1.0 THE PROPONENT

(i) Name of Proponent:

City of Fredericton, New Brunswick (NB) (herein referred to as "the City")

(ii) Address of Proponent:

City of Fredericton Town Hall,
Engineering and Public Works,
397 Queen Street,
Fredericton, New Brunswick
E3B 4Y7

(iii) Chief Executive Officer (or City Representative):

Neil Thomas, P.Eng. – City of Fredericton Senior Water and Sewer Engineer

(iv) Principal Contact Person for purposes of Environmental Impact Assessment:

Neil Thomas, P.Eng. – City of Fredericton Senior Water and Sewer Engineer

(v) Property Ownership:

The proposed drilling target site is owned by the City of Fredericton on PID 75529669.

Crown land is not involved.

2.0 THE UNDERTAKING

(i) Name of the Undertaking:

Construction and hydraulic testing of a new production-scale groundwater supply well (PW12) in the existing South-Central Fredericton (Queen Square) Wellfield, Fredericton, New Brunswick.

(ii) Project Overview:

The project involves the drilling of a single new groundwater production-scale well (PSW) PW12, with the intent to add more flexibility, redundancy and sustainable capacity in the existing South-Central (Queen Square) Wellfield, presently consisting a total of three production wells (PW9, PW10 and PW11) with a combined maximum regulated allowable withdrawal of 17 ML/d. This new production-scale well, PW12, will be constructed at a target location that was predetermined and planned by the City in 2005 (EIA No.'s 4561-3-964 and 4561-3-813). The planned PW12 target location is on the same parcel of land where an existing Queen Square Wellfield production well (PW10) has been operational since this new wellfield came online in mid-2009.

The scope of work for this project involves the drilling, development, hydraulic testing and sampling of a single 150 mm (6 inch) test well (MW20-01) at a predetermined target location on PID 75529669 (refer to Figures 1 through 8 and Drawings 1 and 2 from the WSSA Initial Application document). It is not expected that tree cutting or road building will be required to access the drill targets, but some (minimal) drill-pad preparation (possibly including placement of a small amount of fill) may be needed before commencing drilling at the proposed target site.

Contingent upon results from the test well, a larger production-scale well (457 mm diameter, screened

and gravel-packed well-column) will be designed and then constructed adjacent to the test well, which would include another round of (larger-scale) drilling, well development and hydraulic testing to determine its viability for use as a future production well for the Queen Square Wellfield. The new test well (MW20-01) then would serve as an additional observation well for the wellfield, including in the follow-up hydraulic testing of the new production-scale well. The hydraulic testing of the production-scale well would include periods of simultaneous pumping with the existing Queen Square Wellfield production wells over an estimated 14-day period. A series of water quality samples will be collected at each of the pumping wells involved in the test (i.e., PW12, PW11, PW10 and PW9) to assess the individual (well) and overall (wellfield) water chemistry with time under these higher (than presently regulated) pumping conditions. To the extent possible, the existing production wells in the City's other Wilmot Park Wellfield (PW1 through PW8) will be turned off, or their pumping minimized to meet the City's prevailing water demand, throughout this 14-day testing period.

The hydraulic testing program is proposed to be completed in a similar approach to that completed previously at PW11, following construction in 2005. Stage 1 of the testing program will consist of a step-test at PW12, in order to assess the as-built specific capacity, well and formation losses, and provide a preliminary estimate of well yield including an appropriate rate for the multi-staged (constant rate) aquifer pumping test. The step-test will then be followed by a multi-staged aquifer pumping test, which allows for assessment of yields and drawdowns at each well, and quantification of well interferences. It is expected that the hydraulic testing program will be completed over a 14-day period, as follows:

- Stage 1 – Complete a step-test at PW12. Each of the other Queen Square Wellfield production wells (PW9, PW10 and PW11) will be turned off during the step-test.
- Stage 2 – Begin pumping PW12 at a constant rate, which will be the start of the aquifer pumping test. The test will be started following the recovery of water levels from the earlier step-test (which is anticipated to be within one day of completing the Stage 1 step-test). Each of the other Queen Square Wellfield production wells (PW9, PW10 and PW11) will be turned off during this stage of the pumping test.
- Stage 3 – Begin pumping PW11 at a constant rate after two days of pumping at PW12.
- Stage 4 – Begin pumping PW10 at a constant rate after three days of pumping at PW12.
- Stage 5 – Begin pumping PW9 at a constant rate after four days of pumping at PW12. The four wells will then be pumped simultaneously at their respective constant rates for a period of three consecutive days (72 hours).
- Stage 6 – Cease pumping PW11 after seven days of pumping at PW12.
- Stage 7 – Cease pumping PW10 after eight days of pumping at PW12.
- Stage 8 – Cease pumping PW9 after nine days of pumping at PW12.
- Stage 9 – Cease pumping PW12 after 10 days of continuous pumping. The recovery of PW12 and the wellfield (including PW9, PW10 and PW11) will then be monitored for an additional three days.

The order and timing of pumping from the production wells during the multiple well pumping test may be subject to change from what is presented above. Regardless, representative water quality samples will be collected from each of the pumped wells for subsequent laboratory (inorganic, organic and microbiological) analyses throughout the pumping test, immediately after they are turned on and every 48 hours thereafter while they are pumping, including immediately before they are turned off. These water quality data should be sufficient to assess the individual (well) and overall (wellfield) water chemistry over time under these higher (than presently regulated) pumping conditions.

Appropriate water control measures (e.g., sandbags, shallow trenches, silt fencing, hay bales, and/or above-ground piping), will be implemented by the well driller during the drilling, development and test pumping phases of the project to help prevent excess water impacts to the University Avenue right-of-way, and nearby residential properties. During the pumping test, additional measures will be taken to mitigate artificial recharge to the aquifer. This may require the placement of additional above-ground piping to capture and direct the discharged water into the City's nearby storm/sanitary sewers, and/or at an adequate distance away from the pumped well(s) to discharge outside of the silt-clay window area (i.e., that area where the silt-clay aquitard is absent), into a natural surface drainage area or system where

the silt-clay aquitard is present. To the extent feasible, the drill site will be restored to pre-existing conditions after completing the production-scale well hydraulic testing.

Following completion of the above hydraulic testing of PW12 and the wellfield in the fall of 2020, the associated findings and analytical results from the construction and hydraulic testing program will be generated in a Hydrogeological Assessment Report, and submitted for regulatory review late in 2020 (possibly later if there are any unforeseen delays). Based on the results from the hydraulic testing, it is expected that a long-term sustainable well yield will be recommended for the new production-scale well, and a determination of whether it can be used as a new supply well for the Queen Square Wellfield. The hydraulic testing results will also likely determine whether a recommendation can be made to increase the current approved 17 ML/d withdrawal rate for the Queen Square Wellfield.

The estimated project schedule is summarized below in Table 1. Note that the beginning and end of task dates are tentative as noted below in the table. This preliminary project schedule is aggressive at this stage of the project due to prior Covid-19-related circumstances. Additional project delays, including but not limited to additional unforeseen Covid-19-related matters, are possible. Any significant changes to this schedule will be communicated as soon as they become apparent.

Table 1. Estimated preliminary project schedule for completion of tasks.

Phase	Task	Beginning of Task	End of Task
WSSA Initial Application	1. Reconnaissance and Drill Target Selection	June 2020	July 2020
	2. Regulatory Correspondence	June 2020	July 2020
	3. Driller Selection, Cost Estimate Updates and Field Preparation	June 2020	August 2020
Hydrogeological Assessment	4. Test Well Construction and Testing	August 2020	August 2020
	5. Production-Scale Well Construction	August 2020	September 2020
	6. Production-Scale Well Hydraulic Testing	August 2020	September 2020
	7. Test Data Processing and Analysis	September 2020	November 2020
	8. Hydrogeological Assessment Report	September 2020	December 2020

Note:

1. This proposed project schedule is preliminary and approximate and may be subject to change as there may be circumstances beyond BGC's control that can affect the schedule (e.g., regulatory review and approval, well driller's availability and drilling approach, the City's ability to complete a longer-term pumping test for the wellfield, weather conditions, and circumstances surrounding restrictions or delays due to the COVID-19 pandemic).

(iii) Purpose/Rationale/Need for the Undertaking:

The City proposes to develop a new groundwater supply well (PW12) to add flexibility, redundancy and sustainable capacity to its existing potable groundwater system. Currently, ten groundwater supply wells operate in two separate municipal wellfields within the City's southern downtown plat with a regulatory approval to withdraw a total of 42 million litres per day (ML/d) (New Brunswick Department of Environment and Local Government [NBDELG], July 25, 2003). Seven of these wells (PW1 through PW8, excluding

PW4 which was taken offline in 2001) are located within the older South-West (Wilmot Park) Wellfield. These wells have a combined allowable withdrawal of 25 ML/d (TerrAtlantic Engineering Limited [TerrAtlantic], May 11, 2001), and this wellfield has been an operating municipal supply since PW1 and PW2 were constructed in the 1950's. The raw groundwater withdrawn from the Wilmot Park Wellfield production wells is presently treated at the William L. Barrett Water Treatment Plant before being distributed for consumption. An additional three production wells (PW9, PW10, and PW11) are located within the newer South-Central (Queen Square) Wellfield, which has an additional allowable withdrawal of 17 ML/d since this wellfield was formally brought online in mid-2009 (NBDELG, May 5, 2006) – refer to Figure 1 of the WSSA Initial Application document. The raw groundwater withdrawn from the Queen Square Wellfield production wells is presently treated at the E. John Bliss Water Treatment Plant before being distributed for consumption.

Municipal sanitary sewer collection and treatment services are also being provided throughout the City.

It is understood that all water being supplied throughout the City is sourced from the above two municipal wellfields, and there are no other alternative water supplies being sourced in the area of the proposed well target locations (e.g., surface water from the river or use of individual domestic or commercial supply wells). The recent potable supply demand for the City (from both wellfields) has been up to approximately 22 ML/d.

The available well yield and operational pumping rate for production-scale well PW12 will be determined through an aquifer pumping test that includes the simultaneous pumping from production-scale well PW12, and the three existing production wells of the Queen Square Wellfield (PW9, PW10 and PW11). The expected yield from a new production well in this wellfield is estimated to be similar to that of the existing production wells (up to approximately 6.5 ML/d, or 75 L/s), and contribute to the current maximum regulated withdrawal of 17 ML/d for the Queen Square Wellfield. Production-scale well PW12 is intended to eventually be added to the pumping rotation in this wellfield. The hydraulic testing results will also likely determine whether the current approved 17 ML/d withdrawal rate for the Queen Square Wellfield can be increased.

In the City's approved, adopted and implemented Wellfield Protection Study (TerrAtlantic and ADI Limited, May 16, 2005), it was assumed that the Queen Square Wellfield would eventually comprise five production wells from which a combined total of 25.2 ML/d could be withdrawn (refer to Figure 1 from the WSSA Initial Application document). Therefore, the proposed addition of PW12 should not trigger the requirement for additional 3D numerical groundwater modelling as this (future) production well was included in the above-noted wellfield protection model, and the limits of the current wellfield protection zones (A, B and C) already reflects (future) pumping from PW12.

(iv) Project Location:

The location of the project is shown in Figure 2 and Drawing 1 of the WSSA Initial Application document. The associated parcel identification number (PID) as referenced by Service New Brunswick (SNB) is 75529669, which is owned by the City of Fredericton.

The civic address of the proposed drilling target location is identified in SNB as #369 University Avenue, Fredericton, NB.

(v) Physical Components and Dimensions of the Project:

The general well target location for PW12 has already been pre-planned by the City in 2005, well in advance of its construction, on the property with parcel identification number (PID) of 75529669. As a result, the proposed drilling locations for the new test well (MW20-01) and the follow-up PW12 production-scale well have been approximated through coordination with the City and its civil engineering consultant (EXP). Please refer to Drawing 1 of the WSSA Initial Application document for the proposed locations for the new test well (MW20-01), the PW12 production-scale well and its planned future pump-house

footprint, underground infrastructure and property boundary information. This information provides confirmation that the planned water infrastructure will be constructed on City-owned land, with appropriate regulatory setbacks.

The project drilling site would be approximately 10 metres by 10 metres (i.e., 100 square metres in area), to accommodate a safe working area and equipment staging. There are no watercourses within the proposed target drill site. The closest watercourse (a drainage ditch) is located approximately 230 metres to the southwest of the target location, as shown on Figure 2 of the WSSA Initial Application document. Access to the drill site will be made in such a manner to have no adverse impact on the nearby watercourse. A municipal storm water sewer network is also present in the general area of the proposed drill target site (along University Avenue and the walking trail), which drains surface runoff from the area directly to the St. John River. The nearest storm sewer drains to the site are identified on Figure 2 of the WSSA Initial Application.

The key physical components of the project include:

a. WSSA Initial Application and EIA Registration of the project.
b. Procurement of a qualified NB licensed well driller.
c. Provision of temporary access to the drill sites for the selected NB licensed well driller. A small amount of fill may need to be placed at the target drilling site to accommodate the drill-rig.
d. The drilling of a single test well (MW20-01), with a subsequent hydraulic pumping test to assess preliminary water quality and quantity of the source groundwater, and aid with the design and construction of the production-scale well (PW12) which would follow.
e. The drilling, construction and hydraulic test pumping of one larger diameter production-scale well (PW12) to determine its viability as a new future production well for the Queen Square Wellfield.
f. The discharge of pumped water to the environment in such a manner that artificial aquifer recharge is not encouraged and all potential environmental effects (such as erosion, sedimentation, excessive water impacts, etc.) are mitigated.
g. The restoration of the drill site to pre-existing conditions as best as practicable.
h. Completion of a Hydrogeological Assessment Report of all findings from the well construction and testing project, which will be submitted for regulatory review.

The total duration of the test well and production-scale well construction and associated hydraulic testing periods is estimated to be two to three months (late-summer to fall 2020), and will depend on timing of the regulatory review and approval, timing for the selected well driller's procurement, availability and associated drilling approach, the City's ability to complete a longer-term pumping test for the wellfield, weather conditions, and circumstances surrounding restrictions or delays due to the ongoing COVID-19 pandemic.

(vi) **Construction Details** (if applicable):

Drilling of one 150 mm diameter exploratory test well (MW20-01), plus one larger diameter (457 mm) screened and gravel-packed production-scale well (PW12).

Based on the results of the test well MW20-01 construction and testing, the production-scale well will be designed and then constructed adjacent to the test well, provided conditions observed in the test well are favourable. The test well would then serve as an additional observation well for the wellfield, and for the follow-up production-scale well pumping test. BGC has found this approach (i.e., construction of test well(s) before the production-scale well) to be highly successful on numerous projects across the Province, including those completed for the City previously (PW6 through PW11). Each of the City's three existing production wells in the Queen Square Wellfield were constructed with a 457 mm (18-inch) diameter well-column and screen, and a 660 mm (26-inch) diameter outer protective well casing installed above the screened interval, with 10 mm minus silica gravel-pack infilling the annulus between these

casings to surface. A bentonite seal is also installed around the outside of the outer protective casing. Similar well design characteristics are envisaged for production-scale well PW12, but these design characteristics and its viability for use as a future production well for the Queen Square Wellfield will be confirmed during the proposed drilling and testing programs. The preliminary construction details for production-scale well PW12 (and associated infrastructure) are outlined in Figure 7 and Drawing 1 of the WSSA Initial Application document.

The available well yield and operational pumping rate for production-scale well PW12 will be determined through an aquifer pumping test that includes the simultaneous pumping from production-scale well PW12, and the three existing production wells of the Queen Square Wellfield (PW9, PW10 and PW11). To the extent possible, each of the City's other existing Wilmot Park Wellfield production wells (PW1 to PW8) will be turned off throughout this hydraulic testing period. The expected yield from a new production well in this wellfield is estimated to be similar to that of the existing production wells (up to approximately 6.5 ML/d, or 75 L/s), and contribute to the current maximum regulated withdrawal of 17 ML/d for the Queen Square Wellfield. Production-scale well PW12 is intended to eventually be added to the pumping rotation in this wellfield, provided the results and findings from the construction and testing phases allow such. The proposed hydraulic testing of PW12 with the existing Queen Square Wellfield production wells (PW9, PW10 and PW11) will also determine if a recommendation can be made to increase the current maximum allowable withdrawal for this wellfield.

Flowing artesian conditions are not expected to be encountered while drilling in the overburden at either of the proposed well target locations.

(vii) Operation and Maintenance Details:

The key features of the operation would be as per (vi) above. Maintenance would be undertaken, as follows:

.1 The well driller should become familiar with the site conditions and requirements for completing the work prior to bidding, and/or mobilizing to complete the work. Obtain the necessary licensing and well permits and then mobilize to the site all personnel, materials and equipment required to complete the intended works. Take such measures as required to provide access to each well site. This may include snow clearing, cutting, filling, grading, and redirecting surface drainage.

.2 Provide and maintain environmental (sedimentation and erosion) controls to the satisfaction of the Hydrogeologist and New Brunswick Department of Environment and Local Government (NBDELG or the Regulator) such that surface erosion is minimized and the off-site migration of sediment-laden water into sensitive areas is prevented.

.3 Provide adequate temporary safety fencing around the perimeter of the site to limit unauthorized access for the duration of the work (day and night).

.4 Daily Contractor working hours during the drilling and well development phases of the work are anticipated to be between 7 am and 7 pm. Permission may be required by the City to work outside these anticipated daily working hours while drilling and developing. While completing the hydraulic pumping test at the production-scale well, daily working hours for the Contractor will be 24 hrs per day to allow the Contractor to collect and record the required periodic measurements of water levels and flow throughout the (10 consecutive day) pumping phase of the test.

.5 Keep all cutting to the minimum and to the extent feasible, restore the site to pre-existing conditions.

.6 Ensure that neighbouring properties are not adversely affected by drill cuttings and/or discharged water during the execution of the work.

.7 Development and implementation of an appropriate health and safety plan (HASP) and

environmental protection plan (EPP) for the duration of the Contractor's work, including implementation of current accepted COVID-19 WorkSafe NB safe work practices for their field staff and site activity (current practices are available from the WorkSafeNB website (https://www.worksafenb.ca/safety-topics/covid-19/covid-19-what-workers-and-employers-need-to-know/).

(viii) Future Modifications, Extensions, or Abandonment:

This application refers to the currently proposed test well (20-01) and production-scale well (PW12) target drilling site only. An extension to this registration will be sought or the submission of a new registration will be made if the City decides to explore one or more additional well target locations. Any recommended modifications to the current allowable withdrawal for the Queen Square Wellfield will be pursued through the routine regulatory review and approvals process (with NBDELG's EIA and WSSA Branch).

(ix) Project-Related Documents:

One document is attached:

a. City of Fredericton PW12 - WSSA Initial Application, submitted and dated July 2020.

3.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

(i) Physical and Natural Features:

The hydrostratigraphic unit being targeted for the screened intervals of the proposed new test well (MW20-01) and production-scale well (PW12) is the coarse sand and gravels of the Fredericton Aquifer. An illustration of the infilled channel deposits, including the various identified recharge sources for the Fredericton Aquifer (blue), is in Figure 3 of the WSSA Initial Application document (Conceptual Cross-Section of the Fredericton Aquifer with Recharge Sources). The surficial geology of the Fredericton Aquifer has been described in detail in past work (McLean, 1990; TerrAtlantic, May 11, 2001). The following is a synopsis of the interpretation provided within these two references. As a result of the periodic advance and retreat of glacial ice in the last ice age, a complex sequence of glacial till, granular outwash and lacustrine silt and clay was deposited in the bedrock channel now occupied by the St. John River. The river contributed the alluvium that now covers the downtown plat at surface.

The silt and clay unit is not always continuous, and this gap or "window", believed to be approximately 200 metres wide, extends from the Woodstock Road /Delta Hotel through to Waterloo Row/Elmcroft Place, and intercepts the St. John River at both extents. A significant portion of recharge to the Fredericton Aquifer occurs via riverbank filtration where the window intercepts the St. John River at its northwest and southeast extents across the downtown plat. The location of this window in the area of the Queen Square Wellfield is approximately as shown in Figure 4 of the WSSA Initial Application document. The absence of clay may reflect the erosion of a channel by a meandering St. John River and its subsequent infilling with granular alluvium. More likely, the clay/silt layer was fairly uniformly eroded, exposing the underlying sands and gravels at the top of the ridge. Where present, the silt and clay unit varies in thickness, and in places this exceeds 50 metres.

The sedimentary bedrock is of Pennsylvanian age, and comprises shale, siltstone, locally arkosic sandstone and polymictic to quartz pebble conglomerate. The rock is typically red, grey or green in colour, and is sub-horizontally bedded with joint spacings as little as 100 mm (GEMTEC, 1994). The typical trend of vertical joints and faults is either northeast/southwest or west to east, and is now reflected by the preferred orientation of surface drainage courses which have cut into the bedrock.

The Fredericton Aquifer is recharged from three main sources: (a) the St. John River; (b) the overlying perched water table within the alluvium; and (c) the underlying bedrock (McLean, 1990; TerrAtlantic, May 2001). The relative contributions made by each source depend on numerous factors, including the rate at

which water is withdrawn from the production wells and seasonal variability of water levels, and is therefore difficult to estimate. Based on the available information, it has been interpreted that the River is the primary source of recharge for the aquifer, via riverbank filtration (TerrAtlantic and ADI Limited, May 16, 2005).

Interpreted subsurface cross-sections through the Queen Square Wellfield are shown in Figure 5 (a northwest-southeast sub-surface cross-section AA' – looking east) and Figure 6 (a northeast-southwest sub-surface cross-section BB' – looking north) of the WSSA Initial Application document. These sub-surface cross-sections were generated from exploratory data collected for the City by TerrAtlantic Engineering Limited in the early stages of the development of the Queen Square Wellfield between 2000 and 2005, and were reported previously in TerrAtlantic, December 19, 2005, following the construction and hydraulic testing of PW11. A plan view showing the location of each cross-section (with red lines) is included in Figure 4 of the WSSA Initial Application document. The details shown in Figures 4, 5 and 6 are interpretations and should be considered with the context that they are originally presented.

The surface of the proposed drilling target area consists of a relatively flat, gravel (unpaved) surface with an approximate ground surface elevation of 8.71 metres Geodetic. The site has historically been used as a parking lot. The natural surface drainage direction would likely flow to the south-southeast, towards the adjacent University Avenue right-of-way, although some surface drainage may also flow to the west, given the relatively flat nature of the (parking lot) site.

(ii) Cultural Features:

The eastern area of the subject parcel being proposed for drilling of a new test well (MW20-01) and production-scale well (PW12) is presently being used as a parking lot. The City's existing production well PW10 is present on the western portion of the subject parcel. As in prior wellfield development registrations completed for the development of the Queen Square Wellfield (PW9, PW10 and PW11) throughout 2000 to 2005, there are no recognized recreational sites or features, tourism features or attractions, cultural activities, hunting, fishing, gathering, reserves, traditional uses by First Nations, etc. are known for either the subject property or adjacent lands.

No recognized heritage and/or built heritage resources/areas (e.g., historic sites, historic buildings or structures, national or provincial parks, fossils, archaeological sites, etc.) are known for the subject property or adjacent lands.

(iii) Existing and Historic Land Uses:

The historical land use of the proposed drilling target site has been a parking lot owned by the City of Fredericton. The existing production well PW10 resides at the western end of this subject land parcel. A number of other groundwater monitoring and observation wells are also present on the subject parcel (multi-level monitoring well 6-00S, 6-00M and 6-00D near the proposed drilling targets, including monitoring wells 3-01 and 2-02 which are adjacent to PW10). Some of these nearby wells, among other existing Queen Square Wellfield monitoring wells, will be used as observation wells during the hydraulic testing of the new test well (MW20-01) and the production-scale well (PW12) (i.e., 6-00S/M/D, 2-02, 1-05, 18-04D, 4-00, as needed).

A land-use and zoning map for the site and surrounding area is attached in Drawing 2 of the WSSA Initial Application document, which is from the approved, adopted and implemented Wellfield Protection Plan for the City (TerrAtlantic and ADI Ltd., May 16, 2005). The subject site is situated in Wellfield Protection Zone A2, within the Queen Square Wellfield, and the proposed target areas are identified as a red circle within a white-coloured parcel adjacent to University Avenue, labelled as Aquifer Code "H-Parking Lot".

4.0 SUMMARY OF ENVIRONMENTAL IMPACTS

Possible environmental impacts from the project work include:

i. Damage to vegetation during construction of the drill-pad to accommodate the drill-rig;
ii. Contamination due to an inadvertent chemical or petroleum release;
iii. Noise from construction, well drilling and pumping equipment, including from electrical generation, if used;
iv. Siltation from surface water or pumped water due to the erosion of disturbed ground; and
v. Inadvertent flooding, or excessive water impacts of the subject or adjacent properties during completion of the drilling, well development and hydraulic testing phases of the project.

5.0 SUMMARY OF PROPOSED MITIGATION

Damage to vegetation during construction of site access: It is not expected that tree cutting or road building will be required to access the drill targets, but some (minimal) drill-pad preparation (possibly including placement of a small amount of fill, or cutting of some tree-branches) may be needed before commencing drilling at the proposed target site. Efforts will be taken to minimize tree cutting and vegetation removal, and later, to revegetate disturbed areas. Monitoring and inspection will take place.

Contamination due to an inadvertent chemical or petroleum release: An environmental protection plan and protocol for refueling and waste disposal activities will be instituted. Stringent leak and spill prevention plans for an operating wellfield (Protection Zone A), addressing equipment maintenance, materials storage and handling, will be in place. A contingency plan for spill notification and clean-up will be developed. Monitoring and inspection will take place. All spills or leaks, such as from machinery or storage tanks, must be promptly contained and cleaned up by the Contractor (sorbents and booms must be available onsite for quick containment and recovery) and reported to the 24-hour environmental emergencies reporting system (1-800-565-1633), the City, and to the Hydrogeologist.

Noise from construction, well drilling and pumping equipment, including from electrical generation if used: Daily Contractor working hours during the drilling and well development phases of the work are anticipated to be between 7 am and 7 pm. Permission willy be required by the City to work outside these anticipated daily working hours while drilling and developing. While completing the hydraulic pumping test at the production-scale well, daily working hours for the Contractor will be 24 hrs per day to allow the Contractor to collect and record the required periodic measurements of water levels and flow throughout the (10 consecutive day) pumping phase of the test. Use of electrical pumps will be sought for use, in lieu of generators, during the course of the pumping tests.

Siltation from surface water or pumped water due to the erosion of disturbed ground: The works will not be located near (i.e., within 30 metres of) identified watercourses or wetlands. Erosion and sedimentation control plans will be instituted. Monitoring and inspection of the storm sewer and nearest watercourse will take place.

Inadvertent flooding, or excessive water impacts of the subject or adjacent properties during completion of the drilling, well development and hydraulic testing phases of the project: A storm water management plan will be in place. Pumped water will be piped away from site and adjacent properties to the Southwest, toward the nearby drainage ditch and/or municipal storm sewer system. Monitoring and inspection will take place.

6.0 PUBLIC INVOLVEMENT

The construction project has been approved by City Council. This is the extent of public involvement that has occurred at the time of project registration. City Water & Sewer Division Staff will engage with the local Ward City Councilor and public as typically conducted for infrastructure projects. More detailed public consultation may be required with adjacent property owners regarding the planned drilling and hydraulic testing work and associated water control measures, prior to the work proceeding.

7.0 APPROVAL OF THE UNDERTAKING

A submission has been made for Water Supply Source Assessment (WSSA) approval by DELG under the *Water Quality Regulation* of the *Clean Environment Act*. The NBDELG WSSA application contact telephone number is (506) 453-7945.

8.0 FUNDING

No applications for a grant or loan of capital funds from a government agency have been or will be submitted. This project is self-funded by the City's Water & Sewer utility.

9.0 SIGNATURE

Signature: _____ **Date:** July 17, 2020

Date and Signature of Chief Executive Officer (or City representative)
(Neil Thomas, P.Eng. – City of Fredericton Senior Water and Sewer Engineer)

References

GEMTEC Limited and Fiander-Good Associates Limited. (1994, December). *South Fredericton Aquifer Study, Background Documen*.

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TerrAtlantic. (2005, December 19). *Exploration, Construction and Pump Testing of Municipal Well PW11* Fredericton, NB [Report]. Prepared for the City of Fredericton.

Figures

(refer to each of the eight Figures included in the WSSA Initial Application for this file)

Drawings

(refer to each of the two Drawings included in the WSSA Initial Application for this file)

Water Supply Source Assessment
Initial Application

Submission Date: July 17, 2020

Please provide the following information:

1) Name of proponent.

City of Fredericton (herein "the City"), New Brunswick, Canada

2) Location of drill targets (including property PID) and purpose of the proposed water supply.

The City proposes to develop a new groundwater supply well (PW12) with the intent to add more flexibility, redundancy and additional sustainable capacity to its existing potable groundwater system. Currently, ten groundwater supply wells operate in two separate municipal wellfields within the City's southern downtown plat (see Figure 1) with a regulatory approval to withdraw a total of 42 million litres per day (ML/d) (New Brunswick Department of Environment and Local Government [NBDELG], July 25, 2003). Seven of these wells (PW1 through PW8, excluding PW4 which was taken offline in 2001) are located within the older South-West (Wilmot Park) Wellfield. These wells have a combined allowable withdrawal of 25 ML/d (TerrAtlantic Engineering Limited [TerrAtlantic], May 11, 2001). An additional three production wells (PW9, PW10, and PW11) are located within the newer South-Central (Queen Square) Wellfield, which has an additional allowable withdrawal of 17 ML/d (NBDELG, May 5, 2006) – refer to Figure 1. All figures and drawings are attached in the associated Figures and Drawings sections at the end of this document.

The general well target location for PW12 has already been planned by the City, in advance of its construction, on the City-owned property with parcel identification number (PID) of 75529669. As a result, the proposed drilling locations for the new test well (MW20-01) and the follow-up PW12 production-scale well have been approximated through coordination with the City and its civil engineering consultant (EXP). Please refer to the attached preliminary drawing (Drawing 1) for the proposed locations for the new test well, the PW12 production-scale well and associated pump-house, including underground infrastructure and property boundary information. This information provides confirmation that the new proposed water infrastructure will be constructed on City-owned land, with appropriate regulatory setbacks.

A secondary (back-up) target location (identified as PW13 in Figure 1 and Figure 2) has also been planned by the City on PID 75334177. This secondary location will only be considered and evaluated if the findings and results from MW20-01 or production-scale well PW12 turn out to be unfavourable. In that event, a separate test well construction and hydraulic testing scope of work would need to be proposed for the identified PW13 location.

3) Required water quantity (in m^3/day) and/or required pumping rate.

The available well yield and operational pumping rate for production-scale well PW12 will be determined through an aquifer pumping test that includes the simultaneous pumping from production-scale well PW12, and the three existing production wells of the Queen Square Wellfield (PW9, PW10 and PW11). The expected yield from a new production well in this wellfield is estimated to be similar to that of the existing production wells (i.e., up to approximately 6.5 ML/d, or 75 litres per second, L/s), and will contribute to the current maximum regulated withdrawal of 17 ML/d for the Queen Square Wellfield. Production-scale well PW12 is intended to eventually be added to the pumping rotation in this wellfield, and the proposed hydraulic testing of PW12 with the existing Queen Square Wellfield production wells (PW9, PW10 and PW11) will determine if a recommendation can be made to increase the current maximum allowable withdrawal for this wellfield. The recent potable supply demand for the City (from both wellfields) has been up to approximately 22 ML/d.

In the City's approved, adopted and implemented Wellfield Protection Study (TerrAtlantic and ADI Limited, May 16, 2005), it was assumed that the Queen Square Wellfield would eventually comprise five production wells from which a combined total of 25.2 ML/d could be withdrawn (Figure 1). Therefore, the proposed addition of PW12 should not trigger the requirement for additional 3D numerical groundwater modelling as this (future) well was included in the above-noted wellfield protection model, and the limits of the current wellfield protection zones (A, B and C) already incorporate (future) pumping from PW12.

4) List alternate water supply sources in area (including municipal systems).

There are three existing groundwater production wells (PW9, PW10 and PW11) operating within the Queen Square Wellfield since it formally came online in mid-2009, and currently has an approved combined allowable withdrawal rate of 17 ML/d (NBDELG, May 5, 2006). These existing supply wells are located approximately 70 m (PW10), 140 metres (PW11) and 230 metres (PW9) north-northwest from the proposed drill target for production-scale well PW12. The raw groundwater withdrawn from the Queen Square Wellfield production wells is presently treated at the E. John Bliss Water Treatment Plant before being distributed for consumption.

Seven additional operating groundwater production wells (PW1 through PW8, excluding PW4 which was taken offline in 2001) are located within the older, original South-West (Wilmot Park) Wellfield, ranging between 1,930 metres (PW3) and 2,415 metres (PW6) northwest of the proposed drill target for production-scale well PW12. The Wilmot Park Wellfield has an approved combined allowable withdrawal rate of 25 ML/d (TerrAtlantic, May 11, 2001) and has been operating as a municipal water supply for the City since the construction of PW1 and PW2 in the 1950's. The raw groundwater withdrawn from the Wilmot Park Wellfield production wells is presently treated at the William L. Barrett Water Treatment Plant before being distributed for consumption.

It is understood that all water being supplied throughout the City is sourced from the above two (provincially designated) municipal wellfields, and there are no other alternative water supplies (e.g., surface water from the river or use of individual domestic or commercial supply wells) being sourced in the area of the proposed well target locations.

Municipal sanitary sewer collection and treatment services are also provided throughout the City.

5) Discuss area hydrogeology as it relates to the project requirements.

The hydrostratigraphic unit being targeted for the screened intervals of the proposed new test well (MW20-01) and production-scale well (PW12) is the coarse sand and gravels of the Fredericton Aquifer (refer to Figure 3 for the Conceptual Cross-Section of the Fredericton Aquifer). The surficial geology of the Fredericton Aquifer has been described in detail in past work (McLean, 1990; TerrAtlantic, May 11, 2001). The following is a synopsis of the interpretation provided within these two references. As a result of the periodic advance and retreat of glacial ice in the last ice age, a complex sequence of glacial till, granular outwash and lacustrine silt and clay was deposited in the bedrock channel now occupied by the St. John River. The river contributed the alluvium that now covers the downtown plat.

The alluvial deposits represent the upper five or so metres of unconsolidated sediment in the valley and consist of fine to coarse sands. The water table is located within the alluvium, being perched on the underlying silts and clays where these lower permeability soils are present. The hydraulic conductivity of the alluvium is approximately $1x10^{-4}$ m/s. The St. John River Valley in Fredericton was once submerged approximately 50 to 80 m above present sea level due to ice-blocking of the river at some point downstream. Silty clay to clayey silt was deposited in this lake against and above the ridge of underlying glacio-fluvial sands and gravels. The silt and clay unit is not always continuous, and this gap or "window," believed to be approximately 200 metres wide, extends from the Woodstock Road /Delta Hotel through to Waterloo Row/Elmcroft Place, and intercepts the St. John River at both extents. A significant portion of recharge to the Fredericton Aquifer occurs via riverbank filtration where the window intercepts the St. John River at its northwest and southeast extents across the downtown plat. The location of this window in the area of the Queen Square Wellfield is approximately as shown in Figure 4. The absence of clay/silt may reflect the fairly uniform erosion of the clay/silt layer, exposing the underlying sands and gravels at the top of the ridge. Where present, the silt and clay unit varies in thickness, and in places this exceeds 50 metres. The hydraulic conductivity of this deposit is approximately $1x10^{-7}$ m/s to $1x10^{-10}$ m/s.

The glacio-fluvial unit that constitutes the producing aquifer comprises sands and gravels that were deposited during the retreat of the ice front. A number of depositional models have been suggested, including a conventional esker, and overlapping esker fans (McLean, 1990). Whatever the origin, the end result is evidently a fairly flat but distinct buried sand and gravel ridge extending from northwest to southeast across the downtown plat fairly close to the valley wall. The deposit is at its thickest beneath Wilmot Park, along the north side of Queen Square and in the Waterloo Row /Elmcroft Place area (TerrAtlantic Engineering Limited, May 2001). The maximum thickness of the unit is approximately 60 metres. The gradation of the glacio-fluvial sands and gravels changes rapidly over short distances, both horizontally and vertically. Fine sand seams or layers are present, as are ice-rafted cobbles and boulders. The aquifer is relatively permeable, with a transmissivity in the range of 2,500 to 7,000 m^2/d. The hydraulic conductivity of the sand and gravel (Fredericton Aquifer) is approximately $2x10^{-3}$ m/s.

The lodgement glacial till found in South Fredericton is reddish brown to grey in colour, and comprises very dense silty, clayey, sands and gravels with large clasts of locally derived sandstone and shale (ADI Limited, 1982). Where present, the till generally occurs as a thin veneer or blanket above the bedrock, but in places there are intervening sands and gravels. Thin layers of till were observed within the sands and gravels at prior test wells drilled at the eastern end of the Queen Square Wellfield (e.g., prior exploratory test wells 2-00, 4-00 and 6-00 (Figure 4) – refer to a northwest-southeast sub-surface cross-section of the Queen Square Wellfield in Figure 5, and a northeast-southwest sub-surface cross-section of the Queen Square Wellfield in Figure 6). These sub-sections were generated from exploratory data collected for the City by TerrAtlantic Engineering Limited in the early stages of the development of the Queen Square Wellfield between 2000 and 2005, and were reported previously in TerrAtlantic, December 19, 2005, following the construction and hydraulic testing of PW11. The details shown in these figures (i.e. Figures 4, 5 and 6) are interpretations and should be considered with the context that they are originally presented.

The sedimentary bedrock is of Pennsylvanian age, and comprises shale, siltstone, locally arkosic sandstone and polymictic to quartz pebble conglomerate. The rock is typically red, grey or green in colour, and is sub-horizontally bedded with joint spacings as little as 100 mm (GEMTEC, 1994). The typical trend of vertical joints and faults is either northeast/southwest or west to east, and this trend is now reflected by the preferred orientation of surface drainage courses which have cut into the bedrock.

The Fredericton Aquifer is recharged from three main sources: (a) the St. John River; (b) the overlying perched water table within the alluvium; and (c) the underlying bedrock (McLean, 1990; TerrAtlantic, May 11, 2001). The relative contributions made by each source depend on numerous factors, including the rate at which water is withdrawn from the production wells and seasonal variability of water levels, and is therefore difficult to estimate. Based on the available information, it has been interpreted that the St. John River is the primary source of recharge for the aquifer, via riverbank filtration (TerrAtlantic and ADI Limited, May 16, 2005).

Flowing artesian conditions are not expected to be encountered while drilling in the overburden at each of the proposed well target locations.

6) Outline the proposed hydrogeological testing and work schedule.

A single 150 mm (6 inch) diameter test well will be drilled at the preferred target location by the well driller in the summer of 2020. Soil samples will be collected at regular intervals during the test well drilling process, and gradational analyses will be completed on a select number of these samples to determine the preferred screened interval(s), screen slot-size, and gravel-pack design for the production-scale well. The preferred water-bearing interval(s) will be screened in the test well (by means of stainless-steel screen installation(s) or test well casing perforations) and sufficiently developed. Well development will be completed by the selected well driller and likely involve air-lifting and/or air-jetting and/or surging of the well using specialized well development tools supplied by the well driller. BGC will monitor the progress of this work and determine when an adequate duration of development has been completed by measuring the well discharge and water quality parameters in the field with development time (e.g., sediment

content, temperature, pH, conductivity, total dissolved solids, redox potential and dissolved oxygen).

Once the well has been sufficiently developed, pumping tests will be completed at the test well in late summer 2020 to determine the aquifer's hydraulic properties and assess the potential well yield and water quality of this location prior to constructing a production-scale well. The pumping tests will include a multiple-step pumping test (step-test) and a short constant-rate pumping test (e.g., up to 12 hours in duration). Monitoring recovery of the pumping well and wellfield will also be completed immediately following completion of the pumping phase of the tests. In this phase, the water levels are monitored in the pumped well and observation wells until the groundwater levels have substantially recovered to the pre-testing (or near-static) conditions.

A water sample will be collected from the test well near the end of the constant-rate test to assess the water quality of this location prior to constructing a production-scale well. The water sample will be submitted for laboratory analyses of general chemistry with dissolved trace metals (including mercury and fluoride), volatile organic compounds (VOCs), Polycyclic Aromatic Hydrocarbons (PAHs), petroleum hydrocarbons (Atlantic MUST), and microbiology (i.e., E.coli, total coliforms and total faecal coliforms). The associated analytical results will be compared against the most recent Health Canada (2019) Guidelines for Canadian Drinking Water Quality (GCDWQ).

Based on the results of the test well construction and testing, the production-scale well will be designed and then constructed adjacent to the test well in late summer 2020, provided conditions observed in the test well are favourable. In general, this task will involve drilling a larger diameter production-scale well adjacent to the test well; the latter then would serve as an additional observation well for the wellfield. BGC has found this approach (i.e., construction of test well(s) before the production-scale well) to be highly successful on numerous projects across the Province, including those completed for the City previously (PW6 through PW11). Each of the City's three production wells in the Queen Square Wellfield were constructed with a 457 mm (18-inch) diameter well-column and screen, and a 660 mm (26-inch) diameter outer protective well casing installed above the screened interval, with 10 mm minus silica gravel-pack infilling the annulus between these casings to surface. Similar well design characteristics are envisaged for production-scale well PW12, but these design characteristics and its viability for use as a future production well for the Queen Square Wellfield will be confirmed during the proposed drilling and testing programs. The preliminary design and construction details for production-scale well PW12 are illustrated in Figure 7.

Sufficient well development will be necessary following construction of the production-scale well. Based on BGC's experience with similar sized production wells, 50 hours of development time is often required to remove finer-grained material, settle the gravel-pack and maximize the hydraulic efficiency of the well. A well development process similar to that of the test well will be used for production-scale well PW12.

Appropriate water control measures (e.g., sandbags, shallow trenches, silt fencing, hay bales, and/or above-ground piping), will be implemented by the well driller during the drilling, development and test pumping phases to help prevent excess water impacts to the University Avenue right-of-way, and nearby residential properties. During the pumping

test, additional measures will be taken to mitigate artificial recharge to the aquifer. This may require the placement of additional above-ground piping to capture and direct the discharged water into the City's nearby storm/sanitary sewers, and/or at an adequate distance away from the pumped well(s) to discharge outside of the silt-clay window area (i.e., that area where the silt-clay aquitard is absent), into a natural surface drainage area or system.

Pumping tests will be completed at the production-scale well in late summer to early fall 2020 to determine the aquifer's hydraulic properties, the sustainability of the production-scale well, and to further evaluate the overall sustainability of the groundwater source with the possible addition of a new production well (PW12) in future. The hydraulic testing program is proposed to be completed in a similar approach to that completed previously at PW11, following construction in 2005. Stage 1 of the testing program will consist of a step-test at PW12, in order to assess the as-built specific capacity, well and formation losses, and provide a preliminary estimate of well yield. The step-test will then be followed by a multi-staged aquifer pumping test, which allows for assessment of yields and drawdowns at each well, and quantification of well interferences. It is expected that the hydraulic testing program will be completed over a 14-day period, as follows. To the extent possible, the existing production wells in the Wilmot Park Wellfield (PW1 through PW8) will be turned off, or their pumping minimized to meet the City's prevailing water demand, throughout this 14-day testing period.

Stage 1 – Complete a step-test at production-scale well PW12. Each of the other Queen Square Wellfield production wells (PW9, PW10 and PW11) will be turned off during the step-test.

Stage 2 – Begin pumping PW12 at a constant rate, which will be the start of the aquifer pumping test. The test will be started following the recovery of water levels from the earlier step-test (which is anticipated to be within one day of completing the Stage 1 step-test). Each of the other Queen Square Wellfield production wells (PW9, PW10 and PW11) will be turned off during this stage of the pumping test.

Stage 3 – Begin pumping PW11 at a constant rate after two days of pumping at PW12.

Stage 4 – Begin pumping PW10 at a constant rate after three days of pumping at PW12.

Stage 5 – Begin pumping PW9 at a constant rate after four days of pumping at PW12. The four wells will then be pumped simultaneously at their respective constant rates for a period of three consecutive days (72 hours).

Stage 6 – Cease pumping PW11 after seven days of pumping at PW12.

Stage 7 – Cease pumping PW10 after eight days of pumping at PW12.

Stage 8 – Cease pumping PW9 after nine days of pumping at PW12.

Stage 9 – Cease pumping PW12 after 10 days of continuous pumping. The recovery of PW12 and the wellfield will then be monitored for an additional three days. Each of the other Queen Square Wellfield production wells (PW9, PW10 and PW11) will be turned off during this recovery phase of the test.

The order and timing of pumping from other production wells during the multiple well pumping test may be subject to change from what is presented above. Representative water quality samples will be collected from each of the pumped wells for subsequent laboratory (inorganic, organic and microbiological) analyses throughout the constant rate test, immediately after they are turned on and every 48 hours thereafter while they are pumping, including immediately before they are turned off. This water quality data should be sufficient to assess the individual (well) and overall (wellfield) water chemistry with time under these higher pumping conditions.

Following completion of the above hydraulic testing of PW12 and the wellfield in the fall of 2020, the associated findings and analytical results from the construction and hydraulic testing program will be generated in a Hydrogeological Assessment Report, which will be submitted for regulatory review late in 2020 or early 2021. Based on the results from the hydraulic testing, it is expected that a long-term sustainable well yield will be recommended for the new production-scale well. An assessment of the well yield and water quality findings will determine whether production-scale well PW12 will be recommended for use as a new supply well for the Queen Square Wellfield. The hydraulic testing results will also likely determine whether a recommendation can be made to increase the current approved 17 ML/d withdrawal rate for the Queen Square Wellfield.

The estimated project schedule is summarized below in Table 1. Note that the beginning and end of task dates are tentative as noted below in the table.

Table 1. Estimated preliminary project schedule.

Phase	Task	Beginning of Task	End of Task
WSSA Initial Application	1. Reconnaissance and Drill Target Selection	June 2020	July 2020
	2. Regulatory Correspondence	June 2020	July 2020
	3. Driller Selection, Cost Estimate Updates and Field Preparation	June 2020	August 2020
Hydrogeological Assessment	4. Test Well Construction and Testing	August 2020	August 2020
	5. Production-Scale Well Construction	August 2020	September 2020
	6. Production-Scale Well Hydraulic Testing	August 2020	September 2020
	7. Test Data Processing and Analysis	September 2020	November 2020
	8. Hydrogeological Assessment Report	September 2020	December 2020

Note:

1. *This proposed project schedule is preliminary and approximate and may be subject to change as there may be circumstances beyond BGC's control that can affect the schedule (e.g., regulatory review and approval, well driller's availability and drilling approach, the City's ability to complete a longer-term pumping test for the wellfield, weather conditions, and circumstances surrounding restrictions or delays due to the COVID-19 pandemic).*

This preliminary project schedule is aggressive at this stage of the project due to prior Covid-19-related circumstances. Additional project delays, including but not limited to additional unforeseen Covid-19-related matters, are possible. Any significant changes to this schedule will be communicated as soon as they become apparent.

7) Identify any existing pollution or contamination hazards within a minimum radius of 500 m from the proposed drill targets. Historical land use that might pose a contamination hazard (i.e. tannery, industrial, waste disposal, etc.) should also be discussed.

BGC (and previously TerrAtlantic) has been involved with the wellfield development, protection, monitoring and maintenance programs for the City in both the Wilmot Park and Queen Square Wellfields since 2000. This involvement includes the development of the Queen Square Wellfield through the construction of PW9, PW10 and PW11, development of an extensive groundwater monitoring network, completion of a routine groundwater monitoring program, and completion of an annual well regeneration program. From these past and on-going projects, BGC has investigated the impact of contaminants near or within the wellfields regularly.

An earlier study identified 18 known or potentially contaminated sites near the Queen Square Wellfield (TerrAtlantic Engineering Limited, August 2, 2001). Of these, the greatest concerns were (then) judged to be: (a) petroleum contamination on two adjacent properties on McLeod Avenue, which have since been remediated, "closed" and developed into a commercial apartment complex in 2012; (b) a furnace oil release on a residential property on University Avenue, which has since been further assessed and "closed" in 2002; and (c) chlorinated solvents (i.e., perchloroethylene and trichloroethylene) impacts to the shallow (perched) groundwater system to the north of Brunswick Street, which was further delineated and evaluated for the City in 2012 (TerrAtlantic, November 15, 2012) and 2015 (BGC, June 5, 2015).

The project team developed a Wellfield Protection Plan for the City (TerrAtlantic and ADI Ltd., May 16, 2005) that was implemented as part of the City's adoption of the Provincial Wellfield Protected Area Designation Order (WfPADO - NB Reg 200-47), and included the delineation of Wellfield Protection Zones A, B and C for each wellfield (Figure 1), with varying levels of restrictions/regulations for property owners and developers. As part of that plan, non-conforming land uses and potentially contaminated sites were identified and mitigation measures were recommended to reduce or eliminate the potential impact from these sites to the City's wellfields. The City has subsequently enacted these mitigation measures, one of which is regular monitoring of groundwater chemistry within the capture zones of the individual production wells and aggregate wellfields and assisting the Province with enforcing restricted land-use activity and development that are regulated within the wellfields.

Notwithstanding the above studies, groundwater quantity and quality in the production wells have not been problematic as a result of historical land use and contamination. The project team at BGC (previously TerrAtlantic) developed and implemented a detailed Wellfield Monitoring Plan (TerrAtlantic, December 4, 2006) for the City, which currently

involves regular (bi-annual) sampling and analysis of inorganic and organic groundwater chemistry from an extensive groundwater monitoring well network developed in both operating wellfields. This bi-annual monitoring effort is completed by the City in addition to the routine water quality compliance monitoring that is regulated by the Province for each of their operating production wells. Control limits for identified contaminants are established and contingency plans are in place should these limits be exceeded.

Groundwater samples are collected bi-annually from an extensive groundwater monitoring well network established at both of the City's operating wellfields. The additional sampling of the production wells is completed by the City separately, as part of the compliance monitoring and reporting requirements for municipal drinking water supplies, and is not discussed here (recent water quality results from the operating production wells are available upon request). The most recent wellfield monitoring events are Groundwater Monitoring Event No's 42 and 43 for the Queen Square Wellfield (in BGC, July 18, 2019 and BGC, March 9, 2020) and Monitoring Event No's 12 and 13 for the Wilmot Park Wellfield (in BGC, September 16, 2019 and BGC, May 5, 2020) from May and November 2019, respectively. Based on these monitoring events, groundwater samples collected from monitoring wells throughout both wellfields met the applied Atlantic Risk-Based Corrective Action (RBCA) Tier I Risk Based Screening Levels (RBSLs) for the light aromatic hydrocarbons benzene, toluene, ethyl benzene and xylenes (BTEX) and Modified total petroleum hydrocarbons (TPH) concentrations in a residential, potable, coarse-grained soil setting. These monitoring well samples also met the Health Canada Guidelines for Canadian Drinking Water Quality (GCDWQ) for a list of six separate chlorinated solvent compounds (which have remained non-detect at each of the monitored locations, to date).

Although low to trace levels of Modified TPH have periodically been detected in some of the monitoring wells since the formal wellfield monitoring programs commenced in the Queen Square Wellfield in 2000, and in the Wilmot Park Wellfield in 2013, the assessment of these monitoring results has concluded that these observed impacts are not likely to adversely affect the production wells (BGC, July 18, 2019; BGC, March 9, 2020; BGC, September 16, 2019; BGC, May 5, 2020).

8) Identify any groundwater use problems (quantity or quality) that have occurred in the area.

No problematic groundwater quantity or quality issues have been observed in the wellfield to date. Historical land-use and contaminated sites have not been observed to impact the raw groundwater at each of the City's production wells to date. An annual well regeneration program is completed by the City (since 2005) to mitigate water quantity impacts that can arise from the effects of localized biofouling at the production wells.

With respect to the analyzed inorganic chemistry, elevated concentrations of manganese, iron and pH have been observed in some of the groundwater samples collected from monitoring wells in both wellfields over the years. These elevated parameter concentrations are attributed to the natural background chemistry for the Fredericton Aquifer (Thomas, et al., 1994). The major ion chemistry for groundwater sampled from the Queen Square and Wilmot Park Wellfield production wells, during their hydraulic testing programs in 2002 and 2005, is summarized in the attached Trilinear diagram (refer to

Figure 8). Based on this, it is expected that the groundwater chemistry from the new production-scale well (PW12) would be similar to that observed at PW10 (sodium bicarbonate-type water).

9) Identify any watercourse(s) (stream, brook, river, wetland, etc.) within 60 m of the proposed drill targets.

The drill targets are located greater than 60 m from the nearest identified watercourse (via Service New Brunswick GeoNB Mapviewer search completed on June 23, 2020). The closest watercourse is a small unnamed stream/drainage ditch that is approximately 230 m to the southwest of the proposed drill target location (see Figure 2). This watercourse originates in a small drainage ditch situated immediately south of a large apartment building at 845 McLeod Avenue and directs surface water to the southeast, immediately north and parallel with Beaverbrook Street and the walking trail, through an engineered catchment area west of the E. John Bliss Water Treatment Plant, and ultimately empties into the St. John River east of Waterloo Row, approximately 1 kilometre southeast of the proposed drill target locations.

A municipal storm water sewer network is also present in the general area of the proposed drill target site (along University Avenue and the walking trail), which drains surface runoff from the area directly to the St. John River. The nearest storm sewer drains to the site are identified on Figure 2.

10) Identify site supervisory personnel involved in the source development (municipal officials, consultants and drillers).

City of Fredericton Personnel:

1. *Neil Thomas, M.Eng., P.Eng. – Senior Water and Sewer Engineer*
2. *Rick Larlee – Supervisor – City Water and Sewer Division*

BGC Engineering Inc. Personnel:

1. *Marc W. Hodder, P.Geo., P.Eng – Senior Hydrogeologist / Geological Engineer*
2. *Wesley Tibbet, M.Eng., P.Eng. – Hydrogeological Engineer*
3. *Calvin O'Neill, EIT – Hydrogeological Engineer-In-Training*

EXP Personnel:

1. *Charles Goguen, M.Eng., P.Eng. – Infrastructure Manager*
2. *Eric Bell, P.Eng – Water and Sewer Process Engineer*

Well Drilling Personnel:

To be determined after drilling contract award.

In progress, and to be determined. While regulatory approval is being reviewed by NBDELG, BGC will pursue the relevant permissions and utility clearances for the identified drilling target locations, and assist the City with completing the process of selecting a qualified, New Brunswick-licensed well driller to complete the proposed well construction and hydraulic testing work on behalf of the City.

11) Attach a 1:10000 map and/or recent air photo clearly identifying the following:

- proposed location of drill targets and property PID

- domestic or production wells within a 500 m radius from the drill target(s)

- any potential hazards identified in question 7.

These features are identified on the attached Figures 1, 2, 4 and Drawing 1.

12) Attach a land use/ zoning map of the area (if any). Superimpose drill targets on this map.

These features are identified on the attached Figures 1 and 2. A land-use and zoning map for the area is attached in Drawing 2, which is from the approved, adopted and implemented Wellfield Protection Plan for the City (TerrAtlantic and ADI Ltd., May 16, 2005). The proposed drill targets are located on a parcel zoned as "H - Parking Lot", situated immediately west of University Avenue, between Grey Street and Lansdowne Street (see red circle on Drawing 2).

13) Contingency plan for open loop earth energy systems (see Section 2.3).

Not applicable.

Submit WSSA Initial Application:

c/o Manager
Department of Environment and Local Government
Environmental Assessment Section
Tel: (506) 444-5382
Fax: (506) 453-2627
Mailing Address:
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

Physical Address:
20 McGloin Street, Marysville Place
Fredericton, New Brunswick
E3A 5T8

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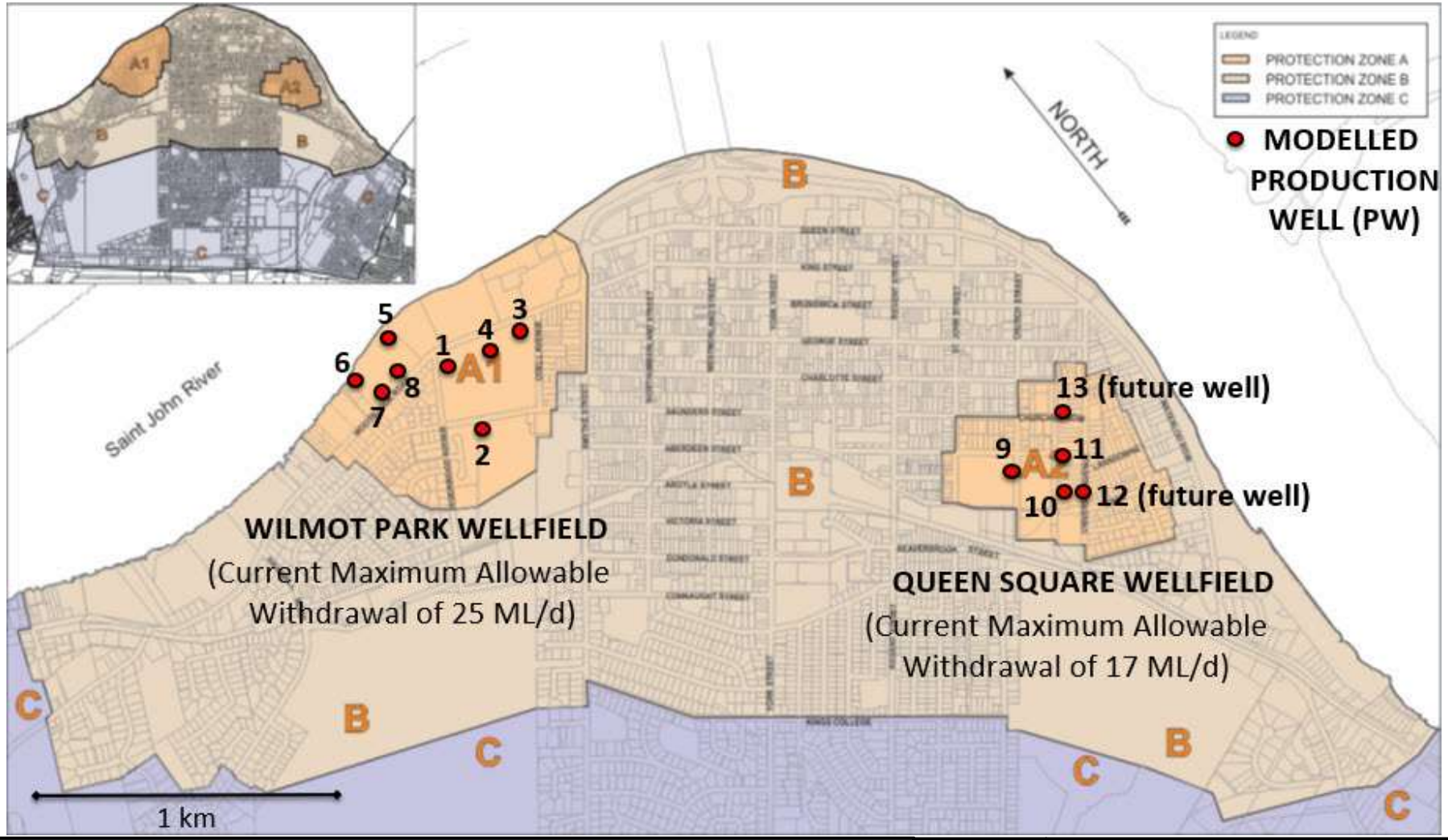
Thomas, N.E., Kan, K.T., Bray, D.I. and MacQuarrie, K. (1994), *Temporal Changes in Manganese Concentrations in Water from the Fredericton Aquifer*, *New Brunswick*. Ground Water, 32: 650-656.

Figures



1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure was originally presented in TerrAtlantic Engineering Limited and ADI Limited (May 16, 2005).
3. If investigation of the PW12 target location as a new production-scale well in the Queen Square Wellfield proves unsuccessful, a secondary location (indicated on this figure as PW13) would be investigated separately.

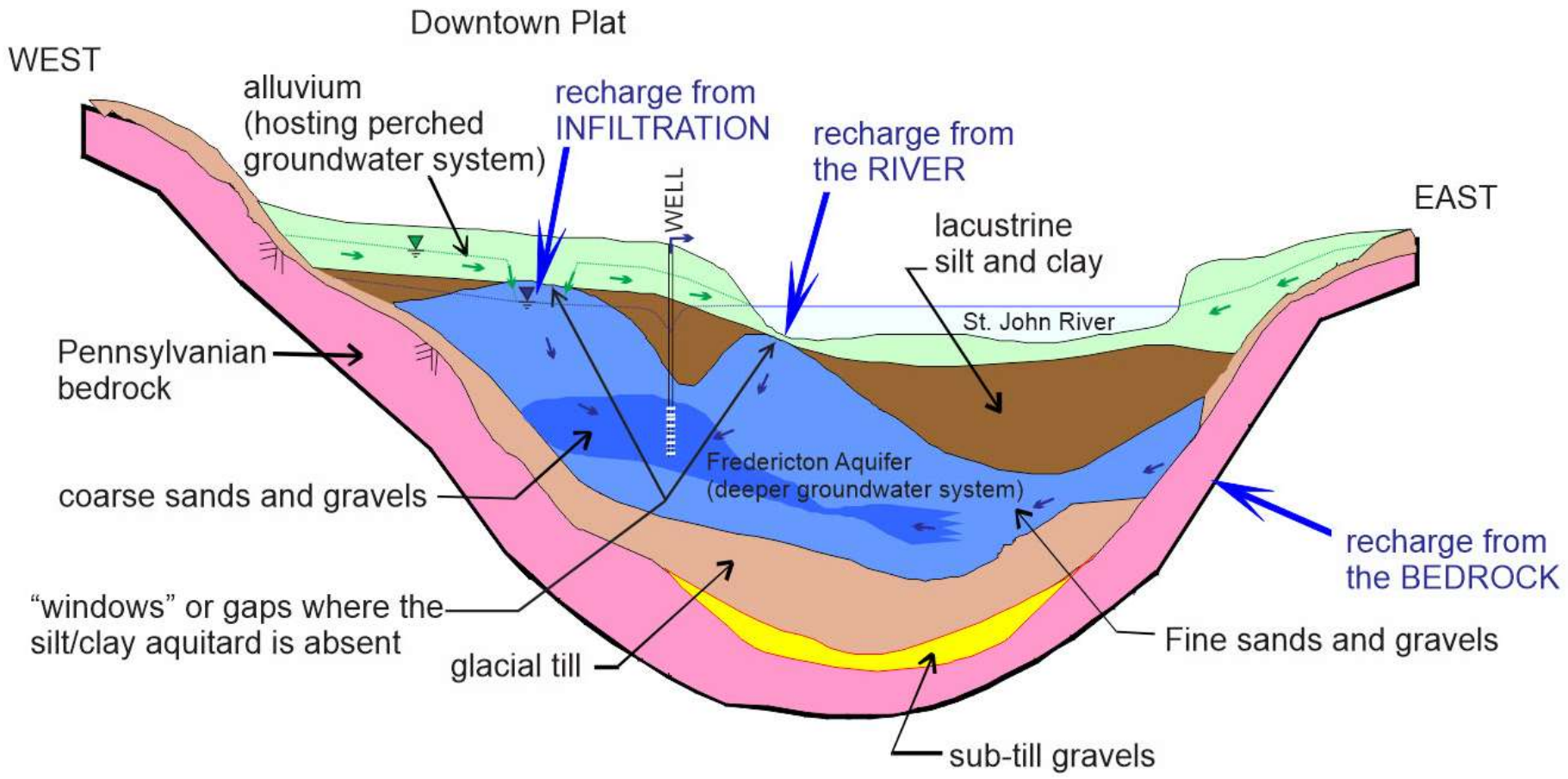
PREPARED BY:	FIGURE TITLE: FREDERICTON WELLFIELD PROTECTION ZONES WITH MAXIMUM ALLOWABLE WITHDRAWALS FOR EACH WELLFIELD		
CO			
CHECKED BY:	CLIENT:		
WT	CITY OF FREDERICTON		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
MH	AS SHOWN	1295-005	1

0 5 10 mm in ANSI A sized paper

1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.

PREPARED BY: CO	FIGURE TITLE: PROPOSED TARGET LOCATIONS WITHIN THE QUEEN SQUARE WELLFIELD		
CHECKED BY: WT	CLIENT: CITY OF FREDERICTON		
APPROVED BY: MH	SCALE: AS SHOWN	PROJECT NO: 1295-005	FIGURE NO: 2

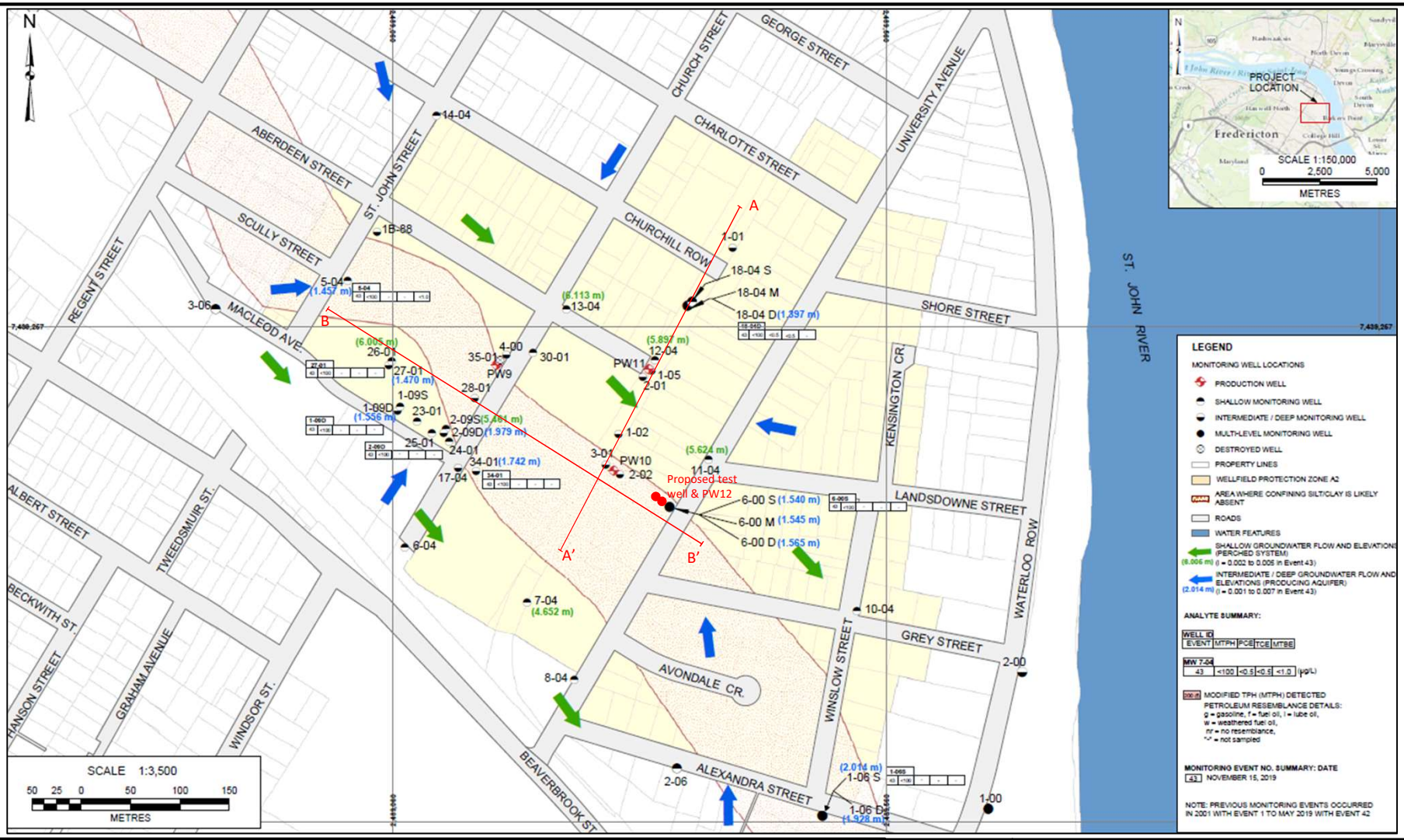
0 5 10 mm in ANSI A sized paper



1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure is modified from the original presented in TerrAtlantic Engineering Limited (December 4, 2006).
3. The conceptual water levels presented for the river and the perched and deeper groundwater systems are approximate and for illustrative purposes.

PREPARED BY: CO	FIGURE TITLE: CONCEPTUAL CROSS SECTION OF THE FREDERICTON AQUIFER		
CHECKED BY: WT	CLIENT: CITY OF FREDERICTON		
APPROVED BY: MH	SCALE: NOT TO SCALE	PROJECT NO: 1295-005	FIGURE NO: 3

0 5 10 mm in ANSI A sized paper



1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure was originally presented in, and is an excerpt from, BGC (March 9, 2020). The details shown are interpretations and should be considered with the context that they are originally presented.
3. The identified cross-section lines AA' (looking East) and BB' (looking North) are shown in Figure 5 and Figure 6, respectively.

PREPARED BY:	FIGURE TITLE: INTERPRETED SHALLOW AND DEEP GROUNDWATER FLOW DIRECTIONS IN THE QUEEN SQUARE WELLFIELD		
CO			
CHECKED BY:	CLIENT: CITY OF FREDERICTON		
WT			
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
MH	AS SHOWN	1295-005	4

0 5 10 mm in ANSI A sized paper

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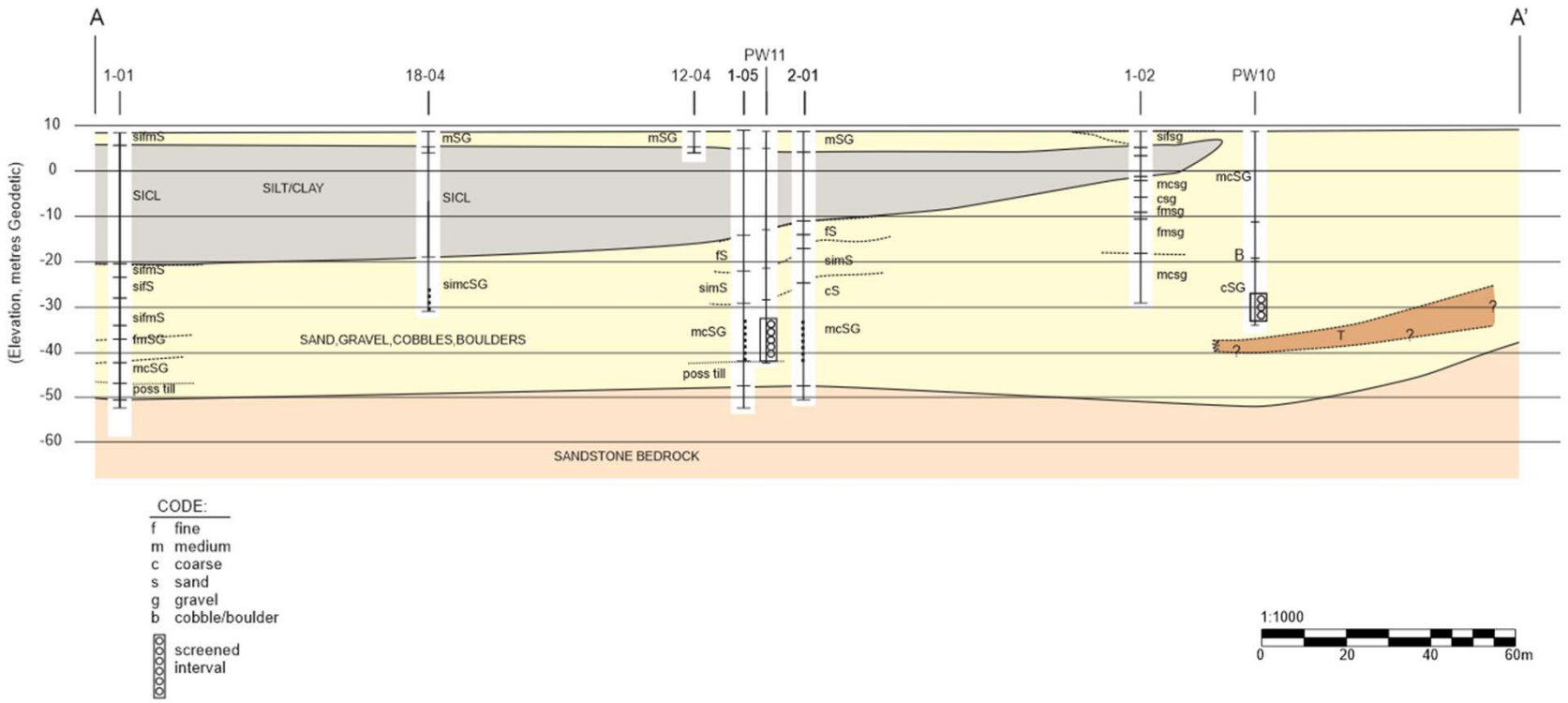
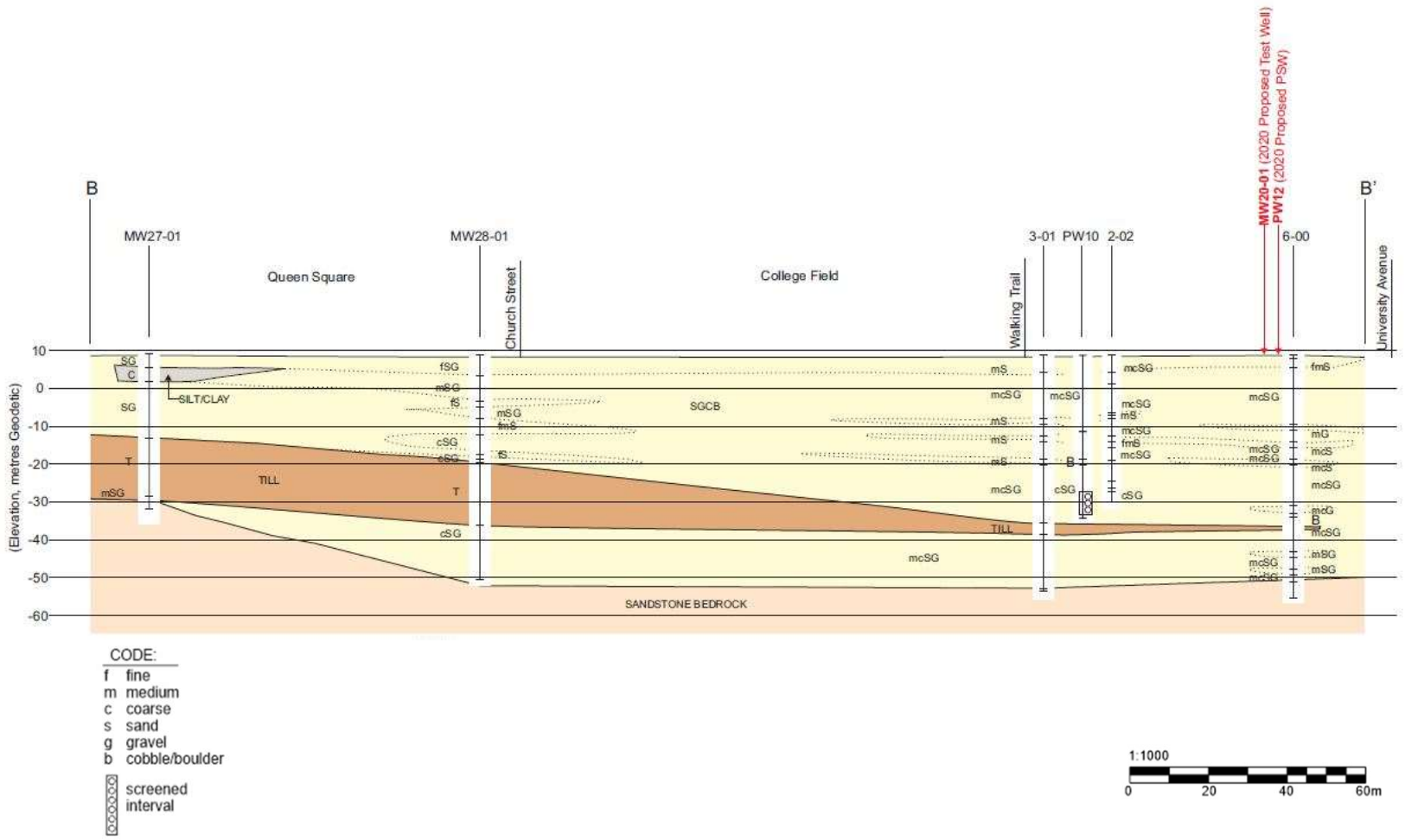


1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure was originally presented in, and is an excerpt from, TerrAtlantic Engineering Limited (December 19, 2005). The details shown are interpretations and should be considered with the context that they are originally presented.
3. Refer to Figure 4 for the plan view and location of this cross-section line.

PREPARED BY:	FIGURE TITLE		
CO	INTERPRETED CROSS SECTION OF QUEEN SQUARE (NORTHEAST-SOUTHWEST LOOKING EAST)		
CHECKED BY:	CLIENT:		
WT	CITY OF FREDERICTON		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
MH	AS SHOWN	1295-005	5

0 5 10 mm in ANSI A sized paper



1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure was originally presented in, and is an excerpt from, TerrAtlantic Engineering Limited (December 19, 2005). The details shown are interpretations and should be considered with the context that they are originally presented.
3. Refer to Figure 4 for the plan view and location of this cross-section line.

PREPARED BY: CO	FIGURE TITLE: INTERPRETED CROSS SECTION OF QUEEN SQUARE (NORTHWEST-SOUTHEAST LOOKING NORTH)		
CHECKED BY: WT	CLIENT: CITY OF FREDERICTON		
APPROVED BY: MH	SCALE: AS SHOWN	PROJECT NO: 1295-005	FIGURE NO: 6

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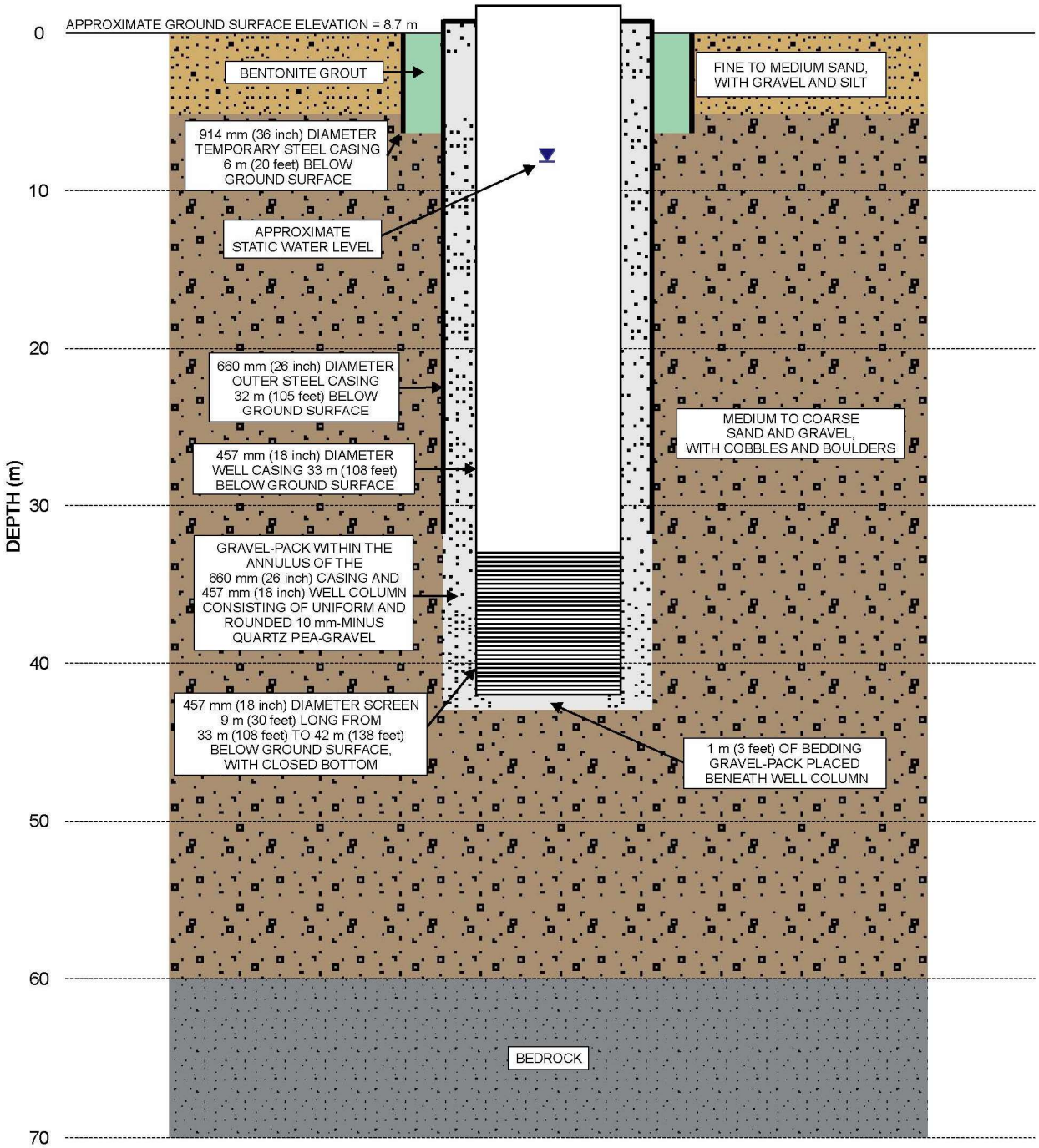
PW12

PRELIMINARY DESIGN DETAILS

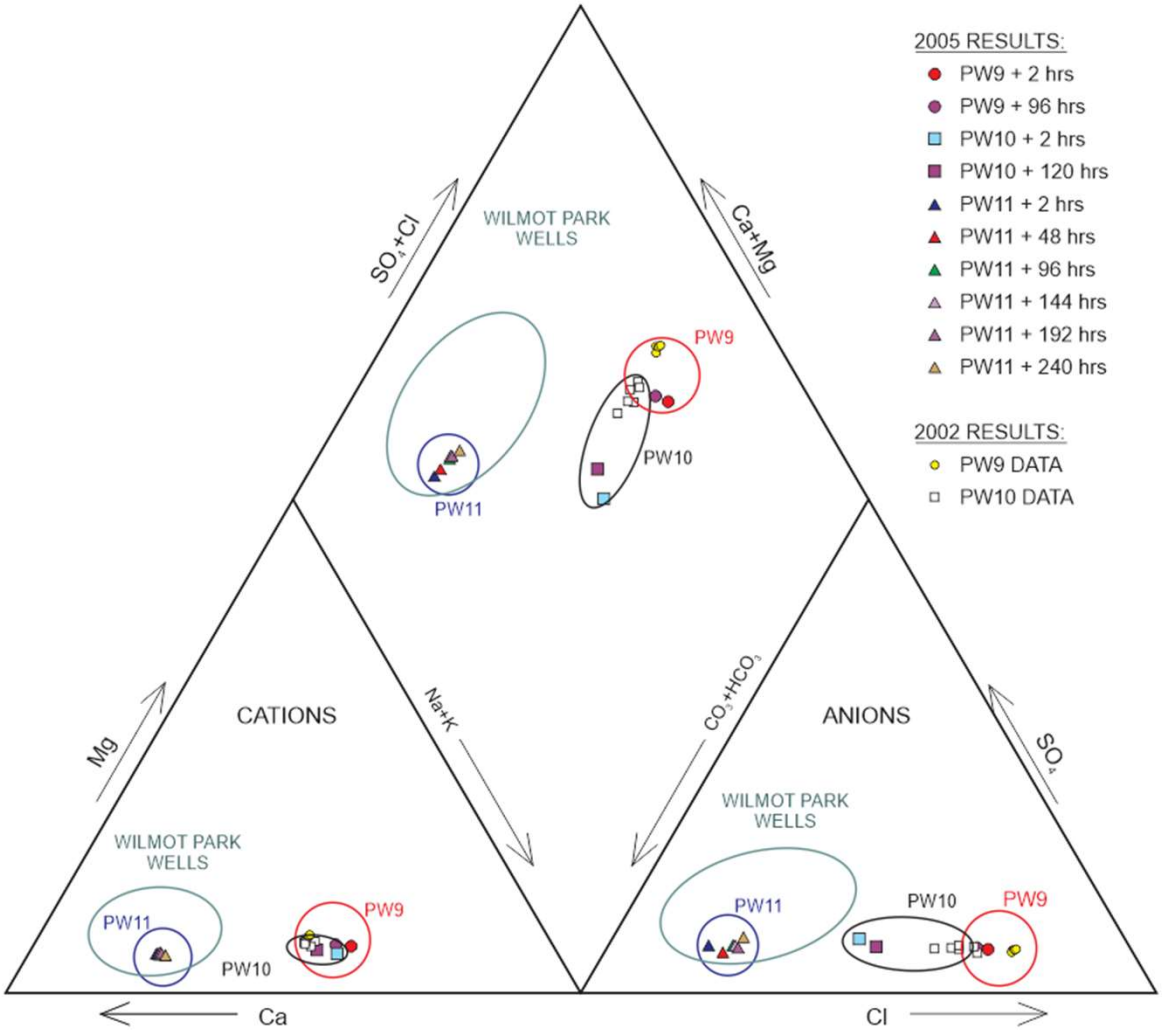


1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. The depths shown are approximate and are based on stratigraphy of existing wells in the immediate area.
3. The well screen and filter-pack will be designed using soil samples collected while drilling the PW12 test well (MW20-01).

PREPARED BY:	FIGURE TITLE		
WT	PRELIMINARY PW12 DESIGN		
CHECKED BY:	CLIENT:		
KW	CITY OF FREDERICTON		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
MH	1:200 VERTICAL 1:20 HORIZONTAL	1295005	7

0 5 10 mm in ANSI A sized paper

BGC ENGINEERING INC.



1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure was originally presented in, and is an excerpt from, TerrAtlantic Engineering Limited (December 19, 2005).

PREPARED BY: CO	FIGURE TITLE: TRILINEAR PLOT OF MAJOR ION CHEMISTRY FOR THE CITY'S WELLFIELDS		
CHECKED BY: WT	CLIENT: CITY OF FREDERICTON		
APPROVED BY: MH	SCALE: AS SHOWN	PROJECT NO: 1295-005	FIGURE NO: 8

0 5 10 mm in ANSI A sized paper

Drawings

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No.	Issue	Date

LEGEND

PROPOSED	EXISTING	
		WATER
		SANITARY
		STORM
		CATCH BASIN
		STORM MANHOLE
		MANHOLE WITH C/B GRATE
		SANITARY MANHOLE
		FIRE HYDRANT
		CURB STOP
		GATE VALVE AND CHAMBER
		BUTTERFLY VALVE AND CHAMBER
		GATE VALVE AND BOX
		CAP / PLUG
		REDUCER
	G	NATURAL GAS MAIN
		PROPERTY LINE
		FENCE
		SIGN POST
		TREE / SHRUB
		TREE LINE
	UP	UTILITY POLE
	L	LIGHT POLE
		UNDERGROUND ELECTRICAL
		NATURAL GAS LINE

No.	Revision	Date

PRELIMINARY

Professional Seal(s)

Drawn By:	PD
Dwg Standards Chd By:	
Designed By:	JFP
Design Checked By:	
Scale:	1:250

Project Title

THE CITY OF FREDERICTION
PRODUCTION WELL #12

Dwg. Title

SITE PLAN

Project No.

FRE-00258821-A0

Dwg. No.	Rev. No.
Drawing 1	----

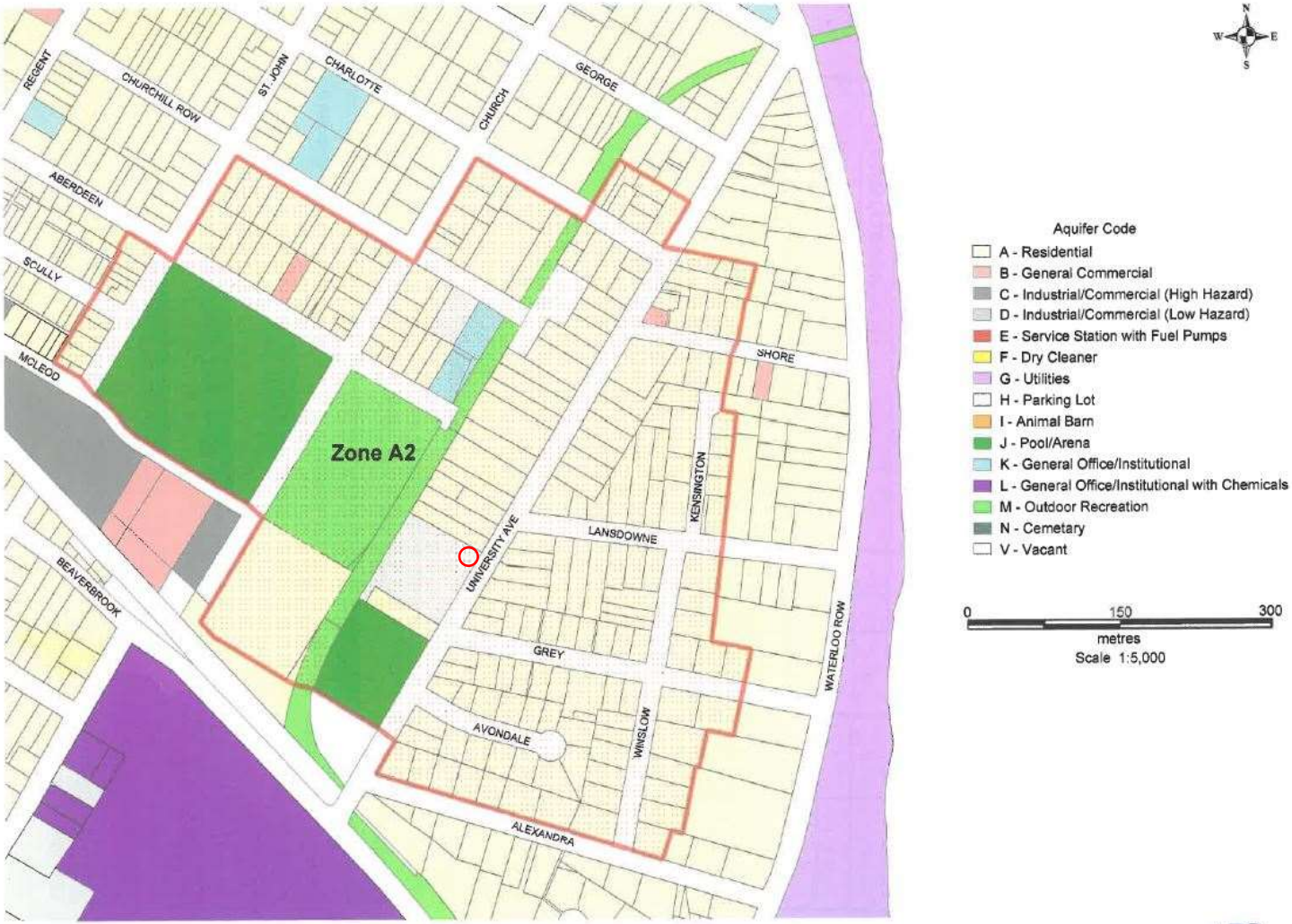

Figure 5.3 - Zone A2 Land Use Codes [2001]

ADI
TerrAtlantic

1. This figure should be read in conjunction with BGC's Water Supply Source Assessment Initial Application (July 2020) to the NBDELG for the construction of a new production-scale well (PW12) in the City of Fredericton.
2. This figure was originally presented in, and an excerpt from, TerrAtlantic Engineering Limited and ADI Limited (May 16, 2005).

SCALE: AS SHOWN		PROJECT: CITY OF FREDERICTON PW12 CONSTRUCTION AND TESTING	
PREPARED BY: CO		FIGURE TITLE: QUEEN SQUARE WELLFIELD LAND USE ZONES	
CHECKED BY: WT	CLIENT: CITY OF FREDERICTON	PROJECT NO: 1295-005	FIGURE NO: Drawing 2
APPROVED BY: MH			

0 5 10 mm in ANSI A sized paper