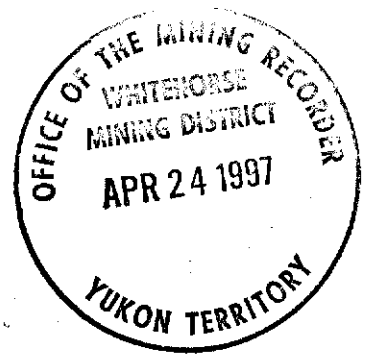
Report No. 033002/1



Anvil Range Mining Complex -

1996 Drilling And Piezometer Installation Program

Prepared for:

Anvil Range Mining Corporation

Prepared by:

ROBERTSON GEOCONSULTANTS INC.

093636

in association with

STEFFEN, ROBERTSON AND KIRSTEN (CANADA) INC.

ROBERTSON GEOCONSULTANTS INC.

A Robertson Group Company

Consulting Geotechnical and Environmental Engineers

Suite 902, 580 Hornby Street, Vancouver, B.C. Canada V6C 3B6
Phone: (604) 684-8072 Fax: (604) 681-4166
E-mail: andyr@info-mine.com

Project No. 033002

January 21, 1996

ANVIL RANGE MINING CORPORATION
117 Industrial Road
Whitehorse, Yukon
Y1A 2T8
Ph. : 403 668 4866
Fax: 403 633 3216

Attention: Eric Denholm
Sr. Environmental Engineer

Dear Eric:

Re: Report on 1996 Drilling and Piezometer Installation Program

Please find enclosed two copies of the final report providing details on the Drilling and Piezometer Installation Program conducted during the period August 28 to September 10, 1996 at the Faro and Vangorda Plateau minesites. As requested, one copy is unbound for further reproduction of the report.

As outlined in the report, we recommend that all but two of the new piezometers be included into the routine water quality monitoring program currently conducted by Anvil Range Mining Corporation. A semi-annual sampling interval is recommended.

Two piezometers (MW96-1 and MW96-2) were screened within the granular toe drain of the Intermediate Dam to allow monitoring of pore pressures within the dam. Piezometric readings indicate that currently no significant excess pore water pressures exist within the toe drain. It is recommended to monitor the water levels in these two piezometers on a semi-annual basis.

We trust that this document satisfies your needs.

Yours sincerely,

ROBERTSON GEOCONSULTANTS INC.

Christoph Wels, Ph.D.
Senior Hydrogeologist

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Anvil Range Mining Complex -

1996 Drilling and Piezometer Installation Program

1. Background

1.1 Introduction

Robertson GeoConsultants Inc. (RGC) was retained by Anvil Range Mining Corporation (ARMC) in 1996 to supervise the drilling and hydraulic testing program of several monitoring wells at the Anvil Range minesite.

The majority of these wells were to be drilled in two distinct localities at the Faro minesite:

- Rose Creek Tailings area
- downstream of the Faro rock dumps

The monitoring wells located in the Rose Creek tailings area were intended to replace older (destroyed) monitoring wells which are required sampling stations as part of the existing Faro water licence (IN #89-001, Schedule D) whereas those near the Faro rock dumps represent new monitoring sites.

Additional monitoring wells were to be installed downstream of the Grum Main rock dump at the Vangorda Plateau minesite.

The primary use of all these monitoring wells is to monitor groundwater quality downgradient of the waste rock dumps and tailings.

The number and approximate locations of the monitoring wells were initially decided by Eric Denholm, ARMC, and Dr. Christoph Wels, RGC, during the site visit on July 11-12. Detailed terms of reference for this project were provided in a letter proposal submitted to ARMC on July 19, 1996. As outlined in this proposal, RGC was responsible for supervision of the drilling and piezometer installation work, logging of boreholes and well development. RGC was also responsible for hydraulic testing of monitoring wells at selected sites. The drilling work was contracted out directly to Midnight Sun Drilling Ltd. of Whitehorse, Yukon Territory.

A total of ten boreholes were drilled and 17 piezometers installed at the Faro and Vangorda Plateau minesites. Some aspects of this field investigation (in particular ground water quality) have already been described in the Integrated Conceptual Abandonment Plan (ICAP) for the Anvil Range Mining Complex (RGC Report No. 033001/3). The present report gives a detailed description of the field investigation including drilling, monitoring well installation, hydraulic testing, and the initial round of groundwater quality sampling carried out by ARMC.

1.2 Location and Description

The Anvil Range Mining Complex, currently owned and operated by Anvil Range Mining Corporation, is located near the town of Faro, approximately 200 km NNE of Whitehorse, the capital of Yukon Territory (Figure 1). The Anvil Range Mining Complex consists of the Faro mine site located approximately 15 km north of the Faro town site, and the Vangorda Plateau mine site located approximately 9 km northeast of the Faro town site. The Faro mine site includes the Faro Pit and Dumps, mill facilities as well as a series of tailings impoundments (Figure 2). The Vangorda Plateau minesite includes the Vangorda Pit and Dumps as well as the Grum Pit and Dumps (Figure 3).

1.3 Regional Hydrogeology

The study area is underlain almost exclusively by bedrock consisting of schists and phyllites of Proterozoic and Paleozoic age, which have been intruded by Mesozoic granodiorites and quartz monzonites of the Anvil Batholith. This bedrock does not contain deep, contiguous aquifers of any significant size. Groundwater flow in bedrock occurs predominantly along structural features such as fault zones and individual fractures provided the bedrock is competent and supports open fractures. The anisotropy of groundwater flow is further enhanced by the schistosity of the bedrock in the study region.

Most groundwater flow in the study region is confined to local, shallow aquifers in surficial deposits of glacial till, colluvium and/or alluvial sediments. These surficial deposits are distributed irregularly within the region, typically comprising thin deposits in the upland areas and thicker deposits in the valleys. The direction of shallow groundwater flow is largely controlled by surface and/or bedrock topography. In many uphill areas surficial sediments comprise only a thin veneer of glacial till over bedrock, and shallow groundwater flow occurs at the bedrock/overburden interface, often within a narrow zone of intensely weathered bedrock and overlying permeable sediments. In those upland areas with deeper surficial deposits, groundwater is often confined to narrow zones of permeable sand and gravel which represent high-permeability conduits that deliver shallow groundwater from the hillsides to the valley bottoms.

Shallow groundwater from the hillsides either discharges to surface waters or flows into a valley aquifer located further downstream. The largest aquifer located within the Anvil Range Mining Complex is the Rose Creek Valley aquifer which underlies the Rose Creek Valley Tailings Facility. The sediments in this valley consist of a complex of fluvial and glaciofluvial sands and gravels with irregular and apparently discontinuous fine grained deposits. The fine grained deposits are either lacustrine, silty till-like soils or fine grained layers in flood plain deposits. The sands and gravels and the fine grained portions of the valley fill have all been dissected by fluvial and glacial action. A till layer has been encountered in most places between bedrock and the aquifer complex and in

many areas a thin till-like layer has been reported to overlie the aquifer on the original ground surface (RGC, 1996).

2. Field Investigation

The drilling and piezometer installation/testing work was undertaken from August 28 to September 10, 1996 under the supervision of Mr. Todd Hamilton (SRK Canada Inc.) and Dr. Christoph Wels (Robertson GeoConsultants Inc.). The initial round of groundwater quality sampling was carried out by ARMC staff from September 25 to October 9, 1996 as part of their routine water licence sampling program.

2.1 Drilling and Monitoring Well Installation

2.1.1 Methodology

Drilling was performed by Midnight Sun Drilling of Whitehorse, Y.T., using a track-mounted ODEX air rotary drill. The ODEX system utilizes an eccentric (off-centred) drill bit to under-ream the borehole, allowing casing to fall into place behind the bit. Borehole diameter was approximately 175 mm (7"). The ODEX feature is most useful when drilling through boulders or waste rock, and promotes ease of casing removal. The drilling rig was equipped with a portable hydraulic hammer, enabling the collection of SPT (Standard Penetration Test) data and split-spoon soil samples. Soil and groundwater (where practicable) samples were collected at 3.1 m (10 ft) intervals, or when a change in lithology or groundwater conditions was encountered.

Soil samples were logged in the field with respect to composition, colour, moisture content and evidence of contamination. Groundwater samples were decanted, and measurements of electrical conductance (EC) and pH taken in the field, in order to assess general groundwater quality.

Following drilling to the target depth, 50 mm (2") and 25 mm (1") diameter, flush-jointed PVC monitoring wells were installed in each borehole through pull-back of the well casing. Well screens varying in length from 1.5 m (5 ft) to 4.6 m (15 ft) with 0.254 mm (0.010") or 0.508 mm (0.020") aperture slots, and including a slotted endcap, were placed at the base of each well. The larger slot size was utilized where the screened interval was set within coarser sediments to enable collection of accurate hydraulic data. Where possible, a silica sand filter pack was emplaced around the full length of the screened interval, and extended a minimum of 0.3 m (1 ft) above the screened interval. A bentonite seal with an approximate thickness of 0.6 m (2 ft) was installed above each screened interval. Nested piezometers were installed in five of the boreholes. Where possible, bentonite seals were emplaced between each of the screened intervals, in order to provide hydraulic isolation. Upwelling sand prevented the emplacement of bentonite seals within several of the boreholes, however subsequent hydraulic testing indicated

that no hydraulic "short circuiting" was occurring between nested wells. Each installation was completed with a cement/bentonite seal at surface and a 6" diameter steel protective casing, extending from 0.6 to 0.8 m (2 ft to 3 ft) above surface.

A geodetic survey of the ground surface elevations at the monitoring well locations in the tailings area was carried out by ARMC staff following well completion. The surveying of the boreholes located near the Faro rock dumps and at the foot of the Grum rock dump was not completed at the time of report preparation.

2.1.2 Drilling Results and Monitoring Well Description

Ten boreholes were drilled at various locations within the Anvil Range site, and a total of 17 monitoring wells installed, from August 29 to September 7, 1996. Borehole locations at the Faro and Vangorda Plateau minesites are indicated on Figures 2 and 3, respectively.

Monitoring wells were placed in order to provide both physical and chemical groundwater data from each of the following areas:

BH96-1 to 4	Intermediate Tailings Dam
BH96-5	Second Embankment Tailings Dam
BH96-6 to 8	Faro Rock Dumps
BH96-9	Grum Rock Dump

Borehole logs are shown in Appendix A. Grain size analyses were performed on selected soil samples collected during drilling. Grain size data and plots are included in Appendix B. A summary of all monitoring well installation details is provided in Table 1.

Table 1.

Groundwater Monitoring Well Construction Details

Monitoring Well	Stickup (m)	T.O.P. Elevation (m a.s.l.)	Ground Elevation (m a.s.l.)	Screened Interval (m a.s.l.)	Filter Pack (mbgs)	Seal (mbgs)	Backfill/ Cave (mbgs)
MW 96-1	0.75	1050.1	1049.3	18.77-21.80	18.37-21.30	0.0-0.50	0.50-17.36
						17.36-18.37	21.80-22.25
MW 96-2	0.75	1050.1	1049.3	17.13-20.12	0.20-1.25	1.25-1.55	1.55-16.40
					17.00-20.12	16.40-17.00	
MW 96-3A	0.68	1032.1	1031.4	7.44-8.97	6.50-8.30	1.35-1.85	0.50-1.35
							1.85-6.50
MW 96-3B	0.63	1032.0	1031.4	17.70-19.17	16.80-18.60	16.40-16.80	8.30-16.40
							18.17-19.80
MW 96-4A	0.80	1033.1	1032.3	6.46-6.48	N/A	0.0-1.00	1.00-6.48
MW 96-4B	0.75	1033.0	1032.3	9.80-11.30	N/A	N/A	6.48-11.30
MW 96-4C	0.70	1033.0	1032.3	14.97-16.47	18.37-21.80	N/A	11.30-17.36
below 96-4					28.50-30.63	17.36-18.37	21.80-28.50
MW 96-4D	0.70	1032.9	1032.2	26.84-28.34	0.20-1.00	2.00-2.30	1.00-2.00
					26.00-28.34		2.18-26.00
MW 96-5A	0.69	1052.1	1051.4	2.43-8.53	2.29-9.14	0.0-2.29	N/A
MW 96-5B	0.74	1052.14	1051.4	11.64-14.69	10.67-14.69	9.14-10.67	N/A
MW 96-5C	0.81	1052.2	1051.4	27.86-29.37	27.50-29.37	25.20-25.96	14.69-25.20
							25.96-27.50
							29.37-29.87
MW 96-6	0.73	no survey	no survey	18.07-20.12	15.90-20.12	0.0-3.00	3.00-7.01
						7.01-15.90	
MW 96-7	0.66	no survey	no survey	6.26-9.24	4.20-9.24	0.0-1.20	1.20-3.20
						3.20-4.20	
MW 96-8A	0.70	no survey	no survey	1.15-4.17	1.20-4.30	0.0-1.20	N/A
MW 96-8B	0.78	no survey	no survey	5.50-8.52	5.80-9.20	4.30-5.80	9.20-9.45
MW 96-9A	0.70	no survey	no survey	4.96-9.45	4.04-10.36	0.0-0.80	0.80-3.25
						3.25-4.04	
MW 96-9B	0.60	no survey	no survey	16.53-17.99	15.98-17.99	10.36-15.98	

BHs 96-1 and 2 were drilled through the crest of the Intermediate Dam (inset in Figure 2) to the granular toe drain at the base of the dam in order to acquire dam construction and seepage information, for assessing seepage volumes and dam stability in this permeable earth dam structure. BHs 96-1 and 2 were completed to depths of 22.3 m (73 ft) and 20.1 m (66 ft) respectively, and encountered clean to silty sand and gravel fill material. Single monitoring wells were installed in each of BHs 96-1 and 2, screened within the granular toe drain.

BH96-3 and 4 were drilled at the toe of the Intermediate Dam to obtain groundwater and soil information for the Rose Creek valley sediments underlying the Intermediate Dam. These boreholes replace older groundwater monitoring wells (X24 and X25) which were lost during the last raise of the Intermediate Dam in 1991. BH96-3 is located on the southern flank of the Intermediate Dam replacing the old licence station X25. BH96-4 is located near the northern abutment of the Intermediate Dam replacing the old licence station X24 (inset in Figure 2).

BH96-3 was drilled to a depth of 19.8 m (65 ft), and encountered gravel fill overlying native alluvial sands, gravels and silts. Two aquifers were identified; an upper, unconfined aquifer situated from surface to a depth of approximately 13 m (43 ft), and a deeper, semi-confined to confined aquifer at a depth of approximately 17 to 19 m (56 to 62 ft), with an intervening silty sand aquitard between 13 and 17 m depth. Two monitoring wells were installed in BH96-3, one each within the upper and lower aquifers. Based on the groundwater samples collected during drilling, groundwater quality is relatively uniform within the upper sand and gravel aquifer at this locale, with electrical conductance (EC) ranging from 800 to 920 uS/cm. In the lower aquifer, EC values were somewhat higher (1300 uS/cm) suggesting slightly poorer water quality.

BH96-4-I was drilled to a depth of 30.5 m (100 ft), and also intersected alluvial sands, gravels and silts. Three monitoring wells were installed in BH96-4-I, however difficulties were encountered during the installation process. One well, MW96-4A, was broken during casing pull-back, and was left in the installation as an open-ended monitoring well, with no well screen. BH96-4-II was drilled approximately two metres southwest of BH96-4-I to a depth of 28.0 m (92 ft) and encountered similar stratigraphy to that in BH96-4-I. One monitoring well was installed at the base of BH96-4-II. MW96-4A and 4B were installed in the upper sand and gravel aquifer. Water quality is generally poorer within the upper aquifer at this locale than at BH96-3, with EC in the range of 1600 to 1800 uS/cm. MW96-4C and 4D were installed in deeper aquifers, with similarly poor water quality (EC of 1600 to 2000 uS/cm). The groundwater chemistry in the valley aquifer is discussed in more detail in section 2.4.

Several boreholes were drilled into the Rose Creek valley sediments in 1979-1980 in the immediate vicinity of the Intermediate Dam as part of the original dam construction work and subsequently in 1988 (Golder Associates, 1991). Golder Associates (GA) drawing # 912-2402-2 shows all borehole logs along the longitudinal profile of the Intermediate Dam location. The borehole logs of BH96-3 and BH96-4-I have been superimposed on the original Golder drawing

and are shown in Figure 4 of this report. This hydrostratigraphic cross-section illustrates the complex interlayering of sands, gravels, and silt layers in the vicinity of the Intermediate Dam. Gravel within these aquifers is subangular to angular in form, indicating a rapid depositional environment. The silty aquitards encountered do not appear to represent a continuos layer extending across the valley aquifer.

BH96-5 was drilled at the toe of the Second Embankment to replace the groundwater monitoring station X21 located on the crest of the Second Embankment in the northwestern section (Figure 2). The monitoring wells of station X21 had last been sampled in the fall of 1989 and are now destroyed.

Borehole BH96-5 was completed to a depth of 29.9 m (98 ft), and intersected approximately 8 m (26 ft) of tailings overlying alluvial sands, gravels and silts. Two significant aquifers were encountered in the native sediments, separated by a sandy silt to silty sand aquitard at a depth of 17 to 23.5 m (56 to 77 ft). MW96-5A was installed within the saturated tailings, MW96-5B within the upper aquifer, and MW96-5C within the lower aquifer. Based on water samples collected during drilling, water quality within the upper aquifer is poorest, with EC in the range of 1450 to 1600 uS/cm, while EC in the lower aquifer was measured at 890 uS/cm. No groundwater samples were collected from the tailings while drilling.

There appeared to be significant mixing of tailings and natural aquifer material in the first two to three meters below the tailings deposit based on examination of the cuttings returned by the air rotary drill to the surface. Visual observations of the cuttings also suggested that there were significant pyrite contents (2-5% by weight) present in aquifer material at greater depths in the profile (in particular in the silty aquitard layer at 17 to 23.5 m bgs). A geochemical solids assays (metal and sulphur species content) of cuttings taken from different depths confirmed these visual observations (see Appendix C for details).

BH96-6 was drilled on the northwestern slope of the North Fork of Rose Creek Valley, at the foot of the Intermediate Dump, near the large rock drain (Figure 2). The borehole is located some 20 to 30 meters uphill from the area where North Fork Rose Creek is ponded upstream of the rock drain. The primary purpose of this borehole is to monitor quality of seepage originating from the Intermediate Dump and draining towards the North Fork of Rose Creek.

This borehole encountered approximately 17 m of silty sand and gravel colluvium and glacial tills overlying alluvial gravel. One monitoring well was installed within the alluvial gravel aquifer. Water quality during drilling was consistent within this aquifer, at 550 to 620 uS/cm.

BH96-7 was drilled at the foot of the Main and Intermediate Dumps as indicated in Figure 2. The primary purpose of this borehole is to monitor quality of seepage originating from the Main and Intermediate Dumps (in particular from the "Sulphide Cells") and draining towards North Fork Rose Creek and the Rose Creek Valley aquifer.

Approximately 8 m of silty sand colluvium was encountered overlying fractured phyllite bedrock at this location. BH96-7 was screened across the upper portion of the bedrock, including a gravelly layer overlying bedrock.

BH96-8 was drilled in the old Faro Creek channel, near the toe of the Main Dump, directly east of the surface water monitoring station "X23" (Figure 2). The primary purpose of this borehole is to monitor water quality of seepage originating from the Main, Northwest and Intermediate Dumps (referred to as "X23 watershed" in RGC Report 033001/3) and draining towards the Rose Creek valley.

Drilling intersected approximately 8 m of alluvial sand and gravel overlying phyllite bedrock. Two monitoring wells were installed; a shallow monitoring well (MW96-8A) within the upper alluvial sands and gravels, across the water table. and a deeper monitoring well (MW96-8B) at the bedrock interface. An EC value of 1680 uS/cm was measured at a depth of 6 m, while drilling.

BH96-9 was located at the southern toe of the Grum Main Dump in a small tributary stream valley which drains the centre of the Grum Main Dump (including the "Sulphide Cells"), as indicated on Figure 2. The primary purpose of this borehole is to monitor quality of seepage originating from the Grum Main Dumps (in particular from the Sulphide Cells) and draining towards Vangorda Creek.

This borehole was drilled to a depth of 18.0 m and encountered 3.5 m of silt fill overlying probable colluvial sand and gravel and sandy silt to silty sand till. Permafrost was intersected at an approximate depth of 9.5 m (31 ft), while phyllite bedrock was encountered at a depth of 17.4 m (57 ft). MW96-9A was installed within the upper silty sand and gravel colluvium. MW96-9B was screened across the upper fractured bedrock, and a narrow sand zone immediately above bedrock. This well was flowing immediately following installation.

2.1.3 Well Development

Following well completion, dedicated Waterra™ inertial samplers were installed in each well, and a quantity of water was purged in order to remove as much fine sediment as possible from the zone around the screened interval. Observation of groundwater pH, electrical conductivity (EC), sediment load, colour and odour were made at regular intervals during the well development process. Well development observations are summarized in Table 2.

Well development in MW96-5C deserves special commenting. Very high pyrite contents (~20-40%) were observed in the fines material purged from the deepest piezometer in borehole 96-5 located just downstream of the Second Tailings Impoundment (MW96-5C). The geochemical composition of this fine purged sediment is very similar to that of the tailings deposited near the surface suggesting that some tailings fines were carried downward into the base of the borehole either inside or outside of the casing (see Appendix C for details). The impact of this

"contamination" on groundwater quality is considered to be very limited as most of the pyrite-rich sediment was purged from the piezometer 96-5C during well development. The deep piezometer was the only one at BH96-5 producing pyrite-rich sediment during well development.

Water level observations were also made during the well development process, on the well being developed, and in other wells within the piezometer nest. The observations made indicate there is no significant "short-circuiting" or direct hydraulic connection between wells in any of the piezometer nests.

Table 2

Summary of Well Development Data

Monitoring Well	Volume Purged (l)	pH		Temp. (C)		EC (uS/cm)		Eh (mv)		Comments
		initial	final	initial	final	initial	final	initial	final	
96-1	—	—	—	—	—	—	—	—	—	not developed
96-2	—	—	—	—	—	—	—	—	—	not developed
96-3a	300	5.8	6.5	8	4	810	770	—	—	sl. turbid, brown
96-3b	360	6.8	6.9	8	4	1160	1120	—	—	mod. turbid, orange-brown
96-4a	140	—	6.8	—	4.4	1620	1610	—	+5	sl. turbid, brown
96-4b	30	7.2	6.6	8.0	4.8	1790	1760	+13	+14	turbid, brown
96-4c	260	—	—	—	—	1720	1840	—	-46	rel. clear, H2S odour
96-4d	200	—	6.8	—	—	1920	1930	—	+3	mod. turbid, orange-brown
96-5a	—	—	—	—	—	—	—	—	—	not developed - lost 2 internal check valves
96-5b	150	7.2	7.3	—	—	1340	1390	—	—	mod. silty, grey-brown
96-5c	230	6.6	7.9	—	—	320	360	—	—	turbid, dark grey, fine pyrite
96-6	80	6.3	5.6	4.8	5.5	500	580	+32	+72	sl. turbid, orange-brown
96-7	40	7.5	7.5	4.4	2.7	1470	1440	-34	-36	sl. turbid, brown, dried well out
96-8a	80	6.6	6.6	2.0	2.0	>1990	>1990	+14	+10	sl. turbid, brown, solvent odour
96-8b	120	6.6	6.7	1.3	0.9	>1990	>1990	+13	+7	sl. turbid, brown
96-9a	150	6.5	7.1	4.2	2.5	590	590	+16	-23	turbid, brown
96-9b	50+	7.2		2.2		570		-23		mod. turbid, grey-brown (flowing)

2.2 Permeability Testing

Rising and falling-head slug tests were conducted on eight monitoring wells in order to obtain horizontal transmissivity (or average bulk hydraulic conductivity values K) for the aquifer intervals tested. Water level data was collected using a Troll™ datalogger and pressure transducer assembly, and was processed using WinSitu™ software. At each monitoring well, the pressure transducer was inserted near the base; water levels were subsequently given time to equilibrate. Hydraulic head measurements above the transducer were correlated with water level in the borehole as a quality control measure. Immediately following commencement of data acquisition, a "slug" consisting of a 5 ft long, 25 mm (1") diameter solid PVC pipe, was quickly dropped into, or withdrawn from, the water column. Data was then collected until the water level had returned to the original static level, or until at least 2/3 of the hydraulic response had been observed. Multiple falling and rising head tests were conducted on each monitoring well, in order to procure the most reliable data possible. The volume of the slug injected/removed was also varied between tests, where possible, as a further quality assurance measure.

Data collected through the WinSitu™ program was then exported to a spreadsheet file for analysis and presentation. Depending on the nature of the hydraulic response, slug testing data was analyzed using conventional Hvorslev-type analysis, or using a van der Kamp model for oscillating response types. Hydraulic testing data were also analyzed using the AQTESOLV computer program. All slug test data and the fitted response functions are shown in Appendix D.

Permeability testing results are summarized in Table 3. At MWs 96-3A, 3B, 4C, 4D and 5B, the water level recovery after slug injection/withdrawal was very rapid, and produced an oscillating, or underdamped response. These data were analyzed using a method developed by van der Kamp (1976). MWs 96-5C, 9A and 9B recovered less quickly, producing an overdamped response with no significant oscillation. These data were analyzed using the methods of Hvorslev (1951) for confined aquifers, and Bouwer and Rice (1976) for unconfined aquifers.

Bulk hydraulic conductivity values for the monitoring wells tested ranged from 3×10^{-6} m/s to 2×10^{-3} m/s. The highest of these hydraulic conductivity values is considered to be near the upper range of testing accuracy for the testing setup utilized.

Hydraulic conductivity values for the Rose Creek valley aquifer range from 3×10^{-6} m/s to 2×10^{-3} m/s with a geometric mean of 4×10^{-4} m/s. The hydraulic testing in the tailings area was biased towards high K values since most piezometers in boreholes 96-3 to 96-5 were screened in more permeable, water-bearing units. The bulk permeability of the valley aquifer material is probably less than 1×10^{-4} m/s.

Table 3: Hydraulic Conductivity Testing Results

Monitoring Well	Test Number	Solution Method										Overall		
		van der Kamp*						B & R**	Hvorslev***			Hazen****		
		S			K (m/s)			K (m/s)	K (m/s)			K (m/s)		
		Min	Max	BEJ	Min	Max	BEJ	BEJ	Min	Max	BEJ		Min	Max	BEJ
3A	FH1	0.001	0.1	.01	6E-04	2E-03	1E-03	1E-03					6E-04	2E-03	1E-03
	FH2	0.001	0.1	.01	6E-04	2E-03	1E-03	9E-04					6E-04	2E-03	1E-03
	mean												6E-04	2E-03	1E-03
3B	FH1	0.001	0.1	.01	8E-04	2E-03	2E-03						8E-04	2E-03	2E-03
	FH2	0.001	0.1	.01	8E-04	3E-03	2E-03	1E-03					8E-04	3E-03	2E-03
	RH2	0.001	0.1	.01	5E-04	2E-03	1E-03	2E-03					5E-04	2E-03	1E-03
	mean												7E-04	2E-03	2E-03
4C	FH1	0.001	0.1	.01	2E-04	7E-04	4E-04						2E-04	7E-04	4E-04
	RH3	0.001	0.1	.01	9E-04	2E-03	2E-03	4E-04					4E-04	2E-03	2E-03
	mean												3E-04	1E-03	9E-04
4D	RH1	0.001	0.1	.01	7E-04	2E-03	1E-03	4E-04				8E-03	4E-04	8E-03	1E-03
5B	FH1	0.001	0.1	.01	3E-04	9E-04	6E-04	6E-04					3E-04	9E-04	6E-04
	FH2	0.001	0.1	.01	3E-04	8E-04	5E-04	5E-04					3E-04	8E-04	5E-04
	RH1	0.001	0.1	.01	6E-04	2E-03	1E-03						6E-04	2E-03	1E-03
	mean												4E-04	1E-03	7E-04
5C	RH1								4E-06	4E-06	4E-06		4E-06	4E-06	4E-06
	FH1								3E-06	5E-06	4E-06		3E-06	5E-06	4E-06
	mean												3E-06	4E-06	4E-06
6												1E-02	1E-02	1E-02	2E-03
8B												2E-03	2E-03	2E-03	4E-04
9A	RH1								2E-05	2E-05	2E-05		2E-05	2E-05	2E-05
	RH3								8E-06	2E-05	2E-05		8E-06	2E-05	2E-05
	mean												1E-05	2E-05	2E-05
9B	RH1								2E-05	2E-05	2E-05		2E-05	2E-05	2E-05
	RH2								2E-05	2E-05	2E-05		2E-05	2E-05	2E-05
	mean												2E-05	2E-05	2E-05

N.B. FH = Falling Head Test RH = Rising Head Test BEJ = Best Engineering Judgement

* van der kamp method, van der Kamp, 1976

** Bouwer & Rice method, Bouwer and Rice, 1976

*** Hvorslev method, Hvorslev, 1951

**** Hazen grain-size method, ref. Freeze and Cherry, 1979

Hydraulic conductivity results for MW 96-9a and 9b, situated within colluvial sands and gravels at the Grum Dump, range from 8×10^{-6} to 2×10^{-5} m/s.

For soil samples collected from MWs 96-4, 6 and 8 the hydraulic conductivity was estimated based on the grain size distribution (see Appendix B) and using the Hazen relation:

$$K = 0.01 \cdot (d_{10})^2$$

where:

K = hydraulic conductivity in m/s

d_{10} = grain-size diameter at which 10 % of the particles are finer

Hazen analysis results are presented in Table 4, below.

Table 4.

Hydraulic Conductivity Values Determined by Hazen Grain-Size Analysis.

Monitoring Well	Depth (mbgs)	d_{10} (mm)	Hydraulic Conductivity (m/s)
MW 96-4	29.0 - 30.5	0.91	8×10^{-3}
MW 96-6	18.3	1.05	1×10^{-2}
MW 96-8	7.6	0.41	2×10^{-3}

Hazen grain-size analysis results for the three sand aquifer samples range from 1.2×10^{-3} to 1.1×10^{-2} m/s. Comparison of the hydraulic conductivity values obtained from MW 96-4 using Hazen and slug-testing analyses indicates the Hazen results are substantially higher. This may be explained in part by the angular to subangular nature of the gravel encountered within the Rose Creek Valley aquifer, the effects of which are not incorporated in the Hazen method. In addition, the Hazen method is considered most effective for uniform sands and gravels. The alluvial aquifer samples collected, however, were for the most part well-graded.

2.3 Hydraulic Head Measurements and Interpretation

A complete survey of static water levels in all newly installed monitoring wells was undertaken by RGC staff on September 8, 1996 using a water level tape with acoustic sounder. The results of this water level survey are summarized in Table 5. A brief discussion of these results is given below for the various sites.

Table 5

Summary of static water levels recorded during field investigation, September 8, 1996.

Piezometer	Ground Elevation (m a.s.l.)	Screened Interval (m bgs)	Piezometric Head Readings		
			Date	SWL (m bgs)	SWL (m a.s.l.)
MW96-1	1049.3	18.77-21.80	8-Sep-96	19.31	1029.99
MW96-2	1049.3	17.13-20.12	8-Sep-96	18.99	1030.31
MW96-3A	1031.4	7.44-8.97	8-Sep-96	1.69	1029.41
MW96-3B	1031.4	17.70-19.17	8-Sep-96	1.62	1029.78
MW96-4A	1032.3	6.46-6.48	8-Sep-96	2.31	1029.99
MW96-4B	1032.3	9.80-11.30	8-Sep-96	2.29	1030.01
MW96-4C	1032.3	14.97-16.47	8-Sep-96	2.28	1030.02
MW96-4D	1032.3	26.84-28.34	8-Sep-96	2.18	1030.12
MW96-5A	1051.4	2.43-8.53	8-Sep-96	3.79	1047.61
MW96-5B	1051.4	11.64-14.69	8-Sep-96	3.77	1047.63
MW96-5C	1051.4	27.86-29.37	8-Sep-96	3.80	1047.60
MW96-6	N/A	18.07-20.12	8-Sep-96	12.21	---
MW96-7	N/A	6.26-9.24	8-Sep-96	5.17	---
MW96-8A	N/A	1.15-4.17	8-Sep-96	2.84	---
MW96-8B	N/A	5.50-8.52	8-Sep-96	2.78	---
MW96-9A	N/A	4.96-9.45	8-Sep-96	4.82	---
MW96-9B	N/A	16.53-17.98	8-Sep-96	Flowing @ ~1l/min	

2.3.1 Rose Creek Valley Aquifer

The most detailed information about hydraulic head conditions in the Rose Creek Valley aquifer was obtained from the four new boreholes drilled in the vicinity of the Intermediate Dam. The construction of the Intermediate Tailings Impoundment and the Cross Valley Dam with polishing pond (refered to also as "Down Valley Scheme") has resulted in a significant rise in the water level in the sand and gravel aquifer at this location. Figure 4 shows the current water level of the upper unconfined aquifer of the valley sediments in section along the Intermediate Dam as well as the original water level prior to construction of the Down Valley Scheme. At present, the water level in the sand and gravel aquifer underlying the Intermediate Dam is some 8.5 meters above the original water level surface (Figure 4). This increase in saturated thickness of the aquifer is likely a result of increased recharge to the aquifer from the Intermediate Impoundment.

Seepage through the Intermediate Dam itself appears to be limited to the granular toe drain and underlying fill and/or natural aquifer materials. The piezometric readings taken in MWs 96-1 and 96-2 (screened in the granular toe drains) indicate that there are no significant excess pore pressures in this earth dam suggesting that the toe drain operates as designed. Figure 5 illustrates the hydraulic head conditions for the northern section of the Intermediate Dam (at BH96-2 and 96-4). As indicated in the drawing the phreatic surface in this earth dam lies at or just slightly above the toe drain near the center of the dam with most seepage occurring either in the toe drain itself or in the underlying permeable sands and gravels. The low permeability blanket on the upstream face of the dam (Class VI material) and the deposited tailings slimes probably limits the amount of seepage that occurs directly from the ponded water upstream of the dam to the toe drain.

At the downstream side, the toe seepage and groundwater flowing in the uppermost layers of the valley aquifer is discharging into the Cross Valley pond. As indicated in Figure 5, the horizontal hydraulic gradient between the center base of the dam (BH-96-1) and the downstream toe of the dam (MW96-4A) is approximately 0.9 percent. At the toe of the Intermediate Dam (at BH96-4) there is some upward flow with vertical gradients in the order of ~0.6 percent (see Figure 5).

Similar overall groundwater flow patterns were inferred in the vicinity of BH96-1 and BH96-3 on the southern flank of the Intermediate Dam. However, at this locale the vertical flow gradient was significantly greater (i_{vert}=3.6 percent) suggesting a greater upward groundwater flow component than at the northern locale.

At BH96-5, just downstream of the Second Impoundment (Figure 2) piezometric heads were very similar at different depths (Table 5) with vertical gradients less than 0.2 percent suggesting that groundwater flow in this area is predominantly horizontal. The piezometric head in the aquifer is several meters above the interface of aquifer and tailings material. It is thus possible

that the sand and gravel aquifer is confined in this area by the finer tailings material above due to the differences in permeability. However, the piezometric data are not conclusive since the screening interval of the uppermost monitoring well MW96-5A is not located entirely within the tailings but extends down into the uppermost layers of the aquifer material.

Figure 6 shows the piezometric head contours in the Rose Creek Valley aquifer in plan view. The contour map was derived from piezometric readings taken on September 26-27, 1996 by ARMC staff during the groundwater quality sampling (see section 2.4). The ARMC data were used for contouring since they include readings from the new MW-06 series as well as all other monitoring wells in the Rose Creek Valley area. The point values shown in Figure 6 were taken in the upper-most monitoring well at a given location.

Groundwater flow in the valley aquifer is predominantly horizontal in a northwesterly direction, i.e. parallel to the valley axis (Figure 6). The contour map illustrates that horizontal gradients are greatest in the vicinity of the Intermediate Dam and Cross Valley Dam/Pond (i_{hor} ~ 2.4 percent). The average horizontal gradient beneath the Intermediate Impoundment is approximately 1.2 percent. The lowest horizontal gradients were observed downstream of the Cross Valley Dam (i_{hor} ~ 0.5 percent between monitoring well X16 and X17). These horizontal gradients are significantly higher than horizontal gradients observed in the aquifer prior to construction of the Down Valley Scheme (ranging from 0.2 to 0.8 percent; Klohn Leonoff, 1981). Increased recharge from the tailings impoundments and the polishing pond is the likely cause for the increased horizontal groundwater flow gradients observed in this area today. The piezometric heads in deeper layers of the Rose Creek Valley aquifer are generally very similar to those in the upper layers.

2.3.2 Faro Rock Dumps

At borehole 96-6, located in the North Fork Rose Creek valley at the toe of the Intermediate Rock Dump, the water table was at least 12 meters below the ground surface. Most groundwater flow at this locale occurs in the permeable sand and gravel layer at depth. This gravel layer appears to be confined by the overlying silty sand and silty till. It is likely that the piezometric head in the gravel layer at this location is higher than the water level in the North Fork and that groundwater is flowing into the valley sediments and/or is discharging into the North Fork Rose Creek. However, a geodetic survey of the monitoring well will be required to confirm this contention.

Similar hydraulic conditions were encountered at borehole 96-7, located at the southwestern toe of the Intermediate Rock Dump (Figure 2). Here, shallow groundwater flow occurs at the interface of overburden soils and fractured bedrock. The drilling records suggest that groundwater was confined within this narrow layer. The piezometric head in the water bearing layer was some five meters below ground surface.

The monitoring wells 96-8A and 96-8B were completed in the alluvial soils of the former Faro Creek channel next to the surface water monitoring station X23 (Figure 2). At this location a shallow, unconfined aquifer was encountered in very permeable alluvial sands and gravels with the water table approximately 2.8 m below ground (Table 5). The total saturated thickness is in the order of 5 meters. The piezometric readings suggest that shallow groundwater may be discharging into the near-by creek. A geodetic survey of these piezometers and the near-by creek would be required to confirm this contention.

2.3.3 Grum Rock Dump

Borehole 96-9 was drilled next to a small creek draining the Main Grum Dump (Figure 3). At this location two water-bearing layers were encountered. The upper, unconfined aquifer is located in alluvial sands and gravels with the water table approximately 5 meters below ground surface. This upper aquifer is likely hydraulically connected with the near-by creek.

The lower aquifer is located in a well graded sand layer separated from the upper aquifer by a silt layer which was frozen (probably representing permafrost). The piezometric heads in the lower aquifer were higher than ground surface and the well was flowing at approximately 1 liter per minute. ARMC staff reported that this well was still flowing a month after piezometer installation.

2.4 Groundwater Chemistry

The initial round of groundwater quality sampling was carried out by ARMC as part of their routine water licence monitoring program. The monitoring wells at the Faro minesite were sampled on September 25 and 26, 1996. The monitoring wells at the Vangorda Plateau minesite were sampled on October 9, 1996. The groundwater samples were sent out to Cavendish Laboratory Ltd. for analyses. The chemical parameters analyzed include those specified in water licence IN #89-001, Schedule D and IN #89-002, Part G, Section 4 for the Faro and Vangorda Plateau minesite, respectively. The original groundwater quality data sheets were prepared by ARMC and are attached in Appendix E. The results for selected chemical parameters are shown in Table 6. The water quality data are briefly discussed site by site in the sections below. A more detailed discussion of groundwater quality at the Faro and Vangorda Plateau minesites, including water quality trends over time, is given in the Integrated Comprehensive Abandonment Plan (ICAP) for the Anvil Range Mining Complex (RGC Report No. 033001/3).

Table 6.

Summary of initial groundwater chemistry data collected by Anvil Range Mining Corporation in 1996 monitoring wells.

Site	Date	pH (lab)	Acidity (mg/L) pH 4.5	Acidity (mg/L) pH 8.3	Alkalinity (mg/L CaCO3)	Sulphate (mg/L)	Calcium (mg/L)	Cu (mg/L)	Fe (mg/L)	Zn (mg/L)
MW-96-3A	26-Sept-96	8.05	<1	336	236	260	100.7		0.05	0.03
MW-96-3B	26-Sept-96	7.89		478	277	488	151.8		<.01	0.01
MW-96-4A	26-Sept-96	7.7	<1	618	315	855	311.9		0.04	0.02
MW-96-4B	26-Sept-96	7.68	<1		332	758	352.9		9.19	0.04
MW-96-4C	26-Sept-96	7.55	<1	855	363	1005	100.7		0.06	0.02
MW-96-4D	26-Sept-96	7.33	<1	1102	394	1048	151.8		<.01	0.01
MW-96-5B	26-Sept-96	7.16	<1	35	202	767	178.3		9.89	0.13
MW-96-5C	26-Sept-96	7.54	<1	7	178	12	46.7		0.05	<.01
MW 96-6	26-Sep-96	8.00	<1	114	228	106	67.4	0.008	3.53	0.54
MW 96-7	27-Sep-96	7.66	<1	15	160	882	256.5	<0.002	1.86	<0.01
MW96-8A	26-Sep-96	6.31	<1	102	484	2278	458.6	0.012	0.08	16.1
MW96-8B	26-Sep-96	6.30	<1	173	702	2576	632,2	0.026	0.40	2.37
MW96-9A	9-Oct-96	8.00	<1	<1	175	52	86.9	0.005	0.23	<0.01
MW96-9B	9-Oct-96	8.2	<1	2.9	87	156	43.2	0.004	0..19	<0.01

2.4.1 Rose Creek Valley Aquifer

Borehole BH 96-5 was drilled just downstream below the 1974 tailings berm from the tailings surface into the valley aquifer to replace the X21 monitoring wells which were destroyed in 1989 (see Figure 2). The groundwater immediately below the tailings in natural aquifer material (MW96-B) shows a water quality typical of buffered acid rock drainage (ARD) (Table 6). The pH is near-neutral, sulphate concentrations are high (767 mg/L) and dissolved metal concentrations are elevated (0.13 mg/L zinc and 9.89 mg/L Fe). The elevated concentrations

of sulphate and metals are most likely caused by recharge from tailings pore water infiltrating into the valley aquifer. The available data are inconclusive, however, as to whether the contaminants are introduced from the tailings located immediately above the monitoring well (i.e. in the Intermediate Impoundment) or from the older tailings located in the Original and Second Impoundments further upstream (Figure 2). No water quality data are available from the upper piezometer (MW96-5A) screened in the tailings above the original ground surface.

The deep piezometer (MW96-5C) was completed in a gravel layer confined above by a low permeability silt layer. The very low concentrations of zinc, iron and sulphate in this layer may be a result of limited recharge from the upper contaminated aquifer. Alternatively, they could be a result of reducing conditions in this lower, confined aquifer causing a reduction of sulphate to sulfide and subsequent precipitation of zinc and other metals. The observed very low vertical (downward) hydraulic gradients favour the hypothesis of limited mixing of the upper and lower aquifers.

Similar groundwater quality conditions were observed near the northern abutment of the Intermediate Dam, i.e. at BH96-4 which replaces the old monitoring wells of station X24 (Figure 2). Again, the groundwater quality data indicate well-buffered ARD with elevated concentrations of metals (in particular iron) and sulphate in the upper aquifer (MWs 96-4A and 96-4B; see Table 6). Zinc concentrations are above background, but significantly lower than at MW96-5B), possibly as a result of greater distance from the source (oxidized tailings further upstream).

At this location the sulphate concentrations are high even at greater depths (Table 6) suggesting that there is significant vertical mixing within the aquifer. Field observations of upward groundwater flow and the lack of a confining silt layer (as for example at BH96-5) is consistent with this contention.

At the southern side of the Intermediate Dam, i.e. at BH96-3 which replaces the old monitoring station X25, the groundwater is less impacted by ARD than on the northern side. Here, the groundwater is typically more alkaline (pH ~ 8.0) and the sulphate concentrations are significantly lower than at any depth at BH96-4 (Table 6). Similar trends were observed in the past for monitoring wells installed at X24 and X25 (RGC, 1996). Several mechanisms could contribute to the higher contaminant levels in the northern side of the valley aquifer. First, the source of contamination may be greater on the northern side of the Rose Creek Valley, e.g. due to more reactive tailings and/or higher infiltration through the tailings. Second, the "contaminant plume" may be traveling slower on the southern side of the valley due to lower permeability material in this portion of the aquifer. Finally, groundwater on the southern side of the aquifer may receive recharge from the Rose Creek Diversion thus diluting any contamination introduced by seepage from the tailings.

2.4.2 Faro Rock Dumps

Monitoring well MW96-6 was installed upslope of the Rose Creek valley below the toe of the Intermediate Dump (see Figure 2) screening a water-bearing layer of sandy gravel at a depth of approximately 18 m. The groundwater in this gravel layer down-gradient of the Intermediate Dump is slightly alkaline (pH = 8.00) and has an alkalinity of 228 mg/L. This groundwater is relatively high in iron and zinc (3.53 mg/L Fe and 0.54 mg/L Zn). Presumably, the elevated metal concentrations observed in BH 96-6 are a result of oxidation of mine rock from the Intermediate Dump. It should be noted, that the concentration of sulphate is relatively low (106 mg/L SO_4) suggesting only limited neutralisation.

Monitoring well MW96-7 was installed at the toe of the Intermediate Dump upslope near the drainage divide between North Fork and Faro Creek (see Figure 2). At this location, the shallow groundwater is slightly alkaline (pH ~7.7) and has an alkalinity of 160 mg/L. Concentrations of sulphate and iron are elevated (882 mg/L and 1.86 mg/L, respectively) suggesting some influence of acid rock drainage. However, metal concentrations of Zn and Cu were below the detection limit suggesting that these metals are either not released from the dump areas draining towards this location or are immobilized in the soil profile.

Monitoring wells MW96-8A/B were installed in the lower Faro Creek valley southwest of the Main Dump (Figure 2). This valley is the main discharge point for seepage from the Faro rock dumps. Significant portions of the Main Dumps and the Northwest Dumps drain towards this valley. There is sufficient accumulation of dump seepage in this valley to maintain a small, perennial stream which emerges just below the Main Dump near the sampling station X23 (see Figure 2). This stream shows consistently high levels of zinc, sulphate and other oxidation products (RGC, 1996).

As expected, the shallow groundwater in the lower Faro Creek valley is impacted by acid rock drainage showing high sulphate and elevated zinc concentrations both in the upper piezometer (MW96-8A) and in the lower piezometer (MW96-8B) (Table 6). The pH is slightly acidic (pH ~6.3) but alkalinity values are relatively high (484-702 mg/L). There is a notable vertical gradient in zinc concentrations with high concentrations in the upper sediments (16.1 mg/L) and lower concentrations near the sediment-bedrock interface (2.37 mg/L). The water quality of shallow groundwater in the upper valley sediments is very similar to that of the near-by stream (e.g. ~23 mg/L Zn measured at X23) suggesting that there is a hydraulic connection between the stream and the groundwater.

2.4.3 Grum Rock Dump

Monitoring wells MW96-9A/B were installed in a small valley next to a tributary to Grum Creek which drains the central portion of the Grum Dump (Figure 3). The groundwater quality in the upper, unconfined layer (MW96-9A) shows no signs of acid rock drainage. The shallow groundwater has a pH around 8.0 and an alkalinity of 178 mg/L. The concentrations of

dissolved metals are very low (iron ~0.23 mg/L and Zn < 0.01 mg/L). Sulphate concentrations are also low (54 mg/L) suggesting that there has been little or no release of contaminated seepage from the Grum Dump to date.

The groundwater quality in the lower confined sand layer (MW96-9B) is similar with pH at 8.2 and an alkalinity of 87 mg/L. Sulphate concentrations are somewhat higher (156 mg/L) but dissolved iron and zinc are both very low (Fe = 0.19 mg/L and Zn < 0.01 mg/L).

3. Summary and Recommendations

A total of 17 monitoring wells were installed during the 1996 drilling program at the Anvil Range Mining Complex.

Eleven monitoring wells were installed in the Rose Creek tailings area, nine of which replace older (destroyed) monitoring wells which are required sampling stations as part of the existing Faro water licence (IN #89-001, Schedule D):

Water Licence Station	Monitoring Well
X21A/B/C	MW96-5A/B/C
X24A/B/C/D	MW96-4A/B/C/D
X25A/B	MW96-3A/B

These monitoring wells should be sampled for groundwater quality according to the specifications laid out in the existing Faro water licence. A semi-annual sampling interval is recommended.

Two monitoring wells were screened in the toe drain of the Intermediate Dam (MW96-1 and MW96-2) to monitor the piezometric conditions at the base of the dam. Readings of piezometric head (water level in piezometer) should be taken at least at a semi-annual interval in these piezometers.

A total of four monitoring wells (MWs 96-6, 96-7 and 96-8A/B) were installed downstream of the Faro Rock Dumps (Intermediate and Main Dumps including Sulphide Cells). These monitoring wells are intended for monitoring seepage quality draining from the rock dumps. They complement the existing monitoring wells located in the North Fork Rose Creek ("BH series") and downstream of the Intermediate Dump ("Sulphide series"). Monitoring of seepage quality downstream of the Faro Rock Dumps is an integral part of the closure plan philosophy for this site, i.e. "collect and treat" (RGC, 1996). It is recommended to monitor groundwater quality in these new monitoring wells in a semi-annual interval. The suite of chemical parameters

analyzed in the first round of sampling (see Appendix E) is sufficient for an evaluation of ARD development at the site.

It is further recommended to survey the position of these new monitoring wells (location as well as elevation of top of piezometer) to allow a more detailed interpretation of flow patterns, in particular any hydraulic connection between the shallow groundwater and the near-by creeks.

Two monitoring wells (MW96-9A/B) were installed downstream of the Grum Rock Dump in a narrow valley of a small tributary draining towards Vangorda Creek. These wells are intended for monitoring seepage quality draining from the Grum Main dump and specifically the Sulphide Cells. The permeable sand and gravel layers in this area are more likely to transmit groundwater downstream than the valley slopes where only a thin veneer of low permeability till is present. Hence these monitoring wells could serve as early indicators of potential development of ARD in the shallow groundwater. Continued monitoring of groundwater quality in these boreholes is recommended to detect any potential ARD well before it reaches the downstream receiving waters. A semi-annual sampling interval is recommended.

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CHRISTOPH WELS
Hydrogeologist/Hydrologist

Education	Ph.D., Hydrogeology, University of British Columbia, 1995 Fellowship, Environmental & Soil Chemistry, Syracuse University, New York, 1990-1991 M.Sc., Hydrology, Trent University, Ontario, 1989 B.Sc., Geography/Biology, Trent University (Freiburg University), 1985
Specialization	Hydrogeology, hydrology, environmental chemistry, computer sciences, languages (German, Spanish and French)

Experience

1995	**Hydrogeologist/Hydrologist, Robertson GeoConsultants Inc.**
1990 (summer)	**Lab Assistant, Water Institute, Freiburg, Germany** Analysis of PCB in oil samples.
1989 (Feb - Sept)	**Hydrogeologist, Chalk River Laboratories, AECL, Ontario** - modelling of contaminant transport across the sediment-water interface - construction of a seepage facility to simulate groundwater flux into lakes
1987 (fall)	**Participant, Chalk River Laboratories, AECL, Ontario** Short course: Radioactive Tracer Tests
1985 - 1986	**Hydrochemist, Freiburg Municipality/Albert Ludwigs University, Germany** - planning and implementation of a monitoring network for surface water quality in the municipality - development of a hydrochemistry laboratory
1985 (summer)	**Lab Assistant, Water Institute, Freiburg, Germany** Routine chemical analyses of water samples (AAS, Ion Chromatography, photometry)

CHRISTOPH WELS
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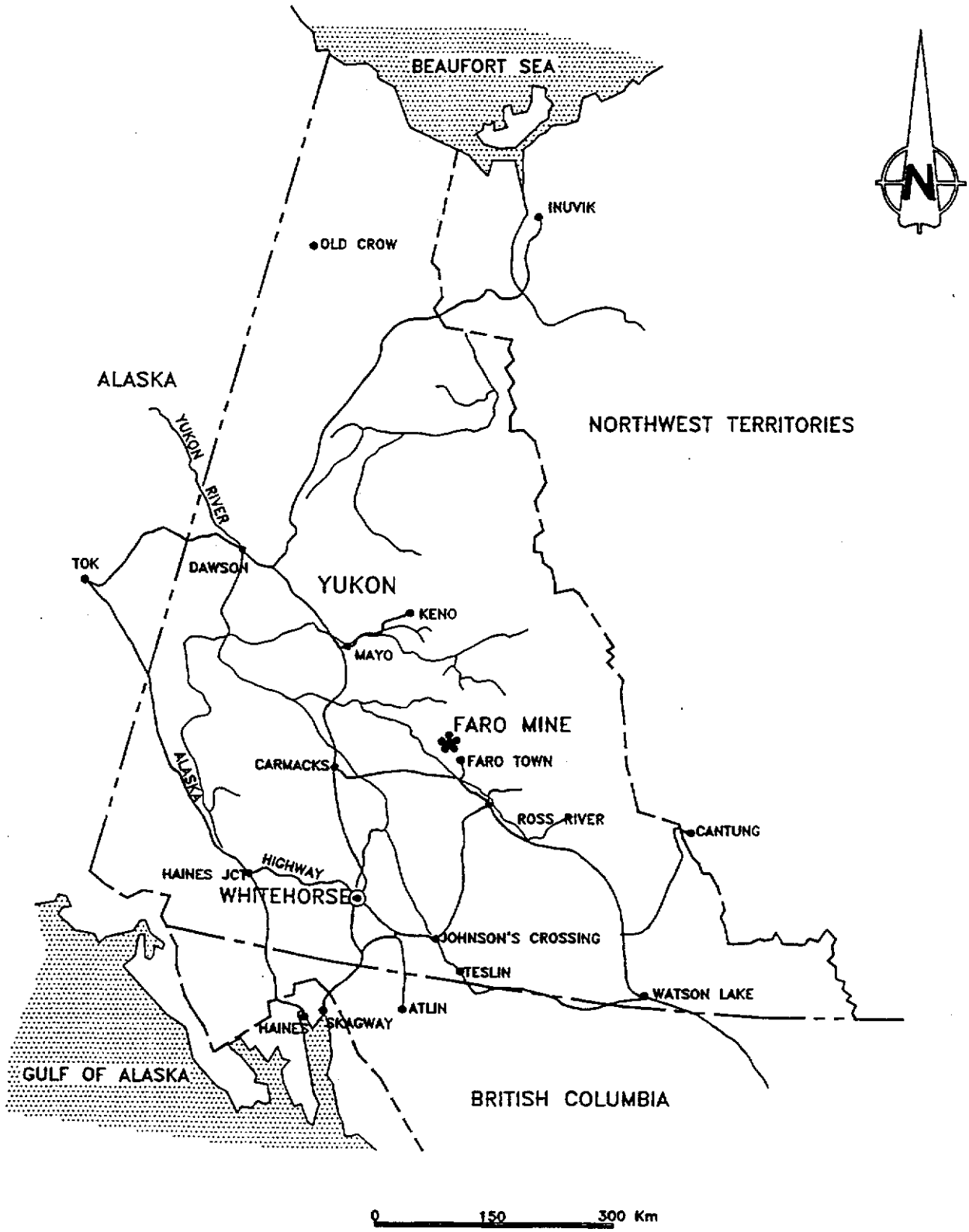
Figures



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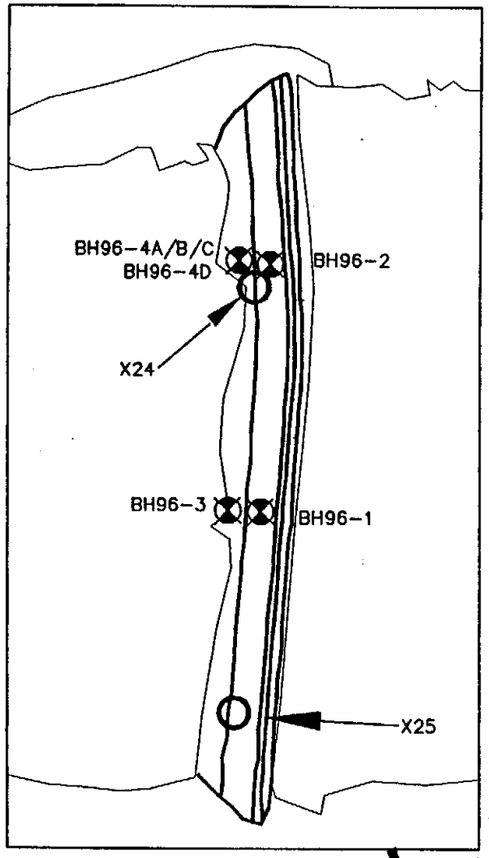
Consulting Geotechnical and Environmental Engineers

Anvil Range Mining Corporation

1996 Drilling Program

Yukon Territory

PROJECT NO.	DATE	APPROVED	FIGURE
033001	Dec. 1996		1



1996 Drilling Program
Licenced Boreholes (Replaced)
Existing Groundwater Monitoring Stations

TAILINGS PIPELINE
MAIN ROCK DUMP
SULPHIDE CELLS
BH96-6
X23
BH96-8A/B
WATER SUPPLY PIPELINE
BH96-7
NORTH FORK DIVERSION
ROCK DRAIN
NORTH WALL INTERCEPTOR DITCH (MINE LEG)
Guardhouse Ck
ROAD
1200
1100
ORIGINAL TAILINGS IMPOUNDMENT
CROSS VALLEY DAM
INTERMEDIATE DAM
X18
X16
X17
BH96-4A/B/C
BH96-4D
BH96-2
X24
BH96-3
BH96-1
X25
INTERMEDIATE IMPOUNDMENT
BH96-5 A/B/C
X21
SECOND IMPOUNDMENT
P81-04
P81-09
PUMPHOUSE POND
ROSE CREEK DIVERSION

0 500 1000 1500 metres

SCALE 1:15 000

Notes:

1. Base Map supplied by the Orthoshop, January 1991
   Based on Aerial Photography Sept., 1990
   North American Datum 1927
   Contour Interval 100 m
   Universal Transverse Mercator Projection
2. Locations of boreholes at toe of Faro rock dumps are approximate only.

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1996 Drilling Program

Borehole Locations Faro Mine Site

PROJECT NO.	DATE	APPROVED	FIGURE
033002	Dec. 1996		2

GRUM PIT

TILL DUMP

VANGORDA PIT

NEW DITCH ROAD

BURIED PIPELINE FROM LITTLE CREEK TO WATER TREATMENT PLANT

VANGORDA CREEK DIVERSION (FLUME)

PLUNGE POOL

SHEEP PAD PONDS

PELLY POND

TILL STOCKPILE

LUBE STATION

OLD SHOP U/G PORTAL

FUEL TANKS

MAINTENANCE STORAGE AREA

CORE SHACKS

SOUTH WEST DUMP

MAIN DUMP

GRUM ROCK DUMPS

GRUM CREEK

ROAD

MOOSE POND

LITTLE CREEK DAM

VANGORDA CREEK

VANGORDA DUMPS

BH96-9A/B

P9404A/B(V46/47)

GW9404(V37)

P9403A/B(V44/45)

GW9405(V38)

GW9403(V36)

P9402A/B(V41/42)

P9402C(V43)

GW9401(V34)

P9401A/B(V39/40)

GW9402(V35)

SEEPAGE COLLECTION DITCH

ROAD

6,903,000 N

3,000,595

593,000 E

E 902,000 N

591,000

995,000 N

592,000 E

LEGEND

- Existing Monitoring Wells
- 1996 Drilling Program

0 100 200 300 400 500 600 700 800 900 1000m

Scale 1:10 000

Note:
Contours of Grum Pit and Dumps as of early Spring 1996.
Coordinates are UTM in metres.
Base Map supplied by Anvil Range Mining Corporation.
Elevations are relative to Mean Sea Level (NAD27)

Contour Interval 10 metres

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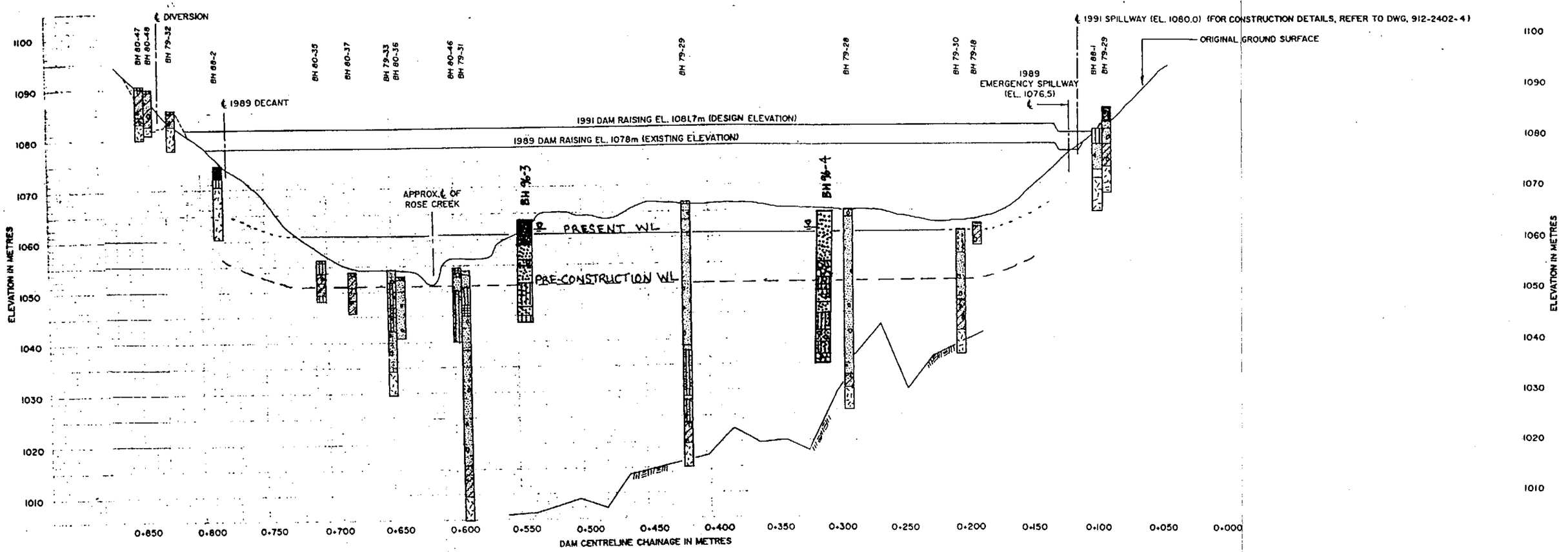
Anvil Range Mining Corporation

1996 Drilling Program

Vangorda Plateau Ground Water Monitoring Stations

PROJECT NO.	DATE	APPROVED	FIGURE
033001	Dec. 1996		3



SECTION A – A'

SCALE: 1 : 3000 HORIZONTAL
1 : 750 VERTICAL

Fill
Organics & Debris
Organic Silt
Volcanic Ash
Boulders & Cobbles
Gravel
Sand & Gravel (Alluvium)
Sand
Silt
Clay
Till or Colluvium
Bedrock
T.P. Test Pit
B.H. Borehole

LEGEND

DRAWING TAKEN FROM:

NOTES

1. ALL ELEVATION ARE REFERENCED TO THE DOWN VALLEY PROJECT DATUM. SUBTRACT 32.3 m FROM ELEVATIONS SHOWN TO CORRECT TO SEA LEVEL DATUM.

DISCLAIMER

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H.B. GILCHRIST — PROFESSIONAL ENGINEER — NORTHWEST TERRITORIES

Scale: as shown	
Job No. 912-2402	
Drawing No. 912-2402-2	
Drawn by: RK	Reviewed by: PW/HBG
Date: JUL 91	Date: JUL 91

CURRAGH RESOURCES INC.
Faro
Yukon Territory

INTERMEDIATE DAM
1991 RAISING
PLAN AND PROFILE

INT. DAM RAISING & CV DAM TOE DRAIN...

Golder Associates Ltd.

Sheet 2 of 8

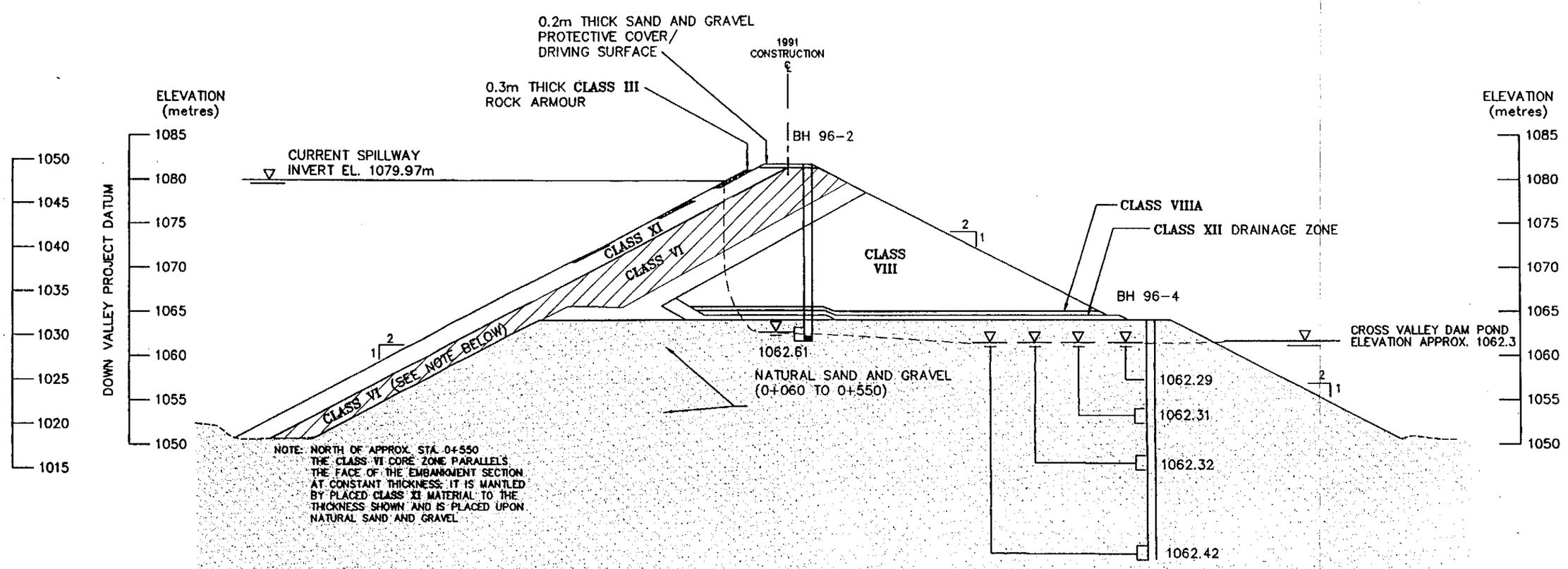
ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

Anvil Range Mining Corporation

Anvil Complex Closure Plan

INTERMEDIATE DAM LONGITUDINAL PROFILE

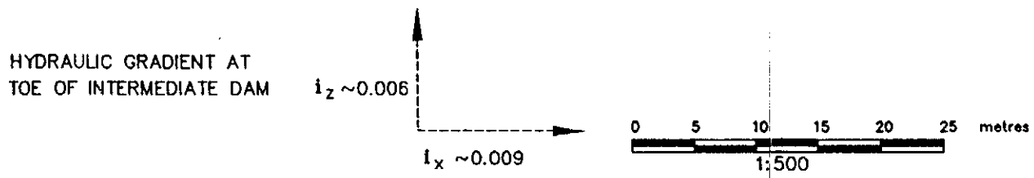
PROJECT NO.	DATE	APPROVED	FIGURE
033001	Nov. 1996		4



NOTES :

1. Embankment geometry and internal zoning as shown in Golder Associates Drawing 912-2402-3, Int. Dam Raising & C.V. Dam Toe Drain, Cross Section and Detailed Plan, Rev. 1, Aug. 8, 1991.
2. All elevations are referenced to Down Valley Project Datum. Subtract 32.3m from elevations shown to convert to mean sea level (NAD27) datum.
3. Refer to Golder Associates as built reports for detailed descriptions of material classes. General descriptions as follows :

CLASS VI	Dam Core (glacial till)
CLASS VII	Upstream Shell (silty sand and gravel)
CLASS VIII	Downstream Shell (sand and gravel)
CLASS VIIIA	Drainage Filter (sand and gravel)
CLASS IX	Upstream Filter (silty sand)
CLASS X	Downstream Filter (sand and gravel)
CLASS XI	Tailings Sand (fine to medium sand)
CLASS XII	Drainage Zone (gravel)



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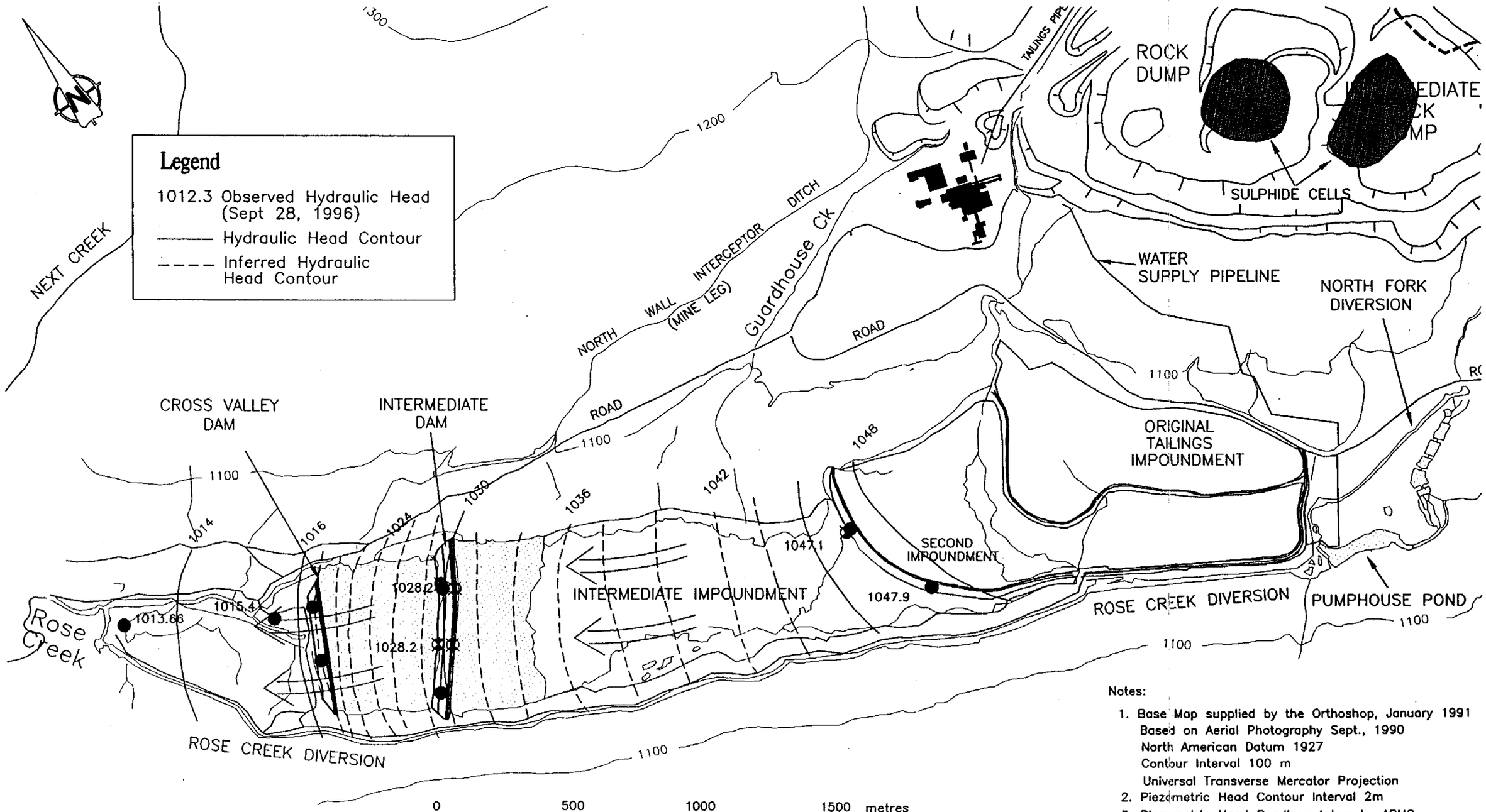
Anvil Range Mining Corporation

1996 Drilling Program

PIEZOMETRIC HEAD CONDITIONS AT INTERMEDIATE DAM

PROJECT NO.	DATE	APPROVED	FIGURE
033002	Dec. 1996		5



Notes:

1. Base Map supplied by the Orthoshop, January 1991
   Based on Aerial Photography Sept., 1990
   North American Datum 1927
   Contour Interval 100 m
   Universal Transverse Mercator Projection
2. Piezometric Head Contour Interval 2m
3. Piezometric Head Readings taken by ARMC on September 26–27, 1996.

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Anvil Range Mining Corporation

1996 Drilling Program

Hydraulic Head Contour Map Rose Creek Valley Aquifer Late September, 1996

PROJECT NO.	DATE	APPROVED	FIGURE
033002	Dec. 1996		6

Appendix A

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-1
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Crest of Int. Dam (South Side)	UTM ZONE: - N6913921.3 E580550.5	ELEVATION: 1049.3 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE	SPT(N)	DEPTH(ft)
0.0		SAND (FILL) - very fine to fine grained, silty, trace angular to subangular gravel, damp, dense, greenish brown.	- well stickup = 0.75 m ags - well completed with 6" diameter steel protective casing			0.0
2.0						5.0
4.0					40	10.0
6.0		SAND (FILL) - gravelly, some silt, trace cobbles, damp, dense to very dense, greenish-brown.			50/10	20.0
8.0						25.0
10.0		GRAVEL (FILL) - subangular to subrounded, sandy, trace silt, dry to damp, green-brown.			56/15	30.0
		SAND AND GRAVEL (FILL) - subangular to subrounded, trace silt, damp, green-brown.				35.0
12.0					50/14	40.0
		GRAVEL (FILL) - subangular to subrounded, sandy, trace silt, dry to damp, light brown.				45.0
14.0		SAND (FILL) - gravelly, trace silt, damp, light brown.				50.0
16.0		GRAVEL AND SAND (FILL) - subangular to subrounded, trace silt, dry to damp, light brown.			90	55.0
18.0		- increasing moisture content below about 18.3 m.				60.0
20.0			- water level on September 8, 1996			65.0

SPT (#blows/30 cm): 20 40 60 80

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LOGGED BY: TH/CW	COMPLETION DEPTH: 22.3 m
REVIEWED BY: AR	COMPLETE: 30/08/96
Fig. No: 1	Page 1 of 2

96/12/10 02:23PM (MONWELL1)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-1
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Crest of Int. Dam (South Side)	UTM ZONE: - N6913921.3 E580550.5	ELEVATION: 1049.3 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	WELL INSTALLATION	Additional Comments	SAMPLE TYPE	SPT(N)	● SPT (#blows/30 cm) ● 20 40 60 80	DEPTH(ft)
20.0		SAND (FILL) - trace gravel, moist to wet, light brown.						70.0
22.0		GRAVEL (FILL) - coarse grained, subrounded, some sand, trace silt, wet, light brown.						75.0
		GRAVEL (FILL) - fine grained, subrounded to subangular, sandy, trace silt, wet, light brown.						
24.0		BOREHOLE TERMINATED AT 22.3 m IN SANDY GRAVEL FILL. MONITORING WELL INSTALLED.						80.0
26.0								85.0
28.0								90.0
								95.0
30.0								100.0
32.0								105.0
34.0								110.0
								115.0
36.0								120.0
38.0								125.0
40.0								130.0

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LOGGED BY: TH/CW	COMPLETION DEPTH: 22.3 m
REVIEWED BY: AR	COMPLETE: 30/08/96
Fig. No: 1	Page 2 of 2

96/12/10 02:23PM (BOREWELL1)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-2
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Crest of Int. Dam (North Side)	UTM ZONE: - N6914103.8 E580685.6	ELEVATION: 1049.3 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE	DEPTH(ft)
0.0		SAND (FILL) - fine grained, silty, trace gravel, dry to damp, green-brown.	- well stickup = 0.75 m ags - well completed with 6" diameter steel protective casing		0.0
6.0		SAND (FILL)- fine grained, some silt, trace gravel, dry to damp, green-brown.			25.0
10.0		GRAVEL (FILL) - some sand to sandy, trace silt, damp to moist, light green-brown.			35.0
14.0		SAND (FILL) - gravelly, some silt, dry to damp, green-brown.			45.0
18.0			- water level on September 8, 1996		60.0
20.0		GRAVEL (FILL) - predominantly coarse			65.0

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LOGGED BY: TH/CW	COMPLETION DEPTH: 19.0 m
REVIEWED BY: AR	COMPLETE: 30/08/96
Fig. No: 2	Page 1 of 1

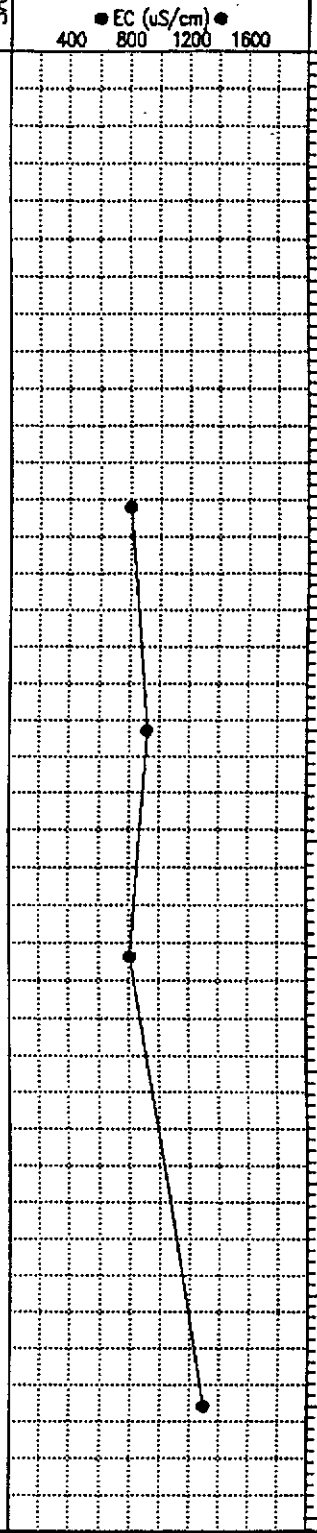
98/12/10 02:23PM (BOREHOLE2)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-3
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Toe of Int. Dam (South Side)	UTM ZONE: - N6913945.4 E580519.3	ELEVATION: 1031.4 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE
0.0		GRAVEL (FILL) - well graded, subrounded, sandy, some silt, damp to moist, light brown.	- well stickups: 3A (shallow) - 0.68 m ags 3B (deep) - 0.63 m ags - wells completed with 6" diameter steel protective casing - water levels: 3A - 1.69 m bgs 3B - 1.62 m bgs (September 8, 1996)	
2.0		- becomes wet at about 2 m. - some sand, trace silt below about 2.3 m.		
4.0		- sandy below about 3.8 m (native?).		
6.0		SAND (NATIVE?) - well graded, some gravel, silt, wet, loose to compact (heaving into casing), brown.	- water EC = 800 uS/cm	
8.0		GRAVEL - subrounded, sandy, trace silt, wet, loose to compact, medium brown.	- water EC = 920 uS/cm	
10.0		SAND - well graded, gravelly (fine), trace silt, wet, loose to compact, medium brown.		
12.0			- water EC = 810 uS/cm	
14.0		SAND - fine grained, silty, trace gravel, wet, loose to compact, light brown.		
16.0				
18.0		SAND - well graded to coarse grained, gravelly, trace silt, wet, loose to compact, medium orange brown.	- water EC = 1300 uS/cm	
20.0		- some silt, some gravel below 18.9 m. SILT - sandy to silty sand, wet, grey.		



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LOGGED BY: TH/CW	COMPLETION DEPTH: 19.8 m
REVIEWED BY: AR	COMPLETE: 31/08/96
Fig. No: 3	Page 1 of 1

96/12/10 02:23PM (BOREHOLE)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-4-1
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Toe of Int. Dam (North Side)	UTM ZONE: - N6914123.8 E580654.8	ELEVATION: 1032.3 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments
0.0		SAND (FILL + NATIVE) - well graded, some gravel, some silt, moist, compact, light brown.	- well stickups: 4A (shallow) - 0.80 m ags 4B (upp. mid)- 0.75 m ags 4C (low. mid)- 0.70 m ags - well completed with 6" diameter steel protective casing - water levels: 4A - 2.31 m bgs 4B - 2.29 m bgs 4C - 2.28 m bgs (September 8, 1996)
2.0		- becomes wet at about 1.8 m.	
4.0		- trace gravel below 3.7 m (native?).	
6.0			- pipe broken on MW96-4A at 5.7 m bgs; open hole below
8.0		- some gravel, silt below 7.6 m.	
10.0		GRAVEL (NATIVE) - subrounded, some sand, trace silt, wet, permeable, compact, light brown.	- MW96-4B completed as 1" diameter well
12.0			
14.0		SAND - silty, trace gravel, wet, medium brown.	- water EC = 1600 uS/cm pH = 6.9
		GRAVEL - subrounded, sandy, wet, permeable, medium brown.	
16.0		SAND - silty, trace gravel, wet, medium brown.	
		SAND - gravelly, trace to some silt, wet, medium brown.	- water EC = 1970 uS/cm pH = 6.4
18.0			
20.0			- water EC = 1630 uS/cm

SAMPLE TYPE

pH: 6.6 7.2 7.8 8.4

EC (uS/cm): 400 800 1200 1600

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

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LOGGED BY: TH/CW	COMPLETION DEPTH: 30.6 m
REVIEWED BY: AR	COMPLETE: 02/09/96
Fig. No: 4	Page 1 of 2

96/12/10 02:23PM (MONWELL4)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-4-1
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Toe of Int. Dam (North Side)	UTM ZONE: - N6914123.8 E580654.8	ELEVATION: 1032.3 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	WELL INSTALLATION	Additional Comments	SAMPLE TYPE	pH / EC (uS/cm)	DEPTH(ft)
20.0		SAND - silty, trace gravel, wet, loose to compact (fast drilling), light brown.		pH = 6.8			70.0
22.0		GRAVEL - sandy, some silt, wet, brown.					75.0
		SAND - silty, trace gravel, wet, loose to compact, light brown.					
24.0		GRAVEL - sandy, some silt, wet, permeable, light brown.		- water EC = 1660 uS/cm pH = 7.1			80.0
26.0		SAND - silty, some gravel to sandy silt, wet, relatively soft, orange-brown (Fe oxides).					85.0
28.0		GRAVEL - fine to coarse, occasional cobbles, boulders, subangular to subrounded, sandy, trace silt, wet, dense?, light orange-brown (Fe oxides).		- water EC = 1900 uS/cm pH = 7.2			90.0
30.0		- boulder from 29.6 to 29.9.		- deep well broken during installation; left down-hole - grain size analysis: 62 % gravel 33 % sand 5 % silt			95.0
		BOREHOLE TERMINATED AT 30.6 m IN GRAVEL. 3 MONITORING WELLS INSTALLED.					100.0
32.0							105.0
34.0							110.0
36.0							115.0
38.0							120.0
40.0							125.0
							130.0

pH: 6.6 7.2 7.8 8.4

EC (uS/cm): 400 800 1200 1600

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LOGGED BY: TH/CW | COMPLETION DEPTH: 30.6 m

REVIEWED BY: AR | COMPLETE: 02/09/96

Fig. No: 4 | Page 2 of 2

96/12/10 02:24PM (WOWELL4)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-4-II
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: 2 m southwest of 96-4-I	UTM ZONE: - N6914123.5 E580653.2	ELEVATION: 1032.2 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE	EC (uS/cm) 400 800 1200 1600	DEPTH(ft)
0.0		GRAVEL (FILL + NATIVE) - subangular to subrounded, sandy, trace silt, moist, light brown.	- well stickup: 0.70 m ags - well completed with 6" diameter steel protective casing - water level on September 8, 1996.			0.0
2.0		- becomes wet at 1.8 m.				5.0
4.0						10.0
6.0		SAND - well graded, trace gravel, silt, wet, dark brown.				15.0
8.0		GRAVEL - well graded, sandy, trace silt, wet, grey-brown.				20.0
10.0						25.0
12.0		SAND - fine to medium grained, silty, trace gravel, wet, brown.				30.0
14.0		GRAVEL - well graded, sandy, trace silt, wet, grey-brown.				35.0
16.0			- water EC = 1640 uS/cm			40.0
18.0		- coarser grained below 18.3 m.				45.0
20.0						50.0
						55.0
						60.0
						65.0

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LOGGED BY: TH/CW | COMPLETION DEPTH: 28.0 m
REVIEWED BY: AR | COMPLETE: 03/09/96
Fig. No: 48 |

96/12/10 02:24PM (NORWELD3)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-4-II
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: 2 m southwest of 96-4-I	UTM ZONE: - N6914123.5 E580653.2	ELEVATION: 1032.2 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	WELL INSTALLATION	Additional Comments	SAMPLE TYPE	DEPTH(ft)
20.0						70.0
22.0		- some sand, orange-brown below 21.3 m.		- water EC = 1490 uS/cm		75.0
24.0				- water EC = 1640 uS/cm		80.0
26.0		- permeable, water-bearing zone from 26.2 to 27.7 m.		- water EC = 1880 uS/cm		85.0
28.0		- becomes dark brown at 27.7 m.		- water EC = 1920 uS/cm		90.0
		BOREHOLE TERMINATED AT 28.0 m IN GRAVEL. 1 BOREHOLE INSTALLED.				95.0
30.0						100.0
32.0						105.0
34.0						110.0
36.0						115.0
38.0						120.0
40.0						125.0
						130.0

EC (uS/cm) 400 800 1200 1600

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LOGGED BY: TH/CW	COMPLETION DEPTH: 28.0 m
REVIEWED BY: AR	COMPLETE: 03/09/96
Fig. No: 4B	Page 2 of 2

96/12/10 02:24PM (WBWELL3)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-5
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) – 175 mm	PROJECT NO: 033001
BH Loc: North of 2nd Impoundment	UTM ZONE: – N6913416.7 E581989.3	ELEVATION: 1051.4 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments
0.0		TAILINGS – silty fine sand to fine sand, some silt, approx. 30 – 40% sulphides, dominantly pyrite, trace clay, upper 0.3 – 0.6 m oxidized, orange-brown, moist, compact. – dark grey below about 0.6 m.	– well stickups: 5A – 0.69 m ags; 5B – 0.74 m ags; 5C – 0.81 m ags – wells completed with 6" diameter steel protective casing – MW96-5A completed as a 1" diameter well – water levels: 5A (shallow) – 3.79 m bgs; 5B (mid) – 3.77 m bgs; 5C (deep) – 3.80 m bgs
8.0		SAND AND GRAVEL (FILL) – subrounded gravel, well graded sand, mixed with 20 – 30% tailings, moist, compact, dark grey.	
10.0		SAND (NATIVE?) – well graded, trace to some silt, trace gravel, with estimated 5 % pyrite, wet, medium grey-brown.	
12.0		GRAVEL (NATIVE) – subrounded to subangular, some sand, trace silt, wet, medium grey-brown.	– water EC = 1540 uS/cm pH = 6.9
14.0		SAND – well graded, some gravel, trace to some silt, wet, grey-brown.	
		GRAVEL – subangular to subrounded, some sand, trace silt, wet, brown.	
16.0		SAND – well graded, trace to some gravel, trace to some silt, wet, brown.	
		GRAVEL – subangular to subrounded, some sand, trace silt, wet, brown.	– water EC = 1470 uS/cm pH = 7.1
18.0		SAND – fine to medium grained, some silt to silty, trace gravel, wet, brown.	– water EC = 1560 uS/cm
20.0		SILT – sandy, trace to some clay, trace gravel, estimated 2% pyrite, wet	

SAMPLE TYPE

◆pH◆ 6.6 7.2 7.8 8.4

●EC (uS/cm)● 400 800 1200 1600

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

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LOGGED BY: TH/CW	COMPLETION DEPTH: 29.9 m
REVIEWED BY: AR	COMPLETE: 04/09/96
Fig. No: 5	Page 1 of 2

96/12/10 02:24PM (MOWELL4)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-5
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: North of 2nd Impoundment	UTM ZONE: - N6913416.7 E581989.3	ELEVATION: 1051.4 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | CEMENT | DRILL CUTTINGS | SAND

DEPTH(m)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	WELL INSTALLATION	Additional Comments	SAMPLE TYPE	pH / EC (uS/cm)	DEPTH(ft)
20.0		(spongy), grey-brown.				pH: 6.6 7.2 7.8 8.4	70.0
22.0		- brown-grey below 21.5 m.		- water pH = 8.3		EC (uS/cm): 400 800 1200 1600	75.0
24.0		SAND AND GRAVEL - well graded, subangular gravel, some silt to silty, trace clay, trace py, wet, grey.		- water EC = 890 uS/cm pH = 8.6			80.0
26.0							85.0
28.0		- hard drilling (cobbles?) between 27.4 and 28.0 m.					90.0
30.0		BOREHOLE TERMINATED AT 29.9 m IN SAND AND GRAVEL. 3 MONITORING WELLS INSTALLED.					95.0
32.0							100.0
34.0							105.0
36.0							110.0
38.0							115.0
40.0							120.0
							125.0
							130.0

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LOGGED BY: TH/CW	COMPLETION DEPTH: 29.9 m
REVIEWED BY: AR	COMPLETE: 04/09/96
Fig. No: 5	Page 2 of 2

96/12/10 02:24PM (MONWELL4)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-6
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Faro Rock Dump, N. of Rose Ck.	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)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE	pH (6.6 7.2 7.8 8.4) / EC (uS/cm) (400 800 1200 1600)	DEPTH(ft)
0.0		SAND - fine to medium grained, trace silt, dry to damp, brown.	- well stickup: 0.73 m ags - well completed with 6" diameter steel protective casing			0.0
2.0		SILT (TILL?) - sandy, some gravel, moist, green-brown.				5.0
4.0						10.0
6.0		GRAVEL - subangular to subrounded, silty, some sand, damp to moist, green-brown.				15.0
		SAND - fine to medium grained, silty, trace gravel, moist, green-brown.				20.0
8.0						25.0
10.0		- becomes brown at 10.4 m.				30.0
12			- water level 12.21 m bgs on September 8, 1996			40
14.0		- increasing coarse gravel below 13.7 m.				45.0
16.0		SAND - some gravel, silt, damp, dense, orange-brown; mica flakes.	- water EC = 550 uS/cm pH = 7.8			50.0
		GRAVEL AND SAND - subangular to subrounded gravel, trace silt, wet, dark brown.				55.0
18.0			- grain size analysis: 48 % gravel 48 % sand 4 % silt			60.0
		GRAVEL - coarse, subangular to subrounded, some cobbles, boulders, trace sand,	- water EC = 620 uS/cm			65.0
20.0						

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LOGGED BY: TH/CW	COMPLETION DEPTH: 20.1 m
REVIEWED BY: AR	COMPLETE: 05/09/96
Fig. No: 6	Page 1 of 2

06/12/10 02:25PM (BOREHOLE4)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-6
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Faro Rock Dump, N. of Rose Ck.	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)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	WELL INSTALLATION	Additional Comments	SAMPLE TYPE	◆pH◆ 6.6 7.2 7.8 8.4 / ● EC (uS/cm) ● 400 800 1200 1600	DEPTH(ft)
20.0		silt, wet, permeable, brown.		pH = 7.8			70.0
		BOREHOLE TERMINATED AT 20.1 m IN GRAVEL.					
		MONITORING WELL INSTALLED.					
22.0							75.0
24.0							80.0
26.0							85.0
28.0							90.0
30.0							95.0
32.0							100.0
34.0							105.0
36.0							110.0
38.0							115.0
40.0							120.0
							125.0
							130.0

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LOGGED BY: TH/CW	COMPLETION DEPTH: 20.1 m
REVIEWED BY: AR	COMPLETE: 05/09/96
Fig. No: 6	Page 2 of 2

96/12/10 02:25PM (BOREHOLE4)

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)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE	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
2.0					5.0
					10.0
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.			15.0
6.0			- water level 5.17 m bgs on September 8, 1996		20.0
8.0		- becomes moist to wet at about 7.6 m. PHYLLITE BEDROCK - aphanitic, well foliated, fractured, light green, some water.			25.0
					30.0
10.0		BOREHOLE TERMINATED AT 9.2 m IN PHYLLITE BEDROCK. MONITORING WELL INSTALLED.			35.0
12.0					40.0
14.0					45.0
16.0					50.0
					55.0
18.0					60.0
20.0					65.0

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LOGGED BY: TH/CW	COMPLETION DEPTH: 9.2 m
REVIEWED BY: AR	COMPLETE: 06/09/96
Fig. No: 7	Page 1 of 1

98/12/10 02:25PM (WORWELL2)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-8
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: Faro Rock Dump - Lower Faro Ck.	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)	SOIL SYMBOL	SOILS/ROCK DESCRIPTION	Additional Comments	SAMPLE TYPE	pH / EC (uS/cm)	DEPTH(ft)
0.0		GRAVEL (COBBLES, BOULDERS) - subrounded, some sand, trace silt, dry to damp, light brown.	- well stickups: 8A (shallow) - 0.70 m ags 8B (deep) - 0.78 m ags - well completed with 6" diameter steel protective casing		pH: 6.6 7.2 7.8 8.4 EC (uS/cm): 400 800 1200 1600	0.0
2.0						5.0
		SAND - fine grained, silty, trace to some gravel, damp to moist, light grey-brown.	- water levels: 8A - 2.84 m bgs 8B - 2.78 m bgs (September 8, 1996)			10.0
4.0		- becomes moist to wet at 3.7 m.				15.0
		- becomes brown, some gravel at 4.6 m.				
		- becomes light grey-brown at 5.5 m.				
6.0		SAND - medium to coarse grained, some gravel, trace to some silt, moist to wet, water-bearing, grey orange-brown.	- water EC = 1680 uS/cm pH = 6.5			20.0
8.0		GRAVEL AND SAND - subangular to subrounded, coarse grained sand, trace silt, wet, brown.	- grain size analysis: 60 % gravel 35 % sand 5 % silt			25.0
		PHYLLITE BEDROCK - aphanitic, well foliated, moderately weathered, wet.				30.0
10.0		- open, weathered seam at 8.6 to 8.8 m.				35.0
		BOREHOLE TERMINATED AT 9.5 m IN PHYLLITE BEDROCK. TWO MONITORING WELLS INSTALLED.				40.0
12.0						45.0
14.0						50.0
16.0						55.0
18.0						60.0
20.0						65.0

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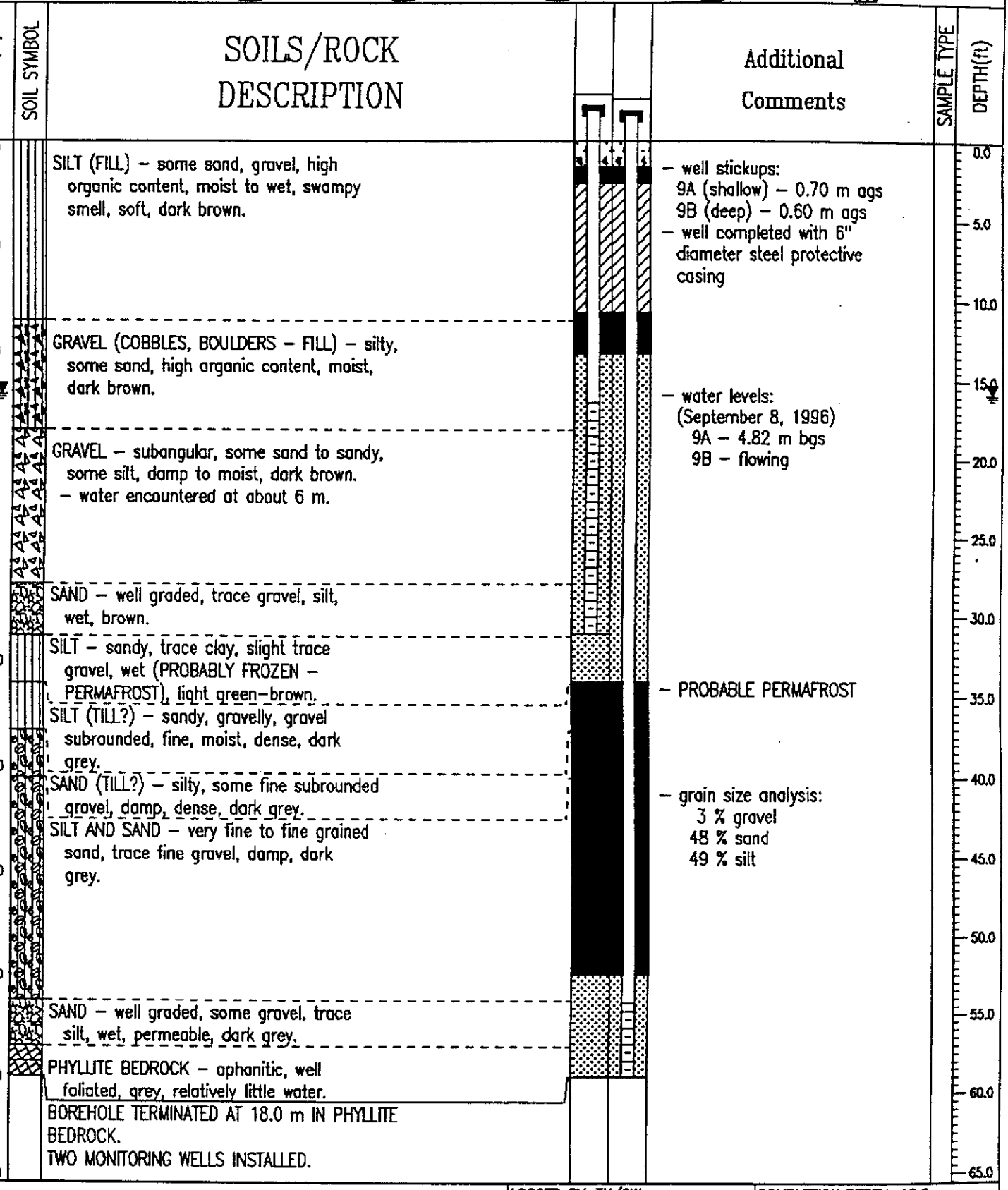
LOGGED BY: TH/CW	COMPLETION DEPTH: 9.4 m
REVIEWED BY: AR	COMPLETE: 06/09/96
Fig. No: 8	Page 1 of 1

96/12/10 02:25PM (WDWELL4)

Client Name: Anvil Range Mining Corp.	Driller: Midnight Sun Drilling	BOREHOLE NO: BH96-9
Location: Faro, Yukon	Track-mounted Air-rotary (ODEX) - 175 mm	PROJECT NO: 033001
BH Loc: South of Grumm 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



ROBERTSON GEOCONSULTANTS INC. Vancouver, B.C.	LOGGED BY: TH/CW	COMPLETION DEPTH: 18.0 m
	REVIEWED BY: AR	COMPLETE: 07/09/96
	Fig. No: 9	Page 1 of 1

96/12/10 02:25PM (BOREWELL2)

Appendix B

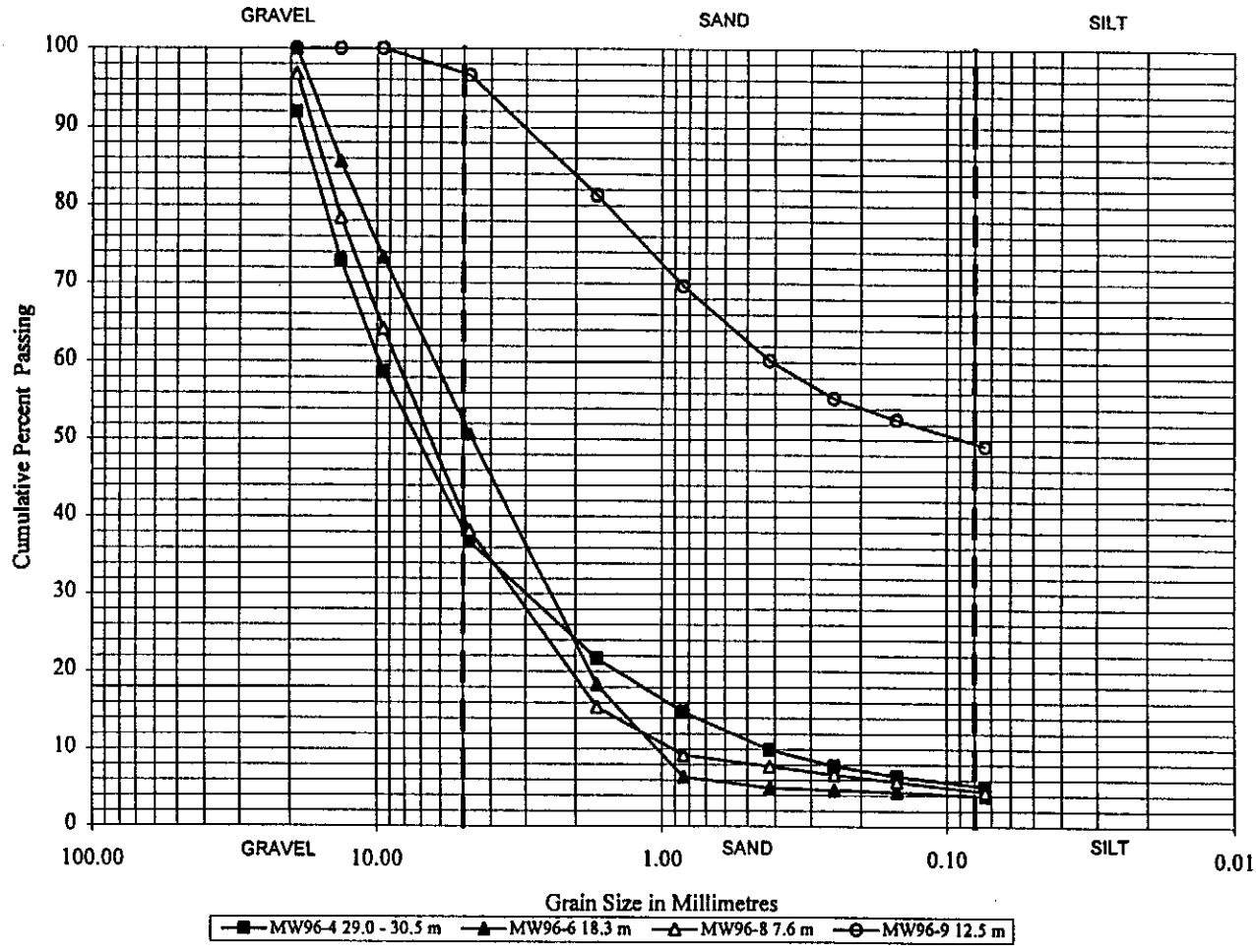


FIGURE: B-1	TITLE: Summary of Grain Size Analyses

Project Number: 33002
Sampled By: Todd Hamilton/Christoph Wels
Screen Analysis By: Todd Hamilton

Project Name: Anvil Range - 1996 Drilling Program
Date Sampled: Sep-96
Date Analyzed: Oct-96

ROBERTSON GEOCONSULTANTS INC.

Consulting Geotechnical and Environmental Engineers
A Robertson Group Company

TABLE B1
SIEVE ANALYSES RESULTS

PROJECT **Anvil Range - 1996 Drilling Program**

REMARKS Samples from Groundwater Monitoring Wells (identified by depth in metres below ground surface)

MONITORING WELL			MW96-4		MW96-6		MW96-8		MW96-9					
SAMPLE LOCATION (ft)			29.0 - 30.5 m		18.3 m		7.6 m		12.5 m					
U.S. SIEVE NO.	SIEVE OPENING		CUMULATIVE % PASSING											
	INCHES	MM	GRAMS	%	GRAMS	%	GRAMS	%						
.750"	.750	19.05	68	92	0	100	15	97	0	100				
.525"	.525	13.34	229	73	130	86	96	78	0	100				
.375"	.375	9.53	349	59	240	73	160	64	0	100				
4	.187	4.75	534	37	443	51	275	38	8	97				
12	.066	1.68	661	22	734	18	376	15	45	81				
20	.033	0.84	718	15	841	6	404	9	73	70				
40	.017	0.42	760	10	853	5	411	8	96	60				
60	.010	0.25	778	8	856	5	416	7	108	55				
100	.006	0.15	789	6	858	4	420	6	115	53				
200	.003	0.07	800	5	863	4	425	4	123	49				
TOTAL			843	100	898	100	445	100	242	100				

Appendix C

Appendix C

Geochemical Assay Results for Borehole 96-5

Borehole 96-5 was drilled through approximately 10 meters of tailings into the underlying Rose Creek valley aquifer. Visual observations of the cuttings suggested that there were significant pyrite contents (2-5% by weight) present in aquifer material at greater depths in the profile (in particular in the silty aquitard layer at 17 to 23.5 m (56 ft - 77 ft) bgs). Very high pyrite contents (~20-40%) were also observed in the fines material purged from the deepest piezometer (MW96-5C).

High pyrite contents in the aquifer material could significantly influence groundwater quality producing elevated concentrations of metals and sulphate under oxidizing conditions. However, there was concern that these high levels of pyrite were not representative of the formation material itself but instead represent fine tailings material introduced from above by the drilling process. A solids assay of metal and sulphur species content was performed by Chemex Labs in Vancouver on selected cuttings from this borehole (including a sample from the tailings at ~15 ft) and a sample of the purged sediment from MW96-5C in order to verify visual observations and to ascertain whether the pyrite at depth could have been introduced by the drilling through the tailings deposit.

The results of the solids assay are summarized in Table C1. Detailed results of the laboratory analyses are shown in the attached laboratory certificates. Note that bulk samples were used for analysis, i.e. the samples were not screened to a particular size prior to crushing and digestion. The data indicate that the purged sediment sample from the MW96-5C piezometer is very similar in composition to that of the tailings near surface (~ 30% pyrite by weight and ~1.1 to 1.4% Zn by weight). In contrast, the cuttings taken from the screened interval (sample 96-5-89') contains only about 0.41% sulfide, presumably most in the form of pyrite, and only negligible amounts of Zn (0.016% by weight) (Table C1).

The solids assay data strongly suggest that some tailings fines were carried downward into the base of the borehole either inside or outside of the casing. Most of the pyrite-rich sediment was purged from the piezometer 96-5C during well development (see section 2.1.3). The deep piezometer was the only one producing pyrite-rich sediment during well development at BH96-5.

The solids assay of the cuttings taken from the 30 ft and 70 ft levels show above background concentrations of iron (~5% by wt), lead (0.05-0.06% by wt) and zinc (0.08-0.1% by wt) which is consistent with field observations of elevated pyrite contents. It is unclear whether these elevated metal contents also represent "contamination" from the tailings above introduced during drilling. A microscopic evaluation of the pyrite grains would be required to confirm this contention.

Table C1

Results of Solids Assay on Cuttings and purged sediment from BH96-5.

SAMPLE	Ag ppm (AAS)	Al % (ICP)	Ba % (ICP)	Ca % (ICP)	Fe % (ICP)	Pb % (AAS)	Zn % (AAS)	S % Total	S % Sulfide	S % Sulfate
96-5-15'	17.0	1.15	0.02	0.25	29.8	0.682	1.486	30.00	28.83	0.77
96-5-30'	1.0	6.25	0.21	2.20	5.0	0.062	0.098	-----	-----	-----
96-5-50'	<1.0	5.90	0.11	2.90	3.1	0.008	0.008	-----	----	----
96-5-70'	1.0	6.20	0.19	2.40	4.9	0.050	0.078	----	-----	-----
96-5-89'	<1	6.35	0.10	3.65	3.4	0.017	0.016	0.43	0.41	0.02
96-5C-purged sediment sample	16.0	1.10	0.01	0.35	>30.0	0.541	1.102	33.40	31.97	0.83

Chemex Labs Ltd.

Analytical Chemists * Geochemists * Registered Assayers

212 Brooksbank Ave., North Vancouver
British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: ROBERTSON GEOCONSULTANTS INC.

640 - 580 HORNBY ST.
VANCOUVER, BC
V6C 3B6

A9636598

Comments: ATTN:C.WELS

CERTIFICATE A9636598

(OFU) - ROBERTSON GEOCONSULTANTS INC.

Project: 033022
P.O. # :

Samples submitted to our lab in Vancouver, BC.
This report was printed on 10-NOV-96.

SAMPLE PREPARATION

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION
209	2	High grade assay ring
290	2	Assay HF ICP digestion charge

ANALYTICAL PROCEDURES

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION	METHOD	DETECTION LIMIT	UPPER LIMIT
1263	2	Ag ppm: high grade 24 element	AAS	0.5	200
4031	2	Al %: A22 ICP package	ICP-AES	0.05	30.0
4032	2	Ba ppm: A22 ICP package	ICP-AES	100	50000
4033	2	Be ppm: A22 ICP package	ICP-AES	10	10000
4034	2	Bi ppm: A22 ICP package	ICP-AES	20	50000
4035	2	Ca %: A22 ICP package	ICP-AES	0.05	30000
4036	2	Cd ppm: A22 ICP package	ICP-AES	10	10000
4037	2	Co ppm: A22 ICP package	ICP-AES	10	100000
4038	2	Cr ppm: A22 ICP package	ICP-AES	10	100000
4039	2	Cu ppm: A22 ICP package	ICP-AES	10	100000
4040	2	Fe %: A22 ICP package	ICP-AES	0.05	30.0
4041	2	K %: A22 ICP package	ICP-AES	0.1	20.0
4042	2	Mg %: A22 ICP package	ICP-AES	0.05	30.0
4043	2	Mn ppm: A22 ICP package	ICP-AES	10	100000
4044	2	Mo ppm: A22 ICP package	ICP-AES	10	100000
4045	2	Na %: A22 ICP package	ICP-AES	0.05	20.0
4046	2	Ni ppm: A22 ICP package	ICP-AES	10	100000
4075	2	Pb %: high grade 24 element	AAS	0.001	10.00
4047	2	Sr ppm: A22 ICP package	ICP-AES	10	100000
4048	2	Ti %: A22 ICP package	ICP-AES	0.05	20.0
4049	2	V ppm: A22 ICP package	ICP-AES	10	50000
4050	2	Zn ppm: A22 ICP package	ICP-AES	20	100000
1380	2	S %: Leco furnace	LECO-IR DETECTOR	0.01	100.0
1066	2	S %: HNO3-bromide digestion	GRAVIMETRIC	0.01	100.00
1379	2	Sulfate S %: Acid or H2O leach	GRAVIMETRIC	0.01	100.00

Chemex Labs Ltd.

Analytical Chemists * Geochemists * Registered Assayers

212 Brooksbank Ave., North Vancouver
British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: [redacted]

640 - 580 HORNBY ST.
VANCOUVER, BC
V6C 3B6

Project : 033022
Comments: ATTN:C.WELS

Page Number :1-A
Total Pages :1
Certificate Date: 10-NOV-96
Invoice No. :I9636598
P.O. Number :
Account :OFU

CERTIFICATE OF ANALYSIS A9636598

SAMPLE	PREP CODE		Ag ppm AAS	Al % (ICP)	Ba ppm (ICP)	Be ppm (ICP)	Bi ppm (ICP)	Ca % (ICP)	Cd ppm (ICP)	Co ppm (ICP)	Cr ppm (ICP)	Cu ppm (ICP)	Fe % (ICP)	K % (ICP)	Mg % (ICP)	Mn ppm (ICP)
96-5-15'	209	290	17.0	1.15	200	< 10	< 20	0.25	10	140	120	1330	29.8	0.1	0.25	970
MW5C-Ps	209	290	16.0	1.10	100	< 10	< 20	0.35	10	130	160	1140	>30.0	0.1	0.25	740

NOTE: * HYDROCHLORIC ACID SOLUBLE SULFATE
NOTE: *** NITRIC ACID SOLUBLE SULFIDE

CERTIFICATION: [signature]

Chemex Labs Ltd.

Analytical Chemists * Geochemists * Registered Assayers
212 Brooksbank Ave., North Vancouver
British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: ROBERTSON GEOCONSULTANTS INC.

640 - 580 HORNBY ST.
VANCOUVER, BC
V6C 3B6

Project : 033022
Comments: ATTN:C.WELS

Page Number :1-B
Total Pages :1
Certificate Date: 10-NOV-96
Invoice No. :I9636598
P.O. Number :
Account :OFU

CERTIFICATE OF ANALYSIS A9636598

SAMPLE	PREP CODE		Mo ppm (ICP)	Na % (ICP)	Ni ppm (ICP)	Pb % AAS	Sr ppm (ICP)	Ti % (ICP)	V ppm (ICP)	Zn ppm (ICP)	S % Total	S % *** Sulfide	S % * Sulfate
96-5-15'	209	290	< 10	0.05	40	0.682	50	< 0.05	30	14860	30.0	28.83	0.77
MW5C-PS	209	290	< 10	0.15	30	0.541	50	< 0.05	10	11020	33.4	31.97	0.83

NOTE: * HYDROCHLORIC ACID SOLUBLE SULFATE
NOTE: *** NITRIC ACID SOLUBLE SULFIDE

CERTIFICATION: [signature]

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British Columbia, Canada V7J 2C1
PHONE: 604-984-0221 FAX: 604-984-0218

To: ROBERTSON GEOCONSULTANTS INC.

640 - 580 HORNBY ST.
VANCOUVER, BC
V6C 3B6

A9636601

Comments: ATTN:C.WELS

CERTIFICATE A9636601

(OFU) - ROBERTSON GEOCONSULTANTS INC.

Project: 033022
P.O. # :

Samples submitted to our lab in Vancouver, BC.
This report was printed on 10-NOV-96.

SAMPLE PREPARATION

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION
208	4	Assay ring to approx 150 mesh
226	4	0-3 Kg crush and split
3202	4	Rock - save entire reject
290	4	Assay HF ICP digestion charge

ANALYTICAL PROCEDURES

CHEMEX CODE	NUMBER SAMPLES	DESCRIPTION	METHOD	DETECTION LIMIT	UPPER LIMIT
1263	4	Ag ppm: high grade 24 element	AAS	0.5	200
4031	4	Al %: A22 ICP package	ICP-AES	0.05	30.0
4032	4	Ba ppm: A22 ICP package	ICP-AES	100	50000
4033	4	Be ppm: A22 ICP package	ICP-AES	10	10000
4034	4	Bi ppm: A22 ICP package	ICP-AES	20	50000
4035	4	Ca %: A22 ICP package	ICP-AES	0.05	30000
4036	4	Cd ppm: A22 ICP package	ICP-AES	10	10000
4037	4	Co ppm: A22 ICP package	ICP-AES	10	100000
4038	4	Cr ppm: A22 ICP package	ICP-AES	10	100000
4039	4	Cu ppm: A22 ICP package	ICP-AES	10	100000
4040	4	Fe %: A22 ICP package	ICP-AES	0.05	30.0
4041	4	K %: A22 ICP package	ICP-AES	0.1	20.0
4042	4	Mg %: A22 ICP package	ICP-AES	0.05	30.0
4043	4	Mn ppm: A22 ICP package	ICP-AES	10	100000
4044	4	Mo ppm: A22 ICP package	ICP-AES	10	100000
4045	4	Na %: A22 ICP package	ICP-AES	0.05	20.0
4046	4	Ni ppm: A22 ICP package	ICP-AES	10	100000
4075	4	Pb %: high grade 24 element	AAS	0.001	10.00
4047	4	Sr ppm: A22 ICP package	ICP-AES	10	100000
4048	4	Ti %: A22 ICP package	ICP-AES	0.05	20.0
4049	4	V ppm: A22 ICP package	ICP-AES	10	50000
4050	4	Zn ppm: A22 ICP package	ICP-AES	20	100000
1380	1	S %: Leco furnace	LECO-IR DETECTOR	0.01	100.0
1066	1	S %: HNO3-bromide digestion	GRAVIMETRIC	0.01	100.00
1379	1	Sulfate S %: Acid or H2O leach	GRAVIMETRIC	0.01	100.00

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To: ROBERTSON GEOCONSULTANTS INC.

640 - 580 HORNBY ST.
VANCOUVER, BC
V6C 3B6

Project : 033022
Comments: ATTN:C.WELS

Page Number :1-A
Total Pages :1
Certificate Date: 10-NOV-96
Invoice No. :I9636601
P.O. Number :
Account :OFU

CERTIFICATE OF ANALYSIS A9636601

SAMPLE	PREP CODE		Ag ppm AAS	Al % (ICP)	Ba ppm (ICP)	Be ppm (ICP)	Bi ppm (ICP)	Ca % (ICP)	Cd ppm (ICP)	Co ppm (ICP)	Cr ppm (ICP)	Cu ppm (ICP)	Fe % (ICP)	K % (ICP)	Mg % (ICP)	Mn ppm (ICP)
96-5-30'	208	226	1.0	6.25	2100	< 10	< 20	2.20	< 10	20	170	100	5.00	2.0	1.10	500
96-5-50'	208	226	< 1.0	5.90	1100	< 10	< 20	2.90	< 10	< 10	130	30	3.05	1.6	1.15	460
96-5-70'	208	226	1.0	6.20	1900	< 10	< 20	2.40	< 10	20	160	90	4.90	1.8	1.20	570
96-5-89'	208	226	< 1.0	6.35	1000	< 10	< 20	3.65	< 10	10	150	40	3.40	1.9	1.80	630

NOTE: * HYDROCHLORIC ACID SOLUBLE SULFATE
NOTE: *** NITRIC ACID SOLUBLE SULFIDE

CERTIFICATION: Ian R. Pulsifer

Chemex Labs Ltd.

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CERTIFICATE OF ANALYSIS A9636601

SAMPLE	PREP CODE		Mo ppm (ICP)	Na % (ICP)	Ni ppm (ICP)	Pb % AAS	Sr ppm (ICP)	Ti % (ICP)	V ppm (ICP)	Zn ppm (ICP)	S % Total	S % *** Sulfide	S % * Sulfate
96-5-30'	208	226	< 10	1.45	60	0.062	290	0.30	60	980	-----	-----	-----
96-5-50'	208	226	< 10	1.10	50	0.008	230	0.30	80	80	-----	-----	-----
96-5-70'	208	226	< 10	1.05	70	0.050	200	0.35	110	780	-----	-----	-----
96-5-89'	208	226	< 10	1.50	60	0.017	240	0.40	100	160	0.43	0.41	0.02

NOTE: * HYDROCHLORIC ACID SOLUBLE SULFATE
NOTE: *** NITRIC ACID SOLUBLE SULFIDE

CERTIFICATION: [signature]

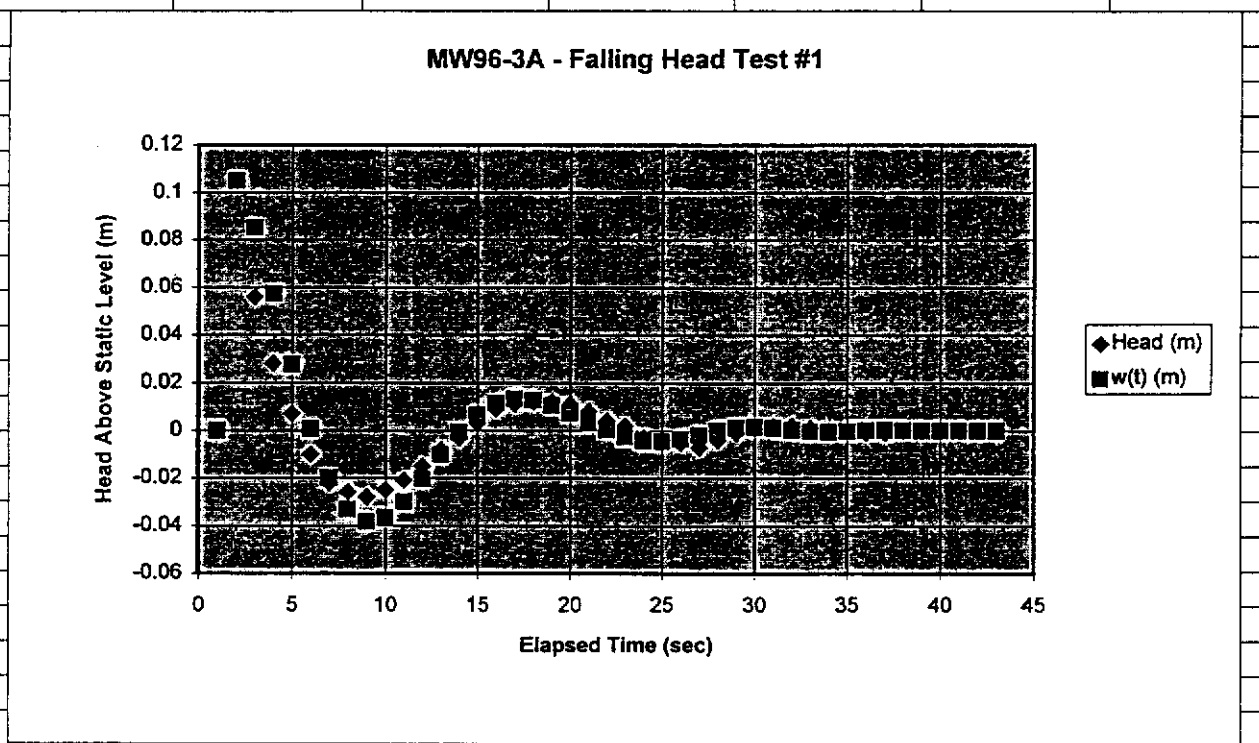
Appendix D

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro		**Well:**	MW96-3A	
Test:	Falling Head Test #1				
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976				
Method:					
Step (1) :	Plot oscillating response data.				
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation				
	through iterative curve matching using $w(t) = w_0 e^{-(\gamma)t}\cos(\omega)t$, noting that where solution				
	is appropriate (response is underdamped), γ is significantly less than ω.				
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity				
	Angular frequency (ω) =		1.3	(s^{-1})	
	Damping constant (γ) =		0.44	(s^{-1})	

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	9:53:01	0.0	0.105	0.105	0.11
	9:53:01	0.3	0.056		0.09
	9:53:01	0.6	0.028		0.06
	9:53:01	0.9	0.007		0.03
	9:53:02	1.2	-0.01		0.00
	9:53:02	1.5	-0.022		-0.02
	9:53:02	1.8	-0.026		-0.03
	9:53:03	2.1	-0.028		-0.04
	9:53:03	2.4	-0.025		-0.04
	9:53:03	2.7	-0.021		-0.03
	9:53:04	3.0	-0.015		-0.02
	9:53:04	3.3	-0.008		-0.01
	9:53:04	3.6	-0.003		0.00
	9:53:04	3.9	0.003		0.01
	9:53:05	4.2	0.009		0.01
	9:53:05	4.5	0.011		0.01
	9:53:05	4.8	0.012		0.01
	9:53:06	5.1	0.012		0.01
	9:53:06	5.4	0.011		0.01
	9:53:06	5.7	0.008		0.00
	9:53:07	6.0	0.004		0.00
	9:53:07	6.3	0.002		0.00

	9:53:07	6.7	-0.003		0.00	
	9:53:08	7.1	-0.004		0.00	
	9:53:08	7.5	-0.005		0.00	
	9:53:08	8.0	-0.007		0.00	
	9:53:09	8.4	-0.004		0.00	
	9:53:09	8.9	-0.001		0.00	
	9:53:10	9.5	0.001		0.00	
	9:53:11	10.0	0.002		0.00	
	9:53:11	10.6	0.002		0.00	
	9:53:12	11.3	0.001		0.00	
	9:53:12	11.9	0		0.00	
	9:53:13	12.6	0		0.00	
	9:53:14	13.4	-0.001		0.00	
	9:53:15	14.1	-0.001		0.00	
	9:53:15	15.0	0		0.00	
	9:53:16	15.9	0		0.00	
	9:53:17	16.8	0		0.00	
	9:53:18	17.8	0		0.00	
	9:53:19	18.9	0		0.00	
	9:53:21	20.0	0		0.00	

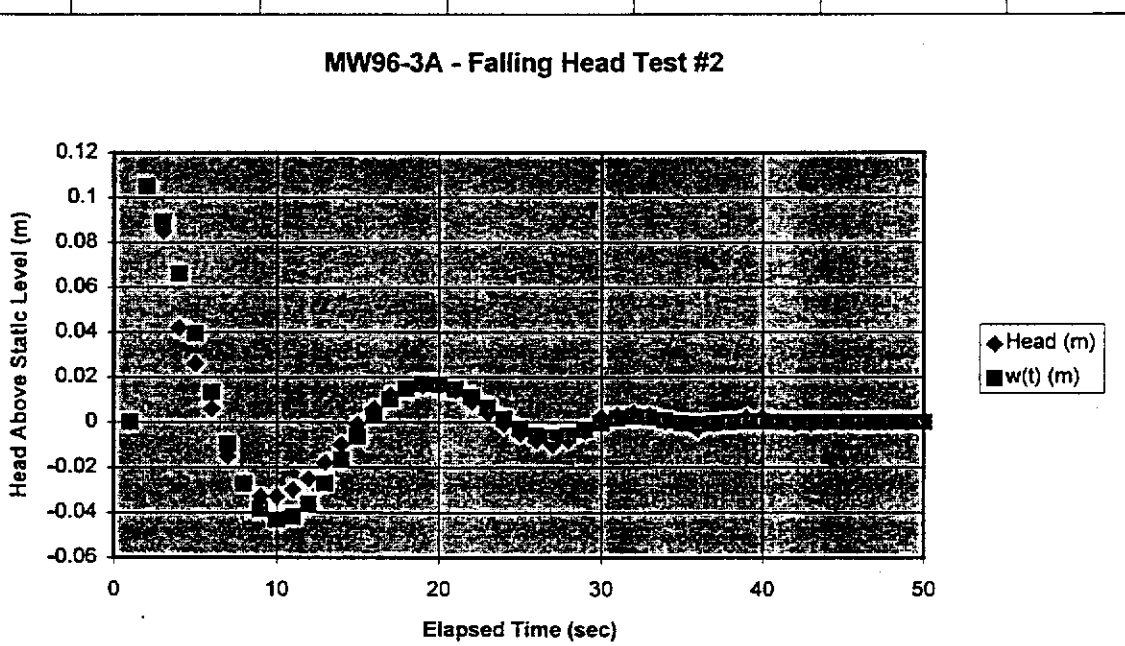


Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	5.2	m
				L (meas) =	6.7	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where $d = \gamma/(g/L)^{1/2}$, then a, where $a = r_c^2(g/L)^{1/2}/8d$,					
	d =	0.32				
	For underdamped solution, d should be less than 0.7					
	a =	3.34E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	4.75E-03	4.75E-03	2.96E-03	2.80E-03	2.79E-03	2.78E-03
0.01	3.98E-03	3.98E-03	2.13E-03	1.92E-03	1.89E-03	1.88E-03
0.1	3.21E-03	3.21E-03	1.29E-03	9.85E-04	8.95E-04	8.63E-04
	T =	8.63E-04	to	2.78E-03	m^2/s	
	Intake Length	1.53	m			
	K =	5.6E-04	to	1.8E-03	m/s	

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro		**Well:**	MW96-3A	
Test:	Falling Head Test #2				
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976				
Method:					
Step (1) :	Plot oscillating response data.				
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation				
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(\omega)t$, noting that where solution				
	is appropriate (response is underdamped), γ is significantly less than ω.				
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity				
	Angular frequency (ω) =		1.15	(s^{-1})	
	Damping constant (γ) =		0.34	(s^{-1})	
			Head	w_0	w(t)
Date	Time	ET (sec)	(m)	(m)	(m)
9/10/96	10:03:34	0.0	0.105	0.105	0.11
	10:03:34	0.3	0.085		0.09
	10:03:34	0.6	0.042		0.07
	10:03:34	0.9	0.026		0.04
	10:03:35	1.2	0.006		0.01
	10:03:35	1.5	-0.015		-0.01
	10:03:35	1.8	-0.027		-0.03
	10:03:36	2.1	-0.033		-0.04
	10:03:36	2.4	-0.033		-0.04
	10:03:36	2.7	-0.030		-0.04
	10:03:37	3.0	-0.025		-0.04
	10:03:37	3.3	-0.018		-0.03
	10:03:37	3.6	-0.010		-0.02
	10:03:37	3.9	-0.001		-0.01
	10:03:38	4.2	0.006		0.00
	10:03:38	4.5	0.012		0.01
	10:03:38	4.8	0.015		0.01
	10:03:39	5.1	0.016		0.02
	10:03:39	5.4	0.016		0.02
	10:03:39	5.7	0.014		0.01
	10:03:40	6.0	0.009		0.01
	10:03:40	6.3	0.004		0.01

	10:03:40	6.7	-0.001		0.00	
	10:03:41	7.1	-0.005		0.00	
	10:03:41	7.5	-0.008		-0.01	
	10:03:41	8.0	-0.010		-0.01	
	10:03:42	8.4	-0.008		-0.01	
	10:03:42	8.9	-0.004		0.00	
	10:03:43	9.5	0.002		0.00	
	10:03:44	10.0	0.003		0.00	
	10:03:44	10.6	0.004		0.00	
	10:03:45	11.3	0.003		0.00	
	10:03:45	11.9	0.000		0.00	
	10:03:46	12.6	-0.001		0.00	
	10:03:47	13.4	-0.003		0.00	
	10:03:48	14.1	-0.001		0.00	
	10:03:48	15.0	0.000		0.00	
	10:03:49	15.9	0.002		0.00	
	10:03:50	16.8	0.002		0.00	
	10:03:51	17.8	0.000		0.00	
	10:03:52	18.9	-0.001		0.00	
	10:03:54	20.0	-0.001		0.00	
	10:03:55	21.2	0.000		0.00	
	10:03:56	22.5	0.000		0.00	
	10:03:57	23.8	0.000		0.00	
	10:03:59	25.2	0.000		0.00	
	10:04:00	26.7	0.000		0.00	
	10:04:02	28.2	0.000		0.00	
	10:04:03	29.8	0.000		0.00	



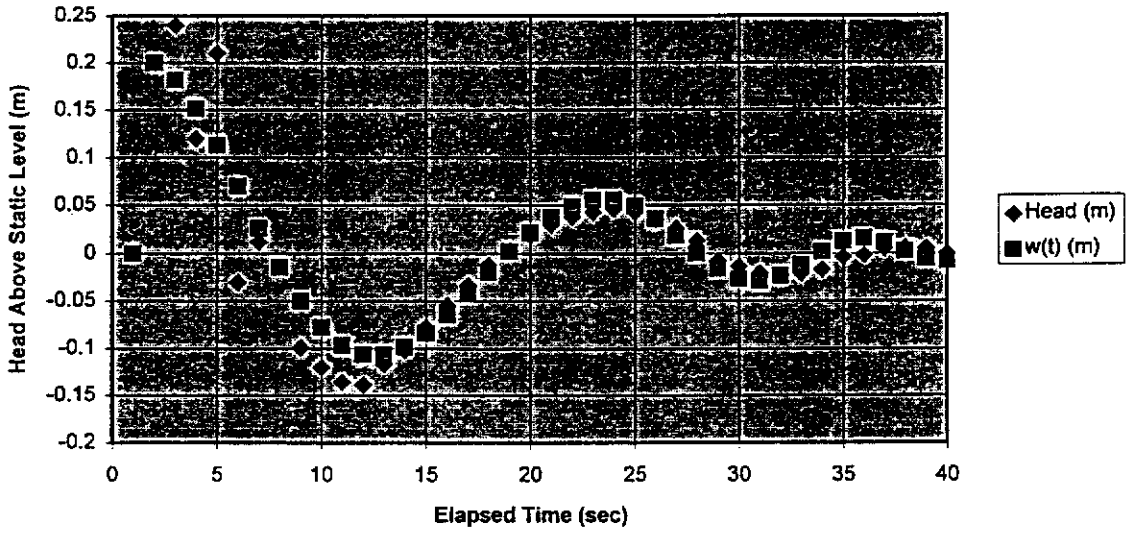
Step (3):	Calculate L, where L = g/(ω2 + γ2)			L (calc) =	6.8	m
				L (meas) =	6.7	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solution;					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where $d = \gamma/(g/L)^{1/2}$, then a, where $a = r_c^2(g/L)^{1/2}/8d$,					
	d =	0.28				
	For underdamped solution, d should be less than 0.7					
	a =	3.30E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	4.74E-03	4.74E-03	2.97E-03	2.82E-03	2.80E-03	2.80E-03
0.01	3.98E-03	3.98E-03	2.15E-03	1.95E-03	1.92E-03	1.91E-03
0.1	3.22E-03	3.22E-03	1.32E-03	1.03E-03	9.42E-04	9.14E-04
	T =	9.14E-04	to	2.80E-03	m^2/s	
	Intake Length	1.53	m			
	K =	6.0E-04	to	1.8E-03	m/s	

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro		**Well:**	MW96-3B	
Test:	Falling Head Test #1				
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976				
Method:					
Step (1) :	Plot oscillating response data.				
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation				
	through iterative curve matching using $w(t) = w0e^{-(\gamma)t}\cos(\omega)t$, noting that where solution				
	is appropriate (response is underdamped), γ is significantly less than ω.				
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity				
	Angular frequency (ω) =		0.93	(s^{-1})	
	Damping constant (γ) =		0.19	(s^{-1})	

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	12:01:08	0.0	0.2	0.2	0.20
	12:01:08	0.3	0.24		0.18
	12:01:08	0.6	0.12		0.15
	12:01:08	0.9	0.21		0.11
	12:01:09	1.2	-0.031		0.07
	12:01:09	1.5	0.012		0.03
	12:01:09	1.8	-0.29		-0.01
	12:01:10	2.1	-0.099		-0.05
	12:01:10	2.4	-0.12		-0.08
	12:01:10	2.7	-0.136		-0.10
	12:01:11	3.0	-0.139		-0.11
	12:01:11	3.3	-0.117		-0.11
	12:01:11	3.6	-0.102		-0.10
	12:01:11	3.9	-0.078		-0.08
	12:01:12	4.2	-0.055		-0.06
	12:01:12	4.5	-0.034		-0.04
	12:01:12	4.8	-0.012		-0.02
	12:01:13	5.1	0.003		0.00
	12:01:13	5.4	0.019		0.02
	12:01:13	5.7	0.03		0.04
	12:01:14	6.0	0.038		0.05

	12:01:14	6.3	0.043		0.06	
	12:01:14	6.7	0.046		0.06	
	12:01:15	7.1	0.043		0.05	
	12:01:15	7.5	0.035		0.04	
	12:01:15	8.0	0.026		0.02	
	12:01:16	8.4	0.013		0.00	
	12:01:16	8.9	-0.008		-0.02	
	12:01:17	9.5	-0.014		-0.03	
	12:01:18	10.0	-0.021		-0.03	
	12:01:18	10.6	-0.023		-0.02	
	12:01:19	11.3	-0.021		-0.01	
	12:01:19	11.9	-0.017		0.00	
	12:01:20	12.6	-0.004		0.01	
	12:01:21	13.4	-0.002		0.02	
	12:01:22	14.1	0.005		0.01	
	12:01:22	15.0	0.006		0.00	
	12:01:23	15.9	0.005		-0.01	
	12:01:24	16.8	0		-0.01	



Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	10.9	m
				L (meas) =	6.7	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solution;					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.20				
	For underdamped solution, d should be less than 0.7					
	a =	3.70E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2 S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		

S	b	T_0	T_1	T_2	T_3	T_4
0.001	5.40E-03	5.40E-03	3.46E-03	3.30E-03	3.28E-03	3.28E-03
.01	4.55E-03	4.55E-03	2.55E-03	2.33E-03	2.30E-03	2.30E-03
0.1	3.69E-03	3.69E-03	1.62E-03	1.31E-03	1.23E-03	1.21E-03

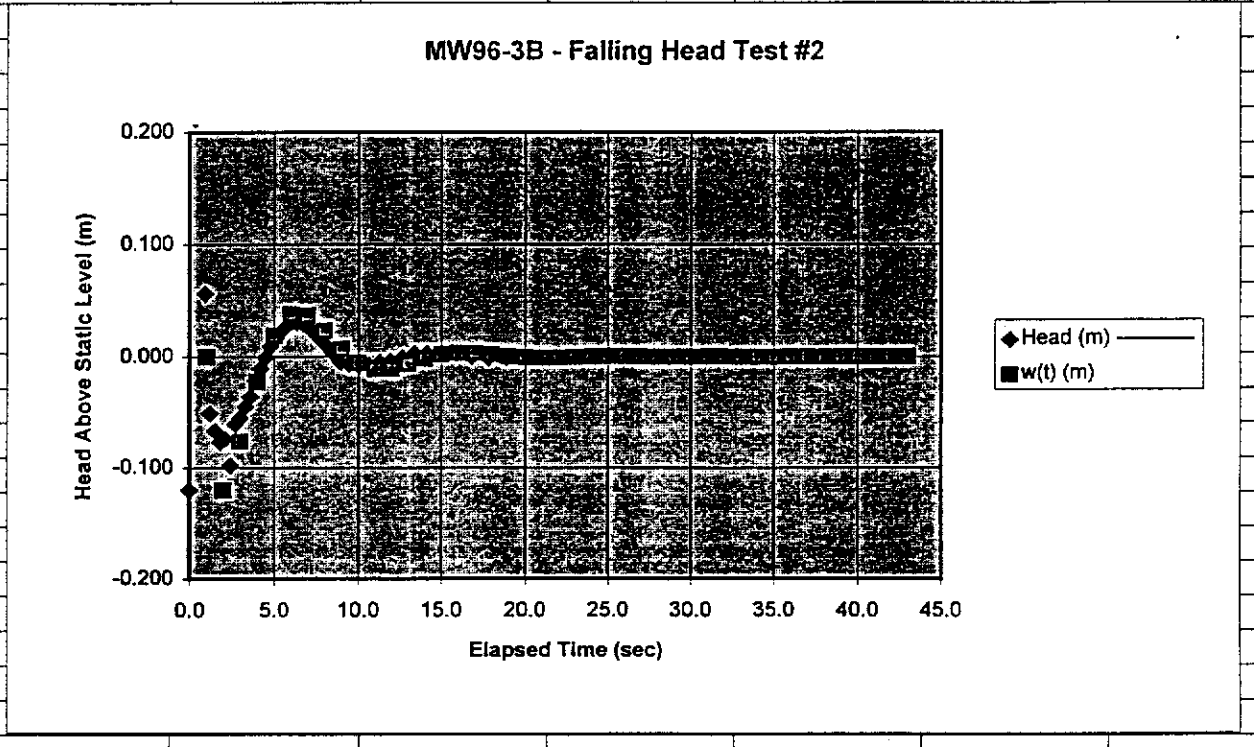
	T =	1.21E-03	to	3.28E-03	m^2/s
	Intake Length	1.47	m		
	K =	8.2E-04	to	2.2E-03	m/s

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro	**Well:**	MW96-3B	
Test:	Falling Head Test #2			
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976			
Method:				
Step (1) :	Plot oscillating response data.			
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation			
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution			
	is appropriate (response is underdamped), γ is significantly less than ω.			
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity			
	Angular frequency (ω) =	2.1	(s^{-1})	
	Damping constant (γ) =	0.8	(s^{-1})	

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	12:06:53	0.0	-0.120	-0.12	-0.120
	12:06:53	0.3	0.212		-0.076
	12:06:53	0.6	-0.882		-0.023
	12:06:53	0.9	0.056		0.018
	12:06:54	1.2	-0.051		0.037
	12:06:54	1.5	-0.067		0.036
	12:06:54	1.8	-0.077		0.023
	12:06:55	2.1	-0.074		0.007
	12:06:55	2.4	-0.098		-0.006
	12:06:55	2.7	-0.061		-0.011
	12:06:56	3.0	-0.055		-0.011
	12:06:56	3.3	-0.045		-0.007
	12:06:56	3.6	-0.036		-0.002
	12:06:56	3.9	-0.022		0.002
	12:06:57	4.2	-0.011		0.003
	12:06:57	4.5	-0.001		0.003
	12:06:57	4.8	0.009		0.002
	12:06:58	5.1	0.016		0.001
	12:06:58	5.4	0.022		-0.001
	12:06:58	5.7	0.026		-0.001
	12:06:59	6.0	0.030		-0.001

	12:06:59	6.3	0.030		-0.001	
	12:06:59	6.7	0.029		0.000	
	12:07:00	7.1	0.025		0.000	
	12:07:00	7.5	0.019		0.000	
	12:07:00	8.0	0.012		0.000	
	12:07:01	8.4	0.004		0.000	
	12:07:01	8.9	-0.005		0.000	
	12:07:02	9.5	-0.007		0.000	
	12:07:03	10.0	-0.008		0.000	
	12:07:03	10.6	-0.008		0.000	
	12:07:04	11.3	-0.005		0.000	
	12:07:04	11.9	-0.004		0.000	
	12:07:05	12.6	-0.001		0.000	
	12:07:06	13.4	0.003		0.000	
	12:07:07	14.1	0.003		0.000	
	12:07:07	15.0	0.003		0.000	
	12:07:08	15.9	0.003		0.000	
	12:07:09	16.8	0.000		0.000	
	12:07:10	17.8	-0.001		0.000	
	12:07:11	18.9	-0.001		0.000	
	12:07:13	20.0	-0.001		0.000	



Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	1.9	m
				L (meas) =	18.2	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.36				
	For underdamped solution, d should be less than 0.7					
	a =	4.93E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2 S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		

S	b	T_0	T_1	T_2	T_3	T_4
0.001	6.76E-03	6.76E-03	4.30E-03	4.07E-03	4.05E-03	4.04E-03
0.01	5.63E-03	5.63E-03	3.07E-03	2.77E-03	2.72E-03	2.71E-03
0.1	4.49E-03	4.49E-03	1.83E-03	1.38E-03	1.24E-03	1.19E-03

	T =	1.19E-03	to	4.04E-03	m^2/s
	Intake Length	1.47	m		
	K =	8.1E-04	to	2.8E-03	m/s

Slug Test Interpretation - van der Kamp Method

Project: Anvil Range - Faro **Well:** MW96-3B

Test: Rising Head Test #2

Reference: van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976

Method:

Step (1) : Plot oscillating response data.

Step (2) : Determine angular frequency (ω) and damping constant (γ) of water level oscillation through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution is appropriate (response is underdamped), γ is significantly less than ω.

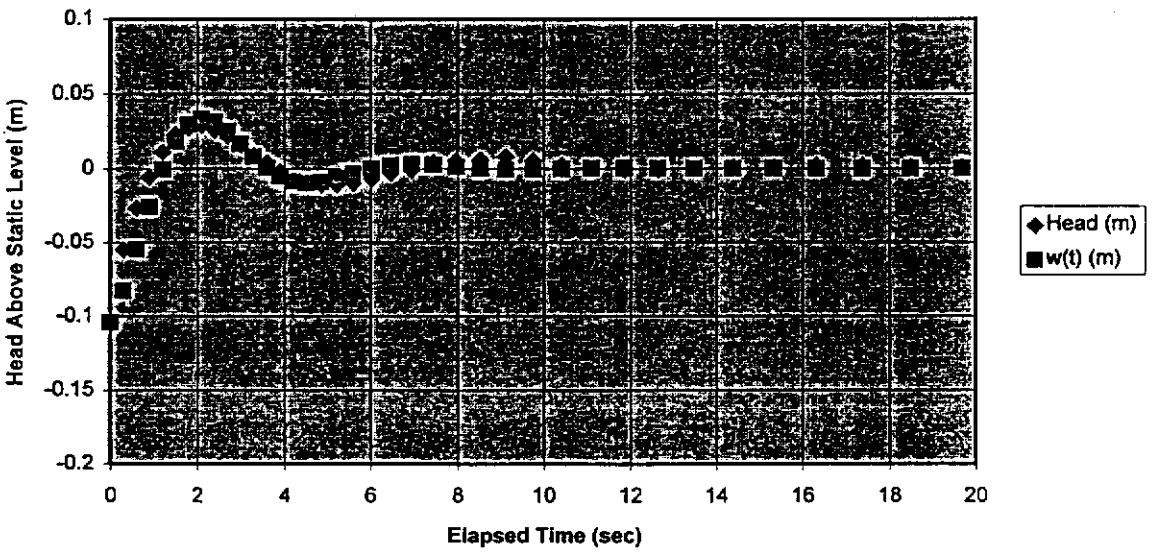
$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity

Angular frequency (ω) = 1.3 (s^{-1})

Damping constant (γ) = 0.5 (s^{-1})

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	12:09:54	0.0	-0.104	-0.104	-0.104
	12:09:54	0.3	-0.055		-0.083
	12:09:55	0.6	-0.027		-0.055
	12:09:55	0.9	-0.006		-0.026
	12:09:55	1.2	0.011		-0.001
	12:09:56	1.5	0.023		0.018
	12:09:56	1.8	0.027		0.029
	12:09:56	2.1	0.029		0.033
	12:09:56	2.4	0.026		0.031
	12:09:57	2.7	0.022		0.025
	12:09:57	3.0	0.016		0.017
	12:09:57	3.3	0.009		0.008
	12:09:58	3.6	0.004		0.001
	12:09:58	3.9	-0.002		-0.005
	12:09:58	4.2	-0.008		-0.009
	12:09:59	4.5	-0.010		-0.010
	12:09:59	4.8	-0.011		-0.009
	12:09:59	5.2	-0.011		-0.007
	12:10:00	5.6	-0.010		-0.003
	12:10:00	6.0	-0.007		0.000
	12:10:00	6.5	-0.003		0.002
	12:10:01	6.9	-0.001		0.003

	12:10:01	7.4	0.004		0.002	
	12:10:02	8.0	0.005		0.001	
	12:10:03	8.5	0.006		0.000	
	12:10:03	9.1	0.008		-0.001	
	12:10:04	9.8	0.005		-0.001	
	12:10:04	10.4	0.002		0.000	
	12:10:05	11.1	0.000		0.000	
	12:10:06	11.9	-0.001		0.000	
	12:10:07	12.6	-0.001		0.000	
	12:10:07	13.5	0.000		0.000	
	12:10:08	14.4	0.001		0.000	
	12:10:09	15.3	0.001		0.000	
	12:10:10	16.3	0.002		0.000	
	12:10:11	17.4	0.002		0.000	
	12:10:13	18.5	0.001		0.000	
	12:10:14	19.7	0.001		0.000	
	12:10:15	21.0	0.001		0.000	
	12:10:16	22.3	0.001		0.000	
	12:10:18	23.7	0.001		0.000	
	12:10:19	25.2	0.001		0.000	
	12:10:21	26.7	0.001		0.000	
	12:10:22	28.3	0.001		0.000	
	12:10:24	30.0	0.001		0.000	
	12:10:26	31.8	0.001		0.000	
	12:10:28	33.7	0.001		0.000	



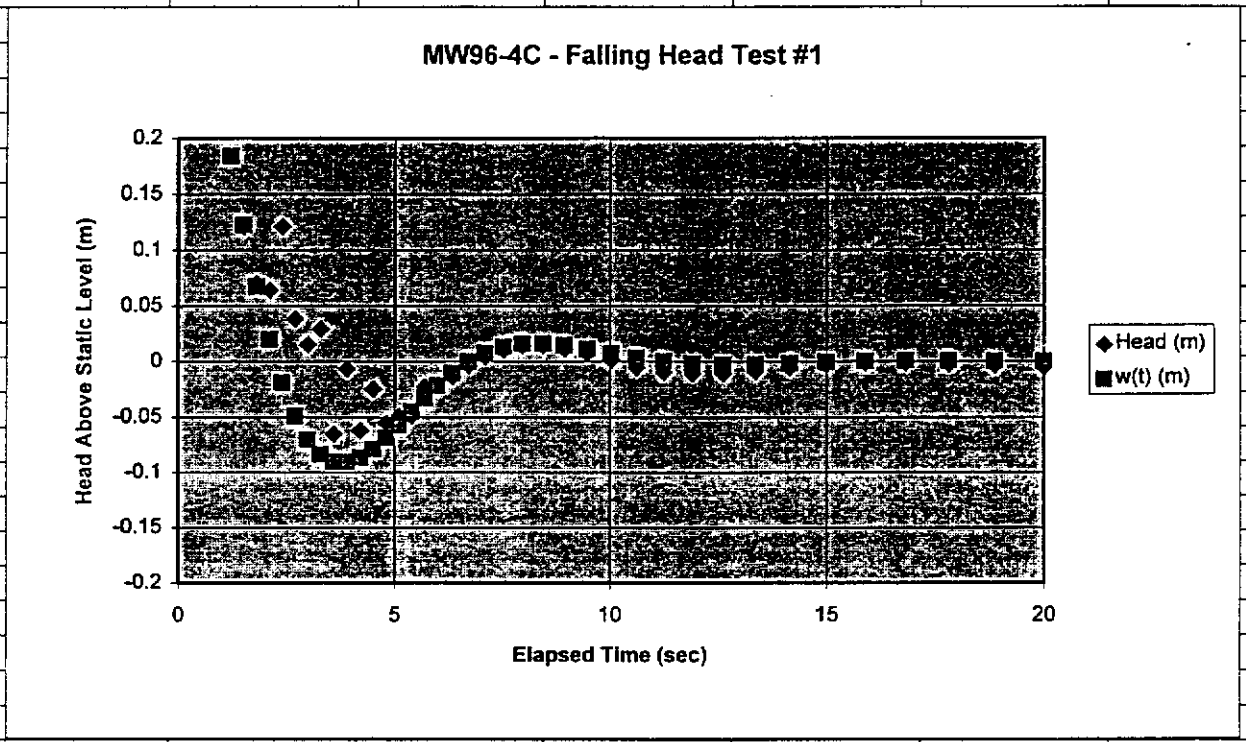
Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	5.1	m
				L (meas) =	17.0	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.36				
	For underdamped solution, d should be less than 0.7					
	a =	3.03E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	4.30E-03	4.30E-03	2.65E-03	2.50E-03	2.49E-03	2.48E-03
0.01	3.60E-03	3.60E-03	1.90E-03	1.70E-03	1.67E-03	1.67E-03
0.1	2.91E-03	2.91E-03	1.13E-03	8.50E-04	7.62E-04	7.29E-04
	T =	7.29E-04	to	2.48E-03	m^2/s	
	Intake Length	1.47	m			
	K =	5.0E-04	to	1.7E-03	m/s	

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro	**Well:**	MW96-4C	
Test:	Falling Head Test #1			
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976			
Method:				
Step (1) :	Plot oscillating response data.			
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation			
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution			
	is appropriate (response is underdamped), γ is significantly less than ω.			
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity			
	Angular frequency (ω) =	0.7	(s^{-1})	
	Damping constant (γ) =	0.38	(s^{-1})	

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/6/96	9:56:08	0.0	0.435	0.435	0.435
9/6/96	9:56:08	0.3	0.678		0.380
	9:56:08	0.6	0.514		0.316
	9:56:08	0.9	0.406		0.250
	9:56:09	1.2	0.227		0.184
	9:56:09	1.5	0.121		0.122
	9:56:09	1.8	0.070		0.067
	9:56:10	2.1	0.064		0.020
	9:56:10	2.4	0.121		-0.019
	9:56:10	2.7	0.038		-0.049
	9:56:11	3.0	0.015		-0.070
	9:56:11	3.3	0.029		-0.084
	9:56:11	3.6	-0.065		-0.090
	9:56:11	3.9	-0.007		-0.091
	9:56:12	4.2	-0.062		-0.086
	9:56:12	4.5	-0.025		-0.079
	9:56:12	4.8	-0.055		-0.069
	9:56:13	5.1	-0.049		-0.057
	9:56:13	5.4	-0.049		-0.045
	9:56:13	5.7	-0.023		-0.033
	9:56:14	6.0	-0.021		-0.022

	9:56:14	6.3	-0.014		-0.010	
	9:56:14	6.7	-0.004		0.000	
	9:56:15	7.1	0.004		0.008	
	9:56:15	7.5	0.010		0.013	
	9:56:15	8.0	0.014		0.016	
	9:56:16	8.4	0.014		0.016	
	9:56:16	8.9	0.011		0.015	
	9:56:17	9.5	0.007		0.011	
	9:56:18	10.0	0.001		0.007	
	9:56:18	10.6	-0.006		0.003	
	9:56:19	11.3	-0.010		0.000	
	9:56:19	11.9	-0.011		-0.002	
	9:56:20	12.6	-0.011		-0.003	
	9:56:21	13.4	-0.009		-0.003	
	9:56:22	14.1	-0.006		-0.002	
	9:56:22	15.0	-0.003		-0.001	
	9:56:23	15.9	-0.002		0.000	
	9:56:24	16.8	-0.002		0.001	
	9:56:25	17.8	-0.003		0.000	
	9:56:26	18.9	-0.004		0.000	
	9:56:28	20.0	-0.006		0.000	



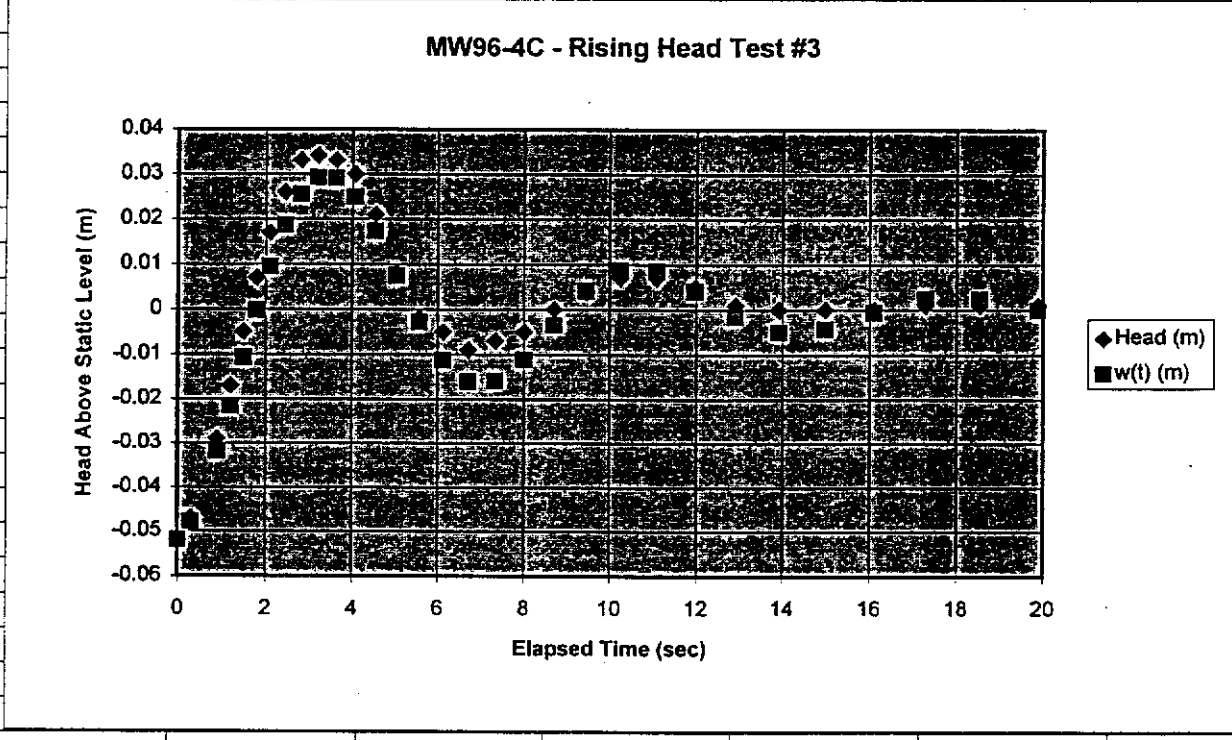
Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	15.4	m
				L (meas) =	13.5	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.48				
	For underdamped solution, d should be less than 0.7					
	a =	1.30E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	1.92E-03	1.92E-03	1.11E-03	1.04E-03	1.03E-03	1.03E-03
0.01	1.62E-03	1.62E-03	7.86E-04	6.91E-04	6.74E-04	6.71E-04
0.1	1.32E-03	1.32E-03	4.59E-04	3.20E-04	2.74E-04	2.53E-04
	T =	2.53E-04	to	1.03E-03	m^2/s	
	Intake Length	1.53	m			
	K =	1.7E-04	to	6.7E-04	m/s	

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro	**Well:**	MW4C-R3	
Test:	Rising Head Test #3			
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976			
Method:				
Step (1) :	Plot oscillating response data.			
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation			
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution			
	is appropriate (response is underdamped), γ is significantly less than ω.			
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity			
	Angular frequency (ω) =	0.87	(s^{-1})	
	Damping constant (γ) =	0.16	(s^{-1})	

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/6/96	10:23:07	0.0	-0.052	-0.052	-0.052
	10:23:08	0.3	-0.047		-0.048
	10:23:08	0.9	-0.029		-0.032
	10:23:09	1.2	-0.017		-0.022
	10:23:09	1.5	-0.005		-0.011
	10:23:09	1.8	0.007		0.000
	10:23:10	2.1	0.017		0.009
	10:23:10	2.4	0.026		0.019
	10:23:10	2.8	0.033		0.026
	10:23:11	3.2	0.034		0.029
	10:23:11	3.6	0.033		0.029
	10:23:11	4.1	0.030		0.025
	10:23:12	4.5	0.021		0.017
	10:23:12	5.0	0.008		0.007
	10:23:13	5.6	-0.002		-0.003
	10:23:14	6.1	-0.005		-0.011
	10:23:14	6.7	-0.009		-0.016
	10:23:15	7.4	-0.007		-0.016
	10:23:15	8.0	-0.005		-0.011
	10:23:16	8.7	0.000		-0.003
	10:23:17	9.5	0.004		0.004
	10:23:18	10.2	0.007		0.009

	10:23:18	11.1	0.007		0.009	
	10:23:19	12.0	0.005		0.004	
	10:23:20	12.9	0.001		-0.002	
	10:23:21	13.9	0.000		-0.005	
	10:23:22	15.0	0.000		-0.004	
	10:23:24	16.1	0.000		-0.001	
	10:23:25	17.3	0.001		0.003	
	10:23:26	18.6	0.001		0.002	
	10:23:27	19.9	0.001		0.000	
	10:23:29	21.3	0.000		-0.002	
	10:23:30	22.8	0.000		-0.001	
	10:23:32	24.3	0.000		0.001	
	10:23:33	25.9	0.000		0.001	
	10:23:35	27.6	0.000		0.000	
	10:23:37	29.4	0.000		0.000	
	10:23:39	31.3	0.000		0.000	
	10:23:41	33.4	0.000		0.000	
	10:23:43	35.6	0.000		0.000	
	10:23:45	37.9	0.000		0.000	
	10:23:48	40.4	-0.002		0.000	
	10:23:50	43.0	0.000		0.000	
	10:23:53	45.8	0.000		0.000	



Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	12.5	m
				L (meas) =	14.3	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.18				
	For underdamped solution, d should be less than 0.7					
	a =	3.82E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a/n(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a/n T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a/n T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		

S	b	T_0	T_1	T_2	T_3	T_4
0.001	5.60E-03	5.60E-03	3.61E-03	3.45E-03	3.43E-03	3.43E-03
0.01	4.72E-03	4.72E-03	2.67E-03	2.45E-03	2.42E-03	2.41E-03
0.1	3.84E-03	3.84E-03	1.71E-03	1.40E-03	1.33E-03	1.30E-03

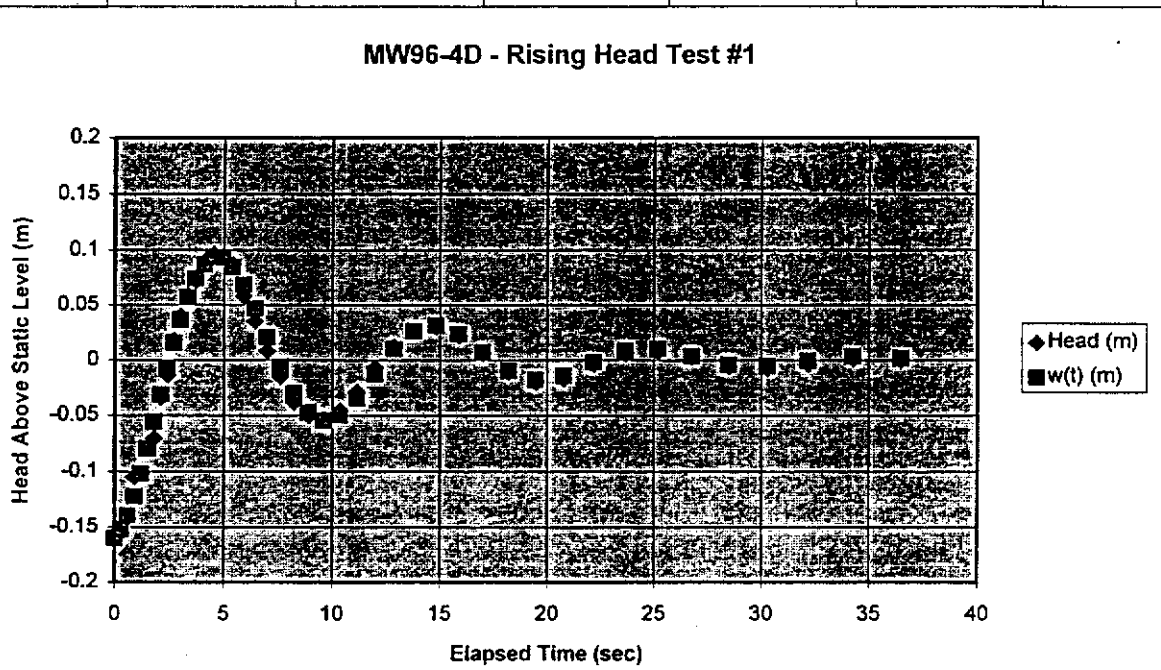
	T =	1.30E-03	to	3.43E-03	m^2/s
	Intake Length	1.5	m		
	K =	8.7E-04	to	2.3E-03	m/s

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro		**Well:**	MW96-4D	
Test:	Rising Head Test #1				
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976				
Method:					
Step (1) :	Plot oscillating response data.				
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation				
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution				
	is appropriate (response is underdamped), γ is significantly less than ω.				
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity				
	Angular frequency (ω) =	0.63	(s^{-1})		
	Damping constant (γ) =	0.11	(s^{-1})		

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/6/96	8:45:09	0	-0.16	-0.16	-0.160
	8:45:09	0.3	-0.155		-0.152
	8:45:09	0.6	-0.142		-0.139
	8:45:09	0.9	-0.105		-0.122
	8:45:10	1.2	-0.102		-0.102
	8:45:10	1.5	-0.078		-0.079
	8:45:10	1.8	-0.07		-0.056
	8:45:11	2.1	-0.034		-0.031
	8:45:11	2.4	-0.014		-0.007
	8:45:11	2.7	0.018		0.015
	8:45:12	3	0.04		0.036
	8:45:12	3.348	0.059		0.057
	8:45:12	3.72	0.072		0.074
	8:45:13	4.11	0.089		0.087
	8:45:13	4.53	0.096		0.093
	8:45:13	4.968	0.094		0.093
	8:45:14	5.442	0.087		0.084
	8:45:14	5.94	0.058		0.069
	8:45:15	6.468	0.035		0.047
	8:45:16	7.032	0.008		0.021
	8:45:16	7.62	-0.015		-0.006
	8:45:17	8.25	-0.038		-0.030

	8:45:17	8.91	-0.05		-0.047	
	8:45:18	9.612	-0.054		-0.054	
	8:45:19	10.362	-0.046		-0.050	
	8:45:20	11.148	-0.029		-0.035	
	8:45:20	11.988	-0.007		-0.013	
	8:45:21	12.882	0.012		0.010	
	8:45:22	13.818	0.026		0.026	
	8:45:23	14.82	0.03		0.031	
	8:45:24	15.882	0.022		0.023	
	8:45:26	16.998	0.006		0.007	
	8:45:27	18.192	-0.011		-0.010	
	8:45:28	19.452	-0.02		-0.018	
	8:45:29	20.778	-0.017		-0.014	
	8:45:31	22.188	-0.004		-0.002	
	8:45:32	23.682	0.006		0.008	
	8:45:34	25.182	0.008		0.010	
	8:45:35	26.778	0.003		0.003	
	8:45:37	28.482	-0.006		-0.004	
	8:45:39	30.282	-0.008		-0.006	
	8:45:41	32.178	-0.004		-0.001	
	8:45:43	34.278	0.001		0.003	
	8:45:45	36.48	0		0.002	



Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	24.0	m
				L (meas) =	26.2	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.17				
	For underdamped solution, d should be less than 0.7					
	a =	2.90E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		

S	b	T_0	T_1	T_2	T_3	T_4
0.001	4.35E-03	4.35E-03	2.77E-03	2.64E-03	2.62E-03	2.62E-03
0.01	3.68E-03	3.68E-03	2.05E-03	1.88E-03	1.86E-03	1.85E-03
0.1	3.01E-03	3.01E-03	1.32E-03	1.09E-03	1.03E-03	1.01E-03

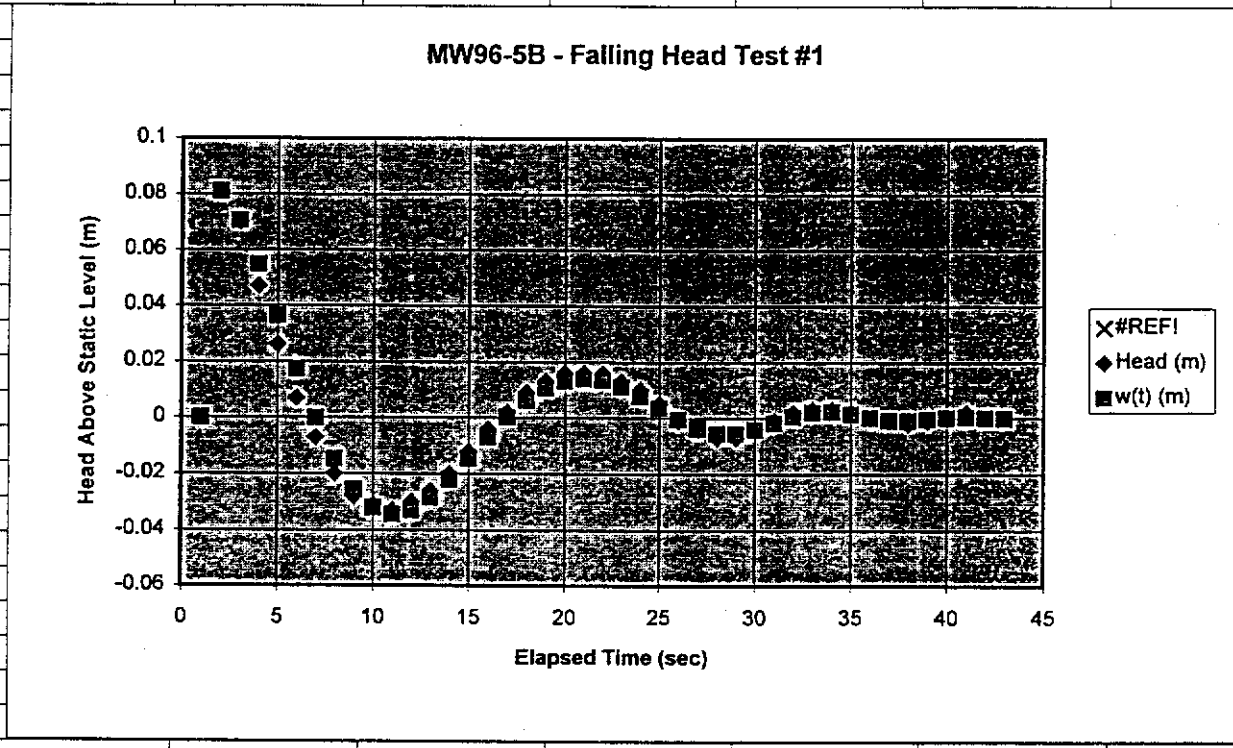
	T =	1.01E-03	to	2.62E-03	m^2/s
	Intake Length	1.5	m		
	K =	6.7E-04	to	1.7E-03	m/s

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro	**Well:**	MW96-5B
Test:	Falling Head Test #1		
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976		
Method:			
Step (1) :	Plot oscillating response data.		
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation		
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution		
	is appropriate (response is underdamped), γ is significantly less than ω.		
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity		
	Angular frequency (ω) =	1.05	(s^{-1})
	Damping constant (γ) =	0.3	(s^{-1})

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	13:29:06	0	0.081	0.081	0.081
	13:29:06	0.3	0.070		0.070
	13:29:06	0.6	0.047		0.055
	13:29:07	0.9	0.026		0.036
	13:29:07	1.2	0.007		0.017
	13:29:07	1.5	-0.007		0.000
	13:29:08	1.8	-0.020		-0.015
	13:29:08	2.1	-0.028		-0.026
	13:29:08	2.4	-0.031		-0.032
	13:29:09	2.7	-0.033		-0.034
	13:29:09	3.0	-0.030		-0.033
	13:29:09	3.3	-0.026		-0.029
	13:29:09	3.6	-0.020		-0.022
	13:29:10	3.9	-0.012		-0.015
	13:29:10	4.2	-0.004		-0.007
	13:29:10	4.5	0.002		0.000
	13:29:11	4.8	0.009		0.006
	13:29:11	5.1	0.013		0.011
	13:29:11	5.4	0.016		0.013
	13:29:12	5.7	0.016		0.014
	13:29:12	6.0	0.016		0.013
	13:29:12	6.3	0.013		0.011

	13:29:13	6.7	0.010		0.008	
	13:29:13	7.1	0.005		0.004	
	13:29:13	7.5	-0.001		0.000	
	13:29:14	8.0	-0.004		-0.004	
	13:29:14	8.4	-0.007		-0.005	
	13:29:15	8.9	-0.007		-0.006	
	13:29:16	9.5	-0.004		-0.004	
	13:29:16	10.0	-0.001		-0.002	
	13:29:17	10.6	0.002		0.001	
	13:29:17	11.3	0.003		0.002	
	13:29:18	11.9	0.003		0.002	
	13:29:19	12.6	0.002		0.001	
	13:29:20	13.4	0.000		0.000	
	13:29:20	14.1	-0.001		-0.001	
	13:29:21	15.0	-0.002		-0.001	
	13:29:22	15.9	-0.001		0.000	
	13:29:23	16.8	0.000		0.000	
	13:29:24	17.8	0.002		0.000	
	13:29:26	18.9	0.000		0.000	
	13:29:27	20.0	0.000		0.000	



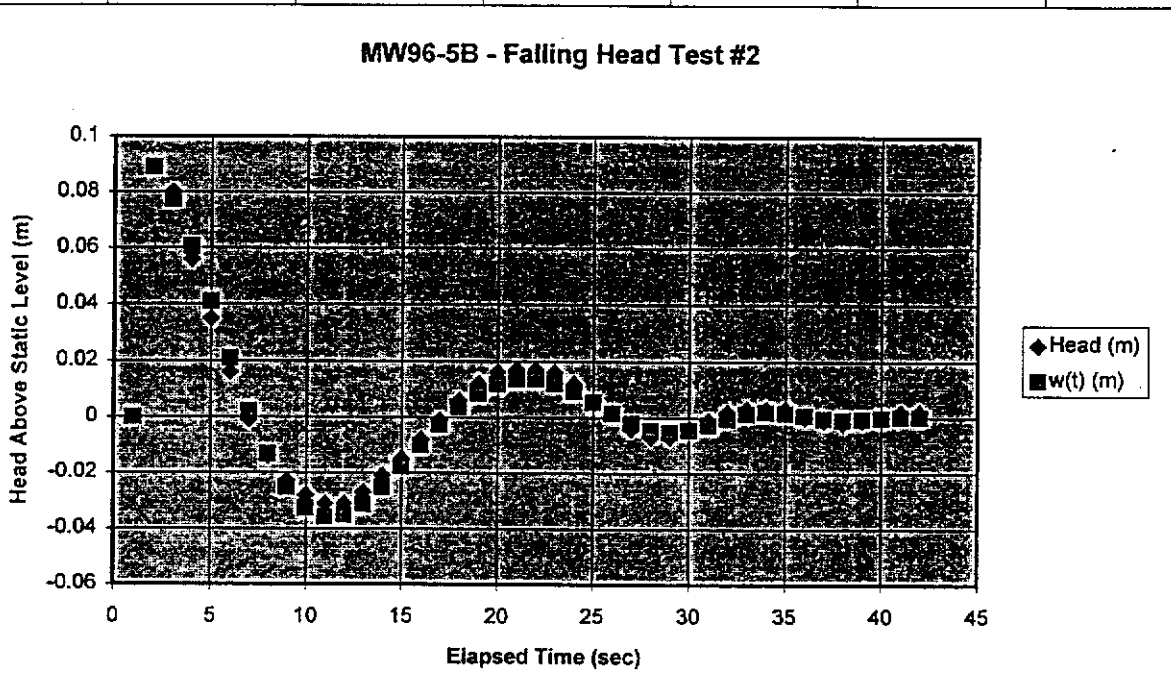
Step (3):	Calculate L, where L = $g/(\omega^2 + \gamma^2)$			L (calc) =	8.2	m
				L (meas) =	10.9	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.27				
	For underdamped solution, d should be less than 0.7					
	a =	3.11E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where b = $-a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from T = b + a*ln* T through an iterative procedure with a first estimate of T_0 = b					
	and proceeding to T_n = b + a*ln* T_{n-1}, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	4.48E-03	4.48E-03	2.80E-03	2.66E-03	2.64E-03	2.64E-03
0.01	3.77E-03	3.77E-03	2.03E-03	1.84E-03	1.81E-03	1.81E-03
0.1	3.05E-03	3.05E-03	1.25E-03	9.77E-04	9.00E-04	8.74E-04
	T =	8.74E-04	to	2.64E-03	m^2/s	
	Intake Length	3.05	m			
	K =	2.9E-04	to	8.7E-04	m/s	

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro		**Well:**	MW96-5B	
Test:	Falling Head Test #2				
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976				
Method:					
Step (1) :	Plot oscillating response data.				
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation				
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution				
	is appropriate (response is underdamped), γ is significantly less than ω.				
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity				
	Angular frequency (ω) =		1.02	(s^{-1})	
	Damping constant (γ) =		0.31	(s^{-1})	

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	13:34:29	0.0	0.089	0.089	0.089
	13:34:29	0.3	0.080		0.077
	13:34:29	0.6	0.056		0.060
	13:34:30	0.9	0.035		0.041
	13:34:30	1.2	0.016		0.021
	13:34:30	1.5	-0.001		0.002
	13:34:31	1.8	-0.014		-0.013
	13:34:31	2.1	-0.023		-0.025
	13:34:31	2.4	-0.028		-0.033
	13:34:32	2.7	-0.031		-0.036
	13:34:32	3.0	-0.031		-0.035
	13:34:32	3.3	-0.027		-0.031
	13:34:32	3.6	-0.021		-0.025
	13:34:33	3.9	-0.015		-0.018
	13:34:33	4.2	-0.008		-0.010
	13:34:33	4.5	-0.001		-0.003
	13:34:34	4.8	0.006		0.004
	13:34:34	5.1	0.012		0.009
	13:34:34	5.4	0.016		0.012
	13:34:35	5.7	0.017		0.014
	13:34:35	6.0	0.017		0.014
	13:34:35	6.3	0.016		0.012

	13:34:36	6.7	0.012		0.009	
	13:34:36	7.1	0.006		0.006	
	13:34:36	7.5	0.002		0.001	
	13:34:37	8.0	-0.004		-0.002	
	13:34:37	8.4	-0.007		-0.004	
	13:34:38	8.9	-0.007		-0.005	
	13:34:39	9.5	-0.004		-0.005	
	13:34:39	10.0	-0.001		-0.003	
	13:34:40	10.6	0.002		-0.001	
	13:34:40	11.3	0.003		0.001	
	13:34:41	11.9	0.003		0.002	
	13:34:42	12.6	0.003		0.002	
	13:34:43	13.4	0.000		0.001	
	13:34:43	14.1	-0.001		0.000	
	13:34:44	15.0	-0.002		-0.001	
	13:34:45	15.9	-0.001		-0.001	
	13:34:46	16.8	0.000		0.000	
	13:34:47	17.8	0.002		0.000	
	13:34:49	18.9	0.002		0.000	



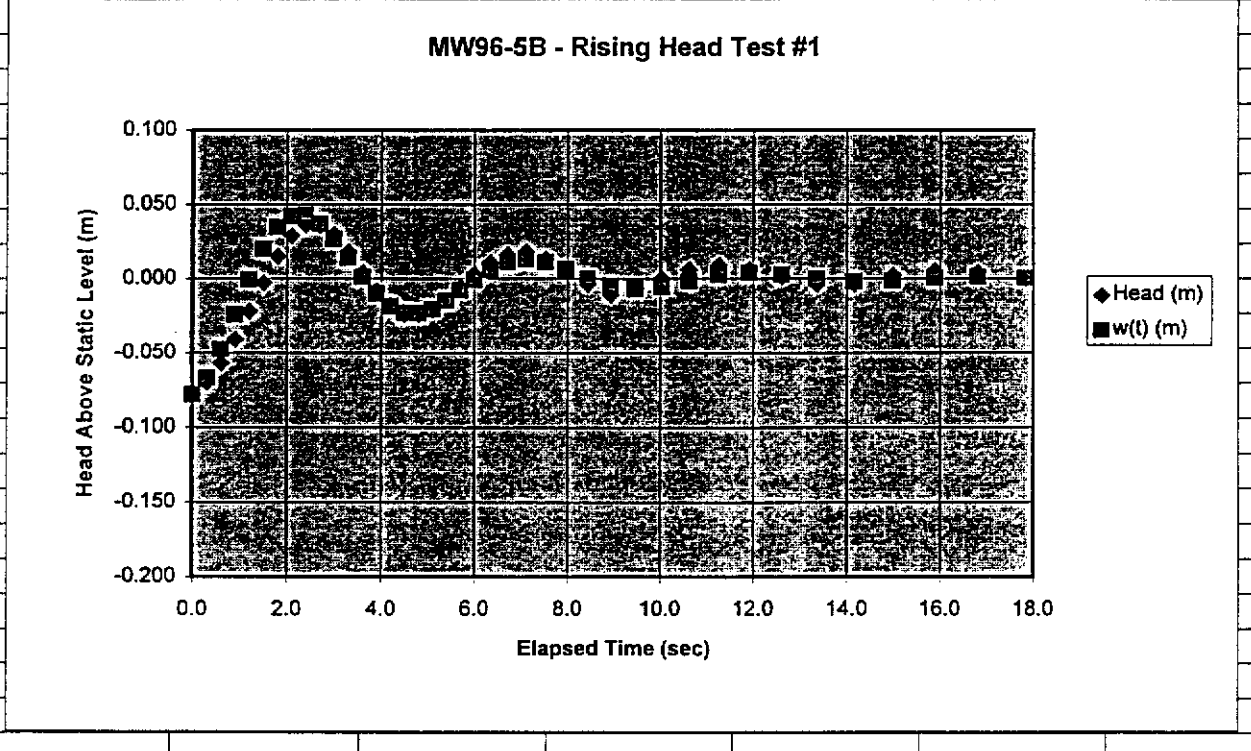
Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	8.6	m
				L (meas) =	10.9	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.29				
	For underdamped solution, d should be less than 0.7					
	a =	2.86E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79 r_f^2 S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from $T = b + a\ln T$ through an iterative procedure with a first estimate of $T_0 = b$					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	4.14E-03	4.14E-03	2.57E-03	2.43E-03	2.42E-03	2.42E-03
0.01	3.48E-03	3.48E-03	1.86E-03	1.68E-03	1.65E-03	1.65E-03
0.1	2.82E-03	2.82E-03	1.14E-03	8.81E-04	8.07E-04	7.82E-04
	T =	7.82E-04	to	2.42E-03	m^2/s	
	Intake Length	3.05	m			
	K =	2.6E-04	to	7.9E-04	m/s	

Slug Test Interpretation - van der Kamp Method

Project:	Anvil Range - Faro		**Well:**	MW96-5B	
Test:	Rising Head Test #1				
Reference:	van der Kamp, Garth, **The Underdamped Case**. Water Res. Res., February 1976				
Method:					
Step (1) :	Plot oscillating response data.				
Step (2) :	Determine angular frequency (ω) and damping constant (γ) of water level oscillation				
	through iterative curve matching using $w(t) = w_0 e^{-(g)t}\cos(w)t$, noting that where solution				
	is appropriate (response is underdamped), γ is significantly less than ω.				
	$L = g/(\omega^2 + \gamma^2)$, where L = effective length of water column and g = accel. due to gravity				
	Angular frequency (ω) =	1.3	(s^{-1})		
	Damping constant (γ) =	0.25	(s^{-1})		

Date	Time	ET (sec)	Head (m)	w_0 (m)	w(t) (m)
9/10/96	13:31:34	0.0	-0.078	-0.078	-0.078
	13:31:34	0.3	-0.070		-0.067
	13:31:34	0.6	-0.057		-0.048
	13:31:34	0.9	-0.041		-0.024
	13:31:35	1.2	-0.022		-0.001
	13:31:35	1.5	-0.003		0.020
	13:31:35	1.8	0.015		0.035
	13:31:36	2.1	0.029		0.042
	13:31:36	2.4	0.036		0.043
	13:31:36	2.7	0.036		0.037
	13:31:37	3.0	0.030		0.027
	13:31:37	3.3	0.018		0.014
	13:31:37	3.6	0.004		0.001
	13:31:37	3.9	-0.008		-0.010
	13:31:38	4.2	-0.018		-0.019
	13:31:38	4.5	-0.024		-0.023
	13:31:38	4.8	-0.024		-0.023
	13:31:39	5.1	-0.021		-0.020
	13:31:39	5.4	-0.015		-0.015
	13:31:39	5.7	-0.006		-0.008
	13:31:40	6.0	0.003		-0.001
	13:31:40	6.3	0.011		0.006

	13:31:40	6.7	0.016		0.011	
	13:31:41	7.1	0.018		0.013	
	13:31:41	7.5	0.013		0.011	
	13:31:41	8.0	0.006		0.006	
	13:31:42	8.4	-0.004		0.000	
	13:31:42	8.9	-0.011		-0.005	
	13:31:43	9.5	-0.007		-0.007	
	13:31:44	10.0	0.000		-0.006	
	13:31:44	10.6	0.006		-0.002	
	13:31:45	11.3	0.009		0.002	
	13:31:45	11.9	0.006		0.004	
	13:31:46	12.6	0.001		0.003	
	13:31:47	13.4	-0.004		0.000	
	13:31:48	14.1	-0.004		-0.002	
	13:31:48	15.0	0.002		-0.001	
	13:31:49	15.9	0.005		0.000	
	13:31:50	16.8	0.004		0.001	
	13:31:51	17.8	0.000		0.000	



Step (3):	Calculate L, where $L = g/(\omega^2 + \gamma^2)$			L (calc) =	5.6	m
				L (meas) =	11.0	m
	Compare calculated and measured values of L; this provides a measure of accuracy of solutio					
	the two values should be reasonably close (within a factor of 2?)					
	Calculate d where d = γ/(g/L)1/2, then a, where a = rc2(g/L)1/2/8d,					
	d =	0.19				
	For underdamped solution, d should be less than 0.7					
	a =	5.48E-04	where:	r_c =	0.025	m
Step (4):	Calculate b, where $b = -a\ln(0.79r_f^2S(g/L)^{1/2})$ where S = Storativity (estimate)					
	Calculate T from T = b + a*ln* T through an iterative procedure with a first estimate of T_0 = b					
	and proceeding to $T_n = b + a\ln T_{n-1}$, n>1, convergence should take place within 3 or 4 iterations					
	where:	r_f =	0.025	m		
S	b	T_0	T_1	T_2	T_3	T_4
0.001	7.80E-03	7.80E-03	5.14E-03	4.91E-03	4.89E-03	4.88E-03
0.01	6.54E-03	6.54E-03	3.78E-03	3.48E-03	3.44E-03	3.43E-03
0.1	5.28E-03	5.28E-03	2.40E-03	1.97E-03	1.87E-03	1.84E-03
	T =	1.84E-03	to	4.88E-03	m^2/s	
	Intake Length	3.05	m			
	K =	6.0E-04	to	1.6E-03	m/s	

STEFFEN, ROBERTSON AND KIRSTEN (CANADA) INC.

SLUG TEST DATA SHEET

Test Details

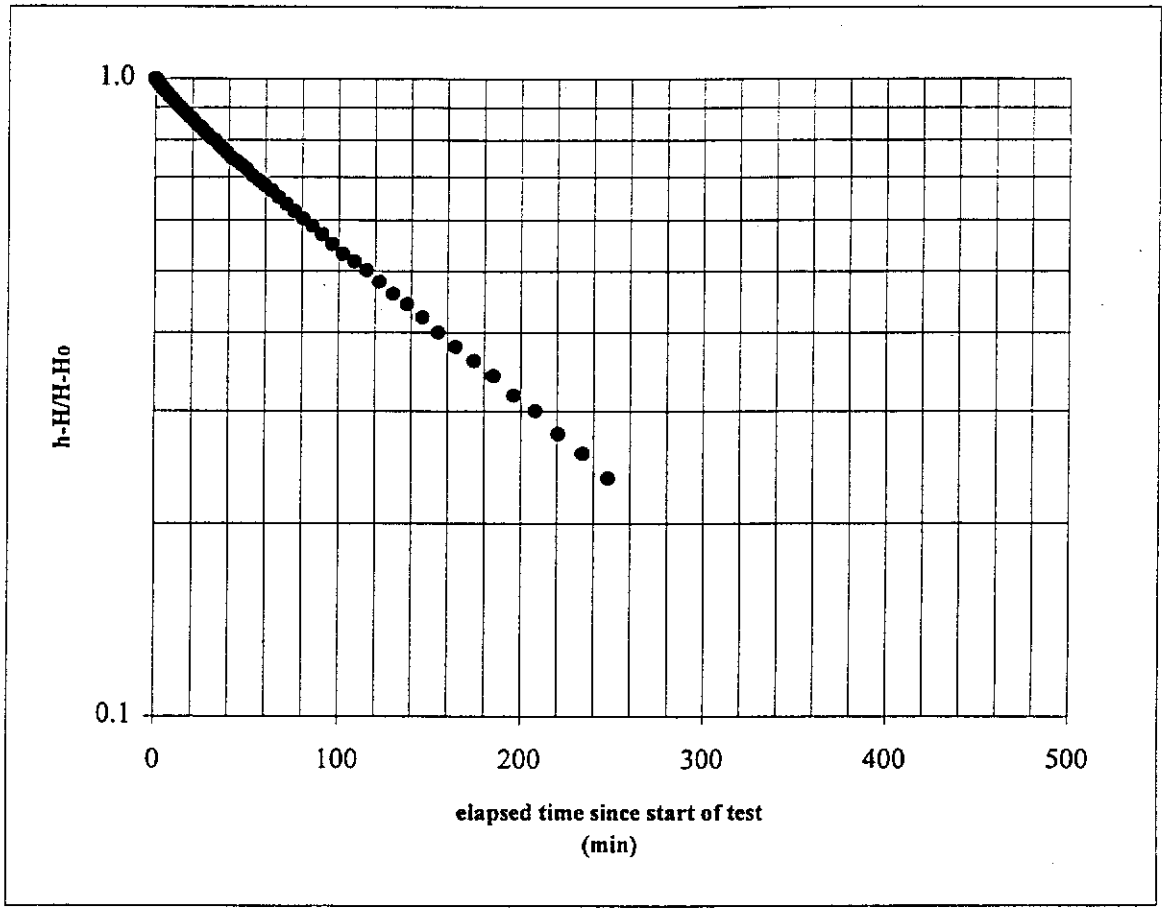
Project Name:	Anvil Range - Faro
Project Number:	330001
Well I.D.:	MW96-5C
Type of Test:	Falling Head Test #1
Date of Test:	9-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	1.5
Static Level (H)(mbtp):	3.1
Initial Level (H_0)(mbtp):	2.468
Slot Size:	10 slot
H_0-H (m):	-0.632
Unconfined Conditions:	yes

Actual Time	Elapsed Time (min)	Depth to Water (h) (m)	h-H (m)	h-H/H_0-H
24-Sep-96				
1:44 PM	0	2.468	-0.632	1.000
13:44	0	2.470	-0.63	0.997
13:44	1	2.472	-0.628	0.994
13:44	1	2.472	-0.628	0.994
13:44	1	2.475	-0.625	0.989
13:44	1.5	2.477	-0.623	0.986
13:44	1.8	2.479	-0.621	0.983
13:44	2.1	2.479	-0.621	0.983
13:44	2.4	2.482	-0.618	0.978
13:44	2.7	2.484	-0.616	0.975
13:44	3	2.484	-0.616	0.975
13:44	3.3	2.485	-0.615	0.973
13:44	3.648	2.488	-0.612	0.968
13:44	4.02	2.489	-0.611	0.967
13:44	4.41	2.491	-0.609	0.964
13:44	4.83	2.495	-0.605	0.957
13:44	5.268	2.495	-0.605	0.957
13:44	5.742	2.499	-0.601	0.951
13:44	6.24	2.501	-0.599	0.948
13:44	6.768	2.503	-0.597	0.945
13:44	7.332	2.506	-0.594	0.940
13:44	7.92	2.509	-0.591	0.935
13:44	8.55	2.512	-0.588	0.930
13:44	9.21	2.513	-0.587	0.929
13:44	9.912	2.517	-0.583	0.922
13:44	10.662	2.52	-0.58	0.918
13:44	11.448	2.523	-0.577	0.913
13:44	12.288	2.527	-0.573	0.907
13:44	13.182	2.53	-0.57	0.902
13:44	14.118	2.534	-0.566	0.896
13:44	15	2.538	-0.562	0.889
13:44	16	2.542	-0.558	0.883
13:44	17	2.545	-0.555	0.878
13:44	18	2.551	-0.549	0.869
13:44	20	2.553	-0.547	0.866

13:44	21	2.559	-0.541	0.856
13:44	22	2.565	-0.535	0.847
13:44	24	2.569	-0.531	0.840
13:44	25	2.574	-0.526	0.832
13:44	27	2.580	-0.52	0.823
13:44	29	2.585	-0.515	0.815
13:44	31	2.591	-0.509	0.805
13:44	32	2.595	-0.505	0.799
13:44	35	2.603	-0.497	0.786
13:44	37	2.610	-0.49	0.775
13:44	39	2.617	-0.483	0.764
13:44	42	2.626	-0.474	0.750
13:44	44	2.631	-0.469	0.742
13:44	47	2.638	-0.462	0.731
13:44	50	2.645	-0.455	0.720
13:44	53	2.655	-0.445	0.704
13:44	56	2.663	-0.437	0.691
13:45	60	2.671	-0.429	0.679
13:45	63	2.679	-0.421	0.666
13:45	67	2.689	-0.411	0.650
13:45	72	2.699	-0.401	0.634
13:45	76	2.709	-0.391	0.619
13:45	81	2.719	-0.381	0.603
13:45	86	2.729	-0.371	0.587
13:45	91	2.740	-0.36	0.570
13:45	97	2.752	-0.348	0.551
13:45	102	2.764	-0.336	0.532
13:45	109	2.773	-0.327	0.517
13:45	115	2.783	-0.317	0.502
13:46	122	2.796	-0.304	0.481
13:46	130	2.809	-0.291	0.460
13:46	138	2.820	-0.28	0.443
13:46	146	2.833	-0.267	0.422
13:46	155	2.847	-0.253	0.400
13:46	164	2.860	-0.24	0.380
13:46	174	2.872	-0.228	0.361
13:47	185	2.884	-0.216	0.342
13:47	196	2.899	-0.201	0.318
13:47	208	2.910	-0.19	0.301
13:47	221	2.925	-0.175	0.277
13:47	234	2.937	-0.163	0.258
13:48	248	2.951	-0.149	0.236



Test Details

Project Name:	Anvil Range - Faro
Project Number:	330001
Well I.D.:	MW96-5C
Type of Test:	Falling Head Test #1
Date of Test:	9-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	1.5
Static Level (H)(mbtp):	3.1
Initial Level (H_0)(mbtp):	2.468
Slot Size:	10 slot
H_0-H (m):	-0.632
Unconfined Conditions:	yes

Figure: 1 **Falling Head Test #1 for MW96-5C**

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Test Details

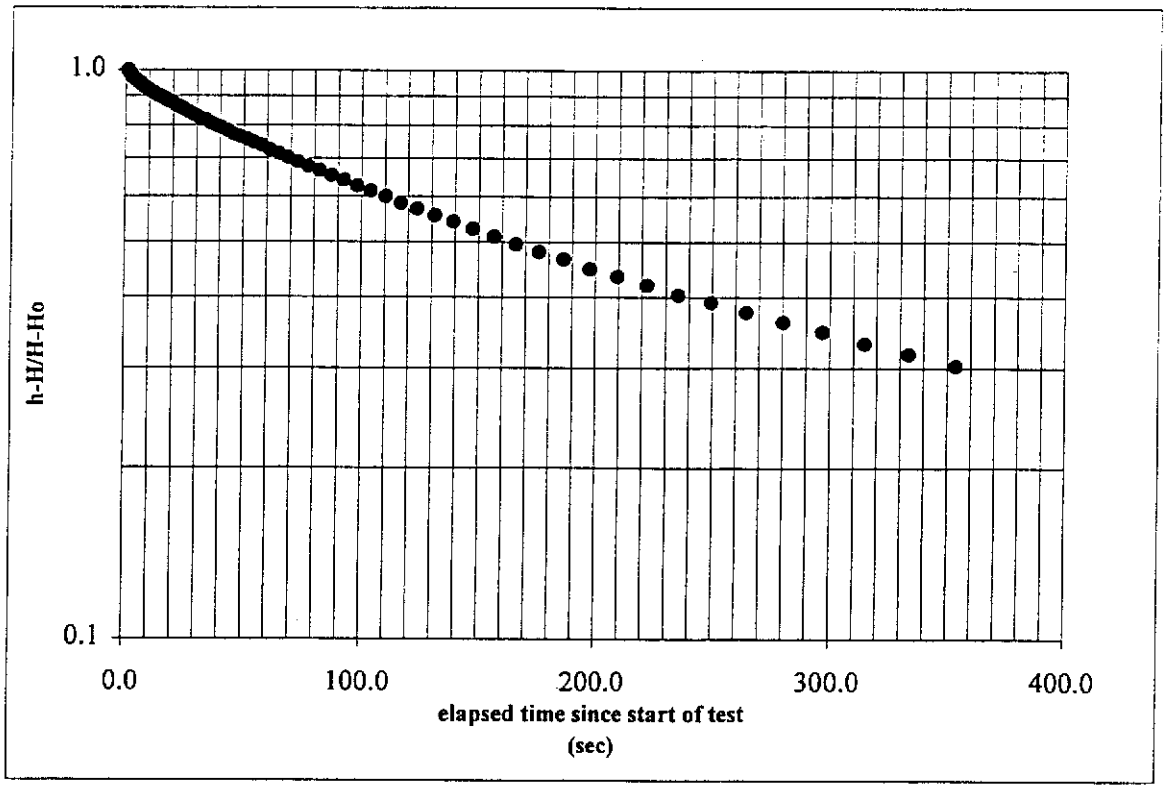
Project Name:	Anvil Range - Faro
Project Number:	33001
Well I.D.:	MW96-5C
Type of Test:	rising head
Date of Test:	10-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	1.5
Static Level (H)(mbtp):	0
Initial Level (H_0)(mbtp):	0.662
Slot Size:	20 slot / 70 µm filter
H_0-H (m):	0.662
Unconfined Conditions:	no

Actual Time	Elapsed Time (sec)	Depth to Water (h) (m)	h-H (m)	h-H/H_0-H
10-Sep-96				
13:59	1.2	0.662	0.662	1.000
13:59	1.5	0.658	0.658	0.994
13:59	1.8	0.657	0.657	0.992
13:59	2.1	0.652	0.652	0.985
13:59	2.4	0.650	0.650	0.982
13:59	2.7	0.645	0.645	0.974
13:59	3.0	0.645	0.645	0.974
13:59	3.3	0.643	0.643	0.971
13:59	3.6	0.641	0.641	0.968
13:59	3.9	0.640	0.640	0.967
13:59	4.2	0.638	0.638	0.964
13:59	4.5	0.636	0.636	0.961
13:59	4.8	0.636	0.636	0.961
13:59	5.1	0.633	0.633	0.956
13:59	5.5	0.632	0.632	0.955
13:59	5.9	0.629	0.629	0.950
13:59	6.3	0.629	0.629	0.950
13:59	6.8	0.626	0.626	0.946
13:59	7.2	0.624	0.624	0.943
13:59	7.7	0.619	0.619	0.935
13:59	8.3	0.617	0.617	0.932
13:59	8.8	0.615	0.615	0.929
13:59	9.4	0.612	0.612	0.924
13:59	10.1	0.611	0.611	0.923
13:59	10.7	0.608	0.608	0.918
13:59	11.4	0.605	0.605	0.914
13:59	12.2	0.603	0.603	0.911
13:59	12.9	0.600	0.600	0.906
13:59	13.8	0.597	0.597	0.902
13:59	14.7	0.595	0.595	0.899
13:59	15.6	0.592	0.592	0.894
13:59	16.6	0.589	0.589	0.890
13:59	17.7	0.585	0.585	0.884
13:59	18.8	0.582	0.582	0.879
13:59	20.0	0.579	0.579	0.875
13:59	21.3	0.574	0.574	0.867
13:59	22.6	0.571	0.571	0.863

13:59	24.0	0.567	0.567	0.856
13:59	25.5	0.562	0.562	0.849
13:59	27.0	0.558	0.558	0.843
13:59	28.6	0.553	0.553	0.835
13:59	30.3	0.549	0.549	0.829
13:59	32.1	0.543	0.543	0.820
13:59	34.0	0.541	0.541	0.817
13:59	36.1	0.534	0.534	0.807
13:59	38.3	0.529	0.529	0.799
13:59	40.6	0.525	0.525	0.793
13:59	43.1	0.518	0.518	0.782
13:59	45.7	0.511	0.511	0.772
13:59	48.5	0.506	0.506	0.764
13:59	51.4	0.501	0.501	0.757
14:00	54.5	0.494	0.494	0.746
14:00	57.8	0.488	0.488	0.737
14:00	61.3	0.479	0.479	0.724
14:00	65.0	0.472	0.472	0.713
14:00	68.9	0.464	0.464	0.701
14:00	73.1	0.456	0.456	0.689
14:00	77.5	0.448	0.448	0.677
14:00	82.2	0.441	0.441	0.666
14:00	87.2	0.432	0.432	0.653
14:00	92.5	0.424	0.424	0.640
14:00	98.1	0.414	0.414	0.625
14:00	104.0	0.406	0.406	0.613
14:00	110.3	0.397	0.397	0.600
14:01	116.9	0.387	0.387	0.585
14:01	123.9	0.378	0.378	0.571
14:01	131.4	0.368	0.368	0.556
14:01	139.3	0.359	0.359	0.542
14:01	147.7	0.349	0.349	0.527
14:01	156.6	0.338	0.338	0.511
14:01	166.0	0.328	0.328	0.495
14:02	176.0	0.318	0.318	0.480
14:02	186.6	0.309	0.309	0.467
14:02	197.8	0.297	0.297	0.449
14:02	209.7	0.288	0.288	0.435
14:02	222.3	0.278	0.278	0.420
14:03	235.6	0.267	0.267	0.403
14:03	249.7	0.259	0.259	0.391
14:03	264.6	0.249	0.249	0.376
14:03	280.4	0.239	0.239	0.361
14:04	297.2	0.230	0.230	0.347
14:04	315.0	0.219	0.219	0.331
14:04	333.8	0.210	0.210	0.317
14:05	353.7	0.200	0.200	0.302



Test Details

Project Name:	Anvil Range - Faro
Project Number:	33001
Well I.D.:	MW96-5C
Type of Test:	Rising Head Test #1
Date of Test:	10-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	1.5
Static Level (H)(mbtp):	0
Initial Level (H_0)(mbtp):	0.662
Slot Size:	20 slot / 70 mm filter
H_0-H (m):	0.662
Unconfined Conditions:	no

Figure: 1	TITLE: Rising head test for well MW96-5C

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Test Details

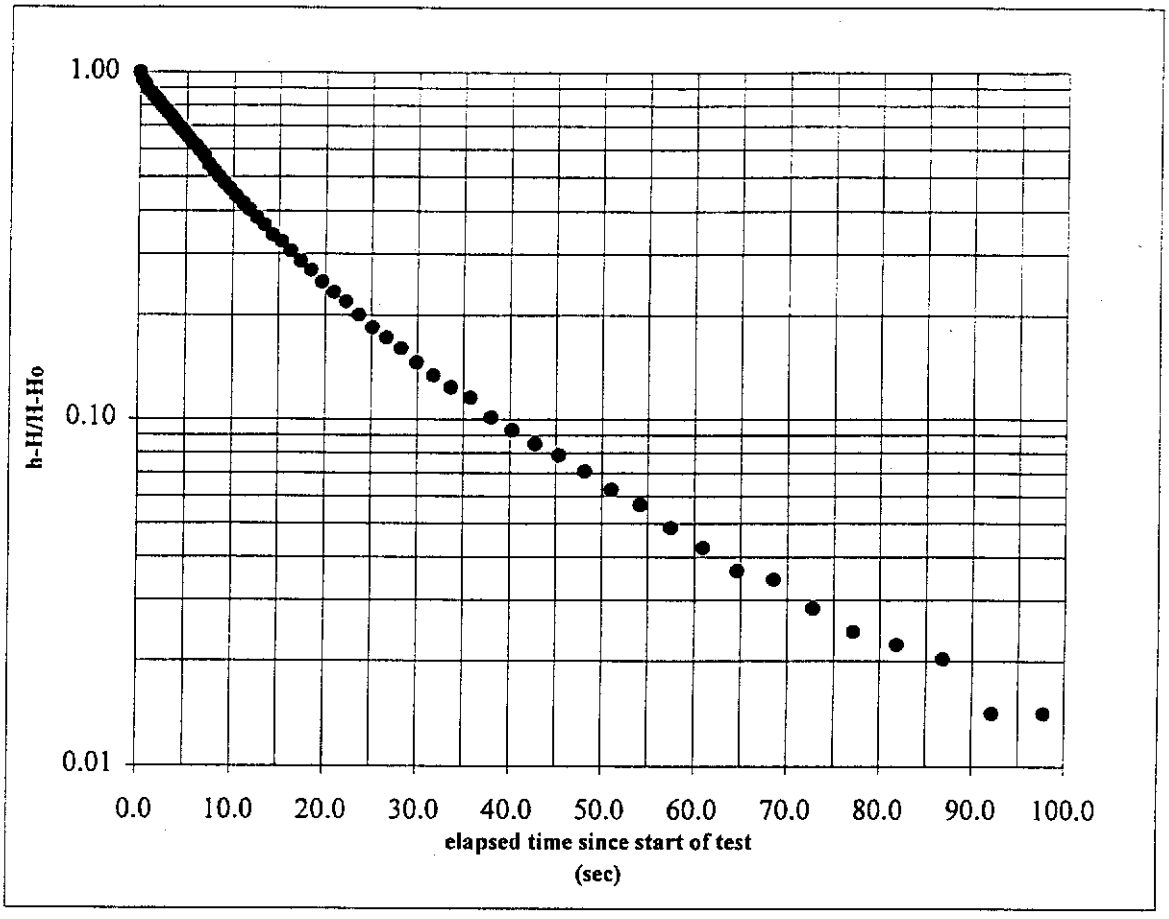
Project Name:	Anvil Range - Faro
Project Number:	33001
Well I.D.:	MW96-9A
Type of Test:	rising head
Date of Test:	10-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	4.5
Static Level (H)(mbtp):	1.53
Initial Level (H_0)(mbtp):	2.024
Slot Size:	10 slot
H_0-H (m):	0.494
Unconfined Conditions:	yes

Actual Time	Elapsed Time (sec)	Depth to Water (h) (m)	h-H (m)	h-H/H_0-H
10-Sep-96				
11:53 AM	0.0	2.024	0.494	1.000
11:53	0.3	1.999	0.469	0.949
11:53	0.6	1.988	0.458	0.927
11:53	0.9	1.969	0.439	0.889
11:53	1.2	1.961	0.431	0.872
11:53	1.5	1.952	0.422	0.854
11:53	1.8	1.942	0.412	0.834
11:53	2.1	1.933	0.403	0.816
11:53	2.4	1.923	0.393	0.796
11:53	2.7	1.915	0.385	0.779
11:53	3.0	1.906	0.376	0.761
11:53	3.3	1.899	0.369	0.747
11:53	3.6	1.890	0.360	0.729
11:53	3.9	1.882	0.352	0.713
11:53	4.2	1.873	0.343	0.694
11:53	4.5	1.867	0.337	0.682
11:53	4.8	1.859	0.329	0.666
11:53	5.2	1.850	0.320	0.648
11:53	5.6	1.840	0.310	0.628
11:53	6.0	1.833	0.303	0.613
11:53	6.5	1.823	0.293	0.593
11:53	6.9	1.813	0.283	0.573
11:53	7.4	1.798	0.268	0.543
11:53	8.0	1.787	0.257	0.520
11:53	8.5	1.777	0.247	0.500
11:53	9.1	1.767	0.237	0.480
11:53	9.8	1.758	0.228	0.462
11:53	10.4	1.748	0.218	0.441
11:53	11.1	1.738	0.208	0.421
11:53	11.9	1.729	0.199	0.403

11:53	12.6	1.719	0.189	0.383
11:53	13.5	1.710	0.180	0.364
11:53	14.4	1.698	0.168	0.340
11:53	15.3	1.691	0.161	0.326
11:53	16.3	1.681	0.151	0.306
11:53	17.4	1.671	0.141	0.285
11:53	18.5	1.663	0.133	0.269
11:53	19.7	1.653	0.123	0.249
11:53	21.0	1.645	0.115	0.233
11:53	22.3	1.638	0.108	0.219
11:53	23.7	1.629	0.099	0.200
11:53	25.2	1.621	0.091	0.184
11:53	26.7	1.615	0.085	0.172
11:53	28.3	1.609	0.079	0.160
11:53	30.0	1.602	0.072	0.146
11:53	31.8	1.596	0.066	0.134
11:53	33.7	1.591	0.061	0.123
11:53	35.8	1.587	0.057	0.115
11:53	38.0	1.580	0.050	0.101
11:53	40.3	1.576	0.046	0.093
11:53	42.8	1.572	0.042	0.085
11:53	45.4	1.569	0.039	0.079
11:53	48.2	1.565	0.035	0.071
11:53	51.1	1.561	0.031	0.063
11:53	54.2	1.558	0.028	0.057
11:53	57.5	1.554	0.024	0.049
11:54	61.0	1.551	0.021	0.043
11:54	64.7	1.548	0.018	0.036
11:54	68.6	1.547	0.017	0.034
11:54	72.8	1.544	0.014	0.028
11:54	77.2	1.542	0.012	0.024
11:54	81.9	1.541	0.011	0.022
11:54	86.9	1.540	0.010	0.020
11:54	92.2	1.537	0.007	0.014
11:54	97.8	1.537	0.007	0.014
11:54	103.7	1.535	0.005	0.010
11:54	110.0	1.535	0.005	0.010
11:54	116.6	1.533	0.003	0.006
11:55	123.6	1.532	0.002	0.004



Test Details

Project Name:	Anvil Range - Faro
Project Number:	33001
Well I.D.:	MW96-9A
Type of Test:	rising head
Date of Test:	10-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	4.5
Static Level (H)(mbtp):	1.53
Initial Level (H_o)(mbtp):	2.024
Slot Size:	10 slot
H_o-H (m):	0.494
Unconfined Conditions:	yes

Figure: 1 **TITLE: Rising head test for well MW96-9A**

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Test Details

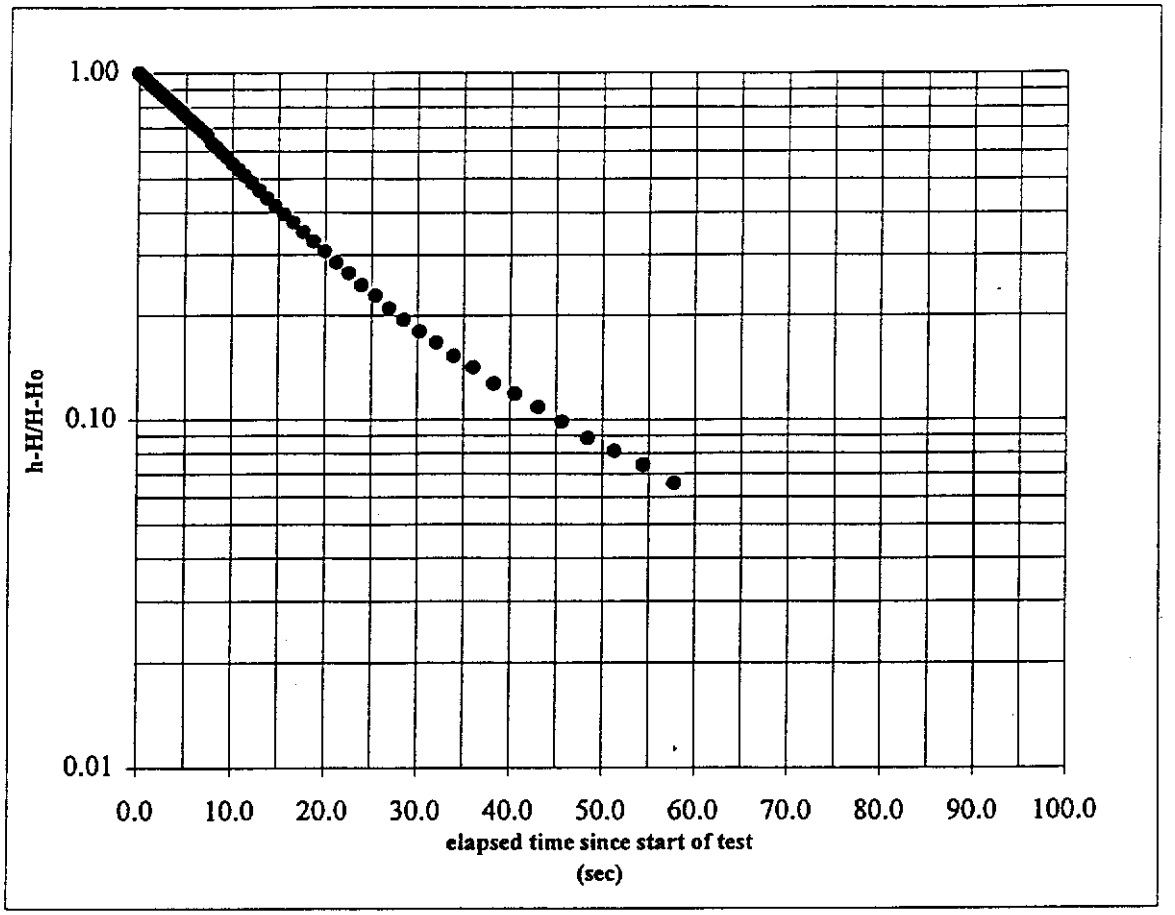
Project Name:	Anvil Range - Faro
Project Number:	33001
Well I.D.:	MW96-9A
Type of Test:	Rising Head Test #3
Date of Test:	10-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	4.5
Static Level (H)(mbtp):	1.25
Initial Level (H_0)(mbtp):	1.95
Slot Size:	10 slot
H_0-H (m):	0.700
Unconfined Conditions:	yes

Actual Time	Elapsed Time (sec)	Depth to Water (h) (m)	h-H (m)	h-H/H_0-H
10-Sep-96				
12:22 PM	0.0	1.950	0.700	1.000
12:22	0.3	1.939	0.689	0.984
12:22	0.6	1.928	0.678	0.969
12:22	0.9	1.916	0.666	0.951
12:22	1.2	1.904	0.654	0.934
12:22	1.5	1.894	0.644	0.920
12:22	1.8	1.883	0.633	0.904
12:22	2.1	1.873	0.623	0.890
12:22	2.4	1.862	0.612	0.874
12:22	2.7	1.852	0.602	0.860
12:22	3.0	1.843	0.593	0.847
12:22	3.3	1.833	0.583	0.833
12:22	3.6	1.822	0.572	0.817
12:22	3.9	1.814	0.564	0.806
12:22	4.2	1.804	0.554	0.791
12:22	4.5	1.796	0.546	0.780
12:22	4.8	1.786	0.536	0.766
12:22	5.1	1.775	0.525	0.750
12:22	5.5	1.764	0.514	0.734
12:22	5.9	1.753	0.503	0.719
12:22	6.3	1.742	0.492	0.703
12:22	6.8	1.729	0.479	0.684
12:22	7.2	1.717	0.467	0.667
12:22	7.7	1.694	0.444	0.634
12:22	8.3	1.682	0.432	0.617
12:22	8.8	1.666	0.416	0.594
12:22	9.4	1.653	0.403	0.576
12:22	10.1	1.636	0.386	0.551
12:22	10.7	1.622	0.372	0.531
12:22	11.4	1.607	0.357	0.510

12:22	12.2	1.591	0.341	0.487
12:22	12.9	1.574	0.324	0.463
12:22	13.8	1.558	0.308	0.440
12:22	14.7	1.542	0.292	0.417
12:22	15.6	1.527	0.277	0.396
12:22	16.6	1.512	0.262	0.374
12:22	17.7	1.495	0.245	0.350
12:22	18.8	1.480	0.230	0.329
12:22	20.0	1.465	0.215	0.307
12:22	21.3	1.449	0.199	0.284
12:22	22.6	1.436	0.186	0.266
12:22	24.0	1.422	0.172	0.246
12:22	25.5	1.410	0.160	0.229
12:22	27.0	1.397	0.147	0.210
12:22	28.6	1.386	0.136	0.194
12:22	30.3	1.376	0.126	0.180
12:22	32.1	1.367	0.117	0.167
12:22	34.0	1.357	0.107	0.153
12:22	36.1	1.349	0.099	0.141
12:22	38.3	1.339	0.089	0.127
12:22	40.6	1.333	0.083	0.119
12:22	43.1	1.326	0.076	0.109
12:23	45.7	1.319	0.069	0.099
12:23	48.5	1.312	0.062	0.089
12:23	51.4	1.307	0.057	0.081
12:23	54.5	1.302	0.052	0.074
12:23	57.8	1.296	0.046	0.066



Test Details

Project Name:	Anvil Range - Faro
Project Number:	33001
Well I.D.:	MW96-9A
Type of Test:	Rising Head Test #3
Date of Test:	10-Sep-96
Tested By:	KTH
Dist.to Lower Bound.:	-

Well Details

Pipe I.D. (mm):	49
Length of Intake (m):	4.5
Static Level (H)(mbtp):	1.25
Initial Level (H_o)(mbtp):	1.95
Slot Size:	10 slot
H_o-H (m):	0.7
Unconfined Conditions:	yes

Figure: 1 | **TITLE: Rising head test for well MW96-9A**

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Appendix E

Table E1. Summary of Groundwater Quality Data Provided by Anvil Range Mining Corporation

Water Quality Data for BH-96 Boreholes, September 1996

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Site	Date	In-Situ pH	Lab pH	Temp. °C	us/cm Conductivity	(m) Depth	(m) SWL	mg/L NFR Susp. Solids	mg/L Sulphate	mg/L NH_3 - N	Acidity pH 4.5	Acidity pH 8.3	mg/L Alkalinity	mg/L Chloride	Comments
BH96-4A NORTH	26-Sep-96	6.53	*7.70*	*3.4*	1364	5.88	3.27	N/A	*835*	*<.05*	<1	59	315	818	
BH96-4B NORTH	27-Sep-96	6.75	*7.56*	*N/A*	1350	10.80	3.25	N/A	*758*	*0.40*	<1	50	332	N/A	Weterra valve replaced twice Sept. 26. Very silty.
BH96-4C NORTH	26-Sep-96	6.47	*7.55*	*2.9*	1492	15.87	3.12	N/A	*1005*	*0.13*	<1	72	363	988	
BH96-4D NORTH	26-Sep-96	6.49	*7.33*	*3.3*	1605	28.22	3.05	N/A	*1048*	*<.05*	<1	79	394	1102	Separate hole from A,B &C.
BH96-3A SOUTH	26-Sep-96	6.78	*8.06*	*3.0*	769	9.65	2.53	N/A	*269*	*2.10*	<1	15	236	336	Below Int. Dam South
BH96-3B SOUTH	26-Sep-96	7.04	*7.69*	*2.7*	1056	19.80	2.40	N/A	*468*	*<.05*	<1	10	277	478	Below Int. Dam South
BH96-5A	26-Sep-96					9.22	4.39								
BH96-5B	26-Sep-96	*6.68*	7.15	*3.5*	1299	15.43	4.49	N/A	*767*	*0.97*	<1	36	202	593	
BH96-5C	26-Sep-96	*7.58*	7.84	*3.3*	363	30.18	4.54	N/A	*12*	*0.38*	<1	7	178	148	Color fluctuated from very Black to clear.
Above Rock Drain BH96-6	25-Sep-96	N/A	8.00	2.3	538	20.85	12.76	N/A	108	<.05	<1	114	228	N/A	
Main Rock Dump BH96-7	27-Sep-96	7.39	7.66	2.5	1227	9.90	5.24	N/A	662	<.05	<1	15	160	N/A	
Old Faro Cr. Channel BH96-8A	26-Sep-96	6.31	7.44	4.5	5430	4.87	3.52	N/A	2278	<.05	<1	102	464	2044	Silty and orange, difficult to filter.
BH96-8B	26-Sep-96	6.30	7.71	3.4	7390	9.30	3.09	N/A	2576	0.08	<1	173	702	2395	Silty and orange, difficult to filter.
Grum Rock Dump BH96-9A	9-Oct-96		8.00		608				52	0.019	<1	<1	175		
BH96-9B	9-Oct-96		8.20		683				156	<0.005	<1	2.9	87		

N/A Data not obtained or meter malfunction

Table E1. Summary of Groundwater Quality Data Provided by Anvil Range Mining Corporation

FARO WATER QUALITY ICP RESULTS CONTINUED FOR SEPTEMBER 1996

METALS ARE DISSOLVED

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As indicated in Schedule A of Water Use License IN89-001

All data that is indicated in normal type is not a requirement of the License

Site	AG	AL	AS	BA	BE	BI	CA	CD	CO	CR	CU	FE	HG	LA
BH96-3A	<.003	0.09	<.02	0.106	0.009	<.04	100.7	<.002	0.020	<.005		*0.009*	0.05	<.02
BH96-3B	<.003	<.05	<.02	0.058	0.006	<.04	151.5	<.002	<.005	<.005		*0.007*	<.01	<.02
BH96-4A	<.003	0.13	<.02	0.102	0.012	<.04	256.3	<.002	<.005	<.005		*0.015*	0.04	<.02
BH96-4B	<.003	5.80	<.02	0.120	0.014	<.04	256.8	<.002	0.010	<.005		*0.034*	9.19	<.02
BH96-4C	<.003	0.26	<.02	0.088	0.012	<.04	311.9	<.002	0.011	<.005		*0.013*	0.06	<.02
BH96-4D	<.003	0.24	<.02	0.092	0.010	<.04	352.9	<.002	<.005	<.005		*0.007*	<.01	<.02
BH96-5A														
BH96-5B	<.003	0.05	<.02	0.090	0.008	<.04	178.3	<.002	<.005	<.005		*0.007*	9.89	<.02
BH96-5C	<.003	0.05	<.02	0.112	0.002	<.04	46.7	<.002	<.005	<.005		*<.002*	0.05	<.02
BH96-6	<.003	0.06	<.02	0.059	0.003	<.04	67.4	0.003	<.005	<.005	0.008	3.53	<.02	<.005
BH96-7	<.003	0.91	<.02	0.104	0.008	<.04	256.5	<.002	<.005	<.005	<.002	1.86	<.02	<.005
BH96-8A	<.003	0.48	<.02	0.088	0.016	<.04	486.6	<.002	<.005	<.005	0.012	0.08	<.02	<.005
BH96-8B	<.003	1.09	<.02	0.156	0.025	<.04	632.3	<.002	<.005	<.005	0.026	0.40	<.02	<.005
BH96-9A	<.003	0.05	<.02	0.114	0.002	<.04	86.9	<.002	<.005	<.005	0.005	0.23	<.02	<.005
BH96-9B	<.003	0.15	<.02	0.073	<.001	<.04	43.2	<.002	<.005	<.005	0.004	0.19	<.02	<.005
BH96-9B DUP	<.003	0.15	<.02	0.076	<.001	<.04	44.1	<.002	<.005	<.005	0.004	0.16	<.02	<.005

Site	MG	MN	MO	NA	NI	P	PB	S	SB	SI	SR	TI	V	W	ZN	
BH96-3A	<.005	24.2	5.68	<.002	25	<.005	0.13	<.02	91	<.03	7.10	0.285	<.005	<.005	<.03	*0.03*
BH96-3B	<.005	28.4	0.11	<.002	<1	<.005	0.18	<.02	154	<.03	5.82	0.400	<.005	<.005	<.03	*0.01*
BH96-4A	<.005	50.6	14.40	<.002	50	0.032	0.09	<.02	281	<.03	8.37	0.854	<.005	<.005	<.03	*0.02*
BH96-4B	<.005	50.5	20.90	<.002	60	0.041	0.06	<.02	217	<.03	18.65	0.773	0.259	<.005	<.03	*0.04*
BH96-4C	<.005	59.6	12.98	<.002	<1	0.051	0.12	<.02	350	<.03	8.49	1.072	<.005	<.005	<.03	*0.02*
BH96-4D	<.005	62.8	0.92	<.002	<1	<.005	0.22	<.02	371	<.03	7.85	1.120	<.005	<.005	<.03	*0.01*
BH96-5A																
BH96-5B	<.005	42.0	10.56	<.002	<1	<.005	0.18	<.02	261	<.03	6.35	0.525	<.005	<.005	<.03	*0.13*
BH96-5C	<.005	8.4	0.22	<.002	9	<.005	0.05	<.02	3	<.03	4.01	0.261	<.005	<.005	<.03	*<.01*
BH96-6	22.7	0.31	<.002	10	0.031	<.04	<.02	52	<.03	10.32	0.304	<.005	<.005	<.03	0.54	
BH96-7	49.8	0.21	<.002	17	<.005	<.04	<.02	240	<.03	6.32	0.544	0.026	<.005	<.03	<.01	
BH96-8A	236.5	1.94	<.002	37	0.103	<.04	0.03	776	<.03	8.30	2.348	<.005	<.005	<.03	16.10	
BH96-8B	232.6	9.28	<.002	47	0.046	0.10	0.65	842	0.31	10.37	2.202	0.016	<.005	<.03	2.37	
BH96-9A	34.4	0.01	<.002	9	<.005	<.04	<.02	16	<.03	6.06	0.554	<.005	<.005	<.03	<.01	
BH96-9B	20.3	0.13	<.002	53	<.005	<.04	<.02	53	<.03	5.65	1.069	<.005	<.005	<.03	<.01	
BH96-9B DUP	20.8	0.14	<.002	53	<.005	<.04	<.02	52	<.03	6.77	1.076	<.005	<.005	<.03	<.01	