Gartner
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Haines Junction Water Well No. 5
Completion Report

Prepared for
The Village of Haines Junction

Prepared by:
Gartner Lee Limited

GLL 22-345

December 2002

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Gartner
Lee
Limited

206 Lowe Street
Suite C
Whitehorse, Yukon
Y1A 1W6

Tel: (867) 633-6474
Fax: (867) 633-6321
www.gartnerlee.com

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December 16, 2002

Colin J. Dean, C.A.O.
The Village of Haines Junction
Box 5339
Haines Junction, Yukon
Y0B 1L0

Dear Mr. Dean:

Re: Hydrogeological and Well Completion Results from Well No. 5

We are pleased to provide the report for the above referenced project. This project proved to be very challenging due to the unique site conditions and artesian water pressures encountered at depth. However, the project team overcame these challenges through the application of some unique well completion methods, which resulted in the successful installation of a highly productive water supply for the Village.

Thank you for allowing Gartner Lee Limited this opportunity to work with the Village of Haines Junction.

If you have any questions or comments please do not hesitate to call me at (867) 633-6474, extension 27.

Yours very truly,
GARTNER LEE LIMITED

Jonathan Kerr, M.Sc.
Hydrogeologist

Executive Summary

Gartner Lee Limited (GLL) on behalf of the Village of Haines Junction has completed hydrogeological services associated with the completion and testing of a new water well, which has been formally identified as Well No. 5.

Drilling operations and well construction actives were completed by Midnight Sun Drilling Co. Ltd., while pumping test services were provided by Aqua Tech Supplies & Services Ltd., both of Whitehorse, Yukon. Inspection of drilling operations, well design/construction, pumping test analyses, contract management, and the completion of a water quality assessment were conducted by Jonathan Kerr, project Hydrogeologist, Gartner Lee Limited, Whitehorse, Yukon.

The results of the pumping tests were analysed and used to assess well performance and to estimate aquifer properties. This report details the well installation procedures, materials used, well testing procedures, and provides major conclusions and recommendations regarding well use, monitoring and water quality.

The principal conclusions of the project are summarized as follows:

- Between August 13 and September 13, 2002, a groundwater well (Well No. 5) was completed within the Municipality of the Village of Haines Junction, to a depth of 369.2 m and was screened within a sand and gravel aquifer between 361.9 m to 369.2m below ground surface.

- Well No. 5 is a flowing artesian well. The estimated hydrostatic head in the well on October 1, 2002 was measured to be approximately 59 m above the ground surface (i.e. 84 psi). When allowed to flow at surface, the estimated flow rate (i.e. artesian flow) was approximately 13 L/s (172 igpm).

- The test results estimated that the maximum long term safe yield of Well No. 5 is approximately 27 L/s (356 igpm). These analyses indicate that when the well is pumped at a rate of 27 L/s, water levels within the well will be drawn down to approximately 81 m below the ground surface. The predicted maximum long-term safe yield and associated draw down should be confirmed with long term measurements of water levels, pumping rates, and artesian pressures.

- With the exception of turbidity, measured concentrations of all tested health-related water quality parameters meet the applicable health-based Canadian Drinking Water Quality Guidelines (CDWQG).

- The elevated turbidity is inferred to be the result of trace residual amounts of drilling fluid. Prolonged pumping may reduce groundwater turbidity to acceptable levels. According to conversations with the Mayor of Haines Junction, John Farynowski on November 8, 2002, the

Village has collected turbidity measurements from Well No. 5 and significant improvements in groundwater quality have been identified in this regard.

- Based on visual observations taken throughout the pumping test, a “sand free” condition of groundwater appears to have been achieved.

- Total iron concentrations in the groundwater exceed the aesthetic CDWQG (0.3 mg/L) by a factor of two. Analyses of dissolved and total metal concentrations however, suggest that the elevated concentrations of total iron in the groundwater may be related to elevated turbidity levels and that a reduction in groundwater turbidity may reduce the total iron concentrations. The primary aesthetic issue relating to elevated total iron concentrations is precipitation of iron oxides (i.e. staining of plumbing fixtures) and potential taste issues.

- The temperature of the groundwater discharged from Well No. 5 throughout the short-term pumping test was relatively consistent at 16.9 ºC.

- The CDWQG suggest an acceptable range for drinking water pH is between 6.5 and 8.5 pH units. The measured pH of groundwater samples collected from Well No. 5 is between 8.5- 9 pH units.

The principal recommendations of the project are summarized as follows:

- Follow-up sampling of groundwater at Well No. 5 should be conducted to determine if turbidity has declined to the acceptable levels in the CDWQG (1 NTU).

- Two supplemental samples of groundwater from Well No. 5 should be analyzed for total metals, pH, hardness, and other general water chemistry parameters. The purpose of the analyses is to assess if concentrations of some water quality parameters (such as total iron) have decreased to concentrations that meet the aesthetic CDWQG.

- Once follow-up sampling events have been conducted a qualified environmental professional should review the results. Furthermore, a water quality monitoring program should be developed to verify that acceptable water quality is maintained.

- High pH levels (> 8.5 pH) can result in a significant reduction in chlorine disinfection efficiency. It is recommended that pH be monitored to assess the significance of this effect on the disinfection process which is required for communal drinking water supplies.

- The collection of long-term water usage and water level measurement data will provide information to help predict the long-term sustainability and management of this important groundwater resource. It is recommended that the pumping rate of Well No. 5 be monitored continuously. If possible, it is also recommended that the artesian pressure of Well No. 5 be monitored when the well is not in use. Further benefit would be obtained with the collection of long-term water level measurements from Well No. 4, as this well is moderately deep, currently not used, and readily assessable, as it is owned by the Village.

Activities documented in this report were undertaken between August 13 and October 1, 2002. A site location map is provided in Figure 1 and a site plan showing the location of Well No. 5 is provided in Figure 2.

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1. Introduction

1.1 Background

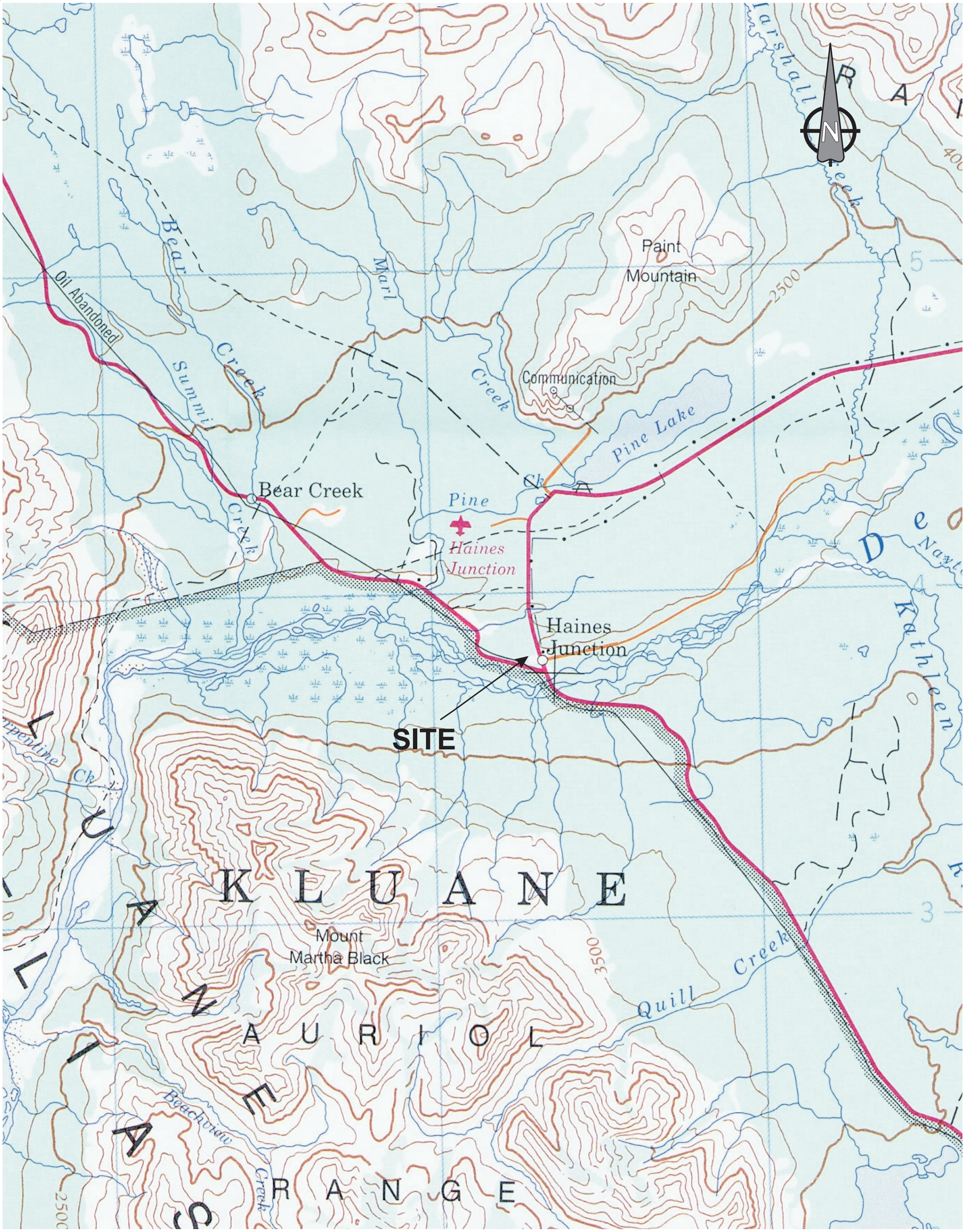
The water supply for the Village of Haines Junction consists of two municipal wells, formally known as Well No. 3 and Well No. 4. Well No. 4 has had a history of producing silty water, and is currently not used. However, Well No. 4 remains “on line” in the event of an emergency. Consequently, Well No. 3 currently provides the majority of potable water for the Village.

Well No. 3 is a flowing artesian well that was drilled in 1980. By 1988, the static water levels in Well No. 3 had dropped to 13.57 m below ground surface (Hydrogeological Consultants Ltd. 1997). However, the results of groundwater monitoring initiated in 1997, indicate that since 1997, levels of static water in Well No. 3 have recovered to levels above ground surface, while pumping water levels are approximately 30 m below ground surface. The apparent recovery of static groundwater levels in Well No. 3 to pre-1997 levels may be the result of a decrease in pumping rate, from approximately 286 m^3/day to 143 m^3/day (Hydrogeological Consultants Ltd. 1997). Currently, the demand for water in the Village has increased and the ability of Well No. 3 to meet the increased demand is of concern. In addition, future water demand is anticipated to grow, thereby increasing the need to develop a new supply of municipal potable water.

Limited groundwater resource data exists for the areas along the Dezadeash River, upstream and downstream of the existing Village municipal wells (Hydrogeological Consultants Ltd. 1996). The results of exploration drilling near the Village wells suggested that future groundwater exploration should focus away from this location. Although efforts to develop an aquifer west of the Village have been only moderately successful (Stardust Motel Water Well), it has been recommended that this area be investigated further (Hydrogeological Consultants Ltd., 1997).

It was also recommended that future exploration wells drilled west of the Village be completed to a minimum depth of 61 m and, if necessary, continue to depths of 150 m or deeper (Hydrogeological Consultants Ltd. 1997). Previous recommendations suggested that additional groundwater exploration test wells should not be completed to depths exceeding 185 m, unless greater depths were to be considered (Hydrogeological Consultants Ltd. 1989). The deepest groundwater exploration well near the Village is known as “No. 1-89” drilled by Midnight Sun Drilling Co. Ltd of Whitehorse, Yukon, and was completed to a depth of 249.5 m. No significant water-bearing formations were encountered during the completion of No. 1-89 and water quality in the deepest water bearing formation encountered and tested was considered poor (Hydrogeological Consultants Ltd. 1989).

A drilling specification requirement for this exploration program was that the drilling contractor be expected to drill to a depth of 185 m with a capacity of drilling to 300 m below ground surface.



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SITE LOCATION MAP

Haines Junction Water Well Number 5
Village of Haines Junction

FIGURE

1

Project 22-345
(22\345\fig1.cdr)

1.2 Scope of Work

The project team consisted of the following parties:

1. Midnight Sun Drilling Co. Ltd. of Whitehorse, Yukon (drilling contractor);
2. Aurora Geosciences Ltd. of Whitehorse, Yukon (down hole geophysical surveyor);
3. Gartner Lee Limited of Whitehorse, Yukon (responsible for overseeing all operations).

Due to hydrogeological conditions encountered during the initial phases of drilling (presence of artesian conditions) the project team decided that the test well would be completed as a production well.

The following revised scope of work reflects this change to the original work plan. Although many of the tasks associated with the revised project scope were similar to the original proposed tasks, significant delays and technical difficulties resulted from the depth (approximately 380 m) of operations and the artesian conditions.

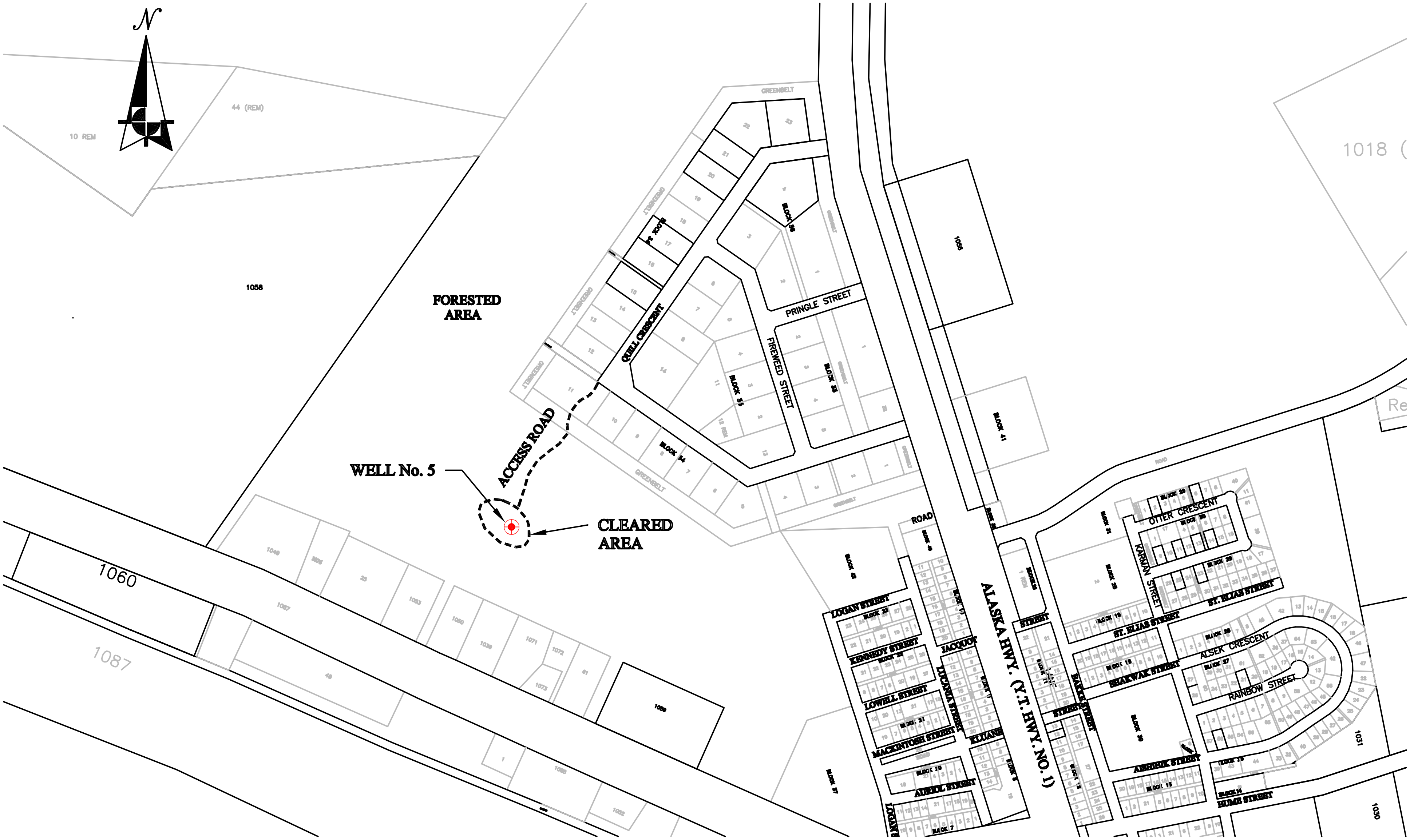
The revised scope of work included the following tasks:

1. Drilling a test well to assess hydrogeological conditions and suitability for installation of a production well;
2. Collection of stratigraphic information;
3. Collection of soil samples for grain size analyses;
4. Undertaking of a down hole geophysical survey;
5. Interpretation of the field data and the design and of a groundwater production well;
6. Installation of a production well;
7. Development and testing of the production well;
8. Assessment of groundwater quality;
9. Formulation of recommendations for production well maintenance, selection of pump-assembly and water quality and flow monitoring programs.

1.3 Site Description

The well is located on relatively flat land, which was cleared of trees to provide access for the drilling equipment. Vegetation near the well consisted mainly of softwoods such as poplar and birch. The site is immediately south of a surveyed, but not developed residential subdivision. Well No. 5 is located within the municipal Village boundary and the development of this well has been included under the Village's Official Community Plan. The location of Well No. 5 is presented in Figure 2.

The Yukon Territorial Government (YTG) currently owns the land on which Well No. 5 is located. It is our understanding that title to this land will be transferred to the Village in the near future. Activities that are documented in this report were undertaken under terms that are specified by the YTG land use permit #2002-0208 that was issued on September 9,2002.



Legend:

Well No. 5

Note: Test well location accurate to within 7 metres.

0 50 100 200 300 400 500 Metres

SCALE 1:10,000

Scales

Designed By:	D.L.	Drawn By:	D.L.
Checked By:	J.C.K.	Approved By:	J.C.K.
Date Issued:	09/09/02	Project No.	22-345
Site Name:	Haines Junction	File Name:	Figure 2.DWG

Village of Haines Junction

Well No. 5 Site Location Map

Gartner Lee Limited

Drawing No.

Figure 2

2. Well Completion

Midnight Sun Drilling Co. Ltd. completed Well No. 5 over a period of 37 days. Installation of the various borehole casings and seals were hampered by high-pressure flowing artesian conditions. A chronological summary of the well completion procedures is provided in Table 1. All drilling was undertaken using a trailer-mounted Schramm T450 mud-rotary drilling rig.

2.1 Drilling Fluids

Mr. Ron Kunstman of Extreme Products and Drilling Supplies of White Rock, BC, was retained by Midnight Sun to oversee and monitor the condition of drilling fluids during the project. Bentonite-based drilling fluids were utilized by Midnight Sun during most of the drilling operations. At shallow depths, the bentonite mud was augmented using polymers to help maintain its consistency. At depth, to overcome hydrostatic conditions that were present in the deep aquifer, a barite compound was added to the bentonite mud to increase its density.

2.2 Geophysical Survey

On September 8, 2002 and September 9, 2002, following installation of the cased borehole to a depth of 382.2 m, Aurora Geosciences, conducted a down hole geophysical survey through the uncased portion of the borehole. The logging was undertaken within a 12-hour period. Table salt was added to the drilling fluid to provide an electrical resistivity contrast between the drilling mud and the formation to improve the quality of the survey results.

The purpose of the geophysical logging was to assess the subsurface conditions and to help identify the geological formation with the greatest aquifer potential. A summary of the geophysical tools used, and methodologies employed during the surveying, including an interpretation of the survey results by Aurora Geosciences is provided in Appendix A.

2.3 Site Stratigraphy

Soil mapping of the Dezadeash Valley shows that the area near Well No. 5 is underlain primarily by glaciolacustrine silt and clay. These deposits were formed in a large proglacial lake known as Glacial Lake Champagne (Day, 1962) that filled the Dezadeash and Takhini Valleys during the retreat of the last glaciers some 10,000 years ago. The borehole of Well No. 4 encountered over 240 m (800 ft.) of glaciolacustrine deposits. It is inferred by GLL, based on the silty quality of water yielded by Well No. 4, that this well is completed in a silty sand unit located within the glaciolacustrine deposits. There are

Table 1 : Chronological Summary of Drilling Operations, Well Completion

Date 2002	*Description of Task*
August 13 to August 15	• Drilled 432 mm diameter borehole with air rotary to a depth of 15.01m and set a 356 mm OD steel casing with Portland cement to create a sanitary surface seal.
August 15 to August 17	• Drilled using mud rotary to a depth of 378.5 m using a 159 mm tricone bit. Artesian conditions were encountered when the drill rods were pulled back to surface. Artesian flow rate estimated to be in excess of 11 L /sec.
August 17 to August 25	• Dewatering was required to prevent on-site flooding created by the artesian condition. • 24 hr monitoring was conducted to prevent on site flooding and to ensure that the discharged groundwater water did not reach a surface water body. • Equipment was mobilized on site to establish control over the artesian condition and allow further drilling and completion of the test well as a production well. • Control over the artesian condition was obtained at 5:17 pm, Aug 25th, by the use of a barite rich drilling fluid, which effectively increased the mud density from a specific gravity of 1.07 to approximately 1.31.
August 26 to August 30	• Borehole reamed to a diameter of 311 mm, and 303.0 m of 244 mm OD casing was set and grouted using $12m^3$ of Portland cement to establish a surface seal, which would be adequate to overcome the artesian pressure.
September 3 to September 5	• Discovered that the 244 mm steel casing had broken at approximately 152.4 m below ground surface. • Reamed hole slightly beyond this depth (152.4 m) to re-establish circulation in the annular space between the 244 mm casing and the 311 mm diameter hole. • A new batch of Portland cement was then added and a good surface seal was obtained in the upper 152.4 m of the well casing.
September 5 to September 8	• Drilled to a depth of 376.05 m below groundsurface with a 222 mm tricone bit and recovered an “undisturbed” sample, using a junk basket, from a depth interval of 376.1 m - 377.0 m below ground surface. • Upon sample recovery the 222 mm tricone bit was tripped back into the hole and the final borehole depth of 382.2 m was reached. • Mike Powers of Aurora Geosciences of Whitehorse, Yukon then logged the borehole. The hole was salted with NaCl to help provide a resistivity contrast in the drilling fluid which would improved the overall quality of the data.
September 11 to September 13	• 217.6 m of 178 mm OD steel casing with 7.32 m of 60-slot Johnson Screen was set into the hole. • The 178 mm OD casing was hung within the 244 mm OD casing using a D Linger Hanger/Packer at a depth of 141.06 below ground surface. • The well was screened across an interval of 361.9m to 369.2 m below ground surface.
September 14 to September 25	• The high-density mud in the borehole was displaced with water and artesian conditions returned. A large valve on the wellhead “diverter” allowed control over the flowing condition. Artesian flow was shut down during the night when development activities were not being conducted. • The well development process began using compressed air, a process known as “air surging”. • Sodium acid pyrophosphate (SAPP) was added to help breakdown the mud cake on the borehole wall during the initial phases of development. • The groundwater would periodically clear however turbidity would return frequently, suggesting the mud cake was slowly breaking down and the aquifer formation was collapsing onto the well screen. • On September 20, the well was super chlorinated with Chlorix to produce a chlorine concentration of approximately 1,200 ppm - 1,400 pmm. The well was then shut down and allowed to sit over of the weekend. Development with air then continued for approximately 3 days. • On Sept 25, development stopped and the valve on the well head was closed.

several other wells near the Village, which are completed from approximately 34 m and 156 m below ground surface. Many of these wells are reported to display artesian conditions (Hydrogeological Consultants 1988). The most successful of these wells is the “Brewster Well” (completed to a depth of 156 m deep, with a reported "low" yield). Well No. 3 is located near the Dezadeash River and is completed at depth of 82.3 m below ground surface. With the exception of Well No. 3, most wells near the Village are reported to be characterized by water quality/quantity issues including low yield, high turbidity (i.e. silt) and elevated concentrations of sulphate. Most such wells are inferred to be completed within coarser grained glaciolacustrine sediments.

During drilling, geological grab samples were collected at approximately 1.5 m depth intervals. These samples were collected directly from the drilling mud return at surface, and therefore are disturbed. These samples provided only a general indication of the subsurface condition and material types. Grain size analyses were conducted on three samples collected from the drilling mud, from 367 m, 370 m, and 373 m below ground surface. The results of the grain size analyses indicate that they consist of more than 94 percent sand. The remaining 2% to 4% were silt and/or clay, likely the result of drilling fluid influences. It should be noted that the mud rotary drilling method does not bring material coarser than grit to small pebble size (e.g. no greater than 5 mm diameter) to surface. The results of these grain size analyses are provided in Appendix B.

A single undisturbed sample was collected from a depth interval of 376.1 m 377.0 m below ground surface, using a “junk basket”. This sample consisted of a clayey pebbly till. A simplified borehole stratigraphy is summarized in Table 2 and is illustrated in more detail on the geophysical log presented in Figure 3.

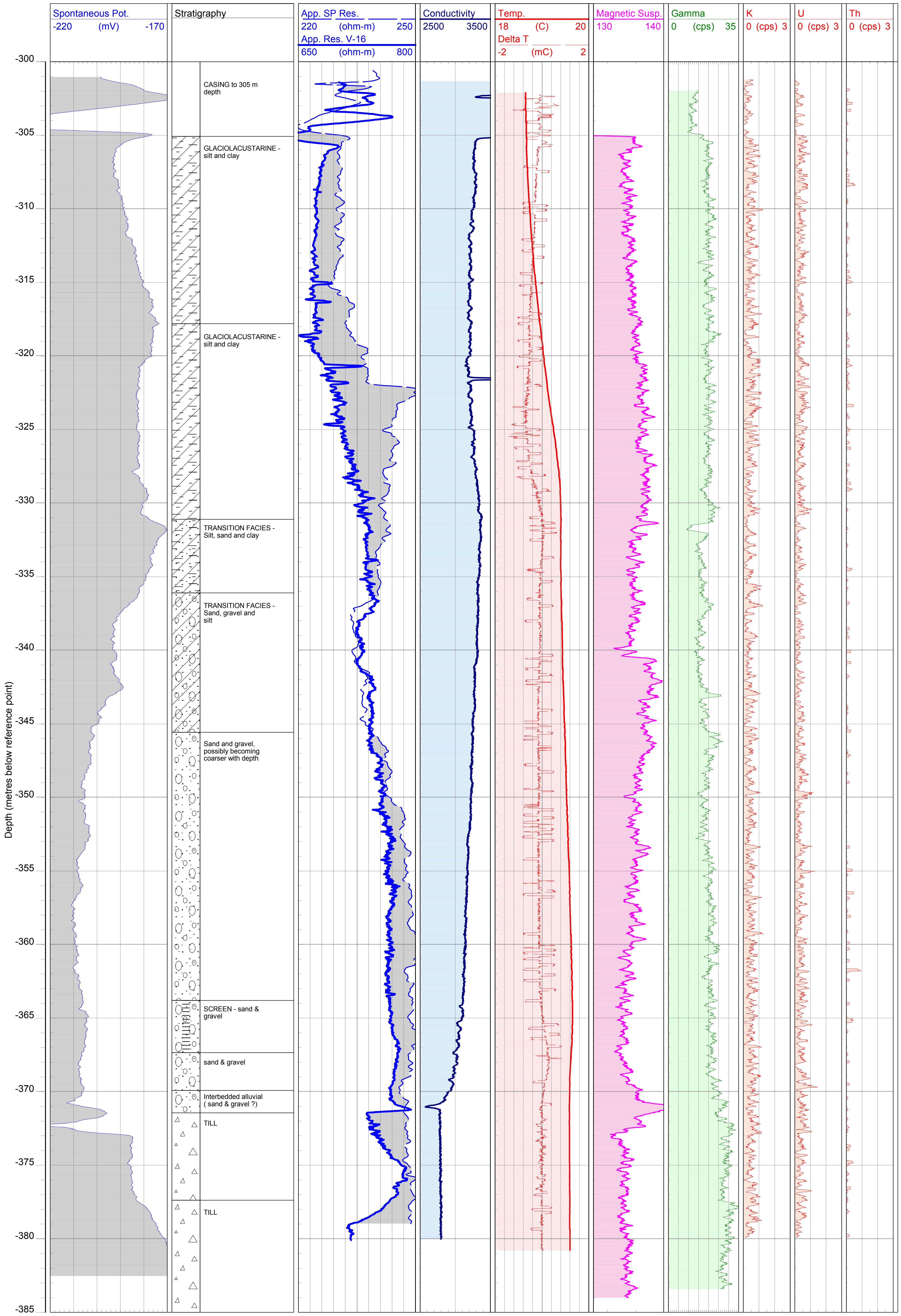
Table 2: Simplified Borehole Stratigraphy

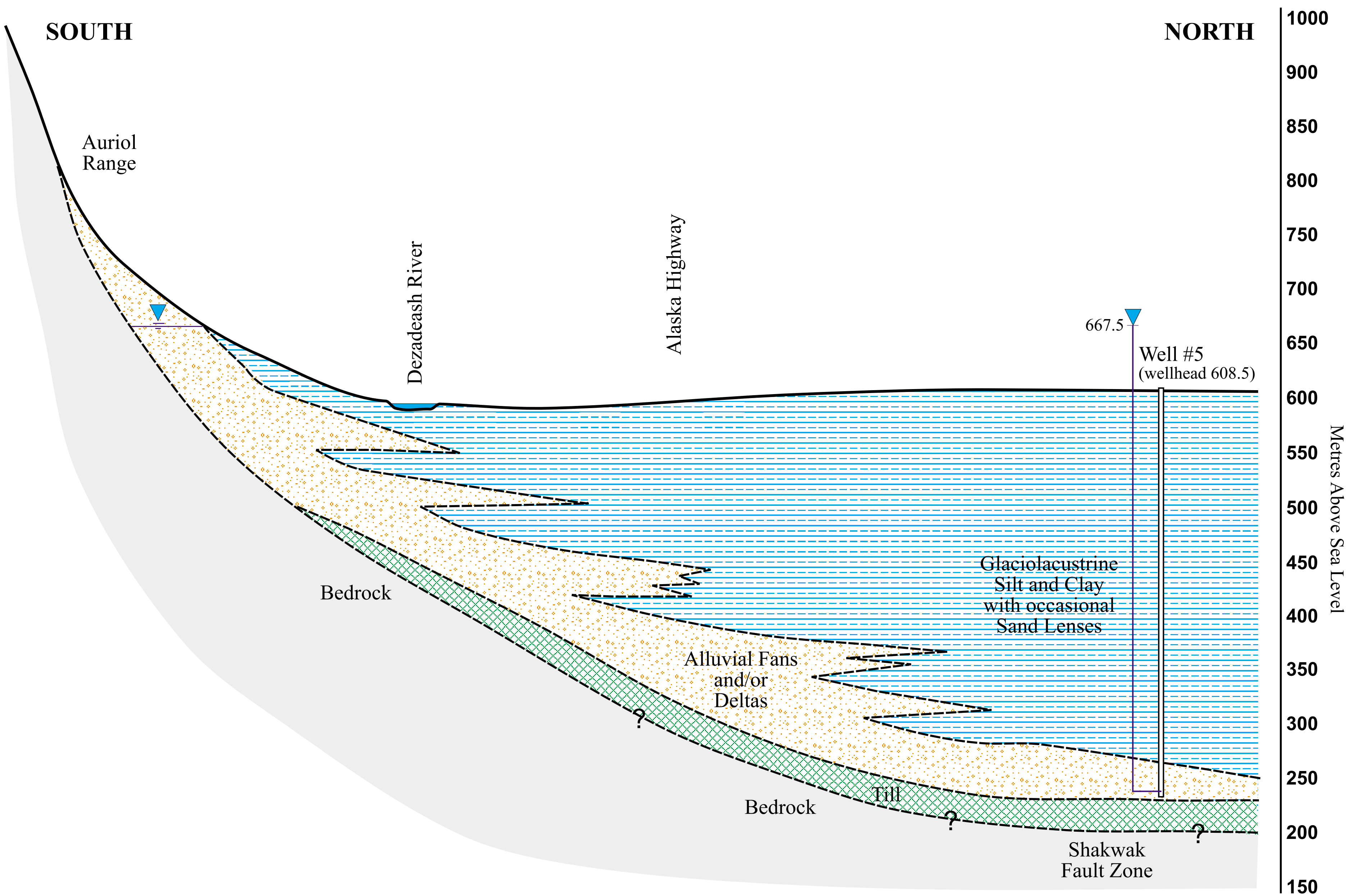
Depth (m below ground surface)	Material Texture	Stratigraphic Unit
0 – 329 m	SILT and CLAY, occasional fine sand lenses and pebbles	Glacial Lake Champagne Glaciolacustrine deposits
329 – 343 m	SILT, SAND and GRAVEL	Transition Facies – interbedded and mixed fluvial and glaciolacustrine deposits
343 – 370 m	SAND and GRAVEL	Alluvial and/or deltaic deposits
>370 m	CLAY, SILT and GRAVEL	Till

It is inferred that the artesian condition at Well No. 5 was likely encountered at a depth of approximately 329 m below ground surface. The stratigraphic setting for Well No. 5 is illustrated conceptually in Figure 4. The water bearing units encountered at Well No. 5 could represent alluvial fans or deltas that have formed off the slope of the Auriol Range south of the Dezadeash River. These deposits likely formed through deposition of sand and gravel either as deltas directly into Glacial Lake Champagne or as fans during period of fluctuating lake levels.

Figure 3. Geophysical and Borehole Log of Well No. 5
Location: Haines Junction, Yukon

Hole Logged By: Aurora Geosciences Ltd., September 9, 2002. Log #3 & #4
Logging Tool: IFG Corp. BFG-06 Multiparameter Probe
Log Prepared By: Gartner Lee Limited, 22-345
Well Location: 362215E 6738404N, Zone 7 (NAD83)
Ground Elevation: 608.5 m ASL Reference Point: +1.9 m Above Ground Surface





Not to Scale

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CONCEPTUAL HYDROGEOLOGICAL MODEL OF WELL No. 5

2002 Water Well Drilling Project
Village of Haines Junction

FIGURE
4

Project 22-345
(22345\2002\X-Section.cdr)

2.4 Screen Selection and Well Construction Details

Based the results of the drilling, field sampling, and the down hole geophysical survey, it was determined that the greatest aquifer potential was most likely between depths of 343 m and 370 m below ground surface. This depth interval coincides with the warmest groundwater temperature that was measured during the geophysical surveying.

Midnight Sun, under the direction of GLL installed a 127 mm diameter, 7.32 m, 60-slot (0.060 inch) stainless steel Johnson well screen between the depths of 361.9 m and 369.2 m below ground surface. The screen slot size was calculated based on the results of grain size analysis from samples collected across a similar depth interval. The results of the sieve analyses are presented in Appendix B.

During installation, the well screen joints were “tap” welded and attached to the 178 mm well casing using a threaded coupling. The base of the well screen was completed with a threaded base plug.

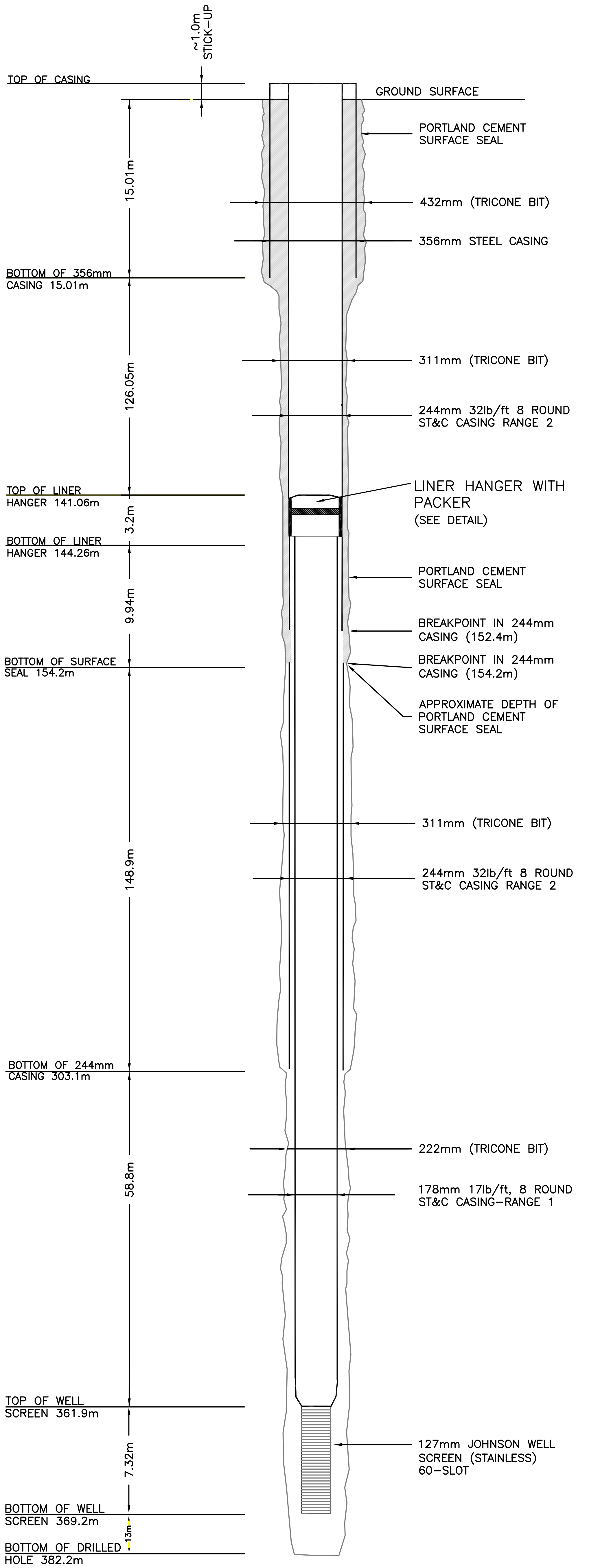
A total of 217.6 m of 178 mm diameter steel casing was installed above the screened section of the well. A combination of 7 centralizes and cement baskets were installed at regular intervals along the length of the casing string. The 178 mm casing assembly were then hung within the 244 mm casing using a “Type D-Liner Hanger with Packer”, manufactured by Baker Hughes. The hanger was set to a depth of 141.06 m below ground surface. This configuration provided for the well's screen to be located between depths of 361.9 m and 369.2 m below ground surface. A schematic diagram showing the principal completion details for Well No. 5 is provided in Figure 5.

Following completion of the well, and as specified by the Village, a borehole-deviation survey was not undertaken. An alignment survey was inferred based on the ability to easily pass the 222 mm tri cone bit through the 244 mm OD casing with no hang-ups.

2.4.1 Well Losses

The velocity of groundwater entering the well through its screen during pumping (i.e. the entrance velocity) was calculated for a variety of pumping rates. The entrance velocity is defined as the velocity at which water enters the open portion of the well screen. This is an important variable with respect to well-screen longevity, as high entrance velocities can lead to excessive screen wear, metal fatigue, or a decrease in well efficiency (i.e. an increases in drawdown for a given flow rate). These process can therefore lead to changes in water quality (i.e. sand production). In general, the maximum recommended entrance velocity for production wells is approximately 0.03 m/sec (Mabillot 1979).

The screen dimensions (i.e. screen length 7.32 m, screen diameter 127 mm OD, and slot width 1.52 mm) chosen for Well No. 5 produce an entrance velocity of 0.03 m/sec when the well is pumped at a rate of 36 L/s or 475 igpm. To provide maximum well efficiency in this regard the well's pumping rate should therefore not exceed 36 L/s or 475 igpm. Screen clogging (due to i.e. growth of bacteria or the lodgment of soil particles in the well screen pores) may also lead to increases in the entrance velocity. It is



WELL COMPLETION NOTES

1) WELL COMPLETED ON: SEPTEMBER 13, 2002
2) WELL COMPLETED USING MUD ROTARY DRILL RIG; 1998 SCHRAMM T685WS
3) INTENDED WATER USE: MUNICIPAL WATER SUPPLY
4) WELL OWNED BY THE VILLAGE OF HAINES JUNCTION
5) LOCATION: E 0362215, N 6738404 (NAD 83) Zone 7
   ELEVATION OF GROUNDSURFACE: 608.5 MASL
6) WELL DRILLED BY MIDNIGHT SUN DRILLING OF WHITEHORSE YUKON.

   (PRIMARY DRILLER: TRENT JAMIESON)

   ____
   (SIGNATURE)

7) WELL ID: WELL #5

ALL DEPTHS SHOWN ARE RELATIVE TO THE GROUND SURFACE (ELEV. 0.00m)

LINER HANGER WITH PACKER

D LINER HANGER/PACKER
Product No. 293–02

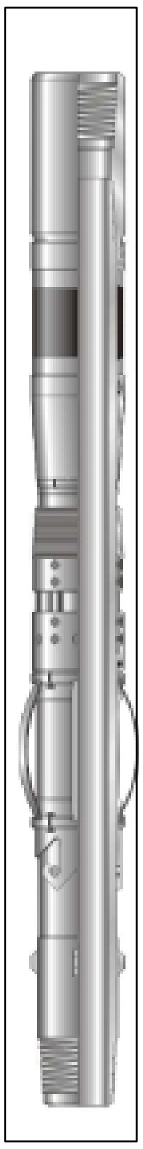
The D Liner Hanger/Packer serves as both a liner hanger and packer when the liner is not to be cemented. As the slips hang the liner, the packing element is also compressed to seal against the casing ID. The D Liner Hanger/Packer is available with right–or left–hand set open–bottom J–cage.

The D Hanger/Packer may be utilized as the lower packer on a scab liner to isolate damaged casing. It is typically run below a compression–set liner packer such as a hyflo 3 Liner Packer with hold–down slips. The D is set by right–or left–hand rotation and weight is slacked off to hang and set the packer seal. The setting tool is then released, and the running string raised to expose the packer setting dogs. The upper packer is then set with set–down weight.

The D Hanger/Packer is also commonly used as an injection packer on disposal wells. The D provides the largest ID available for injection packer applications.

FEATURES/BENEFITS

- Economical, one –piece hanger and packer for uncemented liners
- Automatic J–cage allows hanger slips to return to the run–in position if desired
- Low profile slips reduce possibility of damage while running in
- T–slot bowsprings eliminate use of set screws in J–cage
- Ideal for use as lower packer of scab liner to isolate damaged casing
- Can also be run upside–down and pulled in tension for shallow scab liners
- Available with optional internal lock ring to maintain setting force



WELL COMPLETION DETAILS

CENTRALIZERS & CEMENT BASKETS ARE LOCATED AT THE FOLLOWING DEPTHS BELOW GROUND SURFACE::

ON THE 244 mm OD CASING	ON THE 178 mm OD CASING
1) CEMENT BASKET @ 3.23m	1) CENTRALIZER @ 140.18m
2) CENTRALIZER @ 40.17m	2) CENTRALIZER @ 186.67m
3) CEMENT BASKET @ 77.05m	3) CENTRALIZER @ 246.16m
4) CENTRALIZER @ 113.93m	4) CENTRALIZER @ 300.48m
5) CEMENT BASKET @ 150.81m	5) CEMENT BASKET @ 321.74m
6) CENTRALIZER @ 190.93m	6) CEMENT BASKET @ 328.29m
7) CEMENT BASKET @ 227.87m	7) CENTRALIZER @ 356.66m
8) CENTRALIZER @ 264.69m	
9) CEMENT BASKET @ 301.57m	

CENTRALIZERS:
TOPCO INDUSTRIES CENTRALIZERS – TYPE 300–WELDED BOW CENTRALIZERS

CEMENT BASKETS:
TOPCO INDUSTRIES BASKETS – TYPE 400–CEMENT BASKET

APPROXIMATE LENGTH OF CASING IN–HOLE

217.6m of 178mm
303.0m of 244mm
15.0m of 356mm

LEGEND

PORTLAND CEMENT SURFACE SEAL

SCALES: Not to Scale

Designed By: JK	Drawn By: JK
Checked By: JK	Approved By: JK
Date Issued: DECEMBER 2002	Project No.: 22–345

Village of Haines Junction
Box 5339, Haines Junction, Yukon
YOB 1L0

HAINES JUNCTION WELL No. 5
COMPLETION DIAGRAM

Gartner Lee

FIGURE 5

(N:PROJECTS/2002/22345/2002/acad/22345–1.DWG) recommended that if well efficiency becomes significantly reduced (i.e. more drawdown is required for the same flow rate) then the well be assessed to determine if redevelopment is required.

Well losses can also occur if the velocity of the water traveling up through the well's casing (i.e. the up-hole velocity) exceeds a velocity of approximately 1.5 m/s (Mabillot 1979). To provide maximum well efficiency in this regard the well's pumping rate should not exceed 36 L/s or 475 Igpm. It is a coincidence that this is the same maximum pumping rate that will maintain an acceptable entrance velocity.

2.5 Well Development

Well No. 5 was developed between September 14 and September 25, 2002. The development method used is called “air surging”, in which compressed air is pumped down the well and used to lift standing water out of the well. The purpose of development is to remove fine grain material adjacent to the screen to create a naturally developed sand pack with will maximize yield and improve water quality with respect to sand content in the water. During well development, no evidence of surface seal failure or leakage was observed by GLL. This suggests that the surface seal is properly installed and that control over the artesian pressure should continue to be manageable.

As anticipated, during development, significant amounts of sand were initially observed in the discharge water. However, the amount of sand produced decreased throughout the development process. Sodium Acid Pyrophosphate (SAPP) dissolved in water was added across the screen interval to help penetrate and de-flocculate the drilling fluid that becomes caked onto the borehole wall during drilling. This phosphate-based compound causes the clay to de-flocculate by inhibiting the clay's natural adhesive properties.

As development proceeded, the groundwater periodically cleared, however, high turbidity would return frequently, suggesting the mud cake was slowly breaking down and likely collapsing onto the well screen as anticipated.

On September 20, the well was “Super Chlorinated”. A concentrated solution of chlorine was added to the well screen, which resulted in an estimated chlorine concentration of water within the well casing of approximately 1,200 ppm 1,400 ppm. Once the chlorine was injected across the well screen at depth, the well was shut down and the chlorinated water was allowed to sit (i.e. no flow condition) over the weekend. Development with air then continued for approximately 3 days. The use of high concentrations of chlorine during the development process was recommended by Johnson Well Screen (2002) as it has been found that chlorine effectively breaks down polymer-based additives in the drilling fluid, for which SAPP is not effective.

On Sept 25, 2002, the development procedures stopped and the well was shut off using a temporary valve and wellhead seal. A bleeder line and valve were installed directly onto the well head to prevent freezing along with a pressure gauge to allow the well's static water level to be calculated.

3. Hydrogeological Testing & Analysis

3.1 Field Methodology

Due to the requirement of a "Class B Water License" to conduct hydrogeological testing at pumping rates exceeding 300 m^3/day, the constant rate pumping test that was originally scheduled as part of this project was not conducted. Instead, a short-term pumping test was conducted to provide as much information as possible and to allow the collection of groundwater samples for analytical testing.

On October 1, 2002, a variable rate (i.e. step test) pumping test was conducted over a total period of approximately 535 minutes on Well No. 5. The step test consisted of pumping the well using four different pump rates (i.e. steps). Each step lasted approximately 125 minutes, and consisted of an incremental increase in pumping rate of approximately 2.2 L/s. The last 2 steps however (i.e. Step No. 3 and Step No. 4) had only a slight increase in pumping rate from 18.79 to 19.94 L/s and therefore, have been considered as a single step denoted by "Step No. 3".

Upon arrival at the site, the bleeder valve on the well head was shut off and the artesian pressure was allowed to stabilize for approximately 2 hrs. Within approximately 15 minutes however, the pressure had stabilized at 84 psi, which is equivalent to a static water level of 59.06 m above ground surface.

Following stabilization of static water levels, the wellhead diverter valve was opened, and a down-hole turbine pump was installed, with the pump intake at a depth of 44.6 m below the top of the casing. An electronic flow meter was installed on the pump's discharge line and a 25 mm diameter polyvinyl chloride (PVC) tube was installed to allow manual water level measurements to be taken. The pump was then turned on, and the flow rate was adjusted so that the water level in the well was maintained just below the top of the casing. This was considered to be representative of the artesian flow rate and was measured to be 13 L/s or (170 Igpm).

Because the aquifer being tested is likely to be a confined aquifer and because changes in atmospheric pressure are capable of influencing measurements of groundwater head in confined aquifers, a pressure transducer (Level Logger) was placed beside the well and was used to measure changes in atmospheric pressure throughout the test. The results of the atmospheric monitoring were used to "correct" the induced drawdown effects due to changes in atmospheric pressure. The atmospheric pressure was found to increase slightly throughout the test, and therefore the change in atmosphere pressure as an "equivalent water column", was subtracted from the measured drawdown values. Additionally, all drawdown values were measured relative to the static water level, determined by the stabilized artesian well head pressure at the beginning of the test (84 psi or 59.06 m above ground surface).

3.2 Pumping Step Test Results

Approximately 6.8 hrs elapsed from the time the wellhead diverter valve was opened, the pump was installed and the initiation of the first of three major pumping steps began. A *"Drawdown Versus Time with Discharge"* curve is provided in Figure 6. The data has also been tabulated and is presented in Appendix C.

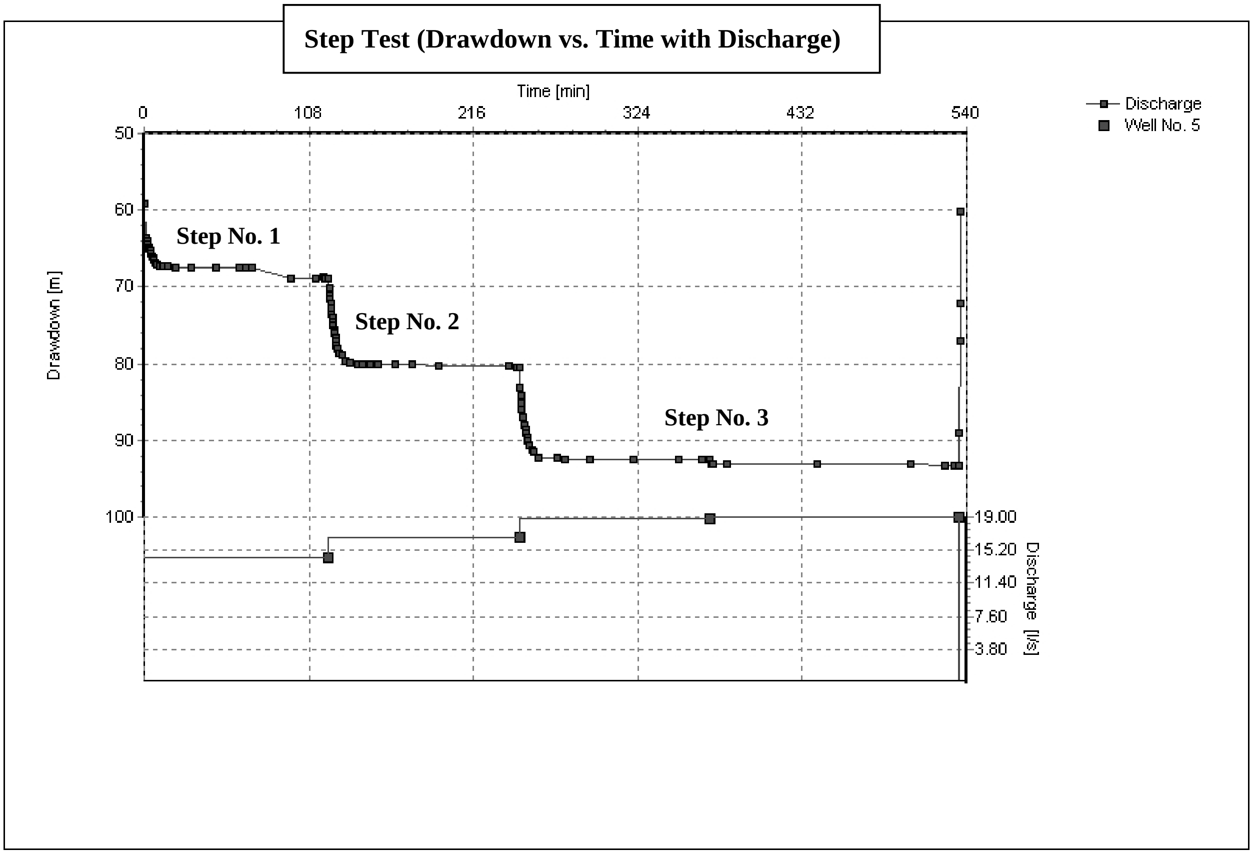


Figure 6: Variable Rate Pumping Test - Drawdown versus Time with Discharge

Based on an initial analysis of the time drawdown data, each increase in pumping rate produced an initial drawdown, however the magnitude of this drawdown appeared to stabilize through time. This type of hydraulic response (i.e. no additional change in drawdown with respect to time) is consistent with that of a "confined leaky aquifer" that is receiving recharge from overlying and or underlying, slightly less permeable, stratum as prolonged pumping takes place. This observation is consistent with the geological formations identified in the borehole log. Additionally, it is quite common in deep sedimentary basins, for leaky aquifers to be one component of a muli-layered aquifer system (Kruseman et al.1994).

The hydraulic properties of the aquifer were estimated based on the behavior of the time drawdown data collected during Step No. 2. The data set was adjusted such that the drawdown was analyzed as a "change in drawdown" relative to the previous step. The flow rate used was also not the absolute flow rate, but rather the "change in flow rate" from the previous step (i.e. 16.27 L/s - 14.4 L/s = 2.27 L/s).

The corrected drawdown data from Step No. 2 indicated that the early time drawdown data was significantly affected by borehole storage as the change in flow rate from the previous step was small (2.27 L/s) and the diameter of the well bore was large (311 mm). Consequently, only late time data was analyzed and fit to the Hantush-Jacob Solution (1955, 1961a., 1961b)

The following assumptions apply to the use of the Hantush-Jacob solution:

- aquifer has infinite areal extent;
- aquifer is homogeneous, isotropic and of uniform thickness;
- pumping well is fully or partially penetrating;
- flow to pumping well is horizontal when pumping well is fully penetrating;
- aquifer is leaky;
- flow is unsteady;
- water is released instantaneously from storage with decline of hydraulic head;
- diameter of pumping well is very small so that storage in the well can be neglected;
- confining bed(s) has infinite areal extent, uniform vertical hydraulic conductivity and uniform thickness;
- confining bed(s) is overlain or underlain by an infinite constant-head plane source;
- flow in the aquitard(s) is vertical.

The results indicate that the aquifer is moderately transmissive, having an interpreted transmissivity value of approximately 23 m^2/day. The raw pumping test data and analyses can be found in Appendix C.

3.3 Well Performance

Data collected during the pumping step test was used to estimate the maximum long term well capacity for Well No. 5. Due to the well construction and artesian conditions, the Total Available Drawdown was calculated as the difference between the elevation of the calculated initial static water level (59.06 m above ground surface) to the top of the Liner Hanger (141.1 m below ground surface). It is assumed that if a pump is installed down hole, that it will be housed within the 244 mm diameter casing (i.e. above the Liner Hanger) to maximize pump size and pumping capacity. It is possible however that a pump could be installed below the Liner Hanger within the 222 mm diameter casing, however a smaller pump and pump capacity should be anticipated. Based on these assumptions, the current Total Available Drawdown is estimated at 200.1 m.

Safe Available Drawdown is "safe" or "allowable" drawdown in a pumped well. Safe Available Drawdown is typically calculated as 70 % (i.e. 140.1 m) of the Total Available Drawdown (200.1 m), with the remaining 30 % (i.e. 60.03 m) reserved for housing the submersible pump, seasonal water-level fluctuations, and decreases in well efficiency (i.e. gradual well screen blockage). For wells in BC, 30 % of the available drawdown is considered to be a reasonable margin of safety (B.C. Ministry of Environment, Lands and Parks 1999). In this specific case however, due to the depth of the well, these assumptions are considered relatively conservative.

To estimate the Maximum Long-Term Well Capacity, (i.e. a pumping rate that will induce the Safe Available Drawdown), the observed steady-state drawdown measured at the end of each "step" was plotted together with the associated flow rate that induced that drawdown. A best-fit line was then placed through each of the points and the slope of this line was calculated. The slope of this line is referred to as the Specific Capacity. The Specific Capacity (1.93 x 10^{-4} m^2/sec) was then multiplied by the Safe Available Drawdown (140.1 m) to estimate a Maximum Long-Term Well Capacity of approximately 27 L/s (360 Igpm). Relative to ground surface, the Safe Available Drawdown is approximately 81.0 m (Figure 7).

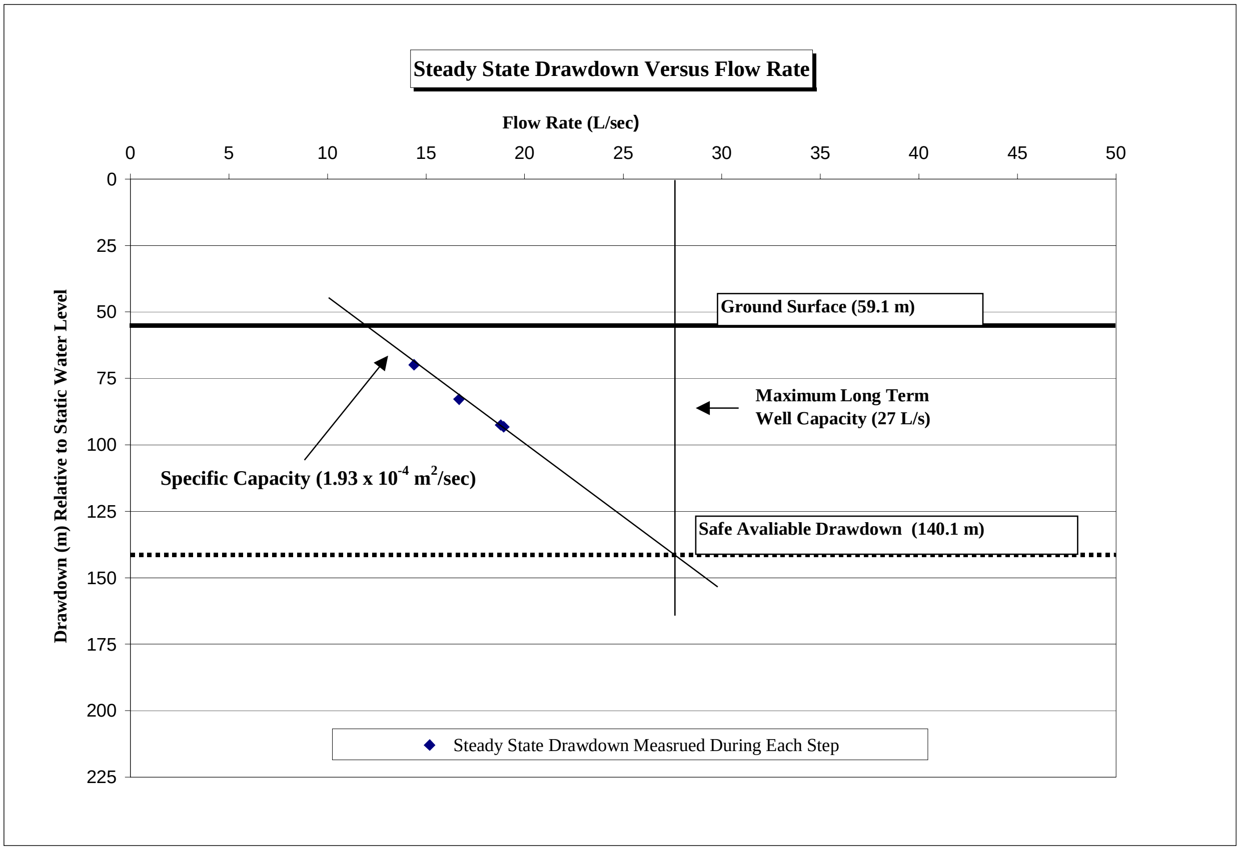


Figure 7 : Estimate of Maximum Long Term Well Capacity

The above analysis assumes a linear extrapolation of the steady state drawdown data collected during this short term pumping test. This assumption is likely valid for flows up to approximately 36 L/s. However, at higher pumping rates, hydraulic well losses may be significant and therefore extrapolation of higher flows outside of this range may not be accurate. Additionally, future reductions in well efficiency may also limit the use of Figure 7 as a tool of predicting expected drawdown levels.

As for any newly installed production well, it is recommended that the pumping rate of Well No. 5 be monitored continuously. If possible, it is also recommend that the artesian pressure of Well No. 5 be monitored when the well is not in use. Further benefit would be obtained with the collection of long-term water level measurements from Well No. 4, as this well is moderately deep, currently is not in use, and is readily assessable as it's owned by the Village.

In summary, the collection of long-term water flow and water level measurements will provide the best information to help predict the long-term sustainability and management of this important groundwater resource.

4. Groundwater Quality

4.1 Sample Collection

All groundwater samples submitted for analyses were collected Jonathan Kerr of GLL, and placed into pre-cleaned bottles supplied by the appropriate laboratory. The following sampling and preservation methods were applied:

- Samples submitted for total metal analysis were placed in 250 mL high density polyethylene (HDPE) bottles and were preserved in the field using laboratory-supplied and measured aliquots of nitric acid (pH < 2).
- Samples submitted for dissolved metals were field filtered using dedicated disposable 45-micron filters and placed into 250 mL HDPE bottles and acidified in the field using laboratory-supplied and measured aliquots of nitric acid (pH < 2).
- Samples submitted for general parameters (i.e. hardness) were placed into 1-L HDPE bottles and were not preserved.
- Samples submitted for bacteriological analysis were collected and placed in prepared bottles that were supplied by Yukon Health and Social Services (YHSS).
- Samples submitted for sulphide analysis were placed into 50 mL glass bottles and were preserved in the field using laboratory-supplied and measured aliquots of zinc acetate and sodium hydroxide.
- Samples submitted for cyanide analysis were placed in 1-L HDPE bottles and were preserved in the field using laboratory-supplied and measured aliquots of sodium hydroxide (pH > 12) .
- Samples submitted for analysis of volatile organic compounds (VOCs) were placed into 40 mL vials with Teflon lids and preserved with laboratory-supplied and measured aliquots of copper sulphate.
- Samples submitted for tri-halomethane formation potential (THMFP) were placed into 2 x 250 mL glass amber jars with no preservative.
- Samples submitted for radiochemistry analysis were placed into four 1-L HDPE bottles and preserved in the field using with laboratory-supplied and measured aliquots of nitric acid (pH<2).
- Samples submitted for extractable petroleum hydrocarbons (EPH) were placed into 250 mL glass jar with a Teflon lid and were not preserved.

Following sample collection, all samples were placed in a chilled cooler (~ 4 ºC) and transported by courier or car to the appropriate laboratory within 24 hours. Samples collected for bacteriological analysis were submitted to the Yukon Health and Social Services (YHSS) Branch, Yukon Government, within 12 hrs after collection.

Groundwater samples were collected at various times throughout the variable rate pumping test. Sample "S1" was collected near the end of the first step, sample "S2" was collected near the end of the second step, and sample "SF" was collected near the end of the third and final step. Samples were also collected in replicate and were identified using the letter "R". For example a replicate of sample "S2" was identified as "S2-R".

4.2 Sample Analyses

ALS Environmental of Vancouver, BC (ALS), a member of the Canadian Association for Environmental Analytical Laboratories (CAEAL), conducted all water analyses, with the exception of those for bacteriological content and radiochemistry. Water scheduled for bacteriological analyses was submitted to Environmental Health Services Branch of Yukon Health and Social Services in Whitehorse, Yukon. Water scheduled for radiochemistry analysis was submitted to the Saskatchewan Research Council, Saskatoon, Saskatchewan. The detection limits used in the analytical procedures provide for a level of accuracy adequate for comparison to the Canadian Drinking Water Quality Guidelines (1996).

4.2.1 Quality Assurance and Quality Control

Quality assurance/quality (QA/QC) measures implemented as part of this program consisted of the following:

- Collection, handling, storage and chemical analysis in accordance with "*Standard Methods for Examination of Water and Wastewater*" and "*Gartner Lee Limited's Groundwater Sampling Protocols*", designed to minimize the potential for cross-contamination of samples.

- Documentation of sample variability due to environmental and sampling variability (i.e. field variability). This was limited to the collection of one replicate sample that was analyzed for its content of total metals.

- Internal laboratory QA/QC measures that were conducted by ALS.

4.3 Discussion of Results

The analytical results are summarized and presented in Table 3. Original laboratory reports for the laboratory analyses are presented in Appendix D.

As with the development of any new water well, the water quality results presented in this report are reflective of water quality immediately following the development process. Trace levels of drilling fluids used during well completion may influence water quality, and where applicable recommendations have made for further follow-up water quality testing.

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Table 3: Summary of Groundwater Quality Well No. 5 - Haines Junction, Yukon, 2002

Parameter		Canadian Drinking Water Quality Guidelines [a]	Detection Limits	Haines Junction Well No. 5	Haines Junction Well No. 5	Haines Junction Well No. 5	Haines Junction Well No. 5
Sample Collection Date		-	-	*Oct 2, 2002*	*Oct 2, 2002*	*Oct 2, 2002*	*Oct 2, 2002*
Sample Collection Time				*2:25am,*	*4:46am,*	*12:19pm*	*12:19pm*
Sample ID		-	-	S1	S2	SF	SF-R
ALS Sample ID				1	2	3	3
Physical Tests							
Colour	CU	15	5	<5	<5	<5	-
Laboratory Conductivity	umhos/cm	-	2	252	251	249	-
Field Conductivity	umhos/cm	-	2	243	242	-	-
Total Dissolved Solids		500	10	172	171	164	-
Hardness	CaCO3	-	0.7	15.1	14.4	10.1	13
pH		6.5 - 8.5	0.01	8.61	8.71	8.74	-
Laboratory Turbidity	NTU	5	0.1	***25***	***22.8***	***13***	-
Field Turbidity	NTU	5	0.1	***34.2****	***23.4****	***13.7****	-
Dissolved Anions (mg/L)							
Alkalinity-Total	CaCO3	-	1	112	115	115	-
Chloride	Cl	<=250	0.5	<0.5	<0.5	<0.5	-
Fluoride	F	1.5	0.02	0.27	0.26	0.26	-
Silicate	SiO2	-	1	25	25	25	-
Sulphate	SO4	<=500	1	15	15	15	-
Nutrients (mg/L)							
Nitrate Nitrogen	N	10	0.1	<0.1	<0.1	<0.1	-
Nitrite	N	1	0.1	<0.1	<0.1	<0.1	-
Total Phosphate	P	-	0.002	0.134	0.124	0.102	-
Cyanides							
Total Cyanide	CN	-	0.005	-	-	<0.005	-
Total Metals (mg/L)							
Aluminum	T-Al	0.1	0.01	**0.61**	**0.63**	**0.32**	**0.35**
Antimony	T-Sb	0.006	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Arsenic	T-As	0.025	0.001	0.02	0.021	0.02	0.02
Barium	T-Ba	1	0.02	0.71	0.58	0.41	0.31
Beryllium	T-Be	-	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	T-B	5	0.1	0.1	0.1	0.1	0.1
Cadmium	T-Cd	0.005	0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Calcium	T-Ca	-	0.1	4.8	4.5	4	4.3
Chromium	T-Cr	-	0.002	<0.002	<0.002	<0.002	<0.002
Copper	T-Cu	<=1.0	0.01	<0.01	<0.01	<0.01	<0.01
Iron	T-Fe	<=0.3	0.03	**0.73**	**0.75**	**0.45**	**0.63**
Lead	T-Pb	0.01	0.001	<0.001	<0.001	<0.001	<0.001
Magnesium	T-Mg	-	0.1	0.8	0.8	0.6	0.7
Manganese	T-Mn	<=0.05	0.002	0.025	0.023	0.013	0.014
Mercury	T-Hg	0.001	0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	T-Mo	-	0.00005	0.00544	0.00557	0.0056	0.00553
Nickel	T-Ni	-	0.0005	0.0014	0.0013	0.0007	0.0008
Potassium	T-K	-	0.1	0.4	0.4	0.4	0.4
Selenium	T-Se	0.01	0.001	<0.001	<0.001	<0.001	<0.001
Sodium	T-Na	<=200	2	52	52	52	59
Thallium	T-Tl	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Uranium	T-U	0.1	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	T-V	-	0.001	0.002	0.003	0.002	0.002
Zinc	T-Zn	<=5.0	0.05	<0.05	<0.05	<0.05	<0.05
Dissolved Metals (mg/L)							
Aluminum	D-Al	-	0.01	-	-	<0.01	-
Antimony	D-Sb	0.006	0.0005	-	-	<0.0005	-
Arsenic	D-As	0.025	0.001	-	-	0.02	-
Barium	D-Ba	1	0.02	-	-	<0.02	-
Beryllium	D-Be	-	0.0005	-	-	<0.0005	-
Boron	D-B	5	0.1	-	-	0.1	-
Cadmium	D-Cd	0.005	0.0002	-	-	<0.0002	-
Calcium	D-Ca	-	0.1	-	-	3.4	-
Chromium	D-Cr	-	0.002	-	-	<0.002	-
Copper	D-Cu	<=1.0	0.001	-	-	<0.001	-
Iron	D-Fe	<=0.3	0.03	-	-	<0.03	-
Lead	D-Pb	0.01	0.001	-	-	<0.001	-
Magnesium	D-Mg	-	0.1	-	-	0.4	-
Manganese	D-Mn	<=0.05	0.002	-	-	<0.002	-
Mercury	D-Hg	0.001	0.0002	-	-	<0.0002	-
Molybdenum	D-Mo	-	0.00005	-	-	0.00575	-
Nickel	D-Ni	-	0.0005	-	-	<0.0005	-
Potassium	D-K	-	0.1	-	-	0.3	-
Selenium	D-Se	0.01	0.001	-	-	<0.001	-
Sodium	D-Na	<=200	2	-	-	52	-
Thallium	D-Tl	-	0.0001	-	-	<0.0001	-
Uranium	D-U	0.1	0.0001	-	-	<0.0001	-
Vanadium	D-V	-	0.001	-	-	<0.001	-
Zinc	D-Zn	<=5.0	0.05	-	-	<0.05	-

a	*Heath Canada. Guidelines for Canadian Drinking Water Quality, Sixth Ed., 1996.*
*	*Indicates an average result based on three replicates samples*
<	*Indicates less than detection limit*
b	*U.S. EPA Proposed Amendment to Safewater Drinking Water Act, October 1999.*
-	*Indicates no guideline or analysis for this parameter*
bold #	*Indicates parameter exceeds Aesthetic Objective (taste, odour, appearance, etc.)*
bold, itallic #	*Indicates parameter exceeds Maximum Acceptable Concentration (health related)*

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Table 3. Summary of Groundwater Quality Well No. 5 - Haines Junction, Yukon, 2002
(Continued)

Parameter	Canadian Drinking Water Quality Guidelines	Detection Limits	Haines Junction Well No. 5	Haines Junction Well No. 5	Haines Junction Well No. 5
Sample Collection Date	-	-	*Oct 2, 2002*	*Oct 2, 2002*	*Oct 2, 2002*
Sample Collection Time			*12:19pm*	*12:19pm*	*12:19pm*
Sample ID	-	-	SF	SF	SF-R
ALS Sample ID	-	-	3	3a	5
Bacteriological					
Total Coliform Counts per 100 mL	10	<1	0*	-	-
Faecal Coliform Counts per 100mL	1	<1	0*	-	-
Inorganic Parameters					
Sulphide S	0.05	0.02	0.04	-	-
Halogenated Volatiles (mg/L)					
Bromodichloromethane	-	0.001	<0.001	0.001	<0.001
Bromoform	-	0.001	<0.001	<0.001	<0.001
Carbon Tetrachloride	0.005	0.001	<0.001	-	<0.001
Chlorobenzene	-	0.001	<0.001	-	<0.001
Chloroethane	-	0.001	<0.001	-	<0.001
Chloroform	-	0.001	<0.001	0.022	<0.001
Chloromethane	-	0.001	<0.001	-	<0.001
Dibromochloromethane	-	0.001	<0.001	<0.001	<0.001
1,2-Dichlorobenzene	0.2	0.001	<0.001	-	<0.001
1,3-Dichlorobenzene	-	0.001	<0.001	-	<0.001
1,4-Dichlorobenzene	0.005	0.001	<0.001	-	<0.001
1,1-Dichloroethane	-	0.001	<0.001	-	<0.001
1,2-Dichloroethane	0.005	0.001	<0.001	-	<0.001
cis-1,2-Dichloroethylene	-	0.001	<0.001	-	<0.001
trans-1,2-Dichloroethylene	-	0.001	<0.001	-	<0.001
1,1-Dichloroethylene	0.014	0.001	<0.001	-	<0.001
Dichloromethane	0.05	0.005	<0.005	-	<0.005
1,2-Dichloropropane	-	0.001	<0.001	-	<0.001
cis-1,3-Dichloropropylene	-	0.001	<0.001	-	<0.001
trans-1,3-Dichloropropylene	-	0.001	<0.001	-	<0.001
1,1,1,2-Tetrachloroethane	-	0.001	<0.001	-	<0.001
1,1,2,2-Tetrachloroethane	-	0.001	<0.001	-	<0.001
Tetrachloroethylene	0.03	0.001	<0.001	-	<0.001
1,1,1-Trichloroethane	-	0.001	<0.001	-	<0.001
1,1,2-Trichloroethane	-	0.001	<0.001	-	<0.001
Trichloroethylene	0.05	0.001	<0.001	-	<0.001
Trichlorofluoromethane	-	0.001	<0.001	-	<0.001
Vinyl Chloride	0.002	0.001	<0.001	-	<0.001
Trihalomethanes (total)	0.1	-	-	0.025[d]	
Non-Halogenated Volatiles (mg/L)					
Benzene	0.005	0.0005	<0.0005	-	<0.0005
Ethylbenzene	<= 0.0024	0.0005	<0.0005	-	<0.0005
Styrene	-	0.0005	<0.0005	-	<0.0005
Toluene	<= 0.024	0.0005	<0.0005	-	<0.0005
meta- & para-Xylene	<=0.3	0.0005	<0.0005	-	<0.0005
ortho-Xylene	<=0.3	0.0005	<0.0005	-	<0.0005
Total Xylenes	-	0.001	<0.001	-	<0.001
Extractable Hydrocarbons (mg/L)					
TPH (C10-32)		1	<1	-	-
Radiochemistry (Bq/L)					
Gross Alpha	0.1[c]	-	-	-	<0.07
Gross Beta	1	-	-	-	<0.05

a *Heath Canada. Guidelines for Canadian Drinking Water Quality, Sixth Ed., 1996.*
* *Indicates an average result based on four replicate samples.*
< *Indicates less than detection limit*
b *U.S. EPA Proposed Amendment to Safewater Drinking Water Act, October 1999.*
\- *Indicates no guideline or analysis for this parameter*
bold # *Indicates parameter exceeds Aesthetic Objective (taste, odour, appearance, etc.)*
bold, itallic # *Indicates parameter exceeds Maximum Acceptable Concentration (health related)*
c *Comliance with the CDWCG may be infered if the measurements from Gross Alpha and Gross Beta activity are <0.1 and <1.0 Bq/L respecivity*
d *A conservative estimate based on the summation of all THM compounds listed. Note that less than values were added directly into the THM total value presented.*

4.3.1 Quality Control/Quality Assurance

Analytical Precision

To assess field sample variability, a set of field replicates were used to calculate the relative percent difference (RPD). RPD is defined as the following:

$$\%RPD = \frac{2(X_1 - X_2)}{(X_1 + X_2)} * 100$$

Where:
X_1 = The concentration of the first sample;
X_2 = The concentration of the second sample (i.e. the replicates).

The repeatability of data between simultaneous grab samples was assessed and the RPD from this replicate sample ranged between 0 and 33%. RPD values of 20% or less are considered to be acceptable if concentrations are more than 5 times the method detection limit (MDL). RPD values of greater than 20% frequently are observed when concentrations are near the MDL. The analytical results received are considered to be acceptable for the intended purpose of this report.

4.3.2 Guidelines and Regulatory Framework

This report has adopted the Canadian Drinking Water Guidelines (CDWG) (Health Canada 1996) as the basis for all recommendations pertaining to water quality. Consequently, all analytical techniques used employ detection limits for direct assessment of the CDWG.

Legislated drinking water quality standards do not exist in either the Yukon or federal jurisdictions. Communities can obtain guidance in the management of their drinking water systems by referring to a comprehensive set of national guidelines (Health Canada 1996). These drinking water quality guidelines identify the following types of limits and objectives for specific contaminants in drinking water supplies:

- *Maximum Acceptable Concentrations* (MACs), have been established for certain substances that are known or suspected to cause adverse effects on health. MACs have been derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration.

- *Aesthetic Objective*s (AOs) apply to certain substances or characteristics of drinking water that can affect its acceptance by consumers or interfere with practices for supplying good-quality water. Substances that exceed AOs and do not have specified MACs are not considered to constitute a health hazard.

A few parameters have both a health-related limit (MAC) and an aesthetic objective (AO). Turbidity is one example, where the guidelines list a MAC of 1 NTU for water entering a distribution system and an AO of 5 NTU. With regards to this issue the guidelines state the following:

> “Excessive turbidity detracts from the appearance of treated water and has often been associated with unacceptable tastes and odours. Turbidity can serve as a source of nutrients for waterborne bacteria, viruses and protozoa, which can be embedded in or adhere to particles in the raw water or become trapped within floc formed during water treatment. Certain water supplies, such as groundwater, may contain non-organic-based turbidity, which may not seriously hinder disinfection, therefore, a less stringent value for turbidity in water entering a distribution system may be permitted if it is demonstrated that the system has a history of acceptable microbiological quality and that a higher turbidity value will not compromise disinfection”.

4.3.3 Physical Tests

Physical water tests conducted as part of this study included measurements of turbidity, colour, total dissolved solids, pH and hardness. These analytical results are discussed in the following paragraphs.

Sand Content and Turbidity

Following the completion of the step test, the well was allowed to flow naturally. While the well was flowing naturally, a survey was conducted to assess the turbidity and sand content of the groundwater. Groundwater samples were collected and analyzed on-site using a field turbidity meter (2100P HACH tubidimeter). Three grab samples of the flowing groundwater were collected simultaneously as replicates from the wellhead diverter pipe. The turbidity of the samples was then measured, and averaged. Figure 8 presents a summary of the turbidity measurements.

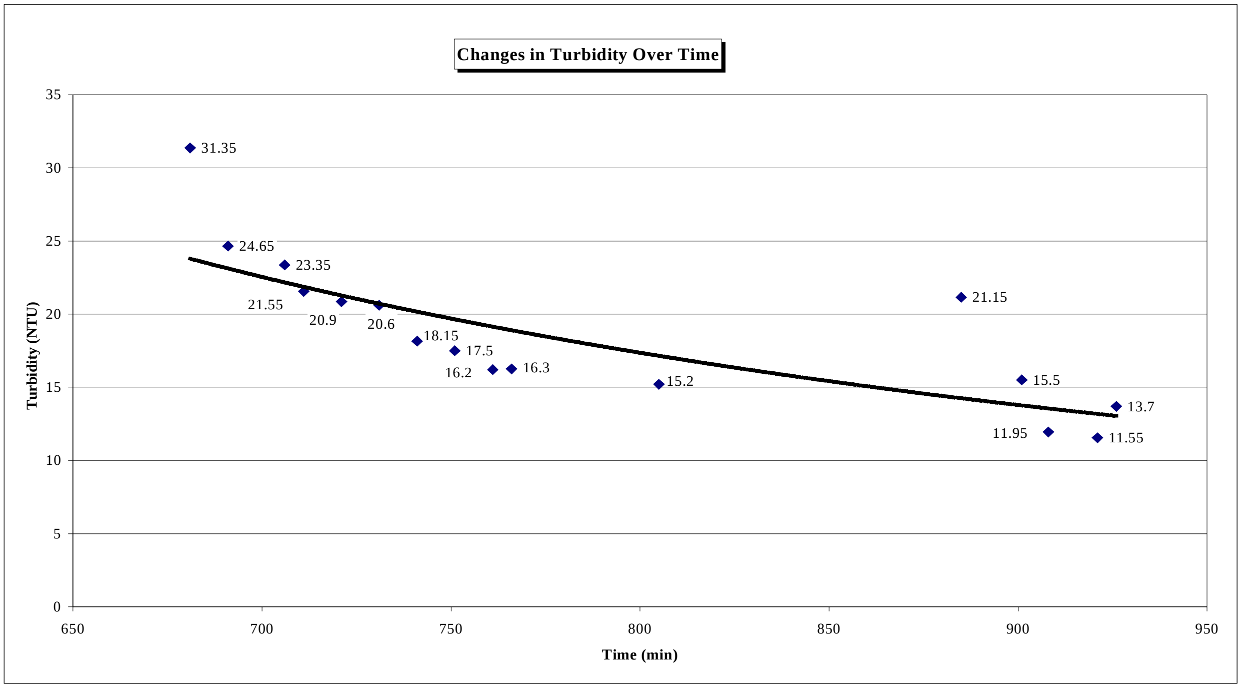

Figure 8: Turbidity Measurements Conducted at the Step Test

Three grab samples of flowing water were also collected approximately midway through Step 2 and Step 3 (not shown on Figure 8) and the turbidity of these samples were also analyzed in the field. These groundwater samples were also found to contain elevated turbidity (up to 33.8 NTU).

In summary, all groundwater samples that were monitored for turbidity exceeded the Canadian Drinking Water Quality Guidelines (CDWQG) for both Maximum Allowable Concentrations (MAC) (1 NTU) for water entering a distribution system and the AO (5 NTU). It should be noted that during the end of the assessment period, as shown in Figure 8, the turbidity values in the groundwater appeared to be decreasing. It is suspected that the groundwater turbidity is likely the result of residual amounts of drilling fluid, and that prolonged pumping is likely to reduce groundwater turbidity to levels below the MAC CDWQG. According to conversations with the Mayor of Haines Junction, (John Farynowski), on November 8, 2002, the turbidity of groundwater that discharges from the well has been monitored by the Village and significant improvements in groundwater quality, with respect to its turbidity, have been reported.

Hardness

Hardness issues related to drinking water are commonly characterized as follows:

Table 4: Classification of Hardness in Groundwater (Carrier, 1965)

Hardness ($CaCO_3$) mg/L	*Classification*	*Comments*
< 50	Soft	-
50 – 150	Medium Hard	May deposit in kettles and hot water heaters.
150 – 200	Hard	Scale build up or staining is likely quite noticeable.
> 200	Very Hard	Recommended that water be softened for household uses.

Based on the water quality results conducted during this assessment, the groundwater would be classified as “soft”.

Groundwater Temperature

Pumped groundwater temperature measurements were continuously monitored throughout the short term pumping test using a digital temperature probe (YSI Model 30/10 FT Salinity Conductivity Temperature Probe). The instrument measurements are considered to be accurate to 0.1 degrees Celsius. The results of the temperature monitoring indicate that groundwater temperatures throughout the test remained stable (Figure 9). It should be noted that the temperature of the groundwater was measured at surface and may represent a slightly reduced temperature from that in the aquifer.

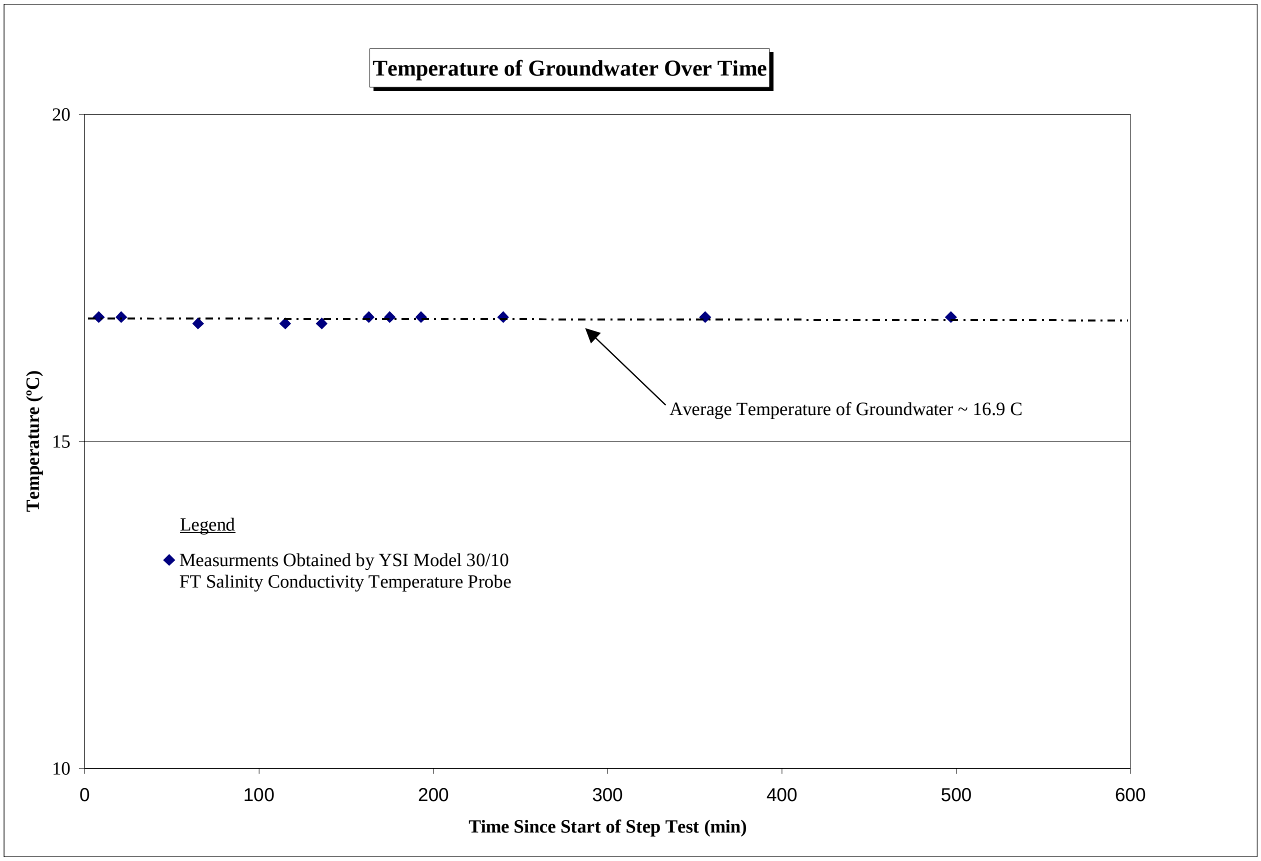

Figure 9: Groundwater Temperature Over Time

The down hole geophysical survey also collected temperature data. Based on the results of this survey, in-situ groundwater temperatures across the screen portion of the well are estimated to be between 19 and 20 ºC. These findings may be slightly biased, (i.e. over estimated) as the drilling fluids were allowed to stabilize for only a short period of time following drilling operations (i.e. approximately 5 hrs). Assuming the down hole temperatures are correct however, it appears that this zone is approximately 2 to 3 ºC warmer than the observed "pumped" groundwater temperatures (Figure 9). This observation suggests that the groundwater is likely being cooled by overlying stratum as it travels through the casing to ground surface. Additionally, the temperature logs suggest that there is a steady increase in groundwater temperatures with depth, and that the warmest zone appears to be the zone where the well screen has been placed.

4.3.4 Dissolved Anions

Dissolved anion concentrations were measured in all three analyzed groundwater samples. Concentrations of dissolved anions in the analyzed samples were found to meet the CDWQG. The low concentrations of sulphate in the analyzed samples (less than 15 mg/L) suggest that poor tasting waster associated with this anion will not likely be an issue.

4.3.5 Nutrients

Nutrients were measured in all three analyzed groundwater samples. Concentrations of all tested nutrient parameters in the analyzed samples were found to meet the CDWQG.

4.3.6 Cyanides

One sample of groundwater (sample "SF") was analyzed for its content of total cyanide. The results of the analysis indicate that no detectable quantities of cyanide in the groundwater were measured (i.e. the sample contained less than 0.005 mg/L of cyanide). The MAC CDWQG for cyanide in drinking water is 0.2 mg/L.

4.3.7 Total and Dissolved Metals

Three total metal samples and one dissolved metal sample were collected as part of the water quality assessment. Sample "S1" was collected at the end of the first step in the pumping test and analyzed for total metals. Sample "S2" was collected at the end of the second step and also analyzed for total metals. The last sample "SF" was collected at the end of the third and final step and analyzed for both total and dissolved metals. (The dissolved metal sample was filtered through a 45-micron filter, prior to acidification). Total metal concentrations should be used as the primary method of water quality assessment for municipal drinking supplies. The dissolved metal sample was taken to assess the effect elevated turbidity levels had on groundwater quality.

It was found that all tested parameters meet the health related CDWQG. Total Iron concentrations however were found to exceed the aesthetic CDWQG, of 0.3 mg/L by approximately two times. Iron commonly contributes to secondary hardness issues, as it will precipitate out of solution (i.e. forming iron oxides) when the groundwater is exposed to the atmosphere. This problem may be exasperated in an alkaline groundwater, such as the groundwater characterized in Well No. 5 (i.e. pH = 9). This moderately high pH tends to further increase the tendency for mineral precipitation. This effect can lead to aesthetic problems such as staining of household toilets or clogging of distribution pipes through time.

Aluminum concentrations were found to exceed an "operation" CDWQG of 0.1 mg/L. A health-based guideline or aesthetic objective has not been established for aluminum in drinking water. Water treatment plants using aluminum-based coagulants should optimize their operations to reduce residual aluminum levels in treated water to the lowest extent possible. For plants using aluminum based coagulants, operational guidance values of less than 0.1 mg/L total aluminum for conventional treatment plants and less than 0.2 mg/L total aluminum for other type of systems (i.e. lime softening plants) are recommended.

Analyses of dissolved and total metal concentrations suggest that the elevated concentrations of both iron and aluminum may be in part related to elevated turbidity levels. As discussed, it is suspected that the turbidity in the groundwater is likely the result of trace residual drilling fluids remaining in the aquifer and that prolonged pumping may bring about acceptable turbidity concentrations and therefore, a reduction in total iron and aluminum concentrations. The degree of this reduction however is not known and should be reassessed once acceptable turbidity levels have been achieved.

Conversely, arsenic concentrations in both total and dissolved metal analyses were very similar indicating that the level of total arsenic will likely not decrease significantly if and when turbidity levels in the groundwater are reduced. Additionally, the concentrations of total arsenic detected in the groundwater were 0.02 mg/L (+/- 0.001 mg/L) in all samples measured throughout the assessment. Although the concentrations of detected arsenic are below the Interim MAC CDWQG limit of 0.025 mg/L, it is recommended that monitoring of this parameter be conducted to ensure acceptable arsenic concentrations are maintained. Additionally, the CDWQG Interim MAC for arsenic may be reduced to 0.001 mg/L in the near future, similar to water quality standards in the United States.

4.3.8 Bacteriological Tests

Prior to the initialization of the short-term pumping test, the well was chlorinated to reduce the likelihood that well materials and pumping equipment would bias the results of the bacteriological testing of the groundwater. Four replicate samples of groundwater were collected at the end of the pumping test. The results of the four samples and four replicates indicate that the analyzed groundwater did not contain detectable numbers of coliforms and fecal coliforms.

4.3.9 Inorganic Parameters

The presence of elevated sulphide (as hydrogen sulphide) in drinking water may cause disagreeable water taste and odour. Accordingly, a CDWQG AO guideline of 0.05 mg/L (expressed as hydrogen sulphide) has been established. One sample of groundwater was analyzed for its content of total sulphide. The measured concentration of sulphide in the analyzed sample was 0.04 mg/L, indicating that the analyzed groundwater met the AO guideline. Throughout the pumping test, GLL monitored the odour of water being discharged from the well. GLL did not detect unusual water odours during the tests.

4.3.10 Halogenated and Non-Halogenated Volatile Organics (VOCs)

One sample of groundwater (SF) and one field replicate (sample SF-R) was analyzed for VOCs. The results of the analyses indicated that both samples met the CDWQG.

A sample was also collected to assess the potential for the formation of trihalomethanes (THMs). Organic compounds, naturally in the groundwater, can complex with chlorine additives used during standard water disinfection, to form THMs. A test known as the "THM Formation Potential", was conducted by the laboratory to assess THM concentrations which potentially could form after chlorination has occurred. The test results found that the THM formation potential in the groundwater could produce up to 0.025 mg/L, which is significantly below the interim MAC CDWQG for THMs of 0.1 mg/L.

4.3.11 Extractable Hydrocarbons

One sample of groundwater was analyzed for its content of EPH. The analyzed sample did not contain detectable concentrations of EPH and met the applicable CDWQG.

4.3.12 Radiochemistry

Compliance with the CDWQG may be inferred if the results of measured "Gross Alpha" and "Gross Beta" "activity" are less than 0.1 Bq/L and 1.0 Bq/L respectively (Health Canada, 1996).

One sample of groundwater was analyzed for Gross Alpha and Gross Beta activities. The results of the analyses indicate that the measured activities of Gross Alpha and Gross Beta did not exceed the method detection limits (0.07 Bq/L and 0.05 Bq/L, respectively). It is therefore inferred from these results that the analyzed groundwater meets the CDWQG, with respect to radiochemistry.

4.3.13 Stability Indices and pH

One of the main objectives in controlling the pH of municipal water is to minimize the potential of the water to corrode and or deposit scales (encrustation). The Ryznar Stability Index (RSI) and the Langlier Saturation Index (LSI) are used widely for predicting the reaction potential of metal objects in saturated subsurface environments. Both indices are based upon a calculated pH of saturation for calcium carbonate (pHs). The calculated pHs value is then used in conjunction with the groundwaters actual pH (8.5 - 9.0) to calculate the values of the indices as follows:

- RSI = 2pHs - pH
- LSI = pH - pHs

Based on the results of the water quality testing undertaken as part of this investigation, both indices suggest that groundwater is not likely to be scale forming or encrusting, but rather may be slightly corrosive. It should be noted, however, that the RSI and LSI indices are most useful as predictors of scaling potential than of corrosion potential.

Additionally, the indices predict moderately well, water that has a low pH and systems which are constructed primarily of ferrous materials. However given the relatively high pH of the groundwater (~8.5 to 9) measured in Well No. 5, a corrosive tendency is unlikely. Additionally, the pH observed in Well No. 5 is slightly higher than what is typical of natural groundwater systems. It is suspected that this observation could be in part the result of residual trace levels of drilling fluids (i.e. turbidity) still remaining in the groundwater (section 4.3.3) as total hardness and alkalinity are relatively low. It is suspected that this could be due, in part, from the presence of residual trace amounts of drilling fluids in the borehole, however monitoring of pH should be conducted to further assess this possibility. According to CDWQG, an acceptable range for drinking water pH is between 6.5 and 8.5 pH units.

5. Conclusions and Recommendations

5.1 Conclusions

The following conclusions are based on the information documented in this report.

- Between August 13 and September 13, 2002, a groundwater well (Well No. 5) was completed within the Municipality of the Village of Haines Junction, to a depth of 369.2 m. The well was screened within a sand and gravel aquifer between 361.9 m to 369.2 m below ground surface. Figure 5 presents a detailed well completion diagram.

- Well No. 5 is a flowing artesian well. The estimated hydrostatic head in the well on October 1, 2002, was measured to be approximately 59 m above the ground surface. When allowed to flow at surface, the estimated flow rate (i.e. artesian flow) was approximately 13 L/s (172 igpm).

- Drilling observations indicate that the artesian condition at Well No. 5 was encountered at a depth of approximately 329 m below ground surface, which is inferred to be the top of the confined artesian sand and gravel aquifer.

- Given the flowing artesian nature of the aquifer in which Well No. 5 is screened, and the inferred thickness of interbedded sands and gravels (approximately 40 m) below a depth of 329 m, it is interpreted that Well No. 5 is completed within a complex deep regional-scale aquifer system.

- Subject to the assumptions identified in the report, analysis of data collected during a single step of the short term pumping test (~120 min in duration), indicate that Well No. 5 has been completed within an aquifer with an estimated transmissivity of approximately 23 m^2/day. The test results also indicate that the maximum long term safe yield of Well No. 5 is approximately 27 L/s (356 Igpm). Additionally, analyses indicate that when the well is pumped at a rate of 27 L/s, water within the well will be lowered to a level of approximately 81 m below ground surface. The predicted maximum long-term safe yield and associated drawdown needs to be confirmed with long term measurements of water levels, pumping rates, and artesian pressures.

- With the exception of turbidity, measured concentrations of all tested health-related water quality parameters, meet the applicable health-based Canadian Drinking Water Quality Guidelines (CDWQG).

- The bacteriological quality of the groundwater was found to meet the CDWQG.

- Turbidity levels in groundwater samples at the end of the water quality assessment were measured to be 12 NTU. The CDWQG Maximum Allowable Concentration (MAC) for turbidity is 1 NTU. The elevated turbidity is inferred to be the result of trace residual amounts of drilling fluid. Prolonged pumping may reduce groundwater turbidity to acceptable levels. According to conversations with the Mayor of Haines Junction, John Farynowski on November 8, 2002, the Village has taken turbidity measurements from Well No. 5 and significant improvements in groundwater quality have been identified in this regard.

- Based on visual observations taken throughout the pumping test, a "sand free" condition of groundwater appears to have been achieved.

- Total Iron concentrations in the groundwater exceed the aesthetic CDWQG (0.3 mg/L) by a factor of two. Analyses of dissolved and total metal concentrations however, suggest that the elevated concentrations of total iron in the groundwater may be related to elevated turbidity levels and that a reduction in groundwater turbidity may reduce the total iron concentrations. The primary aesthetic issue relating to elevated total iron concentration is the precipitation of iron oxides (i.e. staining of plumbing fixtures) and potential taste issues.

- The concentrations of total arsenic detected in the groundwater samples were 0.020 mg/L (+/- 0.001 mg/L), which meets the Interim MAC of the CDWQG limit of 0.025 mg/L. Background concentrations of arsenic groundwater in some parts of Canada exceed the MAC CDWQG.

- The temperature of the groundwater discharged from Well No. 5 throughout the short-term pumping test was relatively consistent at 16.9 ºC. In-situ measurements of groundwater temperature across the screened interval, measured during a down hole geophysical survey, suggest that the temperature of groundwater in the aquifer is slightly warmer (approximately 19 ºC to 20 ºC).

- The CDWQG suggest an acceptable range for drinking water pH is between 6.5 and 8.5 pH units. The measured pH of groundwater in Well No. 5 is slightly higher than what is typical of natural groundwater systems at between 8.5- 9 pH units. It is suspected that this could be due, in part, from the presence of residual trace amounts of drilling fluids in the borehole, however monitoring of pH should be conducted to assess this possibility.

- Based on the completion depth of Well No. 5 (screen interval of 361.9 m to 369.2m below ground surface), the moderately good water quality, and the significant artesian pressure (84 psi), it is suspected that this aquifer has not been encountered during previous drilling exploration or well completion activities.

- The long-term influence of water production at Well No. 5 on the overlying aquifers has not been assessed during this study.

5.2 Recommendations

The following recommendations are provided, should Well No. 5 be brought on-line and used as a source of municipal drinking water:

- Follow-up sampling of groundwater at Well No. 5 should be conducted to determine if turbidity has declined to acceptable Canadian Drinking Water Quality Guidelines (CDWQG) (1 NTU).

- At least two supplemental samples of groundwater from Well No. 5 should be analyzed for total metals, pH, hardness, and other general water chemistry parameters. The purpose of the analyses is to assess if concentrations of some water quality parameters (such as total iron) have decreased to levels that meet aesthetic CDWQG.

- Once follow-up sampling events have been conducted a qualified environmental professional should review the results. Furthermore, a water quality monitoring program should be developed to verify that acceptable water quality is maintained.

- High pH levels (> 8.5 pH) can result in a significant reduction in chlorine disinfection efficiency. It is recommended that pH be monitored to assess the significance of this effect on the disinfection process which is required for communal drinking water supplies.

- It is recommended that the groundwater be tested for bacteriological parameters on a routine basis to ensure acceptable water quality is maintained. Additionally, it is recommended that general chemistry and total metal analyses be conducted on an annual basis to assess potential changes in water quality through time.

- Given the diameter of the surface casing (311 mm OD) the maximum recommended pump diameter size for Well No. 5 is 203 mm (8-inches). Based on the maximum long term well capacity estimated (27 L/s or 360 igpm), and the expected associated drawdown (81 m below ground surface), a 203 mm (8-inch) pump will be capable of operating efficiently within these pumping demands. Larger pumping rates and drawdown levels may also be attainable, however the 244 mm OD casing is reduced to a diameter of 178 mm at a depth of 141 m below ground surface and therefore a pump lowered beyond this depth would also have to be reduced in diameter and capacity.

- Given the nature of the well construction, flow rates above 36 L/s (475 igpm) are not recommended due to excessive hydraulic well losses. Additionally, pumping rates below this threshold will ensure well screen longevity, as high entrance velocities can lead to screen wear, metal fatigue, changes in water quality (i.e. sand production) and a decrease in well efficiency.

- Non-operational wells are often more susceptible to premature reductions in well efficiency and flow. Therefore it is recommended that Well No. 5 operate on a routine basis to maintain its longevity.

- The collection of long-term water usage and water level measurements will provide information to help predict the long-term sustainability and management of this important groundwater resource. It is recommended that the pumping rate of Well No. 5 be monitored continuously. If possible, it is also recommend that the artesian pressure of Well No. 5 be monitored when the well is not in use. Further benefit would be obtained with the collection of long-term water level measurements from Well No. 4, as this well is moderately deep, currently not used, and readily assessable, as it is owned by the Village.

Report Prepared By:

Jonathan Kerr. M.Sc.
Hydrogeologist

Report Reviewed By:

Rob Dickin, M.Sc., P.Geo (B.C)
Senior Hydrogeologist

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Appendices

Appendix A

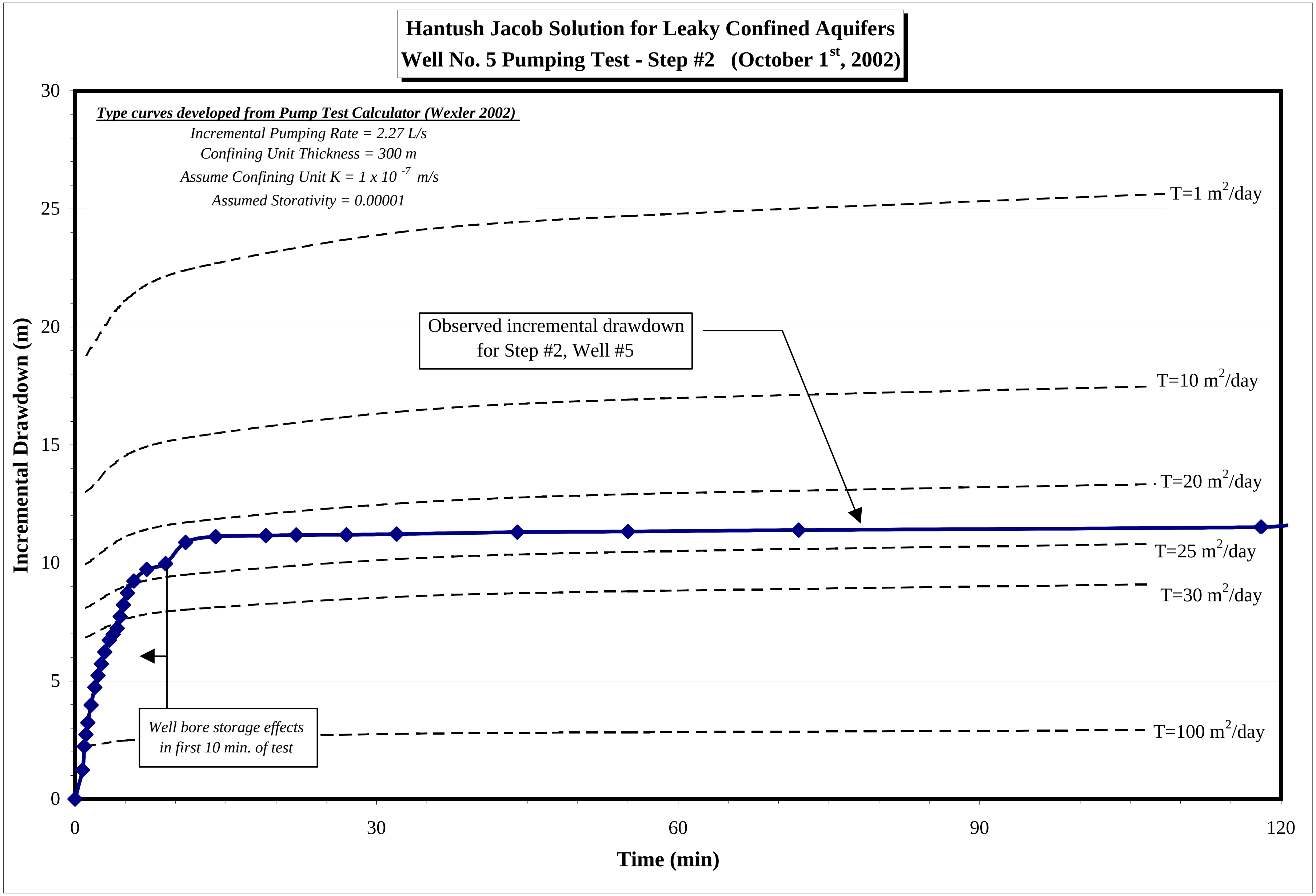
Down Hole Geophysical Surve (see Hard Copy)

Appendix B

Grain Size Analyses (see Hard Copy)

Appendix C

Pumping Test Data and Analyses (see Hard Copy)



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Appendix D

Laboratory Analyses (see Hard Copy)

ALS Environmental

CHEMICAL ANALYSIS REPORT

Date:	November 8, 2002
ALS File No.	S1001r
Report On:	22-345 Water Analysis
Report To:	**Gartner Lee Ltd.** Suite C 206 Lowe Street Whitehorse, YT Y1A 1W6
Attention:	**Mr. Jonathan Kerr**
Received:	October 4, 2002

ALS ENVIRONMENTAL
per:

Brent C. Mack, B.Sc. - Project Chemist
Leanne Harris, B.Sc. - Project Chemist

REMARKS

This report replaces the previously issued S1001 and includes additionally requested Total Metals analysis to the sample identified as "SF-R".

The THMFP analysis was performed according to Method 5710B in Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995.

The THMFP procedure includes a 4 hour chlorine demand analysis to estimate the chlorine dose to achieve a recommended residual chlorine (3-5 mg/L) in the sample after the 7 day incubation.

The THMFP spike of DHBA (dihydroxy-benzoic acid) data is also included in the data section of this report. Even though there are no acceptance criteria provided in the method for the DHBA spike recovery, the spike recovery results are acceptable, based on ALS internal acceptance criteria, (98 % of the target 0.119 mg/L for Total Trihalomethanes as CHCl3)

File No. S1001r

RESULTS OF ANALYSIS - Water

Sample ID		S1	S2	SF	SF-R
Sample Date		02 10 01	02 10 01	02 10 01	02 10 01
Sample Time		12:00	12:00	12:00	12:00
ALS ID		*1*	*2*	*3*	*4*
Physical Tests					
Colour	(CU)	<5	<5	<5	-
Conductivity	(uS/cm)	252	251	249	-
Total Dissolved Solids		172	171	164	-
Hardness	$CaCO_3$	15.1	14.4	10.1	13.6
pH		8.61	8.71	8.74	-
Turbidity	(NTU)	25.0	22.8	13.0	-
Dissolved Anions					
Alkalinity-Total	$CaCO_3$	112	115	115	-
Chloride	Cl	<0.5	<0.5	<0.5	-
Fluoride	F	0.27	0.26	0.26	-
Silicate	SiO_2	25	25	25	-
Sulphate	SO_4	15	15	15	-
Nutrients					
Nitrate Nitrogen	N	<0.1	<0.1	<0.1	-
Nitrite Nitrogen	N	<0.1	<0.1	<0.1	-
Total Phosphate	P	0.134	0.124	0.102	-
Cyanides					
Total Cyanide	CN	-	-	<0.005	-

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

File No. S1001r

RESULTS OF ANALYSIS - Water

Sample ID		S1	S2	SF	SF-R
Sample Date		02 10 01	02 10 01	02 10 01	02 10 01
Sample Time		12:00	12:00	12:00	12:00
ALS ID		*1*	*2*	*3*	*4*
Total Metals					
Aluminum	T-Al	0.61	0.63	0.32	0.35
Antimony	T-Sb	<0.0005	<0.0005	<0.0005	<0.0005
Arsenic	T-As	0.020	0.021	0.020	0.020
Barium	T-Ba	0.71	0.58	0.41	0.31
Beryllium	T-Be	<0.0005	<0.0005	<0.0005	<0.0005
Boron	T-B	0.1	0.1	0.1	0.1
Cadmium	T-Cd	<0.0002	<0.0002	<0.0002	<0.0002
Calcium	T-Ca	4.8	4.5	4.0	4.3
Chromium	T-Cr	<0.002	<0.002	<0.002	<0.002
Copper	T-Cu	<0.01	<0.01	<0.01	<0.01
Iron	T-Fe	0.73	0.75	0.45	0.63
Lead	T-Pb	<0.001	<0.001	<0.001	<0.001
Magnesium	T-Mg	0.8	0.8	0.6	0.7
Manganese	T-Mn	0.025	0.023	0.013	0.014
Mercury	T-Hg	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	T-Mo	0.00544	0.00557	0.00560	0.00553
Nickel	T-Ni	0.0014	0.0013	0.0007	0.0008
Potassium	T-K	0.4	0.4	0.4	0.4
Selenium	T-Se	<0.001	<0.001	<0.001	<0.001
Sodium	T-Na	52	52	52	59
Thallium	T-Tl	<0.0001	<0.0001	<0.0001	<0.0001
Uranium	T-U	<0.0001	<0.0001	<0.0001	<0.0001
Vanadium	T-V	0.002	0.003	0.002	0.002
Zinc	T-Zn	<0.05	<0.05	<0.05	<0.05

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

File No. S1001r

RESULTS OF ANALYSIS - Water

Sample ID		SF
Sample Date		02 10 01
Sample Time		12:00
ALS ID		*3*
Dissolved Metals		
Aluminum	D-Al	<0.01
Antimony	D-Sb	<0.0005
Arsenic	D-As	0.020
Barium	D-Ba	<0.02
Beryllium	D-Be	<0.0005
Boron	D-B	0.1
Cadmium	D-Cd	<0.0002
Calcium	D-Ca	3.4
Chromium	D-Cr	<0.002
Copper	D-Cu	<0.001
Iron	D-Fe	<0.03
Lead	D-Pb	<0.001
Magnesium	D-Mg	0.4
Manganese	D-Mn	<0.002
Mercury	D-Hg	<0.0002
Molybdenum	D-Mo	0.00575
Nickel	D-Ni	<0.0005
Potassium	D-K	0.3
Selenium	D-Se	<0.001
Sodium	D-Na	52
Thallium	D-Tl	<0.0001
Uranium	D-U	<0.0001
Vanadium	D-V	<0.001
Zinc	D-Zn	<0.05
Inorganic Parameters		
Sulphide	S	0.04

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

File No. S1001r

RESULTS OF ANALYSIS - Water

Sample ID	SF	SF
Sample Date	02 10 01	02 10 01
Sample Time	12:00	12:00
ALS ID	*3*	*3a*
Halogenated Volatiles		
Bromodichloromethane	<0.001	0.001
Bromoform	<0.001	<0.001
Carbon Tetrachloride	<0.001	-
Chlorobenzene	<0.001	-
Chloroethane	<0.001	-
Chloroform	<0.001	0.022
Chloromethane	<0.001	-
Dibromochloromethane	<0.001	<0.001
1,2-Dichlorobenzene	<0.001	-
1,3-Dichlorobenzene	<0.001	-
1,4-Dichlorobenzene	<0.001	-
1,1-Dichloroethane	<0.001	-
1,2-Dichloroethane	<0.001	-
cis-1,2-Dichloroethylene	<0.001	-
trans-1,2-Dichloroethylene	<0.001	-
1,1-Dichloroethylene	<0.001	-
Dichloromethane	<0.005	-
1,2-Dichloropropane	<0.001	-
cis-1,3-Dichloropropylene	<0.001	-
trans-1,3-Dichloropropylene	<0.001	-
1,1,1,2-Tetrachloroethane	<0.001	-
1,1,2,2-Tetrachloroethane	<0.001	-
Tetrachloroethylene	<0.001	-
1,1,1-Trichloroethane	<0.001	-
1,1,2-Trichloroethane	<0.001	-
Trichloroethylene	<0.001	-
Trichlorofluoromethane	<0.001	-
Vinyl Chloride	<0.001	-
Non-Halogenated Volatiles		
Benzene	<0.0005	-
Ethylbenzene	<0.0005	-
Styrene	<0.0005	-
Toluene	<0.0005	-
meta- & para-Xylene	<0.0005	-
ortho-Xylene	<0.0005	-
Total Xylenes	<0.001	-

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

File No. S1001r

RESULTS OF ANALYSIS - Water

Sample ID	SF
Sample Date	02 10 01
Sample Time	12:00
ALS ID	*3*
Extractable Hydrocarbons	
TPH (C10-32)	<1

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

File No. S1001r

RESULTS OF ANALYSIS - Water

Sample ID	SF-P
Sample Date	
Sample Time	
ALS ID	*5*
Halogenated Volatiles	
Bromodichloromethane	<0.001
Bromoform	<0.001
Carbon Tetrachloride	<0.001
Chlorobenzene	<0.001
Chloroethane	<0.001
Chloroform	<0.001
Chloromethane	<0.001
Dibromochloromethane	<0.001
1,2-Dichlorobenzene	<0.001
1,3-Dichlorobenzene	<0.001
1,4-Dichlorobenzene	<0.001
1,1-Dichloroethane	<0.001
1,2-Dichloroethane	<0.001
cis-1,2-Dichloroethylene	<0.001
trans-1,2-Dichloroethylene	<0.001
1,1-Dichloroethylene	<0.001
Dichloromethane	<0.005
1,2-Dichloropropane	<0.001
cis-1,3-Dichloropropylene	<0.001
trans-1,3-Dichloropropylene	<0.001
1,1,1,2-Tetrachloroethane	<0.001
1,1,2,2-Tetrachloroethane	<0.001
Tetrachloroethylene	<0.001
1,1,1-Trichloroethane	<0.001
1,1,2-Trichloroethane	<0.001
Trichloroethylene	<0.001
Trichlorofluoromethane	<0.001
Vinyl Chloride	<0.001
Non-Halogenated Volatiles	
Benzene	<0.0005
Ethylbenzene	<0.0005
Styrene	<0.0005
Toluene	0.0005
meta- & para-Xylene	<0.0005
ortho-Xylene	<0.0005
Total Xylenes	<0.001

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

File No. S1001r

RESULTS OF ANALYSIS - Quality Control

Sample ID	DHBA Spike % Recovery
Sample Date	
Sample Time	
ALS ID	*DHBA*
Halogenated Volatiles	
Chloroform	98

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

File No. S1001r

Appendix 1 - REGULATORY CRITERIA

Health Canada

Guidelines for Canadian Drinking Water Quality, March 2001.
All limits are Maximum Acceptable Concentration (MAC) unless otherwise indicated.
Limits expressed as milligrams per litre except pH, Turbidity, Colour, and Coliform Bacteria.

		Lower Limit	Upper Limit		Notes
Physical Tests					
Colour	(CU)	-	15	CU	1
Total Dissolved Solids		-	500	mg/L	1
Hardness	CaCO3	-	-		2
pH		6.5	8.5		1
Turbidity	(NTU)	-	5	NTU	1, 3
Dissolved Anions					
Chloride	Cl	-	250	mg/L	1
Fluoride	F	-	1.5	mg/L	
Sulphate	SO4	-	500	mg/L	1, 4
Nutrients					
Nitrate Nitrogen	N	-	10	mg/L	
Nitrite Nitrogen	N	-	1	mg/L	
Cyanides					
Total Cyanide	CN	-	0.2	mg/L	
Total Metals					
Antimony	T-Sb	-	0.006	mg/L	5, 6
Arsenic	T-As	-	0.025	mg/L	5
Barium	T-Ba	-	1	mg/L	
Boron	T-B	-	5	mg/L	5
Cadmium	T-Cd	-	0.005	mg/L	
Chromium	T-Cr	-	0.05	mg/L	
Copper	T-Cu	-	1	mg/L	1, 7
Iron	T-Fe	-	0.3	mg/L	1
Lead	T-Pb	-	0.01	mg/L	7, 6
Manganese	T-Mn	-	0.05	mg/L	1
Mercury	T-Hg	-	0.001	mg/L	
Selenium	T-Se	-	0.01	mg/L	
Sodium	T-Na	-	200	mg/L	1
Uranium	T-U	-	0.02	mg/L	5
Zinc	T-Zn	-	5	mg/L	1, 7

1 Aesthetic Objective (AO) (taste, odour, appearance, etc.)
2 Maximum not established, levels > 200 mg/L are considered poor but may be tolerated.
3 1 NTU maximum allowed for water entering distribution systems.
4 There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L.
5 Interim Maximum Acceptable Concentration (IMAC)
6 First drawn water may be high, flush system before sampling.
7 At point of consumption.

File No. S1001r

Appendix 1 - REGULATORY CRITERIA

Health Canada

Guidelines for Canadian Drinking Water Quality, March 2001.
All limits are Maximum Acceptable Concentration (MAC) unless otherwise indicated.
Limits expressed as milligrams per litre except pH, Turbidity, Colour, and Coliform Bacteria.

		Lower Limit	Upper Limit		Notes
Dissolved Metals					
Antimony	D-Sb	-	0.006	mg/L	1, 2
Arsenic	D-As	-	0.025	mg/L	1
Barium	D-Ba	-	1	mg/L	
Boron	D-B	-	5	mg/L	1
Cadmium	D-Cd	-	0.005	mg/L	
Chromium	D-Cr	-	0.05	mg/L	
Copper	D-Cu	-	1	mg/L	3, 4
Iron	D-Fe	-	0.3	mg/L	3
Lead	D-Pb	-	0.01	mg/L	4, 2
Manganese	D-Mn	-	0.05	mg/L	3
Mercury	D-Hg	-	0.001	mg/L	
Selenium	D-Se	-	0.01	mg/L	
Sodium	D-Na	-	200	mg/L	3
Uranium	D-U	-	0.02	mg/L	1
Zinc	D-Zn	-	5	mg/L	3, 4
Inorganic Parameters					
Sulphide	S	-	0.05	mg/L	3
Halogenated Volatiles					
Carbon Tetrachloride		-	0.005	mg/L	
Chlorobenzene		-	0.08	mg/L	
1,2-Dichlorobenzene		-	0.2	mg/L	
1,4-Dichlorobenzene		-	0.005	mg/L	
1,2-Dichloroethane		-	0.005	mg/L	1
Dichloromethane		-	0.05	mg/L	
Trichloroethylene		-	0.05	mg/L	
Vinyl Chloride		-	0.002	mg/L	

1 Interim Maximum Acceptable Concentration (IMAC)
2 First drawn water may be high, flush system before sampling.
3 Aesthetic Objective (AO) (taste, odour, appearance, etc.)
4 At point of consumption.

Appendix 1 - REGULATORY CRITERIA

Health Canada

Guidelines for Canadian Drinking Water Quality, March 2001.
All limits are Maximum Acceptable Concentration (MAC) unless otherwise indicated.
Limits expressed as milligrams per litre except pH, Turbidity, Colour, and Coliform Bacteria.

	Lower Limit	Upper Limit		Notes
Non-Halogenated Volatiles				
Benzene	-	0.005	mg/L	
Ethylbenzene	-	0.0024	mg/L	1
Toluene	-	0.024	mg/L	1
meta- & para-Xylene	-	0.3	mg/L	1, 2
ortho-Xylene	-	0.3	mg/L	1, 2
Total Xylenes	-	0.3	mg/L	1

1 Aesthetic Objective (AO) (taste, odour, appearance, etc.)
2 Xylenes (total) should not exceed 0.3 mg/L.

Appendix 2 - METHODOLOGY

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

Colour in Water

This analysis is carried out using procedures adapted from APHA Method 2120 "Color". Colour (true colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method.

Recommended Holding Time:
Sample: 2 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Conductivity in Water

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

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Solids in Water

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total dissolved solids (TDS) and total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius, TSS is determined by drying the filter at 104 degrees celsius. Total solids are determined by evaporating a sample to dryness at 104 degrees celsius. Fixed and volatile solids are determined by igniting a dried sample residue at 550 degrees celsius.

Recommended Holding Time:
Sample: 7 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

pH in Water

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

Recommended Holding Time:
Sample: 2 hours
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Turbidity of Water

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

Recommended Holding Time:
Sample: 2 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Alkalinity in Water by Colourimetry

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

Recommended Holding Time:
Sample: 14 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Dissolved Anions in Water by Ion Chromatography

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

Recommended Holding Time:
Sample: 28 days (bromide, chloride, fluoride, sulphate)
Sample: 2 days (nitrate, nitrite)
Reference: APHA and EPA
For more detail see ALS Environmental "Collection & Sampling Guide"

Silicate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-SI'Silica". Silicate (molybdate-reactive silica) is determined by themolybdosilicate colourimetric method.

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see APHA Standard Methods

Phosphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". All forms of phosphate are determined by the ascorbic acidcolourimetric method. Dissolved ortho-phosphate (dissolved reactivephosphorous) is determined by direct measurement. Total phosphate (totalphosphorous) is determined after persulphate digestion of a sample. Total dissolved phosphate (total dissolved phosphorous) is determined by filtering a sample through a 0.45 micron membrane filter followed by persulfate digestionof the filtrate.

Recommended Holding Time:
Sample: 2 days
Reference: EPA
For more detail see ALS Environmental "Collection & Sampling Guide"

Metals in Water

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

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ALS "Collection & Sampling Guide"

Mercury in Water

This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic absorption and/or fluorescence spectrophotometry (EPA Method 7470A/7471A/245.7).

Recommended Holding Time:
Sample: 28 days
Reference: EPA
For more detail see ALS Environmental "Collection & Sampling Guide"

Cyanide Species in Water

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide and weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method. Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode. Thiocyanate is determined by the ferric nitrate colourimetric method.

Recommended Holding Time:
Sample: 14 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Sulphide in Water

This analysis is carried out using procedures adapted from APHA Method 4500-S2 "Sulphide". Sulphide is determined using the methlyene blue colourimetric method.

Recommended Holding Time:
Sample: 7 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Volatile Organic Compounds and Volatile Hydrocarbons in Water

This procedure involves the purge and trap extraction of the sample prior to analysis for Volatile Hydrocarbons (VH) by capillary column gas chromatography with flame-ionization detection (GC/FID) and for specific Volatile Organic Compounds (VOC) by capillary column gas chromatography with mass spectrometric detection (GC/MS). The VH analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Volatile Hydrocarbons in Water by GC/FID" (Version 2.1, July 1999). The VOC analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Method 8260, published by the United States Environmental Protection Agency (EPA).

Recommended Holding Time:
Sample: 7 days Extract: NA
Reference: BCMELP
For more detail see ALS Environmental "Collection & Sampling Guide"

Calculation of Total Xylenes

Total Xylenes is the sum of the ortho, meta, and paraXylene isomer concentrations. It is calculated by adding the concentrations of allXylene isomers that are greater than their detection limits. Results that are below detection limit are treated as zero. The detection limit for this parameter is equal to the sum of the detection limits of theindividual xylene parameters.

Total Petroleum Hydrocarbons in Water

This analysis is carried out using procedures adapted from British ColumbiaMinistry of Environment, Lands and Parks (BCMELP) Analytical Method forContaminated Sites "Extractable Petroleum Hydrocarbons in Solids byGC/FID" (Version 2.1, July 1999) and from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3510 & 8015, published by the United States Environmental Protection Agency (EPA). The procedure involves anextraction of the entire water sample using hexane. The extract undergoesa silica gel clean-up to remove most naturally occurring non-petrogenicorganic compounds. The final extract is exchanged to toluene and analysedby capillary column gas chromatography with flame ionization detection (GC/FID).

Recommended Holding Time:
Sample: 7 days Extract: 40 days
Reference: BCMELP & EPA
For more detail see ALS Environmental "Collection & Sampling Guide"

End of Report