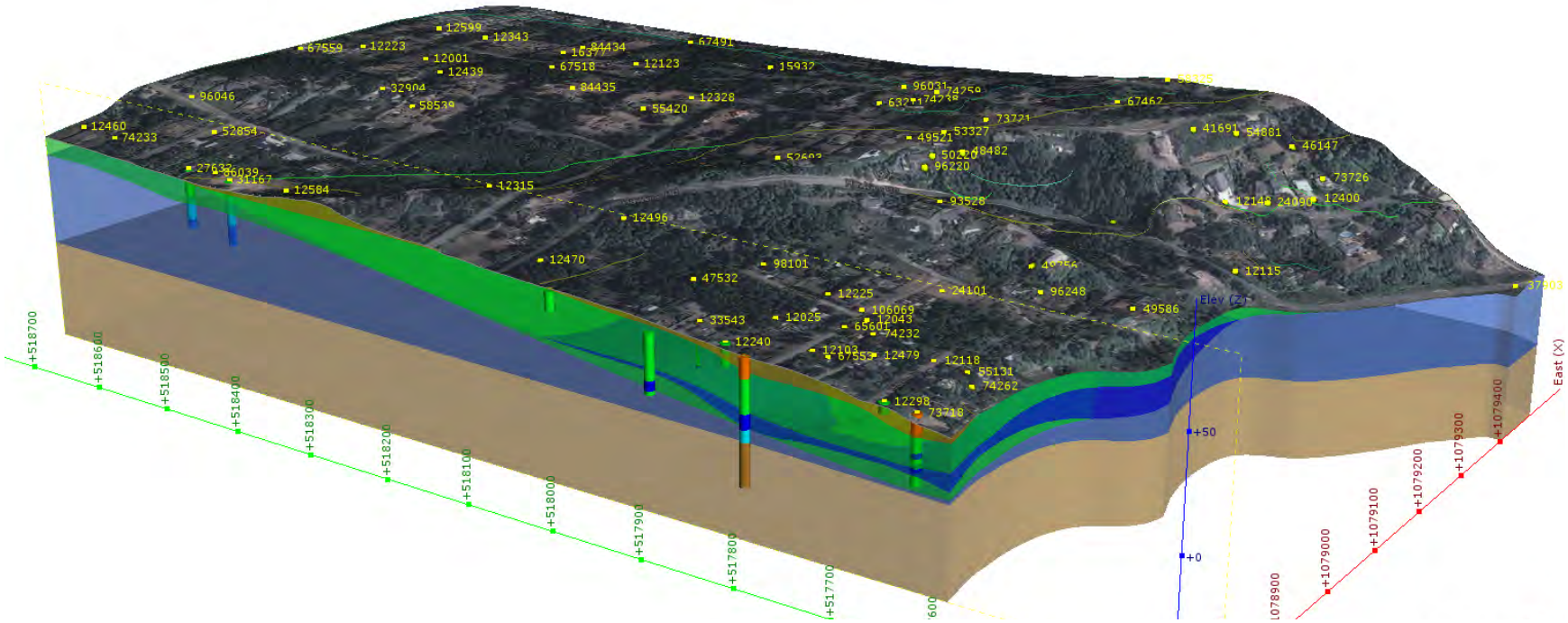


GW Solutions Inc.

Hydrogeological Assessment of Comox Number 2 Pump Station Siting - Comox, British Columbia

Submitted to the Comox Valley Regional District

Comox Valley Regional District
600 Comox Road
Courtenay, BC, V9N 3P6

Attention: Marc Rutten, P. Eng., General Manager of Engineering Services Branch

Re: Hydrogeological Assessment Comox Number 2 Pump Station Siting

Background

The CVRD has selected two potential sites for a future wastewater pump station. Both sites are located in an area of the regional district known as the Croteau Road – Balmoral Beach, Comox neighbourhood (hereafter referred to as the "neighborhood"). Residents within the neighbourhood are concerned about the siting of a wastewater pump station in vicinity, especially as it relates to the future supply and quality of groundwater for their properties both during construction and long-term. The two sites selected by the regional district are shown in Figure 2 and include:

1. Option 1; Croteau Road right of way (ROW) with pump station located at the base of Croteau Road; and
2. Option 2; Beech Street right of way and pump station Located in a residential lot at 98 Beech Street

The neighbourhood area selected for the new wastewater pump station relies solely on ground water for all of its domestic water supply.

GW Solutions was retained by the CVRD to assess the potential impact of the proposed pump station and force main to groundwater and residential wells in the neighborhood. Our area of focus is the residential neighborhood bounded by MacDonald Wood Park and Croteau Road to the west and Hawkins Road to the east and northeast. To do this, we have assembled a series of datasets that illustrate the baseline groundwater conditions in the neighborhood including topography, soils, wells, water table and subsurface geology.

Through our approach, we aim to:

- Establish high-permeability versus low-permeability units in the subsurface and relate these, where possible, to surficial geology and soils;
- Analyze well information form the Ministry of Environment (MoE) Wells database, grouping lithologies according to their role in the groundwater system;
- Define spatial distribution of aquifers and aquitards in a 3D model;

- Estimate the movement of groundwater, highlighting areas likely to play a role in aquifer recharge (where water infiltrates into the subsurface);
- Assess areas of potential aquifer vulnerability to accidental effluent release.

Based on this newly acquired knowledge, we aim to enable decision makers to answer such questions as:

- What potential risk is there to underlying aquifers or water supplies if development were to occur?
- What development management techniques are appropriate to protect natural systems and water supplies?
- What are the potential effects, if any, of the proposed construction on groundwater resources down gradient?

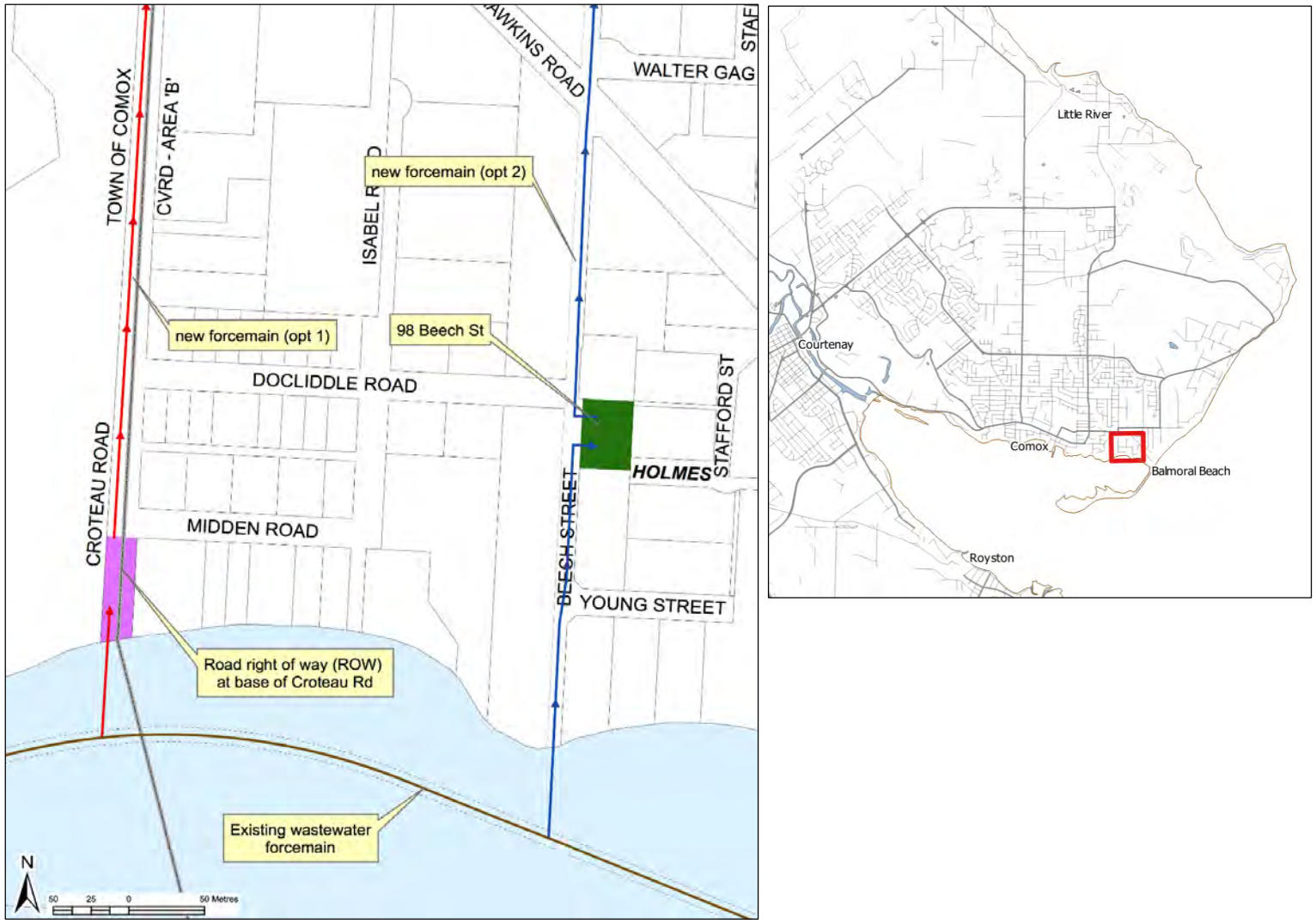


Figure 1. Proposed CVRD wastewater pump station and forcemain locations. Croteau Road Right of Way (Option 1), Beech Street Right of Way (Option 2).

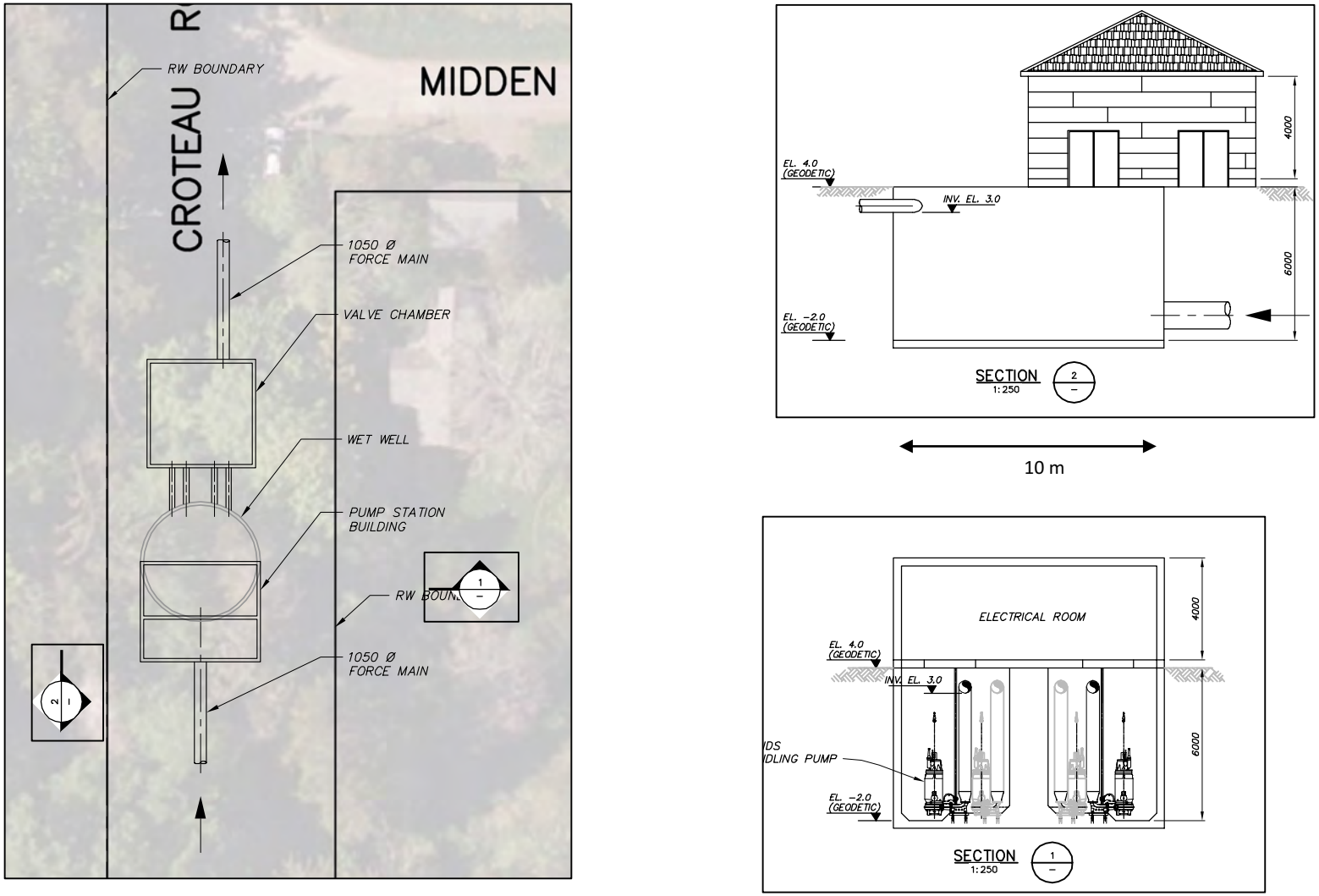


Figure 2. Comox No. 2 Pump Station - Plan and Conceptual Design (from Comox No. 2 Pump Station Siting Study technical memorandum AECOM, December 22, 2015)

Comox No. 2 Pump Station:

GW Solutions was provided with the Pump Station Siting Study technical memorandum from AECOM (dated December 22, 2015). The conceptual design of Comox No. 2 Pump Station (PS) includes a 10 m diameter cylindrical concrete basin (wet-well), installed below grade with a building installed on top of the basin to house electrical equipment (Figure 2). The wet-well is designed to have a bottom elevation of approximately -2 m geodetic. Grade elevation is approximately 4.0 m geodetic in the vicinity of the wet-well, bringing the total excavation depth to approximately 6 m below grade. Construction of the future Comox No. 2 pump station will involve the following key tasks in order to complete the in-ground works:

- Clearing and grubbing of an approximate 30 m long by 20 m wide area. Total 600 m^2
- Excavation of an approximate 15 m long by 15 m wide area by 6 m deep hole
- Dewatering of the excavation during the construction (approximately 26 weeks) to keep the hole dry.
- Installation of formwork, reinforcing steel and embedded steel
- Installation of drainage material and systems to provide future drainage of the ground adjacent to the structure
- Pouring of concrete
- Removal of forms
- Backfilling with non-native soils and compacting

Wastewater Force main

In order to transmit wastewater from the new Comox No. 2 Pump Station to the CVRD's existing wastewater treatment plant located on Brent Road, a new, approximately 1 m diameter, wastewater force main will have to be installed. The routing of the force main will depend on the final pump station location. The force main will be designed and installed to the seismic standards in place for this area. Construction of the future force main will involve the following key tasks in order to complete the in-ground works:

- Clearing and grubbing of the force main route (only those portions with vegetation). The route is generally located adjacent to the existing road network just outside of the paved surface
- Excavation of an approximately 2 m wide by 3 m deep trench along the entire route
- Dewatering of the excavation during construction (only if required depending on depth and water table)
- Backfilling with non-native sand as pipe bedding materials
- Installation of pipe
- Backfilling and replanting

Baseline groundwater conditions

Soils & Infiltration Potential

Modern day soils have developed within the first 1-2m of depth from "parent materials" left by ice age glacial advance, melting and subsequent marine incursion. The infiltration potential of soils is spatially variable but largely governed by topography and soil material properties. The neighborhood is characterized by two distinct soil types:

- Upland areas (above Hawkins Road and east to Beach Street) are mapped as Qualicum soils;
  - Soils here are permeable, meaning that water will infiltrate to the subsurface rapidly.
  - Parent materials (sub-soils) are the 20 to 50 m thick glaciofluvial sand and gravel deposits of the Quadra Sand Formation that makes up the Cape Lazo bluff complex.
- The lower neighborhood (between Beach Street and Croteau Road) are mapped as Quinsam soils;
  - Soils here have low permeability, meaning that water will infiltrate slowly.
  - Parent materials (sub-soils) comprise variably:
    - 0 to 10 m thick glaciomarine deposits of stony, clayey silt to silty sand; and
    - 2-30 m thick glacial till, comprising a mixture of sand, gravel and boulders, in a matrix of consolidated silt and clay.

The potential for water to infiltrate the *shallow* subsurface is interpreted to be relatively high throughout upland areas above Hawkins Road. Infiltration potential of soils throughout the lower neighborhood is interpreted as relatively low. However, localized areas with relatively thicker accumulations of permeable sand and gravel at or close to surface are interpreted in boreholes logs from wells located throughout the lower neighborhood, and immediately adjacent to the Option 2 Pump Station site.

Hydraulic conductivity (K) is a standard measure of the rate at which a soil, sediment or rock can transmit water, and it can vary across several orders of magnitude. Soils developed within the uppermost 1 to 2 m may have higher K (and infiltration capacities), however, the downward movement of water is restricted by underlying glacial sediments that have low K values. Infiltrated water will preferentially flow laterally in directions controlled by topography, with comparatively little flowing vertically into the underlying glacial till. The most recent compilation of published vertical hydraulic conductivities for eastern Vancouver Island surficial geology units are summarized in Table 1 (Benoit and Paradis, (2015), and references therein).

Table 1. Comox area surficial geology units, their relative hydraulic conductivities and role in groundwater infiltration and storage.

Hydro-stratigraphic Unit	Depositional Environment	Characteristic Materials	Thickness at Croteau Rd.	Vertical Hydraulic Conductivity K_z (m/s)[2, 3] min to max	Groundwater Role
Capilano-Salish	post-glacial marine, beach and fluvial	gravel and sand, silty clay to fine sand containing marine shells	0-14m	$3.4x10^{-5}$ to $1x10^{-2}$	Aquifer/ Aquitard
Capilano	glaciomarine	stony clayey silt to silty sand	0-10m	$5x10^{-10}$ to $2.5x10^{-7}$	Aquitard
Vashon Till	Ground moraine	dense till, sand and gravel lenses	2.5-30m	$5x10^{-9}$ to $5x10^{-6}$	Aquitard
Quadra	pro-glacial floodplain, glacial fluvial	sand and minor gravel	20-60m	$2x10^{-7}$ to $4.6x10^{-3}$	Aquifer

1. Interpreted from Fyles (1960).
2. Benoit and Paradis (2015), and references therein.
3. Horizontal hydraulic conductivity K_{xy} min = Kzmin x 10 (after Benoit and Paradis, 2015).

Units with low K values are aquitards. The most widespread, low-permeability layers present locally are the Vashon Till and Capilano glaciomarine units. The thickness and spatial distribution of these low K deposits is of critical importance to aquifer protection. When located above aquifers, they will provide a capping protective layer.

Neighborhood Wells

GW Solutions uses a standardized version of the Ministry of Environment (MoE) Wells database. The database includes a set of well attributes including ground elevation, well use, completion information, groundwater elevations, yield, and standardized lithologies based on hydrogeological units. Based on the most current (2015) provincial database, there are 28 groundwater wells in the neighborhood, compared to the 41 civic addresses. Given that every residence in the area is "self-serviced" in terms of both water supply and wastewater treatment (i.e. septic field), many wells in the neighborhood are clearly missing from the database. Despite the use of a standardized Wells database, the source records in the provincial database were been recorded over many years, using different data standards. The following possible errors sources are inherent in the database and must be acknowledged:

- Old wells may no longer be in use, and newer wells may not have been registered;
- Wells may not be accurately located in the parcel;
- X-Y positional errors will introduce errors in the Z-direction, since the well location will determine the ground elevation from the most accurate available digital elevation model;
- Data entered in the source database may be inaccurate or incomplete.

There are clearly wells being used in the neighborhood that have not been registered with the MoE database, and a survey of existing wells has not been conducted. Despite these factors, we have proceeded with the population of neighborhood wells as input to our model, since it was the best available data.

Croteau Road Groundwater System

The lithology records from the Croteau Road neighborhood indicate that the aquifer is hosted in relatively thin, saturated, sand and gravel lenses that occur at depths ranging from 10 to 30 m below ground surface (Figure 3). The average depth drilled to the aquifer is approximately 20 m. The saturated lenses have a range in thickness from under a metre to over 17 m, and an average thickness of approximately 5 m (Table 2 and Figure 4 – Layer 3).

*Table 2. Summary of Croteau Road Neighborhood confined sand and gravel aquifer derived from model and Wells Database. (Abbreviations: MoE = Ministry of Environment; mbgl = metres below ground level; masl = metres above sea level). *Thick aquifer in WTN 49586 possibly Quadra Sand.*

Well Tag Number (MoE Database)	*Depth to Top of Aquifer (mbgl)*	*Aquifer Thickness (m)*	*Average depth to groundwater (mbgl)*	*Ground Elevation (masl)*
98101	16.5	7.6	14	23.4
47532	21.0	4.0	16.8	23.3
49857	22.3	4.9	8.8	19.6
33543	20.4	1.1	11.6	19.5
49756	30.5	6.1	3.7	18.7
106069	13.4	4.3	6.4	16.1
93618	26.2	7.3	15.2	15.4
24101	18.3	0.8	4	15.5
74232	18.3	2.7	7.6	14.5
67553	28.7	2.4	7.6	14.2
96248	13.7	4.9	7.6	13.6
49586	9.8	17.1*	6.1	11.3
55131	16.8	1.8	4.3	9.2
73718	5.2	9.8	0	6.7
74262	18.6	1.7	6.1	5.8
Average	18.6	5.1	8.0	

The only BC mapped aquifer in the vicinity is Quadra Sand aquifer (BC # 408). The Quadra Sand Aquifer is typified by uniformly fine-grained, gray-coloured sand, with very little gravel content. It is unlikely that the aquifer underlying the neighborhood is Quadra in origin, due to the occurrence of coarse sand, gravel and brown colouring reported in well log descriptions. Without pumping test data, the hydraulic connectivity of the confined aquifer system cannot be assessed, however the hydraulic heads in the two aquifers are possibly inconsistent with a single, contiguous aquifer. Lithology records from neighborhood wells indicate that the Croteau Road sand and gravel aquifer is confined, with high hydraulic heads (i.e., high water table), whereas Quadra aquifer wells have lower hydraulic heads (i.e., relatively deep water table). The Croteau Road neighborhood sand and gravel aquifer is therefore treated herein as a distinct hydrogeologic unit.

A shallow, unconfined system is evident in the neighborhood, although there is uncertainty as to its productivity as a water source. The key findings are as follows:

- Several shallow, possibly dug wells are recorded in the MoE database, however, they appear to be sourcing water from thin sand and gravel lenses present within the glacial till, or possibly Capilano marine sediment (WTN: 12298, 12118, 12479, 12240, 12025, 12225, 12470, 12496, 12115).
- Due to the lack of detailed information on their well logs, it is uncertain whether they are completed in confined or unconfined surface deposits.
- Thick accumulations of permeable sand and gravel at surface are evident in well logs in the neighborhood (WTN: 47532, 33532, 93618, 67553, 98101, 52693, 96248, 49756), however, well records do not indicate whether these permeable soils are saturated or not.

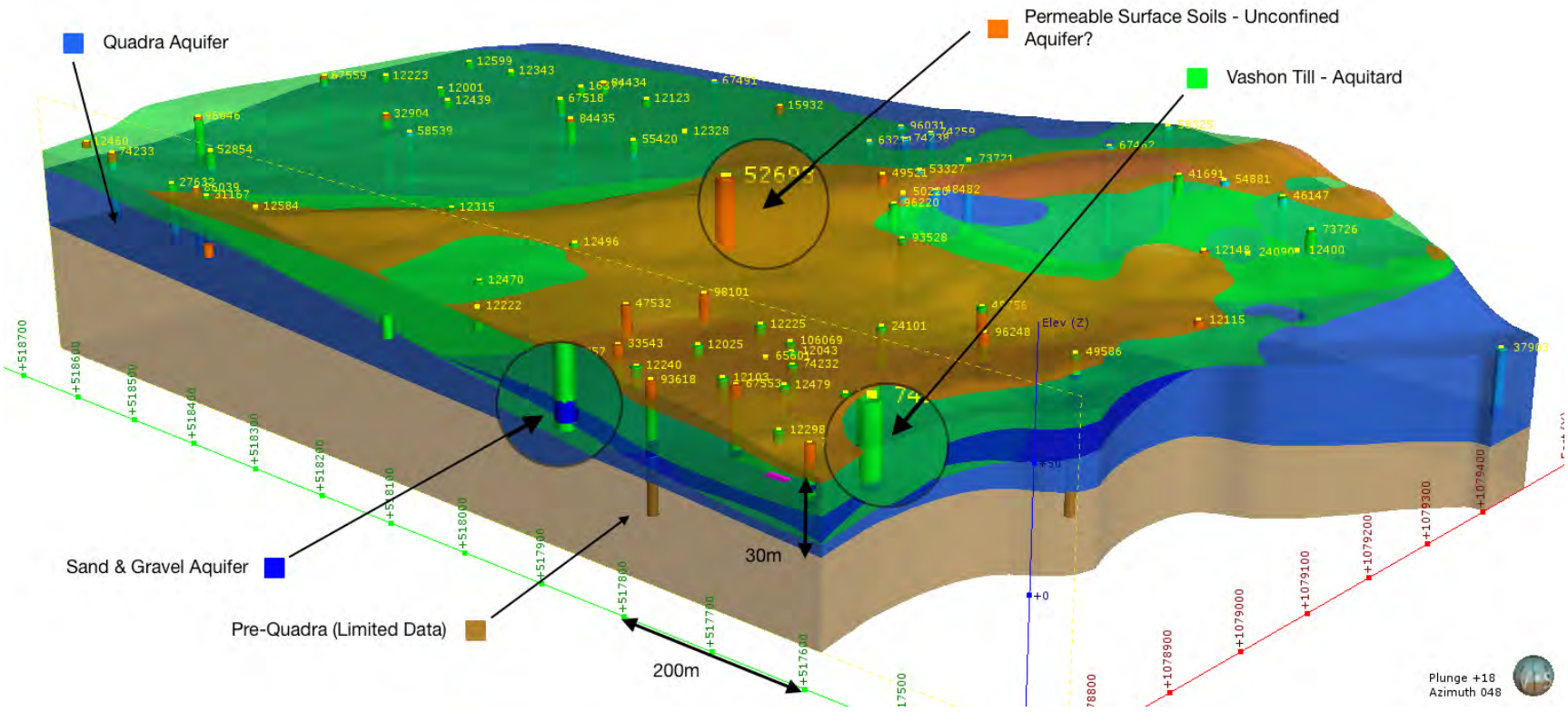
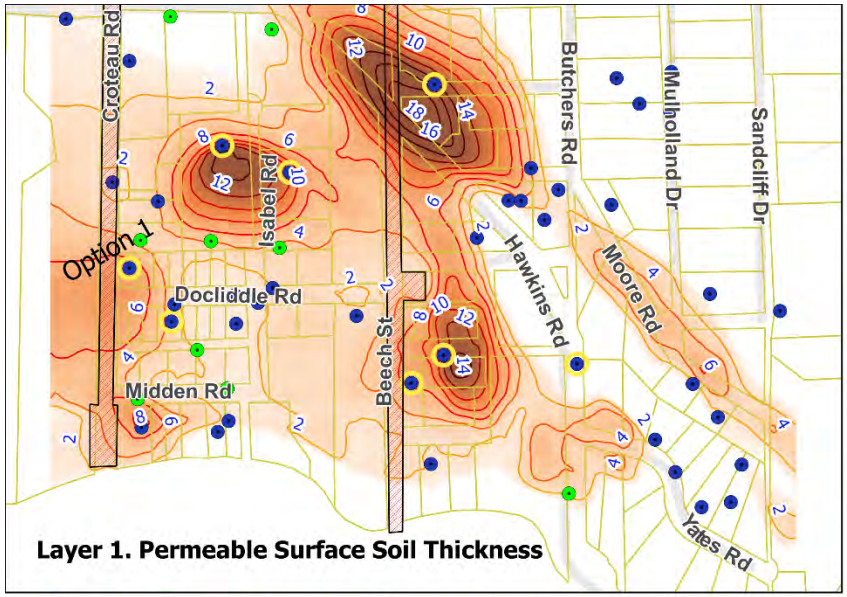
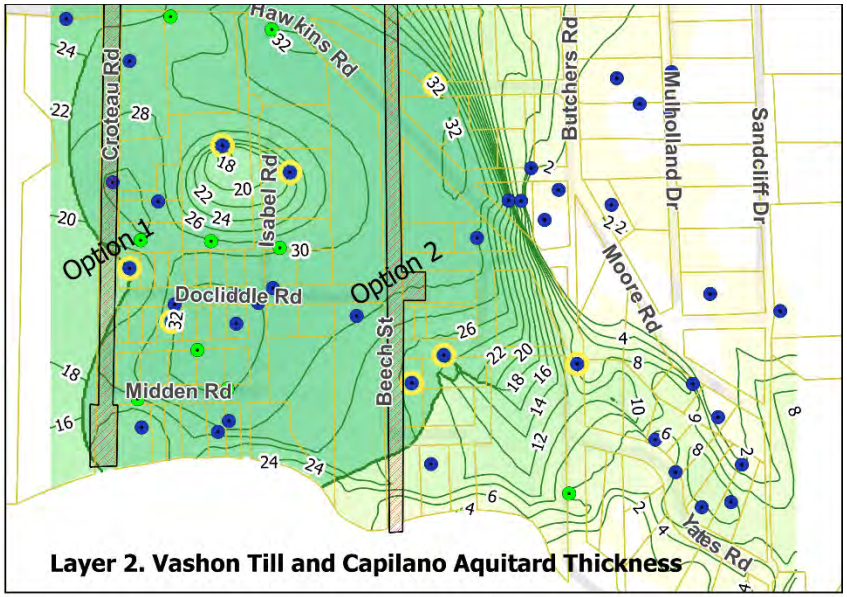


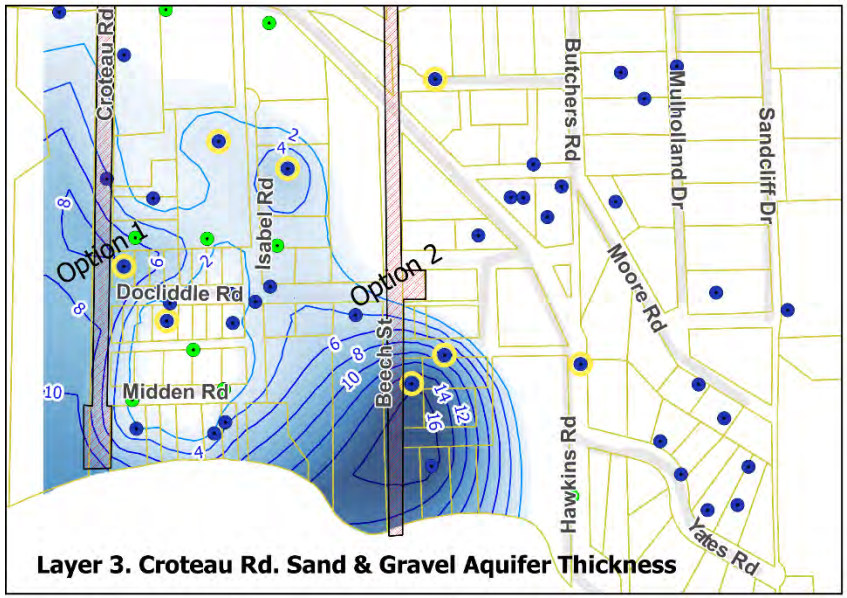
Figure 3. 3D block model showing main hydrogeological units in the groundwater system at Croteau Road.

Aquitard layers are also evident throughout the lower neighborhood (Figure 4 – Layer 2), and the key findings are as follows:

- The protective Vashon Till and Capilano aquitards are quite thin in some wells and are absent over upland areas around Butchers and Moores Road, outside of the Option 1 (Croteau Rd) ROW, but within the Option 2 (Beech St) ROW.
- The Vashon Till and Capilano aquitards are particularly thin (approximately 2.5 m thick) in WTN 98101, located approximately 100 m down gradient from the Option 2 ROW.
- The Vashon Till and Capilano aquitards appears to be relatively thick (approximately 7 to 24 m thick) along much of the Option 1 ROW.







Legend

ROW

Wells

- Shallow glacial till aquifer
- Thick sand & gravel at surface
- Confined sand & gravel aquifer

Groundwater System

- Permeable Surface Soil Thickness
- Net Aquitard Thickness
- Net Sand & Gravel Aquifer Thickness

Figure 4. Thickness of Permeable surface soils, Vashon Till/Capilano aquitard and Croteau Road Aquifer, interpolated from groundwater wells throughout the neighborhood.

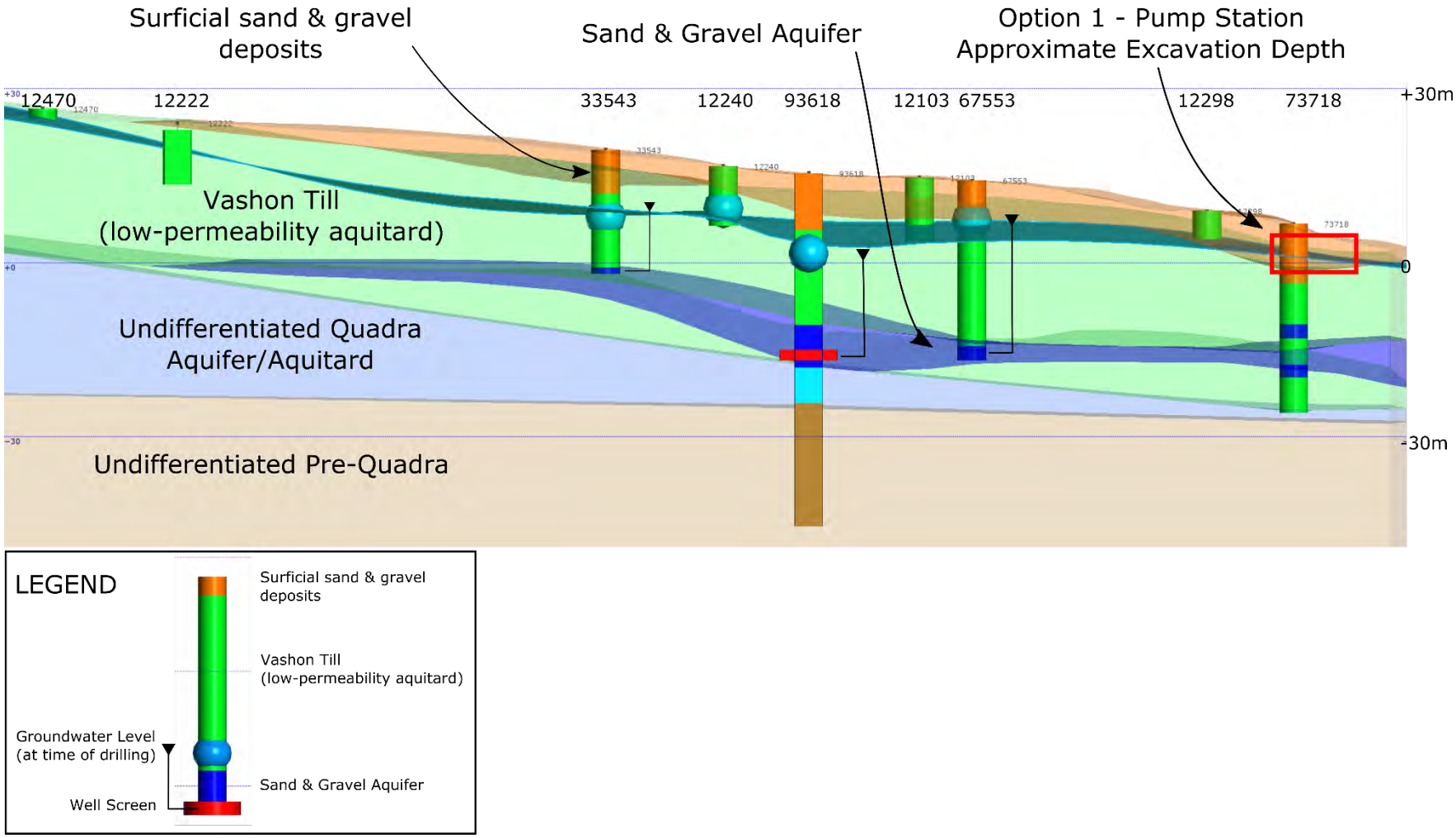


Figure 5. Hydrogeological model slice A (looking east) through neighborhood aquifer, recognized in the subsurface as lenses of sand and gravel lenses (dark blue "blob") surrounded by green aquitard material (interpreted as Vashon Till). Blue circles indicate reported piezometric levels from wells. For location, see Figure 7.

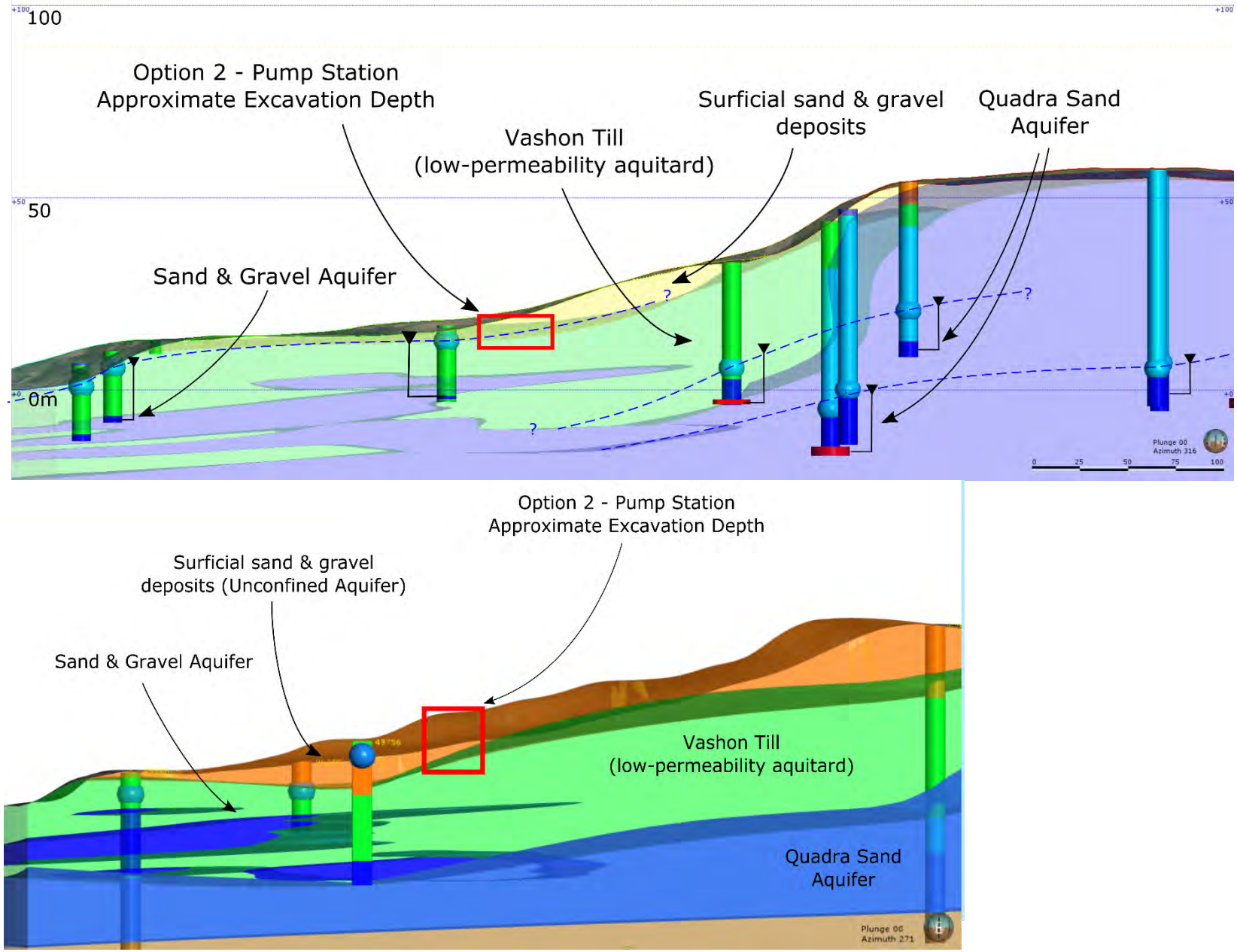


Figure 6. Option 2 hydrogeological model slices: Upper = Slice B (looking northwest); Lower = Slice C (looking west).

Figure 7. Locations of cross sections A-A' (Figure 5) and B- B' (Figure 6). Arrows indicate the direction of section view.

Hydraulic Heads and Gradients

Water levels recorded at the time of drilling are the only evidence we have of the depth to water table or piezometric levels in the neighborhood. Although these water levels were measured over many years and seasons, they are nevertheless useful in delineating *confined* versus *unconfined* aquifer conditions. This is because, in an unconfined aquifer, the top of the saturated soil corresponds to both the piezometric level *and* the water table. In a confined aquifer, the piezometric level is above the "ceiling" of the saturated soils composing the aquifer (Figure 8). Another essential quality of a confined aquifer is the presence of an overlying low-permeability layer such as clay or glacial till which acts as a protective layer to the aquifer.

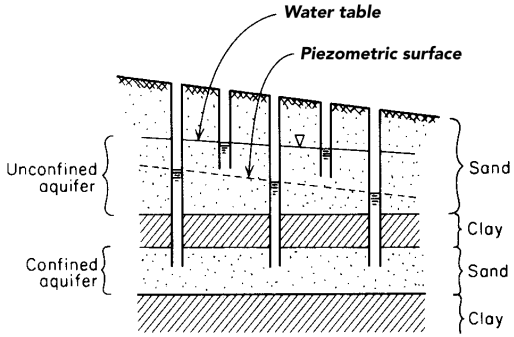


Figure 8. Diagram of unconfined and confined aquifers. Source: Freeze and Cherry (1979)

Horizontal hydraulic gradient is simply the slope of the *water table* or *potentiometric surface*, calculated as the difference in hydraulic heads over the distance between two wells. The hydraulic gradients of the neighborhood unconfined aquifer (water table) is generally oriented to the southwest, towards Comox harbour (Figure 10 – Upper panel). For the confined aquifer, wells at lower elevations generally have higher hydraulic heads (Figure 10 – Lower panel). Wells in the upper bench that are completed within the Quadra Sand aquifer (#408) have reported water levels that are not much higher that the saturated sands indicating that the Quadra Sand aquifer is likely unconfined at this location. In contrast, wells located in the lower neighborhood display water levels that are significantly higher than the top of the aquifer, indicating that the aquifer is relatively pressurized. The well located adjacent to the Option 1 Pump Station (WTN 73718, outlined in red in Figure 9) is a *flowing artesian well* (i.e. water reaches the ground surface under the natural pressure of the aquifer). The conditions of high hydraulic head apparently present in the confined aquifer at the beach end of Croteau Road, should be further investigated prior to excavation at this location.

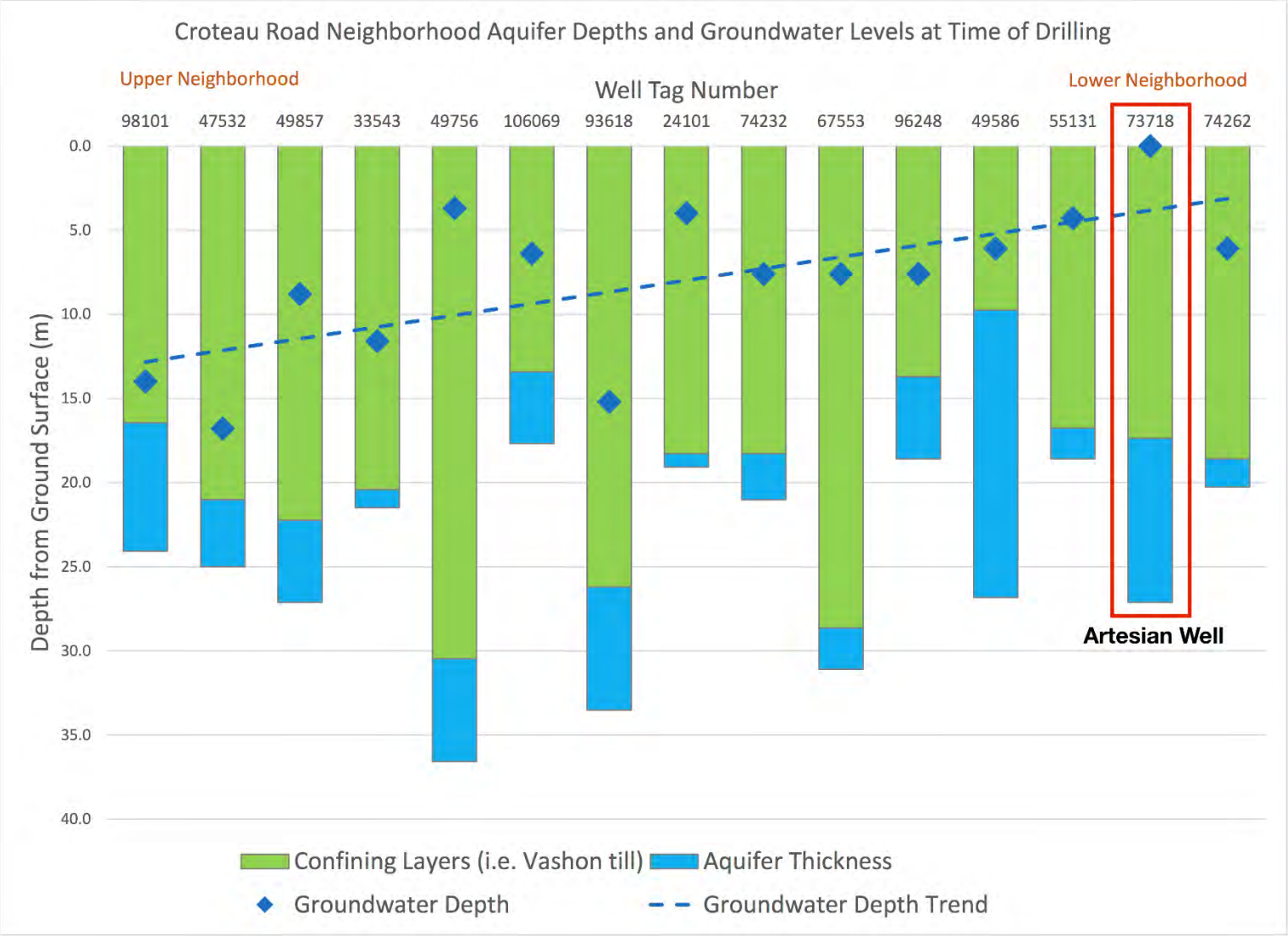
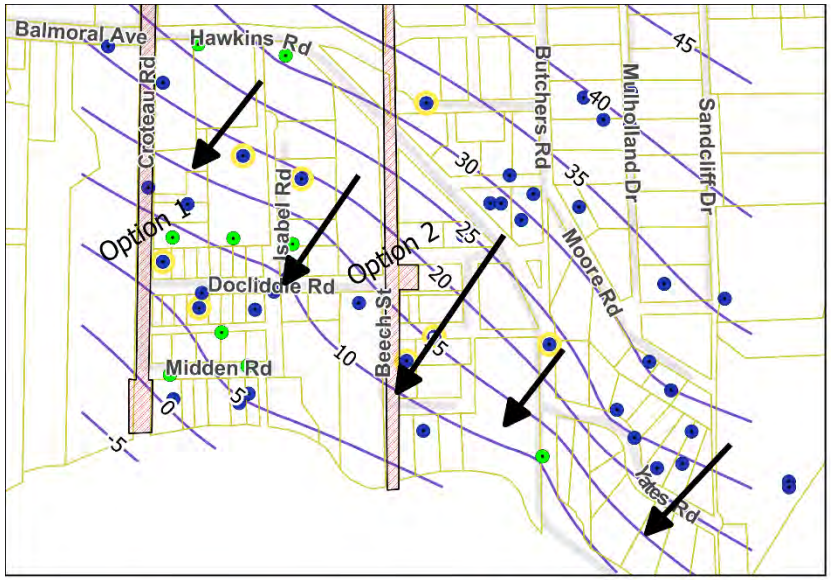


Figure 9. Croteau Road neighborhood aquifer depths and groundwater levels. Neighborhood wells are arranged from highest elevation (left) to lowest (right). The trend line of groundwater depths indicates that lower elevation wells generally have higher hydraulic heads. The pump station wet well is designed to be excavated to a depth of 6 m below ground level, and the base of excavation is anticipated to be within the Vashon Till/Capilano marine aquitard layer. The artesian well (WTN 73718), indicated by a water depth of zero, is the closest well to the Option 2 wet well excavation.



Unconfined Aquifer Water Table

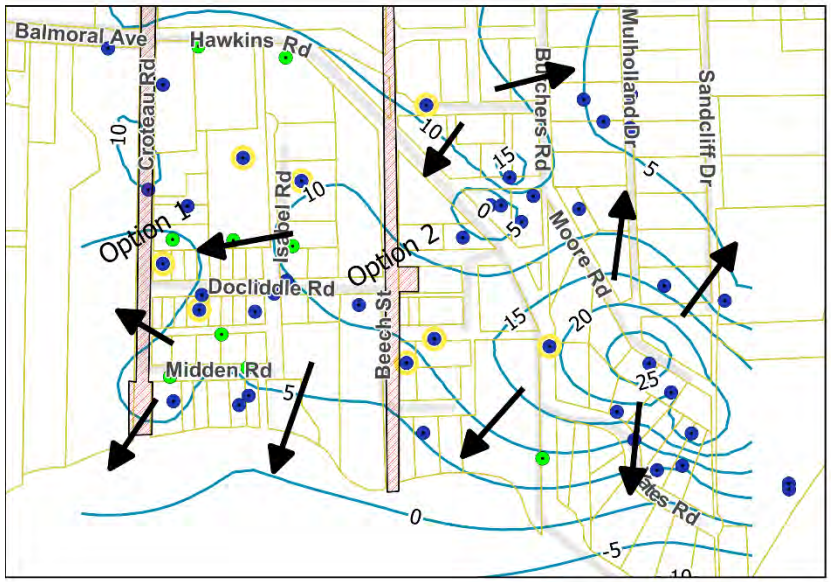
ROW

Wells

- Shallow glacial till aquifer
- Thick sand & gravel at surface
- Confined sand & gravel aquifer

Water Table at time of drilling

Water Table Elevation contours (masl)



Confined Sand & Gravel Aquifer

ROW

Wells

- Shallow glacial till aquifer
- Thick sand & gravel at surface
- Confined sand & gravel aquifer

Piezometric Levels at time of drilling

Piezometric Elevation contours (masl)

Figure 10. Water table elevation and Piezometric elevation contours derived from groundwater levels in wells recorded at the time of drilling.

Discussion

The potential sources of contamination to groundwater includes a leak or failure of the pump station, and a leak or rupture of the forcemain. The presence of a wastewater pump station in the neighborhood is not in of itself sufficient for an impact to occur. Groundwater is potentially vulnerable to contamination from surface spills if low hydraulic conductivity layers (i.e. aquitards such as clay or till) are thin, discontinuous or absent. Glacial till typically has low hydraulic conductivity (10^{-6} to 10^{-12} m/s), which would confer an adequate level of protection to the deeper groundwater system from surface contamination sources such as septic fields or runoff. Locally, the Vashon till forms the most prevalent, confining layer that offers protection to local aquifers from surface contamination. Well logs indicate the Vashon till extends throughout the entire Croteau Road neighborhood, although its thickness varies from approximately 2 m at its thinnest (WTN 93618) to over 20 m at its thickest (WTN 49857).

Detailed analysis of potential pathways of escaped wastewater is beyond the scope of this study. The potential impacts to neighbouring wells and to the drinking water supply associated with the siting, construction and long-term operation of the pump station and force main are described in the following table.

Table 3. Summary of short and long term potential impacts to groundwater of the construction and siting of wastewater Pump Station #2 and forcemain.

	Option 1 – Croteau Road	**Option 2 – Beech Street**
***Short-term* impacts to ground water related to the project construction**	Dewatering of excavation pit may temporarily lower water levels in nearby shallow wells. Excavation of the trench for the sewer main pipe will temporary create a “ditch” that will collect and carry water.	None anticipated unless water-bearing sand and gravel lenses are encountered during excavation. In this situation, dewatering of excavation pit may temporarily lower water levels in nearby shallow wells. Excavation of the trench for the sewer main pipe will temporary create a “ditch” that will collect and carry water.
***Long-term* impacts to ground water related to the project siting**	The backfilled sewer main trench will act as a more permeable corridor possibly lowering the shallow groundwater. The effect would be anticipated to be local (a few meters from the trench centerline).	The backfilled sewer main trench will act as a more permeable corridor possibly lowering the shallow groundwater. The effect would be anticipated to be local (a few meters from the trench centerline).

	Local disruption of the soil due to excavation and backfill by non native material may create a zone where the existing groundwater regime will be modified (either with enhanced infiltration if the backfilled materials are more permeable that the native soils, or reduced infiltration in the opposite case).	Local disruption of the soil due to excavation and backfill by non native material may create a zone where the existing groundwater regime will be modified (either with enhanced infiltration if the backfilled materials are more permeable that the native soils, or reduced infiltration in the opposite case).
Short & long-term ground water impacts to properties located adjacent to either potential site related to the new pump station	In the event of system failure or rupture there is a low risk to shallow wells located in the vicinity of the pump station because these wells are either up gradient or cross gradient of proposed pump station. Relatively low risk to shallow wells located in the vicinity of the forcemain because contaminated water will follow the forcemain corridor and neighbouring shallow wells are cross gradient of proposed forcemain and only in the event of system failure or rupture. Risks of contamination of the confined aquifer are very low because of upward vertical hydraulic gradient that will prevent the downward movement of any contaminated groundwater	In the event of system failure or rupture there is a moderate potential risk to shallow wells located in the vicinity of the pump station *and* forcemain since these wells are located downgradient of the proposed pump station. In the event of a pipe rupture along the upper bench, there is a moderate risk to both shallow and deep wells due to the thinning of the confining till layer.

Conclusions

Based on the work completed and the information reviewed, GW Solutions draws the following conclusions:

- The hydrogeological conditions are complex in the study area, with a shallow and a deep aquifer, separated by aquitards.
- Residents who rely on shallow, dug wells and who therefore use water from the unconfined shallow aquifer in the neighborhood are potentially more vulnerable to contamination of their water source.
- Residents who have drilled wells completed in the confined deep aquifer in the neighborhood rely on a water source that is less vulnerable to contamination due to the presence of a protective clay and till layer (aquitards) overlying the aquifer.
- The Vashon till aquitard is the most laterally and vertically extensive aquitard layer in the neighborhood. This layer is up to 20 m thick. However, it thins considerably towards the southeast and north east of the neighborhood, and is absent east of Butchers/Moore roads. This aquitard is generally thicker adjacent to the right of way for Option 1 than that of Option 2.
- The Croteau Road Pump Station location (Option 1) is the preferred location because there are no water wells down-gradient of the proposed pump station and the protective aquitard is thick and continuous at this location.
- If the CVRD were to proceed with the Option 1 site for the Pump Station, both the high groundwater pressure (hydraulic head) in the deep aquifer and the thickness of the aquitard need to be better characterized before any excavation.

Recommendations

GW Solutions makes the following recommendations:

1. ***Safeguard local wells prior to construction:***

- *All wells immediately adjacent to the right of way excavation should be accurately located, the depth to water measured, and the adequacy of surface seal protection assessed.*
- *It is assumed that all excavation will follow best practices for sediment erosion and runoff control.*

2. ***Assess the groundwater pressure (hydraulic head) at Option 1 - Croteau Road excavation site***

The conditions of high hydraulic head apparently present in the lower confined aquifer -at the beach end of Croteau Road, should be further investigated prior to excavation at this location. Due to the depth of the excavation (6 m) it is critically important to not penetrate through the Vashon Till layer into the underlying aquifer. ***Prior to excavation,*** *it is recommended that the following be undertaken by a qualified hydrogeologist:*

- *Measure the depth to groundwater, preferably during the months of November to March, at three or more of the wells closest to the site using water level probe to assess the elevation of the water table under wet season conditions;*
- *Drill a 150 mm (6-inch) diameter test well near the proposed excavation site to ascertain the actual depth to the base of till and monitor the hydraulic head of groundwater during construction. This well can serve as a future water source for the Pump Station, or public washrooms. In addition, it could serve as a monitoring well for long term monitoring of groundwater levels and quality in the neighborhood aquifer.*

3. Neighborhood Well Protection

Work cooperatively with area residents to ensure their residential wells meet or exceed the Ministry of Environment' well protection regulations. It is recommended that a survey be conducted in the neighborhood that will:

- *Verify the presence of adequate well head surface seals that prevent ground-level or shallow subsurface contaminants from entering the well.*
- *Verify the presence of secure well caps to prevent direct and unintended entry into the well of floodwater or contaminants.*
- *Adequate levels of well casing stickup. A minimum of 30 cm (12 inches) is recommended that elevates the well opening above ground level flooding; Proper soil grading away from well head.*

4. Compile the most up-to-date and accurate well information

GW Solutions recommends that a survey be conducted in the neighborhood that will:

- *Obtain locations of existing wells using handheld GPS;*
- *Encourage residents to submit their well logs to the Ministry of Environment for inclusion in the provincial Wells Database;*

Limitations

The opinion expressed in this report is based on limited information and on data available at the time of reporting. GW Solutions could not assess hydrogeological conditions for areas lacking borehole information. A detailed field survey of well locations, depths and water levels will be required to confirm the hydrogeological conditions in the neighborhood and adjacent to the proposed pump station and forcemain.

Closure

Conclusions and recommendations presented herein are based on available information at the time of the study. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgment has been applied in producing this memo.

This memo was prepared by personnel with professional experience in the fields covered. Reference should be made to the General Conditions and Limitations attached in Appendix 1.

GW Solutions was pleased to produce this document and is looking forward to working with you on this project. If you have any questions, please do not hesitate to contact us.

Yours truly,
GW Solutions Inc.

DRAFT

Matt Vardal, MSc.,
Project Hydrogeologist

DRAFT

Gilles Wendling, Ph.D., P.Eng.
President

References

Bednarski, J.M., 2015. Surficial Geology and Pleistocene stratigraphy from Deep Bay to Nanoose Harbour, Vancouver Island, British Columbia; Geological Survey of Canada, Open File 7681.

Benoit, N. and Paradis, D., 2015. Three dimensional groundwater flow model of the Nanoose-Deep Bay area, Nanaimo Lowland, British Columbia; Geological Survey of Canada, Open file 7845.

Benoit, N., Paradis, D., Bednarski, J.M., Hamblin, T., and Russell, H.A.J., 2015. Three dimensional hydrostratigraphic model of the Nanoose-Deep Bay area, Nanaimo Lowland, British Columbia; Geological Survey of Canada, Open File 7796.

Freeze R. A. & Cherry J. A. 1979. Groundwater. Prentice Hall. Figure 2.16

Leapfrog Hydro. ARANZ Geo Ltd. Geological Modelling Software.

Ministry of Environment 2006. Well Protection Toolkit. Water Protection & Sustainability Branch, British Columbia Minisitry of Environment. Online Toolkit and Reference available at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/well_protection/wellprotect.html

APPENDIX 1 - GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS

This report incorporates and is subject to these "General Conditions and Limitations".

1.0 USE OF REPORT

This report pertains to a specific area, 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 GW SOLUTIONS's client. GW SOLUTIONS 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 GW SOLUTIONS's client unless otherwise authorized in writing by GW SOLUTIONS. 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 GW SOLUTIONS. Additional copies of the report, if required, may be obtained upon request.

2.0 LIMITATIONS OF REPORT

This report is based solely on the conditions which existed within the study area or on site at the time of GW SOLUTIONS's investigation. The client, and any other parties using this report with the express written consent of the client and GW SOLUTIONS, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive. The client, and any other party using this report with the express written consent of the client and GW SOLUTIONS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the area or subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made. The client acknowledges that GW SOLUTIONS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS

During the performance of the work and the preparation of this report, GW SOLUTIONS may have relied on information provided by persons other than the client. While GW SOLUTIONS endeavours to verify the accuracy of such information when instructed to do so by the client, GW SOLUTIONS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

3.0 LIMITATION OF LIABILITY

The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of GW SOLUTIONS providing the services requested, the client agrees that GW SOLUTIONS's liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

(1) With respect to any claims brought against GW SOLUTIONS by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to GW SOLUTIONS under this Agreement, whether the action is based on breach of contract or tort;

(2) With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless GW SOLUTIONS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by GW SOLUTIONS, whether the claim be brought against GW SOLUTIONS for breach of contract or tort.

4.0 JOB SITE SAFETY

GW SOLUTIONS is only responsible for the activities of its employees on the job site and is not responsible for the supervision of any other persons whatsoever. The presence of GW SOLUTIONS personnel on site shall not be construed in any way to relieve the client or any other persons on site from their responsibility for job site safety.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for

GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

6.0 STANDARD OF CARE
Services performed by GW SOLUTIONS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

7.0 EMERGENCY PROCEDURES
The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These
procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

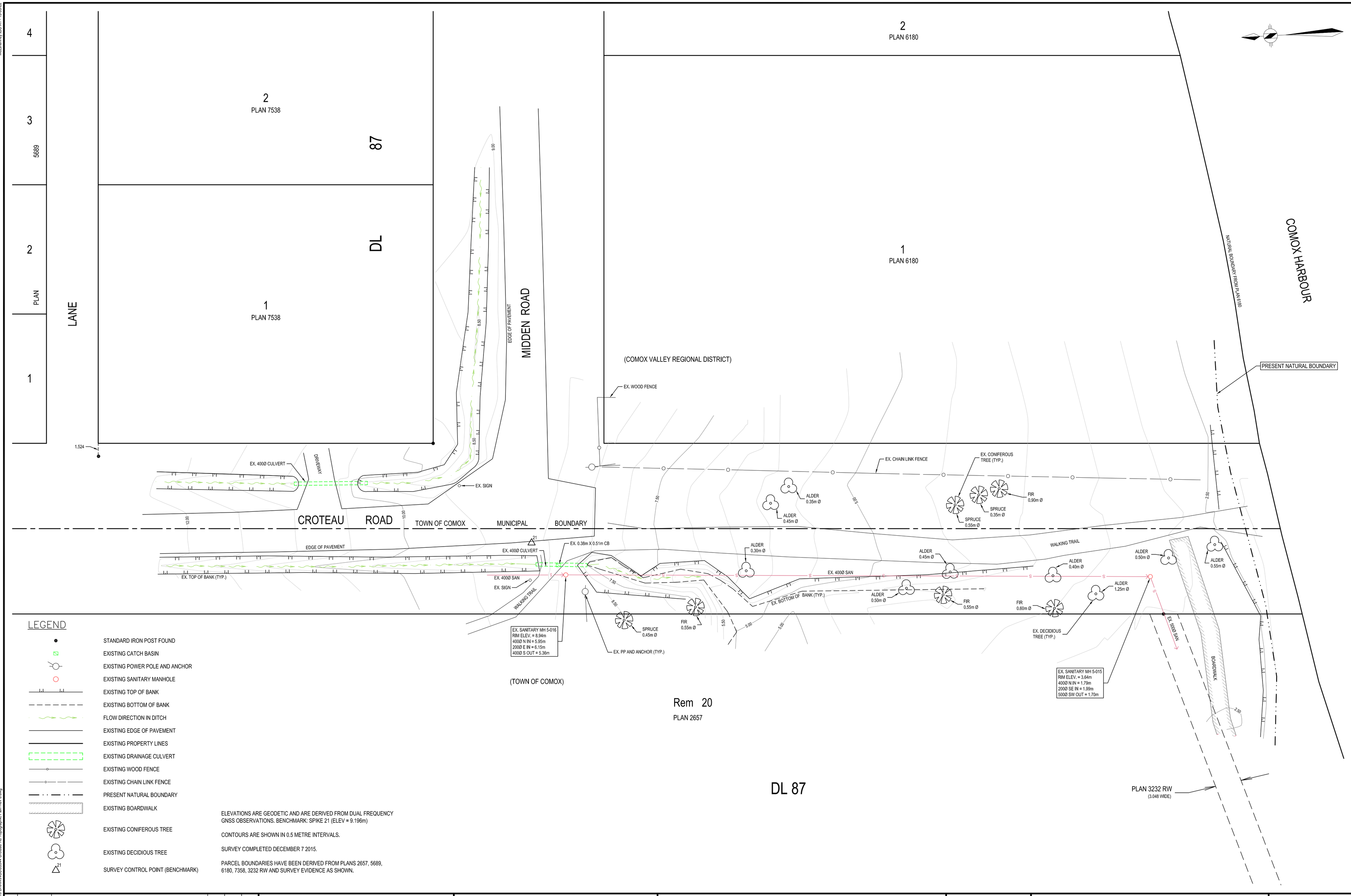
8.0 NOTIFICATION OF AUTHORITIES
The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by GW SOLUTIONS in its reasonably exercised discretion.

9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE
The client acknowledges that all reports, plans, and data generated by GW SOLUTIONS during the performance of the work and other documents prepared by GW SOLUTIONS are considered its professional work product and shall remain the copyright property of GW SOLUTIONS.

10.0 ALTERNATE REPORT FORMAT
Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by GW SOLUTIONS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by GW SOLUTIONS shall be deemed to be the overall original for the Project. The Client agrees that both electronic file and hard copy versions of GW SOLUTIONS's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except GW SOLUTIONS. The Client warrants that GW SOLUTIONS's instruments of professional service will be used only and exactly as submitted by GW SOLUTIONS. The Client recognizes and agrees that electronic files submitted by GW SOLUTIONS have been prepared and submitted using specific software and hardware systems. GW SOLUTIONS makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

Appendix E

McElhanney ISO A1 - 1545-22



LEGEND

- STANDARD IRON POST FOUND
- EXISTING CATCH BASIN
- EXISTING POWER POLE AND ANCHOR
- EXISTING SANITARY MANHOLE
- EXISTING TOP OF BANK
- EXISTING BOTTOM OF BANK
- FLOW DIRECTION IN DITCH
- EXISTING EDGE OF PAVEMENT
- EXISTING PROPERTY LINES
- EXISTING DRAINAGE CULVERT
- EXISTING WOOD FENCE
- EXISTING CHAIN LINK FENCE
- PRESENT NATURAL BOUNDARY
- EXISTING BOARDWALK
- EXISTING CONIFEROUS TREE
- EXISTING DECIDIOUS TREE
- SURVEY CONTROL POINT (BENCHMARK)

ELEVATIONS ARE GEODETIC AND ARE DERIVED FROM DUAL FREQUENCY GNSS OBSERVATIONS. BENCHMARK: SPIKE 21 (ELEV = 9.196m)

CONTOURS ARE SHOWN IN 0.5 METRE INTERVALS.

SURVEY COMPLETED DECEMBER 7 2015.

PARCEL BOUNDARIES HAVE BEEN DERIVED FROM PLANS 2657, 5689, 6180, 7358, 3232 RW AND SURVEY EVIDENCE AS SHOWN.

Rev	Date	Description	Drawn	Design	App'd
0	2016-01-15	ISSUED FOR DESIGN	NP		MH

0 1:200 10

ORIGINAL DWG SIZE: A1 (594 x 841mm)

McElhanney

McElhanney Associates Land Surveying Ltd.

495 Sixth Street
Courtenay BC
Canada V9N 6V4
Tel 250 338 5495

Approved Sealed

COMOX VALLEY REGIONAL DISTRICT
600 COMOX ROAD, COURTENAY, BC

TOPOGRAPHIC SURVEY OF CROTEAU ROAD AT MIDDEN ROAD COMOX, BC

Drawing No. 1

Project Number 2212-05544-0

Rev. 0

DESTROY ALL PRINTS BEARING PREVIOUS REVISION

DATE: JAN. 15, 2016 FILE: K:\LEGAL\05544\100.DRAWINGS\05544 Croteau Rd Topographic Plan Rev 0.dwg