



TETRA TECH EBA

PRELIMINARY AQUIFER AND WELLHEAD PROTECTION PLAN TAKHINI RIVER SUBDIVISION, YUKON



PRESENTED TO
Champagne Aishihik First Nation

MARCH 2014
ISSUED FOR USE
FILE: ENVH2O03005-01.004

This page intentionally left blank.

EXECUTIVE SUMMARY

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by Champagne Aishihik First Nation (CAFN) to develop a Preliminary Aquifer and Wellhead Protection Plan (AWHPP) for the Takhini River Subdivision water supply Well 1 serving the community water system.

The objective of the AWHPP is to provide practical protective measures to identify and manage activities within the inferred well capture zone and recharge areas for the Takhini River Subdivision water supply Well 1 with the intention of reducing risks to the groundwater source.

This plan is important for the protection of the valuable water resource, the health and safety of the community, and to protect the investment in water supply infrastructure. The AWHPP should be considered a living document which should be updated based on activities around the community well that might result in additional risks, or when risks have been addressed.

Groundwater from Well 1 currently meets the Guidelines for Canadian Drinking Water Quality with the exception of arsenic which is removed using a ferric oxide adsorption treatment system. Well 1 is completed in a confined sand and gravel aquifer overlain by a 130 m thick sequence of silt and clay, and is therefore considered to have very low susceptibility to surface sources of contamination based on the local hydrogeological conditions.

Based on the results of this study, Tetra Tech EBA provides the following conclusions and recommendations:

- Tetra Tech EBA applied a conservative approach to the capture zone delineation and risk assessment as part of this AWHPP. The conservative approach is based on a limited set of groundwater data used to infer the groundwater flow direction and gradient. The AWHPP and associated risk assessment regarding APECs potentially located within the well capture zone should be updated based on additional hydrogeological data that may become available in the future.
- A contaminant release within the identified well capture zone presents a potential risk to the confined groundwater aquifer and the water quality from Well 1; however, the thick low-permeability unit of silt and clay overlying the aquifer provides significant natural protection against surface sources of contamination with the well capture zone. The exposure likelihood to any potential contaminants originating from surface sources is therefore deemed by Tetra Tech EBA to be low or very low throughout the well capture zone.
- The highest risks to the community Well 1 are from potential releases and spills from the on-site backup generator fuel tank, residential fuel tanks, leachate from septic fields, a waste transfer facility to the west of the well and a storage yard containing old vehicles and vehicle parts to the northwest of the well.
- The preliminary AWHPP presented in this report should be updated following the completion of the planned backup well for the Takhini River Subdivision community water system. It is also strongly recommended to conduct another site visit during snow-free conditions to identify potential sources of contamination within the defined combined well capture zones of Well 1 and the backup well.

A list of risk reduction strategies is provided in Table 7 for identified areas of potential environmental concern (APECs) within (or in immediate vicinity of) the well capture zone. Recommendations for further risk reduction and management strategies are summarized in Sections 5.2 and 6.2 of this report.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
2.1 Location of Study Area.....	1
2.2 Existing Water and Waste Water System	1
2.3 Drinking Water Protection Measures	2
2.4 Other Wells in Takhini River Subdivision.....	3
2.5 Hydrogeology	3
2.5.1 Topography and Hydrology	3
2.5.2 Surficial and Bedrock Geology.....	4
2.5.3 Hydraulic Gradient and Groundwater Flow Direction.....	4
2.5.4 Aquifer Transmissivity and Hydraulic Conductivity	5
2.5.5 Aquifer Vulnerability	5
3.0 STAGE ONE – RISK FRAMEWORK	5
3.1 Risk Identification Approach.....	5
3.2 Responsible Parties.....	5
3.3 Risk Management Team	5
3.4 Risk Tolerance.....	6
4.0 STAGE TWO – RISK ASSESSMENT	6
4.1 Well Capture Zone Assessment.....	6
4.2 Potential Receptors	9
4.3 Identification of Risk Scenarios	9
4.4 Historical Aerial Photographs.....	10
4.5 Contaminated Sites and Spills Search, Environment Canada	10
4.6 Contaminated Sites and Spill Search, Government of Yukon.....	10
4.7 Surrounding Land Uses	11
4.8 Potential Contaminant Sources in Vicinity of Takhini River Subdivision Well.....	11
4.9 Water Quality Sampling Results.....	11
4.10 Identification of Risk in the Well Capture Zones.....	12
4.10.1 Zone 1 - Regulatory Setback Area (60 m radius)	13
4.10.2 Zone 2 – One Year Travel Time	13
4.10.3 Zone 3 – One to Five Year Travel Time.....	13
4.10.4 Zone 4 – Five to Ten Year Travel Time.....	13
4.11 Risk Evaluation and Mapping.....	14
5.0 STAGE THREE – RISK MANAGEMENT	17
5.1 Risk Management Strategy	17
5.2 Risk Reduction Plan.....	17
5.3 Risk Monitoring.....	20
6.0 CONCLUSIONS AND RECOMMENDATIONS.....	20

6.1	Conclusions.....	20
6.2	Recommendations.....	21

7.0 CLOSURE..... 22

REFERENCES 23

LIST OF TABLES IN TEXT

Table 1: Well Completion Details for Well 1	2
Table 3: Inferred Capture Zone Dimensions	8
Table 5: Exposure and Hazard Categories	15
Table 6: Risk Database and Risk Evaluation	16
Table 7: Risk Reduction/Elimination Strategies to be Considered	18

LIST OF FIGURES IN TEXT

Figure 5: Fundamental concepts of risk and risk management	9
Figure 6: Typical Risk Matrix used for Risk-based Aquifer and Wellhead Protection Planning	14
Figure 7: Risk ranking for APECs identified within or in immediate proximity to the inferred well capture zone.....	16

APPENDIX SECTIONS

TABLES

Table 2	Intrinsic Susceptibility Index Results
Table 4	Summary of Potential Hazards

FIGURES

Figure 1	Site Location Map
Figure 2	Site Plan
Figure 3	Surficial Geology
Figure 4	APEC Map Showing Capture Zone Area

APPENDICES

Appendix A	Tetra Tech EBA's General Conditions
------------	-------------------------------------

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Champagne and Aishihik First Nations and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) 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 the Champagne and Aishihik First Nations, 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 Champagne and Aishihik First Nations (CAFN) to prepare a preliminary Aquifer and Wellhead Protection Plan (AWHPP) for the community drinking water system served by water supply Well 1 in Takhini River Subdivision about 50 km northwest of Whitehorse, Yukon.

The objective of the AWHPP is to provide practical protective measures to identify and manage activities and potential risks within inferred well capture zone and recharge areas for the Takhini River Subdivision water supply well. This AWHPP is important to protect and reduce risks to the valuable groundwater resource, the health and safety of the community, and CAFN's investment in water supply infrastructure. The AWHPP should be considered a living document which should be updated based on activities near the community well that might result in additional risks, or when risks have been addressed and mitigated.

Tetra Tech EBA completed an assessment of the Takhini River Subdivision water system with Yukon Engineering Services (YES) in 2011 as part of an assessment of Large Public Drinking Water Systems in Yukon (YES 2011). The results of this assessment are considered in this report with updated information collected during Tetra Tech EBA's site visit on March 11, 2014. Summit Environmental Consultants Inc. completed a Groundwater Under the Direct Influence (GUDI) of surface water assessment in 2010 (Summit 2010) which contains relevant information pertaining to the risk of potential contamination of the well water from surface sources and was therefore also considered in the development of this AWHPP.

The AWHPP was developed for community water supply Well 1 that is currently supplying water to the Takhini River Subdivision water system. To provide a backup water source, CAFN has proposed the installation of a backup well which is expected to be completed in summer of 2014. Upon completion of the backup well, this preliminary AWHPP should be updated to include the new backup well.

Due to the time of contract award, snow cover was present during field reconnaissance; therefore an additional field reconnaissance is recommended during snow-free conditions. This AWHPP has been prepared as a preliminary exercise and should be updated upon installation of the proposed backup well and additional field reconnaissance.

2.0 SITE DESCRIPTION

2.1 Location of Study Area

The Takhini River Subdivision is located on the Alaska Highway at KM 1470 approximately 50 km northwest of Whitehorse, Yukon. A site location map is included as Figure 1.

2.2 Existing Water and Waste Water System

Takhini River Subdivision is currently served by one well (Well 1) connected to a Water treatment containing a water treatment system. Naturally elevated arsenic is removed from the raw water by ferric oxide adsorptive treatment. Water is also filtered and disinfected with sodium hypochlorite solution (chlorine), then pumped into storage tanks. Water is then hauled by truck to residences and buildings in Takhini River Subdivision.

Well 1 was drilled in May 1995 by Fredelana Enterprises Ltd. The well is enclosed in a metal wrapped insulated enclosure with surface casing extending to 1.2 m above ground surface. Well records do not show a surface sanitary seal for this well and based on this we assume for this AWHPP that no sanitary seal is present. The well completion details for Well 1 are presented in Table 1.

The well had originally been installed without a well screen and was retrofitted with a well screen in 2008 to address issues with raw water turbidity and sand content (EBA 2008).

Table 1: Well Completion Details for Well 1	
Date of Completion:	May 1995
Drilling Contractor/Method:	Fredelana Enterprises
Well Depth:	130.5 m (428 ft) bg
Well Diameter:	0.152 m (6 in)
Screen Size:	Stainless steel, 10-Slot (0.010" slot size)
Screen Interval:	129.3-130.5 m (424 – 428 ft) bg
Screen Length:	1.2 m (3.9 ft)
Static Water Level:	21.7 m (71.2 ft) bgs (Nov 2010)
Sanitary Surface Seal	None reported installed
Recommended Sustainable Yield:	1.20 L/s (19 USgpm)

Note: m bg – metres below ground surface

Wastewater is managed in the Takhini River Subdivision using on-site septic systems. We understand that on-site septic system residuals are routinely pumped out for offsite disposal using a vacuum truck. A site plan including existing water system infrastructure and the locations of the on-site wells is included as Figure 2.

Well 1 was originally rated for a safe yield of 3.28 L/s by Gartner Lee Limited (Gartner Lee 2002). Following the installation of the well screen in 2008, EBA estimated a revised safe yield of 1.2 L/s based on a 24-hour pumping test conducted after the well screen had been installed. Summit Environmental Consultants Inc. (Summit 2010) conducted another pumping test and deemed the current pump rate of about 0.95 L/s as an appropriate pumping rate for the well. YES 2011 estimated the ultimate projected demand for 2030 at 315 m³/week (0.5 L/s) assuming full development of the subdivision (100 lots, three people per lot).

Well 1 was evaluated by Summit Environmental in 2010 to determine whether the well is classifiable as Groundwater Under the Direct Influence of Surface Water (GUDI) or not. Based on the assumption that there is no surface sanitary seal, Well 1 does not meet the requirements of the Guidelines for Water Well Construction. However, based on the depth of the well and the thickness of low permeability sediments between the ground surface and the screen depth, Summit concluded that the lack of a surface seal does not pose a risk to the groundwater source and that Well 1 can be considered non-GUDI.

Currently, Well 1 is operated for about 12 to 14 hours per day twice a week based on information provided by the operator (Mr. John Widney, pers. comm.). The recommended sustainable yield of Well 1 is expected to be sufficient for meeting projected demands of Takhini River Subdivision. A backup water supply well has been proposed to allow for redundancy in the system, in case of a mechanical failure at Well 1.

2.3 Drinking Water Protection Measures

The *Protocol for Safe Drinking Water in First Nation Communities* (INAC 2006) outlines a multi-barrier approach to water protection, which is also the approach used in federal jurisdictions in Canada. This approach is intended to prevent contamination of drinking water. Utilizing a multi-barrier approach incorporates safeguards at each stage of the drinking water system to detect and prevent contamination before it reaches drinking water users.

The multi-barrier approach incorporates these conditions:

- Raw water sources are protected – measures include Aquifer and Wellhead Protection Planning, proper well construction and connection to the distribution system;
- Drinking water is effectively treated – in this case, raw groundwater in the Takhini River Subdivision is treated for arsenic, filtered, and disinfected using chlorine prior to water delivery to the users;
- Water storage and delivery infrastructure are maintained in clean and good working order – measures include regular inspections, proper maintenance procedures, and qualified operators; and
- Appropriate and comprehensive water quality testing is conducted – these include water quality testing of the raw water source, treated water in the treatment plant and distribution system, and end of line samples collected at the user's tap. Testing should be completed on a regular basis and in accordance with applicable regulations.

2.4 Other Wells in Takhini River Subdivision

Upon review of previous engineering reports, Tetra Tech EBA's well log database, and information collected during the site visit in March 2014, the following additional wells were identified in Takhini River Subdivision:

- A total of eight wells were installed as part of the construction of a closed-loop geoexchange system in 2013 by others. Each borehole was drilled to 76 m (250 ft.) and the full length of each borehole was grouted with a closed-loop in place. The geoexchange system will be used to provide heat to the water treatment plant and fire hall; however it has not yet been commissioned. The system will use a food-grade circulation fluid consisting of a 24% solution of propylene glycol mixed with water (JDQ 2014). It therefore poses no health risk to the community water system in the case of a leak and downhole loss of circulation fluid.
- Well 2, drilled under the direction of Gartner Lee in 2003 (Gartner Lee 2004), is located 26 m to the southeast of Well 1. This well was observed to have low yield and has since been incorporated into the multi-well geoexchange system. Well 2 was also completed with a closed-loop heat exchange piping to 76 m (250 ft.) and grouted with the well casing left in place. The encountered lithology in Well 2 consisted of about 5 m of fine sand and silt at surface followed by 343 m of glaciolacustrine silt and clay with some lenses of sand and gravel. Bedrock was encountered at 348 m bgs (Garnter Lee 2004).
- Additional well logs were identified in the general area of the Takhini River Subdivision and indicate similar lithologies as encountered in Wells 1 and 2; however, the well logs do not include an accurate location description and therefore, provide no reliable information in addition to the information from Wells 1 and 2.

2.5 Hydrogeology

2.5.1 Topography and Hydrology

Takhini River Subdivision is located at KM 1470 on the north side of the Alaska Highway. The community is located within a large meander of the Takhini River, in a low-lying valley with very little topographic relief. The nearest major surface water body to Well 1 is the Takhini River about 660 m away. There is a small shallow pond located about 280 m to the south of Well 1 and another pond about 700 m to the southeast.

2.5.2 Surficial and Bedrock Geology

The surficial geology in the area of the Takhini River Subdivision and inferred well capture zone mainly consists of glaciolacustrine deposits composed of silt and clay with some sand and gravel lenses based on the lithologies encountered in Wells 1 and 2, and information in Morison and Klassen (1991). Figure 3 shows a surficial geology map indicating that the glaciolacustrine deposits are extensive in the area. The area of the inferred capture zone completely falls within the glaciolacustrine deposits. Areas along the Takhini River and other creeks in the area contain younger alluvial sediments consisting of gravel, sand, and silt. The glaciolacustrine sediments encountered in the area of the Takhini River Subdivision were likely deposited in historical Glacial Lake Champagne. The lake was likely bounded by glaciers of the Cordilleran ice sheet during the last ice age (Barnes 1997). The best preserved known stand of the lake was at 765 m asl which is considerably higher than the current elevation in the area of the Takhini River Subdivision of about 675 m asl. Glacial Lake Champagne was very extensive and covered an estimated area of more than 2,400 km² and had a maximum depth of about 160 m. The age of the lake was estimated between about 12,500 and 10,500 BP (before present) and likely existed for a period of up to 400 years. The total thickness of sediments deposited in Lake Champagne is unknown but it is likely that the thick silt and clay sequence encountered in Well 1 and 2 also contains older sediments deposited before the presence of Lake Champagne.

Even though the legend on the surficial geology map (Figure 3) obtained from the Yukon Geological Survey indicates that the glaciolacustrine sediments are only about 5 to 10 m thick, this information is based on very large scale mapping of the surficial sediments and appears not representative of the conditions in the area of the Takhini Subdivision. The lithologies encountered in both Wells 1 and 2, as well as in other wells in the area, suggest that the local thickness of the glaciolacustrine deposits is several hundred metres thick, e.g., about 350 m at the location of Well 1 and 2. Tetra Tech EBA therefore believes that it is reasonable to assume that the aquifer in which Well 1 is completed is overlain by a 130 m thick glaciolacustrine sequence consisting of silt and clay with some lenses of sand and gravel within the entire inferred well capture zone.

Bedrock was not encountered in Well 1; however, bedrock was encountered in Well 2 at a depth of 348 m. From geology mapping in the area (Gordey 2008) the underlying bedrock consists of early Jurassic-aged granite and granodiorite from the Long Lake Plutonic Suite.

2.5.3 Hydraulic Gradient and Groundwater Flow Direction

Due to the relatively flat topography in the Takhini River Subdivision area, the regional groundwater flow direction is likely not dictated by local topography. The sand and gravel aquifer lies beneath a 130 m thick layer of glaciolacustrine silts and clays. Due to the thickness of these overlying lacustrine sediments, groundwater recharge is not likely a result of infiltrating surface water in the Takhini River Subdivision area but more likely to occur at some distance upgradient of the wellhead where the productive aquifer zone intersects a source of recharge water near the surface.

Based on the location of the Takhini River Subdivision within a large meander of the Takhini River and the assumption that the aquifer encountered in Well 1 is hydraulically connected to the river, we infer that the groundwater flow direction is north to northeast with an azimuth somewhere between 0° to 60°. In this case, the Takhini River would act as a constant head boundary to the east and south of Well 1.

However, given the depth of the aquifer and the thick low-permeability layer consisting of glaciolacustrine silts and clays, there is also the possibility that the aquifer encountered in Well 1 may not be hydraulically connected to the river and the actual groundwater flow direction may be different from the direction inferred for the purpose of this AWHPP. To account for this uncertainty due to the scarcity of hydrogeological information for the area, we have applied a conservative method for the delineation of the well capture zone of Well 1 (see Section 4.1).

2.5.4 Aquifer Transmissivity and Hydraulic Conductivity

In 2001, Gartner Lee completed a 24-hour pumping test on Well 1 (Gartner Lee 2002). In 2008, EBA completed additional well capacity testing after the well screen installation. The aquifer transmissivity was determined to be $6 \times 10^{-5} \text{ m}^2/\text{s}$ by EBA (2008). The results agree well with the results of the earlier pumping test conducted in 2001 with an estimated transmissivity of $5 \times 10^{-5} \text{ m}^2/\text{s}$. Using a transmissivity of $6 \times 10^{-5} \text{ m}^2/\text{s}$ and aquifer thickness of 1.2 m, the hydraulic conductivity of the aquifer is calculated to be $6 \times 10^{-5} \text{ m}^2/\text{s} / 1.2 \text{ m} = 5 \times 10^{-5} \text{ m/s}$.

2.5.5 Aquifer Vulnerability

Aquifer vulnerability is a measure of the potential of any contaminant introduced at or near surface to reach the groundwater table. The vulnerability of an aquifer is a key component of risk assessment.

Groundwater from Well 1 currently meets the Guidelines for Canadian Drinking Water Quality (GCDWQ) with the exception of arsenic which consistently exceeded the maximum allowable concentration of 0.01 mg/L. From pumping test analysis in 2001, Gartner Lee concluded that Well 1 is completed in a “leaky confined” aquifer (Gartner Lee 2002). Well 1 is completed at a depth of 130.5 m below ground (bg) and screened across a sand and gravel layer encountered within silt and clay materials.

The semi-quantitative Intrinsic Susceptibility Index (ISI) method suggested by the Ontario Ministry of the Environment (2001) provides an estimation of aquifer vulnerability, which is a measure of the aquifer’s risk exposure likelihood should a contaminant be introduced into the subsurface (e.g., from spills or leaks of any contaminant sources). EBA estimated the vulnerability of the aquifer serving Well 1 using the ISI method (EBA 2012). ISI scores from 0 to 30 indicate high vulnerability; 30 to 80 indicate medium vulnerability; and a value greater than 80 indicates the aquifer has low vulnerability to surface sources of contamination. The ISI calculated for Well 1 resulted in a score of 764 indicating that the well has very low vulnerability to surface sources of contamination due to significant natural protection by the thick sequence of glaciolacustrine silt and clay overlying the aquifer (see ISI calculations in Table 2 attached).

3.0 STAGE ONE – RISK FRAMEWORK

3.1 Risk Identification Approach

Risk identification can either be done in a qualitative (descriptive assessment of risk elements; receptors; hazards; and likelihood of exposure) or quantitative (based on probabilistic mathematical analysis of the risk elements resulting in a numerical risk ranking). As the site information is primarily qualitative in nature, the qualitative risk approach will yield the most meaningful and communicable project results.

3.2 Responsible Parties

For risk-based AWHPPs the responsible parties are considered to be the well/water supply system owners responsible for managing the water system (i.e., CAFN representatives), and the fiduciary body responsible for funding the system (i.e. Aboriginal Affairs and Northern Development Canada (AANDC)).

3.3 Risk Management Team

A Risk Management Team is key to the successful development and implementation of a risk-based AWHPP. The risk management team usually comprises representatives from the water supply system owner, technical advisors and key stakeholder groups such as the community well users and other users of the groundwater resource. For the purposes of this AWHPP, at this stage, we consider an appropriate risk management team to

include the Champagne Aishihik First Nation (the owner), CAFN water system operators, the AANDC, and Tetra Tech EBA (the technical advisor).

3.4 Risk Tolerance

For the purposes of implementing a risk-based AWHPP, risk tolerance is defined as a measure of the level of risk deemed acceptable by the risk management team or water supplier. A risk tolerant owner would be prepared to accept or transfer a certain level of risk, while a risk adverse owner would seek to eliminate any risks to the water supply. Terry Rufiange-Holway expressed that CAFN is tolerant of some risk as long as there are mitigation strategies in place for effectively managing the risks.

4.0 STAGE TWO – RISK ASSESSMENT

4.1 Well Capture Zone Assessment

The first technical step in developing an AWHPP is to define a well capture zone, which is the geographic area that contributes groundwater to a well. The capture zone is a key element in an AWHPP, 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.

To define the capture zone for Well 1, Tetra Tech EBA assumed the following:

- The well will be pumped at an average rate of 0.6 L/s. This pump rate provides 20% additional contingency to the long-term projected demand discussed in Section 2.2 for additional growth of the subdivision or the potential supply of potable water for the community of Champagne. For this reason, this is a conservative assumption.
- The groundwater flow direction is inferred to be north to northeast (azimuth of approximately 0° to 60°; see Section 2.5.3) with a very small natural horizontal hydraulic gradient (assumed to be of the same order of magnitude as the gradient of the Takhini River in this area, or $<5 \times 10^{-4}$ m/m).
- The mean transmissivity of the aquifer is about 5×10^{-5} m²/s and hydraulic conductivity is about 5×10^{-5} m/s (see Section 2.5.4).

Given the uncertainty in groundwater flow direction due to the lack of data and the assumption that the natural gradient is very small, Tetra Tech EBA used the Calculated Fixed Radius method suggested by the BC Well Protection Toolkit (BC Water Stewardship Division 2006). This method conservatively assumes a flat hydraulic gradient and extension of the capture zone in all directions based on an induced gradient by the cone of depression under pumping conditions.

The radii of the well capture zone are calculated as follows:

$$r = \sqrt{\frac{10,038 \cdot Q \cdot t}{n \cdot b}}$$

where:

r = calculated radius of the capture zone (m)

Q = estimated pumping rate (0.6 L/s)

t = allowed travel time to the well (1 year, 5 years, and 10 years)

n = aquifer porosity (assumed to be 0.25 for the sand and gravel aquifer)

b = aquifer thickness or screen length (m) (1.2 m of exposed screen and similar aquifer thickness based on driller's well log)

The resulting radii of the well capture zone based on the Calculated Fixed Radius method are used in part to construct the inferred capture zone presented in Table 3. However, the concentric capture zone radii are modified here, as described below.

The Calculated Fixed Radius method does not use aquifer transmissivity to infer the capture zone dimensions. However, several pumping tests to infer aquifer properties have been conducted on Well 1 and Tetra Tech EBA therefore also used the method of Thiem (1906) to infer the extent of the well capture zone.

The Thiem solution for steady-state flow in a confined aquifer is:

$$s = \frac{Q}{2\pi T} \cdot \ln\left(\frac{r}{R}\right)$$

where:

s = drawdown at the radial distance r from the pumping well (m)

T = aquifer transmissivity (m^2/s)

R = radius of influence (m)

Since the radius of influence R is not readily definable, Tetra Tech EBA also performed transient calculations of the drawdown using the Thiem equation. We assumed a quasi-steady-state regime would be reached after about one year of pumping which results in a theoretical extent of the cone of depression of about 10 km. Therefore, a radius of influence of 10 km was used for the steady-state drawdown calculations using the Thiem solution described above.

The distance d to the one-year, five-year, and 10-year time of travel boundary within the cone of depression determined using the Thiem solution is then calculated as follows:

$$d = \frac{t \cdot K \cdot i}{n}$$

where:

d = distance to the 1-year, 5-year, and 10-year travel time boundary within the well capture zone

t = travel time to the well (1 year, 5 years, and 10 years)

K = hydraulic conductivity (m/s)

n = aquifer porosity (assumed to be 0.25 for the sand and gravel aquifer)

i = hydraulic gradient which was determined from the inferred drawdown within the cone of depression induced by the pumping well based on the steady-state solution of Thiem (see above). That is, the hydraulic gradient i was determined based on the hydraulic head difference between the Well 1 and each point within the cone of depression based on the drawdown calculated using the Thiem solution.

Table 3 shows the inferred capture zone dimensions based on the Calculated Fixed Radius and Thiem methods. The Thiem method results in inferred capture zone dimensions that are about twice as large as the Calculated Fixed Radius method.

Table 3: Inferred Capture Zone Dimensions		
Travel Time	Calculated Fixed Radius	Thiem
	<i>r</i> (m)	<i>d</i> (m)
1 Year	142	282
5 Years	317	665
10 Years	448	959

Figures 3 and 4 show the inferred capture zone of Well 1. As a conservative step and in light of the semi-quantitative nature of this evaluation, the Calculated Fixed Radius method was used for the inferred downgradient area of the capture zone (i.e., to the north and east), whereas the Thiem Method was used for the inferred upgradient area of the capture zone (i.e., the west and south). The irregular capture zone shape is therefore a conservative hybrid of these two evaluation methods.

It is important to note that the inferred capture zones depicted in Figures 3 and 4 only accounts for horizontal travel time within the aquifer. Any potential contaminant originating at surface would also have to travel vertically through the thick sequence of glaciolacustrine silt and clay encountered at the location of Well 1. The vertical travel time is difficult to quantify precisely given the lack of information on the extent and thickness of the protective layer in other areas in and around the well capture zone. There is also no measured information on the hydraulic conductivity of the silt and clay formation. However, vertical travel times are likely significant and may even exceed the inferred horizontal travel times considerably. A semi-quantitative estimate of the vertical travel time through the 130 m thick silt and clay unit is presented below and based on the following assumptions:

- Hydraulic conductivity value of $K = 1 \times 10^{-8}$ m/s for silt and clay (Freeze & Cherry 1979);
- Hydraulic gradient of $i = 1$;
- Effective porosity of $n = 0.35$; and,
- Thickness of the glaciolacustrine silt and clay unit of $m = 130$ m

The average linear flow velocity v and travel time t can then be calculated using Darcy's Law as follows:

$$v = \frac{K \cdot i}{n}$$

$$t = m/v$$

Based on the above assumptions, the semi-quantitatively estimated travel time through the glaciolacustrine silt and clay is about 144 years.

The additional protection by the thick silt and clay formation and associated long vertical travel times have been taken into account by Tetra Tech EBA in the assessment of the exposure likelihood to potential contaminants originating from surface (see Section 4.11).

4.2 Potential Receptors

Potential receptors are the users of the community water supply system including piped or trucked water distribution to all of the residents of Takhini River Subdivision. Treated water from Well 1 is pumped into a holding tank and distributed to residents via a trucked delivery system.

4.3 Identification of Risk Scenarios

Risk is defined as the potential for exposure of a receptor to a hazard. Thus the three components of risk are the receptor (1), the hazard (2) and the potential for exposure (3) to that hazard. Risk can be reduced or removed by reducing or eliminating any of the three elements (see Figure 5 below).

Risk assessment as part of an AWHPP is the process of evaluating the potential consequences and severity of the hazard and the likelihood of exposure then ranking and mapping the identified risk scenarios. To create a risk ranking, the components of risk can be evaluated in terms of the potential effects on the receptor:

- Potential for exposure is evaluated in terms of the likelihood of a receptor (e.g., human, animals or plants) coming into contact with a hazard.
- Hazards can be categorized in terms of the severity of the hazard (contaminant toxicity).

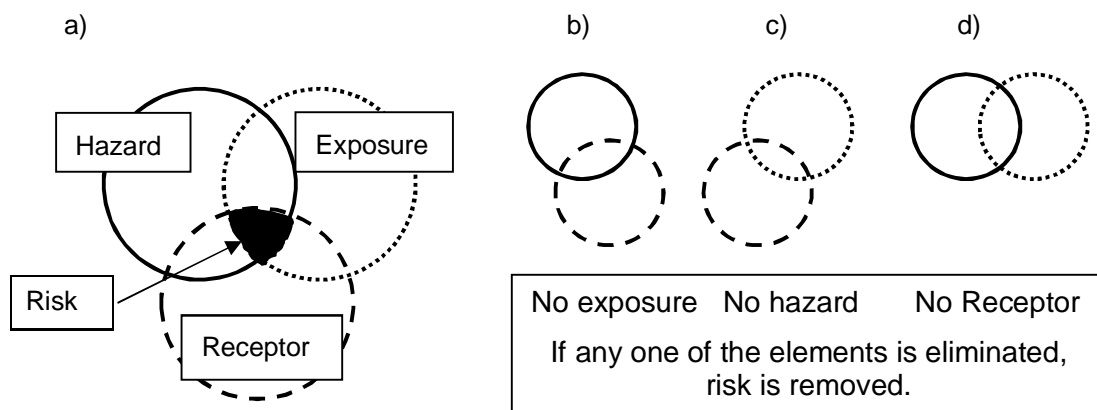


Figure 5: Fundamental concepts of risk and risk management

For the purposes of this conservative assessment, a hazard is assigned the highest potential concern that may be presented at the wellhead for that hazard with no attenuation, retardation or reduction in hazard severity along its travel path to the well.

In order to evaluate potential risks to the community well, potential sources of contamination were identified. These potential sources were investigated and mapped as Areas of Potential Environmental Concern (APEC) on a map with respect to the well capture zones (Figure 3). Tetra Tech EBA identified APECs within about 1 km of the well, which corresponds to the inferred extent of the capture zone, in the surrounding community and along the Alaska Highway.

Tetra Tech EBA used several different methods to identify APECs near and within the inferred well capture zone, including:

- Meeting with CAFN representatives for collection of anecdotal information and visual site reconnaissance (completed on March 11, 2014). Note that the site was snow covered at this date and that another site visit during snow-free conditions is recommended as part of the development of an updated AWHPP that also includes the planned backup well;
- Reviewing current and historical aerial photos for the area for surrounding land use;
- Completing a search of Environment Canada records for contaminated sites and spills in the area of the Takhini River Subdivision;
- Completing an area search (5 km radius of the Site) for contaminated sites and spills within Government of Yukon's database for contaminated sites;
- Reviewing available previous reports pertaining to the site and the immediate vicinity; and
- Reviewing available water quality results.

4.4 Historical Aerial Photographs

Historical aerial photographs of the Takhini River Subdivision area from 1946, 1978, 1986, 1994, and 2007 were reviewed by Tetra Tech EBA. A gravel pit area is visible in the 1946 aerial photograph at the southeast corner of the subdivision near the Alaska Highway. A road can also be seen leading south from the Alaska Highway to the cemetery adjacent to the Takhini River.

Several buildings and a clearing are visible on the south side of the Alaska Highway approximately 200 m west of the Takhini River Bridge. This development, located Alaska Highway KM 1521.5, was used as a military construction camp in the 1940s according to K. Bisset and Associates (Bisset 1995).

The subdivision can be seen in the aerial photograph from 1994 and approximately 15 houses are visible within the subdivision. The south east corner of Lot 96 also appears to be cleared with a rectangular building near the residential road. In 1994, a cleared area is also visible to the north west of the wellhead. This clearing was observed to be a vehicle dump area during the March 2014 site reconnaissance. Two shop buildings and an outdoor ice rink can be seen at Lot 96 adjacent to the wellhead in the 2007 aerial photograph. The residential road extends further to the north, creating another block of residential lots containing 10 additional houses. Several abandoned vehicles appear to be stored in the cleared area to the northwest of the wellhead.

4.5 Contaminated Sites and Spills Search, Environment Canada

A search of the online Government of Canada Federal Contaminated Sites Inventory was conducted to locate contaminated site in the Takhini River Subdivision area. There were no known contaminated sites within 5 km of Well 1.

4.6 Contaminated Sites and Spill Search, Government of Yukon

Government of Yukon, Department of Environment, Environmental Programs Branch (YG EPB) has maintained the Yukon Spills Report Center since 2001. YG EPB conducted a search of spills and contaminated sites records within a 5 km radius of Well 1. No spills or contaminated sites were identified on the site or within the Takhini River subdivision. One spill record was found at km 1564.5 of the Alaska Highway on the north side of the road. The spill record states that fuel was spilled from a truck that went off the highway. The identified spill is located outside of the inferred well capture zone.

4.7 Surrounding Land Uses

Takhini River Subdivision contains approximately 40 residential properties. Development in the area includes farming activities in the Ibex Valley about 5 km to the east of Takhini River Subdivision and a gravel quarry pit about 3 km to the south of the community on the other side of the Takhini River. Both areas are not located within the inferred well capture zone.

4.8 Potential Contaminant Sources in Vicinity of Takhini River Subdivision Well

A list of all APECs located within the inferred well capture zone and their corresponding potential contaminants of concern (PCOCs) are summarized in Table 4. Both potential biological pathogens and chemical contaminants have been considered in this inventory. Figures 2 and 3 show the spatial distribution of the identified APECs in Table 4, in relation to the defined capture zone of Well 1.

Note that only the APECs located within the well capture zone have been considered with respect to risk and within the development of this AWHPP; however, a summary of all APECs identified as part of this study are included in Table 4. The main types of APECs identified in the community are listed below:

Above Ground Storage Tanks (AST) – Tetra Tech EBA identified ASTs within the area of the well capture zone and in the immediate surrounding community.

Septic Systems – Septic fields were identified within the area of the community well capture zone as part of the site visit. During the site visit Tetra Tech EBA observed several septic cleanout pipes to the north of the onsite fire hall building within 60 m of Well 1. The exact location of the septic field could not be determined in the field; however in a letter from consultant Neils Jacobsen to Yukon Environmental Health Services on March 31, 2004 it was stated that the septic field was relocated to provide a 60 m setback from Well 1 (Jacobsen 2004). The location of the septic field is shown on Figure 2 assuming the setback distance of 60 m.

Rock Pit – The fire hall building's garage bay area is equipped with a concrete sump which drains to a rock pit approximately 60 m north of Well 1. The distance from the Rock Pit to Well 1 is based on a hand-drawn map provided by CAFN, and could not be verified by Tetra Tech EBA in the field at the time of the site visit. Any chemical release within the garage bay would drain into the rock pit. The rock pit is therefore considered an APEC.

Waste Transfer Station – A waste transfer station for household waste is located approximately 300 m west of Well 1 within the area of the community well capture zone.

Vehicle Storage Yard – Two old dump areas were observed approximately to the northwest of Well 1 within the area of the community well capture zone. These dump areas were used for storage of abandoned vehicles and various other wastes. Most of the old vehicles have recently been removed; however, there are still a few vehicles and other debris remaining at the site. No assessment of the soil for potential contamination has been carried out.

Cemetery – CAFN representatives reported the existence of an old cemetery near the Takhini River to the south of Well 1.

4.9 Water Quality Sampling Results

Bacteriological

According to the Public Health and Safety Act Drinking Water Regulation O.I.C. 2007/139 (Y-DWR), for a large public drinking water system serving less than 500 users, the owner is required to complete bacteriological testing

twice a month for total coliforms and *Escherichia coli* (*E. coli*) from each raw water source and from the point where treated water enters the distribution system.

Tetra Tech EBA reviewed the results of bacteriological testing completed between April 4, 2005 and April 11, 2011 (YES 2011). This included a total of 377 total coliform and *E. coli* sampling tests completed.

- Over the period of record, there was one positive total coliform result from a raw water sample (1% of raw water tests). There were no positive *E. coli* results reported from raw water samples over the same period. The positive total coliform result was observed on July 10, 2008; subsequent samples from this location did not have total coliform present.
- Over the period of record, there were five positive total coliform results in treated water samples (1.8% of the treated water samples), and no positive *E. coli* results. Three of these positive results were observed in samples taken during a single sampling event on January 10, 2010. The other two positive results were observed in May 10, 2005 from the water truck and September 2, 2008 from the truck delivery hose.
- Bacteriological testing has been conducted on a bi-weekly basis with a few exceptions over the period of record. Since February 2009, the sampling has been completed bi-weekly with no noted exceptions.

General Chemistry and Physical Quality

In accordance with the Y-DWR, testing for general physical and chemical parameters is required to be completed at least once a year for parameters indicated in Schedule B of the regulations. As the Takhini River Subdivision uses only Well 1 as a drinking water source, they are required to sample raw water from this source. YES (2011) reviewed the available analytical data for this system including four sampling events from November 2006 to August 2010. Two sampling events were conducted in 2010 and included both treated and raw water.

Arsenic concentrations were found to exceed the Canadian drinking water guidelines health-based maximum allowable concentration (MAC) of 0.01 mg/L in all four samples. CAFN commissioned an arsenic treatment system in 2013 to address these exceedances.

4.10 Identification of Risk in the Well Capture Zones

For the purposes of this AWHPP, the capture zone of the well has been broken down into zones with different levels of control required to safeguard the water supply. These zones are defined based on applicable regulations and time it will take for a contaminant to reach the well. The well capture zones are defined as follows:

- Zone 1 - Regulatory Setback Area within a radius of 60 m. The Yukon Public Drinking Water Regulations state that potential surface sources of contamination such as septic fields or rock pits should be located outside of the 60 m setback distance. This area requires the highest level of control to protect the groundwater resource, and is considered to be at risk from microbial as well as chemical contaminants.
- Zone 2 – between 60 m and one year travel time to reach the well. Zone 1 is considered to be at risk from both microbial and chemical contaminants.
- Zone 3 – between one and five years to reach the well. Zone 2 is considered to be at risk from chemical contaminants.
- Zone 4 – between five and ten years to reach the well. Zone 3 is considered to be at risk from chemical contaminants.

4.10.1 Zone 1 - Regulatory Setback Area (60 m radius)

Potential hazards within Zone 1 include:

- Spills or leaks of fuel from the fuel storage tank for the backup generator located inside the water treatment building; and
- Spills or leaks when transferring fuel from the fuel truck into the backup generator at the fill point near the northwest corner of the water treatment building.

4.10.2 Zone 2 – One Year Travel Time

Potential hazards within Zone 2 include:

- Biological and chemical contaminants from two on-site septic fields located approximately 63 m north and 63 m west of the wellhead;
- Contaminants from the garage bay sump which drains to the on-site rock pit located approximately 60 m north of the wellhead;
- Potential contaminants from the former vehicle dump areas west of the wellhead;
- Impacts from the solid waste transfer facility west of the wellhead adjacent to Lot 97;
- Biological and chemical contaminants from residential septic fields in the Takhini River Subdivision;
- Spills or leaks of fuel from residential heating oil tanks in the Takhini River Subdivision;
- Chemical or fuel spills due to transportation along the Alaska Highway; and
- Potential groundwater impacts from future development on adjacent lots zoned for commercial and industrial development (Lot 103).

4.10.3 Zone 3 – One to Five Year Travel Time

Potential hazards within Zone 3 include:

- Biological and chemical contaminants from residential septic fields in the Takhini River Subdivision;
- Spills or leaks of fuel from residential heating oil tanks in the Takhini River Subdivision;
- Chemical or fuel spills due to transportation along the Alaska Highway; and
- Potential groundwater impacts from future development on residential or commercially zoned lots in Zone 3.

4.10.4 Zone 4 – Five to Ten Year Travel Time

Potential hazards within Zone 4 include:

- Biological and chemical contaminants from residential septic fields in the Takhini River Subdivision;
- Spills or leaks of fuel from residential heating oil tanks in the Takhini River Subdivision;
- Chemical or fuel spills due to transportation along the Alaska Highway;

- Potential groundwater impacts from future development in Zone 4; and
- Potential groundwater impacts from the cemetery near the Takhini River located approximately 850 m south of the wellhead.

4.11 Risk Evaluation and Mapping

Risk to the well users was evaluated for each of the hazards identified using the Risk Matrix shown in Figure 6. The following factors were used to define the categories of exposure likelihood and hazard consequence:

- Magnitude of the hazard source;
- Location relative to the well (i.e., distance from the well);
- Groundwater travel time from the hazard location to the well;
- The likelihood of the contaminant directly affecting the water well; and
- The severity of the hazard to users of the well.

Given the significant natural protection of the aquifer by the overlying thick sequence of glaciolacustrine silt and clay and the associated large vertical travel time for any potential contaminant originating from a surface source, the inferred exposure likelihood is taking this additional aquifer protection into account by reducing the exposure likelihood to only range from nil to low. Therefore, the exposure likelihood for bacteriological pathogens was deemed by Tetra Tech EBA to range from nil to very low and the exposure likelihood for chemical contaminants was deemed to range from very low to low.

The risk matrix (Figure 6) provides the potential risk posed by each of the hazards identified within the well capture zones. An overall risk of “Very Low”, “Low”, “Medium”, “High” and “Very High” was assigned to each potential contaminant of concern (hazard) identified within the well capture zone. The risk levels were based on the combined exposure likelihood and consequence for the potential contaminant source.

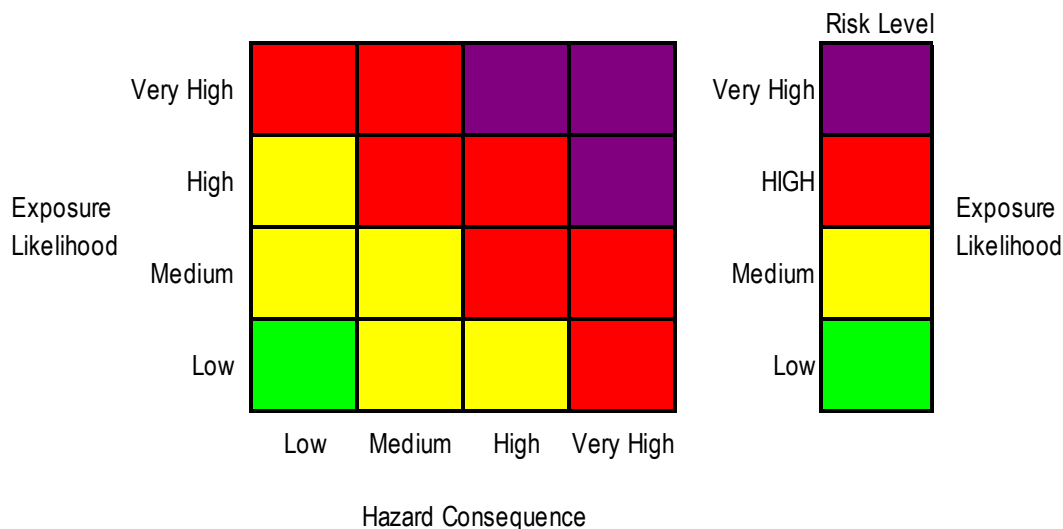


Figure 6: Typical Risk Matrix used for Risk-based Aquifer and Wellhead Protection Planning

Table 5 identifies the rational used for assigning “Low”, “Medium”, “High”, or “Very High” potential values to exposure likelihood and hazard consequence for each APEC in, or within proximity to the well capture zones.

Table 5: Exposure and Hazard Categories		
Exposure Likelihood		Criteria
Bacteriological Pathogen	Chemical Contaminant	
Nil	Very Low	Groundwater travel time 5 to 10 years (Zone 4)
Nil	Very Low	Groundwater travel time 1 to 5 years (Zone 3)
Very Low	Very Low	Groundwater travel time of less than 1 year (Zone 2)
Low	Low	60 m Regulatory Setback (Zone 1)
Hazard Consequence (Bacteriological and Chemical Contaminants)		Human Criteria
Very Low		No substantial health or aesthetic effects
Low		Exceeds aesthetic objectives in drinking water guidelines
Medium		Short-term health conditions (Lost time: days)
High		Chronic health hazard (Lost time: weeks to months)
Very High		Acute health hazard (permanent disabilities or fatalities)

Figure 7 and Table 6 present the risk evaluation for the APECs identified within the inferred well capture zone.

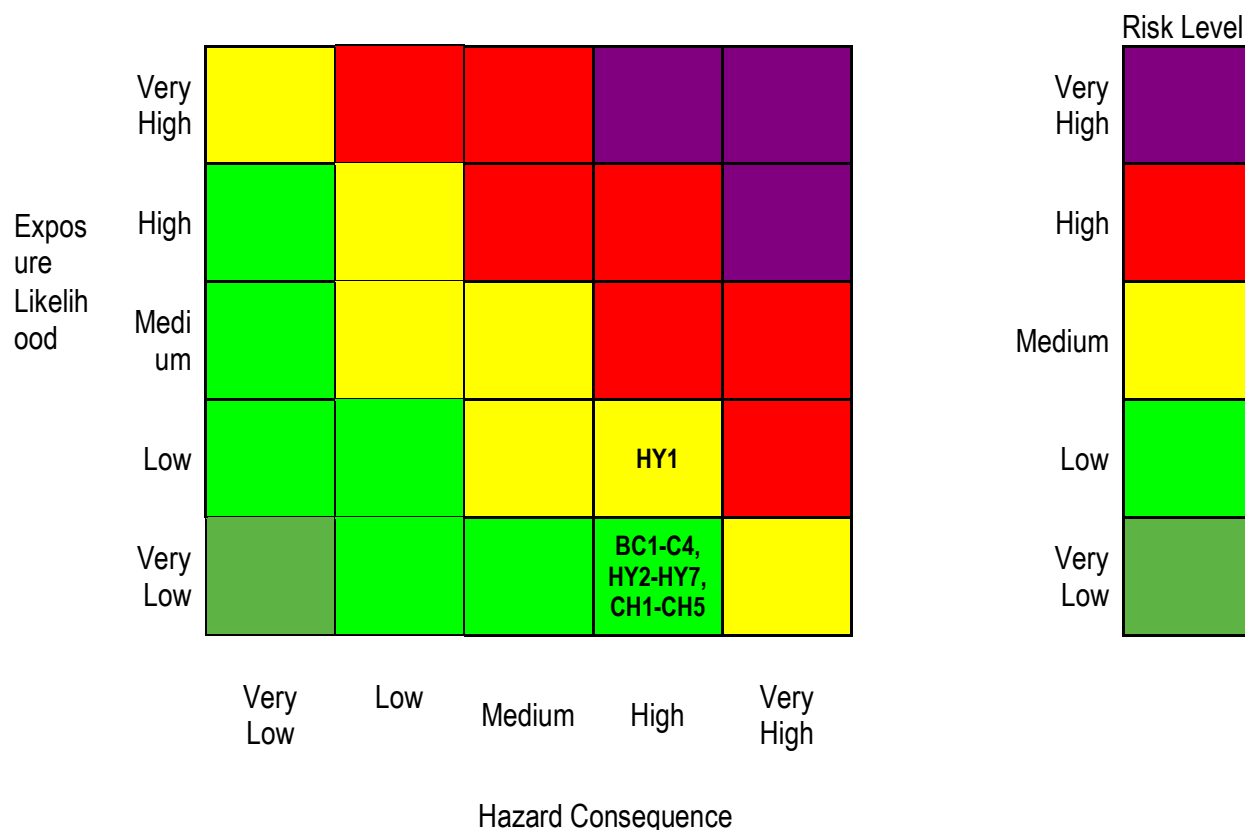


Figure 7: Risk ranking for APECs identified within or in immediate proximity to the inferred well capture zone

Note that the risk ranking is based on a conservative approach of capture zone delineation. If further assessment confirms that the APECs are located outside of the capture zone the risk ranking should be updated accordingly.

Table 6: Risk Database and Risk Evaluation

Map ID	Time (Capture Zone)	Hazard Description	Exposure Likelihood	Hazard Consequence	Risk Rank
BC1-BC4	Zone 2 less than 1 year	Bacteria, Viruses, Protozoa within Zone 2 from septic fields located on site and at Lots 1, 10, and 97, or from any future developments	Very Low	High	Low
CH1-CH3	Zone 2 less than 1 year	Potential chemical releases within Zone 2 such as the on-site rock pit and adjacent dump areas or from any future developments	Very Low	High	Low
CH4	Zone 3 1 to 5 years	Potential chemical releases within Zone 3 such as the solid waste transfer station west of Lot 97	Very Low	High	Low
CH5	Zone 4 5 to 10 years	Potential chemical releases within Zone 4 such as impacts from the cemetery near Takhini River	Very Low	High	Low
HY1	Zone 1 - Regulatory Setback Zone (60 m)	Hydrocarbon (fuel, oil products) spills/leaks within the regulatory setback zone such as leaks from the on-site backup generator fuel tank or fuel truck	Low	High	Medium
HY2 & HY3	Zone 2 less than 1 year	Hydrocarbon (fuel, oil products) spills/leaks within Zone 2 such as leaks from the residential heating oil tank at Lots 97 and 1 or from any future developments	Very Low	High	Low
HY4 to HY6	Zone 3 1 to 5 years	Hydrocarbon (fuel, oil products) spills/leaks within Zone 3 such as leaks from residential heating oil tanks identified at Lots 12, 16, and 19	Very Low	High	Low
HY7	Zone 4 5 to 10 years	Hydrocarbon (fuel, oil products) spills/leaks within Zone 4 such as leaks from the residential heating oil tank identified at Lot 24	Very Low	High	Low

5.0 STAGE THREE – RISK MANAGEMENT

Risk management is the objective of a risk based AWHPP and is the final stage of the process. Risk management involves several components which are discussed in the following sections.

5.1 Risk Management Strategy

The risk management strategy integrates the capture zone and hazard identification information to inform decision making processes and provide workable strategies for preventing, detecting, and responding to risks. These strategies might include:

- Public information sessions to inform water users of potential risks to the groundwater source;
- Endorsing and promoting Best Management Practices (BMPs) in handling, treating, distributing and protecting the water resource;
- Periodic inspections and/or reviews of the AWHPP and wellhead areas; and/or
- Implementing the action and management strategies summarized in Table 7.

Most hazard scenarios identified are potential rather than existing threats to the Takhini River Subdivision well, and the thick silt/clay layer will tend to provide a strong barrier to contaminants reaching the well intake. Therefore, based on the AWHPP 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.

Water quality results from Well 1 do not suggest any considerable impact from upgradient septic fields, fuel tanks or dumping areas on the water quality of the wells at this time. We recommended implementing education and monitoring programs for septic fields and tanks within the regulatory setback of 60 m and the one year travel time zone (Zone 2). No new fuel storage facilities, chemical-heavy operations or fuel stations should be allowed within Zone 1 or Zone 2, without suitable engineered barriers and containment systems.

In terms of risk communication, a Risk Map and Risk Information Poster 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, and reduce potential legal issues.

5.2 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 for the Takhini River Subdivision is provided in Table 7.

Table 7: Risk Reduction/Elimination Strategies to be Considered

Map ID	Hazard Description	Risk	Risk Reduction Options to Consider	Risk Elimination Options to Consider
BC1-BC4	Bacteria, Viruses, Protozoa within Zone 2 from septic fields located on site and at Lots 1, 10, and 97, or from any future developments	Low	<ul style="list-style-type: none"> Ensure that septic systems are maintained properly. Sample regularly for bacteriological analysis. 	<ul style="list-style-type: none"> Decommission individual septic systems and prohibit future individual systems within Zone 2
CH1-CH3	Potential chemical releases within Zone 2 such as the on-site rock pit and adjacent dump areas or from any future developments	Low	<ul style="list-style-type: none"> Remove remaining abandoned vehicles and other waste from the dump area west of the well site. Install an oil water separator in the sump, and as part of the emergency response plan, ensure that any spills into the on-site sump are documented and that well water is monitored closely in the event of a chemical spill. Control future commercial and industrial developments in Zone 2 through zoning regulations (e.g., do not allow for chemical-heavy operations at Lots 90 to 93 and 103 or new commercial lots north of the well site). 	<ul style="list-style-type: none"> Remove sump system and prohibit vehicle maintenance, and use or storage of any chemicals in the garage bay on site. Remove all waste from the dump area west of the well site and assess potential contamination of the soils in the area.
CH4	Potential chemical releases within Zone 3 such as the solid waste transfer station west of Lot 97	Low	<ul style="list-style-type: none"> Complete regular inspections of the solid waste transfer station to ensure that household waste is disposed of properly and that any on-site household chemicals or hazardous wastes are secured and removed immediately. As part of the emergency response plan, ensure that spills at the transfer station are documented and remediated properly. 	<ul style="list-style-type: none"> Relocate the waste transfer station to a location outside the inferred capture zone of the well.
CH5	Potential chemical releases within Zone 4 such as impacts from the cemetery near Takhini River	Low	<ul style="list-style-type: none"> No risk reduction strategies recommended. 	<ul style="list-style-type: none"> No risk elimination strategies recommended

Table 7: Risk Reduction/Elimination Strategies to be Considered

Map ID	Hazard Description	Risk	Risk Reduction Options to Consider	Risk Elimination Options to Consider
HY1	Hydrocarbon (fuel, oil products) spills/leaks within the regulatory setback zone (Zone 1) such as leaks from the on-site backup generator fuel tank or fuel truck	Medium	<ul style="list-style-type: none"> Complete routine checks of the backup generator fuel tank to identify any leaks and monitor the fuel truck closely when it is on site. Install engineered barrier (secondary containment) around fill pipes, and on-site backup generator 	<ul style="list-style-type: none"> Convert back-up generator system to Propane.
HY2 & HY3	Hydrocarbon (fuel, oil products) spills/leaks within Zone 2 such as leaks from the residential heating oil tank at Lots 1 and 97 or from any future developments	Low	<ul style="list-style-type: none"> Equip all residential fuel storage tanks with secondary containment structures as a minimum level of protection. Control future commercial and industrial developments in Zone 2 through zoning regulations (e.g., prohibit tank farms or fuel stations at Lots 90 to 93 and 103 or new commercial lots north of the well site). As part of the emergency response plan, ensure that fuel spills within Zone 2 are documented and cleaned up immediately. Any potential (future) impact on the well water quality should be assessed. 	<ul style="list-style-type: none"> Remove on-site backup generator and all residential heating oil tanks within Zone 2.
HY4 to HY6	Hydrocarbon (fuel, oil products) spills/leaks within Zone 3 such as leaks from residential heating oil tanks identified at Lots 12, 16, and 19	Low	<ul style="list-style-type: none"> Equip all residential fuel storage tanks with secondary containment structures as a minimum level of protection. Control future commercial and industrial developments in Zone 3 through zoning regulations (e.g., prohibit tank farms or fuel stations at Lots 90 to 93 and 103 or new commercial lots north of the well site). As part of the emergency response plan, ensure that fuel spills within Zone 3 are documented and cleaned up immediately. Any potential (future) impact on the well water quality should be assessed. 	<ul style="list-style-type: none"> Remove all residential fuel storage tanks, and prohibit any fuel storage for future developments.

Table 7: Risk Reduction/Elimination Strategies to be Considered

Map ID	Hazard Description	Risk	Risk Reduction Options to Consider	Risk Elimination Options to Consider
HY7	Hydrocarbon (fuel, oil products) spills/leaks within Zone 4 such as leaks from the residential heating oil tank identified at Lot 24	Low	<ul style="list-style-type: none"> Equip all residential fuel storage tanks with secondary containment structures as a minimum level of protection. As part of the emergency response plan, ensure that fuel spills within Zone 4 are documented and cleaned up immediately. Any potential (future) impact on the well water quality should be assessed. 	<ul style="list-style-type: none"> Remove all residential fuel storage tanks, and prohibit any fuel storage for future developments.

5.3 Risk Monitoring

A Risk Monitoring Plan involves periodic reviewing, auditing and updating of the Risk Maps and Risk Database. Once an AWHPP is in place, continued implementation of the program is essential for it to be worthwhile. The Risk Monitoring Plan entails periodically inspecting the community wells and well sites; periodically inspecting the capture zones for new AWHPP hazards; working with residents of the Takhini River Subdivision to identify and establish communication strategies for potential risks to the Community Wells; and updating the status for each identified risk as risk management actions are implemented. The outcome of this would be revised Risk Maps for display or reporting purposes.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Tetra Tech EBA has completed this AWHPP at the request of the Champagne Aishihik First Nation for the Takhini River Subdivision water well, Well 1. Based on the results of this AWHPP, Tetra Tech EBA emphasizes the following conclusions:

- The capture zone estimated and presented herein accounts for uncertainties in the groundwater flow direction and natural hydraulic gradient and is considered by Tetra Tech EBA to be conservative.
- A contaminant release within the identified well capture zone will present a potential risk to the aquifer and the water quality from Well 1. However, the thick glaciolacustrine silt and clay unit overlying the aquifer provides significant protection against potential contaminants originating from surface sources. It is because of this thick protective layer that calculated apparent risks (using matrix table approach) were effectively reduced by one rank for practical further consideration and management options.
- The highest risks to the community Well 1 are from potential releases and spills from above ground storage tanks (ASTs), leachate from septic fields, and a waste transfer station site to the west of the well.
- Old vehicles and other debris that were dumped in an area to the west of the well may also pose a potential risk. Most of the old vehicles have been removed from the site; however, no further assessment has been carried out to identify potential soil contamination in this area.

6.2 Recommendations

In addition to the risk reduction/elimination strategies identified in Table 7, Tetra Tech EBA recommends the following:

- Replace above ground storage tanks within the capture zones with double walled tanks and flex line hosing for secondary containment;
- Endorse and promote hazardous waste minimization and collection programs; hazardous waste (including household hazardous chemicals or old vehicles with remaining fluids, batteries etc.) should not be stored at the waste transfer station or on any of the residential properties;
- Implement contingency planning including emergency response actions and communication. CAFN should develop and update the emergency and spill response plan identifying key personnel responsible to respond in the event of an occurrence or spill when changes in governance;
- Complete regular tracking and monitoring of all risks to the community well (either with internal staff resources or outsourced to Tetra Tech EBA);
- Provide awareness regarding the well capture zone by installing signs identifying entrances to the AWHPP area;
- Review and update the AWHPP on a regular basis. Every five years may be sufficient or as required due to changes affecting the well system or risk management around the well;
- Incorporate this AWHPP into the community development plan and environmental management plan. 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, and designated recharge areas;
 - 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; and
 - A response action plan and remedial action plans as a condition of development for some specified higher risk land uses.
- The preliminary AWHPP presented in this report should be updated following the completion of the planned backup well for the Takhini River Subdivision community water system. It is also strongly recommended to conduct another site visit during snow-free conditions to identify potential sources of contamination within the defined combined well capture zones of Well 1 and the backup well.

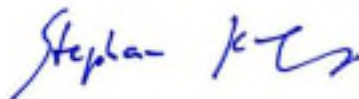
7.0 CLOSURE

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

Respectfully submitted,
Tetra Tech EBA Inc.



Prepared by:
Rob Dickson, EIT
Junior Environmental Engineer – Water Resources
Environment Practice
Direct Line: 867.668.9243
Rob.Dickson@tetrattech.com



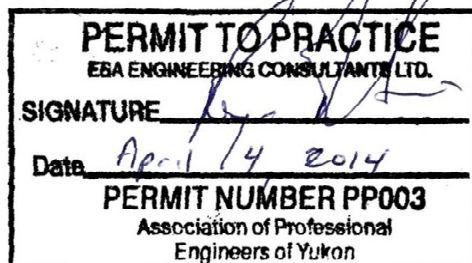
Prepared by:
Stephan Klump, Ph.D.
Senior Hydrogeologist - Water Resources
Environment Practice
Direct Line: 867.668.9220
Stephan.Klump@tetrattech.com



Reviewed by:
Ryan Martin, M.Eng., P.Eng.
Director – Water Resources
Environment Practice
Direct Line: 867.668.9221
Ryan.Martin@tetrattech.com

H. Scott Schillereff, Ph.D., P.Geo.
Principal Specialist – Water Resources
Environment Practice
Direct Line: 250.862.3026
Scott.Schillereff@tetrattech.com

/mt



REFERENCES

- Barnes, S. B. (1997). *The Sedimentology and Paleogeography of Glacial Lake Champagne, Southern Yukon Territory*. Ottawa, Ontario: M.A. Thesis, Department of Geography, Carleton University.
- BC Water Stewardship Division. (2006). *Well Protection Toolkit*.
- EBA Engineering Consultants Ltd. (EBA). (2008). *Takhini Well - Recommendations for Proposed Well Screen Installation*. Prepared for Champagne Aishihik First Nation.
- Freeze, R. A., & Cherry, J. A. (1979). *Groundwater*. Englewood Cliffs, NJ: Prentice Hall.
- Garnter Lee Ltd. (2004). *Groundwater Exploration and Well Completion Report for Well No. 2 at the Takhini Residential Subdivision*. Prepared for Champagne Aishihik First Nations.
- Gartner Lee Ltd. (2002). *Feasibility Study of Water Works Options for the Champagne Aishihik First Nation*. Prepared for Champagne Aishihik First Nation.
- Gordev, S. P. (2008). *Bedrock Geology, Whitehorse 105D, Yukon*. Geological Survey of Canada.
- Indian and Northern Affairs Canada (INAC). (2006). *Protocol for Safe Drinking Water in First Nations Communities*.
- Jacobsen, N. A. (2004). *Letter Regarding Takhini Subdivision Water System - Phase II Report*. Letter to Environmental Health Services, Government of Yukon.
- JDQ Engineering Ltd. (JDQ). (2014). *GSHP Record Drawing and Information, Takhini Community Hall and Works Facility, Takhini River Subdivision, Yukon*. Prepared for Champagne Aishihik First Nation.
- K Bisset & Associates (Bisset). (1995). *Research of Former Military Sites & Activities in the Yukon*. Action on Waste Program Environmental Strategy (AES) - Indian and Northern Affairs Canada.
- Morison, S. R., & Klassen, R. W. (1991). *Surficial Geology, Whitehorse, Yukon Territory*. Geological Survey of Canada, Map 12-1990, (scale 1:250,000).
- Ontario Ministry of Environment. (2001). *Groundwater Studies - Technical Terms of Reference*.
- Summit Environmental Consultants Inc. (Summit). (2010). *C/AFN Supply Well #1 - Determination of Whether Well is Considered Under the Influence of Surface Water (GWUDI)*. Prepared for Champagne Aishihik First Nation.
- Thiem, G. (1906). *Hydrologische Methoden*. (in German). Leipzig: J.M. Gebhardt.
- Vista Tek Ltd. (2005). *Takhini Truck Fill Station - Operation and Maintenance Manual*. Prepared for Champagne Aishihik First Nation.
- Yukon Engineering Services (YES). (2011). *Takhini River Subdivision - Engineering Assessment of the Community Water System*. Prepared for Health and Social Services, Government of Yukon.

TABLES

Table 2	Intrinsic Susceptibility Index Results
Table 4	Summary of Potential Hazards

Table 2: Intrinsic Susceptibility Index for Takhini River Subdivision Well 1

Aquifer assumed to be confined at this location			Aquifer encountered at 129.0 m bgs		
Interval		Effective Thickness (a)	Description	K-Factor (b)	(a*b)
from	to				
0.0	4.9	4.9	Silt and Fine Sand	2	10
4.9	8.2	3.4	Clay, some gravel	3	10
8.2	55.0	46.8	Clay	8	374
55.0	129.0	74.0	Silt and Clay	5	370
Intrinsic Susceptibility Index:					764

Notes:

1. Intrinsic Susceptibility Index Method from Ontario Ministry of the Environment (Groundwater Studies 2001/2002 Technical Terms of References, November, 2001).
2. Aquifer vulnerability is low if the value is greater than 80, the vulnerability is medium if the value is between 30 and 80 and the aquifer vulnerability is high if the value is less than 30.
3. The vulnerability of the confined aquifer encountered by the TRS well is very low

Table 4: Summary of Areas of Potential Environmental Concern (APEC)

APEC ID	Field ID	APECs	Location	Easting	Northing	Notes	PCOC ^{1,2,3}
BC1	Onsite Sceptic Field	Residential sceptic system	Lot 96	458273	6746712	Concern related to septic system effluent seeping into groundwater from on-site septic fields	E. coli, cryptosporidium, viruses, nitrates or sulphates
BC2	Sceptic Field 1		Lot 97	458053	6746673		
BC3	Sceptic Field 2		Lot 1	458413	6746591		
BC4	Sceptic Field 3		Lot 10	458424	6746698		
BC5	Sceptic Field 4		Lot 14	458363	6746846		
BC6	Sceptic Field 5		Lot 19	458386	6746973		
BC7	Sceptic Field 6		Lot 15	458442	6746822		
BC8	Sceptic Field 7		Lot 11	458524	6746708		
BC9	Sceptic Field 8		Lot 12	458599	6746719		
BC10	Sceptic Field 9		Lot 16	458533	6746829		
BC11	Sceptic Field 10		Lot 20	458483	6747002		
BC12	Sceptic Field 11		Lot 24	458372	6747114		
BC13	Sceptic Field 12		Lot 25	458446	6747130		
BC14	Sceptic Field 13		Lot 21	458593	6747009		
BC15	Sceptic Field 14		Lot 17	458611	6746832		
BC16	Sceptic Field 15		Lot 13	458664	6746727		
BC17	Sceptic Field 16		Lot 4	458707	6746619		
BC18	Sceptic Field 17		Lot 6	458820	6746628		
BC19	Sceptic Field 18		Lot 7	458794	6746696		
BC20	Sceptic Field 19		Lot 8	458798	6746783		
BC21	Sceptic Field 20		Lot 18	458697	6746853		
BC22	Sceptic Field 21		Lot 22	458672	6746983		
BC23	Sceptic Field 23		Lot 33	458683	6747208		
BC24	Sceptic Field 24		Lot 28	458750	6747109		
BC25	Sceptic Field 25		Lot 23	458755	6747015		
BC26	Sceptic Field 26		Lot 35	458836	6747256		
BC27	Sceptic Field 27		Lot 29	458886	6747143		
CH1	Rock Pit	Onsite rock pit	Lot 96	458255	6746689	Wastewater discharge from drinking water system	Metals, sodium, chlorine
CH2	Vehicle Dump 1	Old dump area - remediated	Lot 98	458207	6746683	Potential groundwater impact from old dump areas	Metals, sulphate, nitrate/nitrite, hydrocarbons
CH3	Vehicle Dump 2	Old dump area with two abandoned vehicles	Lot 95	458150	6746730	Potential groundwater impact from old dump areas	Metals, sulphate, nitrate/nitrite, hydrocarbons
CH4	Transfer Station	Solid waste transfer station facility	300 m west and adjacent to Lot 97	457932	6746591	Potential spills and/or release of chemicals from waste deposited at the transfer station	Sulphate, nitrate, phosphate, metals
CH5	Cemetery	Historical cemetery area	850 m south near Takhini River	458528	6745838	Potential groundwater impact from cemetery operations	Sulphate, nitrate, phosphate
HY1	Diesel Generator and Fill Point	Spills or leaks of from backup generator or fill point	Lot 96	458263	6746662	Concern related to leakage from backup diesel generator or fill point on site	Hydrocarbons (diesel fuel)
HY2	Heating Oil Tank 1	Spills or leaks from residential heating oil tanks	Lot 97	458059	6746662	Concern related to spills or leaks from residential heating oil tanks	Hydrocarbons (heating oil or diesel fuel)
HY3	Heating Oil Tank 2		Lot 1	458426	6746591		
HY4	Heating Oil Tank 3		Lot 12	458606	6746709		
HY5	Heating Oil Tank 4		Lot 16	458523	6746815		
HY6	Heating Oil Tank 5		Lot 19	458391	6746967		
HY7	Heating Oil Tank 6		Lot 24	458377	6747102		
HY8	Heating Oil Tank 7		Lot 27	458658	6747087		
HY9	Heating Oil Tank 8		Lot 29	458864	6747152		
HY10	Heating Oil Tank 9		Lot 29	458886	6747143		

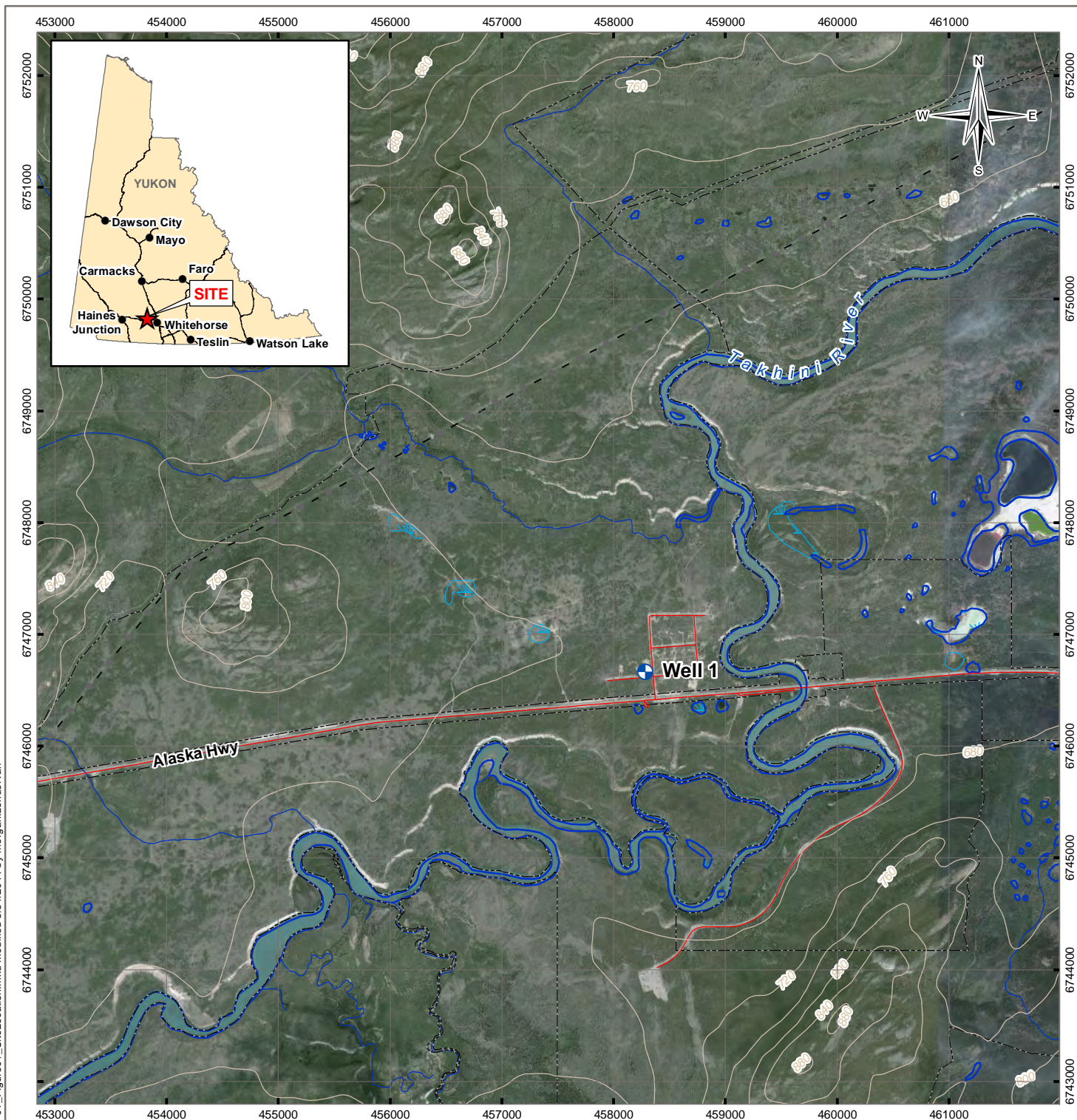
Notes:

1. BC - Indicates biological (bacteria, viruses, protozoa) potential hazard
2. CH - Indicates chemical (nitrites, phosphates) potential hazard
3. HY - Indicates hydrocarbon (fuel, oils) potential hazard

FIGURES

Figure 1	Site Location Map
Figure 2	Site Plan
Figure 3	Surficial Geology
Figure 4	APEC Map Showing Capture Zone Area

Q:\Vancouver\GIS\ENVIRONMENTAL\H2O\H2O03005-01\Figure01_SiteLocation.mxd modified 3/31/2014 by morgan.zondervan



LEGEND

- Community Water Well Location
- Road
- Transmission Line
- Aboriginal Lands
- Contour (40 m)
- Watercourse
- Waterbody
- Wetland

NOTES

Base data source:
CanVec (1:50,000)
Image from Google Earth (2005)

STATUS
ISSUED FOR USE

PRELIMINARY AQUIFER AND WELLHEAD PROTECTION PLAN, TAKHINI RIVER SUBDIVISION, YUKON

Site Location Map

PROJECTION
UTM Zone 8

DATUM
NAD83

CLIENT

**Champagne Aishihik
First Nation**

TETRA TECH EBA

FILE NO.
H2O03005-01_Figure01_SiteLocation.mxd

PROJECT NO.	DWN	CKD	APVD	REV
ENVH2O03005-01	MEZ	SL	RD	0

OFFICE	DATE
Tt EBA-VANC	March 31, 2014

Figure 1

Q:\Vancouver\GIS\ENVIRONMENTAL\H2O\H2O03005-01\Maps\H2O03005-01_Figure02_SitePlan.mxd modified 4/4/2014 by morgan.zondervan



LEGEND

- Community Water Well Location
- Geoexchange Borehole Location
- Site Feature
- Site Feature (approximate)
- Food Grade Glycol Line (approximate)
- Lot Boundary

NOTES

Base data source:
Image from Google Earth (2005)
Lot boundaries are approximate

STATUS
ISSUED FOR USE

PRELIMINARY AQUIFER AND WELLHEAD PROTECTION PLAN, TAKHINI RIVER SUBDIVISION, YUKON

Site Plan

PROJECTION
UTM Zone 8

DATUM
NAD83

CLIENT

Champagne Aishihik First Nation



TETRA TECH EBA

FILE NO.

H2O03005-01_Figure02_SitePlan.mxd

PROJECT NO.
ENVH2O03005-01

DWN
MEZ

CKD
SL

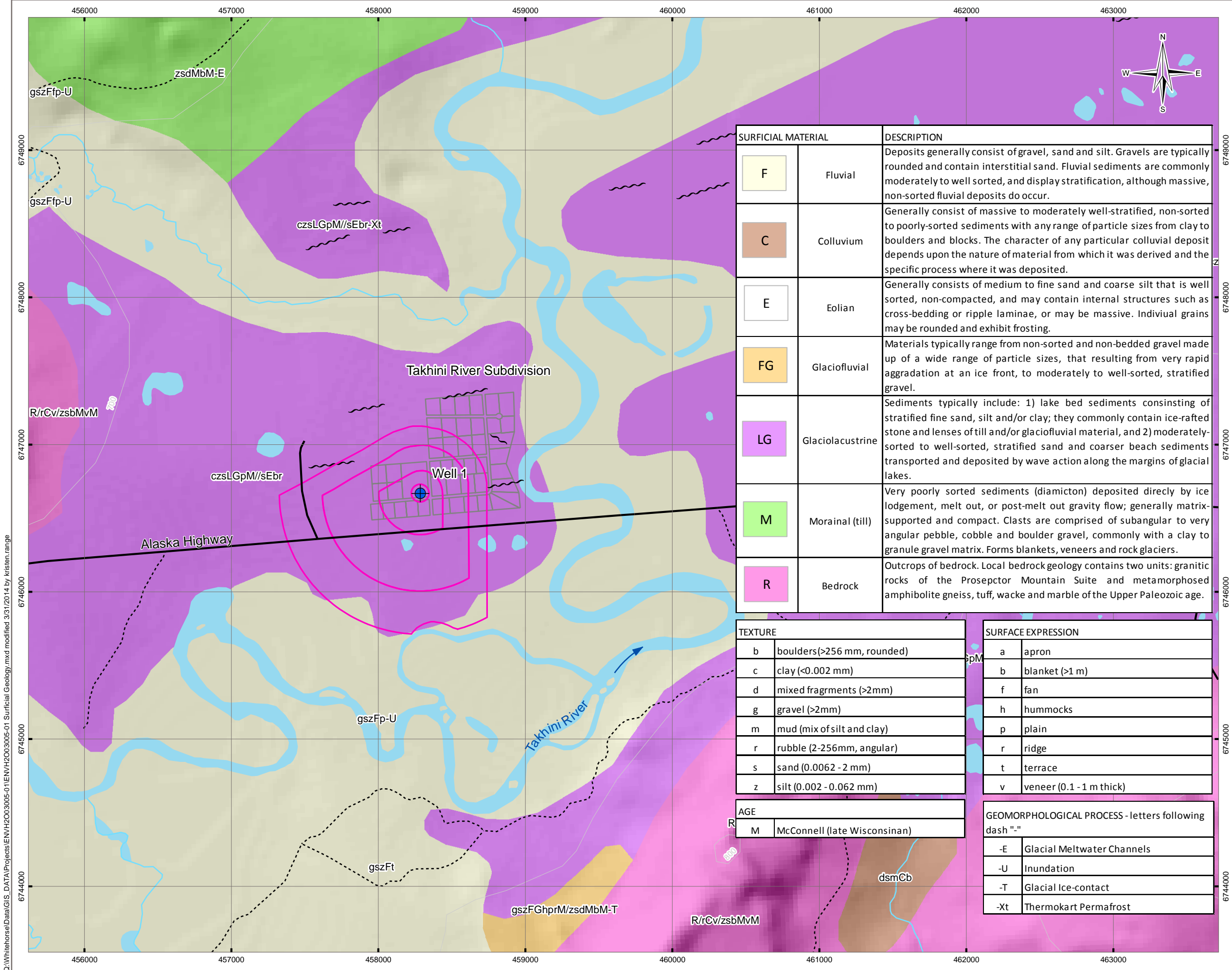
APVD
RD

REV
1

OFFICE
Tl EBA-VANC

DATE
April 4, 2014

Figure 2



Q:\Whitehorse\Data\GIS_DATA\Projects\ENV\H2O03005-01\ENVH2O03005-01\Surficial Geology.mxd modified 3/31/2014 by kristen.range

SURFICIAL MATERIAL		DESCRIPTION
F	Fluvial	Deposits generally consist of gravel, sand and silt. Gravels are typically rounded and contain interstitial sand. Fluvial sediments are commonly moderately to well sorted, and display stratification, although massive, non-sorted fluvial deposits do occur.
C	Colluvium	Generally consist of massive to moderately well-stratified, non-sorted to poorly-sorted sediments with any range of particle sizes from clay to boulders and blocks. The character of any particular colluvial deposit depends upon the nature of material from which it was derived and the specific process where it was deposited.
E	Eolian	Generally consists of medium to fine sand and coarse silt that is well sorted, non-compacted, and may contain internal structures such as cross-bedding or ripple laminae, or may be massive. Individual grains may be rounded and exhibit frosting.
FG	Glaciofluvial	Materials typically range from non-sorted and non-bedded gravel made up of a wide range of particle sizes, that resulting from very rapid aggradation at an ice front, to moderately to well-sorted, stratified gravel.
LG	Glaciolacustrine	Sediments typically include: 1) lake bed sediments consisting of stratified fine sand, silt and/or clay; they commonly contain ice-rafted stone and lenses of till and/or glaciofluvial material, and 2) moderately-sorted to well-sorted, stratified sand and coarser beach sediments transported and deposited by wave action along the margins of glacial lakes.
M	Morainal (till)	Very poorly sorted sediments (diamicton) deposited directly by ice lodgement, melt out, or post-melt out gravity flow; generally matrix-supported and compact. Clasts are comprised of subangular to very angular pebble, cobble and boulder gravel, commonly with a clay to granule gravel matrix. Forms blankets, veneers and rock glaciers.
R	Bedrock	Outcrops of bedrock. Local bedrock geology contains two units: granitic rocks of the Prosepector Mountain Suite and metamorphosed amphibolite gneiss, tuff, wacke and marble of the Upper Paleozoic age.

TEXTURE	
b	boulders(>256 mm, rounded)
c	clay (<0.002 mm)
d	mixed fragments (>2mm)
g	gravel (>2mm)
m	mud (mix of silt and clay)
r	rubble (2-256mm, angular)
s	sand (0.0062 - 2 mm)
z	silt (0.002 - 0.062 mm)

AGE	
M	McConnell (late Wisconsinan)

SURFACE EXPRESSION	
a	apron
b	blanket (>1 m)
f	fan
h	hummocks
p	plain
r	ridge
t	terrace
v	veneer (0.1 - 1 m thick)

GEOMORPHOLOGICAL PROCESS - letters following dash "-"	
-E	Glacial Meltwater Channels
-U	Inundation
-T	Glacial Ice-contact
-Xt	Thermokart Permafrost

LEGEND

Community Water Well Location

Well Capture Zone

Lots

Road

Limited-use Road

Elevation Contour (100 m)

Watercourse

Waterbody

Sand Dunes

TERRAIN CODE

Surficial Material

Surface Expression

Texture

Age

Geomorphological Process

sgFGptM-Xt

Component Delimineters

/

The component in front of the "/" symbol is more extensive than the one that follows

//

The component in front of the "//" symbol is considerably more extensive than the one that follows

NOTES

Base data source:
Surficial Geology Data and Terrain Mapping Code from Yukon Geological Survey

STATUS
ISSUED FOR USE

PRELIMINARY AQUIFER AND
WELLHEAD PROTECTION PLAN
TAKHINI RIVER SUBDIVISION, YUKON

Surficial Geology

PROJECTION
UTM Zone 8

DATUM
NAD83

CLIENT
Champagne Aishihik
First Nation

Scale: 1:25,000

400 200 0 400
Meters

FILE NO.
ENVH2O03005-01 Surficial Geology.mxd

PROJECT NO.
ENVH2O03005-01

OFFICE
Tl EBA-WHSE

DWN
KRR

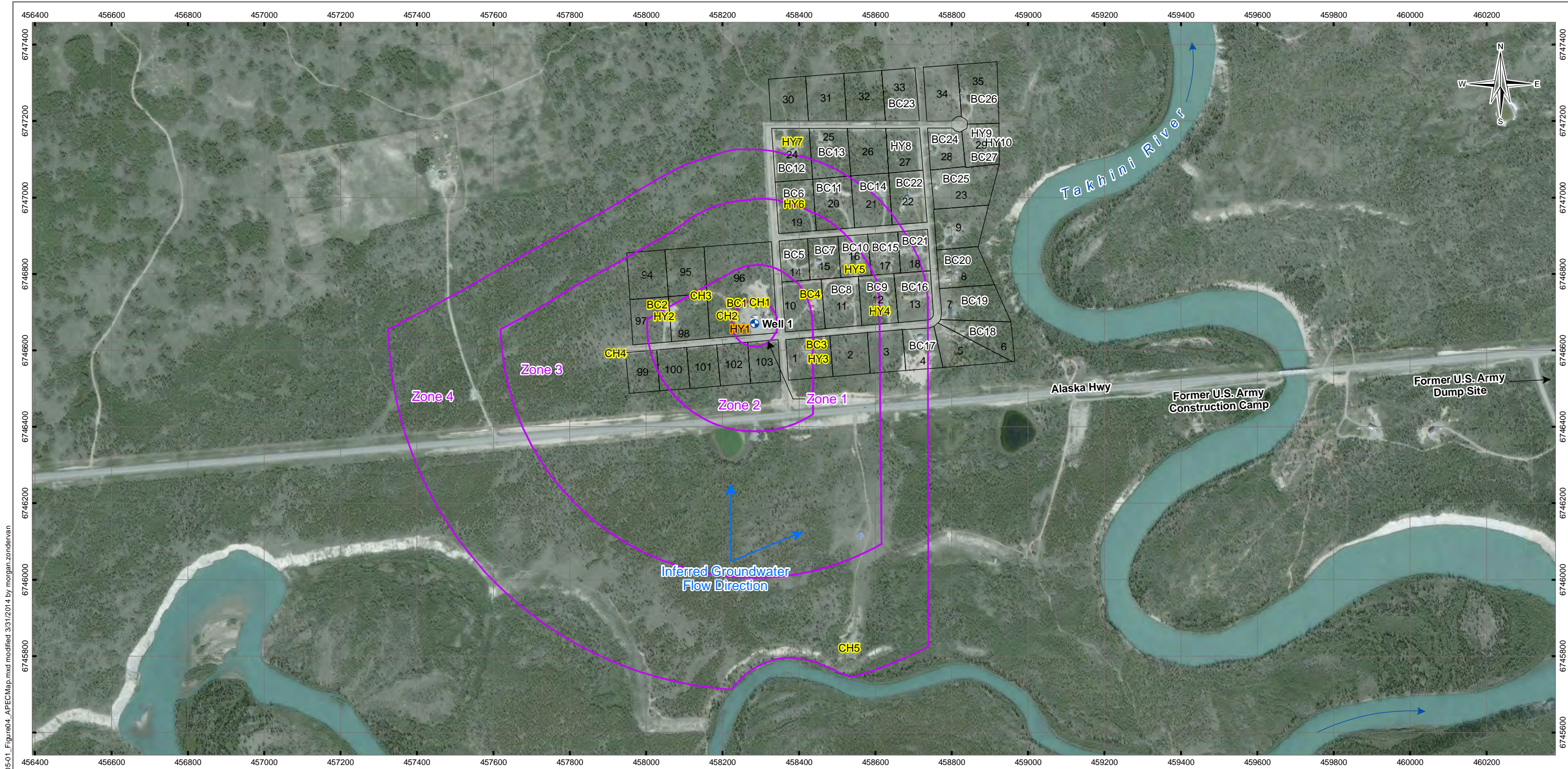
CKD
MZ

APVD
XXX

REV
0

DATE
March 27, 2014

Figure 3



Q:\Vancouver\GIS\ENVIRONMENTAL\H2O\H2O03005-01\Maps\H2O03005-01_Figure04_APECMap.mxd modified 3/31/2014 by morgan.zondervan

LEGEND

- Community Water Well Location
- Lot Boundary
- Capture Zone

Risk Level

- Low
- Medium

- BC Indicates Biological (bacteria, viruses, protozoa) Potential Hazard
- CH Indicates Chemical (nitrites, phosphates, metals, sulphates) Potential Hazard
- HY Indicates Hydrocarbon (fuel, oils) Potential Hazard

NOTES
Base data source:
Image from Google Earth (2005)

Lot boundaries are approximate

PRELIMINARY AQUIFER AND
WELLHEAD PROTECTION PLAN,
TAKHINI RIVER SUBDIVISION, YUKON

APEC Map Showing Capture Zone Area

PROJECTION UTM Zone 8	DATUM NAD83	CLIENT Champagne Aishihik First Nation
Scale: 1:10,000 200 100 0 200 Metre		
FILE NO. H2O03005-01_Figure04_APECMap.mxd		
PROJECT NO. ENVH2O03005-01	DWN MEZ	CKD SL
OFFICE Tt EBA-VANC	APVD RD	REV 0
DATE March 31, 2014		Figure 4

STATUS
ISSUED FOR USE

APPENDIX A

TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEO-ENVIRONMENTAL REPORT

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

1.0 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 EBA's client. Tetra Tech EBA 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 EBA's Client unless otherwise authorized in writing by Tetra Tech EBA. 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 EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA'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 EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA'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 EBA. The Client warrants that Tetra Tech EBA's instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

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

3.0 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 EBA in its reasonably exercised discretion.

4.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

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