TETRA TECH EBA

# DEEP CREEK WATER SUPPLY WELL DC-2 WELL COMPLETION AND AQUIFER AND WELLHEAD PROTECTION REPORT

PRESENTED TO

**YUKON GOVERNMENT, COMMUNITY SERVICES, INFRASTRUCTURE DEVELOPMENT BRANCH**

MARCH 2014
ISSUED FOR USE
FILE: ENVH2O03020-01

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# EXECUTIVE SUMMARY

Tetra Tech EBA Inc. (Tetra Tech EBA) has been retained by Government of Yukon, Community Services, Infrastructure Development Branch (YG-IDB) to prepare a well completion report and an aquifer and wellhead protection plan (AWPP) for a proposed community water supply well (DC-2) to serve the planned Deep Creek Water Supply Facility located in Deep Creek, Yukon. This report has been prepared as per Government of Yukon Contract C00016678.

Well DC-2 was drilled from January 7 to 11, 2014 by Midnight Sun Drilling, Yukon, using an air rotary drill rig. A 203 mm (8") casing was advanced to 15.3 m into competent bedrock. A 152 mm (6") casing was then installed in the well and the annulus between the 152 mm and 203 mm casing was filled with bentonite chips to surface. The 152 mm casing was then advanced into competent bedrock at a final depth of 17.1 m bgs. DC-2 was completed at a depth of 122.5 m. The well was developed for seven hours by airlifting and surging.

The constant rate pumping test completed on the well indicates that it is completed within a fairly productive bedrock aquifer with a theoretical sustainable yield of 1.6 L/s. Tetra Tech EBA identified well DC-2 as non-GUDI based on a Phase 1 initial GUDI screening due to the well siting, construction and depth of the producing fractured bedrock aquifer, and the thickness of overlying competent bedrock. A summary of well information is presented in Table 1 below.

**Table 1: Well Information Summary Table**

| Well ID | DC-2 |
|---|---|
| Date of Completion | January 11, 2014 |
| Static Water Level (January 18, 2014) | 6.70 m bgs |
| Recommended Maximum Pump Rate | 1.6 L/s |
| Depth to Top of Screen | 67.7 m bgs |
| Recommended Depth to Pump Intake | 52.75 m bgs |
| Well Casing Diameter | 152.4 mm |
| Screen Length | 54.9 m bgs |
| Name of Drilling Contractor | Midnight Sun Drilling |

**Note:** m bgs = metres below ground surface

Water samples collected by Tetra Tech EBA from DC-2 on January 21, 2014 were analyzed for typical drinking water screening parameters. All parameters were within *Guidelines for Canadian Drinking Water Quality* (GCDWQ); however, total dissolved solids (TDS) and dissolved iron exceeded the GCDWQ aesthetic objectives and the water contained high hardness.

If this well is to be developed as a community water supply, Tetra Tech EBA recommends that the submersible pump be installed at a depth of approximately 52.75 m bgs (1.5 m above the upper most water-bearing fracture zone) to maximize drawdown and well performance. The pump to be installed in the well should be capable of pumping at 1.8 L/s, overcoming a head of 46 m plus pipe friction losses and possible additional elevation gains to the water treatment plant. Long term pumping rates; however should not exceed the rated safe sustainable yield of the well of 1.6 L/s. DC-2 should be 'shock chlorinated' (disinfected) prior to commissioning. Any alterations to the well should be in compliance with the Public Drinking Water Regulations and the Canadian Groundwater Association's Well Construction Guidelines (CDWA).

Based on the results of the AWPP completed for DC-2, Tetra Tech EBA emphasises the following conclusions:

- Tetra Tech EBA identified the well as non-GUDI as the well is completed within a deep confined bedrock aquifer, all upper fractures were sealed off by the 152 mm and 203 mm casings, the well is significantly more than 60 m from the nearest surface water body, and DC-2 sampling results indicate that water quality is dissimilar to surface water obtained from Deep Creek;
- To date there has been no identified areas of potential contamination within the DC-2 well capture zone, and no indications of contamination in groundwater sampled from DC-2;
- Any release of contaminants within the identified capture zones would represent a potential risk to the aquifer and water quality of the Deep Creek Water Supply Facility; and
- The highest risks to DC-2 are from potential spills or releases within the capture zone areas up-gradient of DC-2 (Klondike Highway and Grizzly Valley);

In addition to the recommended risk reduction/ elimination strategies provided in Table 10, Tetra Tech EBA also recommends that YG complete the following:

- Implement contingency planning including emergency response actions and communication. YG should update the existing emergency and spill response plan identifying key personnel responsible to respond in the event of an occurrence or spill when changes in water treatment operator and/or community leadership changes occur;
- Complete regular tracking and monitoring of all well risks in the DC-2 capture zones (either with internal staff resources or outsourced to Tetra Tech EBA);
- Provide protection to the well capture zones by installing signs identifying entrances to the AWPP area;
- Review and update the AWPP on a regular basis. An annual review may be sufficient; however, thought should be given to an “as required” approach; and
- Incorporate this AWPP into the Deep Creek community development plan, and work with the community council to implement a Groundwater Protection Program for the community of Deep Creek and surrounding area. This Groundwater Protection Program should consist of the following:
  - Formal recognition and protection status for identified well protection zones such as those identified in this report;
  - Enforcement of well protection measures;
  - Restrictions on some land use activities within sensitive areas, well protection zones, designated recharge areas and areas of high vulnerability to contamination of the aquifer from surface sources (such as bedrock outcrops and faults); and
  - Hydrogeological assessment as a requirement of development for land use activities considered as higher risk, and including groundwater monitoring on and adjacent to specified sites as a condition of development.
- A response action plan and remedial action plans as a condition of development for some specified higher risk land uses.

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## LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon and their agents. Tetra Tech EBA Inc. Government of Yukon does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Yukon, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

# 1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by Government of Yukon (YG), Community Services, Infrastructure Development Branch (YG-IDB) to prepare a well completion report and an aquifer and wellhead protection plan (AWPP) for well DC-2, which is proposed to serve a new Deep Creek Water Supply Facility located in Deep Creek, Yukon. This report has been prepared as per YG Contract C00016678.

Previous work conducted by Tetra Tech EBA relating to the Deep Creek Water Supply facility included:

- Preparation of the *Deep Creek Region Water Supply Feasibility Study* (Tetra Tech EBA 2012);
- Coordination of drilling, construction and testing two new cold water test wells in Deep Creek (DC-1) and Grizzly Valley (GV-1) in 2012; and
- Preparation of Completion reports for DC-1 and GV-2 (Tetra Tech EBA 2012).

The intent of YG-IDB is to develop one of the test wells for a water supply facility to be used as a public fill point serving Deep Creek and Grizzly Valley subdivisions, residents of the Ta'an Kwach'an First Nation (TKFN) and Horse Creek (Service Area).

Based on a decision by YG-IDB, Deep Creek subdivision was selected as the preferred location for a water supply facility. The first test well drilled in Deep Creek subdivision (DC-1) was completed in fractured bedrock aquifers. DC-1 was identified as being potentially Groundwater Under the Direct Influence (GUDI) of surface water based on a Phase 1 initial GUDI screening due to bedrock fractures in the upper 15 m of the well. Furthermore, although well DC-1 was drilled significantly greater than the required 120 m set back requirement from the Old Deep Creek Dump; and is 200 m slightly up-gradient of the dump, based on the geology encountered, it was determined that DC-1 could potentially be influenced by historical dumping practices during pumping conditions because of complex bedrock hydrogeology. As further work would be necessary to verify whether this was a legitimate concern, YG-IDB elected to drill a second test well (DC-2) in the Deep Creek area.

Well DC-2 was subsequently drilled on the opposite side of Deep Creek from the Old Deep Creek dump; the creek is considered a discharge area and flow divide thereby significantly reducing risk posed by the dump. This report outlines the well completion for DC-2, aquifer and wellhead conditions, the theoretical well protection area, potential contaminants of concern and recommendations for protecting the potable water supply.

# 2.0 SCOPE OF WORK

The scope of work for this phase of the project included the following tasks which are documented in this report:

- Review of background information and recommendations on well location for DC-2;
- Prepare well drilling, construction, and testing specifications for DC-2;
- Field review of drilling and installation of well DC-2;
- Coordinate and field review of hydraulic testing of DC-2;
- Collect and submit water samples from DC-2;
- Analyze and interpret data from the drilling and pumping test program; and

- Prepare a well completion report and Aquifer and Wellhead Protection Plan for DC-2, documenting potential contaminants of concern within the capture zone and provide risk management strategies.

The following sections provide further detail regarding the scope of work described above.

# 3.0 SITE DESCRIPTION

## 3.1 Location of Study Area

Deep Creek test well DC-2 is located southwest of Lake Laberge adjacent to Deep Creek, Yukon, approximately 45 km north of Whitehorse, Yukon. DC-2 is accessed via Deep Creek Road on the east side of the Klondike Highway. The nearest water course to DC-2 is Deep Creek, which is approximately 200 m to the north. A site location plan is provide in Figure 1.

## 3.2 Existing Water System

Residents of the service area are currently supplied potable drinking water by a variety of sources including private wells, trucked bulk delivery from Whitehorse to domestic water tanks, and personal collection and hauling from Whitehorse.

# 4.0 HYDROGEOLOGY OF THE DEEP CREEK AREA

The hydrogeological regime of the Deep Creek area has been interpreted from data collected from a variety of sources including lithology information presented on well logs, groundwater level measurements taken during field investigations, pumping test results, water quality data, and available topographical, geological and surficial mapping records. Table 2, attached, summarizes well information for existing water wells and groundwater monitoring wells identified by Tetra Tech EBA in the vicinity of DC-2.

## 4.1 Topography and Hydrology

Deep Creek is located between Pilot Mountain to the west and Lake Laberge to the east. The topography in the Deep Creek region gently slopes towards Lake Laberge; however, the local topography surrounding DC-2 slopes south-southeast (based on a topographic survey, within a 50 m radius of DC-2).

Deep Creek crosses the Klondike Highway approximately 320 m southwest of the junction to Deep Creek Road and flows east into Lake Laberge.

## 4.2 Surficial and Bedrock Geology

Geological information was obtained through site visits, review of topographic and geological maps (from the Canadian and Yukon Geological Survey's) and previous reports and maps. The Deep Creek area has undergone several episodes of glaciation, the most recent being the Quaternary McConnell glaciation. The topography and surficial geology of the Deep Creek area have been heavily influenced by glacial erosion and deposition.

The surficial geology in the Deep Creek area is characterized by both outcropping bedrock and glacial deposits. Glacial deposits are varied, including till, valley bottom complexes composed of alluvial, colluvial and glacial deposits, meltwater channels and glaciofluvial complexes. The bedrock is comprised of sedimentary members of the lower to middle Jurassic Laberge Group (around 160 to 200 myo) and Lower Jurassic Nordenskjold Group (around 175 to 200 myo). Laberge Group rock types in the study area are mapped as sedimentary rock, with interbedded mudstones, siltstones and sandstones and a conglomerate member. Nordenskjold Group rock types

occurring in this area are mapped as sedimentary rocks with volcanic beds, dacite, tuff, sandstone, and conglomerate. Rock types encountered during drilling were members of the Laberge group.

Tetra Tech EBA obtained drillers field reports from 13 wells drilled within the Deep Creek area between 1970 and 2012. Logs of wells in the Deep Creek region show bedrock at depths typically between 4.5 m and 17 m, although bedrock outcropped at two well locations. In the Deep Creek region, bedrock was typically overlain by gravelly clay/silt (inferred to be till) with gravel or sand logged at surface in several logs.

### 4.3 Groundwater Flow

The regional groundwater flow regime is interpreted to consist of groundwater recharging via infiltration in the upland areas to the west of DC-2 and groundwater discharging into Deep Creek and Lake Laberge. The regional groundwater flow direction was interpreted to be in an east, northeast direction, which generally corresponds to topography.

As noted in Table 2, the static water level in the various bedrock wells in the Deep Creek ranges from 3.3 m to 10.4 m below ground level. The estimated yield from these wells varies from 0.1 L/s to 1.7 L/s. Yield from bedrock aquifers can be highly variable and is dependent upon the degree of fracturing and fracture connectivity.

## 5.0 FIELD PROGRAM

### 5.1 Well Location

The well location for DC-2 was selected in accordance with the requirements outlined in the guidelines by the Canadian Groundwater Association and the Yukon *Drinking Water Regulation* (Public Health and Safety Act, Part I – Large Public Drinking Water Systems). These guidelines and regulations require the well to be located:

- 60 metres from any part of a sewage disposal system, or other potential sources of pollution that may pose a health and safety risk;
- 120 metres from a solid waste site or dump, and cemetery; and
- 300 metres from a sewage lagoon or pit.

The drilling site was selected in collaboration with YG-IDB to comply with setback distances specified above and considering existing geological and hydrogeological information; and proximity to the proposed site infrastructure. The well location is shown on Figure 2. Relevant comments regarding the site selected for DC-2 are below:

- The well location meets all required set-back distances from sewage disposal systems, potential sources of pollution that may pose a health and safety risk, solid waste site or dump, cemetery and sewage lagoon or pit;
- The well is more than 480 m from the old Deep Creek Dump and across Deep Creek, which is interpreted to be a groundwater discharge area flow divide;
- There is currently no development within 200 m of the well site; the closest development is the Bahai Centre which is about 200 m down-gradient and on the other side of the Deep Creek flow divide;
- Deep Creek is more than 120 m from the well at its closest location; and
- There were no bedrock outcrops located within 60 m of the well; the closest bedrock outcrop was identified to be more than 140 m from DC-2.

## 5.2 Well Drilling and Construction

DC-2 was drilled from January 7 to 11, 2014 by Midnight Sun Drilling, Yukon, using an air rotary drill rig. During the drilling, a Tetra Tech EBA hydrogeologist monitored drilling operations and recorded subsurface conditions encountered. The well log summarizes the subsurface conditions encountered at DC-2 is found in Appendix B.

A 305 mm (12”) casing was initially advanced to a depth of 6.1 m bgs to establish the outer annulus for the sanitary seal. Next, a 203 mm (8”) casing was advanced to a depth of 13.1 m bgs, where a shallow unconfined aquifer was encountered at the bedrock interface with a yield of approximately 30-40 USgpm. The drillers continued to drill a 203 mm (8”) open hole to a depth of 17.1 m bgs, followed by a 152 mm (6”) open hole to a depth of 22.6 m bgs. The well was subsequently developed by airlifting and surging for eight hours. At the end of the development period, the water was very turbid and was not suitable for potable use.

The 203 mm (8”) casing was advanced to 15.3 m into competent bedrock, which cut off flow from fractures in the weathered bedrock. In order to ensure all fractures would be sealed off, the hole was filled with bentonite chips to a depth of 14.8 m bgs. A 152 mm (6”) casing was then installed in the well. The annulus between the 152 mm and 203 mm casing was filled with bentonite chips to surface. The 152 mm casing was then advanced into competent bedrock at a final depth of 17.1 m bgs.

To establish the outer sanitary seal, the 305 mm diameter casing was removed while continuously pumping liquid bentonite grout via tremmie pipe between the annulus of the 305 mm and 203 mm diameter casings. The sanitary seal was established continuously from 6.1 m bgs to ground surface.

DC-2 was completed to a depth of 122.5 m. Construction details are included in Table 3 and the Driller’s Well Log is attached in Appendix C. The well was developed for seven hours by airlifting and surging. The well development was stopped after seven hours when the water was visibly clear and the field turbidity measurements were approximately 10 NTU.

A summary of well construction details is provided as Table 3.

**Table 3: Summary of Well Construction Details**

| | |
|---|---|
| **Date of Construction:** | January 7 – 11, 2014 |
| **Owner of the well:** | Government of Yukon |
| **GPS Coordinates (NAD83):** | UTM Zone 8N<br>0488349.79 E<br>6770522.59 N |
| **Location of well on the property:** | See Figure 2 |
| **Drilling contractor:** | Midnight Sun Drilling, Whitehorse, Yukon |
| **Method of construction:** | Air Rotary |
| **Description, depth, and thickness of geologic materials encountered during construction:** | See well log in Appendix B and drillers well log in Appendix C |
| **Depth and diameter of the well:** | Total depth of well is 122.5 m. Nominal diameter of steel casing to 15.3 m bgs: 203 mm (8”). Nominal diameter of steel casing to 17.1 m bgs: 152 mm (6”). Nominal diameter of PVC liner to 121.0 m bgs: 127 mm (5”). |
| **Type of casing materials and thickness:** | Steel casing: 0.250” (6.35 mm) wall thickness; Schedule 40 PVC liner |
| **Static water level:** | 6.70 m bgs (January 18, 2014) |
| **Type, size, length and location of the screen:** | Slotted PVC liner: 0.020” slot size; 67.7-122.5 m bgs |
| **Major water-bearing fractures (m bgs):** | 54.3, 92.0, and 109.7 |
| **Location, type and thickness of grout sealant placed around the well:** | Bentonite seal was placed in the annulus between the 203 mm (8”) casing and native sediments. Seal is completed from grade to 6.1 m (20 ft) bgs with a radial thickness of 51 mm (2”). Bentonite chips were also placed in the annulus between the 152 mm (6”) casing and the 203 mm (8”) casing from a depth of 17.1m bgs to surface. |

## 5.3 Well and Aquifer Testing

Hydraulic testing was conducted by Arctic Sky Welding and under field review by Tetra Tech EBA on January 18 - 22, 2014. A temporary submersible pump was installed in the well at a depth of approximately 60 m. Solinst dataloggers were deployed in DC-1 and DC-2 to monitor the groundwater level during hydraulic testing. Water levels were also measured manually on specified intervals using a water level sounder.

Arctic Sky Welding monitored flow during the pumping test using a graduated flow meter. Flow was also confirmed by measuring the time to fill a 19 L bucket. Water removed from the well during hydraulic testing was pumped to an area approximately 60 m south of the well and disposed of via infiltration.

Manual data collected during the step and constant rate pumping tests are included as Appendix D.

### 5.3.1 Step Rate Pumping test

A step rate pumping test was conducted to determine the optimal rate at which to perform the constant rate pumping test. The step rate test at DC-2 consisted of four 60 minute steps at rates of 0.4 L/s (6 USgpm), 0.8 L/s (12 USgpm), 1.1 L/s (17 USgpm), and 1.6 L/s (25 USgpm). The results from the step rate test are presented in Figure 3.

### 5.3.2 Constant Rate Pumping Test

A constant rate pumping test was conducted after 98% recovery of the groundwater level from the step rate pumping test (see Figure 3). Based on the step rate test results and the pump capacity, it was determined that DC-2 could be pumped at 1.4 L/s (23 USgpm) for the 48 hour constant rate test.

### 5.3.3 Water Sample Collection

Tetra Tech EBA collected water samples from well DC-2 at the end of the constant rate pumping test on January 21, 2014. The samples were collected in laboratory supplied sample containers in accordance with laboratory sampling procedures. Samples were submitted to ALS in Whitehorse for detailed potability analysis. Samples were also shipped on ice by air cargo to Exova in Surrey, B.C., for trihalomethane (THM) formation potential. The ALS and Exova laboratories are accredited ISO/IEC 17025 testing laboratories.

Samples were also submitted to the Saskatchewan Research Council (SRC) Analytical Lab to test for radiological parameters. Samples for bacteriological analysis were submitted to Environmental Health Services, Whitehorse within the 24-hour holding time.

# 6.0 HYDRAULIC TESTING RESULTS

## 6.1 Pumping Test Results

The observed drawdown in DC-2 during the step rate and constant rate pumping tests and the subsequent recovery periods are shown in Figure 3. After 48-hours, the drawdown in the well during the constant rate pumping test was 25.05 m.

Recovery of the groundwater level in the pumping well to within about 95% of the initial static water level occurred in approximately 15-hours following the constant rate test.

The drawdown data during the pumping test were analyzed using the Theis recovery and Cooper-Jacob Straight-Line Time-Drawdown Methods (e.g., Fetter, 2001). Both interpretation methods were applied using the software AquiferTestTM (by WHI, v2011.1), which was used to analyze the pumping test data (see Appendix D).

The results of the pumping test are presented in Table 4. The geometric mean hydraulic conductivity interpreted from the test was $1.1 \times 10^{-6}$ m/s, is typical for fractured sedimentary bedrock encountered in the test well. This value represents the bulk hydraulic conductivity assuming an aquifer thickness of 68 m corresponding to the saturated thickness from the uppermost saturated fracture zone to the base of the well.

**Table 4: Pumping Test Results**

| Well | Method | T | K |
|---|---|---|---|
| | | [$m^2/s$] | [m/s] |
| DC-2 | Theis Late Recovery | 8.0E-05 | 1.2E-06 |
| | Cooper-Jacob | 7.0E-05 | 1.0E-06 |
| | Geometric Mean | 7.5E-05 | 1.1E-06 |

**Notes:** T- transmissivity
K- Hydraulic Conductivity

## 6.2 Well Capacity

The safe yield of a well was determined by Tetra Tech EBA based on the available drawdown above the pump intake, the capacity of the screen installed in the well, and the transmissivity of the aquifer around the well screen.

To calculate the safe yield of a well, the 100-day specific capacity was multiplied by the safe available drawdown. The 100-day specific capacity of the well (at a given pumping rate) is based on the projection of the observed drawdown at the end of the constant rate pumping test extrapolated to 100 days as shown on Figure 4. This conservatively assumes that the well would be continuously pumped at the same rate for 100-days with no recharge to the aquifer. The safe available drawdown of the well is determined by applying a safety factor of 70% to the physical available drawdown after an allowance has been made for seasonal fluctuations in static water level. The water level in the well should also not be lowered to below the upper most water-bearing fractures of the well (see Table 3). Therefore, the lowest recommended water level during pumping is about 52.75 m bgs (i.e., 1.5 m above the water-bearing fracture at 54.3 m bgs) at which depth the pump should be installed.

The safe yield of a well can also be limited by what the well screen is capable of delivering based on the maximum recommended screen entrance velocity. Based on 55 m (180 feet) of 20-slot screen, with four rows of slots, and a maximum pumping rate of 1.8 L/s the screen entrance velocity is estimated to be 0.002 m/s. A velocity of 0.002 m/s will be laminar and will not be limited by the well screen. Table 5 details the safe yield calculations for the well.

**Table 5: Summary of Safe Yield Calculations**

| Well Parameter | Value | Unit | Key |
|---|---|---|---|
| Constant Rate Pumping Test Discharge Rate | 1.4 | L/s | a |
| Projected 100-Day Drawdown | 28 | m | b |
| Projected 100-Day Specific Capacity | 0.05 | L/s/m | c=a/b |
| Lowest Expected Seasonal Water Table (1 m below static) | 7.70 | m | d |
| Recommended Depth of Pump Intake | 52.75 | m | e |
| Available Drawdown | 45.05 | m | f = e-d |
| Safety Factor | 70 | % | g |
| Safe Available Drawdown | 31.67 | m | h = f x g |
| **Theoretical Safe Yield Based on Constant Rate Pumping Test** | | | |
| Theoretical Safe Sustainable Yield | 1.6 | L/s | i = c x h |
| Theoretical Safe Sustainable Yield | 25.4 | USgpm | |

The long-term sustainable safe well yield determined by this process is a conservative estimate and is unlikely based on the projected system demands. The proposed public-fill point system for DC-2 will likely encounter maximum flows during weekends with periods of stagnation and recovering during weekdays. Durations of higher flows can be sustained from this well as long as the average usage is less than 1.6 L/s. Based on this type of system usage, the maximum pumping rate for a 48-hour period is recommended to be 1.8 L/s based on the results of the constant rate test.

# 7.0 WATER QUALITY RESULTS

Groundwater analytical results and a comparison with the GCDWQ are presented in Table 6, attached. The laboratory reports from DC-2 and certificates are included as Appendix E. Table 7 provides a summary of key water quality design parameters.

Based on analytical results from the sample collected at DC-2 on January 21, 2014, the water quality results met GCDWQ for all parameters tested, except for TDS, iron and hardness, which exceeded aesthetic objectives (AO). When compared to the water quality encountered at DC-1, the key water quality design parameters are very similar.

**Table 7: Key Water Quality Design Parameters**

| Parameter | GCDWQ | DC-2 Water Quality Results (January 21, 2014) |
|---|---|---|
| Iron | <0.3 mg/L | **0.344 mg/L** |
| Manganese | <0.05 mg/L | 0.0102 mg/L |
| Hardness (as CaCO3) | 80 to 100 mg/L (suggested guideline) | 433 mg/L |
| TDS | <500 mg/L | **634 mg/L** |
| Gross Alpha | <0.5 Bq/L | **0.74 Bq/L** |
| Radium-226 | <0.2 Bq/L | <0.05 Bq/L |
| Notes: **Bold** values exceed GCDWQ | | |

The total dissolved concentrations of iron, manganese, calcium and magnesium (hardness) contribute to the high TDS. The iron concentration slightly exceeds the AO of 0.3 mg/l. Iron is common in groundwater supply and is naturally occurring. There are no health impacts associated with the presence of iron; however, it imparts taste, which will deposit or stain storage and plumbing fixtures and will stain clothing when used for laundry.

There is no AO for hardness; however, the GCDWQ recommends levels between 80 and 100 mg/L (as $CaCO_3$) to provide acceptable balance between corrosion and incrustation. Hardness at DC-2 at the time of sampling was 433 mg/L (as $CaCO_3$). Residents using water with high hardness face issues with scaling of plumbing features and more soap/detergent is required for washing, however hardness issues can be addressed using point of use water softening units.

Gross alpha and beta are used to screen for the presence of radioactivity in water. Sample results for radiological parameters were above the GCDWQ for gross alpha (0.74 Bq/L), but below the GCDWQ for gross beta. SRC recommended further analysis to determine the concentration of radium-226 radionuclides, as radium has the most stringent maximum acceptable concentration (MAC) of radiological parameters contributing to the gross alpha concentration. The resulting concentration in DC-2 was below the detection limit (<0.05 Bq/L). Because this result is below the guideline for radium-226 (0.2 Bq/L), the source of the gross alpha remains unknown. However, all other species that contribute to the gross alpha have much higher MACs (greater than 5 Bq/L). As the concentration of the radium-226 was below the detection limit and the total gross alpha concentration does not exceed any MAC for individual species potentially contributing to the concentration of gross alpha, these results confirm that there are no exceedances of any radiological parameters in the samples collected from DC-2.

The lab turbidity measurements from water sample obtained from the supply well was 3.9 NTU. During the sampling event conducted on January 21, 2014, the field turbidity was measured at 0.9 NTU. This measurement is significantly lower than the turbidity measured at the lab and demonstrates that much or all of the turbidity is likely the result of precipitate formation. It should be noted that lab turbidity is often elevated over field turbidity due to precipitate formation prior to analysis. According to Health Canada, the nature of turbidity and its health implications vary with the type of source water. Turbidity in surface and groundwater that comes into contact with surface water (referred to as groundwater under the direct influence of surface water), however, is generally organic in nature and may contain toxins, harbour pathogens, or lead to the formation of THMs. Turbidity in secure groundwater supplies (e.g., not under the influence of surface water) is generally non-organic and should pose no health threat. The health-based guideline and target for turbidity therefore apply only to surface water sources and groundwater under surface water influence. As this well is considered to be secure, the turbidity is not considered to be an issue.

A bacteriological sample taken from the well was submitted to the Environmental Health Services department on January 21, 2014. Sample results showed no presence of total coliforms or *E. coli* on the date sampled.

As part of the envisioned water treatment system for DC-2, chlorine will be used for primary and secondary disinfection. Organics present in water may have the potential to react with chlorine to produce trihalomethanes (THMs).

According to Health Canada, THMs can affect the function of liver and kidneys, and has been linked to colorectal cancer. In order determine if the water from DC-2 has the potential to react with chlorine to generate THMs, a spike concentration of chlorine was added to the water sample collected from DC-2. The sample was then incubated for a period of seven days. The concentration of total THM was 0.023 mg/L, which is below the MAC of 0.1 mg/L.

All hydrocarbons analysed were below detection limit and in consideration with the other water quality data (metals, nutrients) there was no indication of impact of the former landfill on the water quality from the test well (as expected given the distance and the Creek flow divide between the well and the dump site.

# 8.0 GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER AND AQUIFER VULNERABILITY

Well water or groundwater under the direct influence of surface water refers to groundwater sources that have a direct hydraulic connection to surface water sources and are therefore vulnerable to contamination by surface water organisms. The implication of a well being classified as GUDI means that the well water source requires water treatment equivalent to that required for surface water sources.

A shallow fractured bedrock aquifer was encountered at DC-2 from about 13.1 m to 15.2 m bgs. This upper zone, due to its shallow depth may have been under the direct influence of surface water. The well DC-2, however, was drilled through this shallow aquifer zone and a continuous steel casing was advanced into competent bedrock, and a seal was subsequently placed around the casing within the competent bedrock. During drilling, the borehole was then advanced open hole, and the bore remained dry until 54.3 m below grade where the next fractured zone aquifer was encountered.

The water supply well, DC-2, is completed in the deep confined or semi confined bedrock aquifer. Water bearing fractures were encountered between 54.3 and 121.0 m bgs. Protection is provided by overburden sediments to 10.5 m below grade, and a thick layer of competent bedrock extending from 17.1 m bgs to the first water bearing fracture at 54.3 m bgs. The thick competent bedrock layer; and properly constructed well completed with a sanitary seal and a bedrock seal decreases the potential for surface water and surface sources of contamination to infiltrate though and impact the water supply at DC-2.

Tetra Tech EBA conducted a Phase 1 Initial GUDI screening in accordance with the Yukon GUDI Assessment Guideline, and determined that Well DC-2 is non-GUDI according to the guidelines outlined in GY (2006). The following criteria were considered in the Phase 1 Initial GUDI screening:

- **Water Source Location or Type:** The well is not considered to be a vulnerable type as the production zone is significantly deeper than 15 m below grade, the well is completed in a confined or semi confined aquifer, and there are no exposed bedrock outcrops within at least 200 m of the well. To ensure that all shallow fractures in the fractured bedrock were sealed off, the 203 mm casing was advance to 15.2 m and the 152 mm casing was advanced to 17.1m to competent bedrock. The borehole remained dry during drilling, until deep fracture zones were intersected. The annulus between the 152 mm and 203 mm casings was filled with bentonite chips.

- **Proximity to Surface Water:** The well is about 120 m from Deep Creek, the nearest surface water source; significantly exceeding the trigger of 60 m.
- **Well Construction:** The well was constructed in general accordance with the Guidelines for Water Well Construction published by the Canadian Ground Water Association; and
- **Water Quality:** The DC-2 water supply has significantly different chemistry based on the review of surface water data obtained from Deep Creek in January, 2014. Water quality in samples obtained from DC-2 show much higher mineralization, suggesting long residency time in the subsurface, than the water quality in Deep Creek. The water sample collected from DC-2 following the pump test was negative for total coliforms and *E. coli*.

Additional considerations that were made as part of the initial GUDI screening include:

- Based on the average daily pumping rate and corresponding pumping water level at DC 2 and the expected highest water elevation at Deep Creek, the horizontal groundwater travel time from the creek to DC-2 was estimated to be greater than 90 days. Given that the well is completed in a deep confined aquifer, we expect that the travel time would be significantly higher than 90 days (a suggested threshold value in the Phase 2 Yukon GUDI assessment guidelines).

Based the above considerations in accordance with the Yukon GUDI assessment guideline, under the proposed pumping rates (equal to or less than 0.35 L/s average pumping) DC-2 is considered non-GUDI.

# 9.0 AQUIFER AND WELLHEAD PROTECTION PLAN

## 9.1 Introduction

The objective of the Aquifer and Wellhead Protection Plan (AWPP) for DC-2 is to provide practical protective measures to identify and pragmatically manage activities within the well capture zone and recharge areas for the Deep Creek community supply well, DC-2, with the intention of reducing risks to the water supply source. This plan is one important step in a multi barrier approach to protect the valuable resource, the health and safety of the community, and to protect the investment in water supply infrastructure. The AWPP is a living document which should be updated based on activities around the community wells that might result in additional risks, or when risks have been addressed.

Risk-based AWPPs are established to identify, manage, mitigate, monitor, and communicate risks to quality and quantity of water supplying wells used by humans, animals (e.g., livestock), plants (e.g., irrigation) or for industrial process water. Groundwater entering a well comes from an area that is defined as a capture zone or recharge area for that well. The basic objective of risk-based AWPP is to provide realistic protective measures to prudently manage activities in the capture zone or recharge area of a well or well field to reduce risks to a water supply.

The AWPP for Deep Creek water supply well DC-2 has been developed to include the following three stages:

- Stage One – Risk Framework;
- Stage Two – Risk Assessment; and
- Stage Three – Risk Management.

## 9.2 Stage One – Risk Framework

### 9.2.1 Risk Approach

The initial step towards a risk-based AWPP is to determine the appropriate risk approach for the project. Risk identification can be qualitative (a descriptive assessment of the risk elements; hazards, exposure likelihood and receptor) or quantitative, (i.e., based on probabilistic mathematical analysis of the risk elements). Due to the limited site information and resources available for this project, a qualitative risk approach was deemed appropriate.

## 9.3 Responsible Parties

The responsible party in the context of the risk-based AWPP is the Government of Yukon.

## 9.4 Risk Management Team

One of the initial steps to successful development and implementation of an AWPP is to form a risk management team comprising representatives from the owner, technical advisors, and any key stakeholder groups such as domestic and community well users in the area. The risk management team proposed for this AWPP consists of a selection of YG-IDB representatives, the Association of Yukon Communities, the TKFN, water users, future water system operators, and Tetra Tech EBA (the technical advisor).

## 9.5 Risk Tolerance

For this project, risk tolerance is a measure of the acceptable level of risk by the risk management team or water supplier. A risk-tolerant owner would be able to accept or transfer some level of risk, while a risk-adverse owner would seek to eliminate even the lowest level of risk to the water supply. Based on discussions with YG, Tetra Tech EBA considers the Owner to be risk-adverse.

# 10.0 STAGE TWO – RISK ASSESSMENT

## 10.1 Well Capture Zone Assessment

The first technical step in developing this AWPP was to identify the capture zone (the geographic area that contributes groundwater to a well) for DC-2. The capture zone is a key element in an AWPP, since only groundwater within this zone reaches the well. The size and shape of the capture zone depends upon the hydrogeological setting and the design and operational characteristics of the water supply well.

Due to the complex hydrogeology associated with a fractured bedrock aquifer, a conservative capture zone must be considered. To fully characterize a fractured bedrock aquifer, a great deal of geological and hydrogeological data is required. In the absence of comprehensive hydrogeological data, simplifying assumptions must be made. In order to determine the capture zone of DC-2, the following assumptions were made:

- Deep Creek can be considered a natural groundwater flow boundary. During winter conditions, flow was observed in the creek (Deep Creek), indicating that the creek receives base flow from surrounding aquifers and acts as a natural flow divide. This is also supported by the fact that no hydraulic response was observed at DC-1, north of Deep Creek, during the hydraulic testing conducted on DC-2;
- Topography was considered to estimate a logical maximum width of the watershed and capture zone, which also coincides with about a one year travel time;

- Two scenarios of groundwater transport in the bedrock aquifer were considered:
  - Scenario 1: The bulk hydraulic conductivity was calculated to be 1.1 x $10^{-6}$ m/s, assuming the aquifer extended from the first fracture at 54.3 m bgs to the bottom of the well at 122.5 m bgs. The associated porosity for this Scenario would have a very low porosity, which we assumed to be 1% or 0.01.
  - Scenario 2: As groundwater may travel much faster through permeable bedrock fractures, the hydraulic conductivity for Scenario 2 was adjusted assuming that the majority of the groundwater flow occurs in fractures and fault zones within the bedrock. Assuming a total thickness of faults and fractures to be 1.0 m and an aquifer transmissivity to be 7.5 x $10^{-5}$ $m^2/s$, the adjusted hydraulic conductivity of the fractured bedrock is 7.5 x $10^{-5}$ m/s. This hydraulic conductivity is similar to the maximum typical value for fractured sedimentary rock (Freeze & Cherry, 1979). The associated porosity, of a highly fractured zone was estimated to be 10% or 0.1.
- The hydraulic gradient was estimated to be 0.06 m/m based on the topography of the area, and elevations of surface water bodies.

The distance to the 90 day, one-year and ultimate capture zone were estimated using Darcy's law, by the following formula (Well Protection Toolkit):

$$d_{TOT} = \frac{tKi}{n}$$

Where: $d_{TOT}$ = the distance (m) representing the 90 day, one year, and ultimate capture zone:

t = time of travel (90 days, one-, five- years etc.)

K = hydraulic conductivity (1.1 x $10^{-6}$ m/s for scenario 1 and 7.5 x $10^{-5}$ m/s for scenario 2)

i = hydraulic gradient (0.06 m/m for both scenarios)

n = porosity of the aquifer (0.01 for scenario 1 and 0.1 for scenario 2)

We then used the average travel distance from the two methods (about 800 m/ year) to establish the 90 days, one year, and ultimate capture zones as indicated on Figure 6.

## 10.2 Identification of Risks in Well Capture Zones

The AWPP defines areas within the well capture zones, which are determined by the level of control required (and thus groundwater resource management strategies) to safeguard a water supply, including:

- Zone 1 – between 0 and 90 days to reach DC-2;
- Zone 2 – one year or less to reach DC-2; and
- Zone 3 – Between one year and seven years to reach DC-2; also interpreted to be the ultimate capture zone based on surface water boundaries.

## 10.3 Potential Receptors

Potential receptors are the users of the water supply facility, namely the residents of the service area (Deep Creek and Grizzly Valley subdivisions, residents of the Ta'an Kwach'an First Nation (TKFN) and Horse Creek). Other potential receptors include fire protection areas that may be serviced by the firefighting water stored from DC-2.

## 10.4 Identification of Risk Scenarios

Risk can be defined as the potential for exposure of a receptor to a hazard. Risk assessment is the process of evaluating the consequences of hazard severity and likelihood of exposure, then evaluating, ranking and mapping the identified risk scenarios. The three key elements of risk: exposure, hazard, and receptors which, when combined, generate the definition of risk. Risk can be effectively removed or reduced to acceptable levels if any of the three elements are eliminated or blocked. Potential for exposure can be expressed in terms of the likelihood of a receptor (i.e. humans, animals and plants) coming into contact with a hazard. Hazards can be categorized in terms of severity (contaminant toxicity). To be practical and conservative, the evaluation of a hazard in this analysis assigns the highest potential concern that may be presented at the well head for that hazard (i.e. no retardation or reduction in hazard severity along its travel path to the well).

In order to evaluate potential risks to the Community Wells, potential sources of contamination (existing and future) within the capture zone were assessed. Tetra Tech EBA used various methods to identify Areas of Potential Environmental Concern (APECs) near and within the AWPPs, including:

- Completing a search (5 and 10 km radius of the Site) for spill records within Government of Yukon, Department of Environment, Environmental Programs Branch;
- Completing a site investigation and ground reconnaissance of the area surrounding DC-2 up to Deep Creek and Deep Creek Road; and
- Reviewing air photos from the 1950's to present, and current Google Earth images to record changes to surrounding land use and current land uses in surrounding areas.

## 10.5 Contaminated Sites and Spills Search, Government of Yukon

YG, Department of Environment, and Environmental Programs Branch has maintained the Yukon Spills Report Centre since 2001; however, Environment Canada has transferred some of their Yukon contaminated sites and spill database records to YG Environment dating back to the late 1980's for certain areas. A large area search (10 km radius of the site) was conducted for contaminated sites and spills. The search conducted by YG Environment in July 2013 identified five records located between 5 and 10 km from the site; however, only results within a 5 km distance up-gradient of the site were considered to potentially be APECs. One record (Yukon Contaminated Site ID Number LA002) was identified approximately 5.5 km northwest of the site. An abandoned military vehicle was originally reported at this location in 1989. The site was assessed in 2005 and remediated in 2008. Yukon Contaminated Site Records and YG correspondence are presented in Appendix H.

## 10.6 Site Reconnaissance

Tetra Tech EBA conducted a site reconnaissance on July 22, 2013 and November 5, 2013 to document the existing conditions in the area bound by Deep Creek Road, Deep Creek and up-gradient of DC-2. This area is primarily forested with a power transmission line approximately 350 m northwest of DC-2. Trees and brush are cleared approximately 5 m on either side of the transmission line which runs west and connects with to the Klondike Highway.

## 10.7 Air Photo Review

Aerial photographs were reviewed from 1946, 1971, 1986, 1994, 2004 and a Google Earth image from 2013.

The 1946 aerial photograph indicated the surrounding was undeveloped. The 2001 Deep Creek Community Plan states that the Deep Creek Community originated as a federal forestry campground and recreational area. The original subdivision (lots 1-45) was registered in 1955 (Yukon Government - Community Services Branch, 2001).

Deep Creek Road and a cleared area can be seen west of Deep Creek Road north of the site. A large clearing can also be seen approximately 200 m southeast of the site south of Deep Creek Road.

The Klondike Highway can be seen in the 1986 aerial photograph. A clearing and access road can be seen approximately 200 m northeast of the site which appears to be the location of the old landfill facility. A building can be seen in the center of the large clearing to the southeast of the site. The construction of Deep Creek Road South appears to have started south of the site. Several small buildings can also be seen on lots along Deep Creek Road. An apparent gravel pit or borrow area can be seen approximately 1000 m west of the site on the east side of the Klondike Highway.

A power line that appears to be running in the east west direction can be seen approximately 75 m north of the site in the 1994 aerial photograph. The power line appears to extend west to the Klondike Highway.

In the 2004 aerial photograph, additional building shadows can be seen in the clearing southeast of the site. A clearing can be seen approximately 1300 m northwest of the site which appears to be the location of the Deep Creek landfill facility. The apparent gravel pit or borrow area approximately 1000 m west of the site appears to have increased in size.

It can be seen that there are six smaller buildings in the clearing southeast of the site in addition to the original large building upon review of the 2013 Google Earth image. No other changes were observed.

## 10.8 Zone 1 – 90 Day Travel Time (Sanitary Protection Zone)

A bacteriological or chemical contaminant release in Zone 1 presents a high likelihood of exposure to the users of the community well (DC-2). Based on the aquifer transmissivity and hydraulic gradient, analytical equations were used to calculate the theoretical capture area for a travel time of 90 days. Zone 1 therefore includes a quasi-circular area surrounding DC-2 with a radius of approximately 200 m in the up-gradient direction and 150 m in other directions. Zone 1 does not intersect Deep Creek, based on the average pumping rate 0.35 L/s.

There are currently no known sources of contamination in Zone 1; however, Tetra Tech EBA identified the following potential future hazards to this zone:

- Spills/leaks of petrochemical products or other chemicals from off-road recreational vehicles, vehicles accessing the water fill station, travelling on or completing maintenance on Deep Creek Road south; and
- Spills/ leaks from future development (septic fields, fuel tanks) within Zone 1.

## 10.9 Zone 2 – One Year Travel Time

A contaminant release within Zone 2 represents a medium to high (depending on retardation, natural attenuation) exposure likelihood to the users of DC-2. The one year well capture zone includes a semicircular area surrounding DC-2 between a radius of approximately 150 and 800 m and is bound by Deep Creek to the north. This zone does not extend beyond the groundwater elevation contour that matches the lowest expected drawdown at DC-2 based on the anticipated demand of 0.35 L/s. Tetra Tech EBA identified the following potential hazards to this zone:

- Spills/leaks of petrochemical products and other products from off-road recreational vehicles, vehicles completing maintenance on Deep Creek Road south;
- Spill or leaks from future developments within Zone 2; and
- Spills/leaks of chemical products into ponded recharge areas up-gradient of DC-2.

## 10.10 Zone 3 – Seven Year Travel Time (Ultimate Capture Zone)

A contaminant release within Zone 3 represents medium to low (depending on natural attenuation) exposure likelihood to the users of DC-2. Note that the theoretical capture Zone 3 intersects the northern edge of the Grizzly Valley development. Tetra Tech EBA identified the following potential hazards to this zone:

- Spills/leaks of petrochemical or other chemical products from vehicles traveling on the Klondike highway, vehicles working at the gravel pit on the east side of the Klondike Highway;
- Septic disposal fields, fuel storage and handling in the Grizzly Valley residential development located on the west side of the Klondike Highway;
- Spills/leaks of chemical products into ponded recharge areas upgradient of DC-2;
- Spills of chemical products on secondary road to the south of DC-2, which intersects the Klondike highway at km 223; and
- Future potential risk could include groundwater impacts from future developments or industrial activity such as mining and logging.

## 10.11 Risk Evaluation and Mapping

Estimates of the risk to facility users from each hazard have been developed using the Risk Matrix shown in Figure 5. The risk estimates are based on several factors including:

- Size and magnitude of the hazard (point source or non-point source);
- Location (i.e. distance from the well);
- Groundwater travel time to the well;
- The likelihood of the contaminant directly affecting water at the well; and
- The severity of the hazard to water entering the well.

The above mentioned factors were used to define the categories of exposure likelihood and hazard consequence.

Table 8 identifies “Very Low”, “Low”, “Medium”, or “High” potential values to exposure likelihood and hazard consequence for each well capture zone within travel times previously identified.

**Table 8: Exposure and Hazard Categories**

| Exposure Likelihood | | Criteria |
|---|---|---|
| **Bacteriological Pathogen** | **Chemical Pathogen** | |
| Very Low | Medium | Groundwater travel time 1 to 7 years (Zone 3) |
| Low | High | Groundwater travel time - 1 year or less (Zone2) |
| High | Very High | Groundwater travel time less than 90 days (Zone 1) |

The risk matrix (Figure 5) provides the potential risk posed by each hazard within the well capture zone for DC-2. The overall Risk of “Low”, “Medium”, “High” is assigned to each potential hazard identified within the capture zones and is passed on the combined exposure likelihood and hazard consequence for each potential contaminant source. Figure 5 also includes the risk rank results, which are a function of applying the hazard scenario to the risk matrix framework, and provide an overall risk ranking for individual contaminant sources.

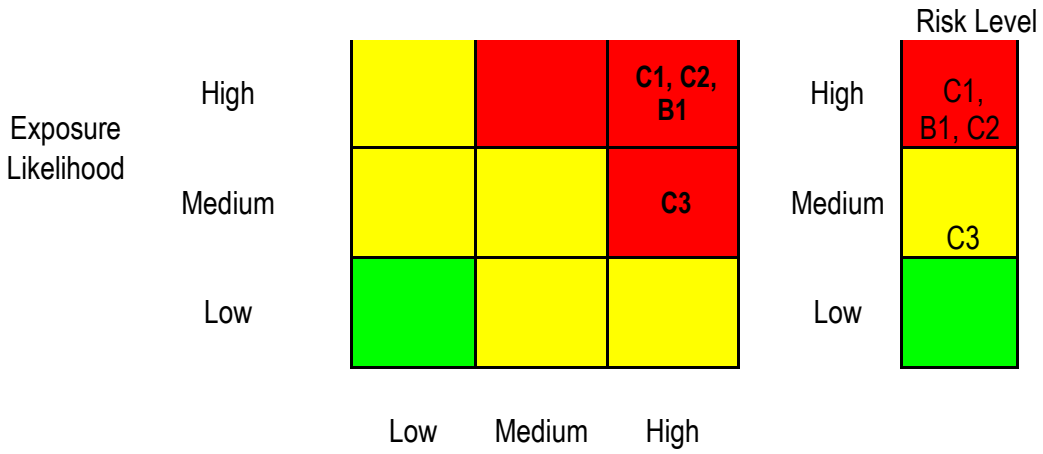


**Figure 5: Exposure Likelihood Versus the Hazard Consequence.**

Table 9 represents a summary of risk scenarios evaluated based on exposure and hazard categories identified in Table 8 using the Risk Matrix (Figure 5).

**Table 9: Risk Database and Risk Evaluation**

| Map ID | Time (Capture Zone) | Hazard Description | Exposure Likelihood | Hazard Consequence | Risk Rank |
|---|---|---|---|---|---|
| C1 | Zone 1 – less than 90 days | Chemical spills/leaks within Zone 1. | High | High | High |
| C2 | Zone 2 – less than one year | Chemical spills/leaks within Zone 2. | High | High | High |
| C3 | Zone 3 – one to seven years | Chemical spills/leaks within Zone 3 | Medium | High | Medium |
| B1 | Zone 1 – less than 90 days | Bacteria, Viruses, Protozoa within Zone 1 | High | High | High |

A Capture Zone Map showing Zones 1 through 3 is included as Figure 6. The capture zones shown on the Capture Zone Map are colour coded according to the travel time and corresponding exposure likelihood.

The Risk Database represents the current conditions of the well and aquifer and should not be considered as a static item. The Risk Database and Capture Zone Map should be updated as new risks are identified and as known risks are managed to low levels and taken off the database.

# 11.0 STAGE THREE – RISK MANAGEMENT

## 11.1 Risk Management Strategy

The risk management strategy integrates information collected during the capture zone delineation and hazard identification steps and provides workable strategies for preventing, detecting, and responding to wellhead protection risks. The following includes examples of such strategies:

- Endorsing and promoting Best Management Practices (BMPs);
- Providing public and landowner information sessions and training; and
- Implementing Action and Management Strategies provided in Table 10.

The hazard scenarios identified are potential rather than existing threats to DC-2. Therefore, based on the AWPP assessment, the most appropriate risk management for this site will be preventative action and contingency planning in the event that one of the potential hazard scenarios occurs.

In terms of risk communication, the Risk Map can form a concise and convenient basis for communicating information regarding the status of potential threats to all stakeholders including the risk management team, water system operators, community organizations, or municipal councils. Frequent reporting is important to document progress, improve public perception, reduce potential legal issues and possibly reduce insurance costs.

## 11.2 Risk Reduction Plan

A Risk Reduction Plan involves pre-planning actions to respond to acute risks situated within the capture zone. For example, this would include emergency response actions and communication should a contaminant release occur within a well capture zone. A list of risk reduction and elimination strategies is provided in Table 10.

**Table 10: Risk Reduction/Elimination Strategies to be Considered**

| Map ID | Hazard Description | Risk | Risk Reduction Options to Consider | Risk Elimination Options to Consider |
|---|---|---|---|---|
| C1,C2, C3, B1 | Release or spill from vehicles, fuel storage, septic disposal or future developments within Zones 1, 2 and 3 | Medium to High | ▪ Prevent future development (with the exception of the water treatment plant) within Zones 1 and 2.<br>▪ Ensure proper grading away from the wellhead.<br>▪ Prohibit higher risk (commercial and industrial) development in the capture zone (Zone 1 to 3).<br>▪ Do not have on-site sewage disposal or fuel storage at the water treatment plant.<br>▪ Develop and implement an Emergency Spill Response Plan (ERP).<br>▪ Community engagement and education regarding best<br>▪ Management Practices for fuel storage and septic disposal in Zone 3. | ▪ It is difficult to eliminate this risk completely since the risks are based on potential activities and development and the Klondike highway is used for transportation of chemical goods to other Yukon communities. |

## 11.3 Risk Monitoring

A Risk Monitoring Plan involves periodic review, auditing and updating of the Risk Maps and Risk Database. Once an AWPP is in place, continued implementation of the program is essential for it to be worthwhile. The Risk Monitoring Plan would include periodic inspections of the DC-2 wellhead, periodic inspections of the capture zones for new AWPP hazards, working together with the community of Deep Creek to identify and create zoning by-laws and updating the status of risks as risk management actions are implemented. Risk monitoring will allow for the Risk Map to be updated regularly for display or reporting purposes.

# 12.0 CONCLUSIONS AND RECOMMENDATIONS

## 12.1 Conclusions

The following conclusions are based on the information presented in the DC-2 well completion report:

- In January 2014, the test well DC-2 was drilled for YG-IDB in the Deep Creek area to a depth of 122.5 m bgs. The well was completed in a confined bedrock aquifer with a PVC liner and a well screen from 67.7 to 122.5 m bgs;
- The well was constructed in accordance with the Canadian Groundwater Association's Guidelines for Water Well Construction (CGWA 1995) and Yukon Drinking water Regulation, Part 1 – Large Public Drinking Water Systems;
- Pumping test results from the well indicate a bulk aquifer transmissivity in the order of $7.5 \times 10^{-5}$ $m^2/s$ (6.5 $m^2$/day);
- The long-term theoretical sustainable yield of DC-2 is 1.6 L/s (25.4 USgpm); with a recommended short term (less than 48 hr) pumping rate not to exceed 1.8 L/s;
- Tetra Tech EBA identified the well as non-GUDI as the well is completed within a deep confined bedrock aquifer, all upper fractures were sealed off by the 152 mm and 203 mm casings, the well is significantly more than 60 m from the nearest surface water body, and DC-2 sampling results indicate that water quality is dissimilar to surface water obtained from Deep Creek; and
- Laboratory results from the water sample collected on January 21, 2014 show that the water quality of the sample from DC-2 met all GCDWG for the parameters tested, except for iron, hardness, and TDS, which exceeded the aesthetic objective.

The AWPP includes capture zones of varying vulnerability for DC-2 which consists of Zone 1, the sanitary zone (immediately around the wellhead and capture zone within a 90 day travel time), Zone 2 (90 day to one year travel time) and Zone 3 (one year to seven year travel time). Based on the findings of this study, Tetra Tech EBA emphasizes the following conclusions:

- To date there has been no identified contamination in groundwater sampled from DC-2;
- There are currently no known sources of contamination in the well capture zone;
- Any release of contaminants within the identified capture zone would represent a potential risk to the aquifer and water quality of the Deep Creek Water Supply Facility; and,
- The highest risks to DC-2 are from potential spills or releases within the capture zone areas up-gradient of DC-2.

## 12.2 Recommendations

### Well Commissioning, Operation and Maintenance

Proper well commissioning, operation and maintenance are fundamental to ensuring a reliable drinking water source. Recommendations pertinent to the commissioning, operation and maintenance of the DC-2 are presented below:

- If this well is to be developed as a community water supply, we recommend that the submersible pump be installed at a depth of approximately 52.75 m bgs (1.5 m above the upper most water-bearing fracture zone) to maximize drawdown and well performance;
- The pump to be installed in the well should be capable of pumping at 1.8 L/s, overcoming a head of 46 m plus pipe friction losses and possible additional elevation gains to the water treatment plant. Long term pumping rates; however should not exceed the rated safe sustainable yield of the well of 1.6 L/s;
- The well should be "shock chlorinated" (disinfected) prior to commissioning; and,
- Any alterations to the well should be in compliance with the Public Drinking Water Regulations and the Canadian Groundwater Association's Well Construction Guidelines (CGWA 1995).

### Aquifer and Wellhead Protection

In addition to the recommended risk reduction/ elimination strategies provided in Table 10, Tetra Tech EBA also recommends that YG complete the following:

- Implement contingency planning including emergency response actions and communication. YG should update the existing emergency and spill response plan identifying key personnel responsible to respond in the event of an occurrence or spill when changes in water treatment operator and/or community leadership changes occur;
- Complete regular tracking and monitoring of all well risks in the DC-2 capture zones (either with internal staff resources or outsourced to Tetra Tech EBA);
- Provide protection to the well capture zones by installing signs identifying entrances to the AWPP area;
- Review and update the AWPP on a regular basis. An annual review may be sufficient; however, thought should be given to an "as required" approach; and
- Incorporate this AWPP into the Deep Creek community development plan, and work with the community council to implement a Groundwater Protection Program for the community of Deep Creek and surrounding area. This Groundwater Protection Program should consist of the following:
  - Formal recognition and protection status for identified well protection zones such as those identified in this report;
  - Enforcement of well protection measures;
  - Restrictions on some land use activities within sensitive areas, well protection zones, designated recharge areas and areas of high vulnerability to contamination of the aquifer from surface sources (such as bedrock outcrops and faults); and

  - Hydrogeological assessment as a requirement of development for land use activities considered as higher risk, and including groundwater monitoring on and adjacent to specified sites as a condition of development.

- A response action plan and remedial action plans as a condition of development for some specified higher risk land uses.

# 13.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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Government of Yukon, Health and Social Services. (2006) Assessment Guideline for Well Water or Groundwater Under the Direct Influence of Surface Water (GUDI).

# TABLES

Table 2 Summary of Existing Water Wells and Groundwater Monitoring Wells in the Vicinity of DC-2.
Table 6 Summary of Water Quality Results for Test Well DC-2 and Deep Creek

## Table 2: Water Wells in Deep Creek and Grizzly Valley Area

| | WELL SUMMARY | EBA WELL # | Approx Location (NAD 83, UTM) | | DATE DRILLED | DIAMETER | TOTAL DRILLED DEPTH (m) | GENERAL LITHOLOGY | COMPLETED IN | DEPTH TO BEDROCK (m) | Static Water Level (m-bgl) | Estimated Yield (USgpm) | Estimated Yield (L/min) | Estimated Yield (L/sec) | WATER QUALITY[1] AND OTHER COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NORTHING | EASTING | | | | | | | | | | | |
| TKFN Land | DC-2 | DC-2 | 6770523 | 488350 | 12-Jan-14 | 6" | 122.5 | CLAY and SILT **over** Bedrock | Bedrock | 10.5 | 6.70 | 23 | 87 | 1.4 | High TDS and hardness, some iron and manganese. |
| | DC-1 | DC-1 | 6770802 | 488394 | 25-Aug-12 | 6" | 101.5 | CLAY and SILT over Bedrock | Bedrock | 11 | 3.35 | 27 | 102 | 1.7 | High TDS, hardness, iron, manganese, and sulphate. |
| | Bahai Camp, Deep Creek | 11 | 6770665 | 488606 | 27-Jun-83 | 5.5" | 93.0 | SAND and GRAVEL **over** TILL **over** Bedrock | Bedrock | 5.2 | NK | 12 - 15 | 45 - 57 | 0.76 - 0.95 | No water chemistry data. Anecdotal information suggests the water has a marginal aesthetic quality with poor taste |
| | Bahai Camp, Deep Creek | 12 | 6770665 | 488606 | 10-Nov-83 | 8" | 17.4 | SAND and SILT **over** CLAY and SILT **over** GRAVEL and SAND **over** Bedrock | Bedrock | 16.5 | 6.7 | 20 | 76 | 1.3 | |
| | Bahai Camp, Deep Creek | 13 | 6770665 | 488606 | 31-Oct-83 | NK | 15.8 | SAND **over** CLAY and GRAVEL **over** GRAVEL and SILT **over** Bedrock | Bedrock | 12.5 | Approx 8.8 m | NR | NR | NR | |
| | Lake Laberge Campground | 14 | 6771263 | 489296 | 10-Jul-70 | 5 3/16" | 12.2 | Bedrock | Bedrock | 9.8 | NK | 2 | 7.6 | 0.13 | |
| | Brad Cathers, Deep Creek | 15 | 6770994 | 489152 | 7-Aug-03 | 5.5" | 42.7 | Bedrock | Bedrock | 10.7 | 5.8 | 15 | 56.8 | 0.95 | Sample provided by owner on September 12, 2011.<br>All results below drinking water standards. |
| | Don Jacobs, Lake Laberge | 16 | Unknown | Unknown | 8-May-97 | NK | 50.9 | Bedrock | Bedrock | 0.0 | NK | 6 | 23 | 0.4 | |
| | Roy Sam, Lake Laberge | 17 | Unknown | Unknown | 10-Nov-78 | NK | 31.7 | GRAVEL **over** CLAY **over** Bedrock | Bedrock | 6.7 | NK | 1.5 | 6 | 0.1 | |
| | Ron Pierson, Lake Laberge | 18 | Unknown | Unknown | 1-Jun-77 | NK | 27.4 | CLAY **over** Bedrock | Bedrock | 6.0 | 9.0 | 4 | 15 | 0.3 | |
| | Kate - Campground | 21 | 489197 | 6771385 | NK | NK | NK | NK | NK | NK | NK | NK | NK | NK | Sample obtained by EBA on August 8, 2011. Owner noted well only draws 40 gal before running dry.<br>Fluctuates with lake elevation - GUDI?<br>Sulphate exceeds Drinking Water Guideline - Health Based value (673 mg/L > 500 mg/L) |
| | Joe, Lot 50 Lake Laberge | 19 | Unknown | Unknown | 9-Jul-90 | NK | 49.7 | SILT sand and gravel **over** Bedrock | Bedrock | 4.0 | 10.4 | 5 | 19 | 0.3 | |

**Notes:**
[1] Water chemistry compared against Schedule 3 – Yukon Contaminated Sites Regulation (O.I.C. 2002/171), Drinking Water Standards

## Table 6: Groundwater Analytical Results

| Parameter | Unit | Canadian Drinking Water[1] | | DC-2 | Deep Creek at Bridge |
|---|---|---|---|---|---|
| | | MAC | AO/OG | 21-Jan-14 | 22-Jan-14 |
| **Physical Tests** | | | | | |
| UV Absorbance @ 254nm | Abs/cm-1 | NG | NG | 0.0120 | |
| True Colour | CU | NG | NG | <5.0 | 6.0 |
| Electrical Conductivity (EC) | uS/cm | NG | NG | 887 | 324 |
| Hardness as $CaCO_3$ | µg/L | NG | NG | 433,000 | 170,000 |
| pH | N/A | NG | 6.5-8.5 | 7.69 - 8.08 | 8.20 |
| Total Suspended Solids (TSS) | µg/L | NG | NG | <3,000 | |
| Total Dissolved Solids (TDS) | µg/L | NG | 500,000 | **634,000** | 193,000 |
| Transmittance, UV (254 nm) | % T | NG | NG | 97.5 | |
| Turbidity | NTU | NG | NG | 3.90 | 1.50 |
| **Anions and Nutrients** | | | | | |
| Alkalinity (Bicarbonate as $CaCO_3$) | µg/L | NG | NG | 214,000 | |
| Alkalinity (Carbonate as $CaCO_3$) | µg/L | NG | NG | <1,000 | |
| Alkalinity (Hydroxide as $CaCO_3$) | µg/L | NG | NG | <1,000 | |
| Alkalinity (Total as $CaCO_3$) | µg/L | NG | NG | 214,000 | 151,000 |
| Chloride (Cl) | µg/L | NG | 250,000 | 5,800 | <500 |
| Fluoride (F) | µg/L | 1,500 | NG | <200 | |
| Nitrate and Nitrite (as N) | µg/L | NG | NG | <51 | |
| Nitrate (as N) | µg/L | 10,000 | NG | <50 | 73.2 |
| Nitrite (as N) | µg/L | 1,000 | NG | 14 | <1.0 |
| Total Kjeldahl Nitrogen (TKN) | µg/L | NG | NG | 160 | 295 |
| Orthophosphate (as P) | µg/L | NG | NG | <1.0 | <1.0 |
| Phosphorus (P) | µg/L | NG | NG | <2.0 | 6.1 |
| Sulphate ($SO_4$) | µg/L | 500,000 | NG | 290,000 | 30,400 |
| **Carbon** | | | | | |
| Dissolved Organic Carbon (DOC) | µg/L | NG | NG | 1,360 | |
| Total Organic Carbon (TOC) | µg/L | NG | NG | 1,630 | |
| **Hydrocarbons** | | | | | |
| Benzene | µg/L | 5 | NG | <0.50 | |
| Ethylbenzene | µg/L | NG | 2.4 | <0.50 | |
| Toluene | µg/L | NG | 24 | <0.50 | |
| Xylene Total | µg/L | NG | 300 | <0.75 | |
| Styrene | µg/L | NG | NG | <0.50 | |
| EPH $C_{10}$-$C_{19}$ | µg/L | NG | NG | <250 | |
| EPH $C_{19}$-$C_{32}$ | µg/L | NG | NG | <250 | |
| LEPH | µg/L | NG | NG | <250 | |
| HEPH | µg/L | NG | NG | <250 | |
| Volatile Hydrocarbons ($VH_{6-10}$) | µg/L | NG | NG | <100 | |
| VPH $C_6$-$C_{10}$ | µg/L | NG | NG | <100 | |
| **Total Metals** | | | | | |
| Aluminium | µg/L | NG | 100 | 6.2 | |
| Antimony | µg/L | 6 | NG | 0.16 | |
| Arsenic | µg/L | 10 | NG | 0.17 | |
| Barium | µg/L | 1,000 | NG | 13.3 | |
| Beryllium | µg/L | NG | NG | <0.10 | |
| Bismuth | µg/L | NG | NG | <0.50 | |
| Boron | µg/L | 5,000 | NG | 35 | |
| Cadmium | µg/L | 5 | NG | <0.010 | |
| Calcium | µg/L | NG | NG | 79,500 | |
| Chromium (hexavalent) | µg/L | NG | NG | <1.0 | |
| Chromium (III+VI) | µg/L | 50 | NG | 0.24 | |
| Chromium (Trivalent) | µg/L | NG | NG | <5.0 | |
| Cobalt | µg/L | NG | NG | <0.10 | |
| Copper | µg/L | NG | 1,000 | <0.50 | |
| Iron | µg/L | NG | 300 | **344** | |
| Lead | µg/L | 10 | NG | <0.050 | |
| Lithium | µg/L | NG | NG | 21.4 | |
| Magnesium | µg/L | NG | NG | 56,600 | |
| Manganese | µg/L | NG | 50 | 10.5 | |
| Mercury | µg/L | 1 | NG | <0.010 | |
| Molybdenum | µg/L | NG | NG | 3.54 | |
| Nickel | µg/L | NG | NG | <0.50 | |
| Potassium | µg/L | NG | NG | 860 | |
| Selenium | µg/L | 10 | NG | <0.10 | |
| Silicon | µg/L | NG | NG | 7,540 | |
| Silver | µg/L | NG | NG | <0.010 | |
| Sodium | µg/L | NG | 200,000 | 37,900 | |
| Strontium | µg/L | NG | NG | 6,300 | |
| Sulphur | µg/L | NG | NG | 94,700 | |
| Thallium | µg/L | NG | NG | <0.010 | |
| Tin | µg/L | NG | NG | <0.10 | |
| Titanium | µg/L | NG | NG | <10 | |
| Uranium | µg/L | 20 | NG | 0.085 | |
| Vanadium | µg/L | NG | NG | <1.0 | |
| Zinc | µg/L | NG | 5,000 | <3.0 | |

**Notes:**

[1] GCDWQ criteria are taken from the "Guidelines for Canadian Drinking Water Quality Summary Table, August 2012"
MAC refers to the Maximum Acceptable Concentration according to the GCDWQ criteria.
AO refers to the Aesthetic Objective according to the GCDWQ criteria.

NG- No guideline

**BOLD** - Exceeds Guideline

*Italic* - Detection limit greater than guideline

N/A - Not applicable

## Table 6: Groundwater Analytical Results

| Parameter | Unit | Canadian Drinking Water[1] | | DC-2 | Deep Creek at Bridge |
|---|---|---|---|---|---|
| | | MAC | AO/OG | 21-Jan-14 | 22-Jan-14 |
| **Dissolved Metals** | | | | | |
| Aluminium | µg/L | NG | 100 | <1.0 | <10 |
| Antimony | µg/L | 6 | NG | 0.13 | <0.50 |
| Arsenic | µg/L | 10 | NG | <0.10 | <0.75 |
| Barium | µg/L | 1,000 | NG | 13.1 | 23 |
| Beryllium | µg/L | NG | NG | <0.10 | <100 |
| Bismuth | µg/L | NG | NG | <0.50 | <0.20 |
| Boron | µg/L | 5,000 | NG | 33 | <100 |
| Cadmium | µg/L | 5 | NG | <0.010 | <0.20 |
| Calcium | µg/L | NG | NG | 80,300 | 47,600 |
| Chromium (hexavalent) | µg/L | NG | NG | <1.0 | <2.0 |
| Chromium (III+VI) | µg/L | 50 | NG | 0.18 | |
| Cobalt | µg/L | NG | NG | <0.10 | |
| Copper | µg/L | NG | 1,000 | <0.20 | 1.1 |
| Iron | µg/L | NG | 300 | **342** | 46 |
| Lead | µg/L | 10 | NG | <0.050 | <0.50 |
| Lithium | µg/L | NG | NG | 21.7 | |
| Magnesium | µg/L | NG | NG | 56,400 | 12,400 |
| Manganese | µg/L | NG | 50 | 10.2 | 8.4 |
| Mercury | µg/L | 1 | NG | <0.010 | <0.20 |
| Molybdenum | µg/L | NG | NG | 3.29 | |
| Nickel | µg/L | NG | NG | <0.50 | |
| Phosphorus | µg/L | NG | NG | <50 | |
| Potassium | µg/L | NG | NG | 970 | 920 |
| Selenium | µg/L | 10 | NG | <0.10 | <1.0 |
| Silicon | µg/L | NG | NG | 7,460 | |
| Silver | µg/L | NG | NG | <0.010 | |
| Sodium | µg/L | NG | 200,000 | 37,300 | 4,500 |
| Strontium | µg/L | NG | NG | 6,270 | |
| Sulphur | µg/L | NG | NG | 90,000 | |
| Thallium | µg/L | NG | NG | <0.010 | |
| Tin | µg/L | NG | NG | <0.10 | |
| Titanium | µg/L | NG | NG | <10 | |
| Uranium | µg/L | 20 | NG | 0.081 | 0.60 |
| Vanadium | µg/L | NG | NG | <1.0 | |
| Zinc | mg/L | NG | 5,000 | <1.0 | <50 |
| **Polycyclic Aromatic Hydrocarbons** | | | | | |
| Acenaphthene | µg/L | NG | NG | <0.050 | |
| Acenaphthylene | µg/L | NG | NG | <0.050 | |
| Acridine | µg/L | NG | NG | <0.050 | |
| Anthracene | µg/L | NG | NG | <0.050 | |
| Benz(a)anthracene | µg/L | NG | NG | <0.050 | |
| Benzo(a) pyrene | µg/L | 0.01 | NG | <0.010 | |
| Benzo(b)fluoranthene | µg/L | NG | NG | <0.050 | |
| Benzo(g,h,i)perylene | µg/L | NG | NG | <0.050 | |
| Benzo(k)fluoranthene | µg/L | NG | NG | <0.050 | |
| Chrysene | µg/L | NG | NG | <0.050 | |
| Dibenz(a,h)anthracene | µg/L | NG | NG | <0.050 | |
| Fluoranthene | µg/L | NG | NG | <0.050 | |
| Fluorene | µg/L | NG | NG | <0.050 | |
| Indeno(1,2,3-c,d)pyrene | µg/L | NG | NG | <0.050 | |
| Naphthalene | µg/L | NG | NG | <0.050 | |
| Phenanthrene | µg/L | NG | NG | <0.050 | |
| Pyrene | µg/L | NG | NG | <0.050 | |
| Quinoline | µg/L | NG | NG | <0.050 | |
| MTBE | µg/L | NG | 15 | <0.50 | |
| **Trihalomethane Formation Potential** | | | | | |
| Bromodichloromethane | mg/L | NG | NG | 0.004 | |
| Bromoform | mg/L | NG | NG | <0.001 | |
| Chloroform | mg/L | NG | NG | 0.017 | |
| Dibromochloromethane | mg/L | NG | NG | 0.002 | |
| Total Trihalomethanes | mg/L | 0.1 | NG | 0.023 | |

**Notes:**

[1] GCDWQ criteria are taken from the "Guidelines for Canadian Drinking Water Quality Summary Table, August 2012"
MAC refers to the Maximum Acceptable Concentration according to the GCDWQ criteria.
AO refers to the Aesthetic Objective according to the GCDWQ criteria.

NG- No guideline

Blank - Not analyzed

**BOLD** - Exceeds Guideline

*Italic* - Detection limit greater than guideline

N/A - Not applicable

# FIGURES

Figure 1 Site Location Plan
Figure 2 Existing Site Conditions
Figure 3 Observed Drawdown During Pumping Tests
Figure 4 Extrapolation of Drawdown During Constant Rate Pumping Test to 100 Days
Figure 6 Local Topography and Aquifer Capture Zones

Q:\Whitehorse\Data\0201drawings\Deep Creek\ENVH2O03020-01\ENVH2O03020-01 Fig.1_R0.dwg [FIGURE 1] December 18, 2014 - 4:14:11 pm (BY: EARL, GARETH)


NOTE : CONTOUR DATA WAS RECEIVED FROM CANVEC 1:50 000 MAPSHEET DATABASE, PROVIDED BY NATIONAL RESOURCES CANADA WEBSITE

LEGEND:

- MONITORING WELL LOCATION
- WATER SUPPLY WELL
- INFERRED GROUNDWATER FLOW DIRECTION
- 640 — GROUND ELEVATION CONTOUR MAMSL (JULY 2013)

0 200

Scale: 1: 4 000 (metres)

CLIENT

Yukon Government

TETRA TECH EBA

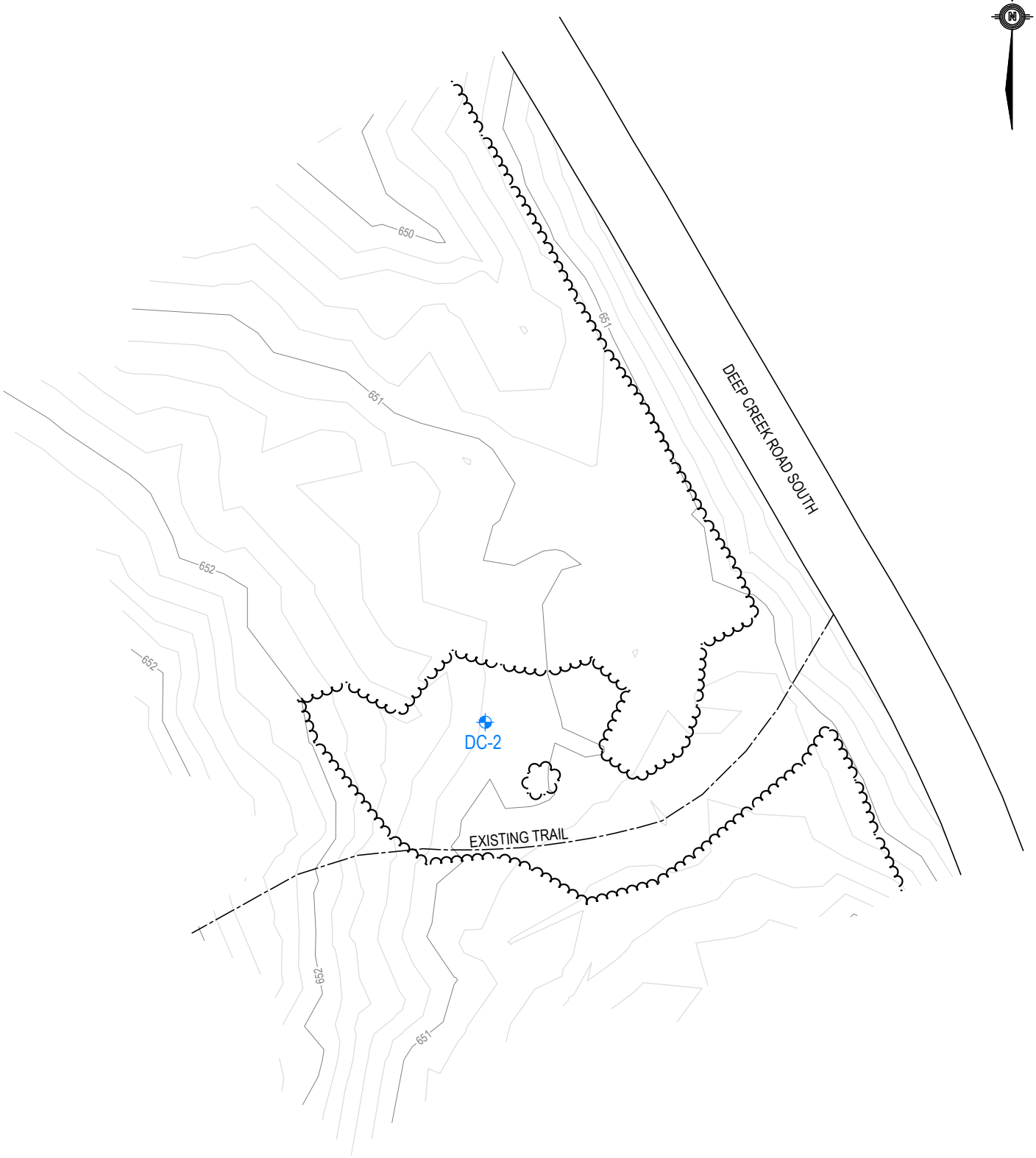
**HYDROGEOLOGICAL SERVICES**
**DEEP CREEK, YUKON**

**SITE LOCATION PLAN**

| PROJECT NO. | DWN | CKD | REV |
|---|---|---|---|
| ENVH2O03020-01 | CB | GJE | 0 |

| OFFICE | DATE |
|---|---|
| EBA-WHSE | February 6, 2014 |

**Figure 1**




LEGEND

- TEST WELL LOCATION
- TREELINE

0 25m

Scale: 1:500 @ 8.5"x11"

CLIENT

Yukon Government

TETRA TECH EBA

**HYDROGEOLOGICAL SERVICES**
**DEEP CREEK, YUKON**

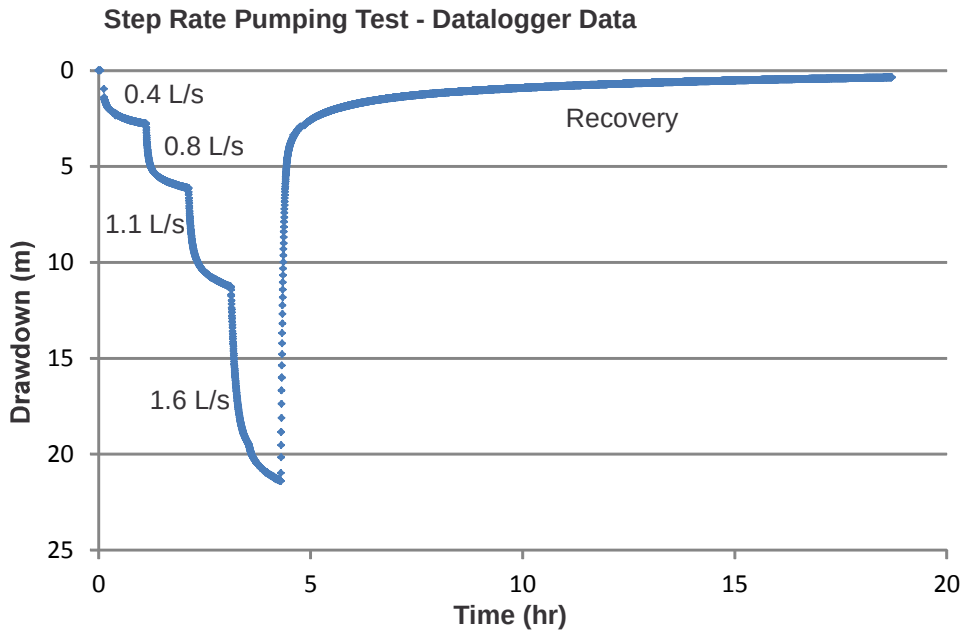
**EXISTING SITE CONDITIONS**

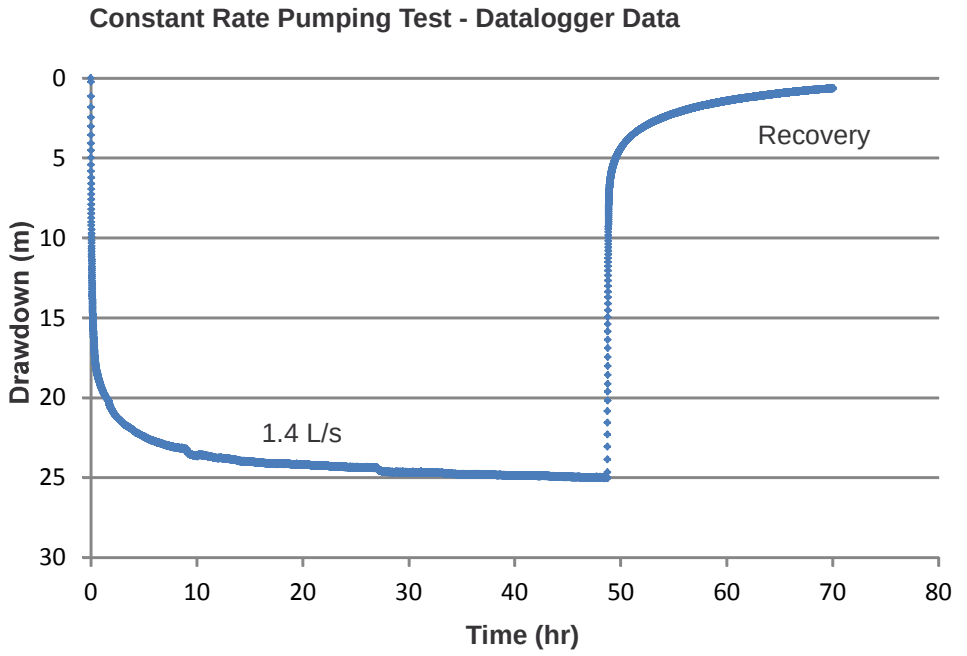
| PROJECT NO. | DWN | CKD | REV |
|---|---|---|---|
| ENVH2O03020-01 | CB | GJE | 0 |

| OFFICE | DATE |
|---|---|
| EBA-WHSE | February 6, 2014 |

**Figure 2**

Q:\Whitehorse\Data\0201drawings\Deep Creek\ENVH2O03020-01\ENVH2O03020-01 Fig.2_R0.dwg [FIGURE 2] February 17, 2014 - 4:23:08 pm (BY: BUCHAN, CAMERON)




**LEGEND**

- DC-2

**NOTES**

**STATUS**
ISSUED FOR USE

**CLIENT**
Yukon Community Services
Community Infrastructure Unit

TETRA TECH EBA

# DC-2 WELL COMPLETION AND AWPP

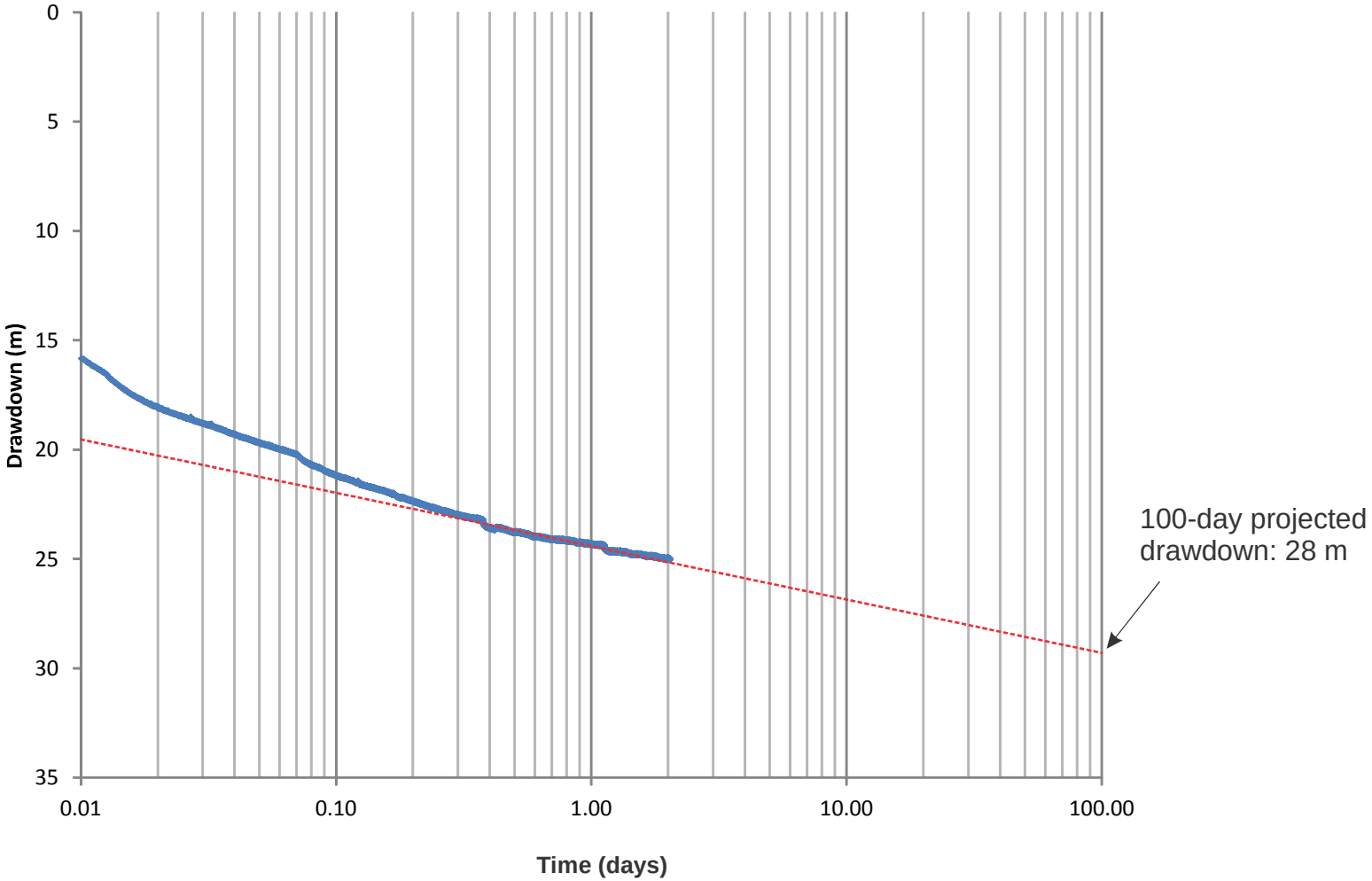
## Observed Drawdown During Pumping Tests

| PROJECT NO. | DWN | CKD | APVD | REV |
|---|---|---|---|---|
| ENVH2O03020-01 | KR | GE | RM | 0 |

| OFFICE | DATE |
|---|---|
| EBA-WHSE | January 28, 2013 |

**Figure 3**

EBA-Tt_Title_Block_8.5x11_Portrait.cdr




## LEGEND

- Drawdown in pumping well during constant rate pumping test
- Extrapolation of drawdown to 100 days

**NOTES**

**STATUS**
ISSUED FOR USE

**CLIENT**
Yukon Community Services
Community Infrastructure Unit

TETRA TECH EBA

# DC-2 WELL COMPLETION AND AWPP REPORT

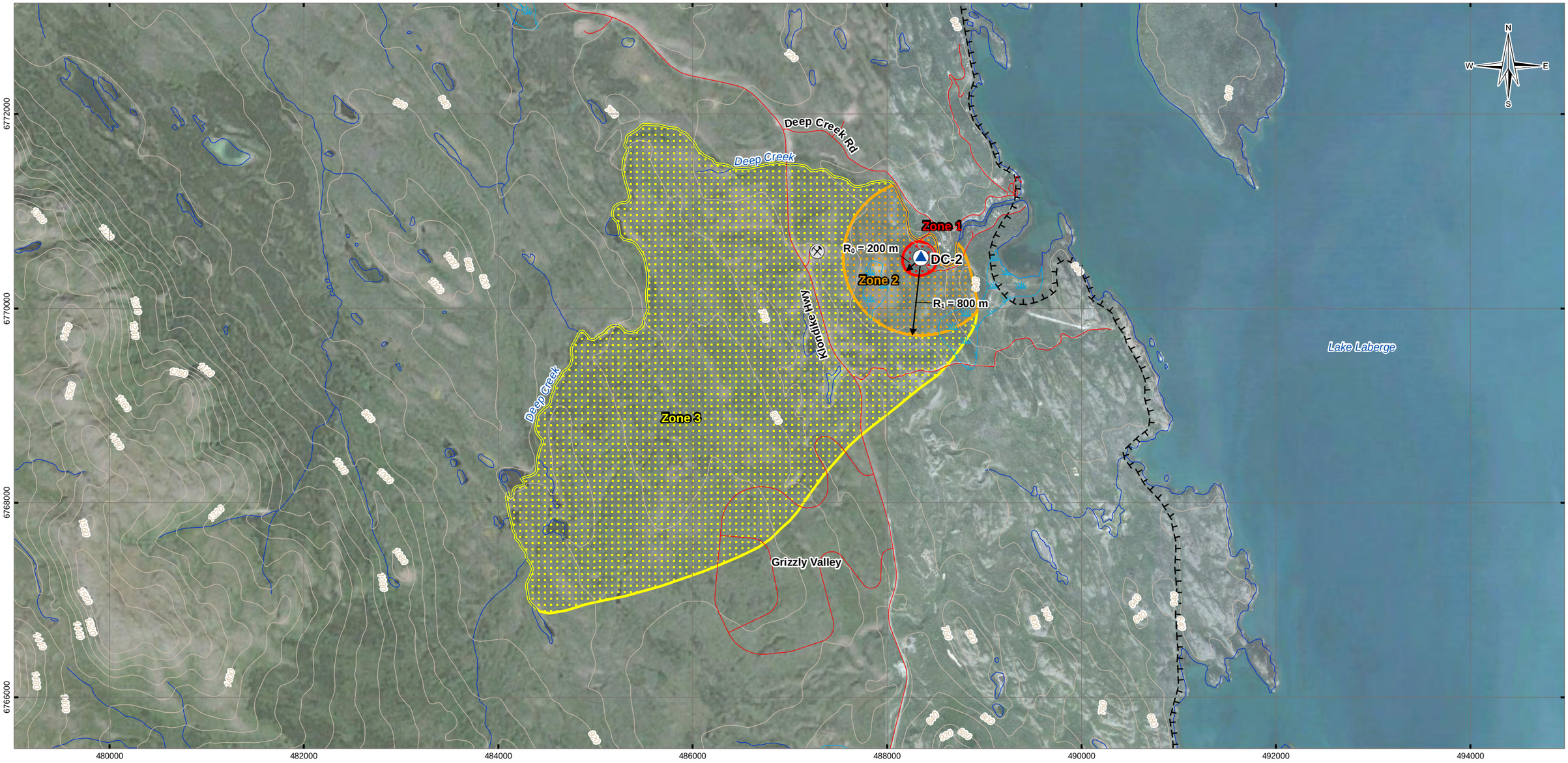
## Extrapolation of Drawdown During Constant Rate Pumping Test to 100 Days

| PROJECT NO. | DWN | CKD | APVD | REV |
|---|---|---|---|---|
| ENVH2O3020-01 | KR | GE | RM | 0 |

| OFFICE | DATE |
|---|---|
| EBA-WHSE | January 28, 2014 |

**Figure 4**

EBA-TT_Title_Block_8.5x11_Landscape.cdr




## LEGEND

- Well
- Gravel Pit
- Road
- Transmission Line
- Contour (40 m)
- Watercourse
- Waterbody
- Wetland

**Aquifer Capture Zone**

- Zone 1 (0 to 90 Days)
- Zone 2 (90 Days to 1 Year)
- Zone 3 (1 to 7 Years)

**NOTES**

1. **Potential Hazards**
   Zone 1: Spills and leaks of petrochemical and other chemicals from off-road recreational and vehicles travelling on Deep Creek Road South.
   Zone 2: Spills and leaks of chemical products into ponded recharge areas upgradient of DC-2.
   Zone 3: Spills and leaks of petrochemical and other chemicals from vehicles or temporary tanks at the gravel pit on the east side of the Klondike Highway or from vehicles travelling on highway and secondary roads within the capture zone (2.8 km along the Klondike Highway, 3 km along the service road in the Grizzly Valley subdivision, and a 1 km section of the road that intersects the Klondike Highway at km 223).
2. Base data source: CanVec 1:50,000; Google Earth Pro (April 2013).

**STATUS**
ISSUED FOR USE

**DEEP CREEK HYDROGEOLOGICAL SERVICES**

# Local Topography and Aquifer Capture Zones

| | | | | | |
|---|---|---|---|---|---|
| **PROJECTION** UTM Zone 8 | | | | | **DATUM** NAD83 |
| Scale: 1:40,000<br>500 250 0 500<br>Metres | | | | | **CLIENT** Government of Yukon |
| **FILE NO.** H2O03020-01_Figure06_Topo_11x17.mxd | | | | | TETRA TECH EBA |
| **PROJECT NO.** ENVH2O03020-01 | **DWN** MEZ | **CKD** SL | **APVD** RD | **REV** 0 | **Figure 6** |
| **OFFICE** Tt EBA-VANC | **DATE** March 3, 2014 | | | | |

Q:\Vancouver\GIS\ENVIRONMENTAL\H2O\H2O03020-01\Maps\H2O03020-01_Figure06_Topo_11x17.mxd modified 3/3/2014 by stephanie.leusink

# APPENDIX A
## TETRA TECH EBA'S GENERAL CONDITIONS

# GENERAL CONDITIONS

## GEO-ENVIRONMENTAL REPORT

This report incorporates and is subject to these “General Conditions”.

### 1.1 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of TETRA TECH’s client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH’s Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the report, if required, may be obtained upon request.

### 1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH’s instruments of professional service); only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of TETRA TECH’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except TETRA TECH. The Client warrants that TETRA TECH’s instruments of professional service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

### 1.3 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

### 1.4 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

# APPENDIX B
## DC-2 WELL LOG

| DC-2 WELL COMPLETION AND AWPP | YUKON GOVERNMENT | PROJECT NO. - BOREHOLE NO. |
|---|---|---|
| | DRILL: AIR ROTARY | ENVH2O03020-01-DC-2 |
| DEEP CREEK, YUKON | 6770522.59N; 488349.79E; Zone 8 | ELEVATION: 651.06 m |

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

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

| Depth (m) | SOIL DESCRIPTION | Elevation (m) |
|---|---|---|
| 0 | SILT - clayey, dry, brown | 651.0 |
| | SILT AND GRAVEL (TILL) - sandy, dry to moist | |
| | CLAY - silty, trace of gravel, wet, no visible free water, boulders, cobbles, gravel | |
| Jan18/14 | SILT - clayey, saturated, loose, muddy | |
| 10 | SAND - silty, clayey, saturated | |
| | SHALE - organic rich, fractured, calcite inclusions | |
| | - competent | |
| 20 | | |
| | - transition to quartz sandstone | |
| | QUARTZ SANDSTONE | |
| 30 | | |
| 40 | SHALE - organic rich | |
| 50 | - 6.1 m thick fault zone - sandstone with calcite and quartz inclusions | 602.0 |

SAMPLE TYPE | MOISTURE CONTENT | PLASTIC M.C. LIQUID (20 40 60 80) | STANDARD PENETRATION (N) (20 40 60 80) | UNC. COMPRESSIVE STRENGTH (kPa) (50 100 150 200) | POCKET PEN. (kPa) (100 200 300 400) | DC-2

Jan18/14

TETRA TECH EBA

| LOGGED BY: KR | COMPLETION DEPTH: 122.53 m |
|---|---|
| REVIEWED BY: GE | COMPLETE: 14/01/11 |
| DRAWING NO: | Page 1 of 3 |

| DC-2 WELL COMPLETION AND AWPP | YUKON GOVERNMENT | PROJECT NO. - BOREHOLE NO. |
|---|---|---|
| | DRILL: AIR ROTARY | ENVH2O03020-01-DC-2 |
| DEEP CREEK, YUKON | 6770522.59N; 488349.79E; Zone 8 | ELEVATION: 651.06 m |

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

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

| Depth (m) | SOIL DESCRIPTION | SAMPLE TYPE | MOISTURE CONTENT (PLASTIC — M.C. — LIQUID; 20 40 60 80) | STANDARD PENETRATION (N) 20 40 60 80; UNC. COMPRESSIVE STRENGTH (kPa) 50 100 150 200; POCKET PEN. (kPa) 100 200 300 400 | DC-2 | Elevation (m) |
|---|---|---|---|---|---|---|
| 50 | - water bearing fracture zone<br>QUARTZ SANDSTONE | | | | | 601.0 – 600.0 – 599.0 – 598.0 – 597.0 – 596.0 – 595.0 – 594.0 – 593.0 – 592.0 |
| 60 | | | | | | 591.0 – 590.0 – 589.0 – 588.0 – 587.0 – 586.0 – 585.0 – 584.0 – 583.0 – 582.0 |
| 70 | | | | | | 581.0 – 580.0 – 579.0 – 578.0 – 577.0 – 576.0 – 575.0 – 574.0 – 573.0 – 572.0 |
| 80 | SHALE - organic rich<br>QUARTZ SANDSTONE | | | | | 571.0 – 570.0 – 569.0 – 568.0 – 567.0 – 566.0 – 565.0 – 564.0 – 563.0 – 562.0 |
| 90 | - water bearing fracture zone | | | | | 561.0 – 560.0 – 559.0 – 558.0 – 557.0 – 556.0 – 555.0 – 554.0 – 553.0 – 552.0 |
| 100 | | | | | | |

TETRA TECH EBA

| LOGGED BY: KR | COMPLETION DEPTH: 122.53 m |
|---|---|
| REVIEWED BY: GE | COMPLETE: 14/01/11 |
| DRAWING NO: | Page 2 of 3 |

| DC-2 WELL COMPLETION AND AWPP | YUKON GOVERNMENT | PROJECT NO. - BOREHOLE NO. |
|---|---|---|
| | DRILL: AIR ROTARY | ENVH2O03020-01-DC-2 |
| DEEP CREEK, YUKON | 6770522.59N; 488349.79E; Zone 8 | ELEVATION: 651.06 m |

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

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

| Depth (m) | SOIL DESCRIPTION | SAMPLE TYPE | MOISTURE CONTENT | PLASTIC M.C. LIQUID (20 40 60 80) | STANDARD PENETRATION (N) (20 40 60 80) / UNC. COMPRESSIVE STRENGTH (kPa) (50 100 150 200) / POCKET PEN. (kPa) (100 200 300 400) | DC-2 | Elevation (m) |
|---|---|---|---|---|---|---|---|
| 100 | - disseminated pyrite | | | | | | 551.0 |
| 110 | - water bearing fracture zone | | | | | | 550.0 – 541.0 |
| 120 | END OF BOREHOLE (122.53 metres)<br>water - 6.70 metres on January 18, 2014<br>A 127 mm diameter PVC liner was installed to a depth of 122.53 metres | | | | | | 540.0 – 528.0 |
| 130 | | | | | | | 527.0 – 521.0 |
| 140 | | | | | | | 520.0 – 511.0 |
| 150 | | | | | | | 510.0 – 502.0 |

TETRA TECH EBA

| LOGGED BY: KR | COMPLETION DEPTH: 122.53 m |
|---|---|
| REVIEWED BY: GE | COMPLETE: 14/01/11 |
| DRAWING NO: | Page 3 of 3 |

# APPENDIX C
## DRILLER'S WELL LOG

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

☑ Well Construction Report
☐ Well Closure Report
☐ Well Alteration Report

Stamp company name/address/ phone/fax/email here, if desired.

Ministry Well ID Plate Number: _____
Ministry Well Tag Number: _____
☐ Confirmation/alternative specs. attached
☐ Original well construction report attached

**Red lettering indicates minimum mandatory information. See reverse for notes & definitions of abbreviations.**

Owner name: Deep Creek

Mailing address: _____ Town _____ Prov. _____ Postal Code _____

Well Location (see note 2): **Address:** Street no. _____ Street name _____ Town _____

(or) Legal description: Lot _____ Plan _____ D.L. _____ Block _____ Sec. _____ Twp. _____ Rg. _____ Land District _____

(or) PID: _____ (and) **Description of well location (attach sketch, if nec.):** _____

**NAD 83: Zone:** _____ (see note 3) (and) **UTM Easting:** 488355 m (or) **Latitude (see note 4):** _____
**UTM Northing:** 6770521 m **Longitude:** _____

**Method of drilling:** ☑ air rotary ☐ dual rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ other (specify): _____

**Orientation of well:** ☑ vertical ☐ horizontal Ground elevation: _____ ft (asl) Method (see note 5) _____

**Class of well (see note 6):** Water Supply **Sub-class of well:** Domestic

Water supply wells: indicate intended water use: ☐ private domestic ☐ water supply system ☐ irrigation ☐ commercial or industrial ☐ other (specify): _____

**Lithologic description (see notes 8-13) or closure description (see notes 14 and 15)**

| From ft (bgl) | To ft (bgl) | Surficial Material: Clay | Silt | Till | Sand, with clay/silt | Sand, fine-med | Sand, med-coarse | Sand with gravel | Bedrock Material: Siltstone/shale | Sandstone | Conglomerate | Limestone | Basalt | Volcanic | Crystalline | Other Surficial/ Bedrock | Colour: Red | Orange | Brown | Tan | Light Grey | Blue | Green | Dark Grey | Hardness: Very Hard | Hard | Dense/Stiff | Loose | Water Content: Dry | Moist | Wet | High Production | Low circulation | Not Available | Observations (e.g. other geological materials (e.g. boulders), est. water bearing flow (USgpm), or closure details) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2 | ✓ | ✓ | | | | | | | | | | | | | | | | ✓ | | | | | | | | ✓ | | ✓ | | | | | | |
| 2 | 10 | ✓ | ✓ | | | | | | | | | | | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | Moist at 10' |
| 10 | 21 | ✓ | | | | | | | | | | | | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | |
| 21 | 31 | ✓ | | | | | | | | | | | | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | |
| 31 | 36 | ✓ | | | | | | | | | | | | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | |
| 36 | 45 | ✓ | | | | | | ✓ | | | | | | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | |
| 45 | 48 | | | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | Bkgrn Rock |
| 48 | 178 | | | | | | | | | | | | ✓ | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | Fracture 5gpm |
| 178 | 302 | | | | | | | | | | | | ✓ | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | Fractures 5gpm |
| 302 | 402 | | | | | | | | | | | | ✓ | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | Fractures-345-5gpm |

**Casing details**

| From ft (bgl) | To ft (bgl) | Dia in | Casing Material/Open Hole (see note 17) | Wall Thickness in | Drive Shoe |
|---|---|---|---|---|---|
| 0 | 50' | 8" | Steel | .330 | Ring |
| 0 | 56' | 6" | Steel | .250 | Ring |
| 0-56 | | | Sealed with Bentonite Chips. | | |

Surface seal: Type: Bentonite Grout Depth: 18 ft
Method of installation: ☐ Poured ☑ Pumped Thickness: 2 in
Backfill: Type: _____ Depth: _____ ft
Liner: ☑ PVC ☐ Other (specify): _____
Diameter: 5" in Thickness: .250 in
From: 0 ft (bgl) To: 402 ft (bgl) Perforated: From: 402 ft (bgl) To: 222 ft (bgl)

**Screen details**

| From ft (bgl) | To ft (bgl) | Dia in | Type (see note 18) | Slot Size |
|---|---|---|---|---|
| 402 | 222 | 5 | PVC | .020 |

Intake: ☑ Screen ☐ Open bottom ☐ Uncased hole
Screen type: ☐ Telescope ☑ Pipe size
Screen material: ☐ Stainless steel ☑ Plastic ☐ Other (specify): _____
Screen opening: ☐ Continuous slot ☑ Slotted ☐ Perforated pipe
Screen bottom: ☐ Ball ☐ Plug ☑ Plate ☐ Other (specify): _____
Filter pack: From: _____ ft To: _____ ft Thickness: _____ in
Type and size of material: Natural.

**Developed by:**
☑ Air lifting ☑ Surging ☐ Jetting ☐ Pumping ☐ Bailing
Other (specify): _____ Total duration: _____ hrs
Notes: _____

**Well yield estimated by:**
☐ Pumping ☐ Air lifting ☐ Bailing ☐ Other (specify): _____
Rate: 15 USgpm Duration: 7 hrs
SWL before test: _____ ft (btoc) Pumping water level: _____ ft (btoc)

**Obvious water quality characteristics:**
☑ Fresh ☐ Salty ☑ Clear ☐ Cloudy ☐ Sediment ☐ Gas
Colour/odour: _____ Water sample collected: ☐

**Well driller (print clearly):**
Name (first, last) (see note 19): Carl Mackenzie
Registration no. (see note 20): OWD0412501
Consultant (if applicable, name and company): _____

**Final well completion data:**
Total depth drilled: 402 ft Finished well depth: 402 ft (bgl)
Final stick up: 30 in Depth to bedrock: 45' ft (bgl)
SWL: _____ ft (btoc) Estimated well yield: 15 USgpm
Artesian flow: _____ USgpm, or Artesian pressure: _____ ft
Type of well cap: Plate Well disinfected: ☑ Yes ☐ No
Where well ID plate is attached: _____

**Well closure information:**
Reason for closure: _____
Method of closure: ☐ Poured ☐ Pumped
Sealant material: _____ Backfill material: _____
Details of closure (see note 16): _____

**Date of work** (YYYY/MM/DD):
**Started:** 2014/01/02 **Completed:** 2014/01/12
Comments: _____

**DECLARATION:** Well construction, well alteration or well closure, as the case may be, has been done in accordance with the requirements in the Water Act and the Ground Water Protection Regulation.

**Signature of Driller Responsible**

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction, alteration or closure, as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works, which may change over time.

white: Customer copy
canary: Driller copy
pink: Ministry copy

Sheet _____ of _____

# APPENDIX D

## STEP AND CONSTANT RATE PUMPING TEST MANUAL DATA AND INTERPRETATION

## STEP-DRAWDOWN PUMPING TEST DATA

| | | | |
|---|---|---|---|
| **EBA Project Number:** | ENVH2O03020-01 | **Project Location:** | Deep Creek |
| **Well Name:** | DC-2 | **Pump Intake Depth (m):** | 60 m |
| **Static Water Level* (m):** | 7.585 m | **Screen Interval (X to Y depth):** | 67 – 121 m |
| **Ref. Point Description:** | Top of 6" PVC | **Screen Slot Size ("):** | .020" |
| **Ref. Point Stick-Up (m):** | 0.89 m | **Safe Available Drawdown** (m):** | 55.0 m |
| **Well Diameter (mm):** | 152.4 mm | **Screen Diameter (mm):** | 127 mm |
| **Total Well Depth (m):** | 121.03 m | **Observer's Name:** | Kristen Range |

*below reference point **equal to (pump depth m – SWL m) x 0.7

| Date | Time | Elapsed Time (min) | Depth to Water (m) | Drawdown (m) | Meter Reading [3] | Flow Rate (IGPM) | Flow Rate (L/s) | Specific Capacity (L/s/m) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 01/18/14 | 4:57:00 | 0 | 7.585 | 0 | 7.23 | 6.02 | 0.38 | | |
| | 4:57:30 | 0.5 | 9.09 | 1.504 | 7.23 | 6.02 | 0.38 | 0.25 | |
| | 4:58:00 | 1 | 9.13 | 1.544 | 7.23 | 6.02 | 0.38 | 0.25 | |
| | 4:58:30 | 1.5 | 9.17 | 1.584 | 7.23 | 6.02 | 0.38 | 0.24 | |
| | 4:59:00 | 2 | 9.22 | 1.634 | 7.23 | 6.02 | 0.38 | 0.23 | |
| | 4:59:30 | 2.5 | 9.27 | 1.684 | 7.23 | 6.02 | 0.38 | 0.23 | |
| | 5:00:00 | 3 | 9.32 | 1.734 | 7.23 | 6.02 | 0.38 | 0.22 | |
| | 5:00:30 | 3.5 | 9.37 | 1.784 | 7.23 | 6.02 | 0.38 | 0.21 | |
| | 5:01:00 | 4 | 9.42 | 1.834 | 7.23 | 6.02 | 0.38 | 0.21 | |
| | 5:01:30 | 4.5 | 9.455 | 1.869 | 7.23 | 6.02 | 0.38 | 0.20 | |
| | 5:02:00 | 5 | 9.475 | 1.889 | 7.23 | 6.02 | 0.38 | 0.20 | |
| | 5:03:00 | 6 | 9.55 | 1.964 | 7.23 | 6.02 | 0.38 | 0.19 | |
| | 5:04:00 | 7 | 9.59 | 2.004 | 7.23 | 6.02 | 0.38 | 0.19 | |
| | 5:05:00 | 8 | 9.63 | 2.044 | 7.23 | 6.02 | 0.38 | 0.19 | |
| | 5:06:00 | 9 | 9.665 | 2.079 | 7.23 | 6.02 | 0.38 | 0.18 | |
| | 5:07:00 | 10 | 9.698 | 2.112 | 7.23 | 6.02 | 0.38 | 0.18 | |
| | 5:09:00 | 12 | 9.765 | 2.179 | 7.23 | 6.02 | 0.38 | 0.17 | |
| | 5:11:00 | 14 | 9.805 | 2.219 | 7.23 | 6.02 | 0.38 | 0.17 | |
| | 5:13:00 | 16 | 9.84 | 2.254 | 7.23 | 6.02 | 0.38 | 0.17 | |
| | 5:15:00 | 18 | 9.89 | 2.304 | 7.23 | 6.02 | 0.38 | 0.16 | |
| | 5:17:00 | 20 | 9.939 | 2.353 | 7.23 | 6.02 | 0.38 | 0.16 | |
| | 5:22:00 | 25 | 10.036 | 2.45 | 7.23 | 6.02 | 0.38 | 0.16 | |
| | 5:27:00 | 30 | 10.113 | 2.527 | 7.23 | 6.02 | 0.38 | 0.15 | |
| | 5:32:00 | 35 | 10.176 | 2.59 | 7.23 | 6.02 | 0.38 | 0.15 | |
| | 5:37:00 | 40 | 10.228 | 2.642 | 7.23 | 6.02 | 0.38 | 0.14 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5:42:00 | 45 | 10.274 | 2.688 | 7.23 | 6.02 | 0.38 | 0.14 | |
| | 5:47:00 | 50 | 10.32 | 2.734 | 7.23 | 6.02 | 0.38 | 0.14 | |
| | 5:52:00 | 55 | 10.35 | 2.764 | 7.23 | 6.02 | 0.38 | 0.14 | |
| | 5:57:00 | 60 | 10.39 | 2.804 | 7.23 | 6.02 | 0.38 | 0.14 | |
| | 5:57:30 | 60.5 | 10.9 | 3.314 | 14.26 | 11.89 | 0.75 | 0.23 | |
| | 5:58:00 | 61 | 10.295 | 2.709 | 14.26 | 11.89 | 0.75 | 0.28 | |
| | 5:58:30 | 61.5 | 11.545 | 3.959 | 14.26 | 11.89 | 0.75 | 0.19 | |
| | 5:59:00 | 62 | 11.74 | 4.154 | 14.26 | 11.89 | 0.75 | 0.18 | |
| | 5:59:30 | 62.5 | 11.925 | 4.339 | 14.26 | 11.89 | 0.75 | 0.17 | |
| | 6:00:00 | 63 | 12.07 | 4.484 | 14.26 | 11.89 | 0.75 | 0.17 | |
| | 6:00:30 | 63.5 | 12.215 | 4.629 | 14.26 | 11.89 | 0.75 | 0.16 | |
| | 6:01:00 | 64 | 12.305 | 4.719 | 14.26 | 11.89 | 0.75 | 0.16 | |
| | 6:01:30 | 64.5 | 12.38 | 4.794 | 14.26 | 11.89 | 0.75 | 0.16 | |
| | 6:02:00 | 65 | 12.47 | 4.884 | 14.26 | 11.89 | 0.75 | 0.15 | |
| | 6:03:00 | 66 | 12.59 | 5.004 | 14.26 | 11.89 | 0.75 | 0.15 | |
| | 6:04:00 | 67 | 12.69 | 5.104 | 14.26 | 11.89 | 0.75 | 0.15 | |
| | 6:05:00 | 68 | 12.76 | 5.174 | 14.26 | 11.89 | 0.75 | 0.14 | |
| | 6:06:00 | 69 | 12.83 | 5.244 | 14.26 | 11.89 | 0.75 | 0.14 | |
| | 6:07:00 | 70 | 12.888 | 5.302 | 14.26 | 11.89 | 0.75 | 0.14 | |
| | 6:09:00 | 72 | 12.98 | 5.394 | 14.26 | 11.89 | 0.75 | 0.14 | |
| | 6:11:00 | 74 | 13.055 | 5.469 | 14.26 | 11.89 | 0.75 | 0.14 | |
| | 6:15:00 | 78 | 13.18 | 5.594 | 14.26 | 11.89 | 0.75 | 0.13 | |
| | 6:17:00 | 80 | 13.23 | 5.644 | 14.26 | 11.89 | 0.75 | 0.13 | |
| | 6:22:00 | 85 | 13.342 | 5.756 | 14.26 | 11.89 | 0.75 | 0.13 | |
| | 6:27:00 | 90 | 13.425 | 5.839 | 14.26 | 11.89 | 0.75 | 0.13 | |
| | 6:32:00 | 95 | 13.497 | 5.911 | 14.26 | 11.89 | 0.75 | 0.13 | |
| | 6:37:00 | 100 | 13.559 | 5.973 | 14.26 | 11.89 | 0.75 | 0.13 | |
| | 6:43:00 | 106 | 13.63 | 6.044 | 14.26 | 11.89 | 0.75 | 0.12 | |
| | 6:47:00 | 110 | 13.675 | 6.089 | 14.26 | 11.89 | 0.75 | 0.12 | |
| | 6:52:00 | 115 | 13.738 | 6.152 | 14.26 | 11.89 | 0.75 | 0.12 | |
| | 6:57:00 | 120 | 13.778 | 6.192 | 20.35 | 16.96 | 1.07 | 0.17 | |
| | 6:57:30 | 120.5 | 14.28 | 6.694 | 20.35 | 16.96 | 1.07 | 0.16 | |
| | 6:58:00 | 121 | 14.72 | 7.134 | 20.35 | 16.96 | 1.07 | 0.15 | |
| | 6:58:30 | 121.5 | 15.08 | 7.494 | 20.35 | 16.96 | 1.07 | 0.14 | |
| | 6:59:00 | 122 | 15.38 | 7.794 | 20.35 | 16.96 | 1.07 | 0.14 | |
| | 6:59:30 | 122.5 | 15.65 | 8.064 | 20.35 | 16.96 | 1.07 | 0.13 | |
| | 7:00:00 | 123 | 15.9 | 8.314 | 20.35 | 16.96 | 1.07 | 0.13 | |
| | 7:01:00 | 124 | 16.255 | 8.669 | 20.35 | 16.96 | 1.07 | 0.12 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7:01:30 | 124.5 | 16.41 | 8.824 | 20.35 | 16.96 | 1.07 | 0.12 | |
| | 7:02:00 | 125 | 16.54 | 8.954 | 20.35 | 16.96 | 1.07 | 0.12 | |
| | 7:03:00 | 126 | 16.778 | 9.192 | 20.35 | 16.96 | 1.07 | 0.12 | |
| | 7:05:00 | 128 | 17.125 | 9.539 | 20.35 | 16.96 | 1.07 | 0.11 | |
| | 7:06:00 | 129 | 17.26 | 9.674 | 20.35 | 16.96 | 1.07 | 0.11 | |
| | 7:07:00 | 130 | 17.43 | 9.844 | 20.35 | 16.96 | 1.07 | 0.11 | |
| | 7:09:00 | 132 | 17.605 | 10.019 | 20.35 | 16.96 | 1.07 | 0.11 | |
| | 7:11:00 | 134 | 17.72 | 10.134 | 20.35 | 16.96 | 1.07 | 0.11 | |
| | 7:13:00 | 136 | 17.85 | 10.264 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:15:00 | 138 | 17.96 | 10.374 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:17:00 | 140 | 18.058 | 10.472 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:22:00 | 145 | 18.23 | 10.644 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:29:30 | 152.5 | 18.44 | 10.854 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:32:00 | 155 | 18.502 | 10.916 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:37:00 | 160 | 18.595 | 11.009 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:42:00 | 165 | 18.689 | 11.103 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:47:00 | 170 | 18.777 | 11.191 | 20.35 | 16.96 | 1.07 | 0.10 | |
| | 7:52:00 | 175 | 18.863 | 11.277 | 20.35 | 16.96 | 1.07 | 0.09 | |
| | 7:56:30 | 178.5 | 18.91 | 11.324 | 20.35 | 16.96 | 1.07 | 0.09 | |
| | 7:57:00 | 180 | 18.93 | 11.344 | 30.62 | 25.52 | 1.61 | 0.14 | |
| | 7:57:30 | 180.5 | 19.42 | 11.834 | 30.62 | 25.52 | 1.61 | 0.14 | |
| | 7:58:00 | 181 | 19.97 | 12.384 | 30.62 | 25.52 | 1.61 | 0.13 | |
| | 7:58:30 | 181.5 | 20.63 | 13.044 | 30.62 | 25.52 | 1.61 | 0.12 | |
| | 7:59:00 | 182 | 20.99 | 13.404 | 30.62 | 25.52 | 1.61 | 0.12 | |
| | 7:59:30 | 182.5 | 21.39 | 13.804 | 30.62 | 25.52 | 1.61 | 0.12 | |
| | 8:00:00 | 183 | 21.61 | 14.024 | 30.62 | 25.52 | 1.61 | 0.11 | |
| | 8:00:30 | 183.5 | 22.17 | 14.584 | 30.62 | 25.52 | 1.61 | 0.11 | |
| | 8:01:00 | 184 | 22.535 | 14.949 | 30.62 | 25.52 | 1.61 | 0.11 | |
| | 8:01:30 | 184.5 | 22.84 | 15.254 | 30.62 | 25.52 | 1.61 | 0.11 | |
| | 8:02:00 | 185 | 23.15 | 15.564 | 30.62 | 25.52 | 1.61 | 0.10 | |
| | 8:03:00 | 186 | 23.64 | 16.054 | 30.62 | 25.52 | 1.61 | 0.10 | |
| | 8:04:00 | 187 | 24.075 | 16.489 | 30.62 | 25.52 | 1.61 | 0.10 | |
| | 8:05:00 | 188 | 24.496 | 16.91 | 30.62 | 25.52 | 1.61 | 0.10 | |
| | 8:06:00 | 189 | 24.87 | 17.284 | 30.62 | 25.52 | 1.61 | 0.09 | |
| | 8:07:00 | 190 | 25.19 | 17.604 | 30.62 | 25.52 | 1.61 | 0.09 | |
| | 8:09:00 | 192 | 25.7 | 18.114 | 30.62 | 25.52 | 1.61 | 0.09 | |
| | 8:11:00 | 194 | 26.183 | 18.597 | 30.62 | 25.52 | 1.61 | 0.09 | |
| | 8:13:00 | 196 | 26.405 | 18.819 | 30.62 | 25.52 | 1.61 | 0.09 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 8:15:00 | 198 | 26.64 | 19.054 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:17:00 | 200 | 26.828 | 19.242 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:22:00 | 205 | 27.165 | 19.579 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:27:00 | 210 | 27.77 | 20.184 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:32:00 | 215 | 28.14 | 20.554 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:37:00 | 220 | 28.315 | 20.729 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:42:00 | 225 | 28.505 | 20.919 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:47:00 | 230 | 28.68 | 21.094 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 8:57:00 | 240 | 28.915 | 21.329 | 30.62 | 25.52 | 1.61 | 0.08 | |
| | 9:07:00 | 250 | 29.11 | 21.524 | 30.62 | 25.52 | 1.61 | 0.07 | Pump Off |
| | 9:07:43 | 250.75 | 29.125 | 21.539 | | | | | Recovery |
| | 9:08:05 | 251 | 27 | 19.414 | | | | | |
| | 9:08:31 | 251.5 | 25 | 17.414 | | | | | |
| | 9:08:46 | 251.75 | 24 | 16.414 | | | | | |
| | 9:09:03 | 252 | 23 | 15.414 | | | | | |
| | 9:09:19 | 252.3 | 22 | 14.414 | | | | | |
| | 9:09:36 | 252.7 | 21 | 13.414 | | | | | |
| | 9:09:58 | 253 | 20 | 12.414 | | | | | |
| | 9:10:24 | 253.5 | 19 | 11.414 | | | | | |
| | 9:10:51 | 253.9 | 18 | 10.414 | | | | | |
| | 9:11:20 | 254.3 | 17 | 9.414 | | | | | |
| | 9:11:54 | 254.9 | 16 | 8.414 | | | | | |
| | 9:12:32 | 255.5 | 15 | 7.414 | | | | | |
| | 9:13:30 | 256.5 | 14 | 6.414 | | | | | |
| | 9:14:52 | 257.9 | 13 | 5.414 | | | | | |
| | 9:19:03 | 262 | 11.75 | 4.164 | | | | | |
| | 9:27:19 | 270.5 | 10.95 | 3.364 | | | | | |
| | 9:34:30 | 277.5 | 10.6 | 3.014 | | | | | |
| | 9:43:30 | 286.5 | 10.211 | 2.625 | | | | | |
| | 9:48:30 | 291.5 | 10.14 | 2.554 | | | | | |
| 01/19/14 | 11:36:00 | 1119 | 8.02 | 0.434 | | | | | |

Notes:

1) Depth to Water below reference point (e.g., top of sounding tube).

2) "-" indicates no data or not applicable.

3) May be from a flow totalizer, instantaneous flow meter or other method of flow rate monitoring. Note in comment column.

## CONSTANT RATE PUMPING TEST DATA

| | | | |
|---|---|---|---|
| **EBA Project Number:** | ENVH2O03020-01 | **Project Location:** | Deep Creek |
| **Well Name:** | DC-2 | **Pump Intake Depth (m):** | 60 m |
| **Static Water Level* (m):** | 8.02 m | **Screen Interval (X to Y depth):** | 67 – 121 m |
| **Ref. Point Description:** | Top of 6" PVC | **Screen Slot Size ("):** | .020" |
| **Ref. Point Stick-Up (m):** | 0.89 m | **Safe Available Drawdown** (m):** | 55.0 m |
| **Well Diameter (mm):** | 152.4 mm | **Screen Diameter (mm):** | 127 mm |
| **Total Well Depth (m):** | 121.03 m | **Observer's Name:** | Kristen Range |

*below reference point **equal to (pump depth m – SWL m) x 0.7

| Date | Time | Elapsed Time (min) | Depth to Water (m) | Drawdown (m) | Meter Reading[3] | Flow Rate (IGPM) | Flow Rate (L/s) | pH | EC | Temp | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01/19/14 | 12:00 | 0 | 8.02 | 0 | | | | | | | |
| | 12:00 | 0.5 | 10.52 | 2.50 | | | | | | | |
| | 12:01 | 1 | 12.64 | 4.62 | | | | | | | |
| | 12:01 | 1.5 | 13.43 | 5.41 | | | | | | | |
| | 12:02 | 2 | 14.66 | 6.64 | | | | | | | |
| | 12:02 | 2.5 | 15.64 | 7.62 | | | | | | | |
| | 12:03 | 3 | 16.48 | 8.46 | | | | | | | |
| | 12:03 | 3.5 | 17.25 | 9.23 | | | | | | | |
| | 12:04 | 4 | 17.93 | 9.91 | | | | | | | |
| | 12:04 | 4.5 | 18.5 | 10.48 | | | | | | | |
| | 12:05 | 5 | 19.04 | 11.02 | | | | | | | |
| | 12:06 | 6 | 19.96 | 11.94 | | | | | | | |
| | 12:07 | 7 | 20.74 | 12.72 | | | | | | | |
| | 12:08 | 8 | 21.38 | 13.36 | | | | | | | |
| | 12:09 | 9 | 21.9 | 13.88 | | | | | | | |
| | 12:10 | 10.5 | 22.63 | 14.61 | | | | | | | |
| | 12:12 | 12 | 23.21 | 15.19 | | | | | | | |
| | 12:15 | 15 | 24.03 | 16.01 | | | | | | | |
| | 12:16 | 16 | 24.23 | 16.21 | | | | | | | |
| | 12:18 | 18 | 24.625 | 16.605 | | | | | | | |
| | 12:20 | 20 | 25.095 | 17.075 | | | | | | | |
| | 12:25 | 25 | 25.8 | 17.78 | | | | | | | |
| | 12:30 | 30 | 26.215 | 18.195 | | | | | | | |
| | 12:36 | 36.5 | 26.585 | 18.565 | | | | | | | |
| | 12:41 | 41 | 26.78 | 18.76 | | | | | | | |
| | 12:48 | 48 | 27.035 | 19.015 | | | | | | | |
| | 12:50 | 50 | 27.105 | 19.085 | | | | | | | |
| | 12:56 | 56 | 27.325 | 19.305 | | | | | | | |
| | 13:00 | 60 | 27.45 | 19.43 | | | | | | | |

| Date | Time | Elapsed Time (min) | Depth to Water (m) | Drawdown (m) | Meter Reading[3] | Flow Rate (IGPM) | Flow Rate (L/s) | pH | EC | Temp | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13:03 | 73 | 27.78 | 19.76 | | | | | | | |
| | 13:20 | 80 | 27.92 | 19.9 | 21.6 | 21.6 | 1.4 | 8.01 | 523 | 2.9 | |
| | 13:32 | 92 | 28.135 | 20.115 | | | | | | | |
| | 13:40 | 100 | 28.279 | 20.259 | | | | | | | |
| | 13:50 | 110 | 28.652 | 20.632 | | | | | | | |
| | 14:00 | 120 | 28.846 | 20.826 | | | | | | | |
| | 14:30 | 150 | 29.339 | 21.319 | | | | | | | |
| | 15:00 | 180 | 29.6 | 21.58 | | | | | | | |
| | 15:30 | 210 | 29.892 | 21.872 | | | | | | | |
| | 16:00 | 240 | 30.129 | 22.109 | | | | | | | |
| | 16:30 | 270 | 30.341 | 22.321 | | | | 7.62 | 528 | 5.2 | |
| | 17:00 | 300 | 30.526 | 22.506 | | | | | | | |
| | 17:30 | 330 | 30.69 | 22.67 | | | | | | | |
| | 18:00 | 360 | 30.828 | 22.808 | 23.8 | 23.8 | 1.5 | 7.72 | 520 | 2.9 | |
| | 19:00 | 420 | 31.051 | 23.031 | | | | | | | |
| | 20:00 | 480 | 31.21 | 23.19 | | | | | | | |
| | 21:00 | 540 | 31.309 | 23.289 | | | | | | | |
| | 22:00 | 600 | 31.741 | 23.721 | | | | 7.72 | 518 | 2.9 | |
| | 23:00 | 660 | 31.76 | 23.74 | | | | | | | |
| 01/20/14 | 0:00 | 720 | 31.893 | 23.873 | | | | | | | |
| | 1:00 | 780 | 31.945 | 23.925 | | | | | | | |
| | 2:00 | 840 | 32.065 | 24.045 | | | | | | | |
| | 3:00 | 900 | 32.11 | 24.09 | | | | | | | |
| | 4:00 | 960 | 32.17 | 24.15 | | | | | | | |
| | 5:00 | 1020 | 32.235 | 24.215 | | | | | | | |
| | 6:00 | 1080 | 32.245 | 24.225 | | | | | | | |
| | 7:00 | 1140 | 32.251 | 24.231 | 23.8 | 23.8 | 1.5 | 7.71 | 517 | 2.8 | |
| | 8:00 | 1200 | 32.311 | 24.291 | | | | | | | |
| | 9:00 | 1260 | 32.389 | 24.369 | | | | | | | |
| | 10:00 | 1320 | 32.398 | 24.378 | | | | | | | |
| | 11:00 | 1380 | 32.441 | 24.421 | | | | | | | |
| | 12:00 | 1440 | 32.487 | 24.467 | | | | | | | |
| | 13:00 | 1500 | 32.514 | 24.494 | | | | | | | |
| | 14:00 | 1560 | 32.531 | 24.511 | 22.1 | 22.1 | 1.4 | 7.75 | 516 | 2.8 | |
| | 15:00 | 1620 | 32.548 | 24.528 | | | | | | | |
| | 16:00 | 1680 | 32.793 | 24.773 | | | | | | | |
| | 17:00 | 1740 | 32.821 | 24.801 | | | | | | | |
| | 18:00 | 1800 | 32.834 | 24.814 | | | | | | | |
| | 19:00 | 1860 | 32.843 | 24.823 | | | | 7.7 | 509 | 2.7 | |

| Date | Time | Elapsed Time (min) | Depth to Water (m) | Drawdown (m) | Meter Reading[3] | Flow Rate (IGPM) | Flow Rate (L/s) | pH | EC | Temp | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20:00 | 1920 | 32.871 | 24.851 | | | | | | | |
| | 21:00 | 1980 | 32.886 | 24.866 | | | | | | | |
| | 22:00 | 2040 | 32.941 | 24.921 | | | | | | | |
| | 23:00 | 2100 | 32.966 | 24.946 | | | | | | | |
| 01/21/14 | 0:00 | 2160 | 32.973 | 24.953 | | | | | | | |
| | 1:00 | 2220 | 32.974 | 24.954 | | | | | | | |
| | 2:00 | 2280 | 32.991 | 24.971 | | | | | | | |
| | 3:00 | 2340 | 33.01 | 24.99 | | | | | | | |
| | 4:00 | 2400 | 32.3023 | 24.2823 | 22.3 | 22.3 | 1.4 | | | | |
| | 5:00 | 2460 | 33.022 | 25.002 | | | | | | | |
| | 6:00 | 2520 | 32.994 | 24.974 | | | | | | | |
| | 7:00 | 2580 | 32.998 | 24.978 | | | | | | | |
| | 8:00 | 2640 | 33.037 | 25.017 | 23.0 | 23.0 | 1.5 | 7.78 | 518 | 2.7 | |
| | 9:00 | 2700 | 33.043 | 25.023 | | | | | | | |
| | 10:00 | 2760 | 33.056 | 25.036 | | | | | | | |
| | 11:00 | 2820 | 33.078 | 25.058 | | | | | | | |
| | 12:00 | 2880 | 33.075 | 25.055 | | | | 8.03 | 518 | 2.9 | Pump Off |
| | 12:44 | 2924 | 33.1 | 25.08 | | | | | | | Recovery |
| | 12:44 | 2924 | 30 | 21.98 | | | | | | | |
| | 12:44 | 2924 | 29 | 20.98 | | | | | | | |
| | 12:45 | 2925 | 28 | 19.98 | | | | | | | |
| | 12:45 | 2925 | 27 | 18.98 | | | | | | | |
| | 12:45 | 2925 | 26 | 17.98 | | | | | | | |
| | 12:46 | 2926 | 25 | 16.98 | | | | | | | |
| | 12:46 | 2926 | 24 | 15.98 | | | | | | | |
| | 12:46 | 2926 | 23 | 14.98 | | | | | | | |
| | 12:47 | 2927 | 22 | 13.98 | | | | | | | |
| | 12:47 | 2927 | 21 | 12.98 | | | | | | | |
| | 12:48 | 2928 | 20 | 11.98 | | | | | | | |
| | 12:48 | 2928 | 19 | 10.98 | | | | | | | |
| | 12:49 | 2929 | 18 | 9.98 | | | | | | | |
| | 12:50 | 2930 | 17 | 8.98 | | | | | | | |
| | 12:52 | 2932 | 16 | 7.98 | | | | | | | |
| | 12:55 | 2935 | 15 | 6.98 | | | | | | | |
| | 12:59 | 2939 | 14.5 | 6.48 | | | | | | | |
| | 13:06 | 2946 | 14 | 5.98 | | | | | | | |
| | 13:17 | 2957 | 13.5 | 5.48 | | | | | | | |
| | 13:33 | 2973 | 13 | 4.98 | | | | | | | |
| | 13:55 | 2995 | 12.5 | 4.48 | | | | | | | |

| Date | Time | Elapsed Time (min) | Depth to Water (m) | Drawdown (m) | Meter Reading[3] | Flow Rate (IGPM) | Flow Rate (L/s) | pH | EC | Temp | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14:00 | 3000 | 14.431 | 6.411 | | | | | | | |
| 01/22/14 | 9:56 | 4196 | 8.655 | 0.635 | | | | | | | |

Notes:

1) Depth to Water below reference point (e.g., top of sounding tube).
2) "-" indicates no data or not applicable.
3) May be from a flow totalizer, instantaneous flow meter or other method of flow rate monitoring. Note in comment column.

**Tetra Tech EBA**
**61 Wasson Place**
**Whitehorse, YT Y1A 0H7**

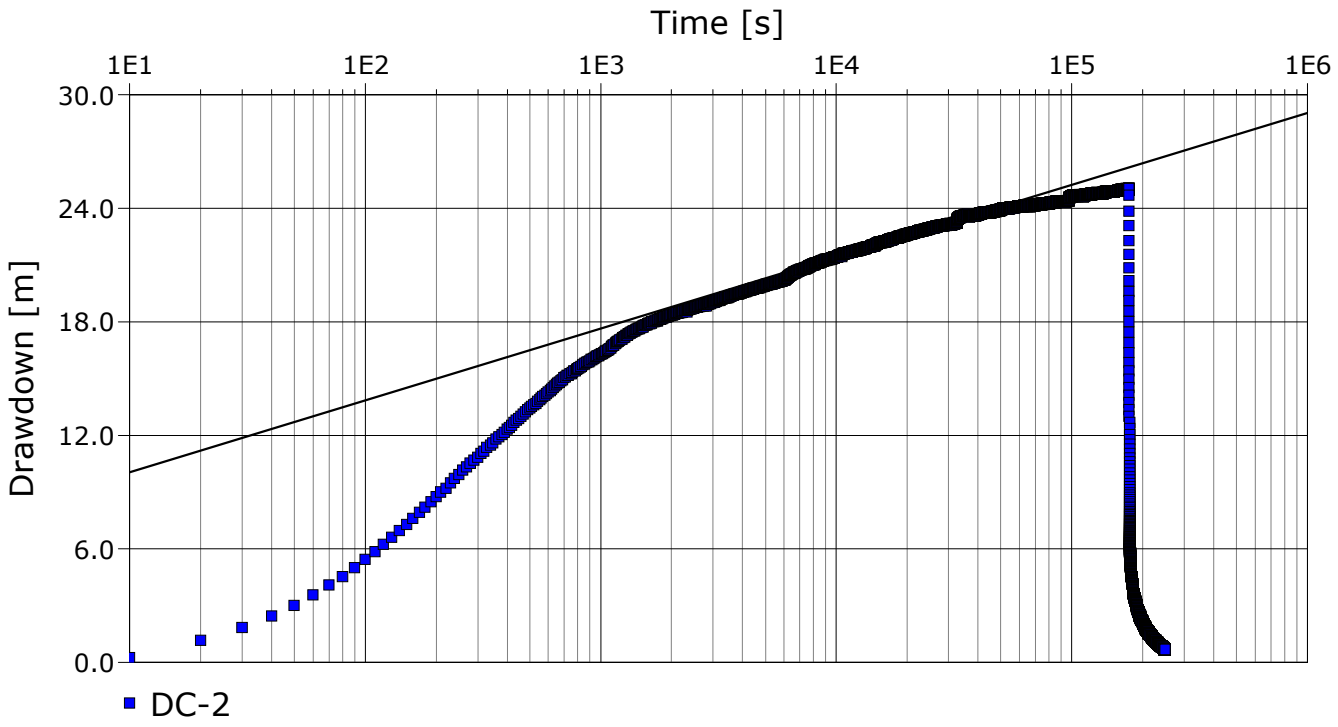
# Pumping Test Analysis Report

Project: DC-2 Well Completion and AWPP

Number: ENVH2O03020-01

Client: Government of Yukon

| | | |
|---|---|---|
| Location: DC-2 | Pumping Test: DC-2 Constant Rate Pumping Test | Pumping Well: DC-2 |
| Test Conducted by: RD/KRR | | Test Date: 1/22/2014 |
| Analysis Performed by: KRR | Cooper & Jacob I | Analysis Date: 1/24/2014 |
| Aquifer Thickness: 68.00 m | Discharge: variable, average rate 23 [U.S. gal/min] | |




Calculation using COOPER & JACOB

| Observation Well | Transmissivity [m²/s] | Hydraulic Conductivity [m/s] | Storage coefficient | Radial Distance to PW [m] | |
|---|---|---|---|---|---|
| DC-2 | $7.00 \times 10^{-5}$ | $1.03 \times 10^{-6}$ | $8.72 \times 10^{-4}$ | | |

**Tetra Tech EBA**
**61 Wasson Place**
**Whitehorse, YT Y1A 0H7**

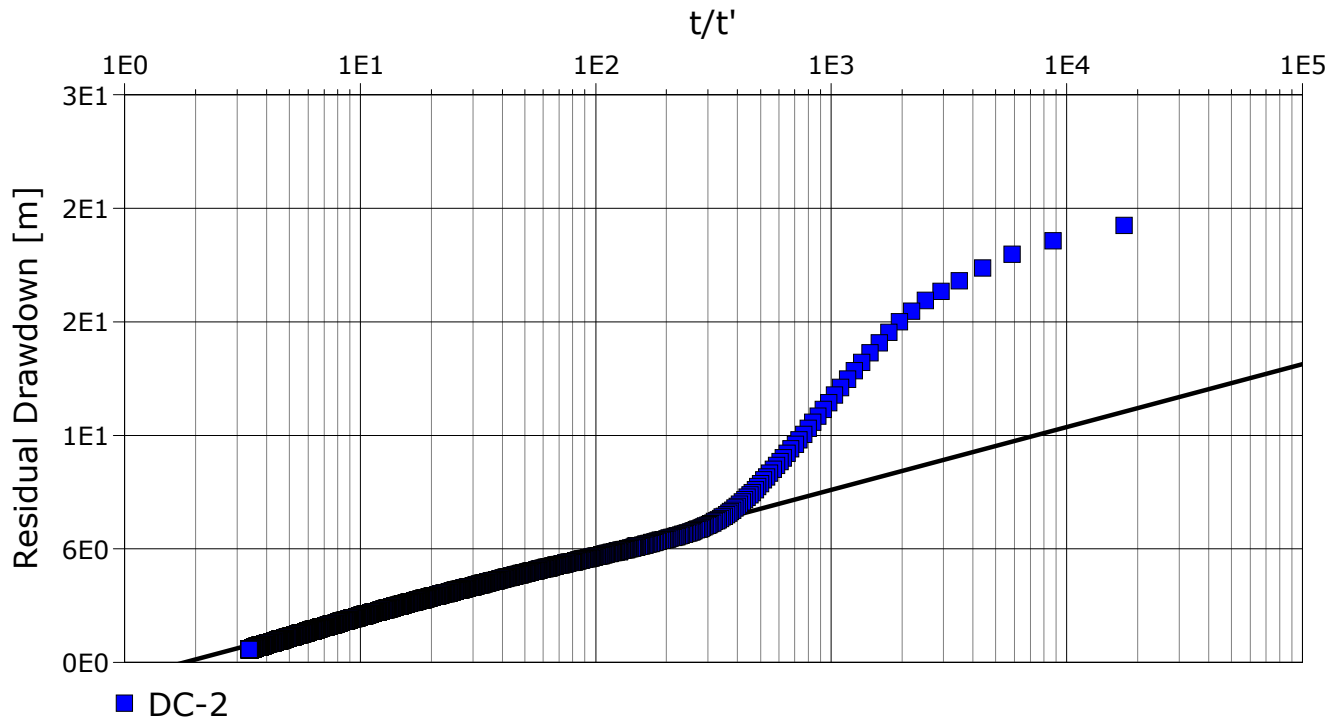
# Pumping Test Analysis Report

Project: DC-2 Well Completion and AWPP

Number: ENVH2O03020-01

Client: Government of Yukon

| | | |
|---|---|---|
| Location: DC-2 | Pumping Test: DC-2 Constant Rate Pumping Test | Pumping Well: DC-2 |
| Test Conducted by: RD/KRR | | Test Date: 1/22/2014 |
| Analysis Performed by: KRR | Theis Recovery | Analysis Date: 1/22/2014 |
| Aquifer Thickness: 68.00 m | Discharge: variable, average rate 23 [U.S. gal/min] | |




Calculation using THEIS & JACOB

| Observation Well | Transmissivity [m²/s] | Hydraulic Conductivity [m/s] | Radial Distance to PW [m] | |
|---|---|---|---|---|
| DC-2 | $8.00 \times 10^{-5}$ | $1.18 \times 10^{-6}$ | | |

# APPENDIX E
## DC-2 LABORATORY RESULTS

Tetra Tech EBA Inc.
ATTN: Gareth Earl
61 Wasson Place
Whitehorse YT Y1A 0H7

Date Received: 21-JAN-14
Report Date: 30-JAN-14 10:51 (MT)
Version: FINAL

Client Phone: 867-668-9222

# Certificate of Analysis

**Lab Work Order #: L1414070**

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 10-267432
Legal Site Desc:

Brent Mack
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | | Sample ID | L1414070-1 | | | | |
|---|---|---|---|---|---|---|---|
| | | Description | Grab | | | | |
| | | Sampled Date | 21-JAN-13 | | | | |
| | | Sampled Time | 12:15 | | | | |
| | | Client ID | DC-2 | | | | |
| **Grouping** | **Analyte** | | | | | | |
| **WATER** | | | | | | | |
| **Physical Tests** | UV Absorbance (254 nm) (Abs/cm-1) | | 0.0120 | | | | |
| | Colour, True (CU) | | <5.0 | | | | |
| | Conductivity (uS/cm) | | 887 | | | | |
| | Hardness (as CaCO3) (ug/L) | | 433000 | | | | |
| | pH (pH) | | 8.08 | | | | |
| | Total Suspended Solids (ug/L) | | <3000 | | | | |
| | Total Dissolved Solids (ug/L) | | 634000 | | | | |
| | Transmittance, UV (254 nm) (% T) | | 97.5 | | | | |
| | Turbidity (NTU) | | 3.90 | | | | |
| **Anions and Nutrients** | Alkalinity, Bicarbonate (as CaCO3) (ug/L) | | 214000 | | | | |
| | Alkalinity, Carbonate (as CaCO3) (ug/L) | | <1000 | | | | |
| | Alkalinity, Hydroxide (as CaCO3) (ug/L) | | <1000 | | | | |
| | Alkalinity, Total (as CaCO3) (ug/L) | | 214000 | | | | |
| | Chloride (Cl) (ug/L) | | 5800 | | | | |
| | Fluoride (F) (ug/L) | | <200 DLM | | | | |
| | Nitrate and Nitrite (as N) (ug/L) | | <51 | | | | |
| | Nitrate (as N) (ug/L) | | <50 DLM | | | | |
| | Nitrite (as N) (ug/L) | | 14 | | | | |
| | Total Kjeldahl Nitrogen (ug/L) | | 160 | | | | |
| | Orthophosphate-Dissolved (as P) (ug/L) | | <1.0 | | | | |
| | Phosphorus (P)-Total (ug/L) | | <2.0 | | | | |
| | Sulfate (SO4) (ug/L) | | 290000 | | | | |
| **Organic / Inorganic Carbon** | Dissolved Organic Carbon (ug/L) | | 1360 | | | | |
| | Total Organic Carbon (ug/L) | | 1630 | | | | |
| **Total Metals** | Aluminum (Al)-Total (ug/L) | | 6.2 | | | | |
| | Antimony (Sb)-Total (ug/L) | | 0.16 | | | | |
| | Arsenic (As)-Total (ug/L) | | 0.17 | | | | |
| | Barium (Ba)-Total (ug/L) | | 13.3 | | | | |
| | Beryllium (Be)-Total (ug/L) | | <0.10 | | | | |
| | Bismuth (Bi)-Total (ug/L) | | <0.50 | | | | |
| | Boron (B)-Total (ug/L) | | 35 | | | | |
| | Cadmium (Cd)-Total (ug/L) | | <0.010 | | | | |
| | Calcium (Ca)-Total (ug/L) | | 79500 | | | | |
| | Chromium (Cr)-Total (ug/L) | | 0.24 | | | | |
| | Cobalt (Co)-Total (ug/L) | | <0.10 | | | | |
| | Copper (Cu)-Total (ug/L) | | <0.50 | | | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Sample ID** | L1414070-1 | | | | |
| | **Description** | Grab | | | | |
| | **Sampled Date** | 21-JAN-13 | | | | |
| | **Sampled Time** | 12:15 | | | | |
| | **Client ID** | DC-2 | | | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Total Metals** | Iron (Fe)-Total (ug/L) | 344 | | | | |
| | Lead (Pb)-Total (ug/L) | <0.050 | | | | |
| | Lithium (Li)-Total (ug/L) | 21.4 | | | | |
| | Magnesium (Mg)-Total (ug/L) | 56600 | | | | |
| | Manganese (Mn)-Total (ug/L) | 10.5 | | | | |
| | Mercury (Hg)-Total (ug/L) | <0.010 | | | | |
| | Molybdenum (Mo)-Total (ug/L) | 3.54 | | | | |
| | Nickel (Ni)-Total (ug/L) | <0.50 | | | | |
| | Phosphorus (P)-Total (ug/L) | <50 | | | | |
| | Potassium (K)-Total (ug/L) | 860 | | | | |
| | Selenium (Se)-Total (ug/L) | <0.10 | | | | |
| | Silicon (Si)-Total (ug/L) | 7540 | | | | |
| | Silver (Ag)-Total (ug/L) | <0.010 | | | | |
| | Sodium (Na)-Total (ug/L) | 37900 | | | | |
| | Strontium (Sr)-Total (ug/L) | 6300 | | | | |
| | Sulfur (S)-Total (ug/L) | 94700 | | | | |
| | Thallium (Tl)-Total (ug/L) | <0.010 | | | | |
| | Tin (Sn)-Total (ug/L) | <0.10 | | | | |
| | Titanium (Ti)-Total (ug/L) | <10 | | | | |
| | Uranium (U)-Total (ug/L) | 0.085 | | | | |
| | Vanadium (V)-Total (ug/L) | <1.0 | | | | |
| | Zinc (Zn)-Total (ug/L) | <3.0 | | | | |
| **Dissolved Metals** | Dissolved Mercury Filtration Location | FIELD | | | | |
| | Dissolved Metals Filtration Location | FIELD | | | | |
| | Aluminum (Al)-Dissolved (ug/L) | <1.0 | | | | |
| | Antimony (Sb)-Dissolved (ug/L) | 0.13 | | | | |
| | Arsenic (As)-Dissolved (ug/L) | <0.10 | | | | |
| | Barium (Ba)-Dissolved (ug/L) | 13.1 | | | | |
| | Beryllium (Be)-Dissolved (ug/L) | <0.10 | | | | |
| | Bismuth (Bi)-Dissolved (ug/L) | <0.50 | | | | |
| | Boron (B)-Dissolved (ug/L) | 33 | | | | |
| | Cadmium (Cd)-Dissolved (ug/L) | <0.010 | | | | |
| | Calcium (Ca)-Dissolved (ug/L) | 80300 | | | | |
| | Chromium (Cr)-Dissolved (ug/L) | 0.18 | | | | |
| | Cobalt (Co)-Dissolved (ug/L) | <0.10 | | | | |
| | Copper (Cu)-Dissolved (ug/L) | <0.20 | | | | |
| | Iron (Fe)-Dissolved (ug/L) | 342 | | | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Sample ID** | L1414070-1 | | | | |
| | **Description** | Grab | | | | |
| | **Sampled Date** | 21-JAN-13 | | | | |
| | **Sampled Time** | 12:15 | | | | |
| | **Client ID** | DC-2 | | | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Dissolved Metals** | Lead (Pb)-Dissolved (ug/L) | <0.050 | | | | |
| | Lithium (Li)-Dissolved (ug/L) | 21.7 | | | | |
| | Magnesium (Mg)-Dissolved (ug/L) | 56400 | | | | |
| | Manganese (Mn)-Dissolved (ug/L) | 10.2 | | | | |
| | Mercury (Hg)-Dissolved (ug/L) | <0.010 | | | | |
| | Molybdenum (Mo)-Dissolved (ug/L) | 3.29 | | | | |
| | Nickel (Ni)-Dissolved (ug/L) | <0.50 | | | | |
| | Phosphorus (P)-Dissolved (ug/L) | <50 | | | | |
| | Potassium (K)-Dissolved (ug/L) | 970 | | | | |
| | Selenium (Se)-Dissolved (ug/L) | <0.10 | | | | |
| | Silicon (Si)-Dissolved (ug/L) | 7460 | | | | |
| | Silver (Ag)-Dissolved (ug/L) | <0.010 | | | | |
| | Sodium (Na)-Dissolved (ug/L) | 37300 | | | | |
| | Strontium (Sr)-Dissolved (ug/L) | 6270 | | | | |
| | Sulfur (S)-Dissolved (ug/L) | 90000 | | | | |
| | Thallium (Tl)-Dissolved (ug/L) | <0.010 | | | | |
| | Tin (Sn)-Dissolved (ug/L) | <0.10 | | | | |
| | Titanium (Ti)-Dissolved (ug/L) | <10 | | | | |
| | Uranium (U)-Dissolved (ug/L) | 0.081 | | | | |
| | Vanadium (V)-Dissolved (ug/L) | <1.0 | | | | |
| | Zinc (Zn)-Dissolved (ug/L) | <1.0 | | | | |
| **Speciated Metals** | Chromium, Trivalent (ug/L) | <5.0 | | | | |
| | Hexavalent Chromium (ug/L) | <1.0 | | | | |
| | Hexavalent Chromium-Dissolved (ug/L) | <1.0 | | | | |
| **Volatile Organic Compounds** | Benzene (ug/L) | <0.50 | | | | |
| | Ethylbenzene (ug/L) | <0.50 | | | | |
| | Methyl t-butyl ether (MTBE) (ug/L) | <0.50 | | | | |
| | Styrene (ug/L) | <0.50 | | | | |
| | Toluene (ug/L) | <0.50 | | | | |
| | ortho-Xylene (ug/L) | <0.50 | | | | |
| | meta- & para-Xylene (ug/L) | <0.50 | | | | |
| | Xylenes (ug/L) | <0.75 | | | | |
| | Surrogate: 4-Bromofluorobenzene (SS) (%) | 98.7 | | | | |
| | Surrogate: 1,4-Difluorobenzene (SS) (%) | 99.8 | | | | |
| **Hydrocarbons** | EPH10-19 (ug/L) | <250 | | | | |
| | EPH19-32 (ug/L) | <250 | | | | |
| | LEPH (ug/L) | <250 | | | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Sample ID** | L1414070-1 | | | | |
| | **Description** | Grab | | | | |
| | **Sampled Date** | 21-JAN-13 | | | | |
| | **Sampled Time** | 12:15 | | | | |
| | **Client ID** | DC-2 | | | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Hydrocarbons** | HEPH (ug/L) | <250 | | | | |
| | Volatile Hydrocarbons (VH6-10) (ug/L) | <100 | | | | |
| | VPH (C6-C10) (ug/L) | <100 | | | | |
| | Surrogate: 3,4-Dichlorotoluene (SS) (%) | 125.9 | | | | |
| **Polycyclic Aromatic Hydrocarbons** | Acenaphthene (ug/L) | <0.050 | | | | |
| | Acenaphthylene (ug/L) | <0.050 | | | | |
| | Acridine (ug/L) | <0.050 | | | | |
| | Anthracene (ug/L) | <0.050 | | | | |
| | Benz(a)anthracene (ug/L) | <0.050 | | | | |
| | Benzo(a)pyrene (ug/L) | <0.010 | | | | |
| | Benzo(b)fluoranthene (ug/L) | <0.050 | | | | |
| | Benzo(g,h,i)perylene (ug/L) | <0.050 | | | | |
| | Benzo(k)fluoranthene (ug/L) | <0.050 | | | | |
| | Chrysene (ug/L) | <0.050 | | | | |
| | Dibenz(a,h)anthracene (ug/L) | <0.050 | | | | |
| | Fluoranthene (ug/L) | <0.050 | | | | |
| | Fluorene (ug/L) | <0.050 | | | | |
| | Indeno(1,2,3-c,d)pyrene (ug/L) | <0.050 | | | | |
| | Naphthalene (ug/L) | <0.050 | | | | |
| | Phenanthrene (ug/L) | <0.050 | | | | |
| | Pyrene (ug/L) | <0.050 | | | | |
| | Quinoline (ug/L) | <0.050 | | | | |
| | Surrogate: Acenaphthene d10 (%) | 87.2 | | | | |
| | Surrogate: Acridine d9 (%) | 78.2 | | | | |
| | Surrogate: Chrysene d12 (%) | 84.1 | | | | |
| | Surrogate: Naphthalene d8 (%) | 86.2 | | | | |
| | Surrogate: Phenanthrene d10 (%) | 83.6 | | | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# Reference Information

**QC Samples with Qualifiers & Comments:**

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Strontium (Sr)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Sodium (Na)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Strontium (Sr)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Barium (Ba)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Cadmium (Cd)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Manganese (Mn)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Strontium (Sr)-Dissolved | MS-B | L1414070-1 |
| Matrix Spike | Total Kjeldahl Nitrogen | MSTN | L1414070-1 |

**Qualifiers for Individual Parameters Listed:**

| Qualifier | Description |
|---|---|
| DLM | Detection Limit Adjusted due to sample matrix effects. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| MSTN | TKN Matrix Spike recovery was low due to interference from high nitrate, which causes negative bias on TKN. |

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ALK-PCT-VA** | Water | Alkalinity by Auto. Titration | APHA 2320 "Alkalinity" |

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

| | | | |
|---|---|---|---|
| **ALK-PCT-VA** | Water | Alkalinity by Auto. Titration | APHA 2320 Alkalinity |

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

| | | | |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-F-IC-VA** | Water | Fluoride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-N+N-CALC-VA** | Water | Nitrite & Nitrate in Water (Calculation) | EPA 300.0 |

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

| | | | |
|---|---|---|---|
| **ANIONS-NO2-IC-VA** | Water | Nitrite in Water by Ion Chromatography | EPA 300.0 |

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

| | | | |
|---|---|---|---|
| **ANIONS-NO3-IC-VA** | Water | Nitrate in Water by Ion Chromatography | EPA 300.0 |

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

| | | | |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **CARBONS-DOC-VA** | Water | Dissolved organic carbon by combustion | APHA 5310 TOTAL ORGANIC CARBON (TOC) |

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

| | | | |
|---|---|---|---|
| **CARBONS-TOC-VA** | Water | Total organic carbon by combustion | APHA 5310 TOTAL ORGANIC CARBON (TOC) |

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

| | | | |
|---|---|---|---|
| **COLOUR-TRUE-VA** | Water | Colour (True) by Spectrometer | BCMOE Colour Single Wavelength |

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." 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. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

| | | | |
|---|---|---|---|
| **CR-CR3-ED** | Water | Chromium, Trivalent (Cr +3) | Total Dissolved Cr - Cr(+6) |

Chromium (III) is calculated as the difference between Total Chromium and Chromium (VI) results.

| | | | |
|---|---|---|---|
| **CR-CR6-ED** | Water | Chromium, Hexavalent (Cr +6) | APHA 3500-Cr C (Ion Chromatography) |

# Reference Information

This analysis is carried out using procedures adapted from method 3500-Cr C in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from Method 1636 published by the United States Environmental Protection Agency (EPA). The procedure involves analysis for chromium (VI) by ion chromatography using diphenylcarbazide in a sulphuric acid solution.
Results are based on an un-filtered, field-preserved sample.

**CR6-D-IC-ED** Water Chromium, Dissolved Hexavalent (Cr +6) APHA 3500-Cr C (Ion Chromatography)

This analysis is carried out using procedures adapted from method 3500-Cr C in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from Method 1636 published by the United States Environmental Protection Agency (EPA). The procedure involves analysis for chromium (VI) by ion chromatography using diphenylcarbazide in a sulphuric acid solution.
Results are based on a field-filtered, field-preserved sample.

**EC-PCT-VA** Water Conductivity (Automated) APHA 2510 Auto. Conduc.

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

**EPH-SF-FID-VA** Water EPH in Water by Tumbler and GCFID BC MOE EPH GCFID

Analysis is in accordance with BC MOE Lab Manual method "Extractable Petroleum Hydrocarbons in Water by GC/FID", v2.1, July 1999. Whole water samples are extracted with DCM prior to gas chromatography with flame ionization detection (GC-FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

**HARDNESS-CALC-VA** Water Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

**HG-DIS-LOW-CVAFS-VA** Water Dissolved Mercury in Water by CVAFS(Low) EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and 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 fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

**HG-TOT-LOW-CVAFS-VA** Water Total Mercury in Water by CVAFS(Low) EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The 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 fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

**LEPH/HEPH-CALC-VA** Water LEPHs and HEPHs BC MOE LABORATORY MANUAL (2005)

Light and Heavy Extractable Petroleum Hydrocarbons in water. These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated by subtracting selected Polycyclic Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for Acenaphthene, Acridine, Anthracene, Fluorene, Naphthalene and Phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for Benz(a)anthracene, Benzo(a)pyrene, Fluoranthene, and Pyrene are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 20, 1999).

**MET-D-CCMS-VA** Water Dissolved Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

**MET-DIS-LOW-ICP-VA** Water Dissolved Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

**MET-T-CCMS-VA** Water Total Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

**MET-TOT-LOW-ICP-VA** Water Total Metals in Water by ICPOES EPA 3005A/6010B

# Reference Information

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

**P-T-COL-VA** Water Total P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

**PAH-SF-MS-VA** Water PAH in Water by GCMS EPA 3510, 8270

The entire water sample is extracted with dichloromethane, prior to analysis by gas chromatography with mass spectrometric detection (GC/MS). Because the two isomers cannot be readily chromatographically separated, benzo(j)fluoranthene is reported as part of the benzo(b)fluoranthene parameter.

**PAH-SURR-MS-VA** Water PAH Surrogates for Waters EPA 3510, 8270

Analysed as per the corresponding PAH test method. Known quantities of surrogate compounds are added prior to analysis to each sample to demonstrate analytical accuracy.

**PH-PCT-VA** Water pH by Meter (Automated) APHA 4500-H "pH Value"

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

It is recommended that this analysis be conducted in the field.

**PH-PCT-VA** Water pH by Meter (Automated) APHA 4500-H pH Value

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

It is recommended that this analysis be conducted in the field.

**PO4-DO-COL-VA** Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

**S-DIS-ICP-VA** Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

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

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

**S-TOT-ICP-VA** Water Total Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

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

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

**TDS-VA** Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

**TKN-F-VA** Water TKN in Water by Fluorescence APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

**TSS-VA** Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

**TURBIDITY-VA** Water Turbidity by Meter APHA 2130 "Turbidity"

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

# Reference Information

| | | | |
|---|---|---|---|
| **TURBIDITY-VA** | Water | Turbidity by Meter | APHA 2130 Turbidity |

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

| | | | |
|---|---|---|---|
| **UV-%TRANS-VA** | Water | % Transmittance by Spectrometry | APHA 5910B UV ABSORPTION METHOD |

This analysis is carried out using procedures adapted from APHA Method 5910B "Ultraviolet Absorption Method" and Method 415.3 "Determination of Total Organic Carbon and Specific UV Absorbance at 254nm in Source Water and Drinking Water", published by the United States Environmental Protection Agency (EPA). The sample is filtered through a 0.45um filter and measured for absorbance in a quartz cell at 254nm and reported as % Transmittance. The analysis is carried out without pH adjustment.

| | | | |
|---|---|---|---|
| **UV-ABS-VA** | Water | UV Absorbance by Spectrometry | APHA 5910B UV ABSORPTION METHOD |

This analysis is carried out using procedures adapted from APHA Method 5910B "Ultraviolet Absorption Method" and Method 415.3 "Determination of Total Organic Carbon and Specific UV Absorbance at 254nm in Source Water and Drinking Water", published by the United States Environmental Protection Agency (EPA). The sample is filtered through a 0.45um filter and measured for absorbance in a quartz cell at 254nm and reported as absorbance per cm (i.e. cm-1). The analysis is carried out without pH adjustment. Alternatively, results can be reported as % Transmittance (over one cm) where the absorbance result is converted to % Transmittance by the following calculation: %T = 100(10 to the power of -A).

| | | | |
|---|---|---|---|
| **VH-HSFID-VA** | Water | VH in Water by Headspace GCFID | B.C. MIN. OF ENV. LAB. MAN. (2009) |

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transfered into a gas chromatograph. Compounds eluting between n-hexane and n-decane are measured and summed together using flame-ionization detection.

| | | | |
|---|---|---|---|
| **VH-SURR-FID-VA** | Water | VH Surrogates for Waters | B.C. MIN. OF ENV. LAB. MAN. (2009) |
| **VOC7-HSMS-VA** | Water | BTEX/MTBE/Styrene by Headspace GCMS | EPA8260B, 5021 |

The water sample, with added reagents, is heated in a sealed vial to equilibrium. The headspace from the vial is transfered into a gas chromatograph. Target compound concentrations are measured using mass spectrometry detection.

| | | | |
|---|---|---|---|
| **VOC7/VOC-SURR-MS-VA** | Water | VOC7 and/or VOC Surrogates for Waters | EPA8260B, 5021 |
| **VPH-CALC-VA** | Water | VPH is VH minus select aromatics | BC MOE LABORATORY MANUAL (2005) |

These results are determined according to the British Columbia Ministry of Environment Analytical Method for Contaminated Sites "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water". The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and, in solids, Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10).

| | | | |
|---|---|---|---|
| **XYLENES-CALC-VA** | Water | Sum of Xylene Isomer Concentrations | CALCULATION |

Calculation of Total Xylenes

Total Xylenes is the sum of the concentrations of the ortho, meta, and para Xylene isomers. Results below detection limit (DL) are treated as zero. The DL for Total Xylenes is set to a value no less than the square root of the sum of the squares of the DLs of the individual Xylenes.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| ED | ALS ENVIRONMENTAL - EDMONTON, ALBERTA, CANADA |
| VA | ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA |

**Chain of Custody Numbers:**

10-267432

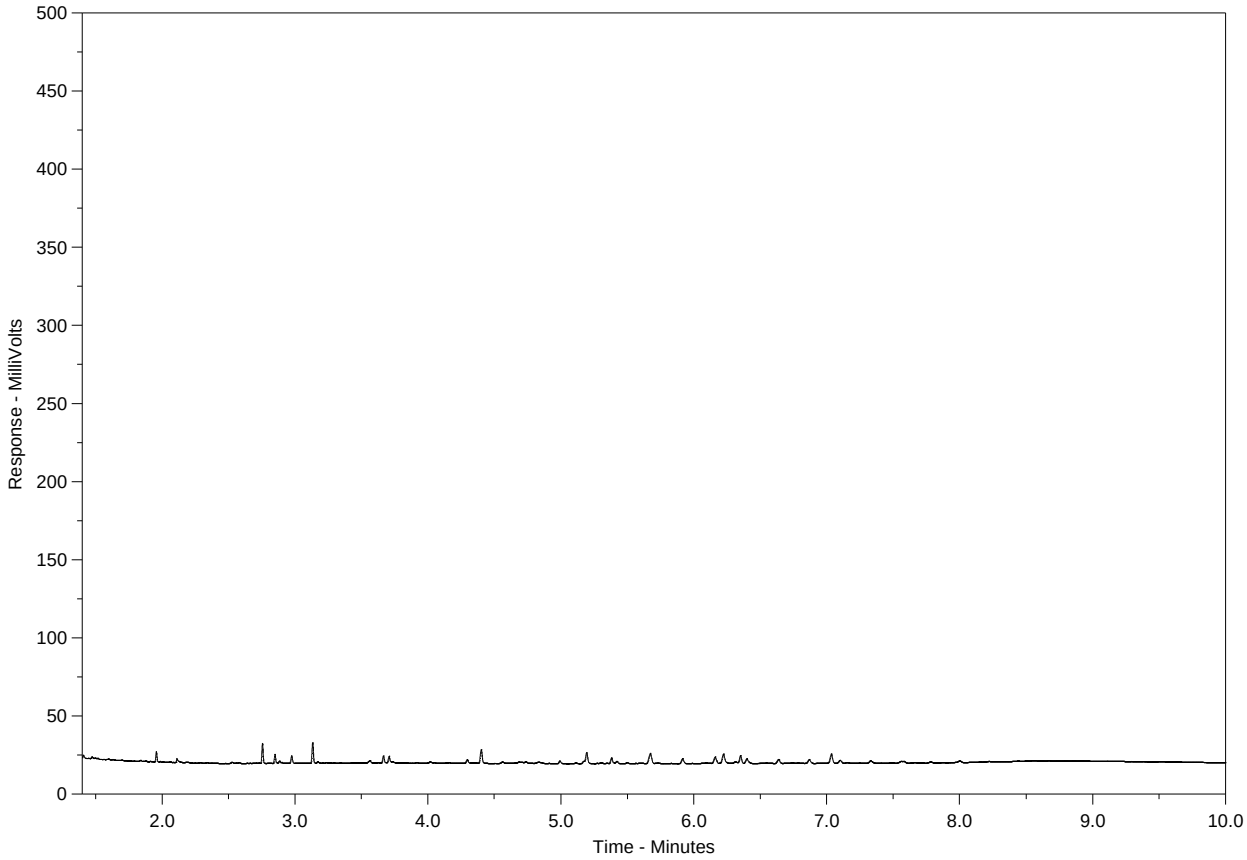
**GLOSSARY OF REPORT TERMS**

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Hydrocarbon Distribution Report

ALS Sample ID: L1414070-1
Client Sample ID: DC-2




| nC10 | nC19 | nC32 |
|---|---|---|
| 174°C | 330°C | 467°C |
| 346°F | 626°F | 873°F |
| ← Gasoline → | ← Motor Oils / Lube Oils / Grease → | |
| ← Diesel / Jet Fuels → | | |

The EPH Hydrocarbon Distribution Report (HDR) is intended to assist you in characterizing hydrocarbon products that may be present in your sample. For further interpretation, a current library of reference products is available on www.alsglobal.com or upon request.

The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and three n-alkane hydrocarbon marker compounds. Retention times may vary between samples by as much as 0.5 minutes.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the response scale at the left.

A "-L-" in the sample ID denotes a low level sample. A "-S-" denotes a silica gel cleaned sample.

10-267432

ALS Environmental

**Chain of Custody / Analytical Request Form**
**Canada Toll Free: 1 800 668 9878**
www.alsglobal.com

Page 1 of 1

| **Report To** | | **Report Format / Distribution** | | **Service Request:** (Rush subject to availability - Contact ALS to confirm TAT) | |
|---|---|---|---|---|---|
| Company: | EBA | Standard: X Other (specify): | | X | Regular (Standard Turnaround Times - Business Days) |
| Contact: | Gareth Earl | Select: PDF X Excel Digital Fax | | | Priority (2-4 Business Days) - 50% surcharge - Contact ALS to confirm TAT |
| Address: | 61 Wasson Rd. Whitehorse | Email 1: gearl@eba.ca. | | | Emergency (1-2 Business Days) - 100% Surcharge - Contact ALS to confirm TAT |
| | | Email 2: | | | Same Day or Weekend Emergency - Contact ALS to confirm TAT |
| Phone: | 868-9221 Fax: | | | **Analysis Request** | |
| **Invoice To** | Same as Report ? (circle) Yes or No (if No, provide details) | **Client / Project Information** | | ( Indicate Filtered or Preserved, F/P ) | |
| | Copy of Invoice with Report? (circle) Yes or No | Job #: | ENVH20030020-01 | | |
| Company: | | PO / AFE: | | | |
| Contact: | | LSD: | | | |
| Address: | | | | | |
| Phone: | Fax: | Quote #: | Q43394 | | |
| **Lab Work Order #** (lab use only) | | **ALS Contact:** | Sampler: ~~KF~~ Kristen Range. | | |

| Sample # | Sample Identification (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | GENERAL | DOC | TOC/TKN | TOTAL METALS (Low) | DISSOLVED METALS (Low) (CP+CS) | TOTAL/DISSOLVED (CP+CS) | BTEX + STYRENE/MTBE | LEPH/HEPH + PAH | | | | | Number of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bottle order BR114872 including total + dissolved metals and anions | 21/Jun/14 | 12:15pm | grab. | X | X | X | X | X | X | X | X | | | | | |
| | DC-2 | | | | | | | | | | | | | | | | |

L1414070-COFC

**Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details**

Ref. Bottle order #BR114872

**Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.**

**By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.**

| SHIPMENT RELEASE (client use) | | | SHIPMENT RECEPTION (lab use only) | | | | SHIPMENT VERIFICATION (lab use only) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Released by: | Date: | Time: | Received by: | Date: | Time: | Temperature: | Verified by: | Date: | Time: | Observations: Yes / No ? If Yes add SIF |
| | | | | 21-JAN-14 | 2:55 | 2.8 °C | | | | |

Exova
#104, 19575-55 A Ave.
Surrey, British Columbia
V3S 8P8, Canada

T: +1 (604) 514-3322
F: +1 (604) 514-3323
E: Surrey@exova.com
W: www.exova.com

## Report Transmission Cover Page

| | | | |
|---|---|---|---|
| Bill To: | Tetra Tech EBA Inc | Project: | |
| Report To: | Tetra Tech EBA Inc | ID: | ENVH2O03020 |
| | 61 Wasson Place | Name: | |
| | Whitehorse, YT, Canada | Location: | Deep Creek |
| | Y1A 0H7 | LSD: | |
| Attn: | Gareth Earl | P.O.: | |
| Sampled By: | Kristen Range | Acct code: | |
| Company: | EBA | | |

| | |
|---|---|
| Lot ID: | **982383** |
| Control Number: | |
| Date Received: | Jan 22, 2014 |
| Date Reported: | Feb 6, 2014 |
| Report Number: | 1890586 |

| Contact & Affiliation | Address | Delivery Commitments |
|---|---|---|
| Ryan Martin<br>Tetra Tech EBA Inc - Edmonton | 61 Wasson Place<br>Whitehorse, Yukon Territory Y1A 0H7<br>Phone: (867) 668-3068<br>Fax: (867) 668-4349<br>Email: ryan.martin@tetratech.com | On [Report Approval] send<br>(Test Report, COC) by Email - Merge Reports<br>On [Report Approval] send<br>(Test Report) by Email - Single Report<br>On [Report Approval] send<br>(Test Report) by Email - Single Report |
| Ingrid Fuller<br>Tetra Tech EBA Inc - Edmonton | 61 Wasson Place,<br>Whitehorse, Yukon Territory Y1A 0H7<br>Phone: (867) 668-2071<br>Fax: (867) 668-4349<br>Email: ifuller@eba.ca | On [Lot Approval and Final Test Report Approval] send<br>(Invoice) by Email - Single Report |
| Gareth Earl<br>Tetra Tech EBA Inc - Edmonton | 61 Wasson Place<br>Whitehorse, Yukon Territory Y1A 0H7<br>Phone: (867) 668-3068<br>Fax: (867) 668-4349<br>Email: Gareth.Earl@tetratech.com | On [Lot Verification] send<br>(COA) by Email - Single Report<br>On [Report Approval] send<br>(COC, Test Report) by Email - Merge Reports<br>On [Report Approval] send<br>(Test Report) by Email - Single Report<br>On [Report Approval] send<br>(Test Report) by Email - Single Report<br>On [Lot Creation] send<br>(COR) by Email - Single Report |

**Notes To Clients:**

Exova
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F: +1 (604) 514-3323
E: Surrey@exova.com
W: www.exova.com

## Sample Custody

| | | | |
|---|---|---|---|
| Bill To: | Tetra Tech EBA Inc | Project: | |
| Report To: | Tetra Tech EBA Inc | ID: | ENVH2O03020 |
| | 61 Wasson Place | Name: | |
| | Whitehorse, YT, Canada | Location: | Deep Creek |
| | Y1A 0H7 | LSD: | |
| Attn: | Gareth Earl | P.O.: | |
| Sampled By: | Kristen Range | Acct code: | |
| Company: | EBA | | |

| | |
|---|---|
| Lot ID: | **982383** |
| Control Number: | |
| Date Received: | Jan 22, 2014 |
| Date Reported: | Feb 6, 2014 |
| Report Number: | 1890586 |

## Sample Disposal Date: May 07, 2014

All samples will be stored until this date unless other instructions are received. Please indicate other requirements below and return this form to the address or fax number on the top of this page.

☐ Extend Sample Storage Until _____ (MM/DD/YY)

The following charges apply to extended sample storage:

| | |
|---|---|
| Storage for an additional 30 days | $ 2.50 per sample |
| Storage for an additional 60 days | $ 5.00 per sample |
| Storage for an additional 90 days | $ 7.50 per sample |

☐ Return Sample, collect, to the address below via:

- ☐ Greyhound
- ☐ DHL
- ☐ Purolator
- ☐ Other (specify) _____

Name _____
Company _____
Address _____
_____
Phone _____
Fax _____

Signature _____

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#104, 19575-55 A Ave.
Surrey, British Columbia
V3S 8P8, Canada

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F: +1 (604) 514-3323
E: Surrey@exova.com
W: www.exova.com



## Analytical Report

| | | | | | |
|---|---|---|---|---|---|
| Bill To: | Tetra Tech EBA Inc | Project: | | Lot ID: | **982383** |
| Report To: | Tetra Tech EBA Inc | ID: | ENVH2O03020 | Control Number: | |
| | 61 Wasson Place | Name: | | Date Received: | Jan 22, 2014 |
| | Whitehorse, YT, Canada | Location: | Deep Creek | Date Reported: | Feb 6, 2014 |
| | Y1A 0H7 | LSD: | | Report Number: | 1890586 |
| Attn: | Gareth Earl | P.O.: | | | |
| Sampled By: | Kristen Range | Acct code: | | | |
| Company: | EBA | | | | |

| | |
|---|---|
| **Reference Number** | 982383-1 |
| **Sample Date** | Jan 21, 2014 |
| **Sample Time** | 13:00 |
| **Sample Location** | |
| **Sample Description** | DC-2 |
| **Matrix** | Water |

| Analyte | | Units | Results | Results | Results | Nominal Detection Limit |
|---|---|---|---|---|---|---|
| **Routine Water** | | | | | | |
| pH | at 25 °C | pH | 7.69 | | | |
| **Trihalomethane Formation Potential** | | | | | | |
| pH adjustment | required prior to THMFP | | No | | | |
| Chlorine | spike concentration | mg/L | 5.0 | | | 0.1 |
| Incubation Time | | Days | 7 | | | 1 |
| Chlorine | final after incubation | mg/L | 3.3 | | | 0.1 |
| Bromodichloromethane | | mg/L | 0.004 | | | 0.001 |
| Bromoform | | mg/L | <0.001 | | | 0.001 |
| Chloroform | | mg/L | 0.017 | | | 0.001 |
| Dibromochloromethane | | mg/L | 0.002 | | | 0.001 |
| Total Trihalomethanes | | mg/L | 0.023 | | | 0.001 |
| **Trihalomethanes - Surrogate Recovery** | | | | | | |
| Dibromofluoromethane | EPA Surrogate | % | 91 | | | 86-118 |
| Toluene-d8 | EPA Surrogate | % | 98 | | | 88-110 |
| Bromofluorobenzene | EPA Surrogate | % | 109 | | | 86-115 |

Approved by:

Mathieu Simoneau
Operations Manager

Exova
#104, 19575-55 A Ave.
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V3S 8P8, Canada

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W: www.exova.com

## Quality Control

| | | | |
|---|---|---|---|
| Bill To: | Tetra Tech EBA Inc | Project: | |
| Report To: | Tetra Tech EBA Inc | ID: | ENVH2O03020 |
| | 61 Wasson Place | Name: | |
| | Whitehorse, YT, Canada | Location: | Deep Creek |
| | Y1A 0H7 | LSD: | |
| Attn: | Gareth Earl | P.O.: | |
| Sampled By: | Kristen Range | Acct code: | |
| Company: | EBA | | |

| | |
|---|---|
| Lot ID: | **982383** |
| Control Number: | |
| Date Received: | Jan 22, 2014 |
| Date Reported: | Feb 6, 2014 |
| Report Number: | 1890586 |

### Routine Water

| Client Sample Replicates | Units | Replicate 1 | Replicate 2 | % RSD Criteria | Absolute Criteria | Passed QC |
|---|---|---|---|---|---|---|
| pH | pH | 7.11 | 7.07 | 0 | 0.50 | yes |
| Date Acquired: | January 22, 2014 | | | | | |
| **Control Sample** | **Units** | **Measured** | **Lower Limit** | **Upper Limit** | | **Passed QC** |
| pH | pH | 4.10 | 3.88 | 4.12 | | yes |
| Date Acquired: | January 22, 2014 | | | | | |
| pH | pH | 8.01 | 7.88 | 8.12 | | yes |
| Date Acquired: | January 22, 2014 | | | | | |

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W: www.exova.com

## Methodology and Notes

| | | | |
|---|---|---|---|
| Bill To: | Tetra Tech EBA Inc | Project: | |
| Report To: | Tetra Tech EBA Inc | ID: | ENVH2O03020 |
| | 61 Wasson Place | Name: | |
| | Whitehorse, YT, Canada | Location: | Deep Creek |
| | Y1A 0H7 | LSD: | |
| Attn: | Gareth Earl | P.O.: | |
| Sampled By: | Kristen Range | Acct code: | |
| Company: | EBA | | |

| | |
|---|---|
| Lot ID: | **982383** |
| Control Number: | |
| Date Received: | Jan 22, 2014 |
| Date Reported: | Feb 6, 2014 |
| Report Number: | 1890586 |

## Method of Analysis

| Method Name | Reference | Method | Date Analysis Started | Location |
|---|---|---|---|---|
| pH in water (Surrey) | APHA | * pH - Electrometric Method, 4500-H+ B | 22-Jan-14 | Exova Surrey |
| Preparation - THM Formation Potential (Surrey) | APHA | * THM Potential, 5710 B | 22-Jan-14 | Exova Surrey |
| THM - PrepWater | US EPA | * US EPA method, 524 | 31-Jan-14 | Exova Calgary |

** Reference Method Modified*

## References

| | |
|---|---|
| APHA | Standard Methods for the Examination of Water and Wastewater |
| US EPA | US Environmental Protection Agency Test Methods |

## Comments:

Exova

Testing
Advisi
Assurir

LOT: 982383 COC

Control Number

# ole Information Sheet

is required in order to proceed with analysis

| Billing Address: | | | Copy of Report To: | | | Copy of invoice: |
|---|---|---|---|---|---|---|
| Company: | Tetra Tech EBA | | Company: | Tetra Tech EBA | | |
| Address: | 61 Wasson Place<br>Whitehorse, YT<br>Y1A 0H7 | QA/QC Report [x] | Address: | 61 Wasson Place<br>Whitehorse, YT<br>Y1A 0H7 | Mail invoice to this address for approval [ ] | |
| | | Report Result: | | | | Report Result: |
| Attention: | Gareth Earl | Fax [ ] | Attention: | Ryan Martin | | Fax [ ] |
| Phone: | 867.668.9222 | Mail [ ] | Phone: | 867.668.9221 | | Mail [ ] |
| Fax: | 867.668.4349 | Courier [ ] | Fax: | 867.668.4349 | | Courier [ ] |
| Cell: | | e-mail [x] | Cell: | | | e-mail [x] |
| e-mail: | Gareth.Earl@tetratech.com | Results Online [ ] | e-mail: | Ryan.Martin@tetratech.com | | Results Online [ ] |

**Information to be included on Report and Invoice**

Project ID: ENVH2O03020
Project Name:
Project Location: Dee
Legal Location:
PO#:
Proj. Acct. Code:
Agreement ID: **87038**

**RUSH** **Please contact the laboratory to confirm rush dates and times before submitting samples.**

Upon filling out this section, client accepts that surcharges will be attached to this analysis

RUSH required on: All Analysis [x] or As indicated [ ]
Date Required: to meet 24hr holding
Signature: GE
Exova Authorization:

Sample Custody (Please Print)
Sampled by: Kristen Range
Company: Tetra Tech EBA Signature: GE
I authorize Exova to proceed with the work work indicated on this form:
Date: January 21, 2014 Initial: GE

RECEIVED JAN 22

| Received by: | Sample Temp. 4.7°C |
|---|---|
| Waybill #: | Date |
| Company | Time |

Special Instructions / Comments
This sample was obtained from a test well;
the water is non-chlorinated - Tetra Tech EBA would like to determine the THM formation potential.

**FOR LAB USE ONLY**
Condiftion of containers/coolers upon arrival at lab
OK

[ ] Check here if Exova is required to report results directly to a regulatory body (Please include contact information)

[X] Check here if you are testing POTABLE WATER for **HUMAN CONSUMPTION**

Please indicate which regulations you are required to meet: _____

| | Sample Identification | Location | Depth IN CM M | Date/Time Sampled | Matrix | Sampling Method | Number of Containers | THM form. pot |
|---|---|---|---|---|---|---|---|---|
| 1 | DC-2 | Deep Creek | | 1/21/14, 1 pm | Water | S. Pump | 2 | [X] |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |

Enter tests above (✓ relevant samples below)

**NOTE: All hazardous samples must be labelled according to WHIMIS guidelines.**

Yukon
Health and Social Services
*Santé et Affaires sociales*
**Environmental Health Services**
***Service d'hygiène du millieu***

# BACTERIOLOGICAL ANALYSIS OF DRINKING WATER
# *ANALYSE BACTÉRIOLOGIQUE DE L'EAU POTABLE*


#2 Hospital Road, Whitehorse, Yukon Y1A 3H8
phone : (867) 667-8391 fax : (867) 667-8322
Toll free: 1-800-661-0408 ext.8391

*2 Hospital Road, Whitehorse (Yukon) Y1A 3H8*
*Tél. : 867-667-8391 Téléc. : 867-667-8322*
*Sans frais au Yukon : 1-800-661-0408, poste 8391*


## Contact Information • *Coordonnées de la personne ressource*

Contact Person / *Personne ressource*: Kristen Kunze (EBA)
Phone / *Téléphone*: 668-9233
Mailing address / *Adresse postale*: 61 Wasson Place
Fax / *Télécopieur*: 668-4243
Postal code / *Code postal*:
First Nation, Municipal or Business Name / *Nom de la Première nation, de la municipalité ou de l'entreprise*: EBA ENGINEERING
Agent / *Agent*:
Fax / *Télécopieur*:

## Sampling Location • *Lieu de la prise d'échantillon*

Municipal Address / *Adresse municipale*: DC-2 Deep Creek
Subdivision / *Lotissement*: Deep Creek
Legal Description Lot / *Désignation officielle Lot*:
Quad / *Quadrilatère*:
Plan no. / *Plan n°*:
Other Information (e.g., Location, Business / Building Name)
*Autres renseignements (ex. : emplacement, nom de l'entreprise, nom de l'édifice)*:

## Sample Collection / *Prélèvement de l'échantillon*

Sample Collected By / *Échantillon prélevé par*: Kristen Kunze
Date / *Date*: 14/01/21 (YY/MM/DD • *AA/MM/JJ*)
Time / *Heure*: 2:25 (am / pm)
Sampling Site (e.g., kitchen tap)
*Point d'échantillonnage (ex. : robinet de cuisine)*: Sampling tap
Is this a Resample from a Previous Test? / *Est-ce un deuxième échantillon d'un test antérieur?*: ☐ Yes / *Oui* ☒ No / *Non*
Previous Sample Number / *Numéro de l'échantillon précédent*:

## Sample Supply / *Source d'approvisionnement en eau*

☒ Public Supply / *Municipal – par canalisation*
☐ Bulk Water Distributor / *Municipal – par camion*
☐ Business / *Privé – entreprise*
☐ Private Residence / *Privé – résidence*

## Sample Source / *Provenance de l'échantillon*

☐ Dug Well / *Puits creusé*
☐ Driven Well / *Puits tubulaire*
☒ Drilled Well / *Puits foré à la sondeuse*
Depth of Well / *Profondeur du puits*: 400ft +
☐ Water Holding Tank / *Réservoir d'eau*
☐ Other (explain) / *Autre (précisez)*:

## Water Treatment / *Traitement de l'eau*

Is the Water Chlorinated? / *L'eau contient-elle du chlore?*: ☐ Yes / *Oui* ☒ No / *Non*
Free Available Chlorine / *Chlore libre disponible*: ppm / mg/L
Other Treatment Systems (e.g., UV, softener, filter)
*Autre dispositif de traitement (ex. : désinfection aux rayons UV, adoucisseur d'eau, filtre)*:

## For Laboratory Use Only / *À l'usage du laboratoire seulement*

**Receipt of Sample** / ***Réception de l'échantillon***: Date / *Date*: 14-01-21 (YY/MM/DD • *AA/MM/JJ*) Time / *Heure*: 245 (am / pm) By / *Par*: SS

**Condition of Sample** / ***État de l'échantillon***: ☑ Satisfactory / *Satisfaisant* ☐ Unsatisfactory / *Non satisfaisant* Details / *Précisez*: 2.2°C

**Incubation** / ***Incubation***: Date / *Date*: 14-01-21 (YY/MM/DD • *AA/MM/JJ*) Time / *Heure*: 300 (am / pm) By / *Par*: SS Incubator / *Incubateur*: 1

**Analysis Completed** / ***Analyse terminée***: Date / *Date*: 14-01-22 (YY/MM/DD • *AA/MM/JJ*) Time / *Heure*: 335 (am / pm) By / *Par*: SS

## Results (See Reverse Side for Interpretation) per 100 ml
## *Résultats (Voir au verso l'interprétation des résultats)*

| **Total Coliforms**/*Coliformes totaux* | | **E. coli**/*E. coli* | |
|---|---|---|---|
| ☐ Present / *Présence* | ☒ Absent / *Absence* | ☐ Present / *Présence* | ☒ Absent / *Absence* |

## Comments / *Commentaires*

Report Authorized By: [signature] Position: MIT Date: 14-01-22

SRC Group # 2014-1054

Feb 04, 2014

# *SRC ANALYTICAL*

422 Downey Road
Saskatoon, Saskatchewan, Canada
S7N 4N1
(306) 933-6932 or 1-800-240-8808

Tetra Tech EBA
61 Wasson Place
Whitehorse, Yukon Y1A 0H7
Attn: Kristen Range

Date Samples Received: Jan-31-2014 Client P.O.: ENVH2O03020-01

---

This is a final report.

Organics results have been authorized by Pat Moser, Supervisor

ICP results have been authorized by Keith Gipman, Supervisor

Inorganics and Radiochemistry results have been authorized by Jeff Zimmer, Supervisor

SLOWPOKE-2 results have been authorized by Dave Chorney

---

* Test methods and data are validated by the laboratory's Quality Assurance Program.

* Routine methods follow recognized procedures from sources such as

    * Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF
    * Environment Canada
    * US EPA
    * CANMET

* The results reported relate only to the test samples as provided by the client.

* Samples will be kept for 30 days after the final report is sent. Please contact the lab if you have any special requirements.

* Additional information is available upon request.

SRC Group # 2014-1054

# *SRC ANALYTICAL*

Feb 04, 2014

422 Downey Road
Saskatoon, Saskatchewan, Canada
S7N 4N1
(306) 933-6932 or 1-800-240-8808

Tetra Tech EBA
61 Wasson Place
Whitehorse, Yukon Y1A 0H7
Attn: Kristen Range

Date Samples Received: Jan-31-2014 Client P.O.: ENVH2O03020-01

**3094 01/21/2014 12:15 DC-2 *WATER***

| Analyte | Units | 3094 |
|---|---|---|
| **Radio Chemistry** | | |
| Gross alpha | Bq/L | 0.74±0.27 |
| Gross beta | Bq/L | 0.74±0.13 |

# APPENDIX F

## YUKON CONTAMINATED SITE RECORDS AND YUKON GOVERNMENT CORRESPONDENCE

## Range, Kristen

**From:** Dickson, Rob
**Sent:** Thursday, February 20, 2014 2:55 PM
**To:** Range, Kristen
**Subject:** FW: ENVH2O03020 Well Head Protection Plan, Lot 1009, Deep Creek, Yukon
**Attachments:** RE: W23103085 Well Head Protection Plan, Lot 1009, Deep Creek, Yukon

---

**From:** Bethany.Peters@gov.yk.ca [mailto:Bethany.Peters@gov.yk.ca]
**Sent:** Tuesday, February 11, 2014 11:11 AM
**To:** Dickson, Rob
**Subject:** RE: ENVH2O03020 Well Head Protection Plan, Lot 1009, Deep Creek, Yukon

Hi Rob,

I just did a quick search of the Spills Database, and there have been no additions since the last time I did a contaminated sites file review search for you (attached email).

Cheers,

**Bethany Peters**
*Environmental Protection Analyst*
Environment Yukon
P: 867.667.8848 F: 867.393.6205
e: Bethany.Peters@gov.yk.ca

---

**From:** Dickson, Rob [mailto:Rob.Dickson@tetratech.com]
**Sent:** Tuesday, February 11, 2014 11:07 AM
**To:** Bethany.Peters
**Subject:** ENVH2O03020 Well Head Protection Plan, Lot 1009, Deep Creek, Yukon

Hi Bethany,

I am preparing a Well Head Protection Plan for a water well site located approximately 300 m southwest of Lot 1009, Deep Creek, YT; Block number Quad 105E/03; Plan number 69329 CLSR YT  72673 LTO YT.

The UTM coordinates for the site is approximately 6 770 798 N and 488 393 E in Zone 8N. The NTS map sheet is 105E/03.

- *It would be preferable to include any spills/contaminated sites within a radius of 10km for the purposes of this project.*

I would appreciate a review of the contaminated sites and spill records to determine if there have been any documented spills on the property or the nearby properties (<10km radius). Thank you for your assistance. If you require any further information, please feel free to contact me.

Please note that your response will be included with the final report, for record keeping.

Thank you,

Rob

**Rob Dickson, EIT** | Environmental Engineer | Water Resources Diclipline | EBA Environment Practice
Direct **+1 (867) 668-9243** | **Rob.Dickson@tetratech.com**

**Tetra Tech** | Complex World, Clear Solutions™
**EBA Environment Practice** | 61 Wasson Place, Whitehorse, YT, Canada Y1A 0H7 | tetratech.com