Deloitte & Touche

Anvil Range Mining Complex Bedrock Data and Groundwater Review for the Lower Rose Creek Valley

2007/08 Task 21 – Final

Prepared for:

Deloitte & Touche Inc.

On behalf of

Faro Mine Closure Planning Office

Prepared by:

SRK Consulting
Engineers and Scientists

Project Reference Number
SRK 1CD003.107

May 2008

Anvil Range Mining Complex
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On behalf of

Faro Mine Closure Planning Office

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SRK Project Number 1CD003.107

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Executive Summary

<u>Title:</u> Anvil Range Mining Complex: Bedrock Data and Groundwater Review for the Lower Rose Creek Valley, 2007/08 Task 21

<u>Consultant:</u> SRK Consulting (Canada) Inc.

<u>Status:</u> Final

<u>Date:</u> May 2008

<u>Size:</u> 10 Pages of text (including cover, introductory and reference list); 4 Appendices containing 59 pages (including 5 non-standard 11 x 17 pages and 5 flysheets).

<u>Digital File:</u> PDF format; 1.4 MB

<u>Objectives and Primary Findings:</u>

This report presents results of a desktop study of bedrock hydrogeology data for the Lower Rose Creek Valley area in the vicinity of the Cross Vally Dam. Existing bedrock data was compiled and specific assessments completed of bedrock quality, hydrogeologic parameters and water quality. Three conclusions were made:

- Available data on bedrock hydraulic characteristics and the presence of potentially transmissive structures is very limited to absent.
- Groundwater quality of the alluvial aquifer is deteriorating.
- Very little bedrock water quality data is available.

<u>Future Work Recommendations:</u>

It is recommended that further assessment of seepage collection in the area include the assessment of existing contamination in bedrock and the possibility of bedrock bypass of any seepage interception system designed for this area. Further, recommendations of the original task proposal should be completed, including: baseline monitoring and bedrock characterization downstream of the Cross Valley Dam and numerical model sensitivity analyses to assess effectiveness of any proposed interception system.

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1 Introduction and Scope of Report

This report presents results of the 2007/08 review of groundwater quality and bedrock flow potential for areas below the Cross Valley Dam at the Anvil Range Mining Complex in the Yukon Territory. This work was completed as part of future work planning, in support of investigations for a potential seepage collection system in this area. Development of the final scope of work was the result of multiple discussions between SRK Consulting (SRK), members of the Independent Peer Review Panel (IPRP) and other project team members.

In June 2007, SRK presented a memo to Deloitte & Touche titled: "Proposed Scope of Work for ARMC 2007/08 Task 21 – Groundwater Investigations". The scope of work outlined in this proposal comprised two tasks with multiple sub-tasks:

1. Planning Studies
   a. Hydrogeological review of Rose Creek Tailings Facility
   b. Detailed structural geology desktop study using available data to target drilling program
   c. Sensitivity analyses using a numerical model.

2. Baseline Monitoring and Bedrock Characterization Downstream of the Cross Valley Dam (CVD).

This memo is included as Appendix A.

Based on discussions with the IPRP and other project team members, the 2007/2008 field work (task 2, above) was deferred to allow the results of the 2007/2008 desktop studies to be integrated into the planning for field studies as early as 2008/2009. Additionally, sub-task 'c'. of the Planning Studies Task, Sensitivity analyses using a numerical model, was deferred until after the field program has been completed and data becomes available for model calibration.

Section 2 of this report presents background pertinent to this study. Sections 3 and 4 summarise results of sub-tasks a and b.

2 Background

The IPRP review of the 2006/07 field investigations and closure discussions identified the concept of a groundwater seepage interception system (SIS) located below the Rose Creek Tailings Facility as a viable option (specifically, below the Cross Valley Dam). The groundwater SIS would probably be a cut-off wall type structure combined with some form of upstream groundwater pumping or ditch collection system. The effectiveness of such a system was considered susceptible to bypass through the underlying bedrock, such that further investigation and monitoring was recommended by the IPRP.

SRK discussed options for bedrock investigations with internal team members and the IPRP, specifically addressing uncertainty of bedrock flow paths and the assumed high level of capture efficiency that would be required for a groundwater SIS in this area. It was concluded that, in order to attain the necessary information from field programs in an efficient manner, sufficient planning studies should be completed prior to field program initiation. These studies included a review of available bedrock data by a structural geologist and review of available water quality data. Pumping tests were considered a probable requirement of the field program as well, so to improve pumping test design a numerical model was to be constructed and used to complete sensitivity analyses prior to pumping test implementation.

Later discussion of the proposed planning studies with the IPRP subsequently concluded that numerical modelling prior to collection of field-derived bedrock flow data was not worthwhile and this sub-task was deferred until after completion of a field program.

3 Bedrock and Structural Geology Review

Review of available bedrock data was completed in two components:

1. Initial compilation and summary – bedrock data was collated from available geologic mapping, exploration and geotechnical investigations. A memorandum summarizing the findings of the bedrock compilation is provided in Appendix B. The entire bedrock compilation, including the YGS Bulletin 15 document, can be found on the CD in the back cover of this report. The following summarises significant findings:
    a. Yukon Geological Survey Bulletin 15, by Lee Pigage, presents the most comprehensive review of bedrock geology publically available.
    b. Exploration drill hole logs are available online at the Yukon Energy, Mines and Resources Library website (http://www.emr.gov.yk.ca/library/index.html) as well as various Mineral Assessment reports (http://www.emr.gov.yk.ca/library/index.html).
    c. Seven specific consultant's reports include a combination of drill hole and seismic investigation results.
    d. Generally speaking, available data suggest heterogeneity in bedrock hydraulic parameters, but no significant structural controls have been identified. Weathering at shallow depths is discussed relatively more frequently.

2. Structural geology review – available bedrock data were reviewed by Chris Bonson, PhD., Structural Geologist (SRK) and recommendations for drill hole targeting were presented. The structural geology review memorandum is provided in Appendix C. The following summarizes significant findings:
    a. "Geologic evidence for the presence of transmissive structures in the area of the tailings ponds is inconclusive".
    b. "Based on evidence reviewed, there is the possibility of the following structures:
        i. Fault along the south side of the valley
        ii. Permeable intrusive contact
        iii. Undetected vertical joints within the bedrock.
    c. A field program consisting of a minimum four inclined drillholes was presented. Oriented coring was recommended.

4 Groundwater Quality

Robertson GeoConsultants completed a review of groundwater quality below the Intermediate and Cross Valley Dams as part of a larger groundwater quality assessment of the entire Rose Creek Tailings Facility and other parts of the Anvil Range Mining Complex. Results of the assessment for areas below the Intermediate and Cross Valley Dams are summarised in a memo included in Appendix D. For reference, the full groundwater quality assessment can be found in the Robertson GeoConsultants report: "***2007 Groundwater Review – Anvil Range Mining Complex, Yukon Territory***". The following summarises findings for the areas of interest for this report:

Intermediate Dam Area

- Historically, groundwater in the northern portion of the Intermediate Dam has shown greater impact than the southern portion (observed high concentrations of SO_4, Mg and alkalinity, but low metal concentrations, to a depth of ~30m).
- Since 2001, SO_4 and Mg concentrations in the northern portion have increased significantly. By 2007, high concentrations were observed in both shallow and deep monitoring wells, suggesting breakthrough of TDS front across the entire depth of the aquifer.
- Concentrations in the southern portion have not shown a significant increase, with only one exception.
- The source is considered to be above the Intermediate Pond, possibly, materials in one or more of the upstream impoundments (Intermediate, Second or Original) or locations in the vicinity of the mine itself. SO_4 and Mg concentrations are significantly higher than observed in the Intermediate Pond itself, though additional loading probably occurs along the reach of the Intermediate Impoundment.

Cross Valley Dam Area

- As with the Intermediate Dam area, oxidation products show higher concentrations along the northern portion and, to a lesser extent, the central portion, as compared to the southern portion.
- The depth profile suggests that groundwater quality is fairly uniform across the aquifer thickness, with only the deepest monitoring point (screened in basal till) showing relatively low concentrations of SO_4 and metals.
- Time trends for at least one monitoring well show increasing levels of SO_4 and Mg over time.
- Concentrations in the southern portion have remained relatively dilute and stable over the past six years, as compared to the northern portion.
- The Polishing Pond is not considered to be the source, as concentrations in groundwater are higher than those observed in the Polishing Pond itself.

- The TDS plume in the northern portion of the Cross Valley Dam is considered to possibly represent the leading edge of breakthrough of the Intermediate Dam plume. It is suggested that future increases in concentrations of acid rock drainage (ARD) products in these areas can be expected.

Downstream of Cross Valley Dam

- Similar to the Intermediate and Cross Valley Dams, concentrations of SO_4, Mg and alkalinity in the northern portion of the Rose Creek aquifer have increased.
- Concentrations have also gradually increased in the central portion of this area, though concentrations are significantly lower than the northern portion of the area.

The assessment concludes by recommending:

- Characterisation of bedrock permeability and water quality as contamination, primarily on the northern side of the valley, is present at depths in the alluvial aquifer and could potentially exist within bedrock.
- Completion of at least three monitoring wells across the Rose Creek Valley for future monitoring.

5 Conclusions and Recommendations

Three general conclusions can be made based on the studies presented here:

1. Available data on bedrock hydraulic characteristics and the presence of potentially transmissive structures is very limited to absent.

2. Groundwater quality of the alluvial aquifer in this area is deteriorating on the northern side of the valley and, to a lesser extent, in the central portion of the valley. Data suggests that a plume of ARD-related contaminants may be breaking through below the Cross Valley Dam.

3. Very little bedrock water quality information is available for this area.

Based on these conclusions, further assessment of seepage collection in this area should include assessment of existing contamination in bedrock and the possibility of SIS bypass through the bedrock. The IPRP has concluded that these investigations should be done along the actual alignment of the SIS, and that data collected off of the alignment is not sufficient for assessing SIS efficiency. Therefore, it is recommended that remaining components of the original proposal be completed once the final alignment has been determined.

This report, "**Bedrock Data and Groundwater Review for the Lower Rose Creek Valley - 2007/08 Task 21**", has been prepared by SRK Consulting (Canada) Inc.

Prepared by

ORIGINAL SIGNED AND STAMPED

Dan Mackie
Senior Consultant, Hydrogeology

Reviewed by

ORIGINAL SIGNED AND STAMPED

Cam Scott, P.Eng.
Principal Engineer

Appendices

Appendix A

Original Program Proposal: "Proposed Scope of Work for ARMC 2007/08 Task 21 – Groundwater Investigations"

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Memo

To:	Valerie Chort	**Date:**	June 1, 2007
cc:	John Brodie, Bill Slater, Stephen Mead, Daryl Hockley, Cam Scott	**From:**	D.Mackie, M. Royle, C.Wels,
Subject:	Proposed Scope of Work for ARMC 2007/08 Task 22 - Groundwater Investigations	**SRK Project #:**	1CY001.011.0005

This memo summarizes the recommended scope of work and preliminary costs related to groundwater investigations at the Anvil Range Mining Complex (ARMC) for 2007/08. The scope of work has been designed to address the groundwater comments of the Independent Peer Review Panel (IPRP) in their review of the ARMC closure alternatives, as identified in the SRK draft report entitled "Example Alternatives Report." Further discussions between the Faro Project Management Team and Deloitte & Touche are warranted before the program is finalized and a formal proposal is submitted for review and authorization.

The main comment of the IPRP that is to be addressed by this investigation is the following:

> "Evaluation of groundwater flow in the bedrock. To date, studies have focussed on collection of groundwater within overburden materials. With the recognition that contaminated groundwater collection requirements may be very high, the potential for flow through bedrock needs to be further investigated."

At this point in the closure program design, it is anticipated that a groundwater capture system will be located downstream of the Intermediate Dam (ID) or the Cross Valley Dam (CVD). The final location will depend on the closure alternative selected for this area, which complicates the design decisions for the groundwater investigation program.

During a teleconference on April 30, 2007 between Ken Raven and Leslie Smith (IPRP), Michael Royle and Dan Mackie (SRK) and Christoph Wels (RGC), it was agreed that:

1. Baseline groundwater quality data in bedrock downstream of the Rose Creek Tailings Facility (RCTF) should be collected to establish current conditions and monitor changing trends in water quality. This information will be provide a baseline for assessing closure performance as part of the Adaptive Management Process (AMP).
2. Monitoring wells should be installed in the bedrock to augment the wells already installed in the overburden;
3. Detailed bedrock lithology, structure and hydraulic data should be collected during the monitoring well installation program. This will require:
    a. oriented diamond core drilling;
    b. hydraulic packer testing;
    c. detailed lithology logging

and most importantly:

4. Detailed hydraulic characterisation along the CVD could not be transposed to the ID, and vice versa, for design purposes. Therefore, the large scale pumping test and detailed characterisation of the bedrock along a proposed cut-off wall should be deferred until the cut-off wall location has been determined. This decision is based on other issues to be resolved in the closure planning process, and will not be completed in time for the 2007 field season.

To satisfy the requirements of points 1 to 3, and considering the constraints of point 4, SRK/RGC propose that a bedrock-focussed drilling program of limited scope be carried out down-gradient of the CVD with the objectives of:

5. Measuring discrete and bulk hydraulic characteristics of the bedrock below the valley overburden; and
6. Allowing for collection of baseline groundwater quality data in the bedrock profile.

The drilling program would be based on the best available geological understanding of the site at this location. Figures 1 and 2 show a plan view and cross-section through the Rose Creek valley aquifer immediately downstream of the Cross Valley Dam. Details of the overburden in this area are reasonably well known, however the bedrock conditions are not well established. Considering that the proposed groundwater collection system is required to have a high probability of success in a massive bedrock environment, we consider that highly conductive lithology contacts, weathering profiles, and most importantly structural features will be the main issues of concern for potential bypass leakage. To the best of our knowledge no structural analysis of the Rose Creek valley has been completed and the faulting in the bedrock underlying the Rose Creek sediments is not well understood. .

Figure 3 shows the available bedrock mapping for the site. Figure 4 shows a cross-section oriented roughly perpendicular to the axis of the Rose Creek valley. This information is currently being compared to available drillhole data from the dam foundation studies and exploration drilling to verify it is best available mapping. The current mapping indicates that the bedrock underlying the dams is phillite and gabbro. Both lithologies have a general strike and dip of approximately 110° / 30°SW. The contact between the lithologies passes directly below each of the dams. This would be one reasonable drill target for the program. As the contact is dipping, it could be intersected by a vertical drillhole.

Proposed 2007 Work Plan

The proposed scope of work will consist of the following subtasks:

1. **Planning Studies**

- Hydrogeological Review of Rose Creek Tailings Facility
  - This work should be done prior to finalizing drill program to optimize monitoring well positioning, etc, and be integrated with the site wide hydrogeochemistry review (Task #36) proposed separately.
  - All available data will be reviewed to determine changes in trends, etc.. Input data will consist of routine monitoring data and compilation of any historic drilling data from exploration drillholes,

dam construction design program, etc. that will provide better conceptualization of the bedrock environment under the RCTF.
  - Estimated cost = $5,000

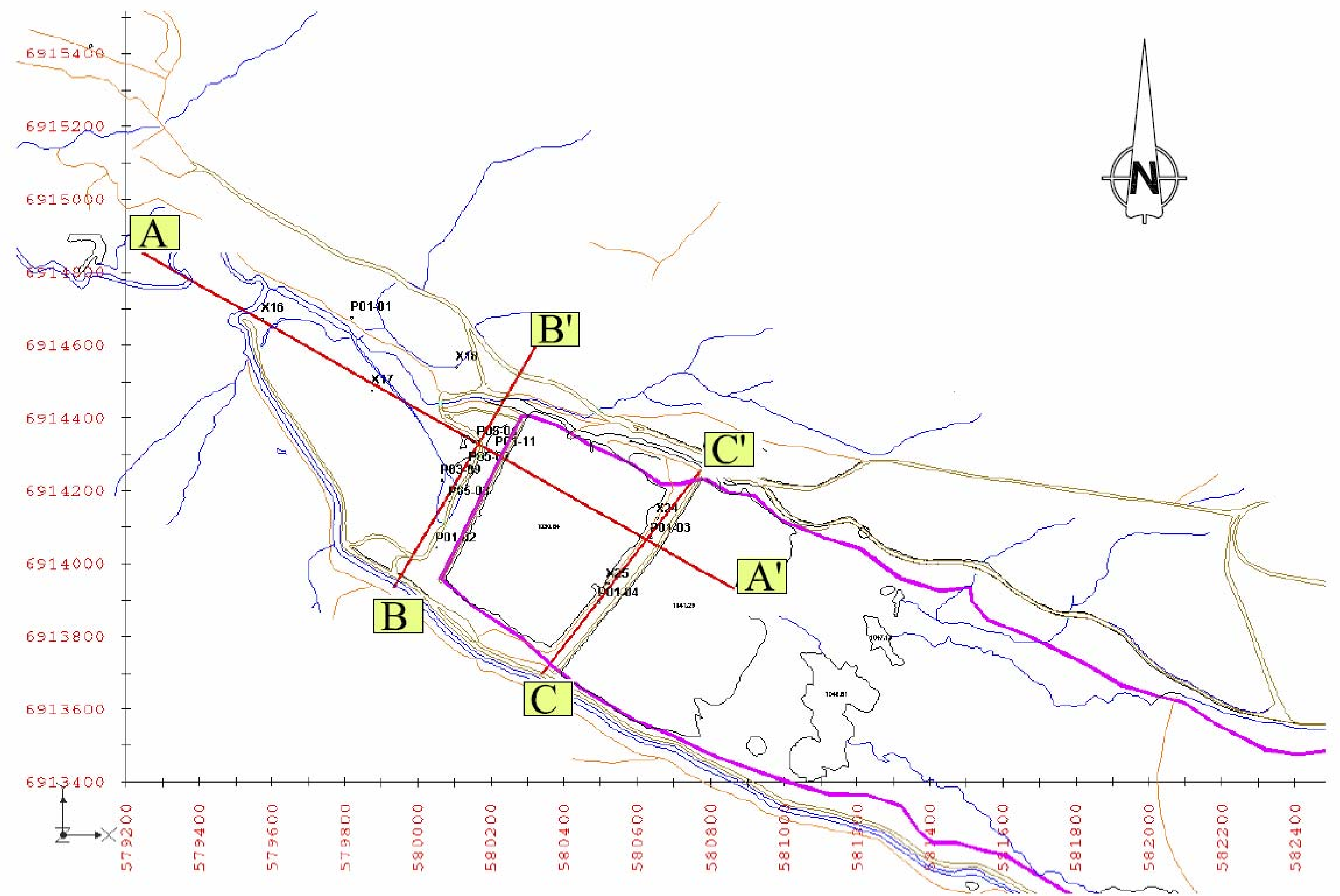
- Detailed structural geology desk study using available data to target drilling program
  - Required for drillhole program planning
  - All historical data will be compiled at evaluated, including exploration drillhole data.
  - Estimated cost = $12,000

- Sensitivity analyses using a numerical model
  - The existing numerical model for the CVD area will be modified to incorporate bedrock and used to simulate the potential response in bedrock wells to pumping in the overburden. Model runs would include variations in bedrock heterogeneity (assuming a randomly distributed bedrock K and/or presence of a fault zone). This work would serve two purposes:
    - examine how many boreholes would be required to reasonably bracket the (assumed) heterogeneity in bedrock permeability;
    - estimate appropriate design parameters for a pumping test (rate, duration) to sufficiently stress the underlying bedrock aquifer for interpretation of effectiveness;
    - Estimated cost = $30,000

2. **RCV - Baseline monitoring and bedrock characterisation downstream of CVD**
   - 1 vertical hole drilled at least 20m into competent bedrock in the north abutment;
   - 3 angled or vertical holes drilled in the valley centre about 30-40m into competent bedrock perpendicular to valley alignment (if angled) to target potential structure (final number, locations and orientation to be determined based on planning studies, see above);
   - Packer testing in weathered and competent bedrock;
   - Monitoring wells installed in weathered zone and competent rock;
   - Estimated cost = $190,000 +/- 25% based on results of task 1.

The location and angle/azimuth/depth of the proposed holes needs to be determined based on the updated lithology.

Costs for Subtask 2 are based on assumed drilling unit rates and mobilization costs. These will need to be verified with drill contractors who are both capable and available to do the work. This information will be provided in an update as soon as available.



6915400
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6914200
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6913800
6913600
6913400
579200
579400
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579800
580000
580200
580400
580600
580800
581800
582000
582200
582400
A
A'
B
B'
C
C'
X16
X17
X18
X24
X25
P01-01
P01-02
P01-03
P01-04
P01-11
P03-09
P05-03
N

Figure 1

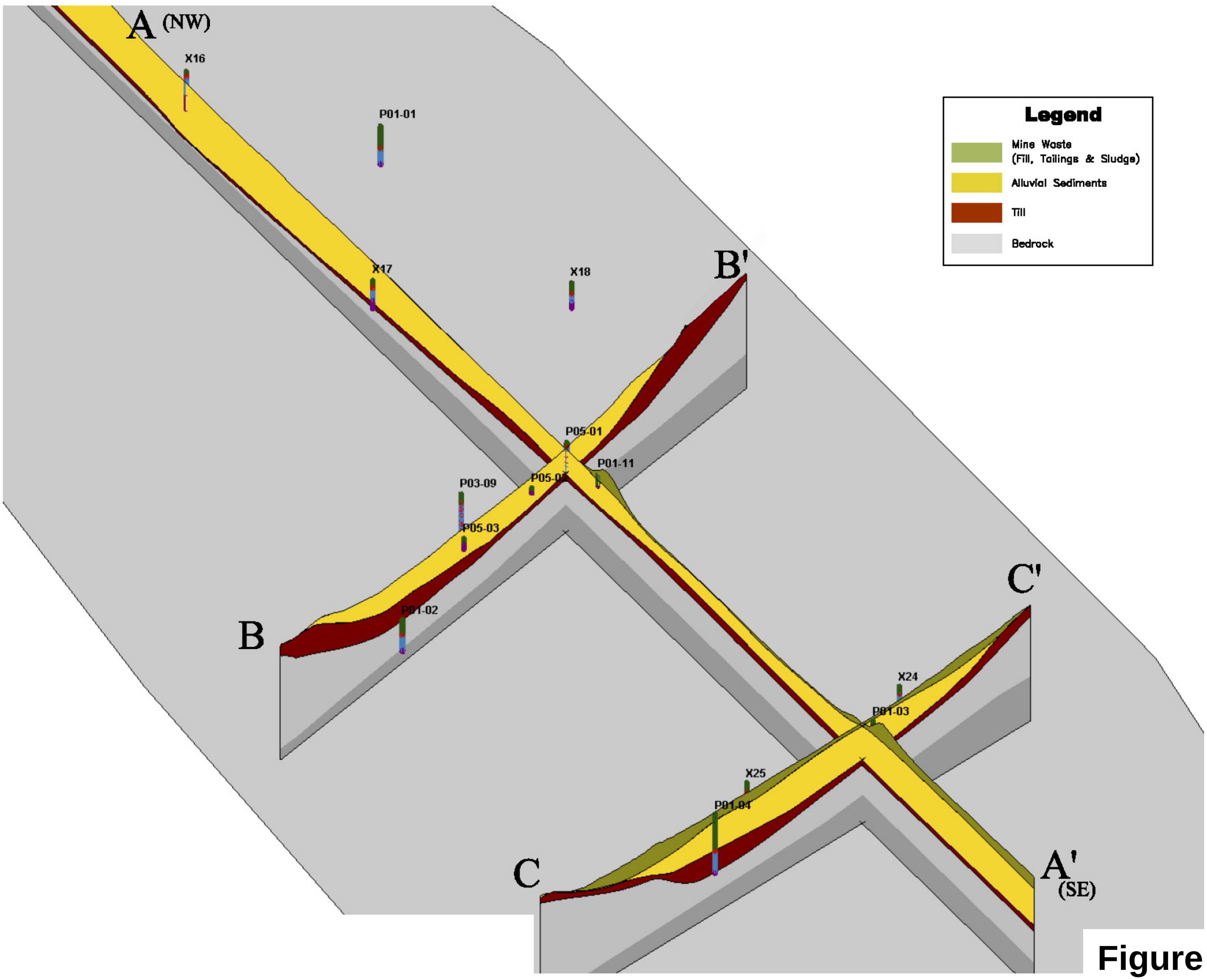
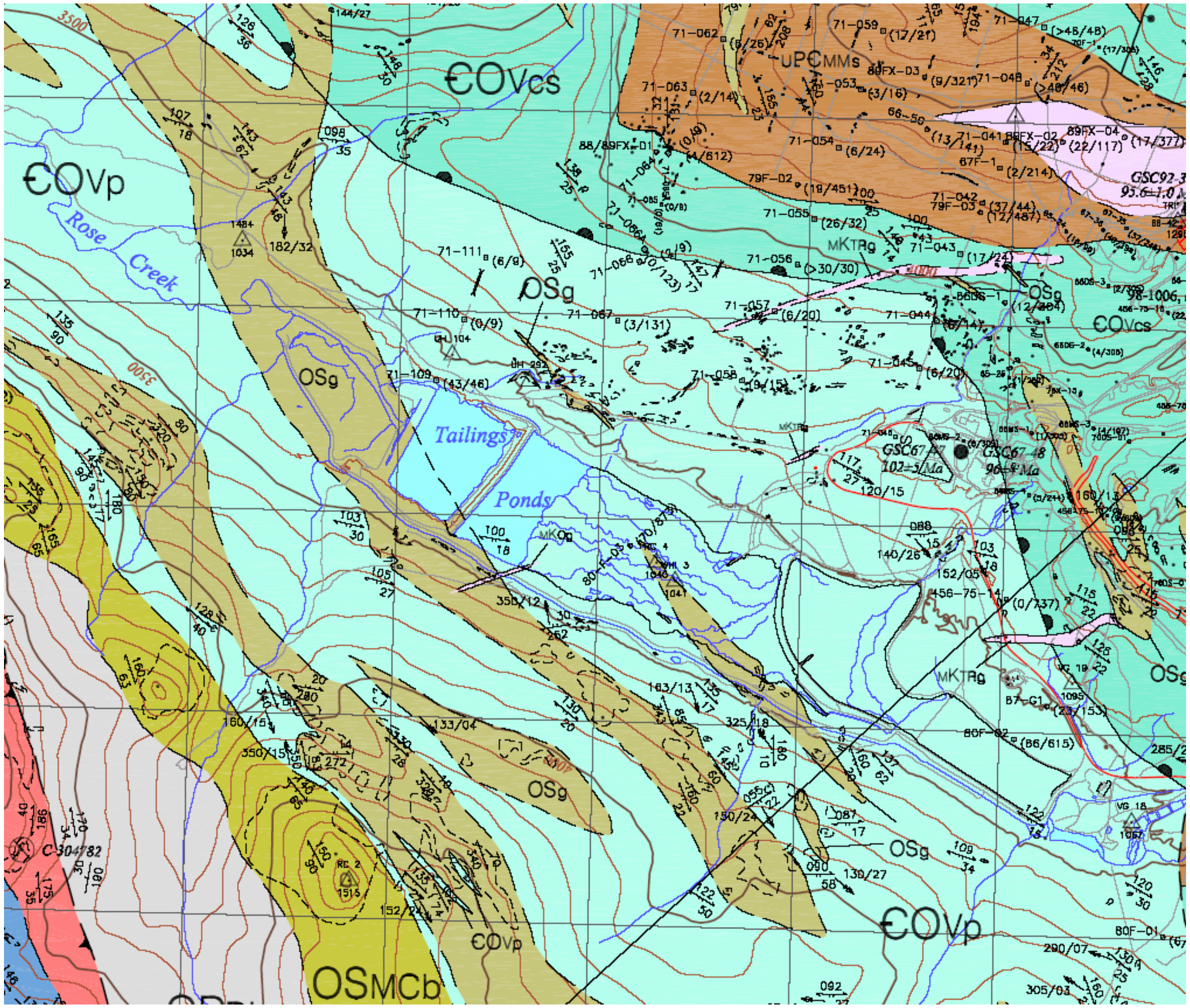
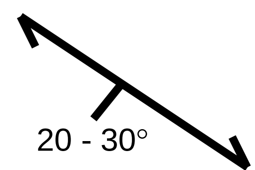

A (NW)
X16
P01-01
X17
X18
B'
Legend
Mine Waste
(Fill, Tailings & Sludge)
Alluvial Sediments
Till
Bedrock
P05-01
P01-11
P03-09
P05-02
P05-03
B
P01-02
C'
X24
P01-03
X25
P01-04
C
A'
(SE)

Figure 2



General strike and dip in region of the Cross Valley Dam and Intermediate Dam



ORDOVICIAN-SILURIAN

gabbro

OSg	dark green, locally magnetic, coarse- to fine-grained, massive to foliated gabbro; subvolcanic dykes and sills to Menzie Creek basalts (OSMCb); enclosing phyllites locally display thin contact metamorphic aureoles

pyroxenite

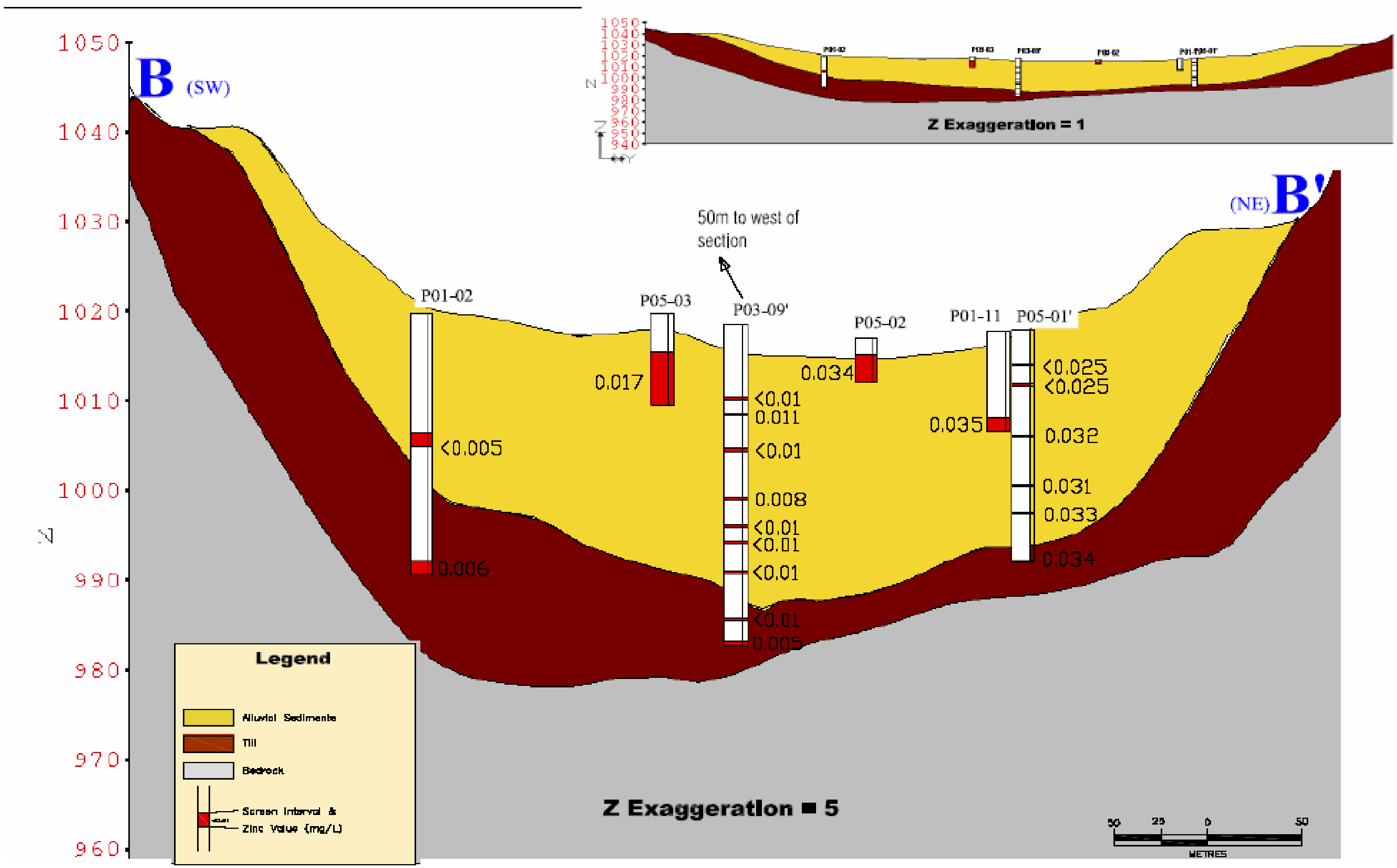
OSpx	dark green, locally magnetic, coarse-grained, massive to foliated, variably serpentinized pyroxenite; subvolcanic dykes and sills to Menzie Creek basalts (OSMCb); enclosing phyllites locally display thin contact metamorphic aureoles

CAMBRIAN-ORDOVICIAN

Vangorda formation

ЄOVp	soft, silvery grey, calcareous phyllite with lesser medium crystalline, grey marble, dark grey to black phyllite and dark green gabbro sills and dykes (OSg)
ЄOVcs	pale green and dark purplish brown, thinly banded calc-silicate rock with lesser black schist, marble and dark green gabbro dykes and sills (OSg)
ЄOVg	black, locally calcareous, carbonaceous phyllite or schist; commonly contains thin quartzose siltstone interbeds; interbanded with dark green gabbro dykes and sills (OSg)
ЄOVl	pale to dark grey, foliated marble

Figure 3



B (SW)
B' (NE)
1050
1040
1030
1020
1010
1000
990
980
970
960
Z
Z Exaggeration = 1
Z Exaggeration = 5
50m to west of section
P01-02
P05-03
P03-09'
P05-02
P01-11
P05-01'
0.017
0.034
<0.005
0.006
<0.01
0.011
<0.01
0.008
<0.01
<0.01
<0.01
<0.01
0.005
0.035
<0.025
<0.025
0.032
0.031
0.033
0.034
Legend
Alluvial Sediments
Till
Bedrock
Screen Interval & Zinc Value (mg/L)
50 25 0 50
METRES

Figure 4

Appendix B

Cover Letter for Bedrock Data Compilation: "Anvil Range 2007 Study Program: Bedrock Geology"

Robertson GeoConsultants Inc.

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Phone: (604) 684-8072 · Fax: (604) 684-8073

DRAFT - Memorandum

DATE: July 13, 2007

TO: Dan Mackie, SRK

FROM: Laura Findlater, Robertson GeoConsultants Inc.

RE: Anvil Range 2007 Study Program: Bedrock Geology

Dan:

As requested, this memo summarizes the lithological and structural information available for the bedrock in the area of the Rose Creek Tailings Facility at the Faro Mine Site, YT.

A. Data Sources

Table 1 summarizes the data sources that were reviewed for this study. The Yukon Geological Survey bulletin and accompanying map are authored by Lee Pigage who was a geologist with the mining company and has been conducting regional bedrock geology mapping programs with the Yukon Geological Survey since 1998. The map is included in Appendix A and both the map and bulletin are available online from the YGS website (http://www.geology.gov.yk.ca/publications/publication_list/TOC.html). According to Pigage (2007, pers. communication), the NTS map contains all the diamond and rotary triconed exploration holes drilled in the area. Most of the logs for the exploration holes are available online as PDF files from the Yukon Energy, Mines and Resources Library website (http://www.emr.gov.yk.ca/library/index.html) and are searchable under "Mining Assessment Reports." The drill logs from the consulting reports are available in hardcopy from Robertson GeoConsultants Inc.

B. Summary of Borehole Data

The following section briefly summarizes the bedrock information contained within each of the data sources. Drillholes known to intersect bedrock in the general vicinity of the Rose Creek Tailings Facility are shown in Figure 1. The test pit locations and seismic lines are shown in Appendix B (Figure 5-1). Tables 2 and 3 summarize the bedrock intervals and lithology descriptions pertaining to the plotted drillholes and test pits.

Table 1. Data Sources Reviewed for Bedrock Study

Author	Date	Document	Data
Publications			
Pigage, L.C.	2004	Geologic Map of Mount Mye (NTS 105K/6 W), central Yukon (1:25 000 scale). Yukon Geological Survey, Geoscience Map 2004-7	Lithology, exploration drillhole locations, structural features
Pigage, L.C.	2004	Bedrock Geology Compilation of the Anvil District (parts of 105K/2, 3, 5, 6, 7, and 11), central Yukon. Yukon Geological Survey Bulletin 15.	Descriptions of bedrock lithology, structure and metamorphism.
Reports from Consultants			
Golder Associates	1980	Final Design Recommendations for the Down Valley Tailings Disposal Project	Seismic sections at Cross Valley Dam, Intermediate Dam; 30+ drillholes (79-# 80-#) and 5+ test pits intersecting bedrock
Gartner Lee Ltd	2002	Rose Creek Tailings Facility - 2001 Hydrogeological and Geochemical Investigations	P01-0# GLL drillholes plus other drillhole data collected 1967-1996 (Appendix I)
Gartner Lee Ltd	2003	2003 Investigation of Rose Creek Tailings Facility, Faro Mine, Report on Coring and Multi-Level Well Installation	P03-0# GLL drillholes
BGC Engineering Ltd.	2005	Task 22F Rose Creek Diversion Channel Preliminary Geotechnical Evaluation	BGC05-0# drillholes
Klohn Crippen	2005	Rose Creek Tailings Dams Seismic Stability Assessment: Intermediate and Secondary Dams	BK04-0# drillholes
Klohn Crippen	2006	Rose Creek Tailings Dams Seismic Stability Assessment: Addendum	BK04-0# drillholes
Robertson GeoConsultants Inc.	2006	Design of Groundwater Interception System for Rose Creek Tailings Facility, Faro Mine, Yukon Territory, October 2006	Monitoring and pumping well logs completed downstream of Cross Valley Dam
Other Sources			
Various	1966-1981	Mineral Assessment Reports (http://www.emr.gov.yk.ca/library/index.html)	Exploration drillholes

B.1 YGS, 2004

The YGS Bulletin No. 15 and accompanying map (Appendix A) are the most comprehensive source of bedrock information available. The following discussion of bedrock lithology and structure is taken directly from the YGS bulletin (Pigage, 2004).

Lithology

A quick inspection of the map (Appendix A) reveals that the majority of the bedrock underlying the tailings facility is the Cambrian-Ordovician Vangorda Formation. At lower metamorphic grades, the Vangorda formation is characterized by medium grey phyllite, very thinly interlayered with light grey calcite±quartz siltstone or marble bands (Pigage, 2004). At higher metamorphic grades, this calcareous phyllite is transformed into a thinly and discontinuously banded, green, cream and purplish brown calc-silicate rock. In the area of the tailings facility (in particular, downstream of the Cross Valley Dam), the Vangorda Formation has been intruded by Ordovician-Silurian metabasite lenses (gabbro). These lenses mainly appear to be conformable with bedding in the Vangorda formation, but in detail are locally cross-cutting. The margins of the lenses are pervasively recrystallized and foliated, and the interiors of thicker bodies are massive and commonly preserve relict igneous textures (Pigage, 2004).

Structure

The Anvil District is complexly polydeformed and polymetamorphosed. It has undergone five deformation phases, the first two (D1 and D2) are the most important as they are regionally developed and are accompanied by regional structural fabrics (Pigage, 2004). D1 and D2 folding was coaxial and trends northwest-southeast. Regionally, northeast-verging thrust faults have been documented as a significant feature of the D1 deformation phase, which was caused by a horizontal compressive stress. Northeast of the tailings facility (and southwest of the Anvil batholith), the "Faro Thrust" manifests itself as a metamorphic boundary where the calcareous phyllites transition to calc-silicate rock, as confirmed by detailed mapping and drill core logging (Pigage, 2004).

The predominant fabric in most of the Anvil District is a gently dipping axial planar crenulation cleavage (S2) formed during the D2 deformation (Pigage, 2004). In the area of the tailings facility, this cleavage dips moderately-to-gently to the southwest, between 15^{o} and 35^{o}. D2 deformation fabric and minor folds are readily visible in drill core. The maximum compressive stress during the D2 deformation and metamorphism is thought to be oriented vertically and is believed to be caused by the intrusion of the Anvil plutonic suite. The D2 deformation is responsible for regional-scale extension faults on the southwest side of the Anvil Batholith. One of these extension faults runs nearly perpendicular to the Rose Creek Valley, upstream of the tailings dam. The extension faults are post-metamorphic as they crosscut metamorphic isograds, however, movement along the faults was occurring while the rocks were at pressure-temperature conditions suitable for coherent recrystallization during displacement (Pigage, 2004).

B2. Golder Associates, 1980

The 1980 Golder Report contains drillhole data, test pit data and seismic information used to design the Cross Valley Dam, Intermediate Dam and Rose Creek Diversion Canal.

Drillhole Data

Approximately 50 boreholes were drilled in three separate field investigations spanning 1979-1980. Most holes were drilled with a Failing 1000 rotary rig and several were logged with downhole geophysics (downhole seismic, nuclear (gamma-gamma) and resistivity). The boreholes that intersected bedrock are summarized in Table 2 and shown in Figure 1. Only seven holes were drilled more than 5 meters into bedrock (highlighted in Table 2). Overall, the bedrock descriptions contained in the logs are very generic - the lithology is described as “schist bedrock” that varies in color from greenish grey to black (79-1). Weathering is noted in boreholes 79-11 and 79-31 while other descriptions mention harder and softer drilling (79-4, 79-19). There is specific mentioning of fractures in the upper 1 m of 79-18 (middle of Cross-Valley Dam). Silt infilling joints or layers in the bedrock is noted in boreholes 79-32 and 80-47 (located at the diversion channel near the Intermediate Dam toe). Perhaps the strongest evidence of bedrock fracturing is recorded in 79-33 (south side of Intermediate Dam), where the pumping rate increased by 20-50 gpm while drilling into bedrock. The log of borehole 79-33 is included in Appendix B. The text of the document suggests that ‘bedrock disturbance may exist at this location’ and that the permeability could be as high as 10^{-4} cm/s. The location of this disturbed bedrock is in line with low seismic velocities observed in the vicinity of the historic Rose Creek channel downstream at the Cross-Valley Dam (Figure 6-7, Appendix C).

Test Pit Data

Numerous test pits were excavated along the proposed Rose Creek diversion canal as well as on the hillside north of the tailings impoundment (Figure 5-1, Appendix C). Most of the test pits were quite shallow (<6 m) however, bedrock was encountered at several locations (Table 2). At one location (TP79-9 on the northern hillside), and the bedrock was observed to dip approximately 30^{o} to the southwest, which agrees with measurements compiled by the YGS. There is also mention of “disturbed” bedrock at TP79-8 (same general area as 79-9).

The report text indicates that the bedrock in the area of the diversion canal was expected to be non-rippable, which was also confirmed by seismic velocities generally exceeding 4000 m/s. However, the document goes on to state “that [it] should be expected that some of the rock near the bedrock surface is disturbed and fractured.” Some disturbed and jointed bedrock was noted in the area around Sta 0+600 where there is a prominent creek.

Seismic Data

During the first field investigation, seismic refraction studies were conducted along baselines of the Cross Valley Dam, canal and on selected cross-sections to these baselines. All seismic studies conducted using a 24-channel recorder with geophones spaced at 10 m intervals. During the second field investigation, seismic refraction surveys were conducted along lines H-H and I-I using 12 channel recorder used with geophones spaced at 20 m (Appendix C). The purpose of I-I line was to investigate the foundation of the Intermediate Dam, while the H-H line was located to examine possible dam foundation conditions upstream of Cross Valley Dam and the feasibility of a slurry trench seepage cutoff.

Only selected geophysical data are presented in the report document. This includes cross-sections along the Cross-Valley and Intermediate Dam baselines with the seismic velocities from lines H-H and I-I projected onto them (Appendix C). As mentioned previously, the bedrock in the vicinity of the historic Rose Creek channel, near the Cross Valley Dam (Figure 6-7, Appendix B), shows seismic velocities much lower than the surrounding bedrock, which Golder has correlated to an area of disturbed bedrock drilled at BH79-33 at the Intermediate Dam baseline.

B3. Gartner Lee, 2002

The 2002 Gartner Lee report includes drill logs from the 2001 Gartner Lee hydrogeological investigation and also includes drill logs for previous investigations (1967-1996) not performed by Gartner Lee. All drill logs included with this report were reviewed and those intersecting bedrock are included Table 2 and shown on Figure 1. Only a handful of boreholes drilled in 2001 (by Gartner Lee) and 1981 (by Klohn Leonoff) were drilled into bedrock and, of those, only DH81-K3 and DH81-K5 were drilled greater than 5 m into bedrock. In these two boreholes, the bedrock was noted to have broken seams. P01-01 and P01-02 indicate bedrock weathering to a depth of 1.5-2 m. Downhole geophysics (conductivity and natural gamma-ray energy) was also performed on these two holes to help provide insight into the migration of ARD.

B4. Other Consulting Reports

Subsequent field investigations have been carried out in the period spanning 2003-2005. A brief review of the drill logs does not reveal any new information about the structure or lithology of the bedrock, as most drill holes only touched the bedrock. Relevant boreholes are included in Table 2 and shown in Figure 1.

B5. Exploration Drillholes

Refering to the YGS map (Appendix A) and Figure 1, it can be seen that there are several exploration holes that were drilled in and around the general area of the tailings facility. As a first pass, only drillholes completed in the phyllite area were reviewed for lithological and structural information. These exploration holes are included in Table 3 and shown on Figure 1. All of the exploration holes are vertical diamond drillholes (inclination is not recorded in 80F-0X logs).

Bedrock descriptions up to 100 m depth are included in Table 3. In some instances, the descriptions could not be read due to poor quality of the scanned logs. In all bores, the first 100 m of bedrock is described as being some variation of a phyllite or calc-silicate rock, which corresponds to the YGS mapped lithology in the area. The exploration logs contain more extensive descriptions of mineralogy than any of the consulting reports, however, there is little mention of structural features. BH67-G1 is the exception in that it contains foliation measurements (10-30^{o}) and mentions a fault zone encountered at 71-73 m. Structural information is not included in the logs of other drillholes completed in the footprint area of the tailings facility (80F-02, 80F-03).

C. Closure

We trust that this memo contains the information required to meet your needs at this time. Please contact the undersigned if you have any questions regarding this memo.

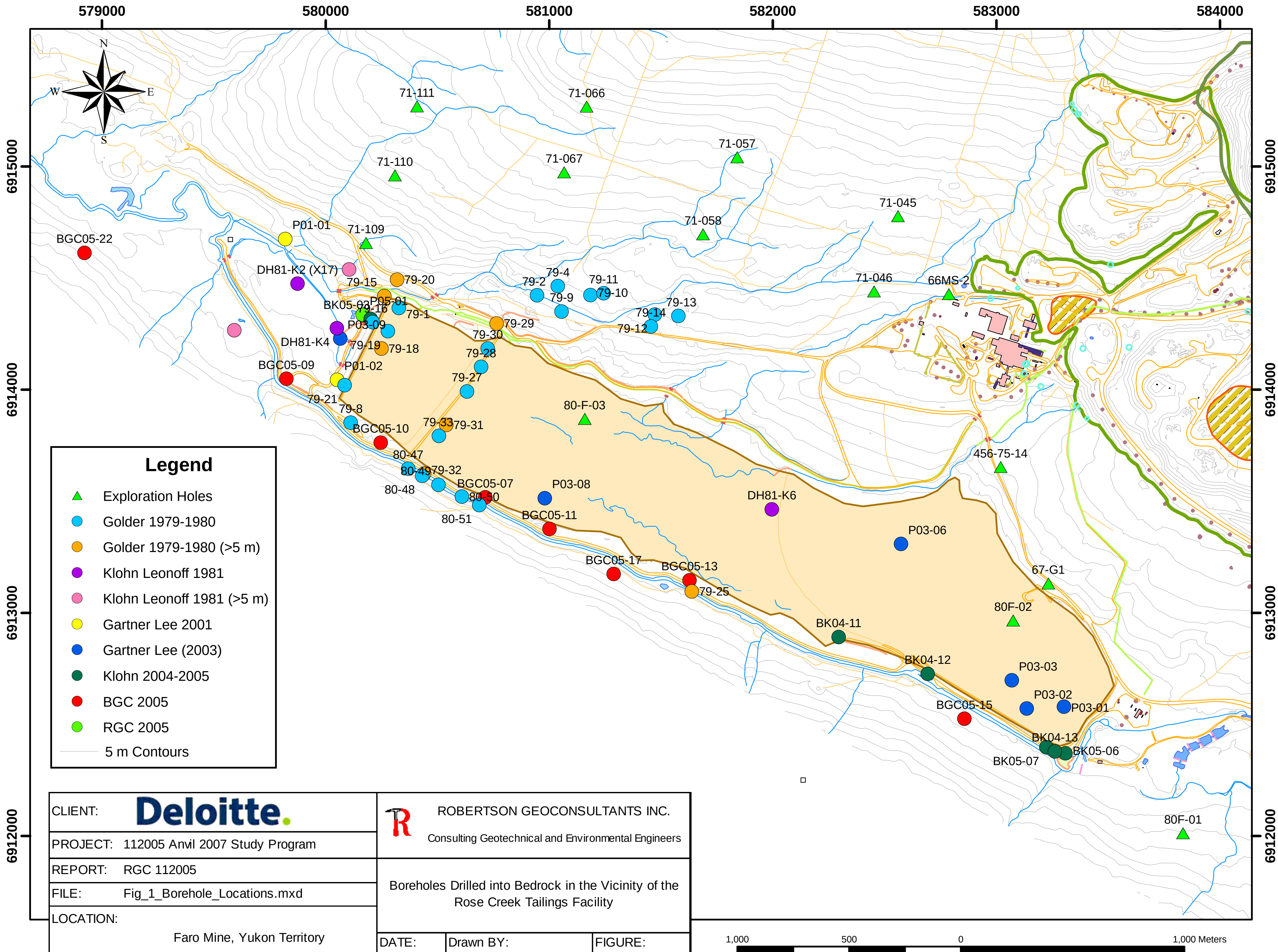
ROBERTSON GEOCONSULTANTS INC.

Laura Findlater, B.Sc.
Hydrogeologist

APPENDIX A

Geologic Map of Mount Mye (NTS 105K/6 W), central Yukon
(1:25 000 scale)

Yukon Geological Survey, Geoscience Map 2004-7



CLIENT:	Deloitte.
PROJECT:	112005 Anvil 2007 Study Program
REPORT:	RGC 112005
FILE:	Fig_1_Borehole_Locations.mxd
LOCATION:	Faro Mine, Yukon Territory

ROBERTSON GEOCONSULTANTS INC.

Consulting Geotechnical and Environmental Engineers

Boreholes Drilled into Bedrock in the Vicinity of the Rose Creek Tailings Facility

DATE:	Drawn BY:	FIGURE:
16-Jul-07	ME	1

Table 2. Bedrock Descriptions from Drillholes (Consultants).

BH ID	X	Y	Rig	Downhole Geophysics	Total Depth (m)	Bedrock Interval (meters)		Bedrock Thickness (m)	Bedrock Description
						From	To		
Final Design Recommendations for the Down Valley Tailings Disposal Project, Golder Associates, June 1980									
79-1	580,326.8	6,914,366.3	Rotary	N	17.8	16.5	17.8	1.4	16.46 - shattered bedrock (at interface?) Bedrock (black schist)
79-2	580,944.5	6,914,422.5	Rotary with Air	N	4.0	3.7	4.0	0.3	Schistose bedrock
79-4	581,038.1	6,914,463.8	Rotary with Air	N	9.1	4.8	9.1	4.4	Schist bedrock. Drilling is easier and cuttings are plastic at about depth 7.9 m
79-8	580,111.7	6,913,851.7	Rotary with Air	N	16.2	12.2	16.2	4.0	Schist bedrock.
79-9	581,055.5	6,914,350.5	Rotary with Air	N	5.2	4.3	5.2	0.9	Schist bedrock.
79-9A			Rotary with Air	N	4.6	3.7	4.6	0.9	Schist bedrock.
79-10	581,184.1	6,914,423.6	Rotary with Air	N	4.6	2.1	4.6	2.4	Schist bedrock.
79-11	581,243.5	6,914,432.4	Rotary with Air	N	4.6	2.4	4.6	2.1	Weathered schist bedrock (dry).
79-12	581,472.3	6,914,336.0	Rotary with Air	N	4.0	2.7	4.0	1.2	Schist bedrock.
79-13	581,576.6	6,914,329.9	Rotary with Air	N	4.6	3.4	4.6	1.2	Grey becoming brown schist bedrock.
79-14	581,454.2	6,914,282.8	Rotary with Air	N	4.6	2.1	4.6	2.4	Grey schist bedrock (dry).
79-15	580,261.6	6,914,419.6	Rotary with mud	Y (n/a)	38.1	31.1	38.1	7.0	Greenish grey becoming grey schist bedrock.
79-16	580,209.6	6,914,301.6	Rotary with Mud	Y	30.5	25.6	28.1	2.4	Very hard schist bedrock.
						28.1	30.5	2.4	Relatively soft schist bedrock.
79-18	580,249.4	6,914,183.9	Rotary with mud	Y	41.2	34.1	35.1	0.9	Possibly fractured bedrock
						35.1	41.2	6.1	Dark grey schist bedrock
79-19	580,278.2	6,914,262.0	Rotary with mud	Y	24.4	22.0	24.4	2.4	Schist bedrock, slightly softer drilling below 22.86m
79-20	580,318.8	6,914,493.0	Rotary with Air	Y	37.2	29.3	37.2	7.9	Grey schistose bedrock.
79-21	580,084.7	6,914,020.1	Rotary with mud	Y	36.6	34.1	36.6	2.4	Grey schist bedrock.
79-25	581,637.0	6,913,096.0	Rotary with mud	Y	12.2	6.6	7.3	0.8	Schist bedrock
						7.3	10.4	3.0	Relatively hard schist bedrock
						10.4	12.2	1.8	Relative soft schist bedrock
79-27	580,632.2	6,913,992.0	Rotary with Air	N	51.8	47.2	51.8	4.6	Greenish grey schist bedrock
79-28	580,694.9	6,914,101.7	Cased rotary with air	N	39.6	35.1	39.6	4.6	Greenish grey schist bedrock
79-29	580,763.6	6,914,296.0	Cased rotary with air	N	17.1	11.6	17.1	5.5	Greenish grey schist bedrock
79-30	580,725.5	6,914,183.5	Cased rotary with air	N	24.4	19.5	24.4	4.9	Greenish grey schist bedrock
79-31	580,538.6	6,913,842.2	Cased rotary with air	N	48.8	38.1	43.9	5.8	Weathered schist bedrock in a till-like matrix
						43.9	48.8	4.9	Greenish grey-schist bedrock
79-32	580,439.9	6,913,624.2	Cased rotary with air	N	7.9	2.7	7.9	5.2	Greenish grey schist bedrock, occasional silty layer
79-33	580,506.1	6,913,793.1	Cased rotary with air	N	25.0	20.1	25.0	4.9	Greenish grey schist bedrock. Pumping rate increasing from 20-50 gpm (1-3 l/sec)
80-47	580,369.3	6,913,645.7	Rotary with Air	N	10.7	7.3	10.7	3.4	Schistose bedrock with brown silt infilling joints or layers

Table 2. Bedrock Descriptions from Drillholes (Consultants).

BH ID	X	Y	Rig	Downhole Geophysics	Total Depth (m)	Bedrock Interval (meters)		Bedrock Thickness (m)	Bedrock Description
						From	To		
80-48	580,432.2	6,913,614.0	Rotary with Air	N	9.1	7.3	9.1	1.8	Grey schistose bedrock.
80-49	580,503.7	6,913,574.3	Rotary with air	N	10.7	9.1	10.7	1.6	Grey schistose bedrock.
80-50	580,608.9	6,913,521.3	Rotary with Air	N	9.1	7.9	9.1	1.2	Schistose bedrock
80-51	580,687.0	6,913,483.5	Rotary with Air	N	13.7	10.7	13.7	3.0	Grey schistose bedrock.
TP79-8	n/a	n/a	D8 Cat & Ripper	N	3.9	3.6	3.9	0.3	Broken grey schist bedrock
TP79-9	n/a	n/a	D8 Cat & Ripper	N	4.3	1.9	2.4	0.4	Disturbed schist bedrock.
						2.4	4.3	1.9	Schist bedrock dipping to SW at approximately 30 degrees
TP79 0+760	n/a	n/a	D8 Cat & Ripper	N	4.0	1.7	4.0	2.3	Greenish grey massive metavolcanic rock dipping into slope
TP79 2+155	n/a	n/a	D8 Cat & Ripper	N	4.3	4.0	4.3	0.3	Blue green massive bedrock
Faro Mine Tailings Abandonment Plan (VA 2758), Klohn Leonoff Consulting Engineers, September 1981 (In Gartner Lee Limited, 2002)									
DH81-K2 (X17)	579,874.3	6,914,474.5	Tricone air rotary	N	25.0	22.9	25.0	2.1	bedrock
DH81-K3 (X18)	580,105.5	6,914,539.1	Tricone air rotary	N	22.9	16.2	22.9	6.7	bedrock with broken seams
DH81-K4	580,050.3	6,914,274.6	Tricone air rotary	N	39.5	38.0	39.5	1.5	bedrock
DH81-K5	579,591.2	6,914,266.2	Tricone air rotary	N	42.7	35.1	42.7	7.6	bedrock with seams of broken rock
DH81-K6	581,994.7	6,913,464.1	Tricone air rotary	N	39.6	38.1	39.6	1.5	bedrock
Rose Creek Tailings Facility - 2001 Hydrogeological and Geochemical Investigations, Gartner Lee Ltd., March 2002									
P01-01	579,819.3	6,914,675.0	Air rotary	Y	35.7	33.5	35.1	1.6	Weathered Bedrock: gray angular gravel with homogeneous lithology, cotains mica and broken rock. Hard Drilling
						35.1	35.7	0.6	Bedrock
P01-02	580,050.7	6,914,044.0	Air rotary	Y	41.6	38.0	39.9	1.9	
						39.9	41.6	1.7	Bedrock: Gray and white bedrock. Fragmented pieces of quartz and phyllite minerals, very uniform.
2003 Investigation of Rose Creek Tailings Facility, Faro Mine, Report on Coring and Multi-Level Well Installation, Gartner Lee Ltd., 2003									
P03-01	583,301.3	6,912,580.3	Sonic	N	47.2	46.9	47.2	0.3	Bedrock: phyllite, angular clasts
P03-02	583,134.7	6,912,572.3	Sonic	N	36.0	36.0	36.6	0.6	Bedrock: phyllite, angular clasts
P03-03	583,068.1	6,912,698.2	Sonic	N	46.6	46.6	46.9	0.3	Bedrock: phyllite, angular clasts, very hard, drilling terminated as bit could not advance further
P03-06	582,572.9	6,913,308.8	Sonic	N	25.8	25.3	25.8	0.5	Bedrock: grey rock fragments, micaceous texture in rock powder
P03-08	580,980.3	6,913,514.3	Sonic	N	32.9	32.5	32.6	0.2	Weathered, bright grey bedrock, phyllite, angular fragments
			Sonic			32.6	32.9	0.3	Bright grey bedrock, phyllite, white rock powder
P03-09	580,065.4	6,914,228.9	Sonic	N	40.6	40.5	41.1	0.6	weatherd Bedrock, phyllite fragments, micaceous rock powder present
Rose Creek Tailings Dams Seismic Stability Assessment, Klohn Crippen, May 2005									
BK04-11	582,293.6	6,912,892.0	Becker	N	12.8	12.5	12.8	0.3	ROCK, flaky, smooth, grey, easy to break, no water yield.
BK04-12	582,691.7	6,912,727.0	Becker	N	14.6	13.1	14.6	1.5	ROCK, angular, hard pieces, some silt, low water yield
BK04-13	583,261.3	6,912,379.0	Becker	N	15.7	11.6	15.7	4.1	ROCK, weathered, flaky pieces, some sand, some silt, brownish grey, no water yield.
Rose Creek Tailings Dams Seismic Stability Assessment Addendum, Klohn Crippen, June 2006									

Table 2. Bedrock Descriptions from Drillholes (Consultants).

BH ID	X	Y	Rig	Downhole Geophysics	Total Depth (m)	Bedrock Interval (meters)		Bedrock Thickness (m)	Bedrock Description
						From	To		
BK05-03	580,200.5	6,914,316.9	Becker	N	25.5	24.4	25.5	1.1	Bedrock (250 blows for 5 cm)
BK05-06	583,308.0	6,912,371.1	Becker	N	17.4	15.7	17.4	1.7	Weathered Bedrock
BK05-07	583,223.4	6,912,397.9	Becker	N	15.5	11.7	15.5	3.8	Bedrock (Schist), weathered, silty, trace rounded gravel (no rounded gravel at bottom of interval)
Task 22F Rose Creek Diversion Canal Preliminary Geotechnical Evaluation, BGC Engineering Inc., December 2005									
BGC05-07	580,714.0	6,913,518.1	Auger	N	11.4	10.9	11.4	0.5	Phyllite/Schist Bedrock: moist, weathered
BGC05-09	579,824.4	6,914,048.6	Auger	N	10.2	9.9	10.2	0.3	Biotite Schist: Top 1 inch weathered surface in contact with sand and silt.
BGC05-10	580,245.8	6,913,763.0	Auger	N	8.6	6.3	8.6	2.3	Phyllite (Bedrock): Weak, highly weathered with quartz veins, some oxidation. No distinct discontinuities.
BGC05-11	581,001.4	6,913,375.9	Auger	N	9.7	7.9	9.7	1.8	Phyllite/Schist: Dark grey, weak, slightly weathered (W 5/6), some oxidation, distinct foliation across SPT sample; at 8.5 m, rock becomes more competent
BGC05-13	581,627.4	6,913,145.8	Auger	N	6.5	6.3	6.5	0.2	Phyllite (Bedrock): weak, weathered (W5), no oxidation
BGC05-15	582,856.1	6,912,526.1	Auger	N	4.0	3.1	4.0	0.9	Phyllite: Fine-grained, greenish grey, weak, weathered (W 4/5), oxidized layers, friable
BGC05-17	581,288.3	6,913,174.2	Auger	N	5.6	5.1	5.6	0.5	Phyllite (Bedrock): fine grained, greenish grey color, slightly weathered (W5), no visible fabric
BGC05-22	578,921.0	6,914,612.7	Auger	N	3.3	2.7	3.3	0.7	Phyllite (Bedrock): fine grained, green color, no distinct fabric or discontinuities.
Design of Groundwater Interception System for Rose Creek Tailings Facility, Faro Mine, Yukon Territory, Robertson GeoConsultants Inc., October 2006									
P05-01	580,165.0	6,914,334.9	Sonic	N	25.9	24.7	25.9	1.2	l.grey phyllite bedrock (rock chips), hard drilling, no weathering, dry

NOTES:

N/A Not available

(yellow) Bedrock interval exceeds 5 m

Table 3. Bedrock Information from Exploration Drillholes.

BHID	NTS Map Grid Square	overburden depth / total depth (m)	EMR Library Call Number[1]	Hole Dip	Interval (meters)		Bedrock Description	Comments
					From	To		
456-75-14	13, 83	0/737						log not found
66MS_2	14, 82	6/305	091237	90	6	12	Graphitic phyllite: biotite banding, small veinlets of quartz	
					15	46	Phyllitic quartzite (chloritic): biotite banding	
					23	24	mostly quartz, some bitotite banding	
					34	43	pronounced bitotite banding	
					43	47	chlorite banding	
					46	115	Graphitic phyllite (chloritic): biotite banding	
67-G1	13, 83	23/153	091713	90	0	23	Overburden (?)	
					23	153	Quartzitic phyllite: medium grey color, graphite banded,thinly foliated, cut by small barren quartz veins 2-4" thick. Hydrothermal quartz veins throughout…	
					24	49	foliation -10 to -20 deg.	
					49	98	foliation -30 deg.	
					71	73	Fault zone: slight gouge, loss of core, broken core	
71-045	14, 82	6/20	060903	90	0	6	Overburden (?)	log not legible
							breccia fragments of phyllite in quartz lenses	
71-046	14, 82	?/14	060903	90	0	4	Overburden (?)	log not legible
71-057	15, 81	6/20	060903	90	0	6	Overburden (?)	
					6	20	Calc-silicates?: Phyllite biotite, strong CO3, marble fragments	
71-058	14, 81	9/15	060903	90	0	9	Calc-silicate?: Phyllite, biotite, probably banded with marble, grey	
71-066	15, 81	3/9	060903	90	0	101	Calc-silicate: (summarized) biotite phyllite, mod-strong CO3 throughout, FeOx fragments (?) on half of sample 10-20ft	logged at 10' intervals
71-067	14, 81	3/131	060903	90	0	3	Overburden (?)	log not legible
					3	131	Calc-cilicate: CO3 stong	
71-109	14, 80	43/46	060903	90	43	46	Calc-silicate: lt grey, mod-strong CO3 reaction	
71-110	14, 81	0/9	060903	90	0	3	Phyllite: bio-seric interlayered with calcite bands, CO3 react mod-strong, non magnetic, non-graphitic, dark grey, breaks tabular	
					6	9	Phyllite: bio, grey black, banded CO3 layers, med-strong CO3 reaction, non-magnetic, non-graphitic	
71-111	15,80	6/9	060903	90	6	9	Phyllite: bio, grey, non-graphitic, non-CO3 reactions (?), non-mag, banded with CO3, breaks to tabular fragments	
80F-01	12, 83	6/463	091714	?90	0	6.1	Overburden (?)	
					6.1	105.1	Calcareous muscovite-chlorite and biotite phyllite	
80F-02	12, 83	66/615	090763	?90	0	65.6	Triconed	
					65.6	93.9	Non-calcareous muscovite-chlorite +/- biotite phyllite	
					93.9	193.1	Non-calcareous muscovite-chlorite +/- biotite	
80F-03	13, 81	70/873	090795	?90	0	70.1	Triconed	
					70.1	220	Calcareous muscovite-chlorite +/- biotite phyllite.	

NOTES:

[1]Call number will direct reader to appropriate on-line file, i.e http://yma.gov.yk.ca/090795.pdf

Shading indicates borehole drilled in footprint area of Rose Creek Tailings Facility.

APPENDIX B

Borehole Log BH79-33
(Golder Associates, 1980)

G.B. 102

PROJECT No. 792 2025

RECORD OF BOREHOLE 79-33

1747.61 N. 301.65 E
LOCATION (See Figure 3)

BORING DATE Dec. 5, 1979

DATUM Project

BOREHOLE TYPE Cased Rotary with Air

BOREHOLE DIAMETER 149 m.m.

SAMPLER HAMMER WEIGHT 63.5 Kg. DROP 76.2 cm.

PEN. TEST HAMMER WEIGHT DROP

ELEVN. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	BLOWS/300 mm	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. / SHEAR STRENGTH C_u, LB./SQ.FT.	COEFFICIENT OF PERMEABILITY k, CM./SEC. / WATER CONTENT, PERCENT (W_p – W – W_L; 10, 20, 30, 40)	ADDITIONAL LAB. TESTING
1054.07	Cleared Ground Surface						
0.00 / 0.30	Frozen sandy SILT trace clay						
	Brown SAND and GRAVEL	1	W.S.				
1051.33 / 2.74	Grey fine sandy SILT trace clay occ. gravel trace organics in upper portion	2	"				G. 12, S. 8, M. 42, C. 8
		3	"			Organic Content 1.2 %	
		4	51mm D.O.	Ph			
		5	W.S.			Organic Content 1.1 % Non Plastic	S. 18, M. 71, C. 11
		6	"				
		7	"			Organic Content 1.0 % Non-Plastic	S. 13, M 77, C 10
		8	51mm D.O.	14			
1041.27 / 12.80	Grey silty SAND and GRAVEL	9	W.S.		Pumping Approx. 50-100 g.p.m (3-6 l./sec)	Water sample taken	
		10	"				
		11	"				
1036.39 / 17.68	Brown SAND and GRAVEL	12	"		Pumping Approx. 50-100 g.p.m (3-6 l./sec)		
1033.95 / 20.12	Greenish grey schist BEDROCK	13	"		Pumping Rate Increasing From 20 to 50 g.p.m. (1-3 l./sec.)		
		14	"				
		15	"				
1029.07 / 25.00	End of Borehole	16	"			Water sample taken @ 25.0 m.	

PIEZOMETER OR STANDPIPE INSTALLATION

NOTE: Standpipe piezometer, Petur piezometer and thermister set were destroyed during installation Dec. 5, 1979. Water level in borehole encountered at about elevation 1051.02 meters during drilling Dec. 5, 1979

15 ○ 5 (10) Percent axial strain at failure

VERTICAL SCALE 1:125

Golder Associates B.H. 79-33

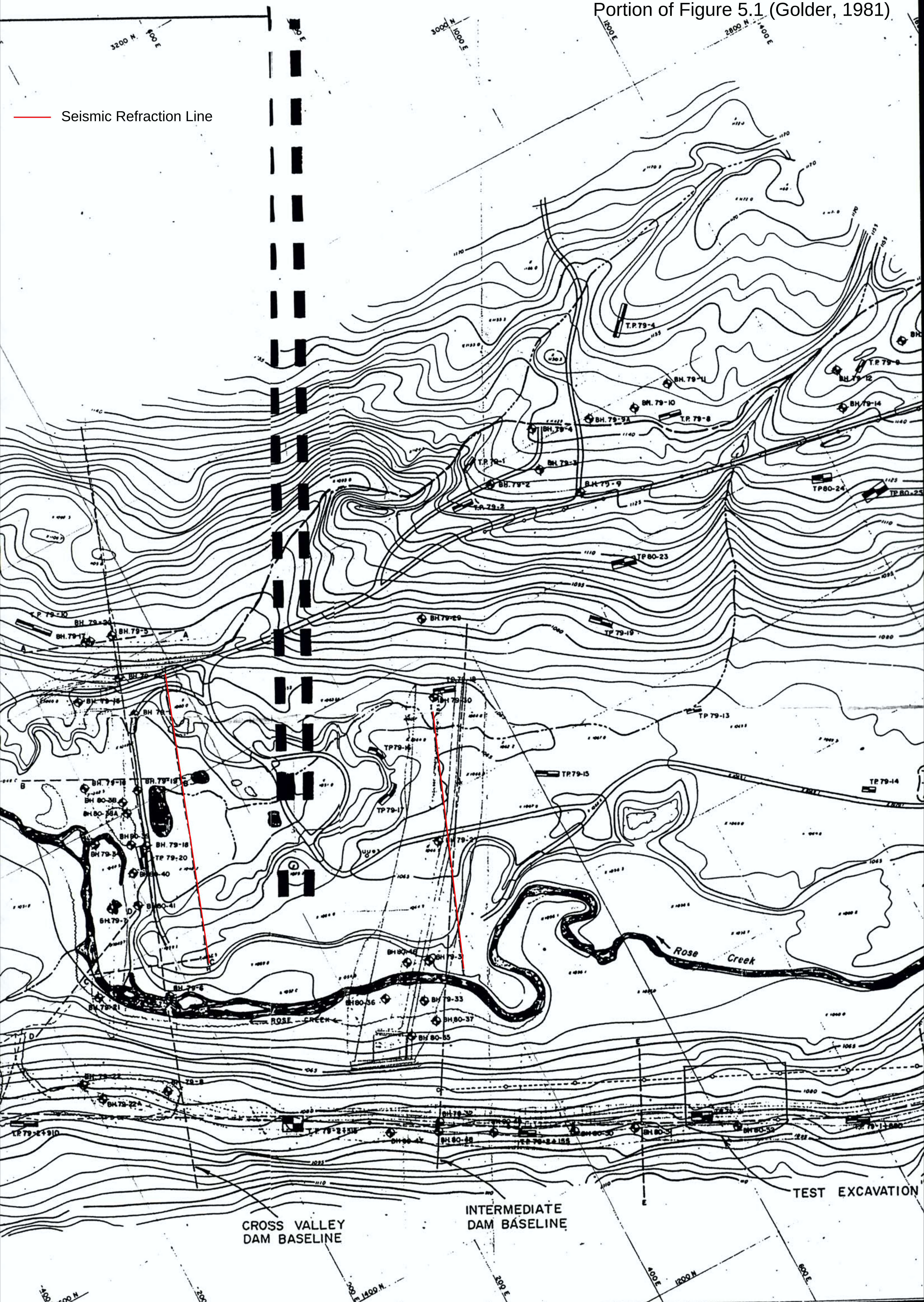
DRAWN R.W.

CHECKED DG

APPENDIX C

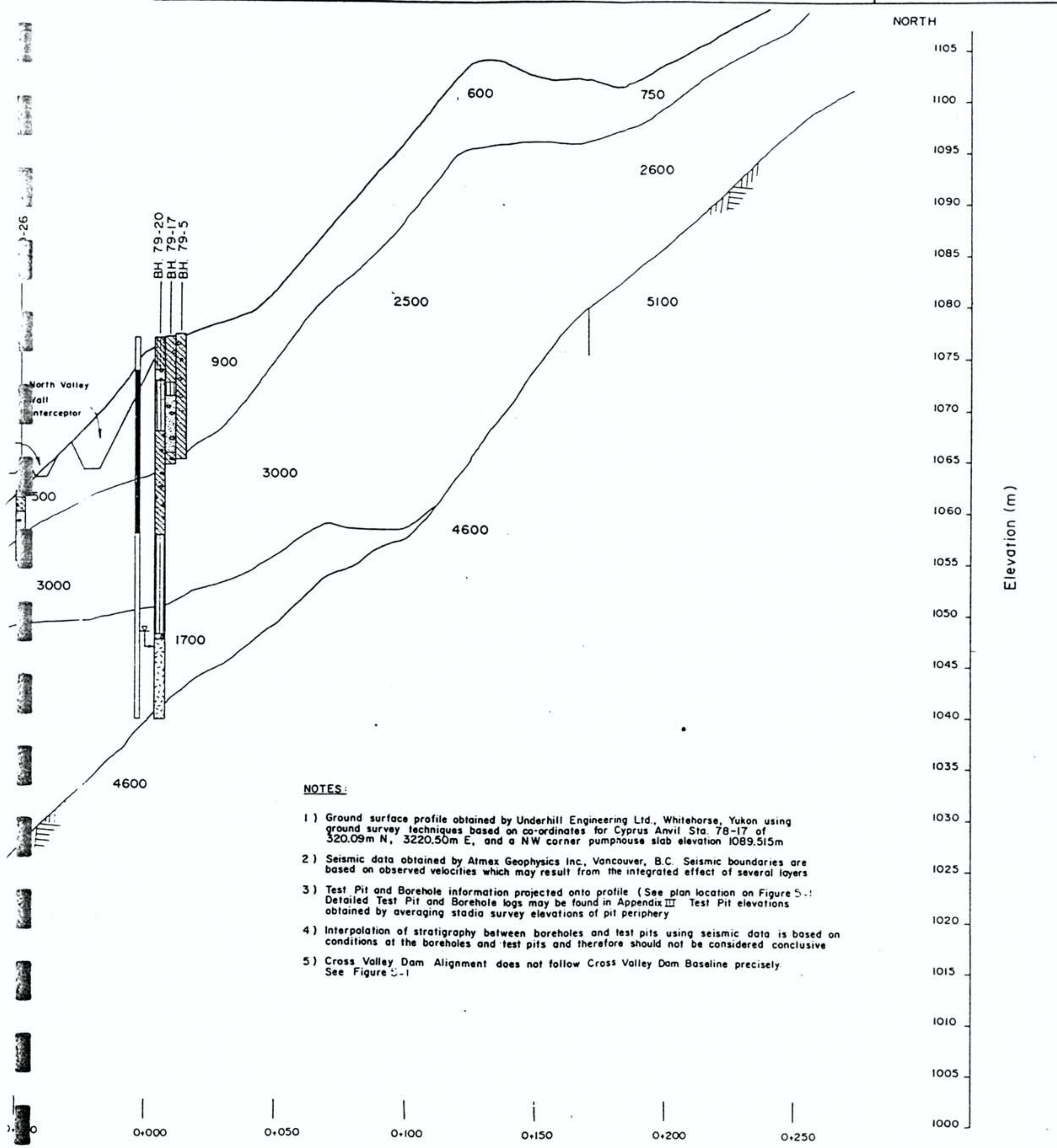
Selected Figures from Golder Associates, 1980

Portion of Figure 5.1 (Golder, 1981)



CROSS VALLEY DAM BASELINE

FIGURE 6-7



NOTES:

1) Ground surface profile obtained by Underhill Engineering Ltd., Whitehorse, Yukon using ground survey techniques based on co-ordinates for Cyprus Anvil Sta. 78-17 of 320.09m N, 3220.50m E, and a NW corner pumphouse slab elevation 1089.515m

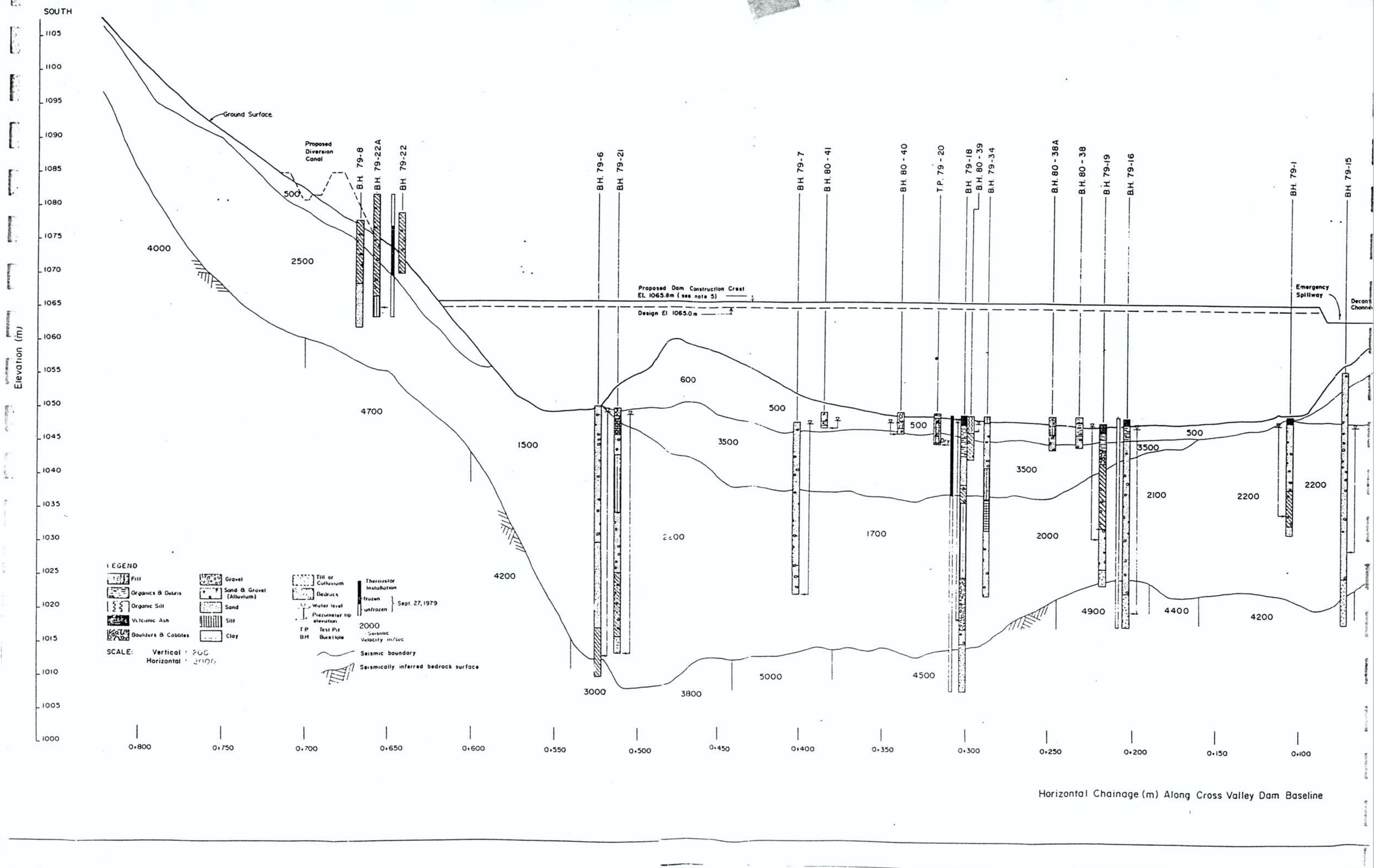
2) Seismic data obtained by Atmex Geophysics Inc., Vancouver, B.C. Seismic boundaries are based on observed velocities which may result from the integrated effect of several layers

3) Test Pit and Borehole information projected onto profile (See plan location on Figure 5-1 Detailed Test Pit and Borehole logs may be found in Appendix III Test Pit elevations obtained by averaging stadia survey elevations of pit periphery

4) Interpolation of stratigraphy between boreholes and test pits using seismic data is based on conditions at the boreholes and test pits and therefore should not be considered conclusive

5) Cross Valley Dam Alignment does not follow Cross Valley Dam Baseline precisely. See Figure 5-1

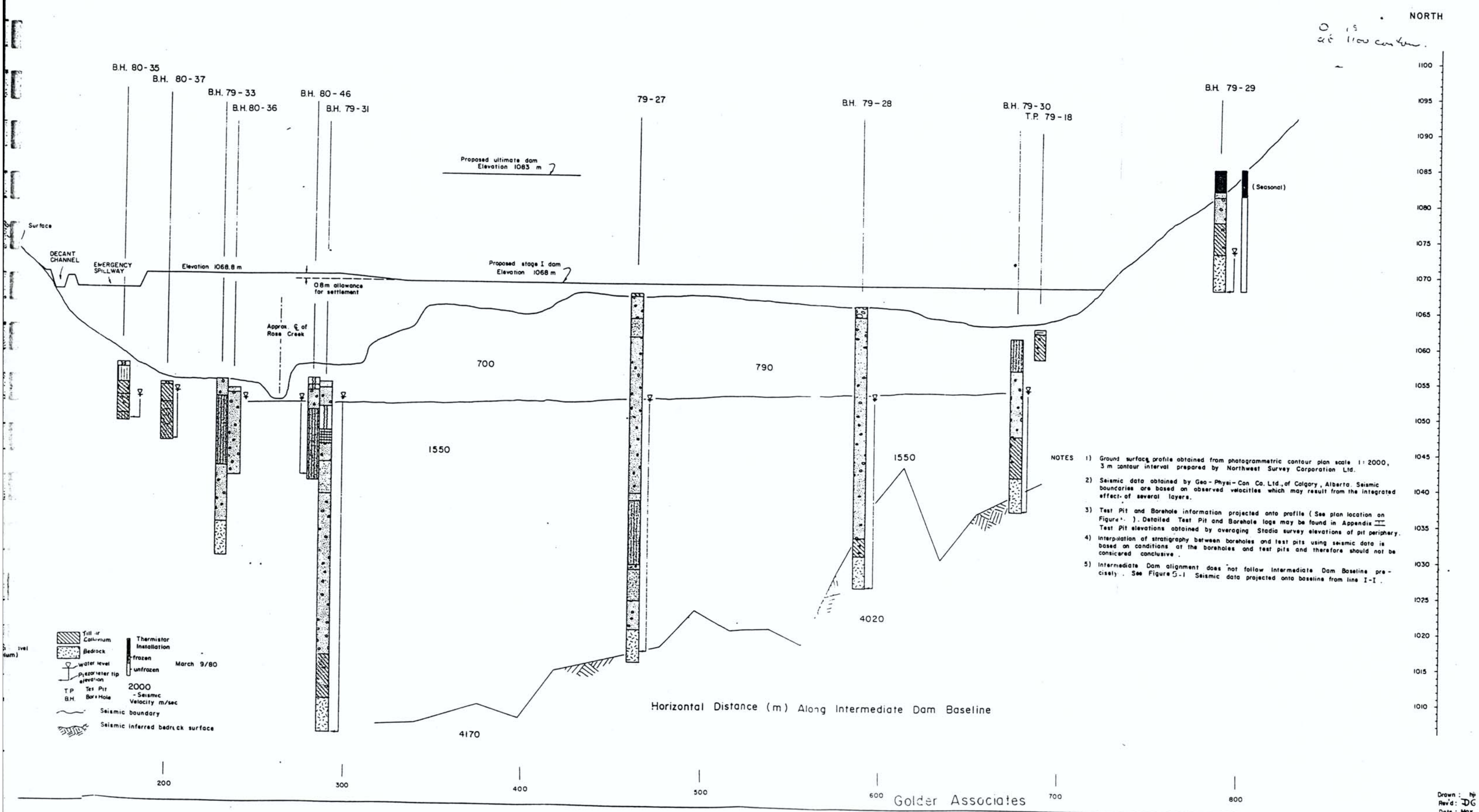
Drawn: R.W
Date: Jan '86
Rev'd: DG



SOUTH
Elevation (m)
1105
1100
1095
1090
1085
1080
1075
1070
1065
1060
1055
1050
1045
1040
1035
1030
1025
1020
1015
1010
1005
1000
Ground Surface
Proposed Diversion Canal
B.H. 79-8
B.H. 79-22A
B.H. 79-22
B.H. 79-6
B.H. 79-21
B.H. 79-7
B.H. 80-41
B.H. 80-40
T.P. 79-20
B.H. 79-18
B.H. 80-39
B.H. 79-34
B.H. 80-38A
B.H. 80-38
B.H. 79-19
B.H. 79-16
B.H. 79-1
B.H. 79-15
Proposed Dam Construction Crest EL 1065.8m (see note 5)
Design El 1065.0m
Emergency Spillway
4000
2500
500
4700
1500
600
500
3500
500
500
3500
3500
2100
2200
2200
4200
1700
2000
4900
4400
4200
3000
3800
5000
4500
LEGEND
Fill
Organics & Debris
Organic Silt
Volcanic Ash
Boulders & Cobbles
Gravel
Sand & Gravel (Alluvium)
Sand
Silt
Clay
Till or Colluvium
Bedrock
Water level
Piezometer tip elevation
T.P. Test Pit
B.H. Borehole
Thermistor Installation
frozen
unfrozen
Sept. 27, 1979
2000 Seismic Velocity m/sec
Seismic boundary
Seismically inferred bedrock surface
SCALE: Vertical 1 : 200
Horizontal 1 : 2000
0+800
0+750
0+700
0+650
0+600
0+550
0+500
0+450
0+400
0+350
0+300
0+250
0+200
0+150
0+100
Horizontal Chainage (m) Along Cross Valley Dam Baseline

GEOTECHNICAL PROFILE ALONG INTERMEDIATE DAM BASELINE

FIGURE 6-8



Appendix C

Structural Geology Review: “Faro Mine Tailings Ponds: Potentially Transmissive Structures”

SRK Consulting (Canada) Inc.
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Memo

To:	Dan Mackie, SRK	**Date:**	20th August 07
cc:		**From:**	Chris Bonson
Subject:	Faro Mine tailings ponds: potentially transmissive structures	**Project #:**	PLEASE ADVISE

Dan,

1 Evidence for Transmissive Geological Structures

I have conducted a cursory review of the following material in order to assess the potential for transmissive geological structures in the area of the Faro Mine tailings ponds:

- Findlater, L. 2007. Memo re: Anvil Range 2007 Study Program: Bedrock Geology. *Robertson GeoConsultants*, *Memo to Dan Mackie, 13th July 07.*
- Bedrock drill hole logs (supplement to memo).
- Pigage, L.C. 2004. Geological Map of Mount Mye, Central Yukon. Yukon Geological Survey 1:25,000 scale map (NTS 105K/6 W).

In my experience transmissive structures typically fall into three basic categories: (1) faults, (2) joints or other fractures, and (3) geological contacts. Evidence for the presence of each in the area of the Faro tailings ponds is briefly described below.

1.1 Faults

Both extensional and reverse faults are present in the Faro Mine area, shown by the map of the YGS (Pigage, 2004). However, the tailings pond is approximately 2km from the nearest mapped fault.

Within the drill-hole logs there is mention of faulting associated with hydrothermal quartz at 71m depth in DDH67-G1, to the ESE of the tailings ponds. There also exists very tentative evidence that a fault *may* exist along the southern margin of the valley in the area of the tailings dams, summarised below:

- The sub-crop bedrock profile of the valley is strongly asymmetric, with a steep gradient along the southern side of the valley, between drill-holes BH79-33 and BH79-31 (approx. 25m elevation change over approx. 60m). It is possible that this erosional recess may be fault controlled.
- As mentioned in Findlater (2007), 'bedrock disturbance' is noted in BH79-33 close to the change in bedrock elevation along the southern valley side.
- Quartz fragments are found in drillhole P01-02. Given the presence of fault-related hydrothermal veins elsewhere (e.g. DDH67-G1) it is possible that these may signify a fault, although it is also

possible that the presence of quartz may be entirely unrelated to faulting. This drillhole is also close to the southern valley side.

If a fault is present along the southern margin of the valley, the (conjectured) outcrop of the gabbroic intrusion precludes it from having a major displacement.

1.2 Joints

Several drillhole descriptions within the vicinity of the westernmost tailings dam mention the presence of broken seams of rock or the possibility of fracturing. No information is given on the orientation of these fractures. It is very possible that the rock is jointed. Unfortunately, all of the drillholes are vertical and therefore do not sample vertical joints.

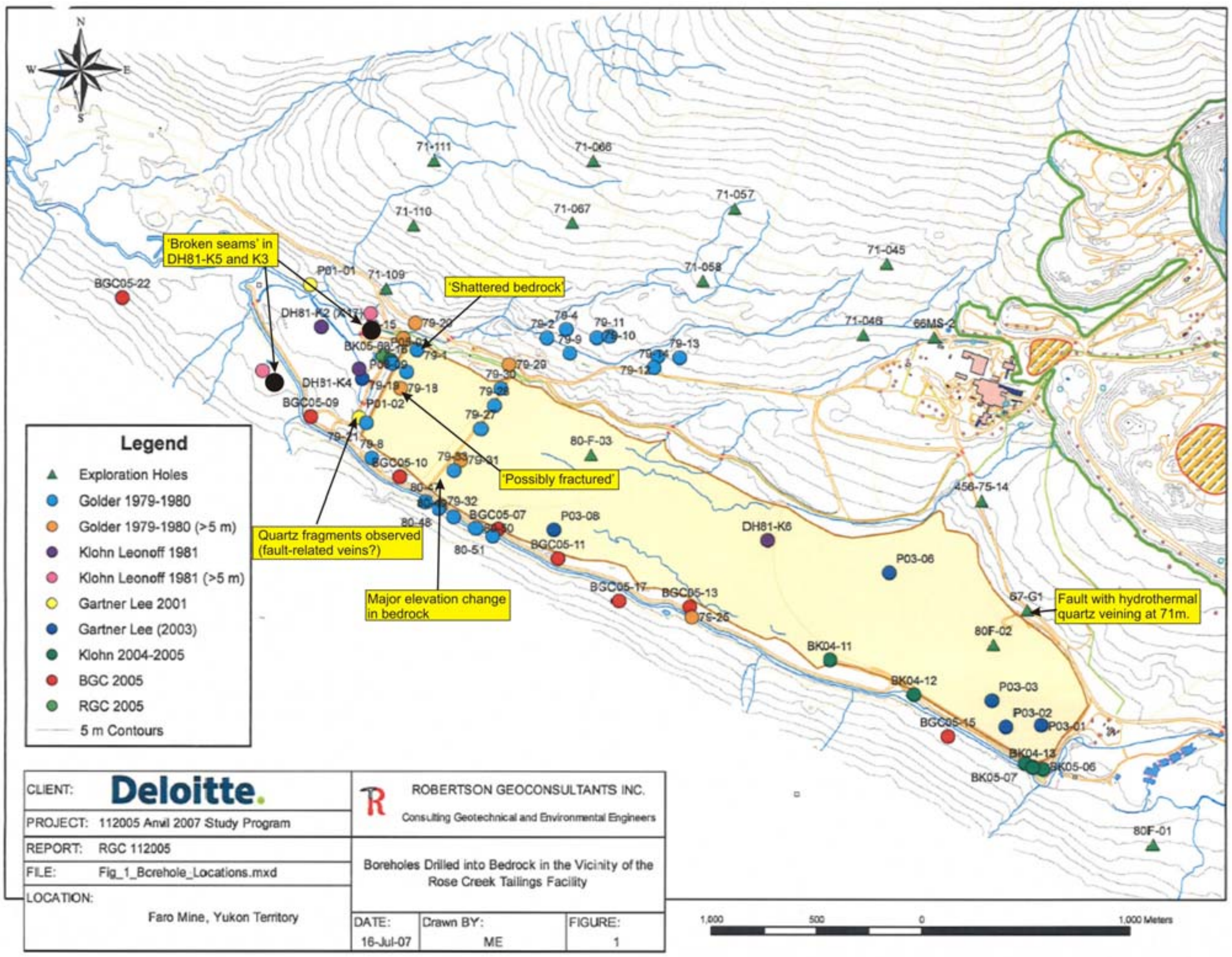


Figure 1. Drillhole observations

1.3 Lithological Contacts

The only mapped geological contacts in the area of the tailings ponds are that between the Cambro-Ordovician calcareous phyllites (Vangorda Fm.) and an Ordovician-Silurian gabbroic intrusive. The nature of this contact is not described. It remains a possibility that, due to the rheological difference between the two rock types, localised minor fault displacements may have been accommodated by the contact creating a hydrological aperture. The hydrological properties of the contact may have also been exacerbated by weathering.

2 Summary and Recommendations

In summary, despite the intrinsic likelihood of a structure with some hydraulic aperture occurring in the bedrock over the 600m wide span of the valley, geological evidence for the presence of transmissive structures in the area of the tailings ponds is inconclusive. Based on the evidence reviewed, there is the possibility of the following structures:

- Fault along the south side of the valley
- Permeable intrusive contact
- Undetected vertical joints within the bedrock

Any of these structures could, potentially, contribute to the permeability of the bedrock.

A program of inclined drillholes targeted appropriately would help to determine the presence of these structures. However, it should be recognised that although it is possible to identify most risks, no practical amount of drilling can absolutely guarantee that all transmissive structures have been detected.

It is recommended that specific structures which are deemed most likely to be transmissive are tested with targeted drillholes (possible fault and geological contact), whilst the background fracture network (joints) are sampled in these and other drill-holes placed in front of the dam.

Drilling recommendations for the recommended tests are made below.

2.1 Test for Fault

Two drill-holes are recommended to test the presence of the potential fault in the bedrock below the southern valley side, illustrated in Figure 2 (Drillholes A and B). The first should be inclined towards the south-southwestern valley side and be designed to intercept the bedrock below the area of the recessive erosion (Drillhole B). This drillhole may intercept a fault if the fault dips into the valley and will yield some information on joints, if present. If no fault is intercepted in this inclined hole, a vertical hole, or hole steeply-inclined hole should be positioned over the area of bedrock elevation change (Drillhole A).

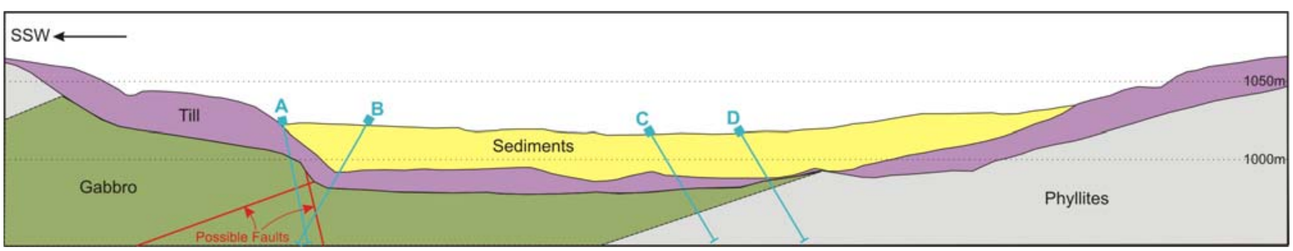


Figure 2. Schematic representation of recommended drillholes. Drillholes A and B are targeted to intercept a possible fault; drillholes B and C are targeted to test the contact of the gabbroic intrusive.

2.2 Test of Faulted or Weathered Intrusive Contact

The lower contact of the gabbroic intrusive should be tested using inclined drillholes oriented to the NNE (Figure 2; drillholes C and D). The contact should be tested both at depth (Drillhole C) and close to the non-solid geology (Drillhole D) to investigate the original and potentially weathered state of the contact.

2.3 Test for Joints

Joint data should be possible to retrieve from the drillholes described above. However, one or two additional holes are recommended to gather a more global picture of the distribution of joints in both the gabbro and phyllites which underlie the valley. In planning these holes, it is recommended that the dip direction (azimuth) should deviate by 30-50º in order to capture all possible joint orientations whilst providing reasonable coverage across the valley.

2.4 General Comment

All holes should be oriented to maximise the information on the structures intercepted. The Reflex ACT tool is recommended for this purpose.

SRK Consulting (Canada) Inc.

Chris Bonson
Senior Consultant (Structural Geology)

Appendix D

Water Quality Assessment: "Anvil Range 2007 Study Program: Review of GWQ at Intermediate Dam and Cross Valley Dam"

Robertson GeoConsultants Inc.

Suite 640, 580 Hornby St., Vancouver, B.C., V6C 3B6
Phone: (604) 684-8072 · Fax: (604) 684-8073

Memorandum

DATE: February 4, 2008

TO: Dan Mackie, SRK Consulting

FROM: Christoph Wels, Robertson GeoConsultants Inc.

RE: FINAL - Anvil Range 2007 Study Program: Review of GWQ at Intermediate Dam and Cross Valley Dam

Dan:

As requested, this memo briefly summarizes a review of the recent groundwater quality monitoring data collected in the lower reaches of the Rose creek valley (i.e. at the toe of the Intermediate Dam and Cross Valley Dam). This review was carried out as part of the 2007 Planning Studies of Task #22 (Groundwater Investigations) and in conjunction with Task #35 (Groundwater Monitoring Program Review).

For groundwater quality time trends in the upper reaches of the Rose Creek Tailings Facility, including a more in-depth discussion of the QA/QC of the water quality monitoring program, the reader is referred to RGC Report 118012/1 entitled "2007 GROUNDWATER REVIEW - ANVIL RANGE MINING COMPLEX, YUKON TERRITORY" (RGC, 2007).

1. Background

Figure 1 shows the general layout of the Rose Creek tailings facility and all available groundwater monitoring wells in the area. The Rose Creek tailings facility comprises the Original Impoundment, Second Impoundment, Intermediate Impoundment (w/ Intermediate Dam), and the Polishing Pond (w/ Cross Valley Dam). Conventional wells are shown in red and multilevel wells are shown in blue. Those monitoring wells not routinely monitored are shown in yellow and decommissioned wells are indicated by a "cross".

This memorandum provides a brief review of the groundwater quality time trends in the lower reaches of the Rose Creek valley (i.e. at the toe of the Intermediate Dam and Cross Valley Dam). A more comprehensive review of groundwater quality time trends for the Rose Creek Tailings Facility, including the upper reaches of the Rose Creek valley, is provided in Robertson GeoConsultants Inc. (2007)[1].

[1] DRAFT - 2007 Groundwater Review, Anvil Range Mining Complex (in review). RGC Report No. 118012 submitted to Deloitte & Touche, December 2007.

For the purpose of this review, the recent time trends of groundwater quality in the Rose Creek valley are discussed separately for the following geographic areas:

- Toe of Intermediate Dam;
- Toe of Cross Valley Dam; and
- Downstream of Cross Valley Dam.

2.0 Review of Groundwater Quality Time Trends

2. 1 Toe of Intermediate Dam

Table 1 lists pertinent information of all groundwater monitoring wells located at the toe of the Intermediate Dam, including year of construction, installation details (total depth, screening interval) and status of monitoring.

Table 1.

Monitoring wells at the toe of the Cross Valley Dam, Rose Creek Tailings Facility.

Well ID	Year of Construction	Total Depth (m bgs)	Top of Screen (m bgs)	Bottom of Screen (m bgs)	Top of Casing Elevation (m asl)	Current Status of Monitoring	Formation
Intermediate Dam							
X24A-96	1996	6.5	6.46	6.48	1033.10	bi-annual	Alluvium
X24B-96	1996	11.3	9.8	11.3	1033.05	not routinely monitored	Alluvium
X24C-96	1996	16.5	14.97	16.47	1033.00	not routinely monitored	Alluvium
X24D-96	1996	28.3	26.84	28.34	1032.90	bi-annual	Alluvium
X25A-96	1996	8.9	7.44	8.97	1032.08	bi-annual	Alluvium
X25B-96	1996	19.1	17.7	19.17	1032.03	bi-annual	Alluvium
P01-03	2001	9.3	7.78	9.3	1032.21	bi-annual	Alluvium
P01-04A	2001	34.1	32.53	34.05	1031.90	bi-annual	Alluvium
P01-04B	2001	53.4	51.89	53.41	1031.89	bi-annual	Till

Figures 2a/b and 3a/b show the water quality time trends in wells screened in the northern section and southern section of the Intermediate Dam, respectively. The following observations can be made:

In the northern portion of the Intermediate Dam (X24A/B/C/D and P01-03):

- Historically, the groundwater quality in the aquifer beneath the northern portion of the Intermediate Dam has shown a greater impact than along the southern portion, showing elevated SO4, Mg and alkalinity but generally low metal concentrations; note that this "TDS plume" in the aquifer extends to significant depth (~30m bgs)
- In recent years (since about 2001), sulphate and magnesium concentrations have increased significantly in all (still functional) wells screened in the aquifer along the north side of the Intermediate Dam; in May 2007, sulphate and magnesium concentrations in the deep well X24D had reached 1,700 mg/L and 120 mg/L, respectively; very similar increases in SO4 and Mg have been observed recently in the shallow well P01-03 suggesting a "breakthrough" of this TDS front across the entire depth of the aquifer;

- Manganese and zinc have also increased significantly in the aquifer along the north side of the Intermediate Dam; in May 2007, manganese and zinc concentrations in the deep well X24D had reached 50 mg/L and 0.1 mg/L, respectively; the shallow well P01-03 showed very similar increases in Mn but Zn has remained significantly lower (<0.02 mg/L) at shallow depth;

The recent increases in oxidation products and metal concentrations in the aquifer at X24 are significant and their cause should be further investigated. Note that the SO4 and Mg concentrations observed recently in the aquifer are significantly higher than observed in the Intermediate Pond (SO4 <1,000mg/L and Mg <70 mg/L), hence seepage from the Intermediate Pond can be ruled out as the main source of contamination. Instead, the source for this seepage must be located further upgradient. Possible upstream sources include (i) coarse tailings beaches located in the northern portion of the Intermediate, Second or Original Impoundments and/or seepage from the Faro Creek channel/diversion channel.

It is noted that SO4 and Mg concentrations observed at depth in X24 are significantly higher than observed at depth in X21 and, until 2007, in P03-06. This would suggest that additional loading occurs along the reach of the Intermediate Impoundment and/or that the shallow contaminant plume is dispersed to greater depths along the flow path. A more detailed hydrogeologic and geochemical analysis, including assessment of hydraulic gradients and geochemical fingerprinting would be required to determine the cause for the recent deterioration in groundwater quality in this portion of the Rose Creek aquifer (such an analysis was beyond the scope of this review).

In the southern portion of the Intermediate Dam (X25A/B, P01-04A/B):

- The groundwater quality in the aquifer beneath the southern portion of the Intermediate Dam shows significantly (3 to 4 times) lower SO4 and Mg concentrations than in the northern portion; zinc concentrations are typically < 0.1 mg/L;

- The groundwater quality does <u>not</u> show a significant increase in SO4 and Mg as observed along the north side, except possibly in well P01-04A[2];

In summary, groundwater in the northern portion of the aquifer shows significantly higher influence of ARD products (SO4, Mg, Zn, Mn) than on the southern side at the Intermediate Dam. Such a distinct difference has not been observed further up-gradient. Potential reasons for the higher TDS along the north side of the aquifer include (i) higher ARD loading on the northern side (e.g. from the coarse tailings beaches and/or seepage from the Faro Creek canyon and/or (ii) dilution from the Rose Creek Diversion along the south side.

Groundwater along the northern side has also experienced a significant increase in ARD products over the last six years. Additional analysis will be required to evaluate whether this increase is related to a recent increase in loading (e.g. X23 seepage, breakthrough of a TDS front in the coarse intermediate tailings) and/or represents a gradual breakthrough of a TDS plume from a near constant source.

2.2 Toe of Cross Valley Dam

Table 2 lists pertinent information of all groundwater monitoring wells located along the toe of the Cross Valley Dam, including year of construction, installation details (total depth, screening interval) and status of monitoring.

Table 2.

Monitoring wells at the toe of the Cross Valley Dam, Rose Creek Tailings Facility.

Well ID	Year of Construction	Total Depth (m bgs)	Top of Screen (m bgs)	Bottom of Screen (m bgs)	Top of Casing Elevation (m asl)	Current Status of Monitoring	Formation
Toe of Cross Valley Dam							
P01-02A	2001	14.1	12.54	14.06	1019.73	bi-annual	Alluvium
P01-02B	2001	28.4	26.88	28.4	1019.71	bi-annual	Till
P01-11	2001	10.7	9.15	10.67	1017.83	bi-annual	Alluvium
P03-09-01	2003	35.1	34.75	35.05	1018.51	bi-annual	Alluvium
P03-09-02	2003	32.3	32.00	32.31	1018.51	bi-annual	Alluvium
P03-09-03	2003	27.1	26.82	27.13	1018.51	bi-annual	Alluvium
P03-09-04	2003	23.8	23.47	23.77	1018.51	bi-annual	Alluvium
P03-09-05	2003	21.9	21.64	21.95	1018.51	bi-annual	Alluvium
P03-09-06	2003	18.9	18.59	18.90	1018.51	bi-annual	Alluvium
P03-09-07	2003	13.4	13.11	13.41	1018.51	bi-annual	Alluvium
P03-09-08	2003	9.4	9.14	9.45	1018.51	bi-annual	Alluvium
P03-09-09	2003	7.6	7.32	7.62	1018.51	bi-annual	Alluvium
MW1	2005	17.7	1.95/12.19	9.74/17.67	1016.97	not routinely monitored	Alluvium
MW2	2005	14.9	2.19	14.89	1018.23	not routinely monitored	Alluvium
P05-01-01	2005	25.5	25.15	25.45	1018.00	not routinely monitored	Till/BR
P05-01-02	2005	19.8	19.67	19.82	1018.00	not routinely monitored	Alluvium
P05-01-03	2005	16.8	16.62	16.77	1018.00	not routinely monitored	Alluvium
P05-01-04	2005	11.3	11.13	11.28	1018.00	not routinely monitored	Alluvium
P05-01-05	2005	5.5	5.33	5.48	1018.00	not routinely monitored	Alluvium
P05-01-06	2005	3.4	3.20	3.35	1018.00	not routinely monitored	Alluvium
P05-02	2005	5.2	1.83	4.88	1016.67	not routinely monitored	Alluvium
P05-03	2005	7.6	3.44	7.62	1019.79	not routinely monitored	Alluvium
RGC-PW1	2005	21.1	4.19/16.38	5.79/19.59	1017.31	not routinely monitored	Alluvium
RGC-PW2	2005	16.9	4.19	15.39	1018.64	not routinely monitored	Alluvium

Figures 4a/b show the water quality time trends in all wells screened near the toe of the Cross Valley Dam. Figures 5a/b and 6a/b show water quality depth profiles for selected dates in the multilevel wells P03-09 and P05-01, respectively. The groundwater quality in vicinity of the Cross Valley Dam shows significant transverse variations (from north to south) suggesting

[2] The time trends strongly suggest that the nested wells P01-04A and P01-04B were mislabeled sometime between the fall 2005 and spring 2006 sampling events; this should be checked by sounding the depth of

greater impact from mine waste seepage along the northern portion of the valley aquifer. The following observations can be made:

North Side of Cross Valley Dam (P01-11, P05-01 and P05-02);

- Groundwater in the northern portion generally shows elevated sulphate (~1,000 mg/L), magnesium (~75 mg/L), and alkalinity (~300 mg/L CaCO3eq); selected metal concentrations are also above background, including iron (10-20 mg/L), manganese (10-15 mg/L) and zinc (~0.03 mg/L);
- The depth profile at P05-01 suggests that groundwater quality is fairly uniform across the entire depth of the valley sediments; only the deepest monitoring point (P05-01-01) screened in highly cemented basal till shows a different composition, including lower sulphate (~400 mg/L) but higher sodium (120-140 mg/L) and higher alkalinity (400-500 mg/L); metal concentrations are also significantly lower at P05-01-01;
- Time trends at P01-11 indicate a gradual increase in SO4 and Mg over time; current SO4 and Mg concentrations are ~1,100 mg/L and ~80 mg/L (May 2007); alkalinity has also shown an increase over time (currently at ~300 mg/L CaCO3 eq); manganese and iron concentrations have also shown a moderate increase at P01-11 since start of monitoring in 2001 (currently at 27 mg/L Fe and 17 mg/L Mn, respectively);
- Despite this significant increase in oxidation products, zinc concentrations at P01-11 have remained at comparatively low concentrations, ranging from 0.01 to 0.1 mg/L; note that the method of detection limit (MDL) for zinc analysis have been very high in recent years (e.g. 0.025 mg/L for the May 2007 survey) making it difficult to assess zinc time trends in this portion of the aquifer (see RGC 2007 for a more in-depth discussion on QA/QC issues);
- The initial (limited) monitoring at P05-01 and P05-02 carried out since 2006 suggest that the increases in ARD products (SO4, Mg etc) observed at P01-11 are representative of the entire northern portion of the Rose Creek aquifer; future monitoring at P05-01 and P05-02 will be required to confirm this contention;

Central Portion of Cross Valley Dam (P03-09, P05-03);

- The groundwater in the central portion of the aquifer at the Cross Valley Dam (at P03-09 and P05-03) shows significantly lower concentrations of all ARD products: SO4 and Mg concentrations range from 300-500 mg/L SO4 and 30-40 mg/L Mg, respectively and all metals (including iron, manganese and zinc) show significantly lower concentrations (note that zinc was generally non-detect but the MDL for zinc was as high as 0.025 mg/L so the actual zinc concentrations in the middle portion of the aquifer are uncertain);
- Detailed depth monitoring at P03-09 indicates fairly uniform groundwater quality throughout the central portion of the sand & gravel aquifer with only slightly higher SO4 and Mg concentrations in the upper portion of the aquifer; only the two deepest ports

each well during future sampling

(screened in very compact basal TILL) show slightly higher sulphate, magnesium, and iron but lower manganese concentrations; zinc was also non-detect in the basal TILL unit;

- The initial (limited) time trend monitoring carried out at P05-03 since 2006 suggests that sulphate and magnesium concentrations are also increasing in the central portion of the aquifer. Note, however that such an increase is not readily apparent at P03-09, possibly due to the seasonal variations in groundwater quality observed at this location (more dilution in the spring sampling); additional monitoring will be required to confirm whether this portion of the aquifer is also showing a gradual deterioration in groundwater quality;

South Side of Cross Valley Dam (P01-2A/B);

- Groundwater in the southern portion of the aquifer is much more dilute than the northern, or even the central portion of the aquifer: SO4 and Mg concentrations range from 100-150 mg/L SO4 and ~25 mg/L Mg, respectively; zinc concentrations are usually below detection and iron and manganese are 1-2 orders of magnitude lower than in the central portion of the aquifer; note that sodium concentrations are also significantly lower (~15 mg/L) than observed elsewhere in the Rose Creek aquifer along this reach suggesting dilution by seepage from the Rose Creek Diversion Canal;
- The groundwater quality in the upper well (P01-02A screened in alluvium) and the lower well (P01-02B screened in basal Till) is generally very similar, except for slightly higher manganese in the upper S&G aquifer (~1 mg/L) and higher iron concentrations (0.8 mg/L) in the deeper till; groundwater quality in both wells has remained very stable over the last six years except for some initial changes in metal concentrations (possibly due to re-equilibration after drilling);

The recent increases in oxidation products and metal concentrations in the northern, and to a lesser extent, in the central portion of the Rose Creek aquifer at the Cross Valley Dam are significant and their cause should be further investigated. Note that the SO4 and Mg concentrations observed recently in the aquifer are significantly higher than observed in the Polishing Pond (SO4 <700mg/L and Mg <40 mg/L), hence seepage from the Polishing Pond can be ruled out as the main source of contamination. Instead, the source for this seepage must be located further upgradient. Note that the chemical composition of the impacted groundwater on the northern side of Cross Valley Dam (P01-11, P05-01 and P05-02) is very similar to that observed on the north side further upgradient at the toe of the Intermediate Dam (at X24C/D) around 2002 (c. Figures 2a/b). It is therefore likely that the breakthrough of ARD products observed at the Cross Valley Dam represents the "leading edge" of the breakthrough observed further upgradient at the Intermediate Dam. If this hypothesis is correct, concentrations of ARD products (including metals such as Mn and Zn) can be expected to further increase in the wells located downgradient of the Cross Valley Dam over time.

Considering the proximity of the Cross Valley Dam to Rose Creek and the potential for groundwater discharge and contaminant loading to Rose Creek (in particular under baseflow conditions) we recommend that a more detailed hydrogeologic and geochemical analysis, including assessment of hydraulic gradients and geochemical fingerprinting be completed, in particular in the reach between the Second Impoundment and the Cross Valley Dam, to determine the cause for the recent deterioration in groundwater quality along the northern portion of the Rose Creek aquifer. As part of this study it should be investigated to what extent seepage from the Faro Creek canyon (as opposed to seepage from the tailings impoundments) is responsible for the recent increases. In the author's opinion, this issue is relevant for predicting future groundwater quality time trends in the Rose Creek aquifer, and may also have a bearing on the selection of a final closure option for the Rose Creek Tailings Facility.

2.3 Downstream of Cross Valley Dam

Table 3 lists pertinent information of all groundwater monitoring wells located downgradient of the Cross Valley Dam, including year of construction, installation details (total depth, screening interval) and status of monitoring.

Table 3.

Monitoring wells downgradient of the Cross Valley Dam, Rose Creek Tailings Facility.

Well ID	Year of Construction	Total Depth (m bgs)	Top of Screen (m bgs)	Bottom of Screen (m bgs)	Top of Casing Elevation (m asl)	Current Status of Monitoring	Formation
Downgradient of Cross Valley Dam							
X16A	1981	6.0	3	6	1016.41	bi-annual	Alluvium
X16B	1981	34.0	20	34	1016.01	bi-annual	Alluvium
X17A	1981	6.2	4.5	6.2	1015.45	bi-annual	Alluvium
X17B	1981	25.0	17	25	1014.89	bi-annual	Alluvium
X18A	1981	10.6	8.8	10.6	1019.59	bi-annual	Alluvium
X18B	1981	22.8	16.6	22.8	1019.65	bi-annual	Alluvium
P01-01A	2001	21.4	19.8	21.36	1015.86	bi-annual	Alluvium
P01-01B	2001	35.3	33.78	35.3	1015.86	bi-annual	Alluvium

Figures 7a/b show the water quality time trends in all wells screened downgradient of the Cross Valley Dam. The recent time trends can be summarized as follows:

North Side of Rose Creek Aquifer (P01-01A/B and X18A/B):

- Monitoring wells X18A/B and P01-01A show very similar time trends in groundwater quality, with a gradual increase in sulphate, magnesium and alkalinity; the highest concentrations were observed in the most recent survey (May 2007) with ~600 mg/L SO4, ~60 mg/L Mg, and ~260 mg/L CaCO3eq; metal concentrations have generally remained low and show no clear increasing trend except for manganese in P01-01A (~4.5 mg/L in May '07); time trends in zinc concentrations have been fairly erratic, at least in part due to problems with the high detection limits for zinc in recent years (see section 3.7.4);

- Monitoring well P01-01B (screened in deep alluvium) has not shown the same recent increases (since 2001) in sulphate and magnesium as observed elsewhere on the north side; note also that manganese concentrations have also remained very low (~0.1 mg/L) in P01-01B;

Central Portion of Rose Creek aquifer (X16A/B and X17A/B):

- The monitoring wells screened in the central portion of the Rose Creek aquifer (at X16A/B and X17A/B) generally show significantly less impact than on the north side, with all ARD products (SO4, Mg, Na and metals) at significantly lower concentrations; however the water quality time trends in those two sets of piezometers show some important differences:
    - Monitoring well X17B, screened in the deeper portion of the alluvial aquifer, has recently shown an increase in most major ions, including SO4, Mg, Na and alkalinity; in addition, iron and manganese concentrations have also shown a slight increase (again, zinc time trends could not be evaluated due to problems with the high MDL); note that the recent time trends also show a distinct seasonal trend, with higher concentrations typically observed during the spring/early summer;
    - Monitoring wells X17A and X16A, both screened in the upper portion of the alluvial aquifer, and X16B (screened in the deeper portion of the aquifer) have not shown the same recent increases in major ions or metals, as observed at X17B;

In summary, the groundwater quality time trends observed in the Rose Creek aquifer further downgradient of the Cross Valley Dam mimic the trends observed along the toe of the Cross Valley Dam, with higher impacts observed on the northern side of the aquifer. The sulphate and magnesium concentrations currently observed further downgradient (at X18A/B and P01-01A) are similar to those observed several years earlier at the toe of the Cross Valley Dam (around 2002 in P01-11). This would suggest that the recent increases in sulphate and magnesium represent the "leading edge" of the contaminant plume observed in the northern portion of the aquifer (at the Cross Valley Dam and Intermediate Dam). In the author's opinion, sulphate and magnesium concentrations will likely continue to increase in wells located along the north side downgradient of the Cross Valley Dam. Further increases in sulphate and magnesium will likely precede any significant increases in zinc or other metals (Fe, Mn).

The recent increases in major ion and selected metal concentrations at X17B differ from that observed elsewhere in that (i) increases in sulphate and magnesium are also accompanied by significant increases in sodium and alkalinity, and (ii) the increases show significant seasonal variations. Elevated sodium and alkalinity levels have also been observed in the deep monitoring points at P03-09 and P05-01, which are screened in compact, basal till. It is therefore possible that the observed seasonal increases in major ions at X17B reflect increased contributions of deep groundwater upwelling from underlying bedrock and/or basal till, in particular during the spring runoff season.

The chemical composition and low ionic strength of the groundwater observed in the other wells (at X17A and X16A/B) is similar to that observed along the southern abutment of the Cross Valley Dam (P01-02A/B). As discussed earlier, leakage of very dilute surface water from the Rose Creek Diversion likely provides significant dilution to the groundwater in the Rose Creek aquifer in those areas.

3.0 Implications for 2008 Field Program

At this point in the closure program design, it is anticipated that a groundwater capture system will be located downstream of the Intermediate Dam (ID) or the Cross Valley Dam (CVD). The final location will be determined by the closure alternative decided for this area. The recent deterioration in groundwater quality in the Rose Creek aquifer in all reaches of the Rose Creek Tailings Facility, i.e. not only within the footprint area of the tailings impoundments but further downstream at the Intermediate Dam and the Cross Valley Dam, emphasizes the need for such an interception system in the not too distant future.

Recent groundwater quality monitoring has also clearly demonstrated that the contamination is occurring throughout the entire depth of the aquifer (at least on the north side); this implies that any groundwater interception system (extraction wells, hydraulic barrier etc) will have to penetrate the entire depth of the aquifer and possibly be keyed into the underlying competent till and/or bedrock. These findings support the need for the planned 2008 field investigation program which is aimed at characterizing the hydraulic properties and groundwater quality of the bedrock unit(s) underlying the alluvial sediments in the vicinity of the Cross Valley Dam.

The recent time trends have also confirmed that the north side of the Rose Creek aquifer is significantly more impacted than the southern, or even central portion of the aquifer. If the bedrock is permeable and hydraulically connected to the overlying sediments similar differences in groundwater quality might be expected in the groundwater residing in the underlying bedrock. We therefore recommend that, at a minimum, one monitoring well each be completed in the northern, central and southern portion of the Rose Creek valley for future monitoring as part of the 2008 field investigation.

4. Closure

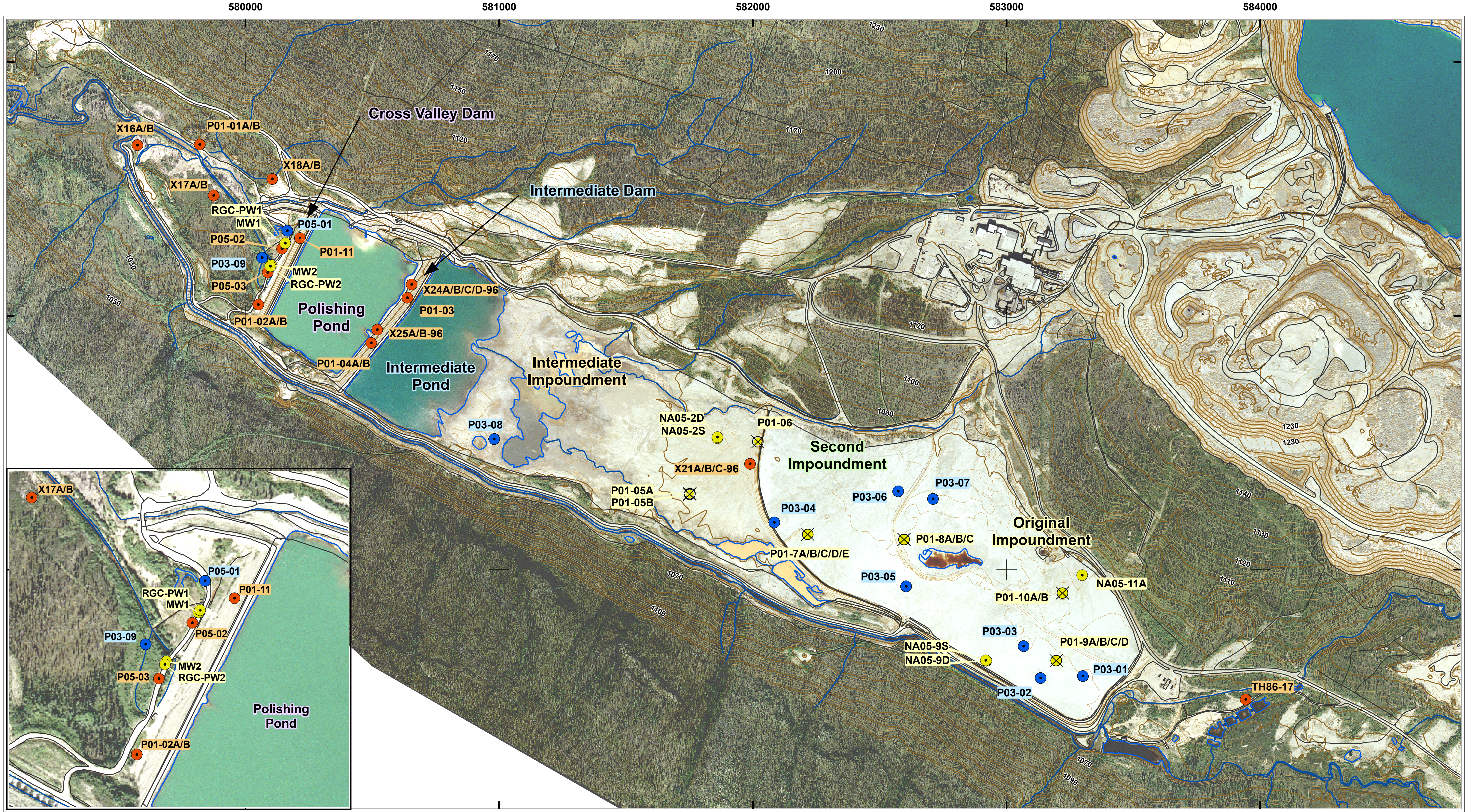
We trust that this memo contains the information required to meet your needs at this time. Please contact the undersigned if you have any questions regarding this memo.

ROBERTSON GEOCONSULTANTS INC.

Christoph Wels, Ph.D.
Principal Hydrogeologist

Attachments:
16 figures (figure 1 in internet version only)

FIGURES



LEGEND

- Monitoring Well
- Multilevel Monitoring Well
- Other Well (not Monitored Routinely)
- Decommissioned Well

PROJECTION: UTM
ZONE: 8
DATUM: NAD 27
UNITS: Meters

CONTOUR INTERVAL: 2M

N
W E
S

SCALE

0 205 410 820 1,230 1,640 Meters

Groundwater Monitoring Wells
Rose Creek Tailings Facility
Anvil Range Mining Complex

Deloitte & Touche

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

CLIENT: Deloitte & Touche Inc.
PROJECT: 2007 Groundwater Review
REPORT: RGC 118012
LOCATION: Anvil Range Mining Complex,YT, Canada

FIGURE: 1

DATE: Feb - 08
DRAWN BY: OM
FILE: Faro_Tailing_area.mxd

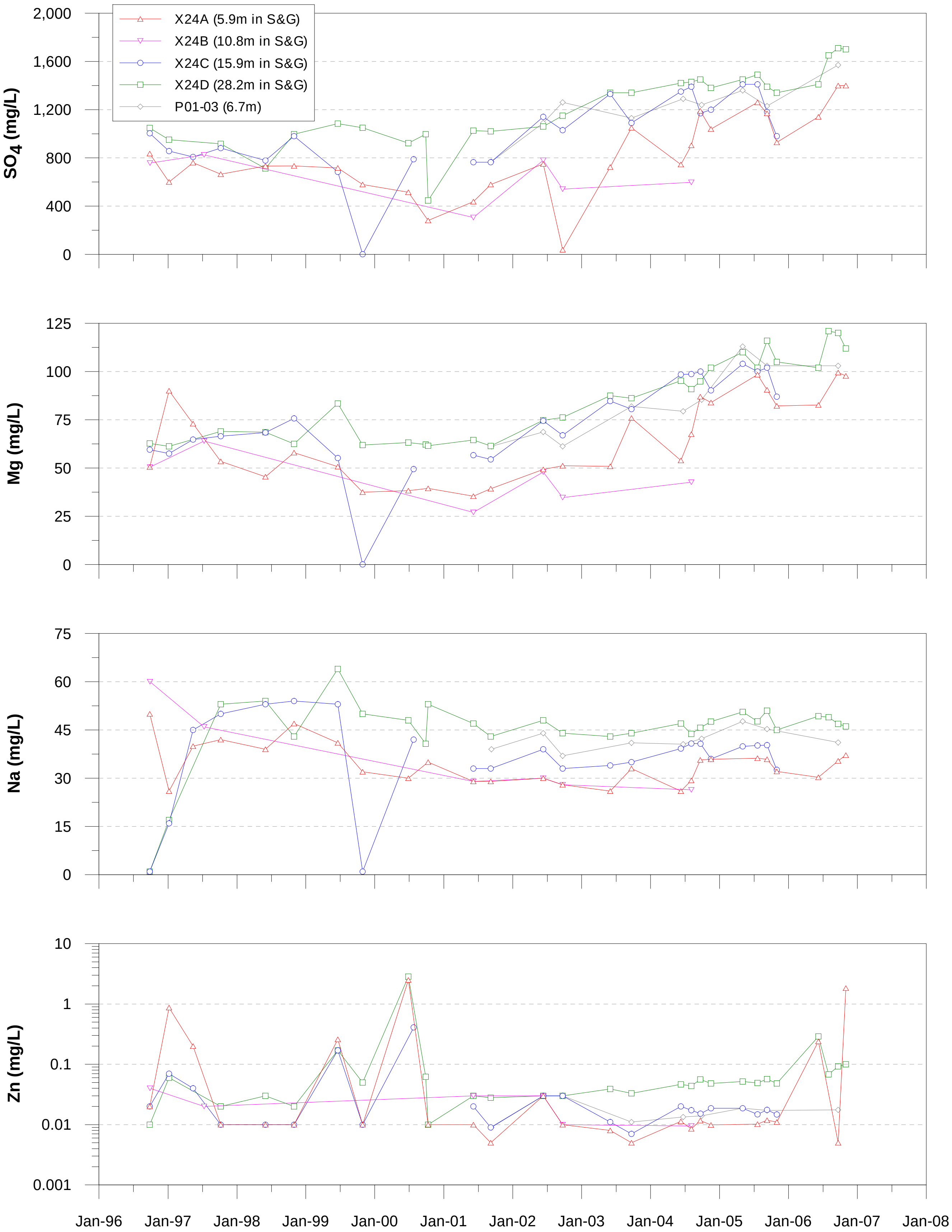


Figure 2a. Water quality (SO_4, Mg, Na and Zn) in X24(96) and P01-03 (north side of Intermediate Dam).

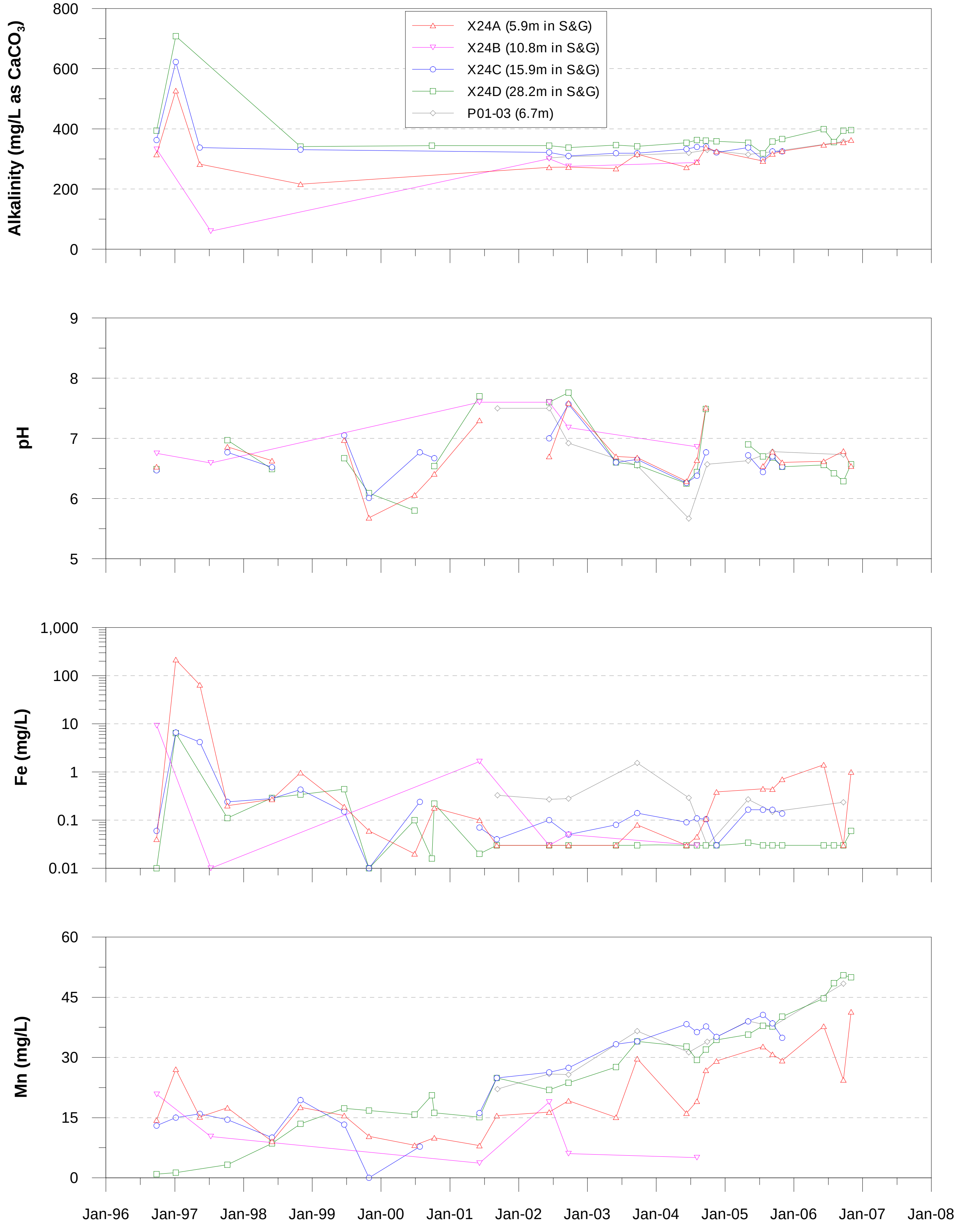


Figure 2b. Water quality (alkalinity, pH, Fe and Mn) in X24(96) and P01-03 (north side of Intermediate Dam).

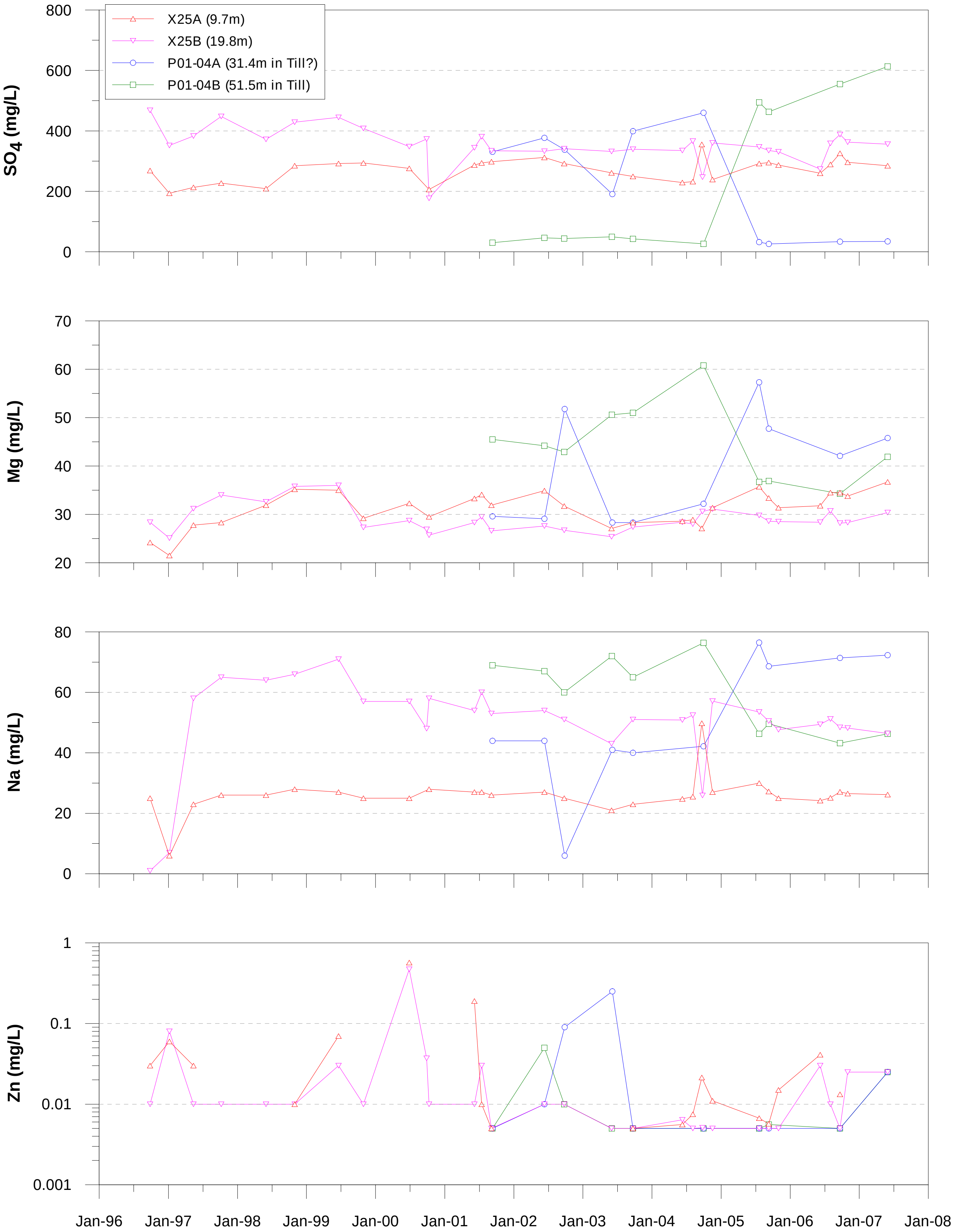


Figure 3a. Water quality (SO_4, Mg, Na and Zn) in X25(96) and P01-04 (south side of Intermediate Dam).

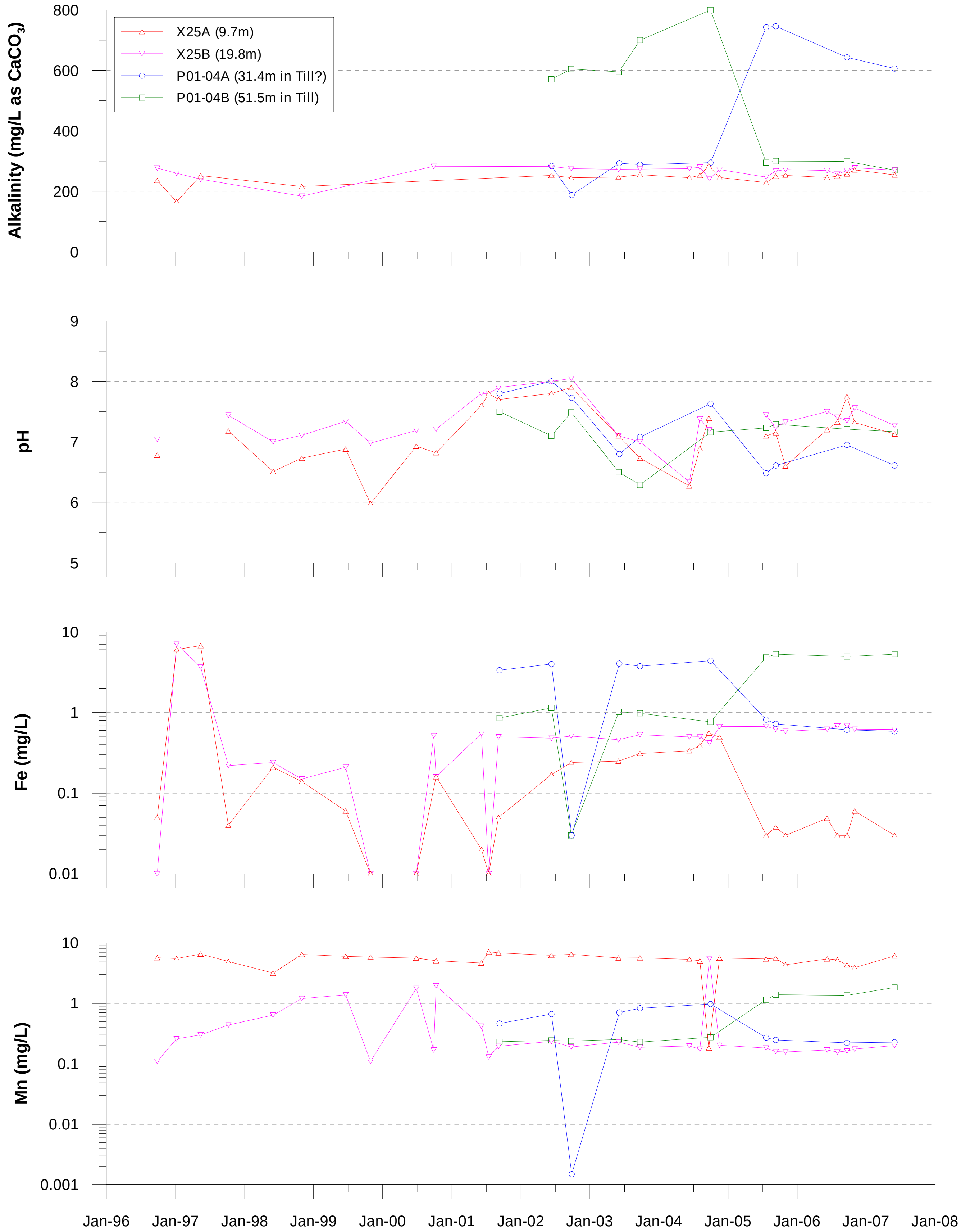


Figure 3b. Water quality (alkalinity, pH, Fe and Mn) in X25(96) and P01-04 (south side of Intermediate Dam).

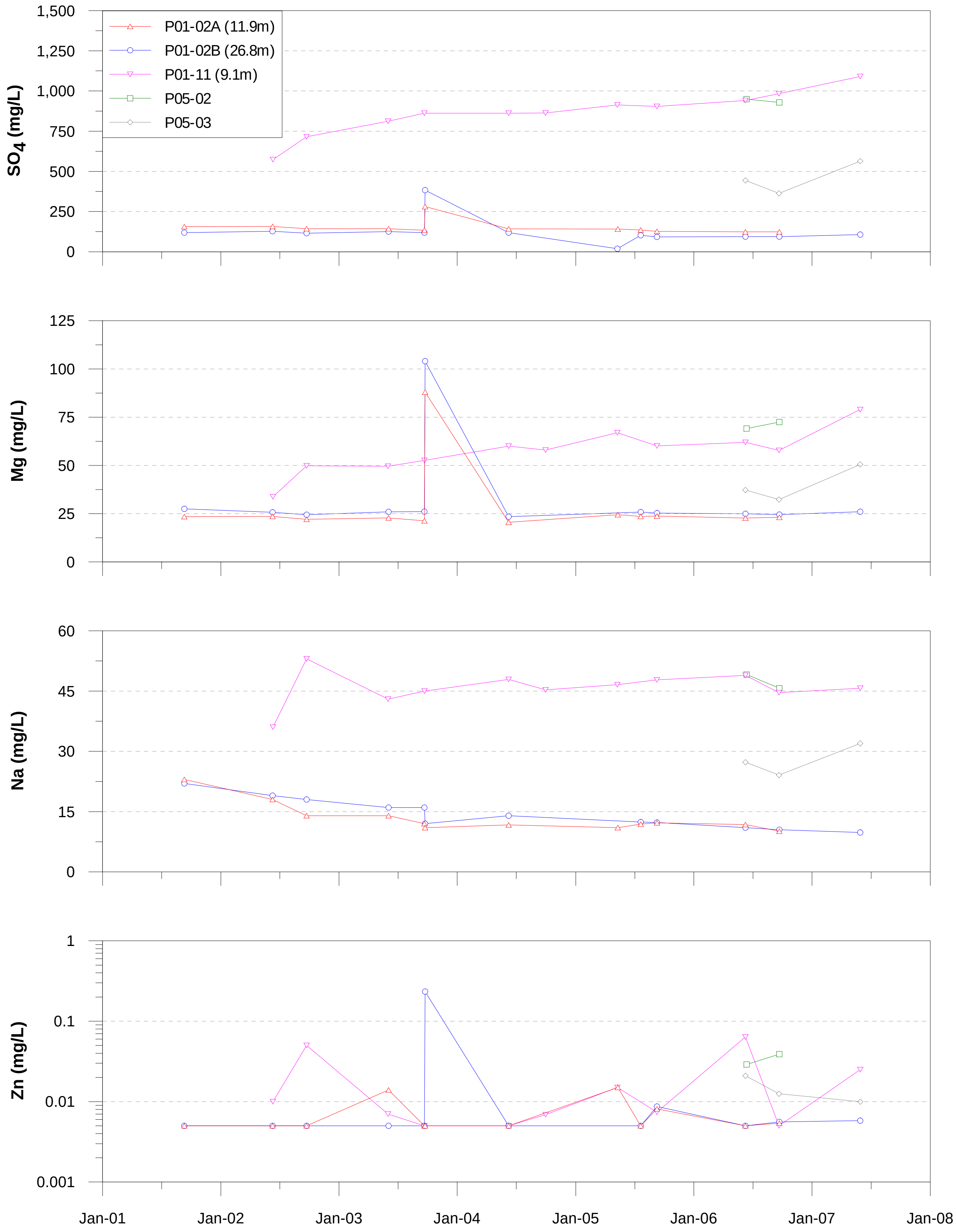


Figure 4a. Water quality (SO_4, Mg, Na and Zn) in wells along toe of Cross Valley Dam.

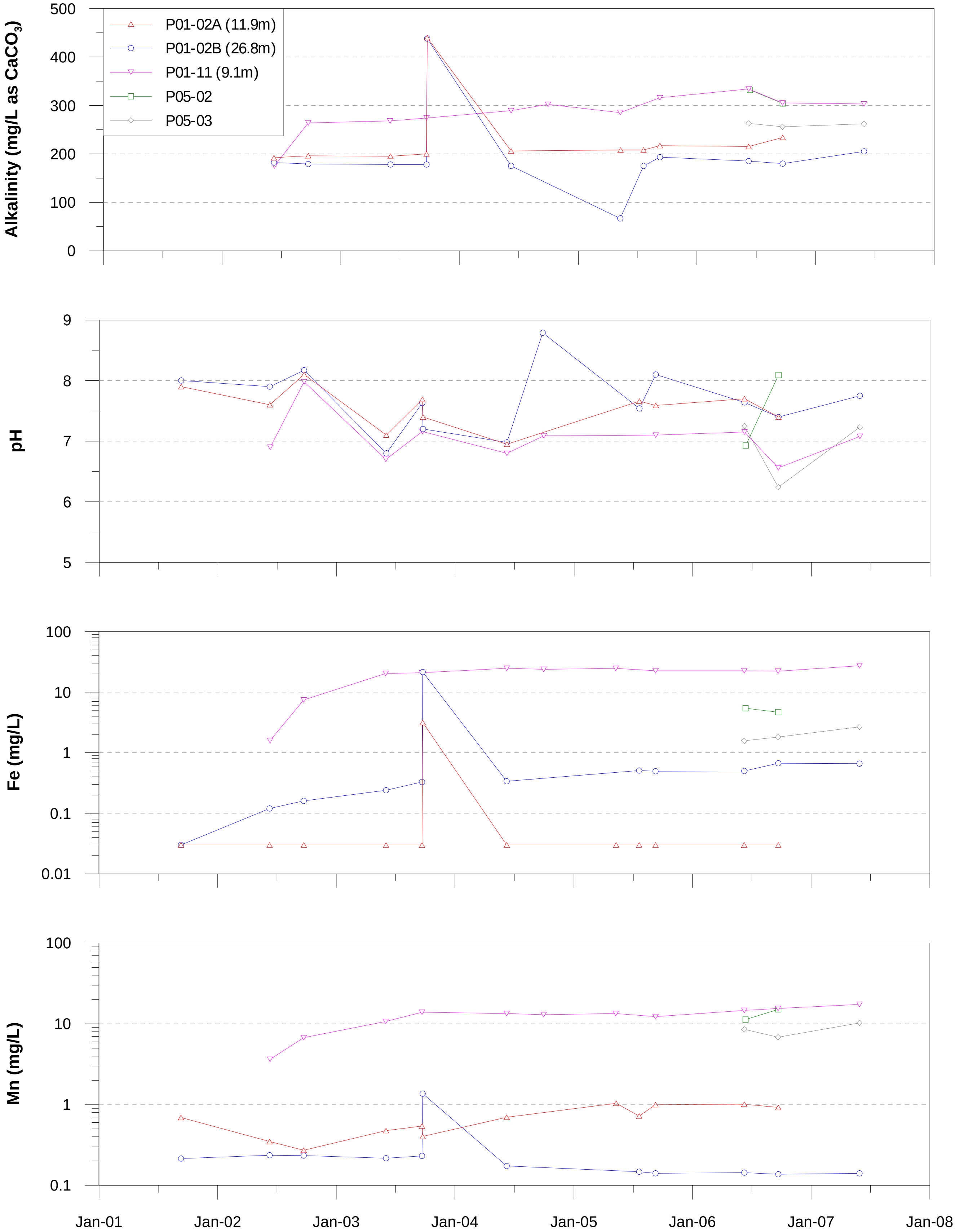


Figure 4b. Water quality (alkalinity, pH, Fe and Mn) in wells along toe of Cross Valley Dam.

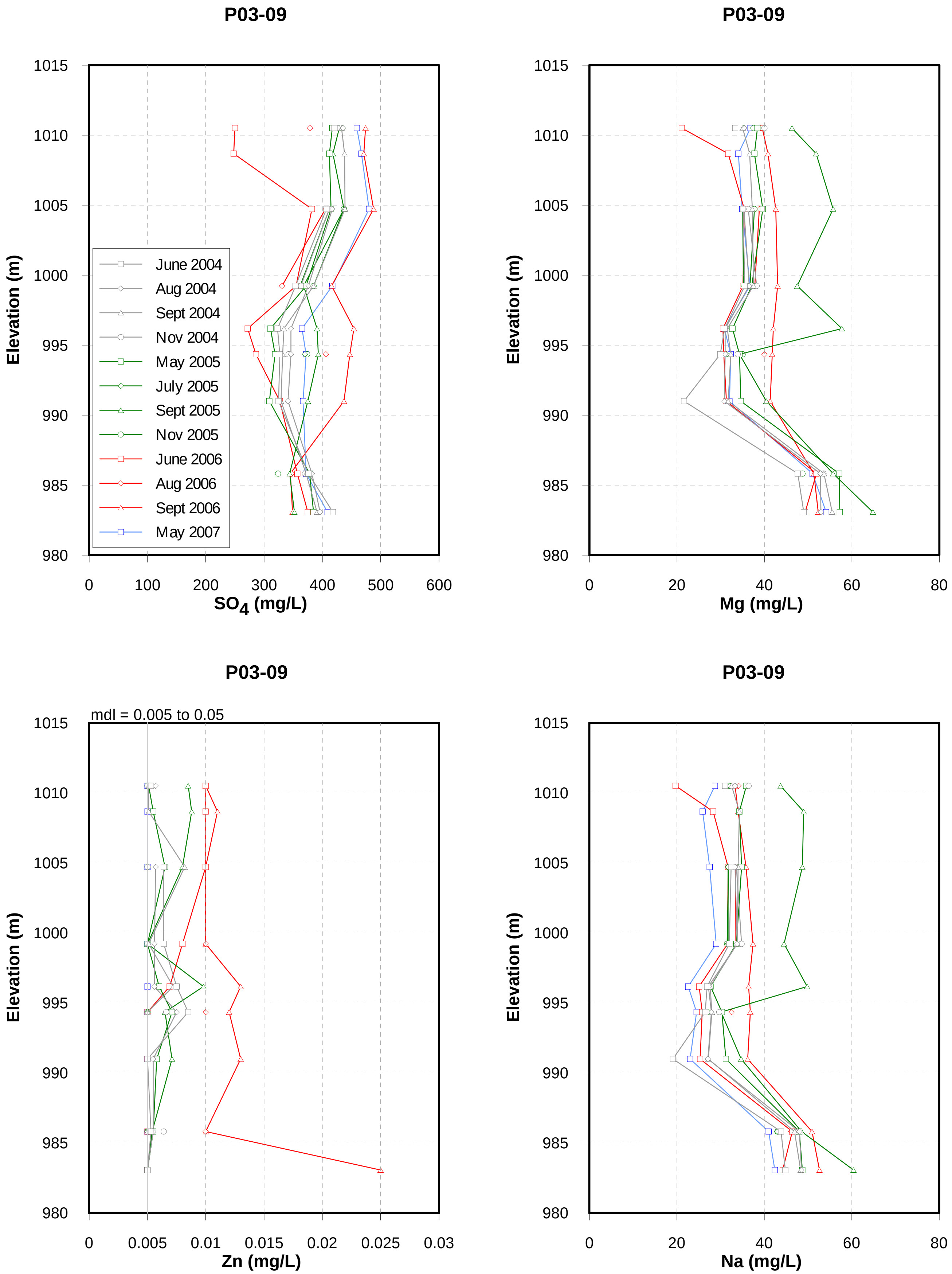


Figure 5a. Water quality depth profiles of SO_4, Mg, Zn and Na in P03-09 (at Cross Valley Dam).

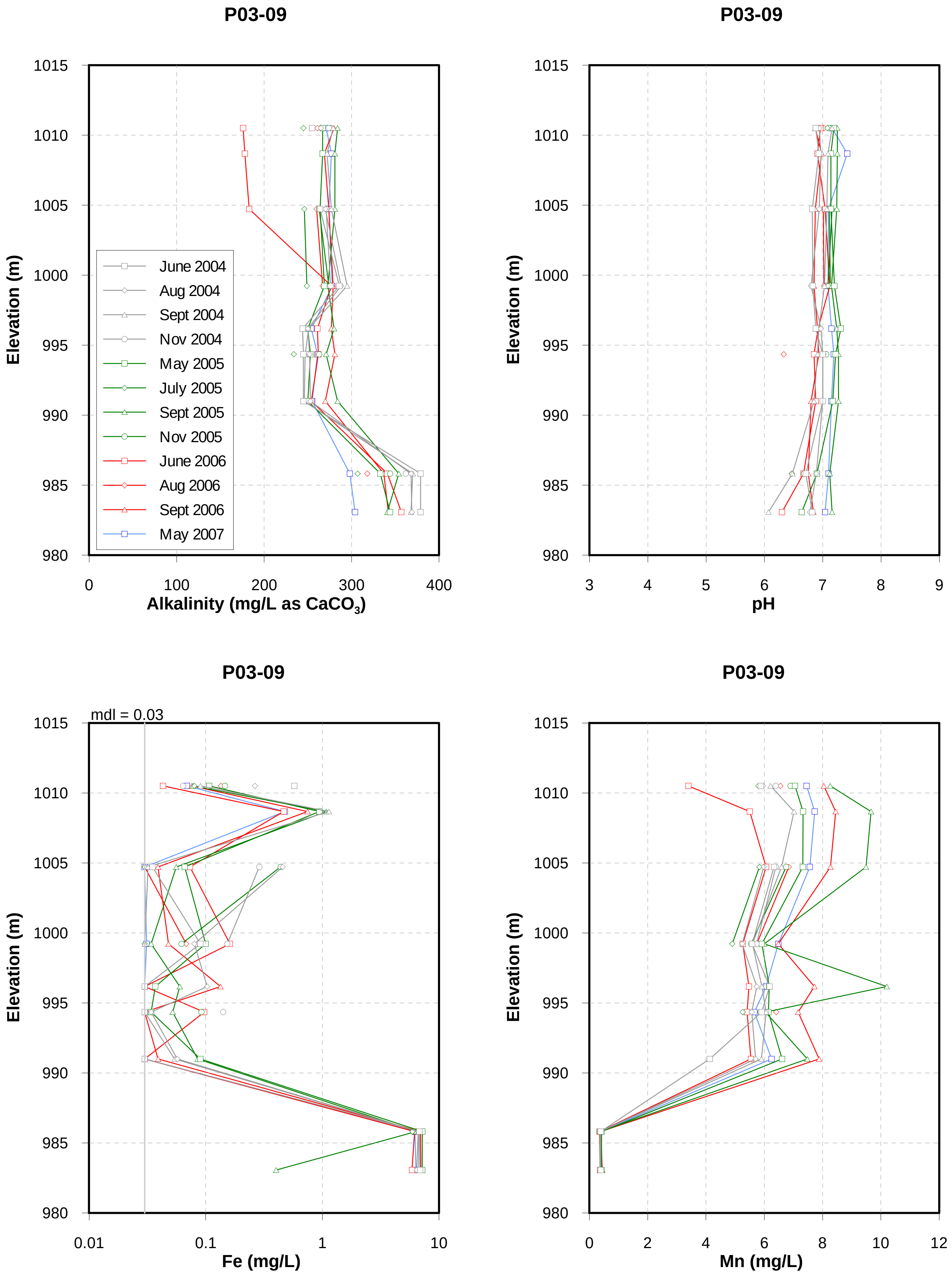


Figure 5b. Water quality depth profiles of alkalinity, pH, Fe and Mn in P03-09 (at Cross Valley Dam).

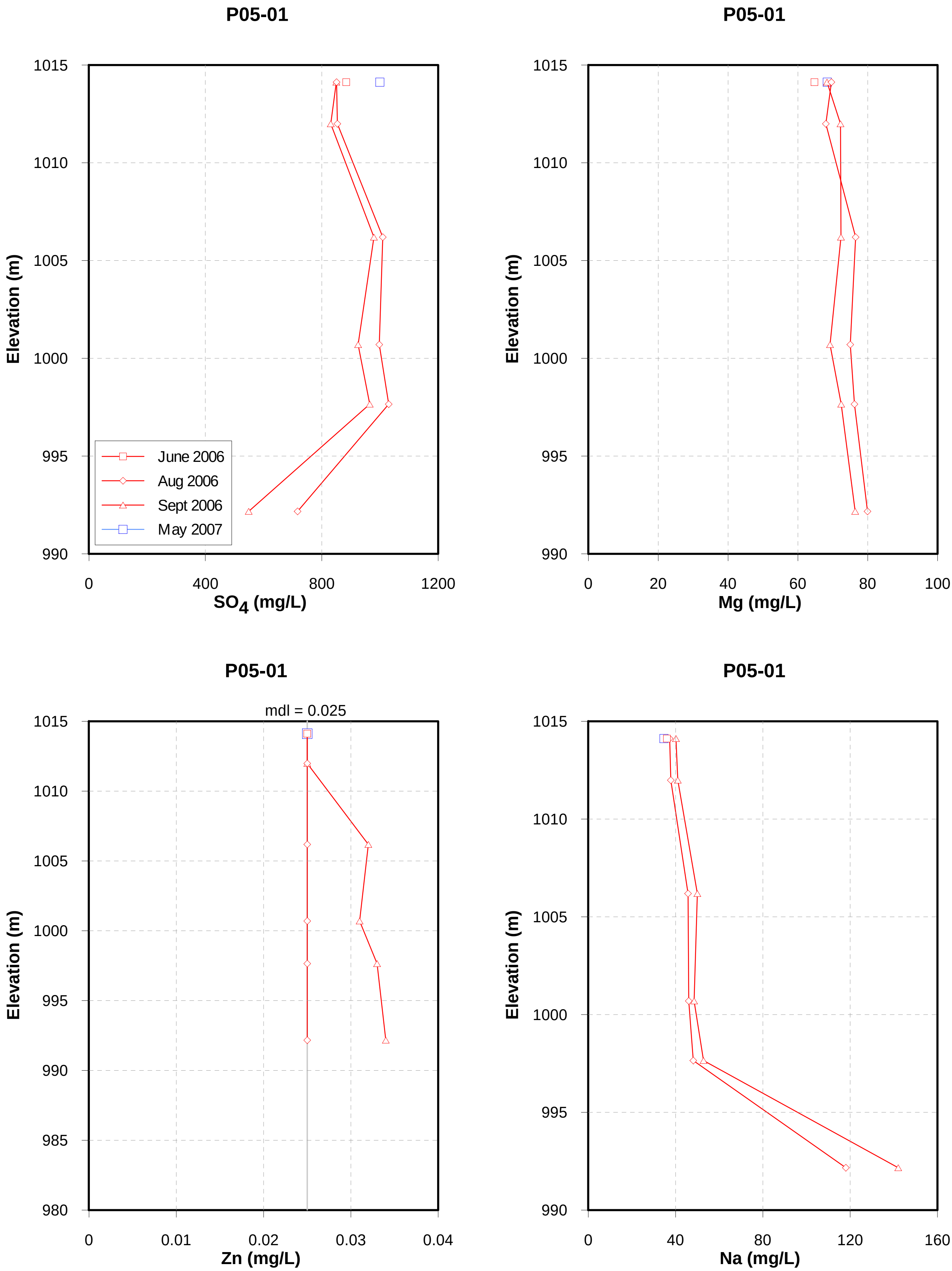


Figure 6a. Water quality depth profiles of SO_4, Mg, Zn and Na in P05-01 (at Cross Valley Dam).

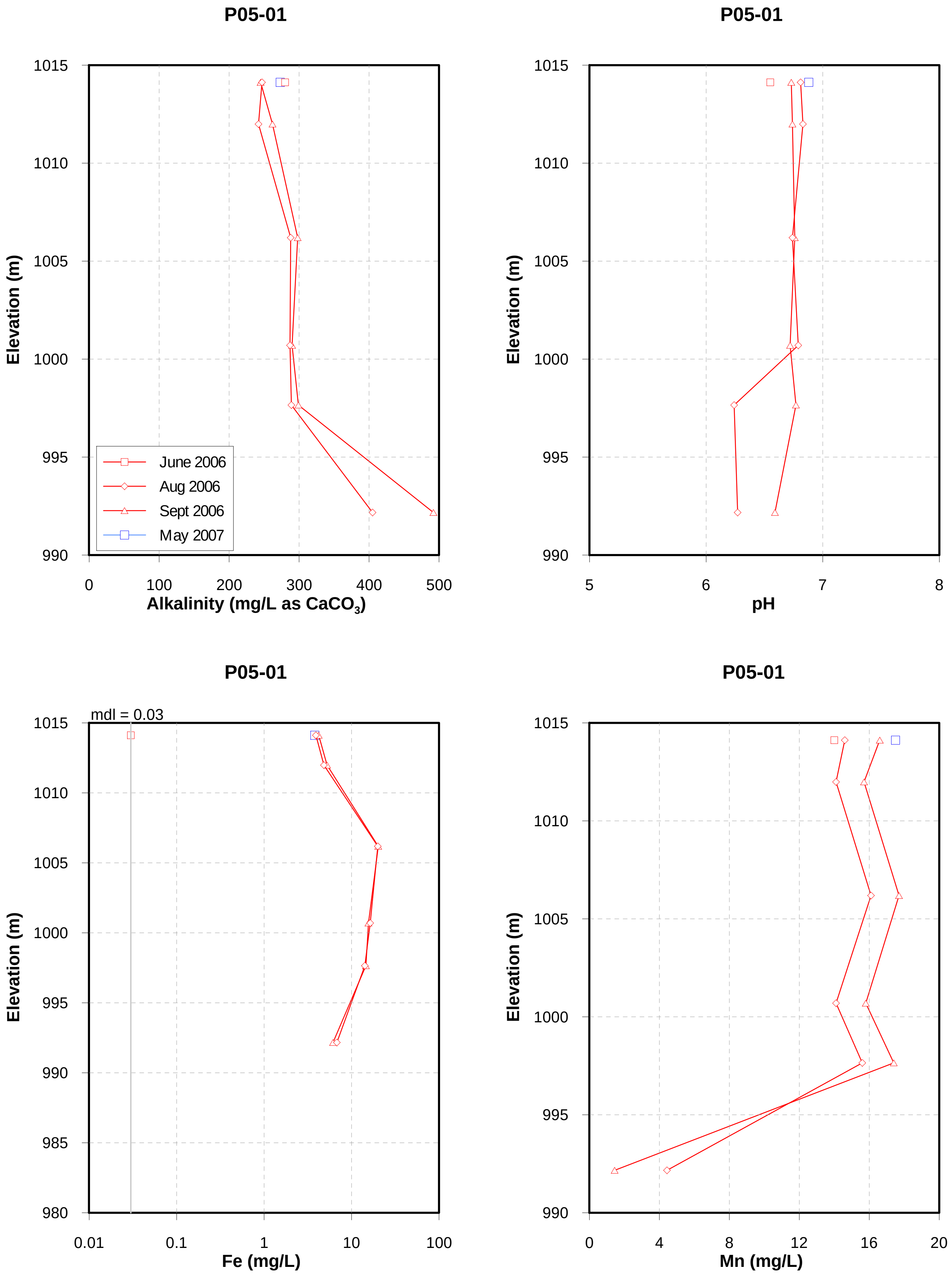


Figure 6b. Water quality depth profiles of alkalinity, pH, Fe and Mn in P05-01 (at Cross Valley Dam).

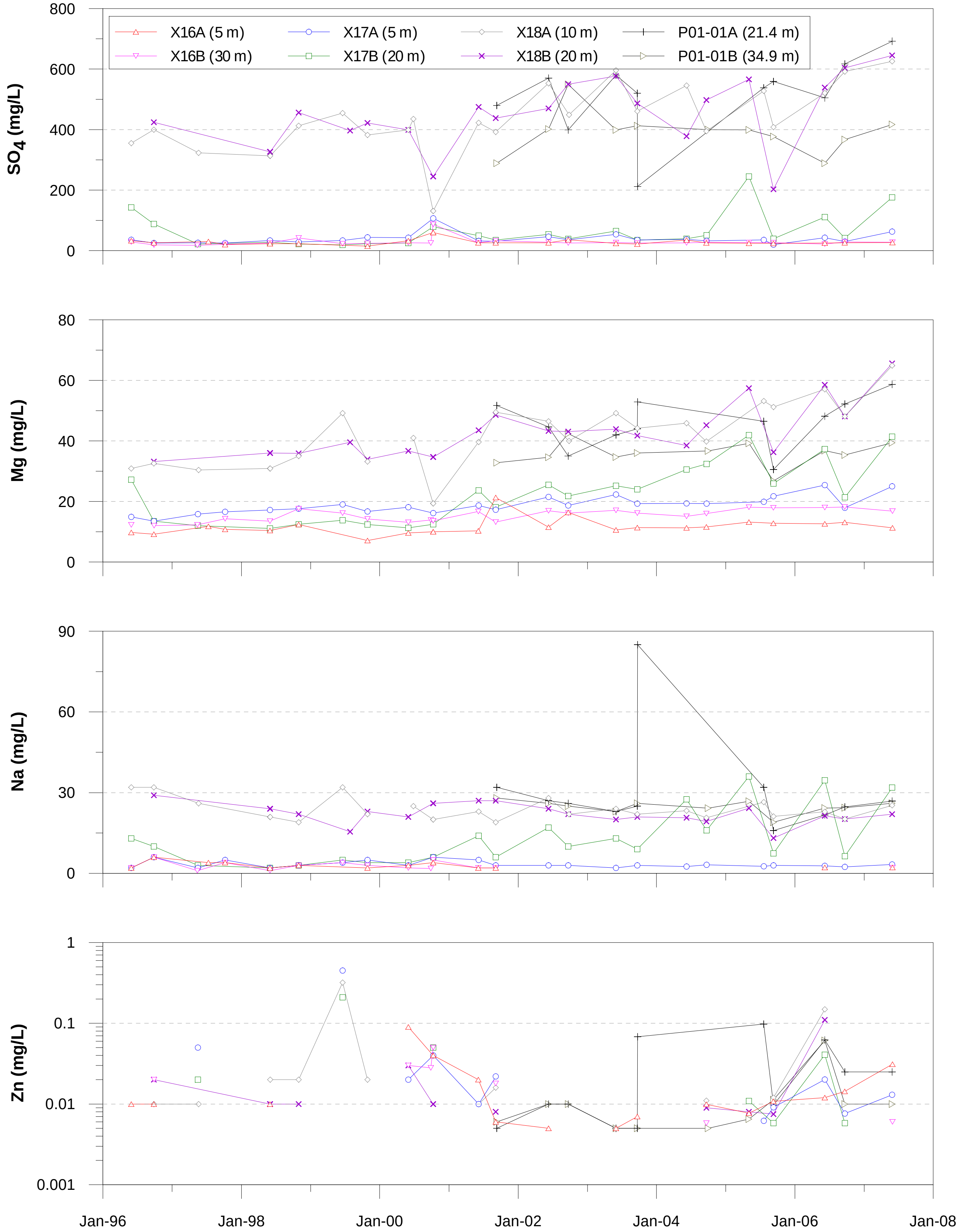


Figure 7a. Water quality (SO_4, Mg, Na and Zn) in wells downgradient of Cross Valley Dam.

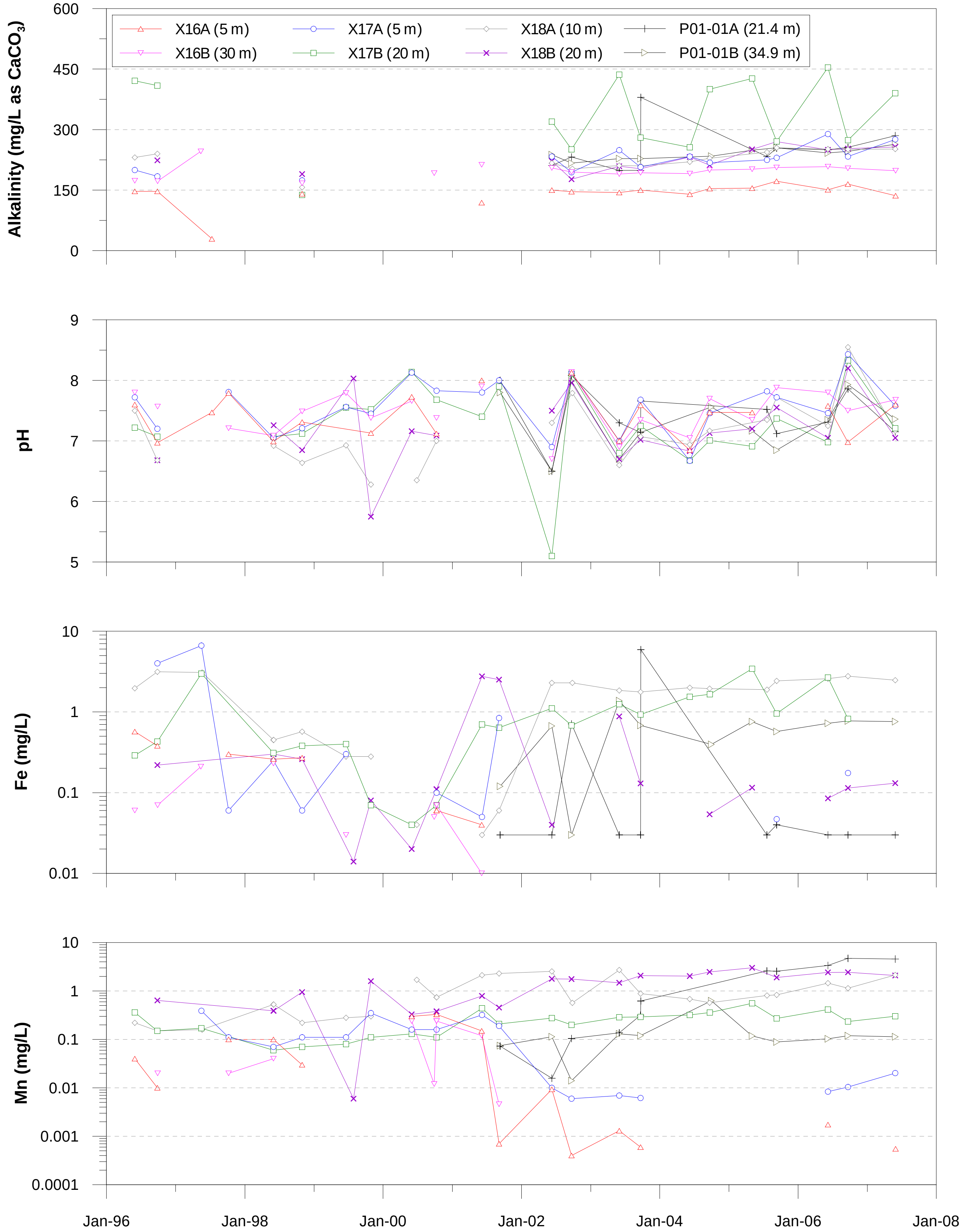


Figure 7b. Water quality (alkalinity, pH, Fe and Mn) in wells downgradient of Cross Valley Dam.