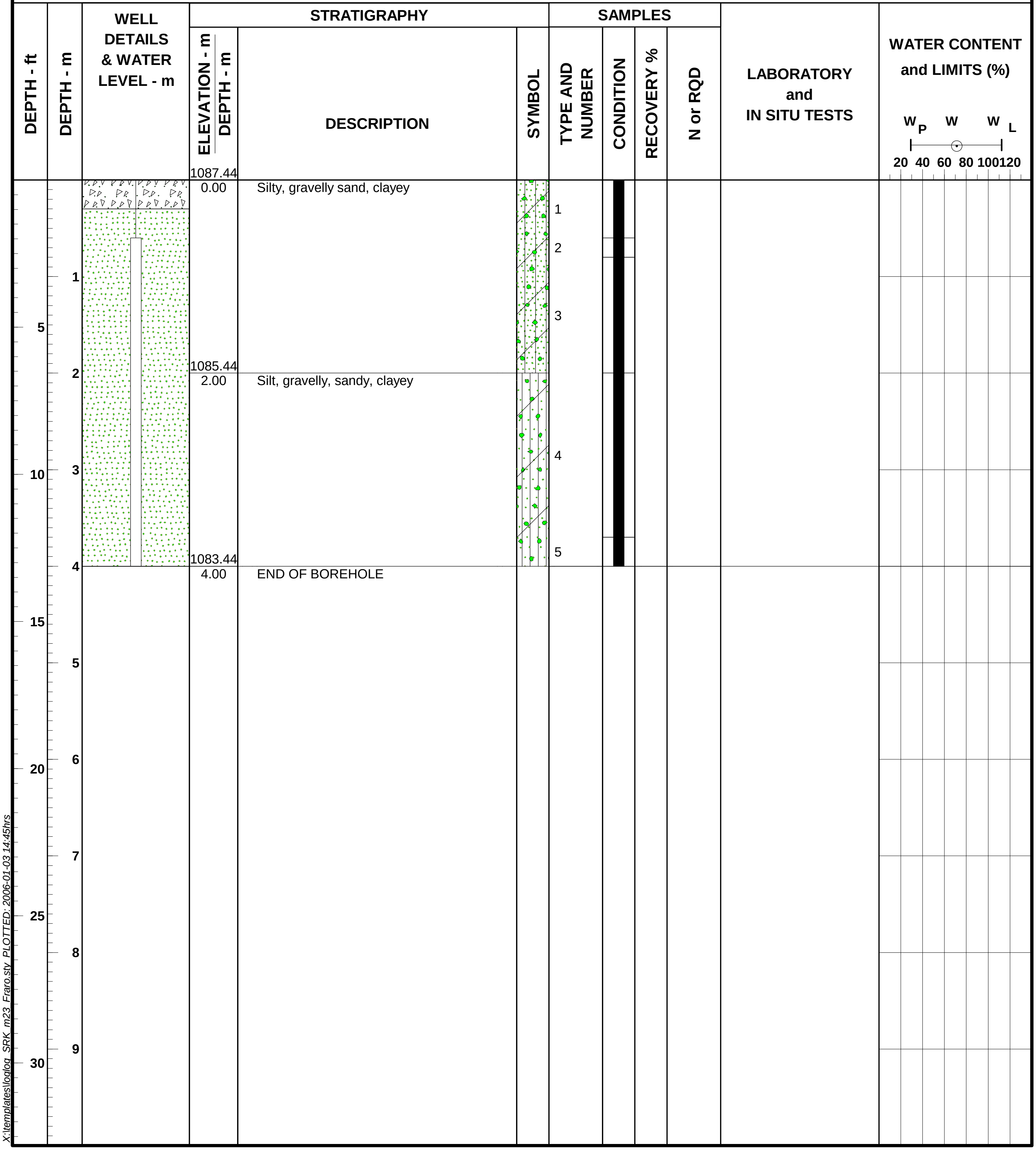
PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-21 **TO** 2005-08-21
DIP: **AZIMUTH:**
COORDINATES: 6912939.00 N 584611.00 E **DATUM:**

BOREHOLE: SRK05-SP4B
PAGE: 1 **OF** 1
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION	
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

TYPE OF SAMPLER	
DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS			
C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



STRATIGRAPHY		SAMPLES				LABORATORY and IN SITU TESTS
ELEVATION - m DEPTH - m	DESCRIPTION	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	
1087.44 0.00	Silty, gravelly sand, clayey	1 2 3	■			
1085.44 2.00	Silt, gravelly, sandy, clayey	4 5	■			
1083.44 4.00	END OF BOREHOLE					

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

BOREHOLE LOG

PROJECT:

LOCATION: NFRC - North Fork Rose Creek

FILE No: FARO (1CD003.73)

BORING DATE: 2005-08-13 **TO** 2005-08-13

DIP: **AZIMUTH:**

COORDINATES: 6912956.00 N 584576.00 E **DATUM:**

BOREHOLE: SRK05-SP5

PAGE: 1 **OF** 2

DRILL TYPE:

DRILL:

CASING:

SAMPLE CONDITION

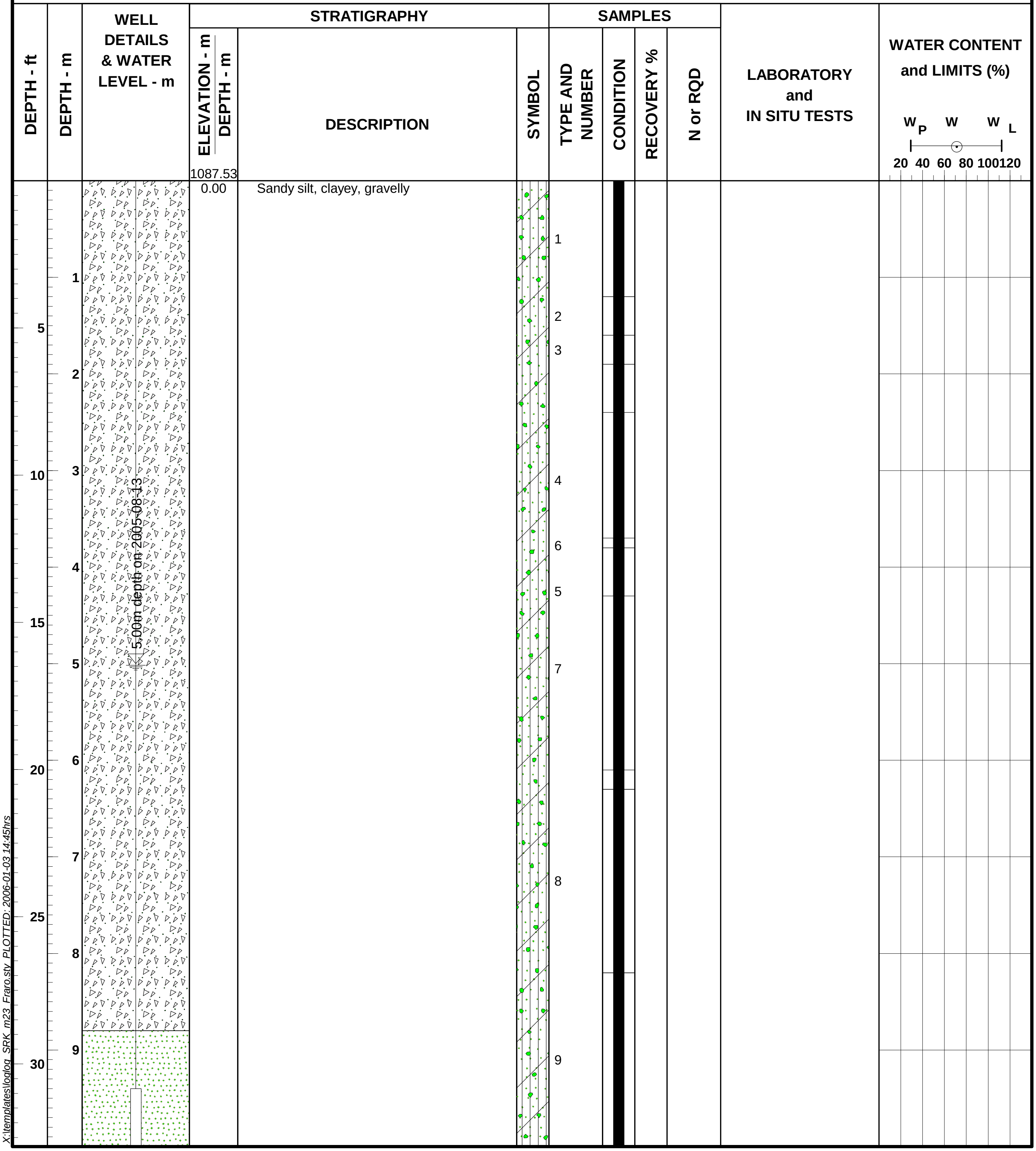
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation
D	Bulk density (kg/m3)
Dr	Specific gravity
Ksat	Saturated hydraulic cond. (cm/s)
Ku	Thermal conductivity Unfrozen (W / m°C)
Kf	Thermal conductivity Frozen (W / m°C)
PS	Particle size analysis



SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-13 **TO** 2005-08-13
DIP: **AZIMUTH:**
COORDINATES: 6912956.00 N 584576.00 E **DATUM:**

BOREHOLE: SRK05-SP5
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION

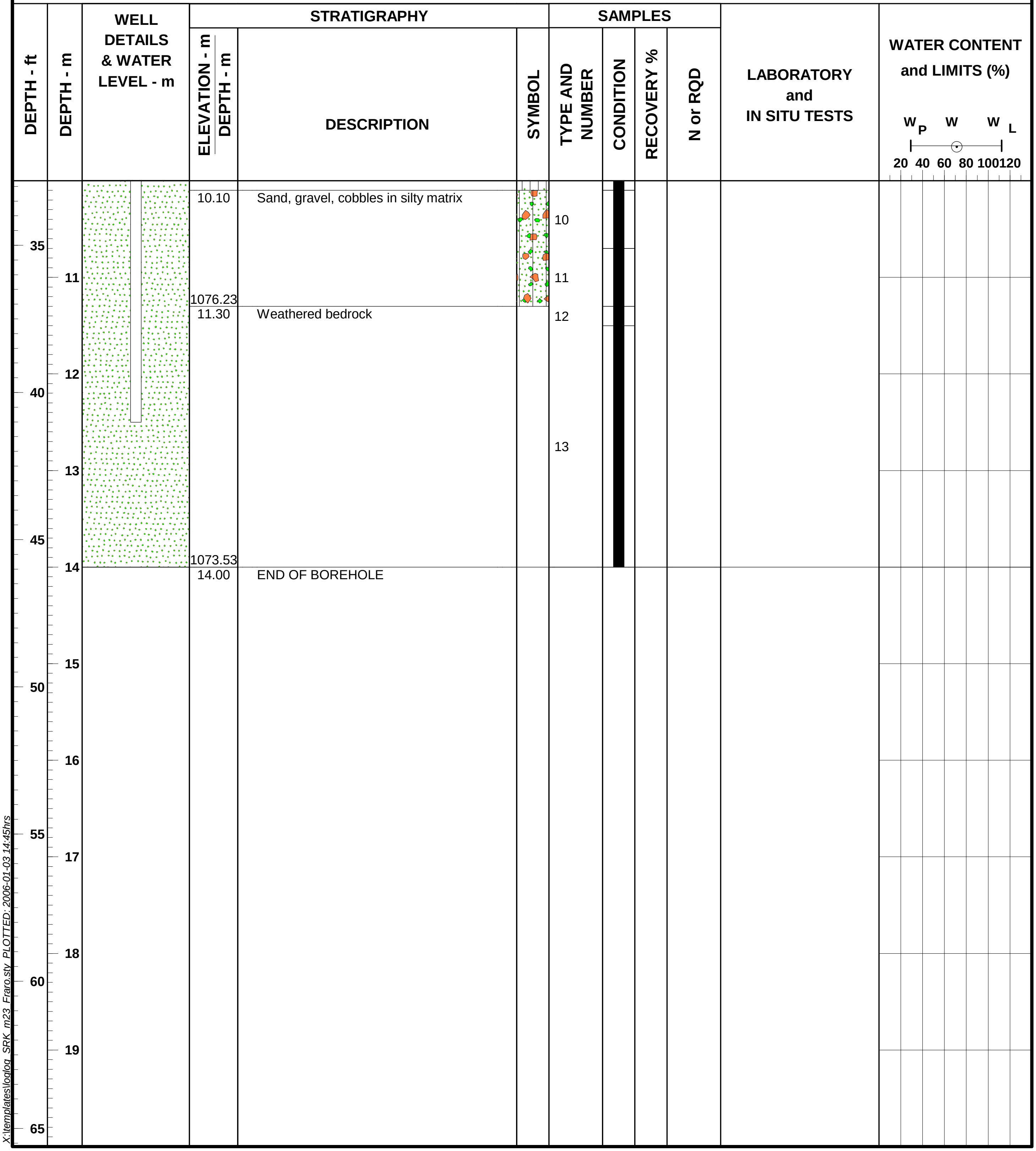
☒	Remoulded
▨	Undisturbed
■	Lost
◧	Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
Dr	Specific gravity	PS	Particle size analysis
Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m DEPTH - m	DESCRIPTION
10.10	Sand, gravel, cobbles in silty matrix
1076.23 11.30	Weathered bedrock
1073.53 14.00	END OF BOREHOLE

X:\templates\loglog_SRK_m23 Fraro.sty PLOTTED: 2006-01-03 14:45hrs

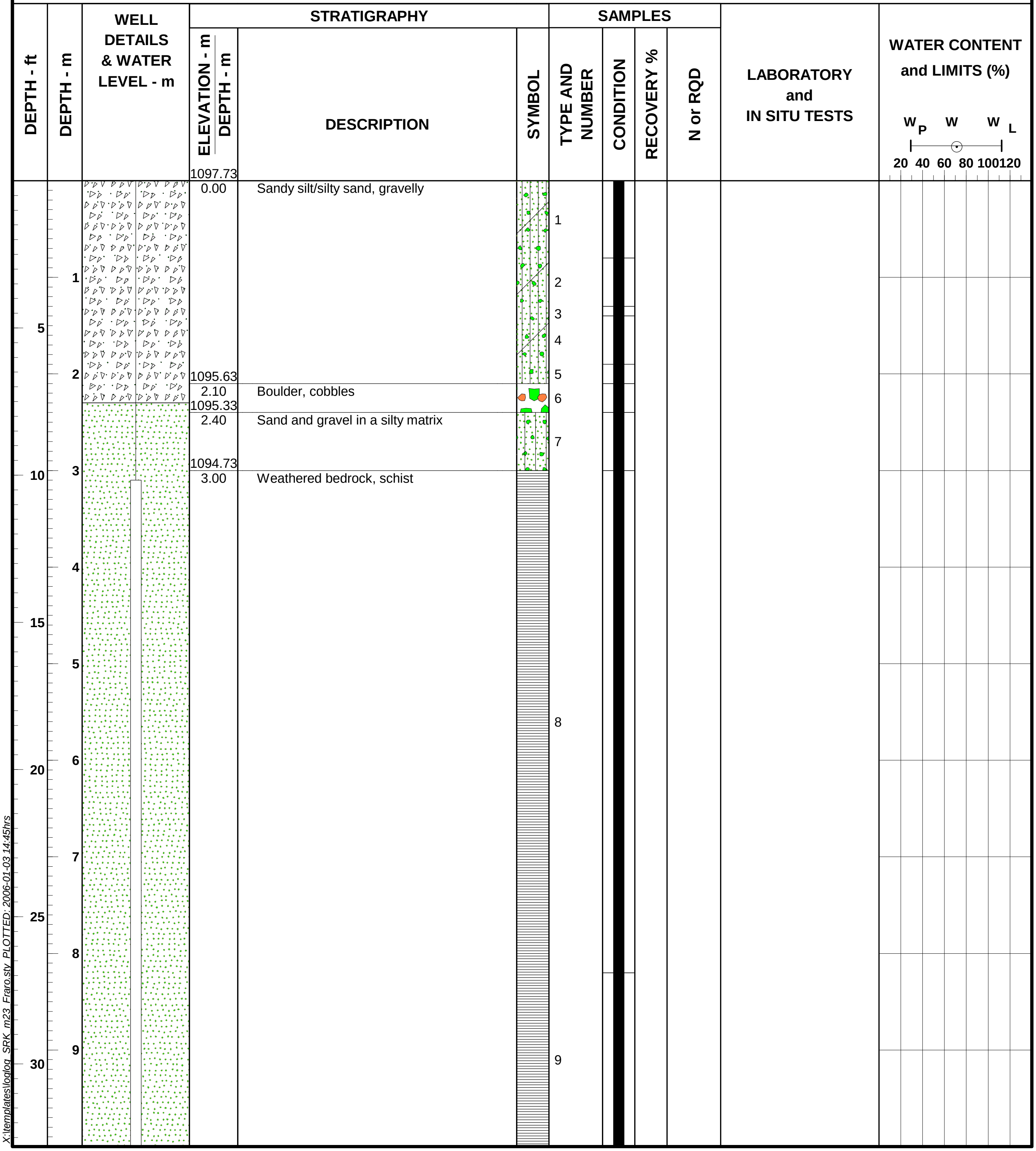
SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-23 **TO** 2005-08-23
DIP: **AZIMUTH:**
COORDINATES: 6912975.00 N 584492.00 E **DATUM:**

BOREHOLE: SRK05-SP-6
PAGE: 1 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION		**TYPE OF SAMPLER**		**LABORATORY AND IN SITU TESTS**			
☒	Remoulded	DC	Diamond core barrel	C	Consolidation	Ku	Thermal conductivity Unfrozen (W / m°C)
▨	Undisturbed	GS	Grab sample	D	Bulk density (kg/m3)	Kf	Thermal conductivity Frozen (W / m°C)
■	Lost	SS	Split spoon	Dr	Specific gravity	PS	Particle size analysis
◧	Core			Ksat	Saturated hydraulic cond. (cm/s)		



ELEVATION - m / DEPTH - m	DESCRIPTION
1097.73 0.00	Sandy silt/silty sand, gravelly
1095.63 2.10	Boulder, cobbles
1095.33 2.40	Sand and gravel in a silty matrix
1094.73 3.00	Weathered bedrock, schist

TYPE AND NUMBER
1
2
3
4
5
6
7
8
9

X:\templates\loglog SRK m23 Fraro.sty PLOTTED: 2006-01-03 14:45hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT:
LOCATION: NFRC - North Fork Rose Creek
FILE No: FARO (1CD003.73)
BORING DATE: 2005-08-23 **TO** 2005-08-23
DIP: **AZIMUTH:**
COORDINATES: 6912975.00 N 584492.00 E **DATUM:**

BOREHOLE: SRK05-SP-6
PAGE: 2 **OF** 2
DRILL TYPE:
DRILL:
CASING:

SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER

DC	Diamond core barrel
GS	Grab sample
SS	Split spoon

LABORATORY AND IN SITU TESTS

C	Consolidation
D	Bulk density (kg/m3)
Dr	Specific gravity
Ksat	Saturated hydraulic cond. (cm/s)
Ku	Thermal conductivity Unfrozen (W / m°C)
Kf	Thermal conductivity Frozen (W / m°C)
PS	Particle size analysis

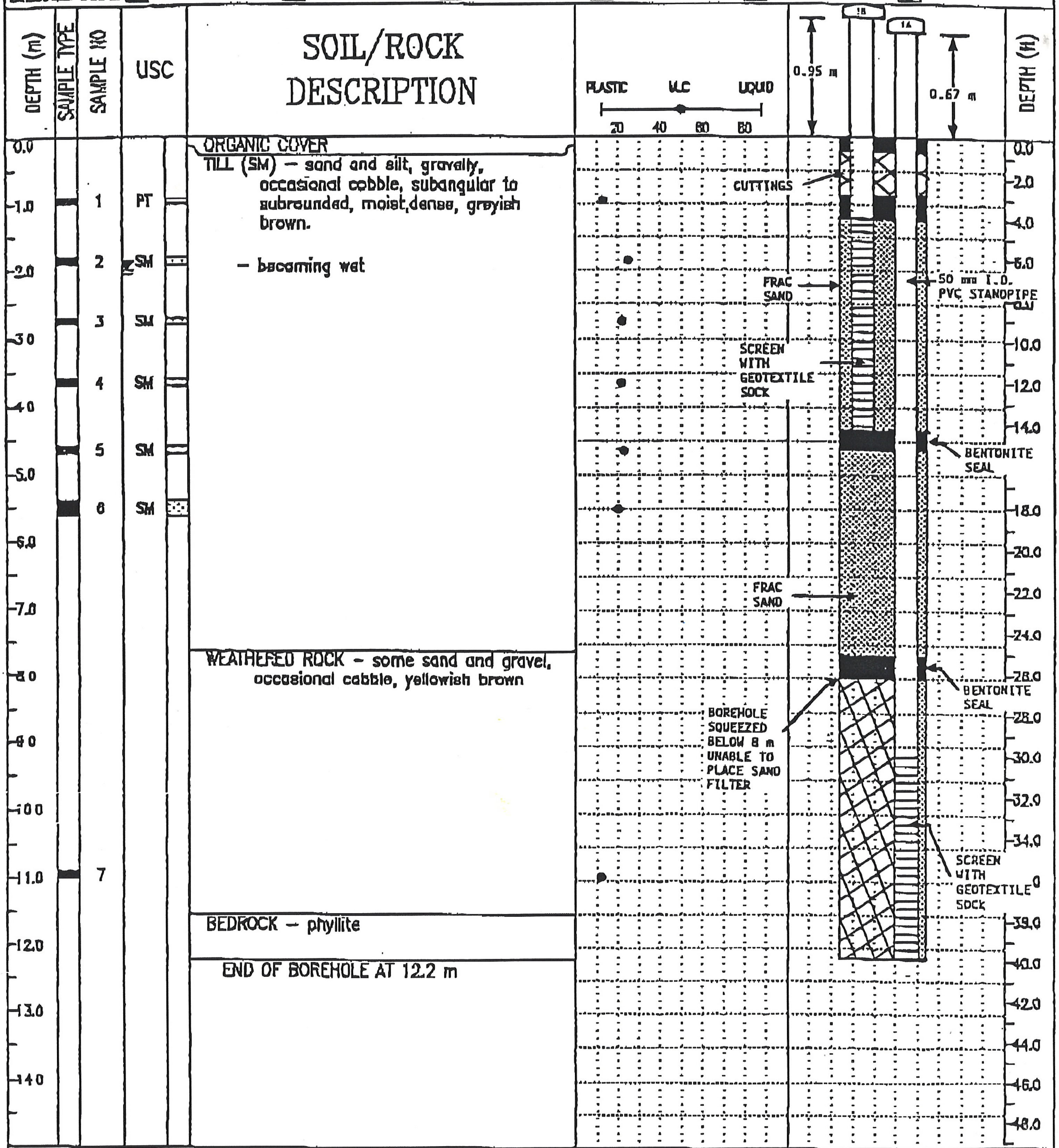
DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	STRATIGRAPHY: ELEVATION - m / DEPTH - m	STRATIGRAPHY: DESCRIPTION	STRATIGRAPHY: SYMBOL	SAMPLES: TYPE AND NUMBER	SAMPLES: CONDITION	SAMPLES: RECOVERY %	SAMPLES: N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120
35											
	11		1086.73 11.00	END OF BOREHOLE							
	12										
40											
	13										
45											
	14										
	15										
50											
	16										
55											
	17										
	18										
60											
	19										
65											

X:\templates\loglog_SRK_m23_Fraro.sty PLOTTED: 2006-01-03 14:45hrs

Original S-cluster Monitoring Wells

PIEZOMETER INSTALLATION – FARO PIT	Drill Rig: CME 750, Solid Shaft Augers	BOREHOLE No. 10028-01
Faro, Yukon		Project No: 0201-10028 (51)
CURRAGH RESOURCES INC.	TM ZONE: – N – E –	ELEVATION 0.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN.



ORGANIC COVER

TILL (SM) – sand and silt, gravelly, occasional cobble, subangular to subrounded, moist, dense, greyish brown.

– becoming wet

WEATHERED ROCK – some sand and gravel, occasional cobble, yellowish brown

BEDROCK – phyllite

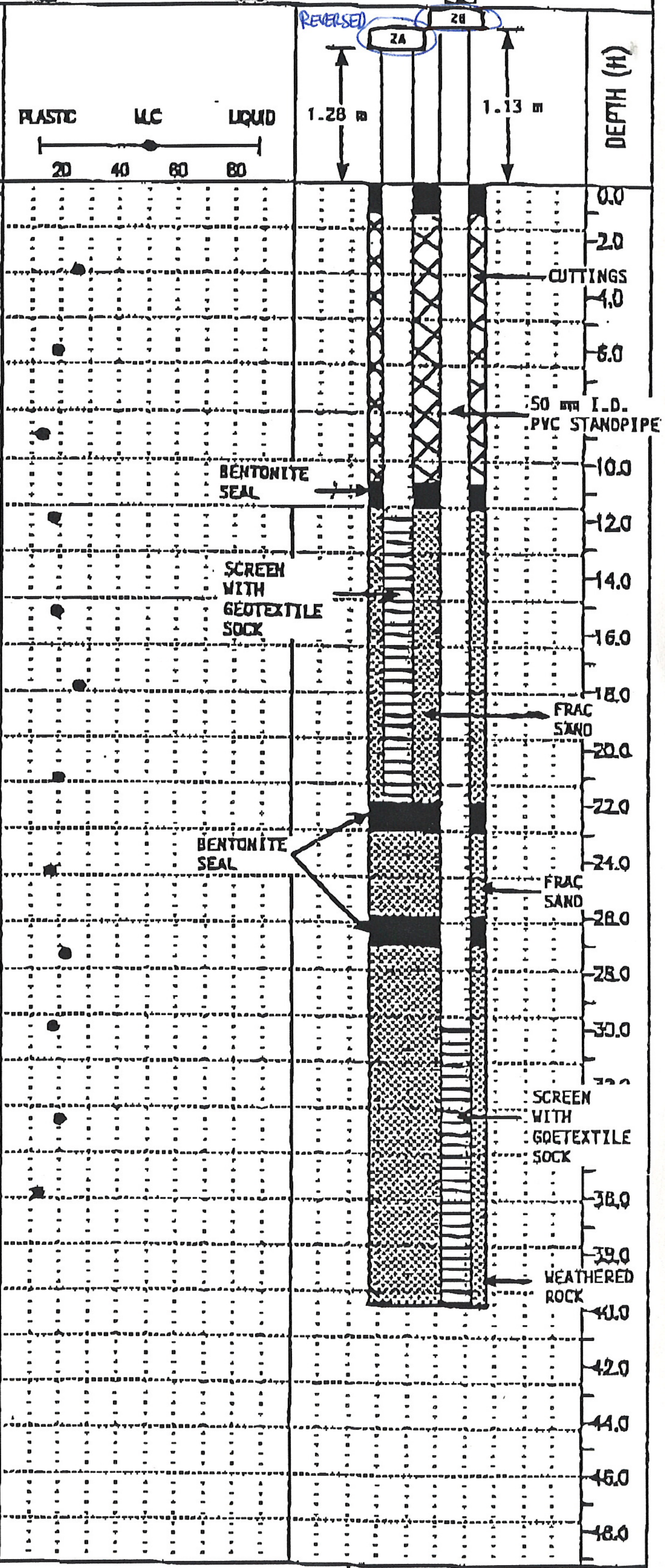
END OF BOREHOLE AT 12.2 m

EBA Engineering Consultants Ltd. Whitehorse, Yukon	COMPLETION DEPTH 12.2 m	COMPLETE 89/04/22
	LOGGED BY TRM	DWG NO.10028-02
		Page 1 of 1

PIEZOMETER INSTALLATION – FARO PIT	Drill Rig: CME 750, Solid Shaft Augers	BOREHOLE No. 10028-02
Faro, Yukon		Project No: 0201-10028 (52)
CURRAGH RESOURCES INC.	TM ZONE: – N – E –	ELEVATION 0.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN.

DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL/ROCK DESCRIPTION
0.0				ORGANIC COVER
				TILL (SM) – sand and silt, gravelly, occasional cobble, moist, greyish brown.
1.0		1	PT	
		2	SM	– becoming brownish grey
2.0				
		3	SM	
3.0				
		4	SM	– becoming moist to wet
4.0				
		5	SM	
5.0				
		6	SM	– saturated
6.0				
		7	SM	
7.0				WEATHERED ROCK – sand and gravel, some silt, saturated, brownish orange.
		8		
8.0				
		9		– occasional cobble
9.0		10		– becoming light greyish brown.
10.0				
		11		
11.0		12		
				BEDROCK – phyllite
12.0		13		END OF BOREHOLE AT 12.2 m.
13.0				
14.0				

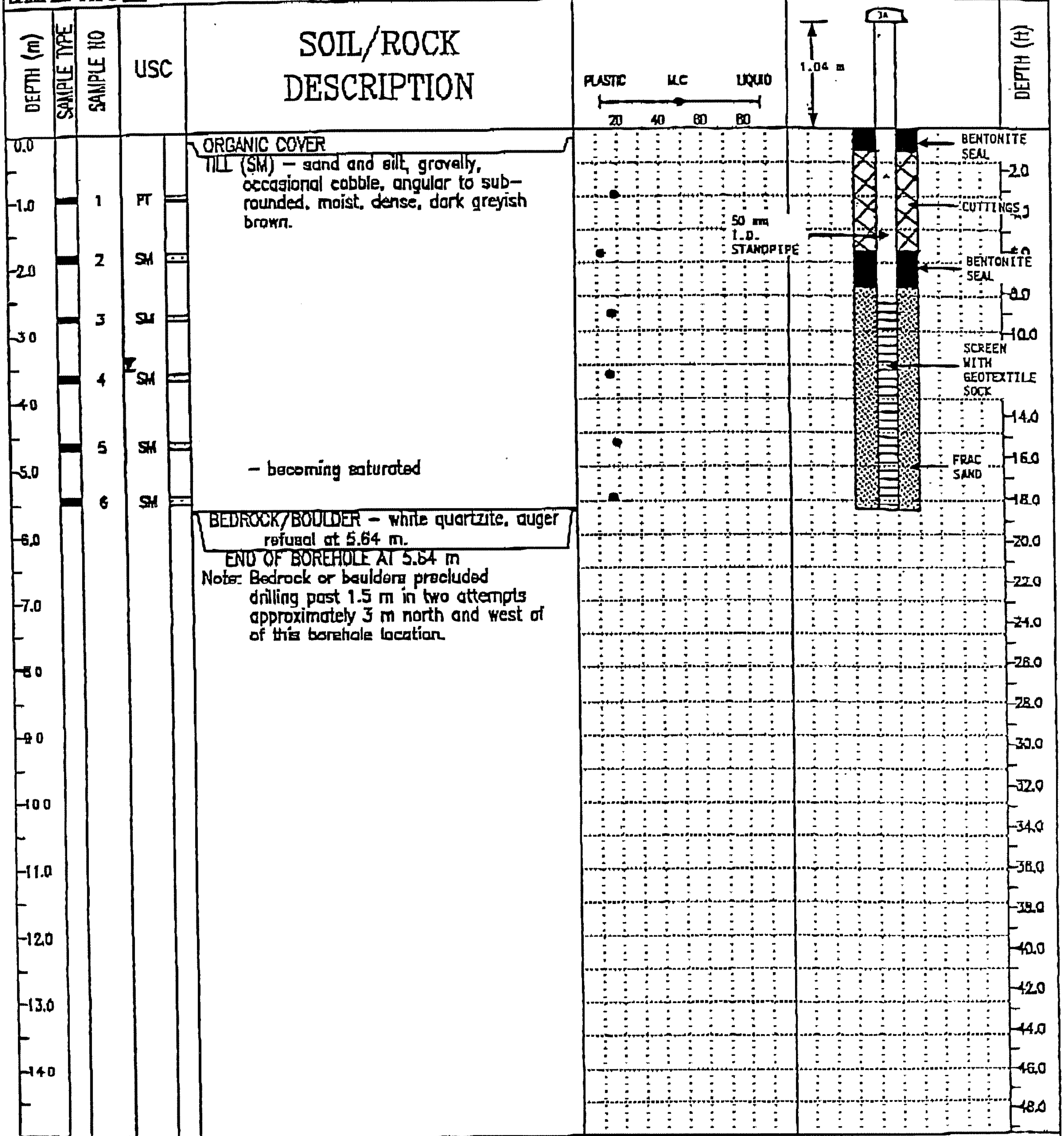


EBA Engineering Consultants Ltd.
Whitehorse, Yukon

COMPLETION DEPTH 12.2 m		COMPLETE 89/04/21
LOGGED BY TRM	DWG NO.10028-03	Page 1 of 1

PIEZOMETER INSTALLATION – FARO PIT	Drill Rig: CME 750, Solid Shaft Augers	BOREHOLE No. 10028-03
Faro, Yukon		Project No: 0201-10028 (S3)
CURRAGH RESOURCES INC.	TM ZONE: – N – E –	ELEVATION 0.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN.



SAMPLE NO	USC
1	PT
2	SM
3	SM
4	SM
5	SM
6	SM

SOIL/ROCK DESCRIPTION

ORGANIC COVER

TILL (SM) – sand and silt, gravelly, occasional cobble, angular to subrounded, moist, dense, dark greyish brown.

– becoming saturated

BEDROCK/BOULDER – white quartzite, auger refusal at 5.64 m.

END OF BOREHOLE AT 5.64 m

Note: Bedrock or boulders precluded drilling past 1.5 m in two attempts approximately 3 m north and west of of this borehole location.

EBA Engineering Consultants Ltd. Whitehorse, Yukon	COMPLETION DEPTH 5.8 m	COMPLETE 89/04/21
	LOGGED BY TRH	DWG NO.10028-04 · Page 1 of 1

P96-7 Monitoring Well

Client Name: Anvil Range Mining Corp.
Driller: Midnight Sun Drilling
BOREHOLE NO: BH96-7
Location: Faro, Yukon
Track-mounted Air-rotary (ODEX) - 175 mm
PROJECT NO: 033001
BH Loc: Faro Rock Dump,
UTM ZONE: - N - E -
ELEVATION:

SAMPLE TYPE	■ DISTURBED	▨ NO RECOVERY	☒ SPT	☰ A-CASING	▥ SHELBY TUBE	▮ CORE
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	⁂ CEMENT	▨ DRILL CUTTINGS	▩ SAND

DEPTH(m)	SOILS/ROCK DESCRIPTION	Additional Comments	DEPTH(ft)
0.0	SAND – fine grained, silty, some gravel, moist, medium brown.	– well stickup: 0.66 m ags – well completed with 6" diameter steel protective casing	0.0
4.0	SAND – very fine to fine grained, some silt to silty, slight trace gravel, micaceous, dry to damp, light brown. – increasing gravel content below 5.5 m. – becomes moist to wet at about 7.6 m.	– water level 5.17 m bgs on September 8, 1996	
8.0	PHYLLITE BEDROCK – aphanitic, well foliated, fractured, light green, some water.		
	BOREHOLE TERMINATED AT 9.2 m IN PHYLLITE BEDROCK. MONITORING WELL INSTALLED.		

DEPTH(m): 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

DEPTH(ft): 0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0

SOIL SYMBOL

SAMPLE TYPE

ROBERTSON GEOCONSULTANTS INC.

Vancouver, B.C.

LOGGED BY: TH/CW
REVIEWED BY: AR
Fig. No: 7
COMPLETION DEPTH: 9.2 m
COMPLETE: 06/09/96

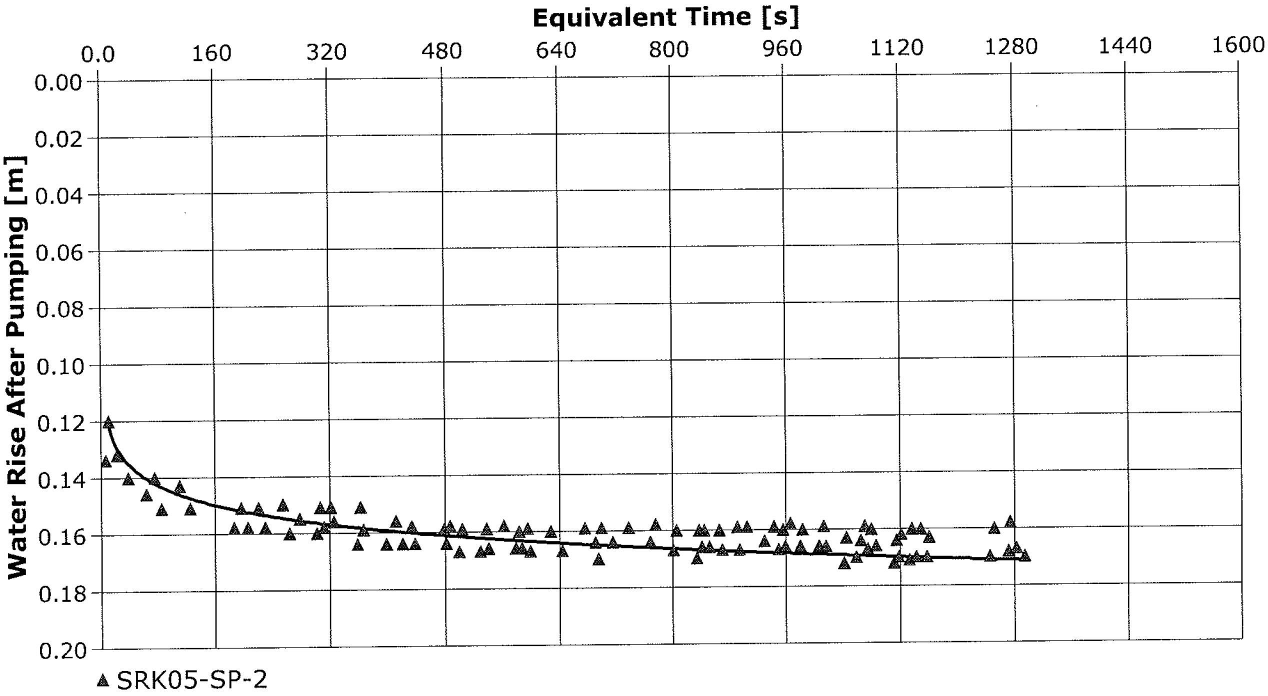
96/12/10 02:25PM (MONWELL2)

Appendix B

Hydraulic Testing Analysis Sheets

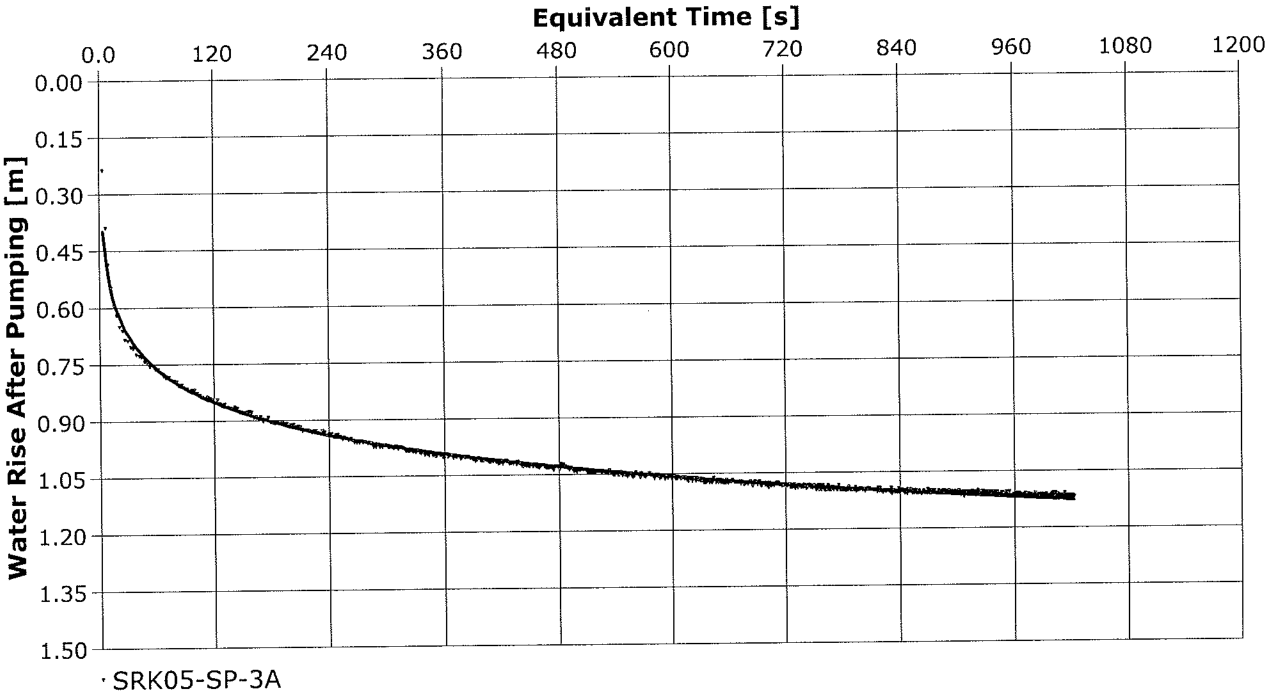
2005 SP Monitoring Wells

Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for SP2	Pumping well: SRK05-SP-2
Test conducted by: M.Prado		Test date: 10/27/2005
Analysis performed by: D.Mackie	Recovery - all time	Date: 10/27/2005
Aquifer Thickness: 6.40 m	Discharge: variable, average rate 0.28797 [l/s]	



Calculation after AGARWAL + Theis					
Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Radial distance to PW [m]	
SRK05-SP-2	3.09×10^{-3}	4.83×10^{-4}	8.06×10^{-4}	0.03	

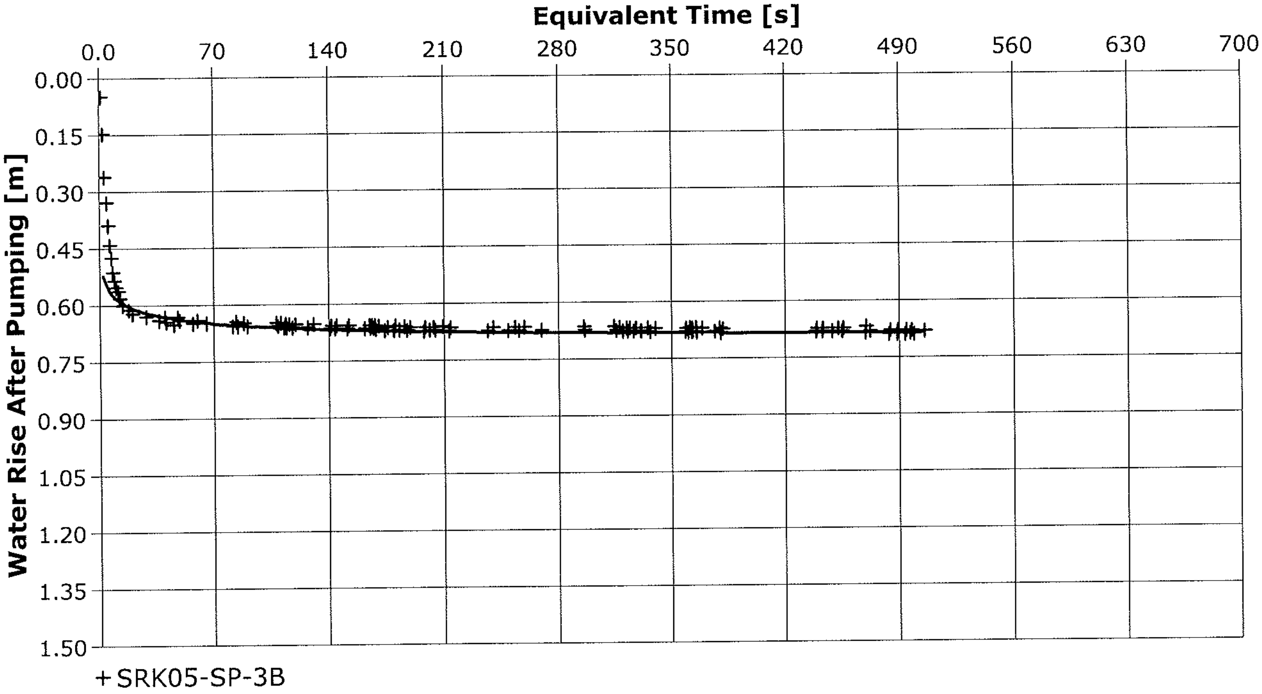
Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for SP3a	Pumping well: SRK05-SP-3A
Test conducted by: M.Prado		Test date: 10/27/2005
Analysis performed by: D.Mackie	Recovery - all time	Date: 10/27/2005
Aquifer Thickness: 13.70 m	Discharge: variable, average rate 0.088637 [l/s]	



Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Radial distance to PW [m]	
SRK05-SP-3A	1.24×10^{-4}	9.05×10^{-6}	6.68×10^{-2}	0.03	

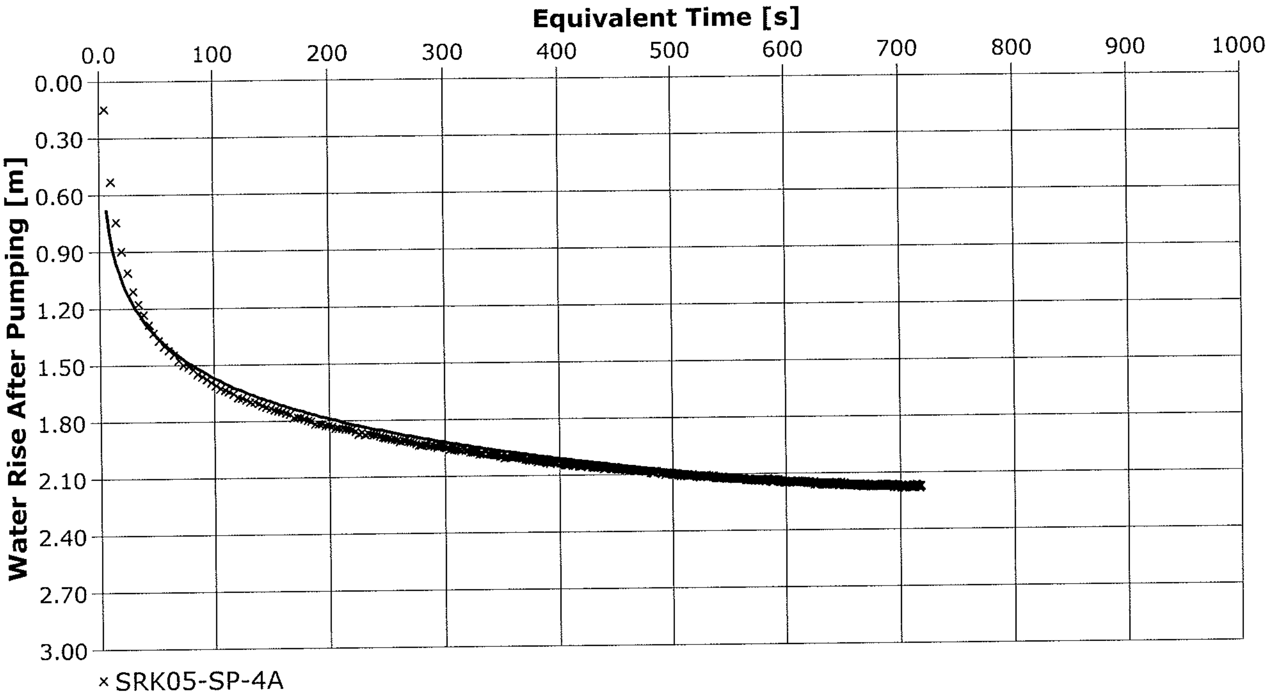
Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for SP3b	Pumping well: SRK05-SP-3B
Test conducted by: M.Prado		Test date: 10/27/2005
Analysis performed by: D.Mackie	Recovery - mid to late time	Date: 10/27/2005
Aquifer Thickness: 3.20 m	Discharge: variable, average rate 0.17235 [l/s]	



Calculation after AGARWAL + Hantush					
Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Hydr. resistance [s]	Radial distance to PW [m]
SRK05-SP-3B	5.13×10^{-4}	1.60×10^{-4}	5.03×10^{-6}	5.01×10^{7}	0.03

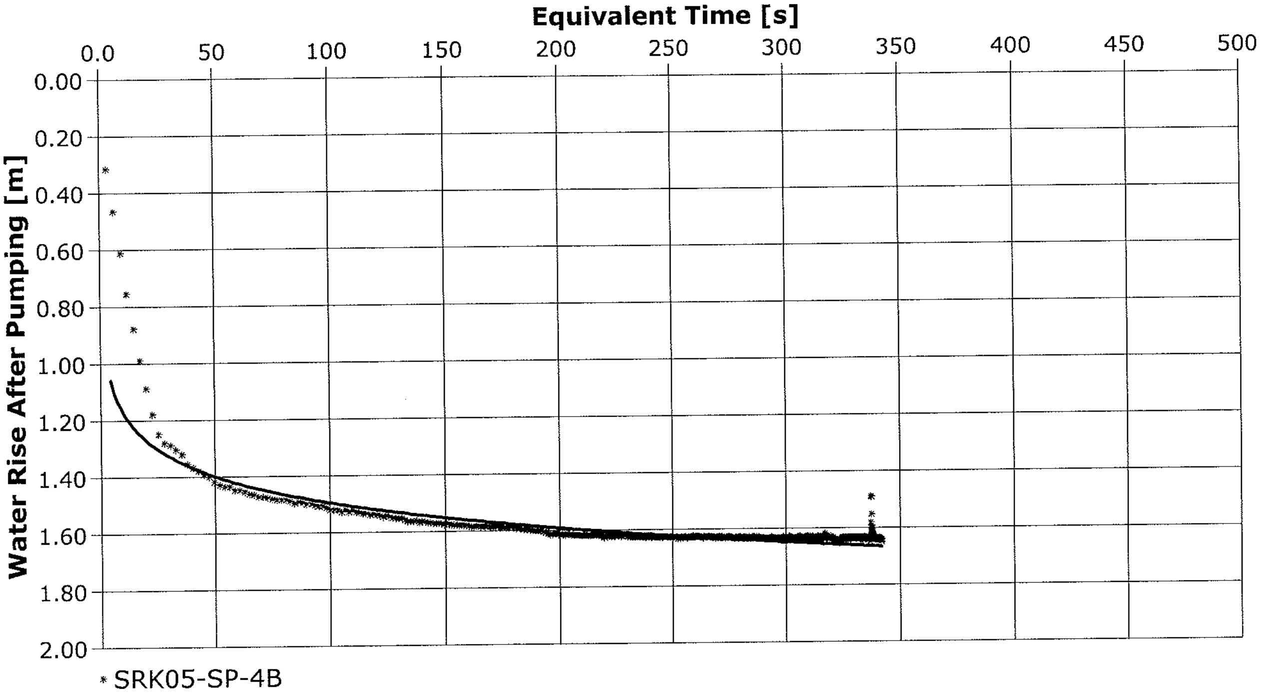
No good match for Theis recovery
Hantush allows better match assuming "leakage"

Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for SP4a	Pumping well: SRK05-SP-4A
Test conducted by: M.Prado		Test date: 10/27/2005
Analysis performed by: D.Mackie	Recovery - all time - Theis	Date: 10/27/2005
Aquifer Thickness: 6.10 m	Discharge: variable, average rate 0.029741 [l/s]	



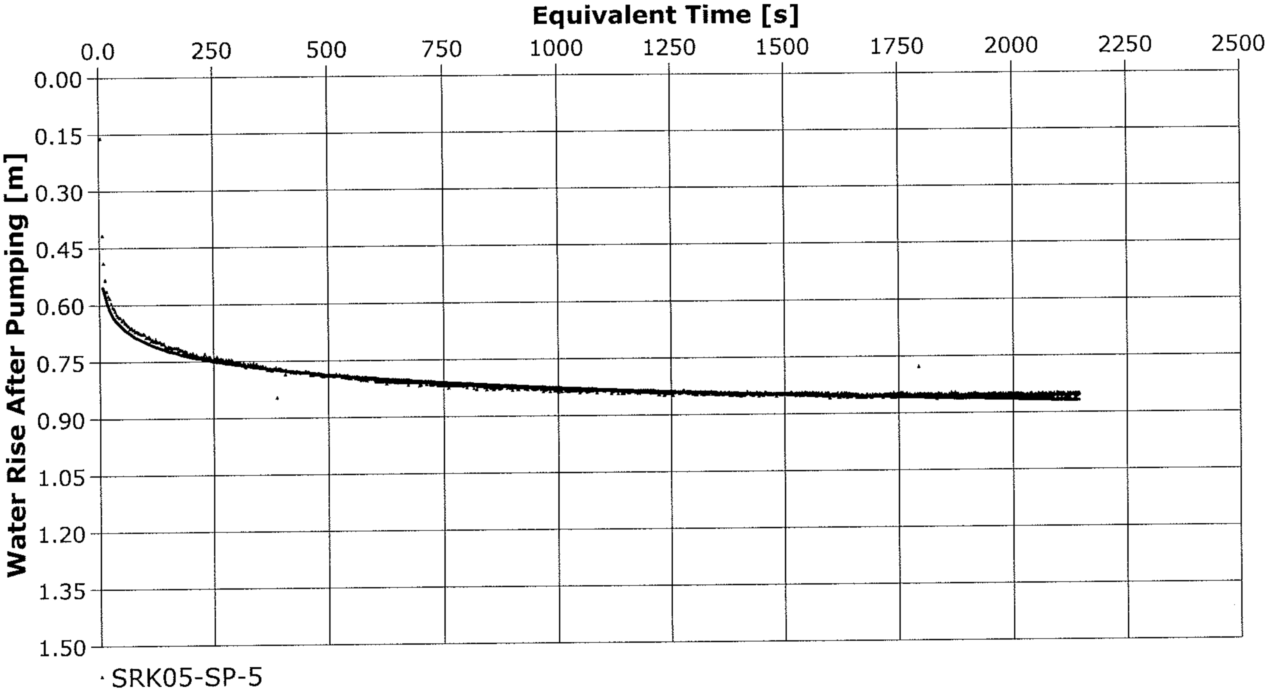
Calculation after AGARWAL + Theis					
Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Radial distance to PW [m]	
SRK05-SP-4A	4.50×10^{-5}	7.37×10^{-6}	1.11×10^{-1}	0.03	

Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for SP4b	Pumping well: SRK05-SP-4B
Test conducted by: M.Prado		Test date: 10/28/2005
Analysis performed by: D.Mackie	Recovery mid to late time	Date: 10/28/2005
Aquifer Thickness: 3.50 m	Discharge: variable, average rate 0.023745 [l/s]	



Calculation after AGARWAL + Theis					
Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Radial distance to PW [m]	
SRK05-SP-4B	1.15×10^{-4}	3.28×10^{-5}	8.06×10^{-4}	0.03	

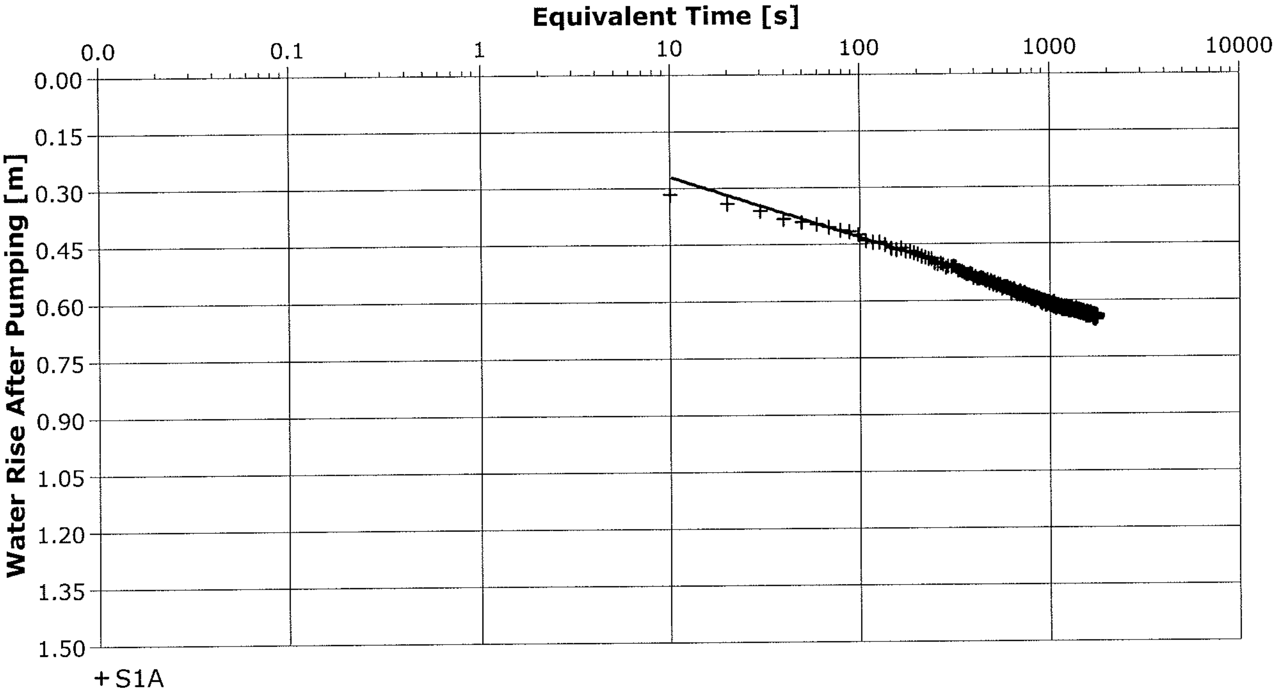
Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for SP5	Pumping well: SRK05-SP-5
Test conducted by: M.Prado		Test date: 10/26/2005
Analysis performed by: D.Mackie	Recovery - all time	Date: 10/26/2005
Aquifer Thickness: 4.30 m	Discharge: variable, average rate 0.14033 [l/s]	



Calculation after AGARWAL + Theis					
Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Radial distance to PW [m]	
SRK05-SP-5	4.75×10^{-4}	1.10×10^{-4}	5.20×10^{-4}	0.03	

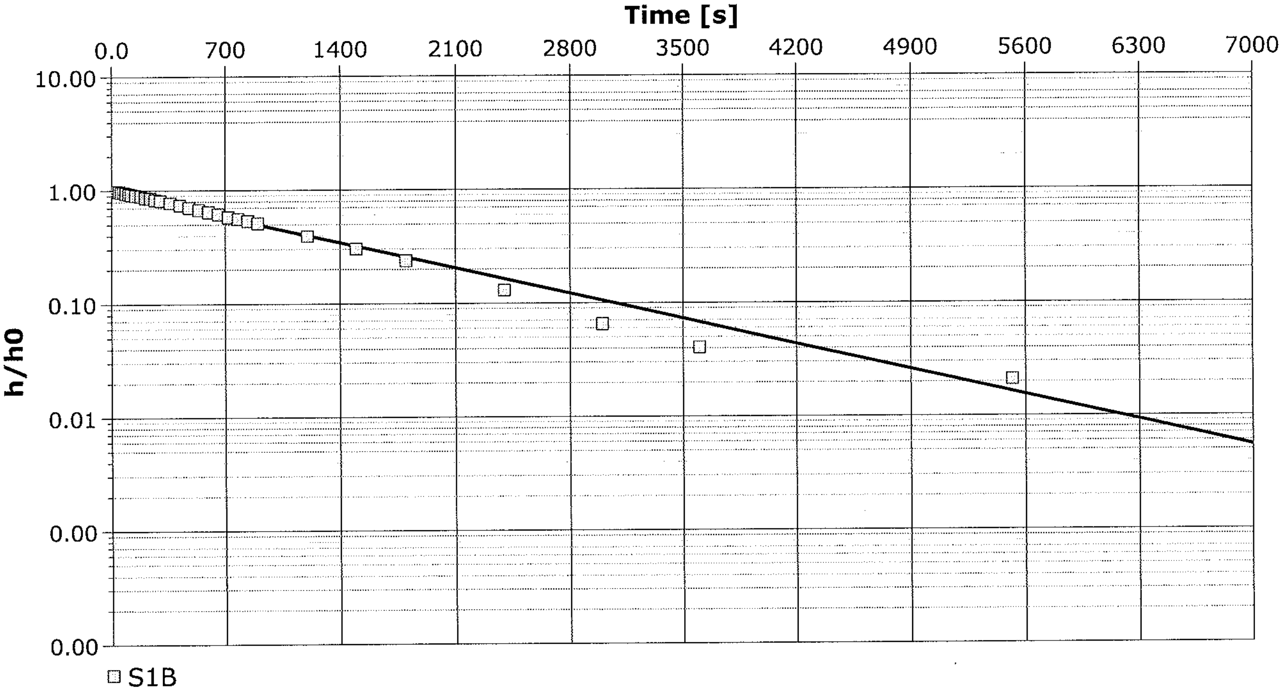
S-cluster Monitoring Wells – 2005

Location: NFRC - S-Cluster Area - Faro Mine	Pumping Test: Mini recovery for S1a	Pumping well: S1A
Test conducted by: M.Prado		Test date: 10/28/2005
Analysis performed by: D.Mackie	Recovery - Theis - all	Date: 10/28/2005
Aquifer Thickness: 12.20 m	Discharge: variable, average rate 0.36522 [l/s]	



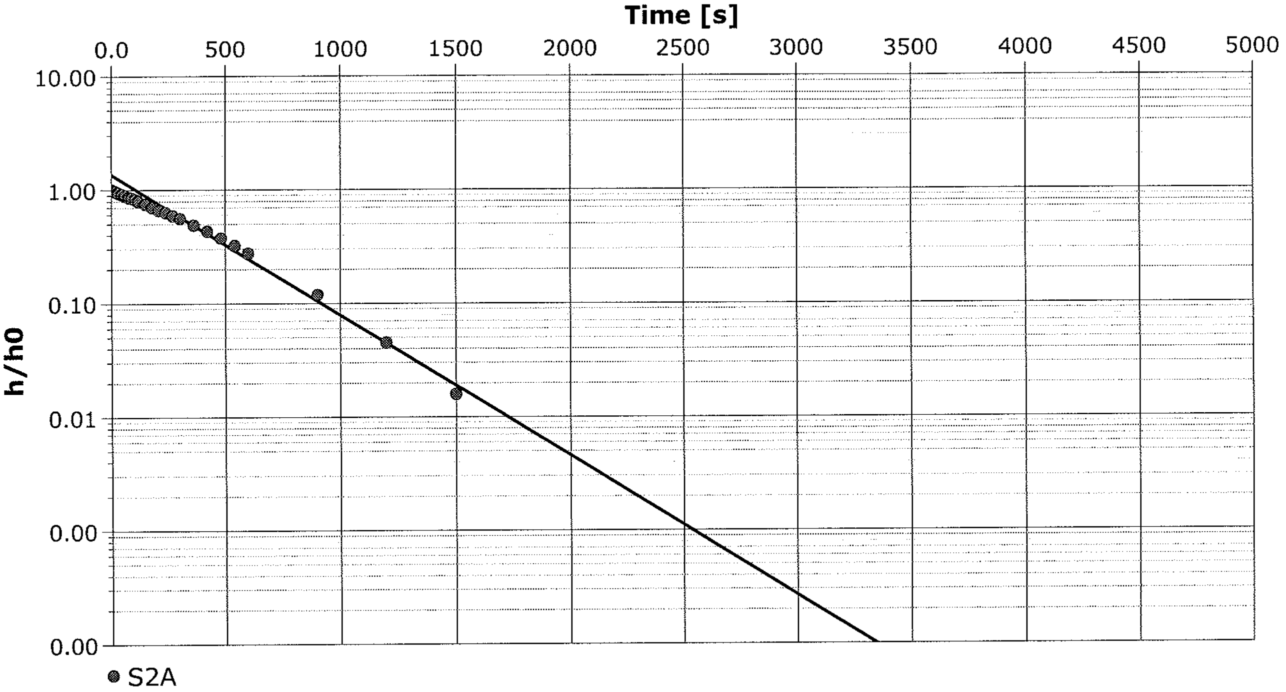
Calculation after AGARWAL + Theis					
Observation well	Transmissivity [m²/s]	K [m/s]	Storage coefficient	Radial distance to PW [m]	
S1A	6.80×10^{-4}	5.57×10^{-5}	5.00×10^{-1}	0.03	

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S1b slug	Test Well: S1B
Test conducted by: M.Prado		Test date: 10/28/2005
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/28/2005
Aquifer Thickness: 4.50 m		



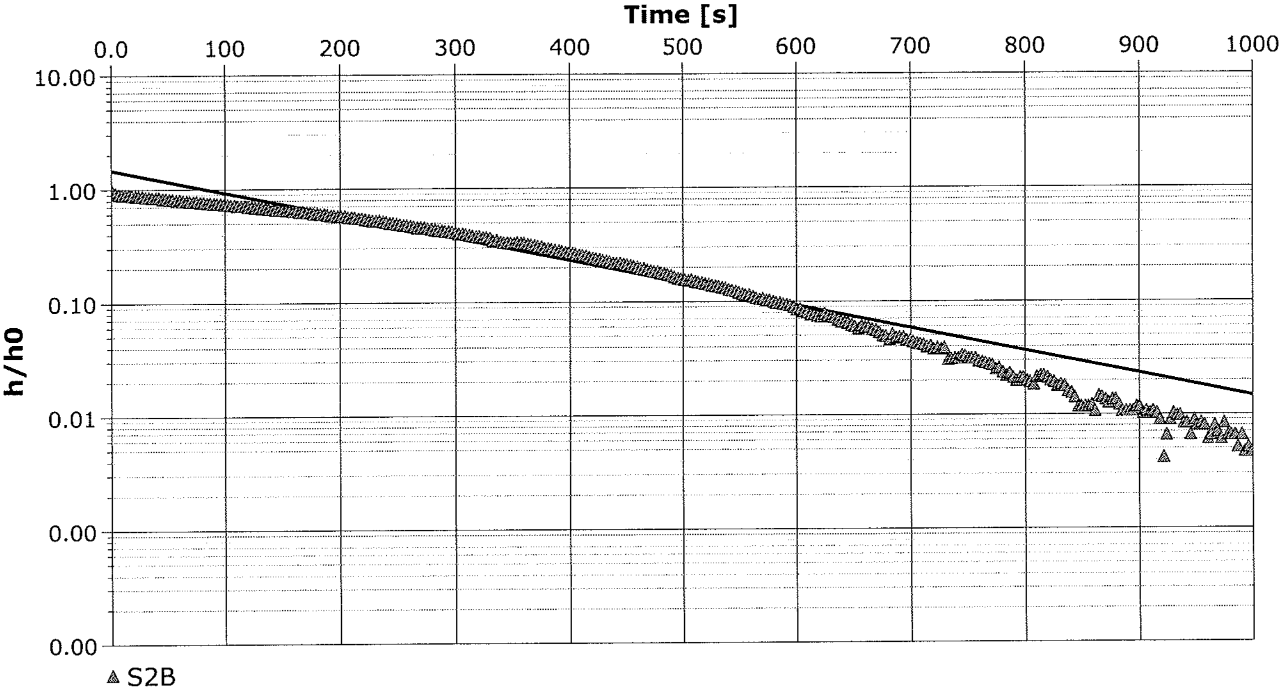
Calculation after Hvorslev		
Observation well	K [m/s]	
S1B	3.89×10^{-7}	

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S2a slug out	Test Well: S2A
Test conducted by: M.Prado		Test date: 10/28/2005
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/28/2005
Aquifer Thickness: 12.20 m		



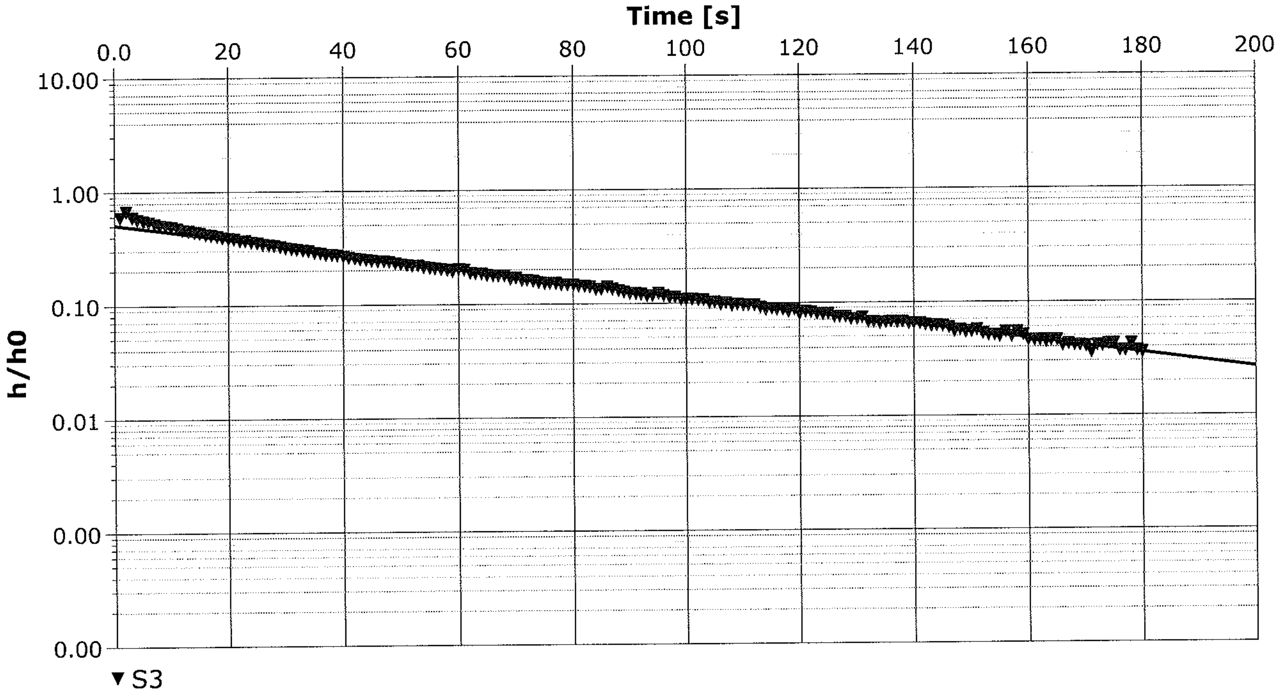
Calculation after Hvorslev		
Observation well	K [m/s]	
S2A	1.50 × 10^{-6}	

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S2b slug out	Test Well: S2B
Test conducted by: M.Prado		Test date: 10/28/2005
Analysis performed by: D.Mackie	Final match	Date: 10/28/2005
Aquifer Thickness: 7.00 m		



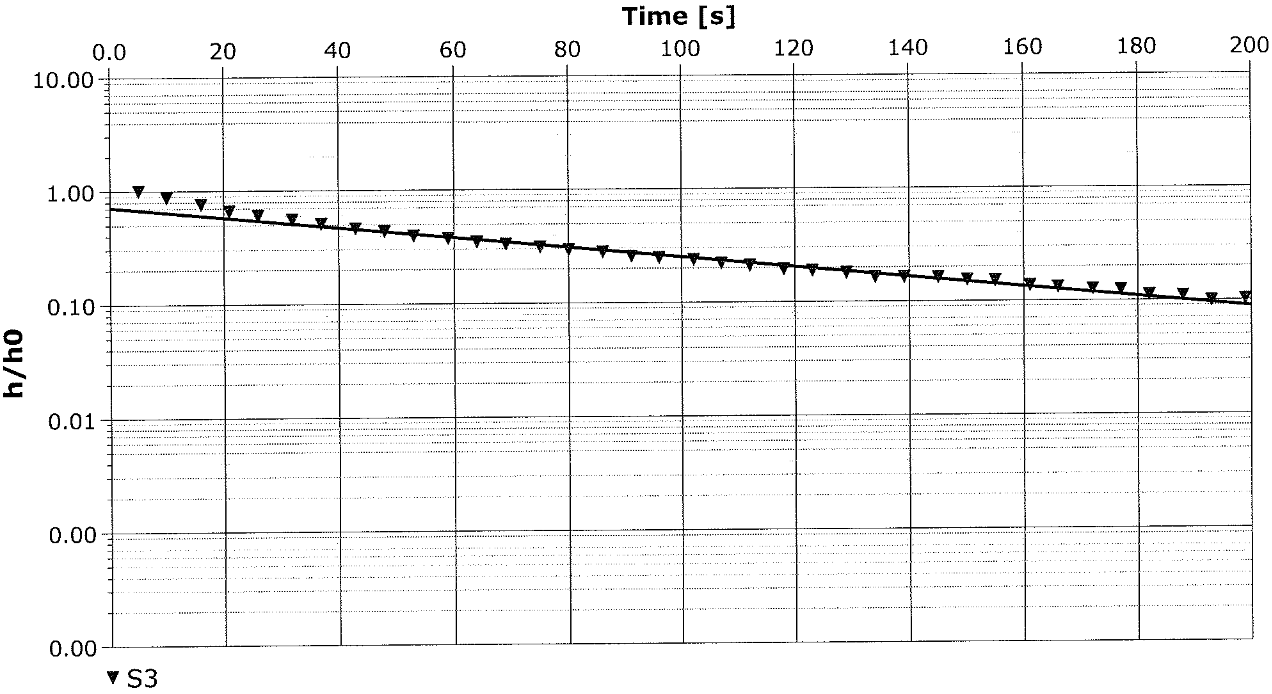
Calculation after Hvorslev		
Observation well	K [m/s]	
S2B	2.43×10^{-6}	

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S3 slug in	Test Well: S3
Test conducted by: M.Prado		Test date: 10/26/2005
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/26/2005
Aquifer Thickness: 5.60 m		



Calculation after Hvorslev		
Observation well	K [m/s]	
S3	7.76×10^{-6}	

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S3 slug out	Test Well: S3
Test conducted by: M.Prado		Test date: 10/27/2005
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/27/2005
Aquifer Thickness: 5.60 m		

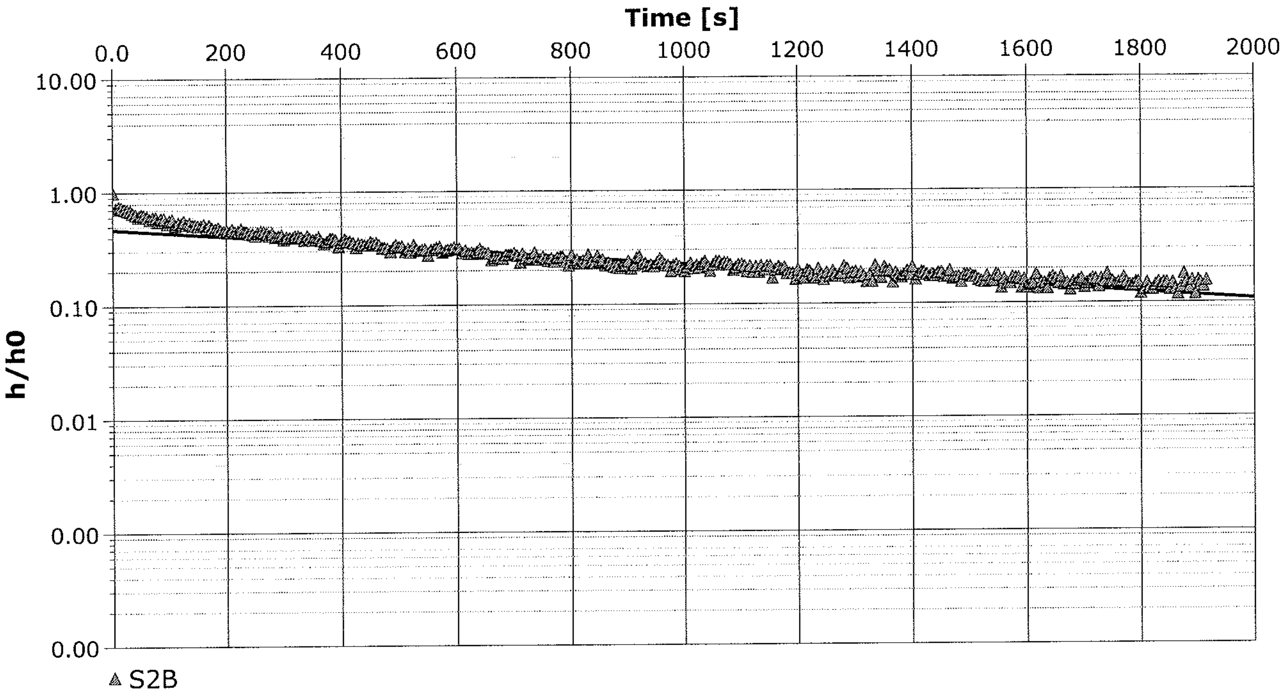


Calculation after Hvorslev

Observation well	K [m/s]	
S3	5.50×10^{-6}	

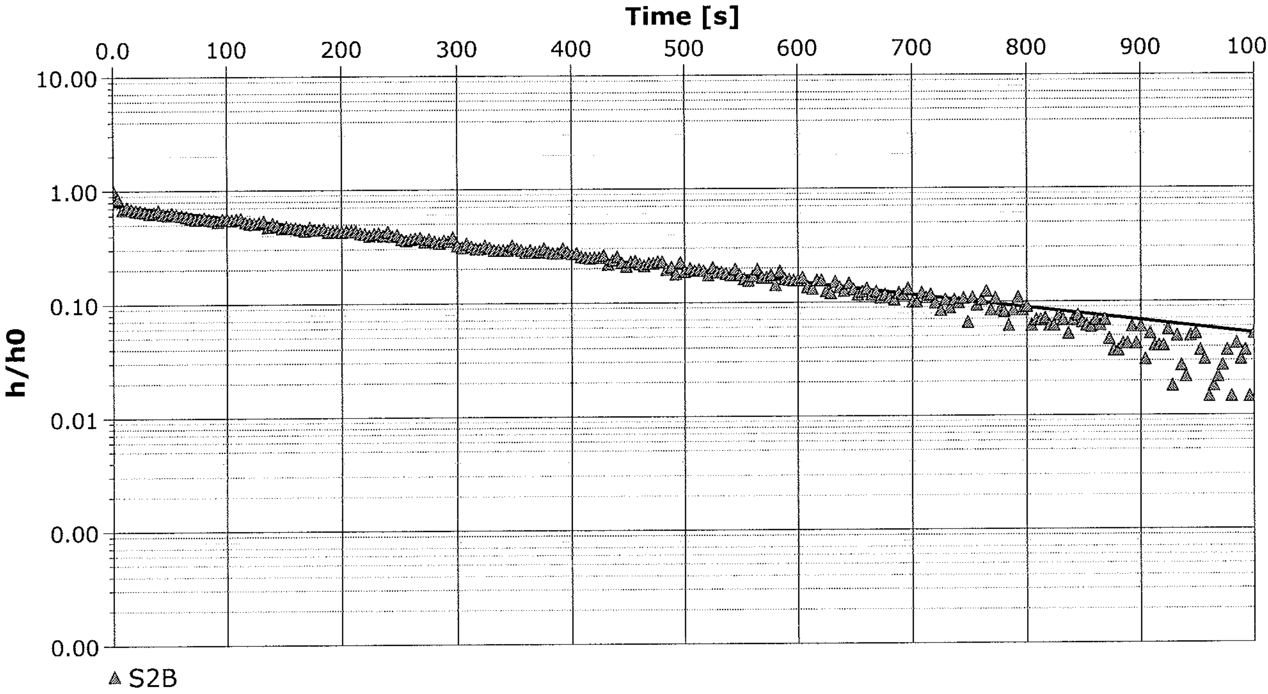
S-cluster Monitoring Wells – 2004

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S2b-2004 Data - Slug in	Test Well: S2B
Test conducted by: D.Mackie		Test date: 9/30/2004
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/31/2005
Aquifer Thickness: 7.00 m		



Calculation after Hvorslev		
Observation well	K [m/s]	
S2B	3.89×10^{-7}	

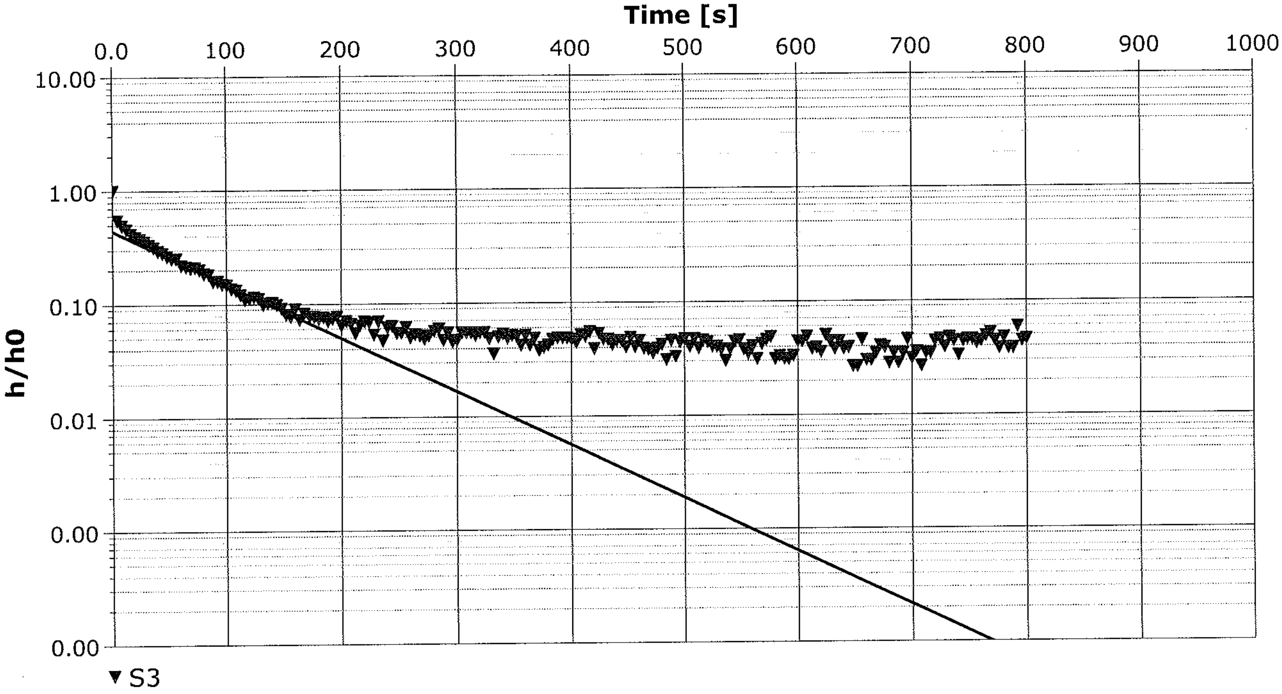
Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S2b-2004 Data - slug out	Test Well: S2B
Test conducted by: D.Mackie		Test date: 9/30/2004
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/31/2005
Aquifer Thickness: 7.00 m		



Calculation after Hvorslev		
Observation well	K [m/s]	
S2B	1.40×10^{-6}	

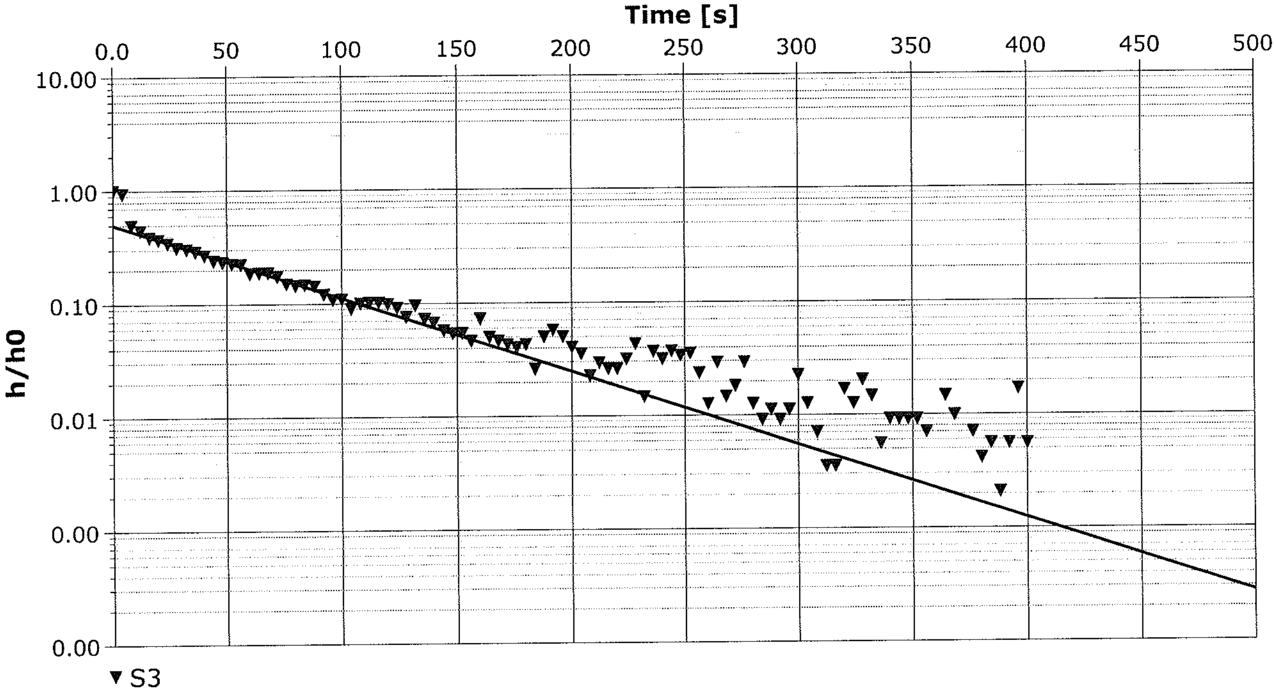
LATE TIME DATA (AFTER 1000s) NOT INCLUDED IN ANALYSIS. LEVELOGGER RESOLUTION COULD NOT MEET TEST REQUIREMENTS AFTER APPROXIMATELY 800s.

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S3-2004 Data - slug in	Test Well: S3
Test conducted by: D.Mackie		Test date: 9/30/2004
Analysis performed by: D.Mackie	Hvorlsev Final Match	Date: 10/31/2005
Aquifer Thickness: 5.70 m		



Calculation after Hvorslev		
Observation well	K [m/s]	
S3	5.75×10^{-6}	

Location: NFRC - S-Cluster Area - Faro Mine	Slug Test: S3-2004 Data - slug out	Test Well: S3
Test conducted by: D.Mackie		Test date: 9/30/2004
Analysis performed by: D.Mackie	Hvorslev - Final match	Date: 10/31/2005
Aquifer Thickness:		



Calculation after Hvorslev		
Observation well	K [m/s]	
S3	7.90×10^{-6}	

TIME AFTER APPROXIMATELY 150 s NOT INCLUDED IN ANALYSIS. LEVELOGGER RESOLUTION COULD NOT MEET TEST REQUIREMENTS AFTER THIS TIME

Appendix C

Laberge Stream Survey Memos

Laberge
ENVIRONMENTAL SERVICES

Memorandum

To: SRK September 12, 2005

Cc: Deloitte, Faro Project Office, RGC, BGC

From: Ken Nordin - LES

Re: Observations at NFRC near the S-Cluster wells

The following is a summary of data related to the flow investigation along the NFRC above and below the S-Cluster monitoring wells for RGC/SRK.

NFRC_20/21 North Fork Rose Creek Upstream NF Rock Drain at Zone II

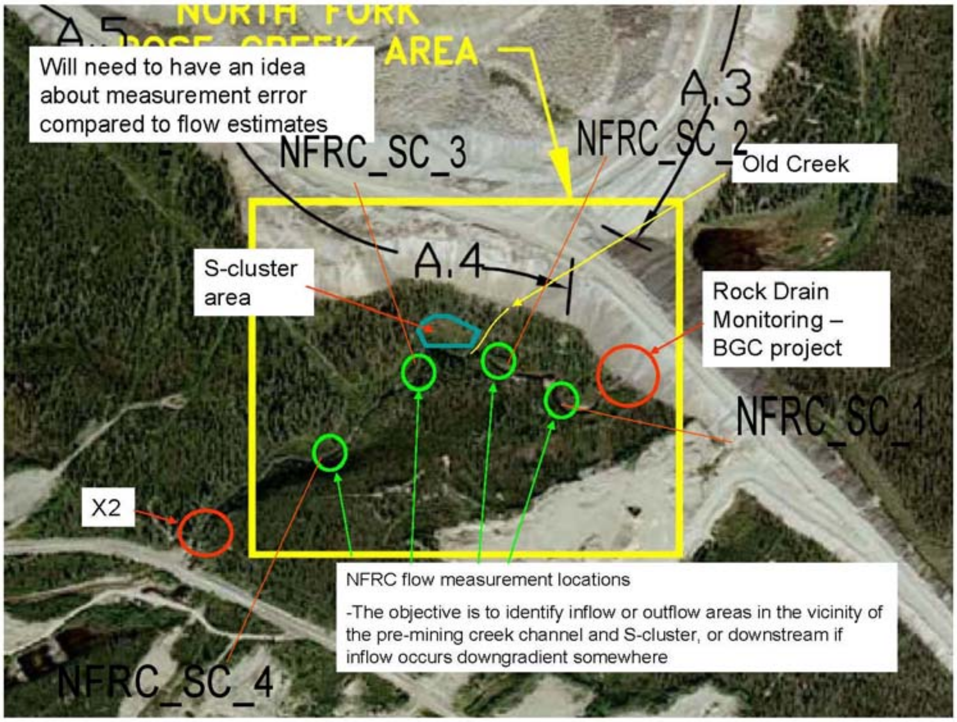
This station includes two staff gauges – NFRC_20 and NFRC_21, with a bench mark. Discharge measurements, taken to date are summarized below.

Date	Time (start Q)	Discharge (m^3/sec)	NFRC_20 (m)	Elevation NFRC_20(m)	NFRC_21 (m)	Elevation NFRC_21 m)
13-May-05		nm (>4.12)	>top		>top	
10-Jun-05		nm (>2.64)	>top		>top	
07-Jul-05	09:00	1.421	0.395	1094.462	0.433	1094.353
10-Aug-05	13:10	1.114	0.370	1094.437	0.425	1094.345
17-Aug-05	18:10	1.132	0.340		0.405	In question
02-Sept-05	14:00	1.069	0.325	1094.400	0.400	1094.330

Notes: Yukon Engineering Services elevation noted on BM as 1095.88m August 10, 2005
Gauge zero NFRC_20 = 1094.067
Gauge zero NFRC_21 = 1093.920

North Fork Rose Creek Downstream of NF Rock Drain

Four sites were selected for discharge measurements along the NFRC between the rock drain and road crossing by RGC and SRK to evaluate the flow regime above and below the "S-cluster" monitoring wells. The four sites, called NFRC_SC_ 1 to 4 were established on July 7, 2005. Temporary bench marks (flagged ½" lag screws in trees) were established at each site and elevation of the water surface relative to these assumed datums was noted during each discharge measurement.



NFRC_SC_1 North Fork Rose 1st downstream of NF Rock Drain upstream of S-Cluster

UTM NAD 27 08V 0584629mE 6913056mN

Date	Time (start Q)	Discharge (m^3/sec)	Elevation (m)	pH	Conductivity *u*S/cm	sample
07-Jul-05	11:25	1.627	97.471	7.87	150.4	no
10-Aug-05	13:50	1.656	97.461	nm	nm	yes

Two significant ponds along the left bank between the rock drain and NFRC_SC_1 were noted. The ponded seepage “SCS_2” was located at 0584554 6912988 with conductivity of 186.2. The second ponded seepage “SCS_3” was at 0584663 6912971 with conductivity of 537 *u*S/cm.

NFRC_SC_2 North Fork Rose 2nd downstream of NF Rock Drain upstream of S-Cluster

UTM NAD 27 08V 0584540mE 6913056mN

Date	Time (start Q)	Discharge (m^3/sec)	Elevation (m)	pH	Conductivity *u*S/cm	sample
07-Jul-05	11:25	1.447	98.503	7.77	150.1	no
10-Aug-05	14:30	1.346	98.486	nm	nm	yes

NFRC_SC_3 North Fork Rose 3rd downstream of NF Rock Drain downstream of S-Cluster

UTM NAD 27 08V 0584540mE 6913056mN

Date	Time (start Q)	Discharge (m^3/sec)	Elevation (m)	pH	Conductivity *u*S/cm	sample
07-Jul-05	12:15	1.553	98.659	7.72	154.1	no
10-Aug-05	15:10	1.496	98.680	nm	nm	yes

NFRC_SC_4 North Fork Rose 3rd downstream of NF Rock Drain downstream of S-Cluster

Date	Time (start Q)	Discharge (m^3/sec)	Elevation (m)	pH	Conductivity *u*S/cm	sample
07-Jul-05	13:10	1.540	98.366	7.73	156.7	no
10-Aug-05	15:10	1.510	98.349	nm	nm	yes

UTM NAD 27 08V 0584278mE 6912911mN

Note that there is a seep "SCS_1" at 0584207mE 6912928mN with conductivity of 3,420 *u*S/cm. On July 7 this seep was barely flowing and not connected by surface to NFRC.

NFRC_22/23 (X_2) North Fork Rose Creek Upstream Access Road

This station includes two staff gauges – NFRC_22 and NFRC_23, with a bench mark in a cottonwood tree on the right bank. Discharge measurements are summarized below.

Date	Time (start Q)	Discharge (m^3/sec)	NFRC_22 (m)	Elevation NFRC_22(m)	NFRC_23 (m)	Elevation NFRC_23 (m)
12-May-05	09:20	6.312				
10-Jun-05	12:38	1.930				
07-Jul-05	14:00	1.593				
10-Aug-05	17:00	1.538*				
17-Aug-05	19:15	1.270				
02-Sept-05	15:00	1.329				

Notes: Yukon Engineering Services elevation of 011508 is 1072.61m September 12, 2005.
Gauge zero NFRC_22 =
Gauge zero NFRC_23 = 1069.335

Laberge
ENVIRONMENTAL SERVICES

Memorandum

To: Dan Mackie SRK, Christoph Wels RGC December 30, 2005
Copies: Deloitte, GLL, Faro Project Office
From: Ken Nordin LES

Re: Monitoring of North Fork Rose Creek in the "S" Cluster Zone December 2005

This is a brief description of the results of the project ***Monitoring of North Fork of Rose Creek in the "S" Cluster Zone*** for December 2005.

SC_1 1st Station below NFRC Rock Drain

Time	10:06	
pH	7.20	
Conductivity	262 *u*S/cm	TDS 111 mg/L
Temp	-0.2 ^{0}C	

Discharge not measured. Sampled through 10 cm ice at x-section SC_1.

SC_2 2nd Station below NFRC Rock Drain

Time	10:40	
pH	7.22	
Conductivity	254 *u*S/cm	TDS 109 mg/L
Temp	-0.3 ^{0}C	

Robust flow, sampled by cutting 10 cm ice near open lead. Discharge by salt slug injection between two open leads. Note peizometer on RB between open leads, two trials.

SC_3 Station just downstream of S Cluster wells

Time	11:20
pH	7.20
Conductivity	262 *u*S/cm
Temp	0.2 ^{0}C

Sampled at turbulent open lead just downstream of an island and 10 m upstream of the flgged station. Measure discharge two trials salt slug injection. Ronnie took skidoo down creek, broke through, followed on foot and also fell through. Got wet, accessed SC_4 overland.

SC_4 Last station, about 100 m upstream of X_2.

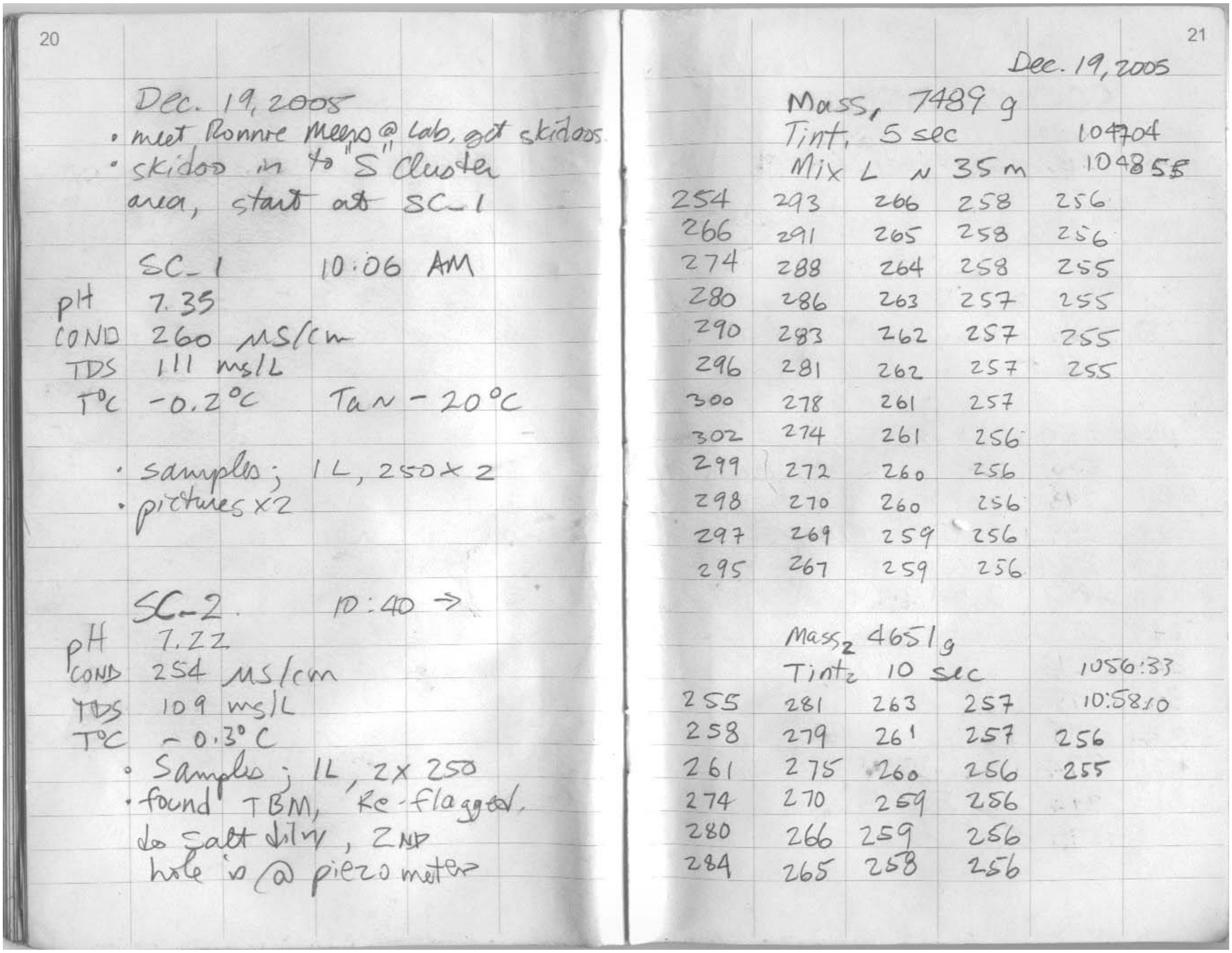
Time	12:10	
pH	7.17	
Conductivity	272 *u*S/cm	TDS 116 mg/L
Temp	0.2 ^{0}C	

Sampled directly below flagged station. Open leads for salt slug injection, do two trials.

Field notes and Chain of Custody form attached. Salt Slug injection workbook in Excel format sent separately.

Discharge summary: (Note that 1st trial may be more reliable due to more mass and shorter time interval)

SC_2	Trial 1 0.358	Trial 2 0.412
SC_3	Trial 1 0.500	Trial 2 0.510
SC_4	Trial 1 0.581	Trial 2 0.524



20

Dec. 19, 2005
- meet Ronnie Meers @ Lab, got skidoos
- skidoo in to "S" Cluster area, start at SC_1

SC_1 10:06 AM
pH 7.35
COND 260 µS/cm
TDS 111 mg/L
T°C -0.2°C Ta ~ -20°C

- samples; 1L, 250 x 2
- pictures x2

SC-2 10:40 →
pH 7.22
COND 254 µS/cm
TDS 109 mg/L
T°C - 0.3° C
- Samples; 1L, 2X 250
- found TBM, Re-flagged, do salt dilu, 2ND hole is @ piezometer

21

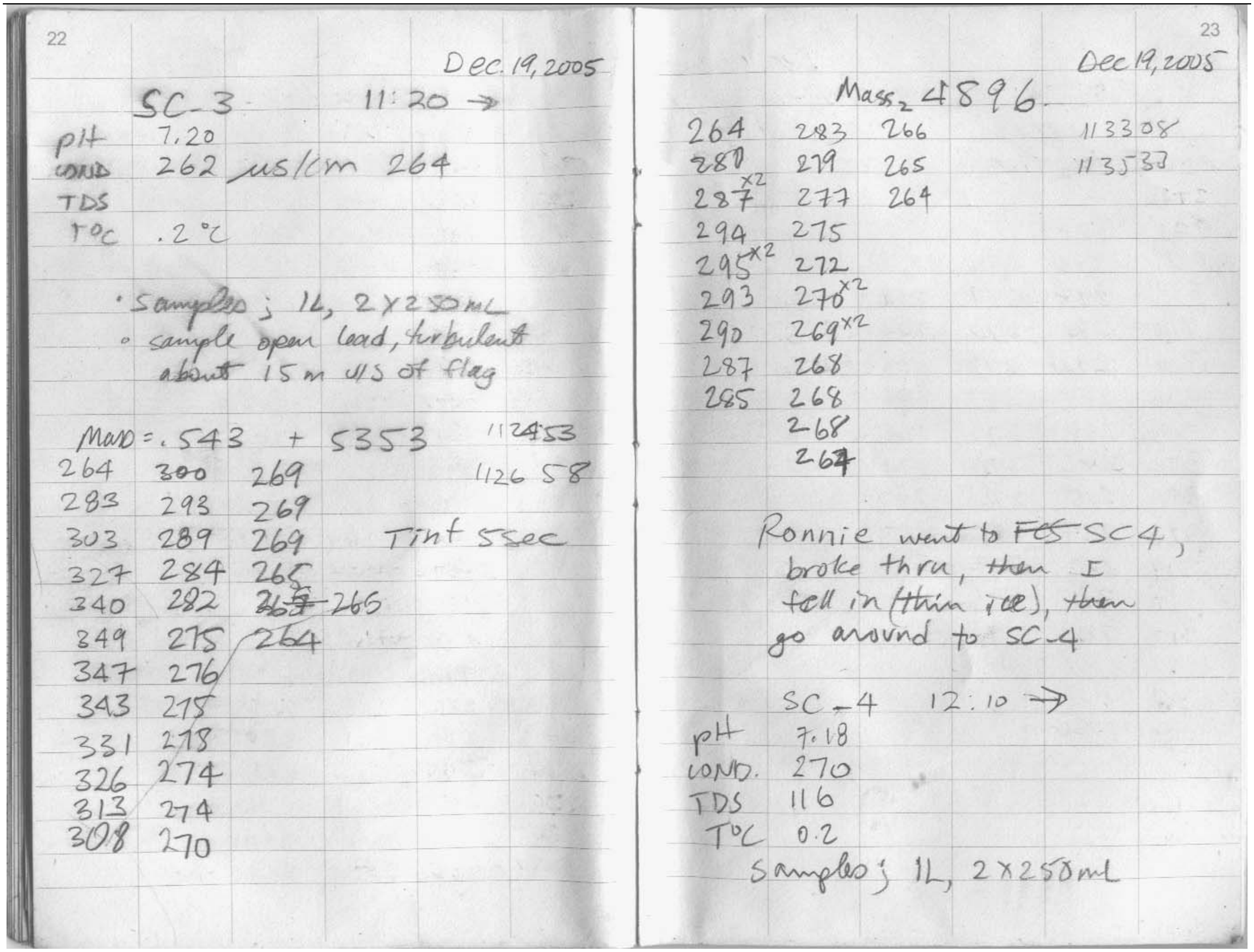
Dec. 19, 2005

Mass, 7489 g
Tint, 5 sec 104704
Mix L ~ 35 m 104855

254	293	266	258	256
266	291	265	258	256
274	288	264	258	255
280	286	263	257	255
290	283	262	257	255
296	281	262	257	255
300	278	261	257	
302	274	261	256	
299	272	260	256	
298	270	260	256	
297	269	259	256	
295	267	259	256	

$Mass_2$ 4651 g
$Tint_2$ 10 sec 1056:33

255	281	263	257	10:58:10
258	279	261	257	256
261	275	260	256	255
274	270	259	256	
280	266	259	256	
284	265	258	256	



Dec. 19, 2005

SC-3 11:20 →

pH 7.20
COND 262 us/cm 264
TDS
T°C .2 °C

- samples; 1L, 2×250mL
- sample open lead, turbulent about 15 m u/s of flag

Mass = .543 + 5353 112453

264	300	269	112658
283	293	269	
303	289	269	Tint 5sec
327	284	265	
340	282	~~265~~ 266	
349	275	264	
347	276		
343	275		
331	278		
326	274		
313	274		
308	270		

Dec 19, 2005

Mass₂ 4896.

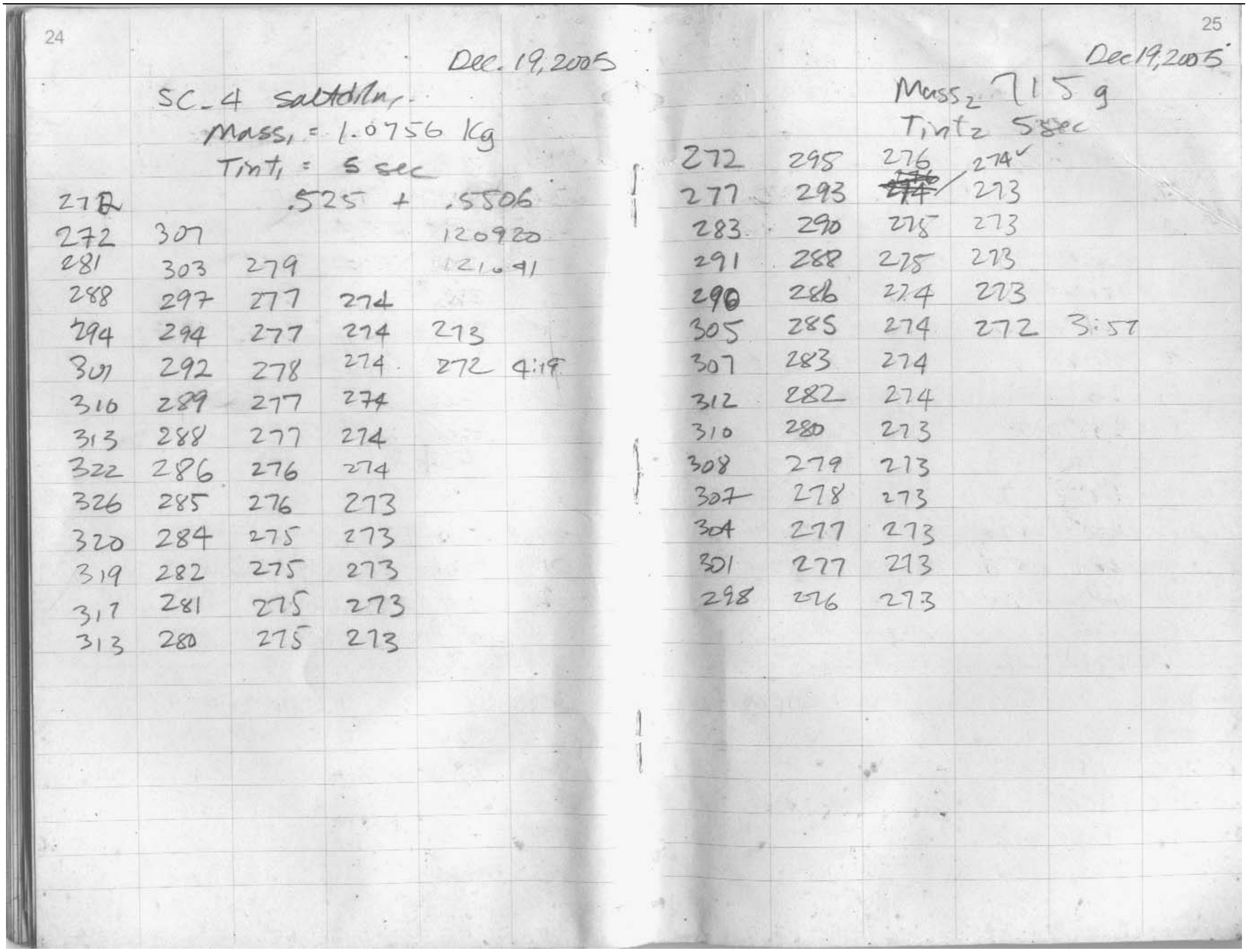
264	283	266	113308
280	279	265	113533
287 ×2	277	264	
294	275		
295 ×2	272		
293	270 ×2		
290	269 ×2		
287	268		
285	268		
	268		
	264		

Ronnie went to ~~FCS~~ SC4, broke thru, then I fell in (thin ice), then go around to SC-4

SC-4 12:10 →

pH 7.18
COND. 270
TDS 116
T°C 0.2

samples; 1L, 2×250mL



Dec. 19, 2005

SC-4 saltdilm.

$Mass_1$ = 1.0756 Kg

$Tint_1$ = 5 sec

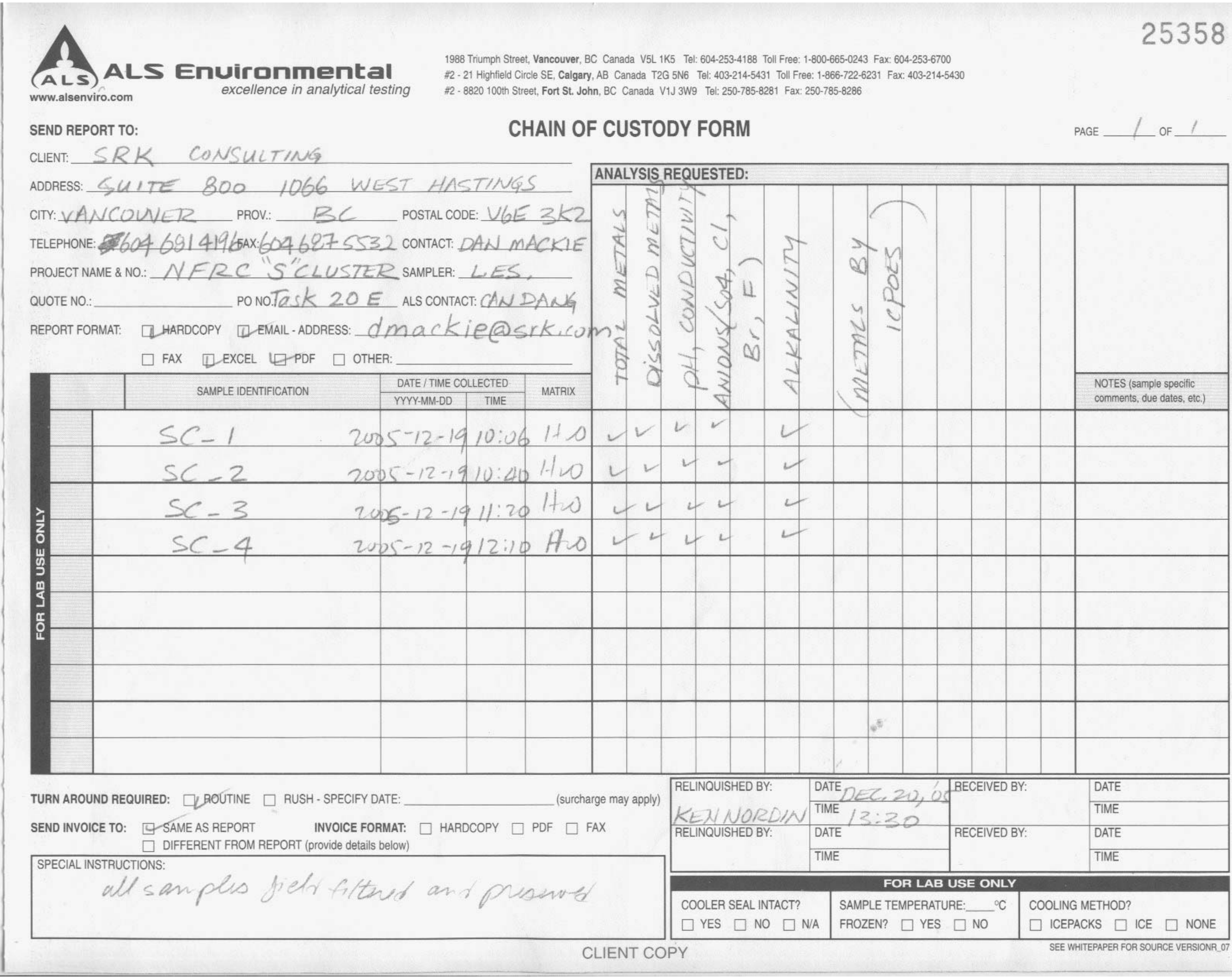
272					
		.525 +		.5506	
272	307			120920	
281	303	279		121.041	
288	297	277	274		
294	294	277	274	273	
307	292	278	274	272	4:19
310	289	277	274		
313	288	277	274		
322	286	276	274		
326	285	276	273		
320	284	275	273		
319	282	275	273		
317	281	275	273		
313	280	275	273		

Dec 19, 2005

$Mass_2$ 715 g

$Tint_2$ 5 sec

272	295	276	274✓	
277	293	~~274~~	273	
283	290	275	273	
291	288	275	273	
290	286	274	273	
305	285	274	272	3:57
307	283	274		
312	282	274		
310	280	273		
308	279	273		
307	278	273		
304	277	273		
301	277	273		
298	276	273		



25358

ALS Environmental
excellence in analytical testing
www.alsenviro.com

1988 Triumph Street, **Vancouver**, BC Canada V5L 1K5 Tel: 604-253-4188 Toll Free: 1-800-665-0243 Fax: 604-253-6700
#2 - 21 Highfield Circle SE, **Calgary**, AB Canada T2G 5N6 Tel: 403-214-5431 Toll Free: 1-866-722-6231 Fax: 403-214-5430
#2 - 8820 100th Street, **Fort St. John**, BC Canada V1J 3W9 Tel: 250-785-8281 Fax: 250-785-8286

CHAIN OF CUSTODY FORM

PAGE 1 OF 1

SEND REPORT TO:

CLIENT: SRK CONSULTING
ADDRESS: SUITE 800 1066 WEST HASTINGS
CITY: VANCOUVER PROV.: BC POSTAL CODE: V6E 3K2
TELEPHONE: 604 681 4196 FAX: 604 687 5532 CONTACT: DAN MACKIE
PROJECT NAME & NO.: NFRC "S" CLUSTER SAMPLER: LES.
QUOTE NO.: PO NO. Task 20 E ALS CONTACT: CAN DANG
REPORT FORMAT: ☑ HARDCOPY ☑ EMAIL - ADDRESS: dmackie@srk.com
☐ FAX ☑ EXCEL ☑ PDF ☐ OTHER:

ANALYSIS REQUESTED:

SAMPLE IDENTIFICATION	DATE / TIME COLLECTED YYYY-MM-DD	TIME	MATRIX	TOTAL METALS	DISSOLVED METALS	pH, CONDUCTIVITY	ANIONS (SO4, Cl, Br, F)	ALKALINITY	(METALS BY ICPOES)	NOTES (sample specific comments, due dates, etc.)
SC-1	2005-12-19	10:06	H2O	✓	✓	✓	✓	✓		
SC-2	2005-12-19	10:40	H2O	✓	✓	✓	✓	✓		
SC-3	2005-12-19	11:20	H2O	✓	✓	✓	✓	✓		
SC-4	2005-12-19	12:10	H2O	✓	✓	✓	✓	✓		

FOR LAB USE ONLY

TURN AROUND REQUIRED: ☑ ROUTINE ☐ RUSH - SPECIFY DATE: (surcharge may apply)

SEND INVOICE TO: ☑ SAME AS REPORT **INVOICE FORMAT:** ☐ HARDCOPY ☐ PDF ☐ FAX
☐ DIFFERENT FROM REPORT (provide details below)

SPECIAL INSTRUCTIONS:
all samples field filtered and preserved

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
KEN NORDIN	DATE DEC. 20, 05 TIME 13:30		DATE TIME
RELINQUISHED BY:	DATE TIME	RECEIVED BY:	DATE TIME

FOR LAB USE ONLY

COOLER SEAL INTACT? ☐ YES ☐ NO ☐ N/A
SAMPLE TEMPERATURE: ____°C
FROZEN? ☐ YES ☐ NO
COOLING METHOD? ☐ ICEPACKS ☐ ICE ☐ NONE

CLIENT COPY

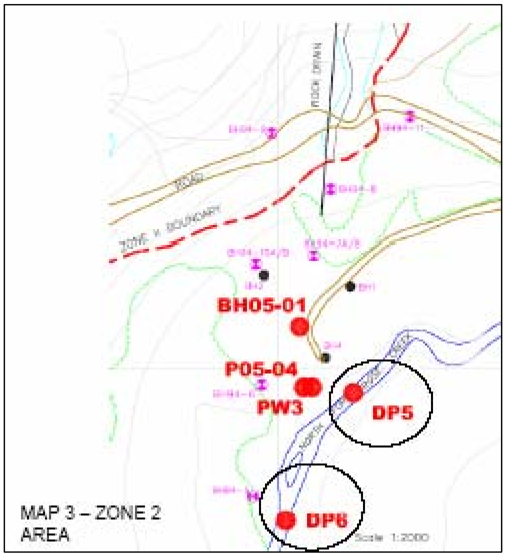
SEE WHITEPAPER FOR SOURCE VERSIONR_07

Laberge
ENVIRONMENTAL SERVICES

Memorandum

To: Christoph Wels RGC, Dan Mackie SRK February 2, 2006
Copies: Deloitte
From: Ken Nordin LES

Re: Drive points and well monitoring Zone II and S-Cluster area of NFRC

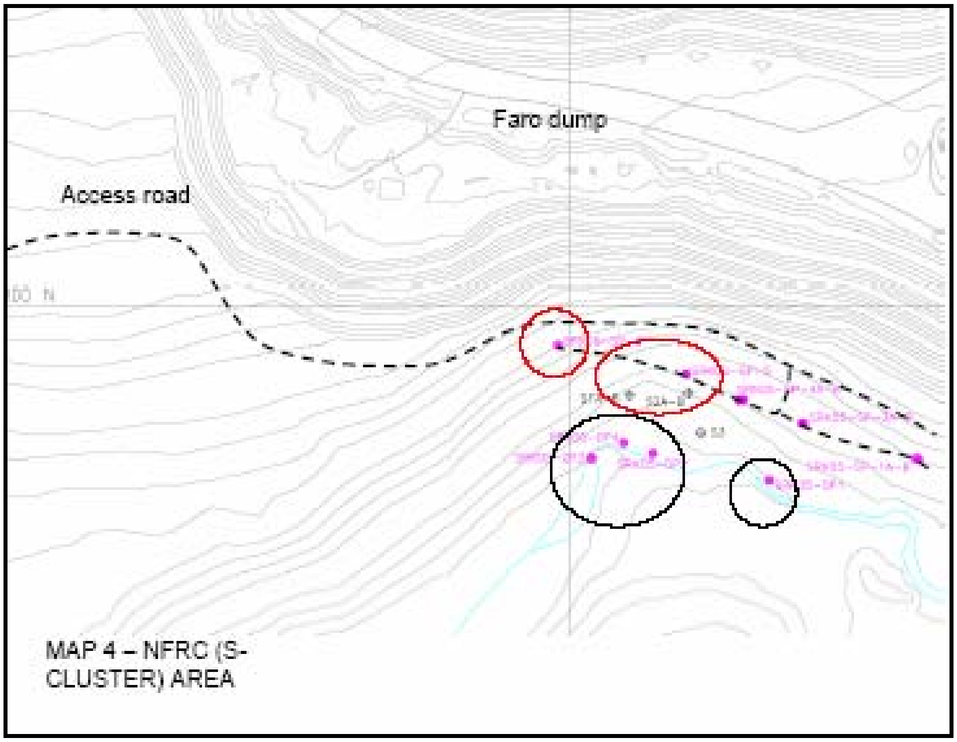


Drive points in the Zone II area were frozen solid. We chopped out and thawed DP-5 and found that it was frozen to the gravel substrate. 116.5 cm from top of steel to the level of ice in the Teflon tube. 153.5 cm from top of steel to frozen substrate.

.

DP-5

DP-6



The Drive points along the S-Cluster area were also frozen solid.

DP-1 54.o cm from top of steel to ice in tube
70.0 cm from top of steel to frozen substrate

DP1 looking upstream

DP-1 looking downstream

DP-3 only tube above ice, repaired **DP-4 – only a few cm of steel above ice**

SRK SP-5 6.40m from top of PVC to water. 20.4 cm from PVC to convex of steel casing.

SRK 05 SP-6 was damp at 11.86 m. There was red mud on the probe but not enough to set off the dipper.

S2-A 3.89 m to top of 2" gray plastic casing with black cap (measured to top of lower casing piece)

S2-B 5.049 m to top of 2" plastic extension – where waterra ends.

S1-A 4.510 m to top of 2" gray extension with black screw cap– waterra ends is in the lower piece

S1-B 4.209 to top of casing with screw cap.

S2 A&B

S1-A&B

Appendix D

Water Quality Analytical Results

Project	NFRC/ETA Water Analysis
Report to	Robertson GeoConsultants Inc.
ALS File No.	W2913
Date Received	8/12/2005
Date:	8/30/2005

RESULTS OF ANALYSIS

Sample ID	NFRC SC-1	NFRC SC-2	NFRC SC-3	NFRC SC-4
Date Sampled	8/10/2005	8/10/2005	8/10/2005	8/10/2005
Time Sampled				
ALS Sample ID	1	2	3	4
Nature	Water	Water	Water	Water
Physical Tests				
Conductivity (uS/cm)	180	180	184	186
pH	7.97	8.01	8.04	8.03
Dissolved Anions				
Bromide Br	<0.050	<0.050	<0.050	<0.050
Chloride Cl	<0.50	<0.50	<0.50	<0.50
Fluoride F	0.110	0.108	0.107	0.111
Sulphate SO4	10.8	10.8	12.7	13.5
Nutrients				
Nitrate Nitrogen N	0.0293	0.0288	0.0268	0.0278
Nitrite Nitrogen N	<0.0010	<0.0010	<0.0010	<0.0010
Total Metals				
Aluminum T-Al	0.0172	0.0187	0.0151	0.0183
Antimony T-Sb	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic T-As	0.00062	0.00061	0.00063	0.00063
Barium T-Ba	0.0449	0.0443	0.0462	0.0461
Beryllium T-Be	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth T-Bi	<0.00050	<0.00050	<0.00050	<0.00050
Boron T-B	<0.010	<0.010	<0.010	<0.010
Cadmium T-Cd	<0.000050	<0.000050	<0.000050	<0.000050
Calcium T-Ca	26.8	26.8	27.1	27.3
Chromium T-Cr	<0.0020	<0.0020	<0.0020	<0.0020
Cobalt T-Co	<0.00010	<0.00010	<0.00010	<0.00010
Copper T-Cu	0.00066	0.00077	0.00068	0.00067
Iron T-Fe	0.152	0.149	0.146	0.159
Lead T-Pb	0.000531	0.000699	0.000495	0.000559
Lithium T-Li	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium T-Mg	5.72	5.67	5.97	6.07
Manganese T-Mn	0.0241	0.0183	0.0225	0.0277
Molybdenum T-Mo	0.000531	0.000500	0.000499	0.000512
Nickel T-Ni	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus T-P	<0.30	<0.30	<0.30	<0.30
Potassium T-K	<2.0	<2.0	<2.0	<2.0
Selenium T-Se	<0.0010	<0.0010	<0.0010	<0.0010
Silicon T-Si	4.71	4.61	4.71	4.65

Sample ID		NFRC SC-1	NFRC SC-2	NFRC SC-3	NFRC SC-4
Silver	T-Ag	<0.000010	<0.000010	<0.000010	<0.000010
Sodium	T-Na	<2.0	<2.0	<2.0	<2.0
Strontium	T-Sr	0.104	0.103	0.107	0.108
Thallium	T-Tl	<0.00010	<0.00010	<0.00010	<0.00010
Tin	T-Sn	<0.00010	<0.00010	<0.00010	<0.00010
Titanium	T-Ti	<0.010	<0.010	<0.010	<0.010
Uranium	T-U	0.00101	0.000993	0.00102	0.00102
Vanadium	T-V	<0.0010	<0.0010	<0.0010	<0.0010
Zinc	T-Zn	0.0070	0.0074	0.0183	0.0185
Dissolved Metals					
Aluminum	D-Al	0.0072	0.0067	0.0068	0.0077
Antimony	D-Sb	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic	D-As	0.00053	0.00053	0.00052	0.00054
Barium	D-Ba	0.0444	0.0442	0.0442	0.0449
Beryllium	D-Be	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth	D-Bi	<0.00050	<0.00050	<0.00050	<0.00050
Boron	D-B	<0.010	<0.010	<0.010	<0.010
Cadmium	D-Cd	<0.000050	<0.000050	<0.000050	<0.000050
Calcium	D-Ca	26.2	26.3	26.4	26.3
Chromium	D-Cr	<0.0020	<0.0020	<0.0020	<0.0020
Cobalt	D-Co	<0.00010	<0.00010	<0.00010	<0.00010
Copper	D-Cu	0.00069	0.00058	0.00058	0.00061
Iron	D-Fe	0.070	0.064	0.065	0.073
Lead	D-Pb	0.000202	0.000163	0.000167	0.000275
Lithium	D-Li	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium	D-Mg	5.58	5.60	5.80	5.86
Manganese	D-Mn	0.0167	0.0112	0.0174	0.0218
Molybdenum	D-Mo	0.000522	0.000505	0.000514	0.000505
Nickel	D-Ni	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus	D-P	<0.30	<0.30	<0.30	<0.30
Potassium	D-K	<2.0	<2.0	<2.0	<2.0
Selenium	D-Se	<0.0010	<0.0010	<0.0010	<0.0010
Silicon	D-Si	4.55	4.61	4.58	4.51
Silver	D-Ag	<0.000010	<0.000010	<0.000010	<0.000010
Sodium	D-Na	<2.0	<2.0	<2.0	<2.0
Strontium	D-Sr	0.106	0.104	0.104	0.107
Thallium	D-Tl	<0.00010	<0.00010	<0.00010	<0.00010
Tin	D-Sn	<0.00010	<0.00010	<0.00010	<0.00010
Titanium	D-Ti	<0.010	<0.010	<0.010	<0.010
Uranium	D-U	0.00101	0.00101	0.000989	0.000995
Vanadium	D-V	<0.0010	<0.0010	<0.0010	<0.0010
Zinc	D-Zn	0.0063	0.0079	0.0158	0.0168

Footnotes:

Results are expressed as milligrams per litre except where noted.

< = Less than the detection limit indicated.

Project NFRC/ETA Water Analysis
Report to Robertson GeoConsultants Inc.
ALS File No. W2913
Date Received 8/12/2005
Date: 8/30/2005

DETECTION LIMITS

Sample ID		NFRC SC-1	NFRC SC-2	NFRC SC-3	NFRC SC-4
Date Sampled		8/10/2005	8/10/2005	8/10/2005	8/10/2005
Time Sampled					
ALS Sample ID		1	2	3	4
Nature		Water	Water	Water	Water
Physical Tests					
Conductivity	(uS/cm)	2.0	2.0	2.0	2.0
pH		0.010	0.010	0.010	0.010
Dissolved Anions					
Bromide	Br	0.050	0.050	0.050	0.050
Chloride	Cl	0.50	0.50	0.50	0.50
Fluoride	F	0.020	0.020	0.020	0.020
Sulphate	SO4	0.50	0.50	0.50	0.50
Nutrients					
Nitrate Nitrogen	N	0.0050	0.0050	0.0050	0.0050
Nitrite Nitrogen	N	0.0010	0.0010	0.0010	0.0010
Total Metals					
Aluminum	T-Al	0.0010	0.0010	0.0010	0.0010
Antimony	T-Sb	0.00010	0.00010	0.00010	0.00010
Arsenic	T-As	0.00010	0.00010	0.00010	0.00010
Barium	T-Ba	0.000050	0.000050	0.000050	0.000050
Beryllium	T-Be	0.00050	0.00050	0.00050	0.00050
Bismuth	T-Bi	0.00050	0.00050	0.00050	0.00050
Boron	T-B	0.010	0.010	0.010	0.010
Cadmium	T-Cd	0.000050	0.000050	0.000050	0.000050
Calcium	T-Ca	0.050	0.050	0.050	0.050
Chromium	T-Cr	0.0020	0.0020	0.0020	0.0020
Cobalt	T-Co	0.00010	0.00010	0.00010	0.00010
Copper	T-Cu	0.00010	0.00010	0.00010	0.00010
Iron	T-Fe	0.030	0.030	0.030	0.030
Lead	T-Pb	0.000050	0.000050	0.000050	0.000050
Lithium	T-Li	0.0050	0.0050	0.0050	0.0050
Magnesium	T-Mg	0.10	0.10	0.10	0.10
Manganese	T-Mn	0.000050	0.000050	0.000050	0.000050
Molybdenum	T-Mo	0.000050	0.000050	0.000050	0.000050
Nickel	T-Ni	0.00050	0.00050	0.00050	0.00050
Phosphorus	T-P	0.30	0.30	0.30	0.30
Potassium	T-K	2.0	2.0	2.0	2.0
Selenium	T-Se	0.0010	0.0010	0.0010	0.0010

Sample ID	NFRC SC-1	NFRC SC-2	NFRC SC-3	NFRC SC-4
Silicon T-Si	0.050	0.050	0.050	0.050
Silver T-Ag	0.000010	0.000010	0.000010	0.000010
Sodium T-Na	2.0	2.0	2.0	2.0
Strontium T-Sr	0.00010	0.00010	0.00010	0.00010
Thallium T-Tl	0.00010	0.00010	0.00010	0.00010
Tin T-Sn	0.00010	0.00010	0.00010	0.00010
Titanium T-Ti	0.010	0.010	0.010	0.010
Uranium T-U	0.000010	0.000010	0.000010	0.000010
Vanadium T-V	0.0010	0.0010	0.0010	0.0010
Zinc T-Zn	0.0010	0.0010	0.0010	0.0010
Dissolved Metals				
Aluminum D-Al	0.0010	0.0010	0.0010	0.0010
Antimony D-Sb	0.00010	0.00010	0.00010	0.00010
Arsenic D-As	0.00010	0.00010	0.00010	0.00010
Barium D-Ba	0.000050	0.000050	0.000050	0.000050
Beryllium D-Be	0.00050	0.00050	0.00050	0.00050
Bismuth D-Bi	0.00050	0.00050	0.00050	0.00050
Boron D-B	0.010	0.010	0.010	0.010
Cadmium D-Cd	0.000050	0.000050	0.000050	0.000050
Calcium D-Ca	0.050	0.050	0.050	0.050
Chromium D-Cr	0.0020	0.0020	0.0020	0.0020
Cobalt D-Co	0.00010	0.00010	0.00010	0.00010
Copper D-Cu	0.00010	0.00010	0.00010	0.00010
Iron D-Fe	0.030	0.030	0.030	0.030
Lead D-Pb	0.000050	0.000050	0.000050	0.000050
Lithium D-Li	0.0050	0.0050	0.0050	0.0050
Magnesium D-Mg	0.10	0.10	0.10	0.10
Manganese D-Mn	0.000050	0.000050	0.000050	0.000050
Molybdenum D-Mo	0.000050	0.000050	0.000050	0.000050
Nickel D-Ni	0.00050	0.00050	0.00050	0.00050
Phosphorus D-P	0.30	0.30	0.30	0.30
Potassium D-K	2.0	2.0	2.0	2.0
Selenium D-Se	0.0010	0.0010	0.0010	0.0010
Silicon D-Si	0.050	0.050	0.050	0.050
Silver D-Ag	0.000010	0.000010	0.000010	0.000010
Sodium D-Na	2.0	2.0	2.0	2.0
Strontium D-Sr	0.00010	0.00010	0.00010	0.00010
Thallium D-Tl	0.00010	0.00010	0.00010	0.00010
Tin D-Sn	0.00010	0.00010	0.00010	0.00010
Titanium D-Ti	0.010	0.010	0.010	0.010
Uranium D-U	0.000010	0.000010	0.000010	0.000010
Vanadium D-V	0.0010	0.0010	0.0010	0.0010
Zinc D-Zn	0.0010	0.0010	0.0010	0.0010

CERTIFICATE OF ANALYSIS

Date: January 3, 2006

ALS File No. W9115

Report On: NFRC "S" Cluster Water Analysis

Report To: **SRK Consulting (Canada) Inc.**
Suite 800
1066 West Hastings St.
Vancouver, BC
V6E 3X2

Attention: **Mr. Dan Mackie**

Received: December 21, 2005

ALS ENVIRONMENTAL
per:

Andre Langlais, M.Sc. - Project Chemist
Can Dang, B.Sc. - Project Chemist

REMARKS

For sample SC-3, we checked and confirmed that for some of the metals the Dissolved are greater than the Total.

For some of the submitted water samples, the measured concentration of specific dissolved parameters is greater than the corresponding total parameters concentration. The explanation for these findings is one or a combination of the following:

- laboratory method variability;
- field sampling method variability;
- bias introduced during general handling, storage, transportation and/or analysis of the sample;
- field sample grab bias - where separate grab samples are processed to produce total and dissolved samples;
- field sample split bias - where total and dissolved parameters samples are produced from the same grab sample.

For further clarification on any of the above information, please contact your ALS representative.

File No. W9115

RESULTS OF ANALYSIS - Water

Sample ID			SC-1	SC-2	SC-3	SC-4
Sample Date			05-12-19	05-12-19	05-12-19	05-12-19
Sample Time			10:06	10:40	11:20	12:10
ALS ID			*1*	*2*	*3*	*4*
Physical Tests						
Conductivity	(uS/cm)		260	259	263	271
pH			8.02	7.90	7.05	7.37
Dissolved Anions						
Alkalinity-Total		CaCO3	123	125	129	125
Bromide	Br		<0.050	<0.050	<0.050	<0.050
Chloride	Cl		<0.50	<0.50	<0.50	<0.50
Fluoride	F		0.139	0.140	0.139	0.139
Sulphate	SO4		18.0	18.3	21.8	25.4
Nutrients						
Nitrate Nitrogen		N	0.239	0.240	0.240	0.240
Nitrite Nitrogen		N	<0.0010	0.0010	<0.0010	<0.0010

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. W9115

RESULTS OF ANALYSIS - Water

Sample ID		SC-1	SC-2	SC-3	SC-4
Sample Date		05-12-19	05-12-19	05-12-19	05-12-19
Sample Time		10:06	10:40	11:20	12:10
ALS ID		*1*	*2*	*3*	*4*
Total Metals					
Aluminum	T-Al	<0.20	<0.20	<0.20	<0.20
Antimony	T-Sb	<0.20	<0.20	<0.20	<0.20
Arsenic	T-As	<0.20	<0.20	<0.20	<0.20
Barium	T-Ba	0.072	0.072	0.072	0.072
Beryllium	T-Be	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth	T-Bi	<0.20	<0.20	<0.20	<0.20
Boron	T-B	<0.10	<0.10	<0.10	<0.10
Cadmium	T-Cd	<0.010	<0.010	<0.010	<0.010
Calcium	T-Ca	41.7	41.6	42.2	43.3
Chromium	T-Cr	<0.010	<0.010	<0.010	<0.010
Cobalt	T-Co	<0.010	<0.010	<0.010	<0.010
Copper	T-Cu	<0.010	<0.010	<0.010	<0.010
Iron	T-Fe	0.129	0.159	0.151	0.182
Lead	T-Pb	<0.050	<0.050	<0.050	<0.050
Lithium	T-Li	<0.010	<0.010	<0.010	<0.010
Magnesium	T-Mg	9.30	9.30	9.95	10.6
Manganese	T-Mn	0.0350	0.0381	0.0558	0.0830
Molybdenum	T-Mo	<0.030	<0.030	<0.030	<0.030
Nickel	T-Ni	<0.050	<0.050	<0.050	<0.050
Phosphorus	T-P	<0.30	<0.30	<0.30	<0.30
Potassium	T-K	<2.0	<2.0	<2.0	<2.0
Selenium	T-Se	<0.20	<0.20	<0.20	<0.20
Silicon	T-Si	5.73	5.76	5.76	5.83
Silver	T-Ag	<0.010	<0.010	<0.010	<0.010
Sodium	T-Na	3.2	3.2	3.5	3.3
Strontium	T-Sr	0.172	0.172	0.174	0.178
Thallium	T-Tl	<0.20	<0.20	<0.20	<0.20
Tin	T-Sn	<0.030	<0.030	<0.030	<0.030
Titanium	T-Ti	<0.010	<0.010	<0.010	<0.010
Vanadium	T-V	<0.030	<0.030	<0.030	<0.030
Zinc	T-Zn	0.0100	0.0114	0.0535	0.0595

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. W9115

RESULTS OF ANALYSIS - Water

Sample ID		SC-1	SC-2	SC-3	SC-4
Sample Date		05-12-19	05-12-19	05-12-19	05-12-19
Sample Time		10:06	10:40	11:20	12:10
ALS ID		*1*	*2*	*3*	*4*
Dissolved Metals					
Aluminum	D-Al	<0.20	<0.20	<0.20	<0.20
Antimony	D-Sb	<0.20	<0.20	<0.20	<0.20
Arsenic	D-As	<0.20	<0.20	<0.20	<0.20
Barium	D-Ba	0.074	0.070	0.077	0.075
Beryllium	D-Be	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth	D-Bi	<0.20	<0.20	<0.20	<0.20
Boron	D-B	<0.10	<0.10	<0.10	<0.10
Cadmium	D-Cd	<0.010	<0.010	<0.010	<0.010
Calcium	D-Ca	42.9	40.6	45.3	44.4
Chromium	D-Cr	<0.010	<0.010	<0.010	<0.010
Cobalt	D-Co	<0.010	<0.010	<0.010	<0.010
Copper	D-Cu	<0.010	<0.010	<0.010	<0.010
Iron	D-Fe	<0.030	0.041	0.040	0.057
Lead	D-Pb	<0.050	<0.050	<0.050	<0.050
Lithium	D-Li	<0.010	<0.010	<0.010	<0.010
Magnesium	D-Mg	9.58	9.07	10.7	11.0
Manganese	D-Mn	0.0324	0.0334	0.0563	0.0800
Molybdenum	D-Mo	<0.030	<0.030	<0.030	<0.030
Nickel	D-Ni	<0.050	<0.050	<0.050	<0.050
Phosphorus	D-P	<0.30	<0.30	<0.30	<0.30
Potassium	D-K	<2.0	<2.0	<2.0	<2.0
Selenium	D-Se	<0.20	<0.20	<0.20	<0.20
Silicon	D-Si	5.98	5.63	6.15	5.99
Silver	D-Ag	<0.010	<0.010	<0.010	<0.010
Sodium	D-Na	3.3	3.1	3.8	3.5
Strontium	D-Sr	0.177	0.168	0.188	0.183
Thallium	D-Tl	<0.20	<0.20	<0.20	<0.20
Tin	D-Sn	<0.030	<0.030	<0.030	<0.030
Titanium	D-Ti	<0.010	<0.010	<0.010	<0.010
Vanadium	D-V	<0.030	<0.030	<0.030	<0.030
Zinc	D-Zn	0.0111	0.0122	0.0566	0.0610

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

Appendix 1 - METHODOLOGY

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Conductivity in Water

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

pH in Water

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

Recommended Holding Time:
Sample: 2 hours
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Alkalinity in Water by Colourimetry

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

Recommended Holding Time:
Sample: 14 days
Reference: APHA

Laboratory Location: ALS Environmental, Vancouver

Dissolved Anions in Water by Ion Chromatography

This analysis is carried out using procedures adapted from APHA Method 4110 "Determination of Anions by Ion Chromatography" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions are determined by filtering the sample through a 0.45 micron membrane filter and injecting the filtrate onto a Dionex IonPac AG17 anion exchange column with a hydroxide eluent stream. Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

Recommended Holding Time:
Sample: 28 days (bromide, chloride, fluoride, sulphate)

Appendix 1 - METHODOLOGY - Continued

Sample: 2 days (nitrate, nitrite)
Reference: APHA and EPA

Laboratory Location: ALS Environmental, Vancouver

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:
Sample: 6 months
Reference: EPA

Laboratory Location: ALS Environmental, Vancouver

Results contained within this certificate relate only to the samples as submitted.

This Certificate Of Analysis shall only be reproduced in full, except with the written approval of ALS Environmental.

End of Report