



Aquifer Impact Assessment (DPA 4)

**Cowichan Green Kitchen
2431 Beverly Street,
Duncan , BC**

September 19, 2023

Submitted to: Ms. Judy Stafford, Executive Director, Cowichan
Green Community
Prepared by McElhanney Ltd.

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1. Introduction

1.1. Terms Of Reference

The Cowichan Green Community, or CGC (the “Client”) contracted McElhanney Ltd. (McElhanney) to undertake an aquifer impact assessment in support of the expansion of their community garden and kitchen located on their property at 2431 Beverly Road in Duncan, BC (the “Subject Property”). The property identification (PID) number is 029-237-424 and the legal description is “Lot 1, Plan EPP35195, Section 19, Range 7, Quamichan Land District”. The zoning for the lot is A6 – Rural Market. The location of the Subject Property is shown in *Figure 1*.

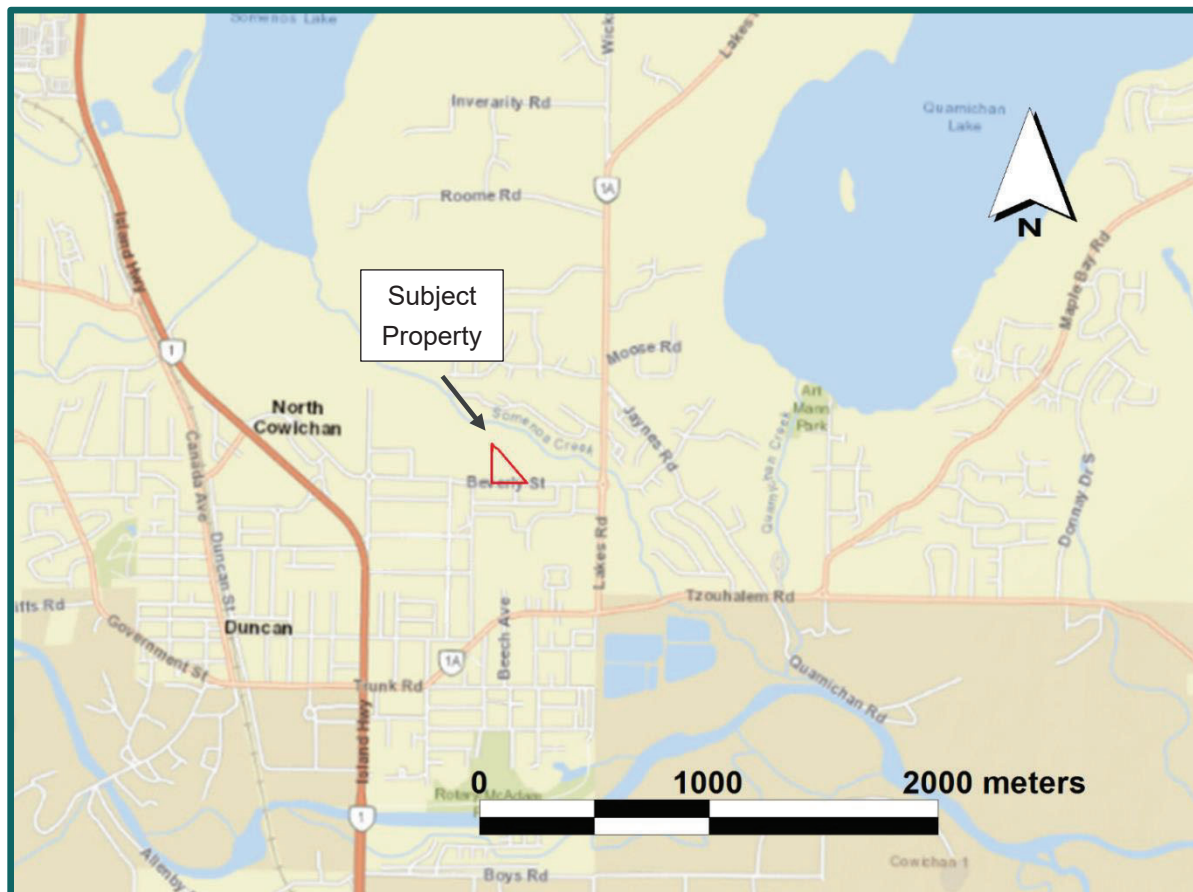


Figure 1. Location of Subject Property

1.2. Regulatory Context

The Subject Property lies within the Municipal District of North Cowichan (MNC). The Official Community Plan (OCP) for the MNC is Bylaw No. 3900, 2022¹. The A6 zoning designation allows for principle uses on the lot including agriculture, agricultural storage, food and beverage processing, food truck and greenhouse. The OCP refers to six Development Permit Areas (DPAs) within MNC and the Subject Property is located within an area designated as DPA 3 – Natural Environment. The basis for the DPA -3 designation is to “establish objectives and guidelines to protect and enhance environmentally sensitive areas, ecosystems and biological diversity, and to ensure development has a positive impact on natural features and functions”². More specifically, a DP-3 designation applies in this case to any land designated as having high groundwater vulnerability as shown on Map 5 in the OCP entitled “Water Source Protection”³.

The OCP refers to Zoning Bylaw 2950 Section 2.4.5 (c)) which states:

Where the possibility of a development impacting an aquifer exists, the applicant must submit to the Municipality a report from a registered professional that includes:

- i. an assessment of the characteristics of the aquifer and its ability to accommodate the additional groundwater demand proposed by the development, including an assessment of the anticipated demand given the development potential of the subject property based on its current zoning, and given potential impacts on adjacent properties.
- ii. a statement backed by a professional assessment that the proposed development will not have a negative impact on the aquifer; and
- iii. recommendations of measures required to ensure the aquifer is protected.

The applicant for a development permit must submit a report prepared by a qualified environmental professional that analyzes the impacts of the proposed development on aquifers in the development permit area in compliance with these documents. In general terms, such report is referred to as an Aquifer Impacts Assessment, or AiA report.

Copies of the documents relating to the requirement for an AiA are included in **Appendix A**, including the DP-3 Natural Environment permit requirement, the Environment DP Guidelines B, and Map 5 from the OCP showing the areas where an AiA is required.

1.3. Overview Of Proposed Development

The Subject Property is located at 2431 Beverly Street, approximately 375 m west of the intersection of Lakes Road with Beverly Street. The property covers 1.37 hectares (13,700 m²) and is triangular in nature, with a constructed dike to the north, Beverly Street to the south and an elementary school to the

¹ Pursuant to section 488(1)(a) of the *Local Government Act*.

² Municipality of North Cowichan Official Community Plan, 2022 and related documents

³ Ibid



west. There is a hiking trail along the top of the dike and irrigated farmland to the northeast. At its closest point, Somenos Creek is located 100 m north of the Subject Property. Further east, at the northwest corner of the intersection of Beverly Street and Lakes Road is a dog park. There is a municipal water well owned by MNC at the northwest corner of the dog park.

The current development on the Subject Property includes 2 relatively long warehouses (greenhouses) located along the south boundary adjacent to Beverly Street, some sheds, temporary pergolas and a portable unit (small movable building). There are several rows of irrigated plantings extending north of the warehouses and some raised garden vegetable planters to the northeast of the greenhouses. There is also a well and pumphouse building adjacent to the well near the entrance off Beverly Street. The well is licensed. The property currently utilizes portable toilets which will be removed and replaced by permanent toilet facilities that will be connected to the municipal sewer system.

The proposed development on the Subject Property includes the construction of a 12m x 36 m (432m²) warehouse building along the eastern side of the property to include contiguous areas for a kitchen, training room, office, washrooms and a production/packaging space. Access to the lot and surrounding the building on the north, west and south sides, plus the north side of the existing greenhouses, will be a semi-pervious gravel paved area. The gravel will accommodate parking stalls and vehicle access to the buildings. As discussed in the SWMP, drainage from buildings will be directed to rock pits and/or underground stormwater detention chambers. Runoff from the gravel paved areas will be directed to an oil/grit/water separator prior to infiltration and/or release to the municipal stormwater system. Wastewater from the site will be directed to the municipal sanitary sewer system. Various sheds and pergolas on the Subject Property will be repositioned to accommodate the new building and gravel paved areas.

A conceptual layout of the proposed development is attached as [Appendix B](#).

1.4. Objectives

Potential aquifer impacts from property developments include:

- Groundwater extraction for water supply;
- Groundwater quality impacts from poorly designed or inadequately maintained sewerage systems;
- Reduction of infiltration (aquifer recharge) from the creation of hardscapes and management of stormwater runoff in closed-system pipes with no onsite retention and infiltration;
- Groundwater quality impacts resulting from the use or disposal of substances or contaminants that may be harmful, including application of agricultural products including fertilizers, herbicides and pesticides;
- Excessive ornamental landscaping that requires substantial irrigation and fertilization, as opposed to native, drought-tolerant species.



Thus, the objectives of this aquifer impact assessment were to:

- Assess the potential impact of groundwater extraction on the regional aquifer(s), as the primary potential impact of the proposed development on groundwater resources; and
- Assess and provide comment on the potential for impacts to aquifer water quality or quantity from the proposed stormwater management system(s) and agricultural land use.

1.5. Scope Of Work And Approach

The approach of the work was designed to assess the potential for the proposed development to have a negative impact on groundwater quality and quantity in local aquifers.

The approach to address potential impacts to groundwater quality included consideration of the overall land use for the proposed development and available information for on-site stormwater management.

The approach to address potential groundwater resource depletion typically consists of:

- Review of the proposed development plan and internal project discussions to understand the site conditions and proposed development;
- Reviews of local and regional hydrogeology information from publicly available sources to identify mapped aquifers, records of water wells, topography, drainage, and local watercourses;
- Review of any stormwater management plans;
- An aquifer water balance assessment to understand the proposed groundwater use in the context of available groundwater resources accounting for total aquifer inflows and other uses/outflows;
- Calculation of a water well capture zone to assess potential impacts on neighbouring groundwater users from the expected water demand from this development and to assess potential risks to groundwater quality for the Project's community water supply; and
- Preparation of this report to document the findings, present a professional opinion regarding potential impacts from the proposed development on groundwater resources and, if applicable, recommendations for the mitigation or monitoring of impacts.

Where a public utility service is provided such as communal water supply or off-site sewerage collection and disposal, portions of the assessment approach are not completed.

McElhanney has also completed a stormwater management plan (SWMP)⁴ for the Subject Property in September 2023. The two reports are consistent in the assessment of groundwater and surface water conditions on the Subject Property and should be considered concurrently in support of the subdivision application.

⁴ McElhanney, 2023. Cowichan Green Kitchen Stormwater Management Plan



2. Physical Setting

2.1. Climate

The Subject Property is in the 'Coast Mountains and Islands' climate region of BC where winters are mild and moist, and summers are mild and dry. The area is in the rain shadow of the Vancouver Island Ranges to the west and the Olympic Mountains to the south, receiving less precipitation than the west coast of Vancouver Island. Most of the annual precipitation occurs from mid-fall through early spring, primarily as rain. Snow is typically limited to higher elevations. Summers are comparatively dry and moisture deficits are common in that season.

Climate change research predicts that the intensity and frequency of fall and winter precipitation events will increase, and in contrast, hot and dry conditions in summer will create a prolonged and increased moisture deficits in that season (AgriServiceBC, 2023). Longer summers, a longer growing season, and higher demand for irrigation in the region will put increased demand on both aquifers and surface water sources where agriculture is prevalent. Despite the increase in summer moisture deficit, an annual precipitation surplus is expected with the potential for increased annual groundwater recharge.

2.2. Vegetation, Topography And Drainage

With the exception of sparsely positioned ornamental tress, the site is covered in soils associated with the floodplain of the Creek.

The topography in the area is generally flat and prone to flooding, hence the constructed dike. Elevation contouring infers the ground slope is less than 3%, from the south and southeast towards the north and northwest. The Creek flows in the opposite direction, to the southeast.

The ground surface across the Subject Property is planar to gently undulating, with some low points in the central portion and overland drainage from southeast to north and northwest. There is a culvert at the north end of the lot which conveys drainage under the Dyke and towards the Creek. The southern portion of the site drains southeast along the base of the Dyke and northeast property line via an overland swale, ultimately flowing into a stormwater sewer along Beverly Street.

2.3. Geology

Based on information available on the BC Water Resources Atlas, or WRA (BCMoe, 2023), the uppermost bedrock in the area consists of the lower Jurassic-aged Bonanza Group, which includes pillowed basalt, andesite flows, laminated tuffs, breccia, and minor sandstone. Sedimentary units that grade upwards from carbonate-rich deltaic sandstone and conglomerate through beds of siltstone, sandstone, and coal-bearing shale, into pure shale and mudstone. Cretaceous-aged Nanaimo Group rocks are rarely exposed at surface in the South Cowichan region as they are covered by unconsolidated sediments, also referred to as overburden.

The surficial sediments in the area are described as till and silty glaciolacustrine (typically silt and clay) deposits (Harris and Usher, 2017). Both units overlie glaciofluvial outwash aprons of sand and gravel. The till is part of the Vashon Drift, which can contain minor interbedded sands and gravels within



predominantly sand-silt textured sediments. If water-saturated and interconnected, the sands and gravels may create aquifers of limited extent. The glaciolacustrine sediments are part of the Capilano Sediments, which consist of silt and clay with minor sand and thus form aquitards. The glaciofluvial sediments are the Quadra Sands, and are expected to contain elongated lenses or beds of sand and gravel with thicknesses in the range of 15-20 m. Where water-saturated, the Quadra Sands form regionally important aquifers (Hammond et al, 2019).

2.4. Regional Hydrogeology & Groundwater Use

Most water wells in the area are completed in BC Aquifer AQ 0186, which is an unconfined aquifer within fluvial sand, gravel and silt deposited by the Cowichan and Koksilah rivers. The aquifer covers an area of 17.4 km² in the Somenos Creek and Cowichan River Watershed. The Subject Property is positioned within the northernmost portion of the aquifer as shown in **Figure 2**. The eastern limit of Aquifer 186 Cowichan Bay where the aquifer is hydraulically connected to the ocean.

Aquifer 186 is unconfined and highly transmissive (high well yields), ranging to a depth of 30 m. The median and average reported static water level is shallow, 2.4 m and 2.7m, respectively.

Using the BC Aquifer Classification System (Berardinucci and Ronneseth, 2002), the aquifer is classified as a type 1A aquifer indicating high productivity, high usage and high vulnerability to impacts from surface contamination sources.

Based on information available in the BC Water Resources Atlas (BCMoE, 2023) there are records for 168 water wells in the associated WELLS database for the aquifer. The reported well depths range from 2 m to 31 m, with a median of 9.75m depth. Water depths range from 1m to 23m with a median of 2.44 m below ground surface. The median well yield for the aquifer is 1.89 L/s, with yields upwards of 200 L/s reported in some community water supply wells at the south end of the aquifer adjacent to the Cowichan River. There are 58 wells located within a 1 km radius of the Subject Property. A summary of information available for these wells is provided in **Appendix C**.

The main sources of natural recharge to Aquifer 186 are infiltration from precipitation falling directly on the aquifer, discharge possibly from the underlying Aquifer 188 and bedrock (Aquifers 176 and 198) where windows in the confining layer occur, lateral inflow from adjacent aquifers (Aquifers 185, 199, and 197), groundwater inflow from the Quamichan Lake and Somenos Lake areas, and groundwater inflow from the Cowichan River and locally from Somenos Creek.

Copies of the aquifer mapping report and aquifer factsheets for AQ 186 that have been prepared by the BC Ministry of environment are attached in **Appendix D**.



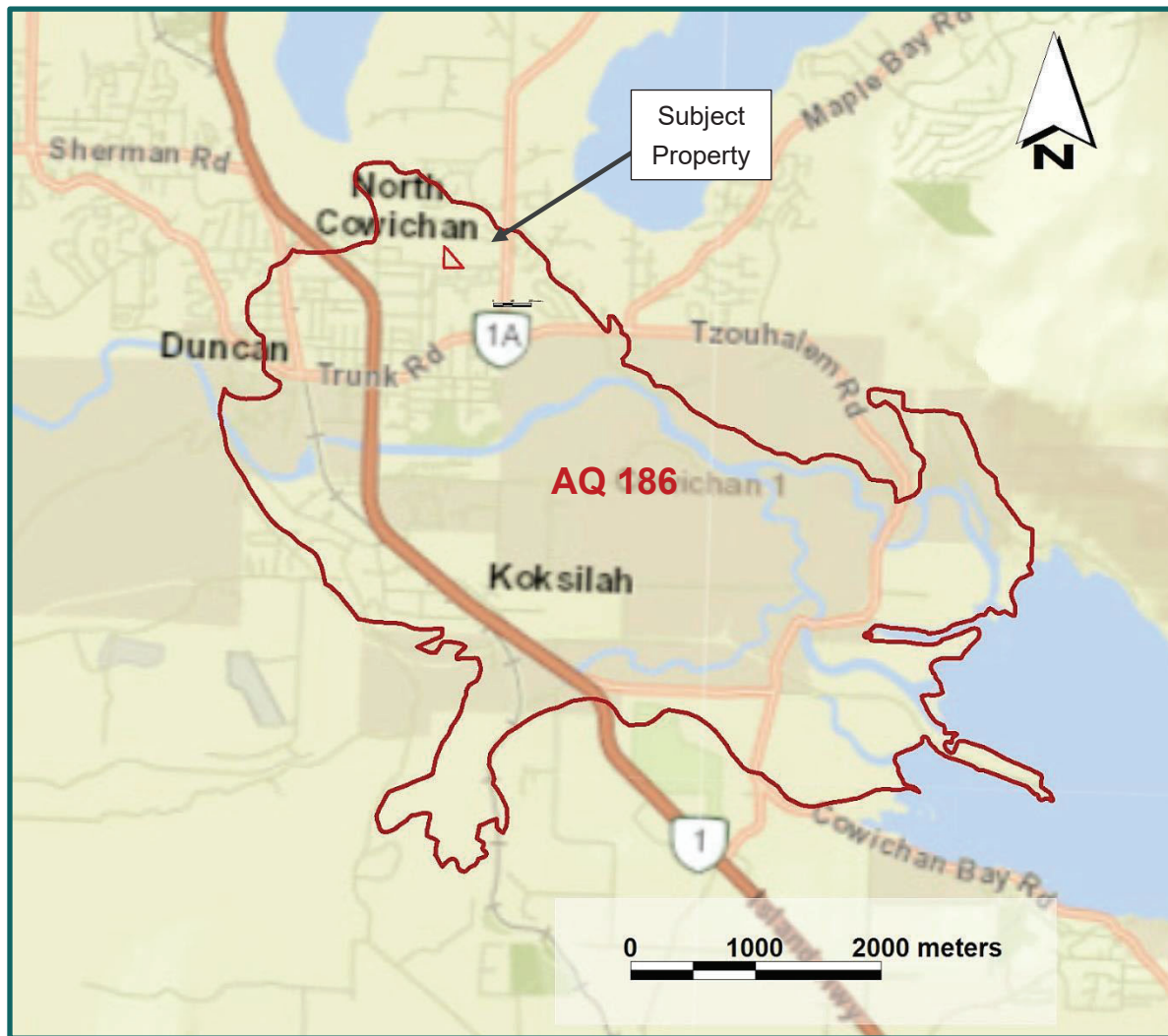


Figure 2. Mapped Extents of BC Aquifer AQ 186

3. Results and Discussion

3.1. Local Aquifer Characterization and Impacts

There are 5 water wells of note on or adjacent to the Subject Property including WTN 111452 (on the Subject Property), WTN 19936 (the MNC municipal well to the east), WTN 19622 (in the field between the subject Property and the Creek), WTN 87376 (at 5847 Chesterfield Avenue) and WTN 96482 at 5860 Lakes Road.

Figure 3 presents a map of the area with the locations of the 5 wells noted. All of the wells are completed in AQ 186 and all have static water levels within 2m of ground surface. The direction of groundwater flow in the aquifer shown as being from northwest to southeast was derived from a



groundwater protection plan report for the Lower Cowichan River Aquifer, which is the same as AQ 186⁵. Available information on top of casing elevation and current static water level for each well is not sufficient to allow for a determination of the flow gradient in the aquifer. For the purposes of this assignment, we have assumed the gradient is relatively flat. However, it should be noted there are 2 wells located down-gradient of the Subject Property, those being WTN 19622 at an unknown location in the field to the east and WTN 19936, the MNC municipal well, located approximately 320m east.

Copies of the records for the 5 wells, as sourced from the BC WELLS database, along with the map of the direction of groundwater flow from the groundwater protection plan, are provided in [Appendix E](#) and [Table 1](#) presents a summary of important characteristics for the wells.

A review of the reported lithology in the records for these wells indicates some intermittent shallow silt and clay layering at 2 m to 3 m depth, but no geological material that would represent a vertical confining layer to substantially limit the vertical migration of potential contaminants from ground surface infiltrating into the more conductive lower portion of the aquifer. This sequence or layering of materials is why the aquifer mapping and factsheets for AQ 168 produced by the Province indicate the aquifer has high vulnerability to potential impact from surface contamination sources.

Our understanding is that the well on the Subject Property is pumped at a maximum rate of approximately 2.2 L/s (35 USgpm). There has been no formal pumping test completed on the well and therefore aquifer hydraulic parameters have not been determined at this location. However, based on a review of the reported geology on the available well record, the approximate aquifer thickness is 5 m. An approximate hydraulic conductivity for the aquifer at this location of 3×10^{-3} m/s is based on lowest (most conservative) limit of the range of values assigned to the aquifer as noted on the AQ 168 Aquifer Factsheet included in [Appendix D](#). Using these parameters, and assuming an aquifer width for the northern portion of the aquifer extending from WTN 87376 to Somenos Creek (roughly 400m) plus a very conservative flow gradient of 0.05, the flow in this portion of the aquifer is estimated to be on the order of 3×10^{-7} m³/yr. If the well on the Subject Property is pumped at 2.2 L/s (35 USgpm) for 6 hours daily for an approximate 180 day long irrigation season, the annual water use would be on the order of 8,550 m³/yr. The estimated water use represents less than 0.02 percent of the annual flow.

⁵ Thurber Engineering, 2001. Groundwater Protection Plan Report for the Lower Cowichan River Aquifer and Chemainus River Aquifer



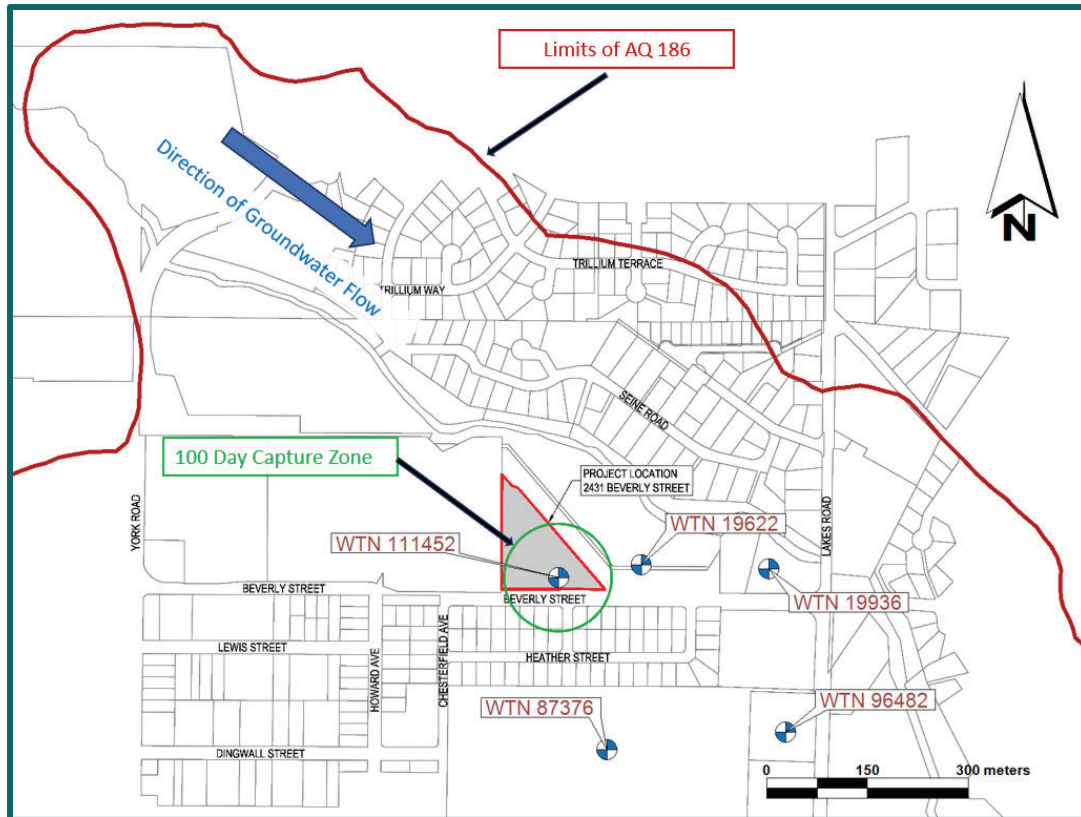


Figure 3. Groundwater Wells in the Area of Subject Property

Table 1 – Summary of Important Well Characteristics in Area of Subject Property

Well Tag Number	Name or address	Easting	Northing	Well Depth (m)	Static Water Level (m)	Well Yield (L/s)	Year Drilled	Licensed
111452	Cowichan Greens Well	449296	5403796	16.76	1.52	3.15	2016	Licensed
87376	5847 Chesterfield Ave.	449368	5403540	30.18	0.61	7.57	-	Unlicensed
96482	5860 Lakes Rd.	449634	5403566	11.28	-	1.26	1983	Unlicensed
19936	MNC Municipal Well	449609	5403809	7.92	0.61	41.01	1966	Unlicensed
19622	in field closer to Creek	449419	5403815	7.62	0.61	-	1966	Unlicensed

Using the same parameters, a 100 day conservative well head capture zone for the well is estimated to be on the order of 80m radius ([Appendix F](#)). The extent of the capture zone covers the majority of the southern portion of the Subject Property, where agricultural activities are focused. It is important to note that there are no wells located immediately up-gradient, to the west and northwest of the well on the Subject Property and that the capture zone for the well does not extend to include other wells. A more detailed calculation which incorporates gradient will generate a capture zone that extends further up-gradient to the northwest towards the school. The circular (conservative) capture zone does not extend to

Somenos Creek and therefore, pumping from the well at 2.2 L/s (35 USgpm) is not expected to draw water from the Creek and thus negatively impact flow.

A capture zone for the MNC municipal well has not been determined as part of this assignment as it is unknown of the well is currently being used. However, the yield of the municipal well is potentially in excess of 31.5 L/s (500 USgpm) and the resultant (conservative) 100 day capture zone would be greater than 300m radius, which would extend to the Subject Property. It is also noted that such a large capture zone would also extend to Somenos Creek and potentially result in significant groundwater interaction with surface water, which in turn may negatively impact flow and represent a groundwater at risk of containing pathogens (GARP) issue. Therefore, it is assumed that if the municipal well were ever used, it would be pumped at substantially less than the potential capacity in order to minimize interaction with the Creek. Regardless, any pumping from the municipal well has the potential to generate a conservative (circular) capture zone, or a more elongated zone based on flow gradient, which may extend to the Subject Property. This is important as land use within the footprint area of a well capture zone may generate water quality impacts to the aquifer than render groundwater as unusable for certain purposes.

3.2. Assessment of Potential Impacts Resulting from Agricultural Activity

Due to the unconfined nature of the aquifer and the relatively very shallow depth to water (static water level), the aquifer has high vulnerability to water quality impacts from potential contaminant sources at ground surface infiltrating into the aquifer. Of particular concern in relation to the Subject Property is the storage and use of agricultural amendments including pesticides, herbicides, and fertilizers, either organic (manure, compost) or inorganic (synthetic materials, chemicals). The use of pesticides or herbicides should not be done on the Subject Property and only organic fertilizers should be used, albeit sparingly.

The capture zone for the well on the Subject Property includes the current area where agricultural activity, including in-ground planting is currently underway. Irrigation of in-ground crops, using water from the well or water provided from the community water supply system, is likely to promote leaching of agricultural amendments into the aquifer and impact water quality. In turn, pumping from the well on the Subject Property is likely to re-capture any impacted water.

We understand that some water quality testing has been done on the well on the Subject Property including analysis of metals. Regular sampling should be completed for the full suite of water potability standards as outlined in the Guidelines for Canadian Drinking Water Quality (GCDWQ)⁶ including specific parameters associated with agriculture such as nitrogen (nutrients including nitrates, nitrites), potassium and phosphorous. Nutrient testing should be undertaken more frequently than general potability testing. Less frequent testing can be undertaken for pesticides and herbicides. Any exceedances as compared to the GCDWQ, should be reported immediately with MNC.

Water from the well should not be used for human consumption.

⁶ Health Canada, 2022. Guidelines for Canadian Drinking Water Quality.



3.3. Assessment of Other Potential Impacts Resulting From Development

As outlined in the SWMP, prepared by McElhanney, all wastewater will be directed into the municipal sewer system. As a result, there will be no on-site sewage treatment and disposal.

The SWMP also dictates that drainage patterns at the north of the property remain as per predevelopment conditions where an existing culvert under the Dike will convey surface water towards the creek. Stormwater at the south end of the property will be collected and treated with an oil/grit/water separator prior to being directed to rock (soakaway) pit and its subsequent controlled release to the community storm sewer.

4. Conclusions and Recommendations

McElhanney has drawn the following conclusions regarding the hydrogeological conditions in the area of the Subject Property and the possible impacts on the groundwater resources in the area resulting from the proposed development:

- The property is being currently used as a community garden. Currently, there are two greenhouses plus some ancillary (temporary) buildings on site and there are several rows of irrigated plantings extending north of the greenhouses, along with raised garden vegetable planters. The proposed additional development on site is to include a new warehouse and gravel areas for access and parking;
- The site will be connected to existing community sanitary and stormwater sewerage systems. Water for the warehouse and ancillary facilities will be accessed from connection to the local community based water utility. Water for irrigation will be from a water well on the property;
- Runoff from the parking lot will be directed to an oil/grit/water separator prior to infiltration and/or release to the municipal stormwater system;
- A stormwater management plan for the site has been prepared, details of which are presented in a separate memo by McElhanney;
- There are 5 water wells on or adjacent to the Subject Property. These wells are within BC Aquifer 186 which is considered to be an overburden aquifer fluvial sand, gravel and silt sediments. This aquifer is considered a type 1A aquifer. It is a highly productive, high usage aquifer which is also highly vulnerable to impacts from surface contamination sources. Water flow is generally towards the south east;

The water well on the Subject Property (WTN 111452) is reportedly pumped at a rate of 2.2 L/s (35 US gpm) and calculations based on operating at this rate for 6 hours per day for 180 days per year indicate the water usage does not adversely impact the quantity of groundwater available to other surface or groundwater users in the vicinity;

McElhanney recommends the following:

- As the aquifer penetrated by the well on the Subject Property is vulnerable to contamination from surface contaminants, the use of pesticides, herbicides and fertilizers should be kept to a minimum;
- Regular water sampling for the full suite of water potability standards should be completed as outlined in the Guidelines for Canadian Drinking Water Quality, including testing for specific parameters associated with agriculture impacts such as nitrogen (nutrient testing including nitrates, nitrites), potassium and phosphorous;



Water from the well on the Subject Property should not be used as a drinking water source as the capture zone for the well includes the area used on site for agricultural activities and there is potential that water from the well may not meet potability standards outlined in the Guidelines for Canadian Water Quality (GCDWQ), specifically for water quality parameters associated with pesticides, herbicides and fertilizers.

5. Limitations

Use of this Report. This report was prepared by McElhanney Ltd. ("McElhanney") for the particular site, design objective, development, and purpose (the "**Project**") described in this report and for the exclusive use of the client identified in this report (the "**Client**"). The data, interpretations and recommendations pertain to the Project and are not applicable to any other project or site location. This report may not be reproduced, used, or relied upon, in whole or in part, by a party other than the Client, without the prior written consent of McElhanney. The Client may provide copies of this report to regulatory authorities for use in relation to and in connection with the Project provided that any reliance, unauthorized use, and/or decisions made based on the information contained in this report are at the sole risk of such parties. McElhanney will not be responsible for the use of this report on projects other than the Project, where this report or the contents hereof have been modified without McElhanney's consent, to the extent that the content is in the nature of an opinion, and if the report is preliminary or draft. This is a technical report and is not a legal representation or interpretation of laws, rules, regulations, or policies of government agencies.

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Information from Client and Third Parties. McElhanney has relied in good faith on information provided by the Client and third parties noted in this report and has assumed such information to be accurate, complete, reliable, non-fringing, and fit for the intended purpose without independent verification. McElhanney accepts no responsibility for any deficiency, misstatements or inaccuracy contained in this report as a result of omissions or errors in information provided by third parties or for omissions, misstatements or fraudulent acts of persons interviewed.

Effect of Changes. All evaluations and conclusions stated in this report are based on facts, observations, site-specific details, legislation, and regulations as they existed at the time of the assessment and report preparation. Some conditions are subject to change over time and the Client recognizes that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site may substantially alter such evaluations and conclusions. McElhanney should be requested to re-evaluate the conclusions of this report and to provide amendments as required prior to any reliance upon the information presented herein upon any of the following events: a) any changes (or possible changes) to the site, purpose, or development plans upon which this report was based, b) any changes to applicable laws subsequent to the issuance of the report, c) new information is discovered in the future during site excavations, construction, building demolition or other activities, or d) additional subsurface assessments or testing conducted by others.

Independent Judgments. McElhanney will not be responsible for the independent conclusions, interpretations, interpolations and/or decisions of the Client, or others, who may come into possession of this report, or any part thereof. This restriction of liability includes decisions made to purchase, finance, or sell land or with respect to public offerings for the sale of securities.

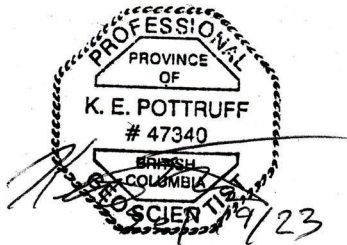


6. Closure

If there are any questions regarding the information presented in this document please contact the Project Manager, Lukas Brezina at 778 841 0729 or lbrezina@mcelhanney.com, or Remi Allard, whose contact information is provided below.

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References

AgriServiceBC, 2023. Investment Agriculture Foundation of BC. Climate Change Adaptation Program, Vancouver Island. <https://bcclimatchangeadaptation.ca/regional-adaptation/vancouver-island/>

BCCOSA, 2023. BC Onsite Sewage Association Membership Directory. Accessed online September 2023 at <https://www.theserenityroom.ca/bc-rowp-database>

BCGOV, 2023a. BC Health Hazards Regulation [BC REG 216/2011]. Accessed online September 2023 at https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/216_2011#section8

BCGOV, 2023b. BC Sewerage System Regulation [BC REG 32/2004]. Accessed online September 2023 at https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/22_326_2004

BCGOV, 2023c. BC Groundwater Protection Regulation [B.C. Reg. 39/2016, Amended December 1, 2022]. Accessed online September 2023 at https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/39_2016

BCMoE, 2023. BC Water Resources Atlas and WELLS database. Accessed online September 2023 at <https://maps.gov.bc.ca/ess/hm/wrbc/>

Berardinucci and Ronneseth, 2002. A guide to using the BC Aquifer Classification Maps for the Protection and Management of Groundwater. BC Ministry of Water Land and Air Protection. Accessed online September 2023 at <https://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=1791>

Hammond, Z., A. Hinnell, and J. Clague, 2019. Detailed Aquifer Mapping Study: Shawnigan Lake Area, Vancouver Island, BC. Water Science Series, WSS2019-02, Prov. B.C., Victoria, BC. Accessed online September 2023 at https://a100.gov.bc.ca/pub/acat/documents/r56659/WSS2019-02,Shawniganareamapping_secured_1581368838565_1368739019.pdf

Harris, M and S. Usher, 2017. Preliminary groundwater budgets, Cobble-Hill / Mill Bay Area, Vancouver Island, BC. Water Science Series, WSS2017-01, Prov. of BC, Victoria, BC. Accessed online September 2023 at https://a100.gov.bc.ca/pub/acat/documents/r52917/Cobble_Budget2017_15091449349849144072763.pdf

Health Canada, 2022. Guidelines for Canadian Drinking Water Quality. Summary Tables. Accessed online September 2023 at <https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html>

McElhanney, September 2023. Memorandum on 1170 Deloume Road, Shawnigan Lake - Stormwater Management Plan. Unpublished technical report submitted to Mr. Martin Buck. 17 pages. McElhanney file: 2233-02097-00.

Thurber Engineering, 2001. Groundwater Protection Plan Report for the Lower Cowichan River Aquifer and Chemainus River Aquifer. Unpublished report prepared for the District of North Cowichan. Accessed online September 2023 at <https://www.northcowichan.ca/assets/Departments/Waste~Water~Management/docs/WellProtectionPlan.pdf>

APPENDIX A

Documentation Relating to the Requirements for an AiA

10.3 DPA-3 NATURAL ENVIRONMENT

PURPOSE

The purpose of the Natural Environment Development Permit Area (DPA-3) is to establish objectives and guidelines to protect and enhance environmentally sensitive areas, ecosystems and biological diversity, and to ensure development has a positive impact on natural features and functions.

DESIGNATION

In accordance with the provision of [Section 488 \(1\)\(a\)](#) of the *Local Government Act*, all lands within the boundaries of Municipality of North Cowichan are designated a development permit area for the protection of the natural environment, its ecosystems and biodiversity.

The Natural Environment Development Permit Area (DPA-3) applies to:

- a. **Streams and Watercourses:**
 - Any development within 30 metres of a stream, as defined by the Riparian Area Protection Regulation.
 - Any development within a Riparian Assessment Area, as defined by the Riparian Area Protection Regulation.
- b. **Environmentally Sensitive Areas:**
 - Development within 15 metres of any environmentally sensitive area shown on Map 4 – Environmentally Sensitive Areas or identified as environmentally sensitive by a qualified environmental professional.
 - Development within 25 metres of a raptor nest tree.
- c. **Marine Riparian Areas:**
 - Any development within a 30 metre horizontal distance of the high water mark of the ocean.
- d. **Aquifer Protection:**
 - Any land with a high vulnerability rating as shown on Map 5 – Water Source Protection.

OBJECTIVES

The objectives for DPA-3 are:

- a. Protect the natural environment, its ecosystems, habitat and biological diversity from potential development impacts.
- b. Restore lost or degraded ecosystems and ecosystem functions.
- c. Promote and encourage ecological resilience in the natural environment to respond to climate change.
- d. Protect against flooding, erosion and sea level rise in ways that preserve environmental, cultural and recreational values.
- e. Establish procedures and guidelines for restoring environmentally sensitive lands damaged by unauthorized development.
- f. Protect shallow and vulnerable aquifers from risk of groundwater contamination.

GUIDELINES

"Environment DP Guidelines B" within Zoning Bylaw 2950 are associated with and applicable to DPA-3.

2.0 Natural Environment Development Permit Guidelines “B”

2.1 Development Permit Guidelines “B”: Objectives & Application

The objectives of this Development Permit Area are to protect, manage and/or mitigate the following key environmental considerations:

- (a) **Sensitive Aquatic Ecosystems:** Environmental significance as habitat for fish and wildlife, their vital functions in natural storage and flood protection, their increasingly important role in reducing the effects of climate change, and their sensitivity to disturbance by development.
- (b) **Sensitive Terrestrial Ecosystems:** Environmental significance as habitat and corridors for wildlife, their contribution to local and regional biodiversity, and their sensitivity to disturbance by development.
- (c) **Groundwater, Aquifers and Watersheds:** Quality and quantity of water supply and flow.
- (d) **Marine Shoreline and Adjacent Coastal Waters:** Environmental significance for forage fish and other species; and their sensitivity to disturbance by development.

The Development Permit Guidelines “B” are associated with DPA-3 Natural Environment will be applied to:

- (a) **Watercourses:** Streams, wetlands, lakes and ponds – shown on Map 4 of the OCP or as determined by the Municipality of North Cowichan through on-site investigation.
 - (i) For all watercourses, DPA-3 applies to a 30.0 m strip of land on both sides of the watercourse, measured from the natural boundary; and
 - (ii) Within a ravine, requirements detailed in the provincial *Riparian Area Regulation* apply.
- (b) **Coastal Areas:** The development permit requirements apply to the 30.0 m horizontal distance upland from the present natural boundary and within the 30 m horizontal distance seaward of the present natural boundary.
- (c) **Terrestrial Habitat and Endangered Species Protection Areas:** Those areas shown on Map 4 of the OCP or as determined by the Municipality of North Cowichan or a qualified professional through on-site investigation; and which include those species listed under the federal *Species at Risk Act (SARA)* and provincially ranked species identified as red-listed or blue-listed by the Provincial Conservation Data Centre or by a qualified professional through on-site investigation
- (d) **Wildlife Trees:** As detailed in the provincial *Wildlife Act* (e.g. those with nests of eagles, herons, osprey, falcons or burrowing owl)
- (e) **Aquifer Protection Areas:** Those areas having a high vulnerability rating as shown on Map 5 of the OCP.

2.2 Development Permit Guidelines “B”: Exemptions

See Table 1: Development Permit Guidelines Exemption Criteria. (Page 150)

Also, an exemption from Development Permit requirements under this DPA may be granted if one or more of the following criteria apply:

- (a) Development activity which occurs outside of the environmentally sensitive area, and which appropriately protects and buffers any environmentally sensitive area on the property.
- (b) The development activity involves any of the following: fence-building, growing, rearing, producing or harvesting of agricultural products in accordance with recognized standards of the *Farm Practices Protection (Right to Farm) Act* or forest management activities on lands subject to the *Forest Act* or *Private Managed Forest Land Act*;

- (c) Emergency works or procedures required to prevent, control or reduce flooding, erosion or other immediate threats to life or property, including:
 - (i) emergency flood or erosion control works;
 - (ii) clearing of an obstruction from a bridge, culvert or drainage flow;
 - (iii) repairs to bridges or safety fences; and
 - (iv) cutting down of hazardous trees within the DPA that present an immediate danger to the safety of persons or will potentially damage public or private property, as determined by an arborist or similar professional.

NOTE: Emergency actions by anyone other than municipal or provincial government staff must be reported immediately to the Municipality.

- (d) Planting and maintenance of native (indigenous) trees, shrubs or groundcover for the purpose of restoring or enhancing habitat values and/or soil stability within the DPA, provided such planting is carried out in accordance with the guidelines or directions provided by the Municipality.
- (e) Works approved by the Municipality, Department of Fisheries and Oceans, or provincial Ministry of Environment, including the installation of public utilities, sewer and water lines, trail construction, stream enhancement, and fish and wildlife habitat restoration;
- (f) Construction of a trail within the DPA, as long as the following conditions are met:
 - (i) only one trail is built;
 - (ii) the trail is for personal, non-vehicular use only;
 - (iii) the trail is less than 1 m wide;
 - (iv) is constructed of a pervious surface (e.g. soil, gravel, mulch);
 - (v) no erosion is caused by the trail's construction or use;
 - (vi) no native trees will be removed;
 - (vii) the overall slope of the trail is less than 10% grade or, where portions are greater than 10% grade, the trail is designed to prevent erosion; and
 - (viii) movement of soil, fill or aggregates occurs within a corridor less than 2 m wide.
- (g) Subdivision of lands containing a portion of the DPA where all of the following apply:
 - (i) minimum lot areas required under the Zoning Bylaw have been achieved exclusive of the Development Permit area where lands are located within the UCB;
 - (ii) no development or development activities (e.g. construction, grading, clearing, trenching, installation of services) relating to the creation of lots or the provision of services for those lots will occur in the DPA; and
 - (iii) the DPA has been protected through dedication, conservation covenant or other provisions acceptable to the Approving Officer.
- (h) Residential development on a lot for which a Riparian Area Assessment or bio inventory report was prepared and the conditions met through the subdivision process, and for which a S.219 covenant to protect the riparian assessment area was registered on title;
- (i) Public works and services (such as construction, repair and maintenance) performed by the Municipality or its authorized agents and contractors, as long as these works and services meet or exceed the conditions of the following guidelines;

- (j) Gardening and yard maintenance activities within an existing landscaped areas, such as lawn mowing, minor pruning of trees and shrubs, planting of vegetation, and minor soil disturbance that does not alter the general contour of the land;
- (k) The removal of invasive plants or noxious weeds on a small scale (such as Scotch broom, Himalayan blackberry, morning glory and purple loosestrife), as long as such works are conducted in accordance with a vegetation management plan and sediment and erosion control plan and the area is replanted immediately (*note: approval by the Municipality is required before any vegetation removal*); and
- (l) Minor additions to existing buildings and structures to a maximum of 25% of the total floor area of the existing building or structure, as well as renovations, repairs or maintenance, as long as the proposed improvements do not result in the building or structure shifting closer to, or further impacting on, an environmentally sensitive feature.
- (m) Exemption for Aquifer Protection Only: development of buildings that house single-family or two-family dwelling units.

2.3 Development Permit Guidelines “B”: General Guidelines

The following guidelines apply to all environmentally sensitive areas within the Development Permit Area (DPA-3 Natural Environment). To protect and maintain these important assets, no alteration of land, disturbance of vegetation, movement of soils or other disturbance of land, water or subdivision of land within the DPA may be undertaken without:

- (a) Development Permit issued under these guidelines; and
- (b) Strict compliance to the terms of such a Development Permit.

Development Permits will only be issued in this Development Permit Area subject to consideration of the following specific design practices. These guidelines should be carefully considered from conceptual design through to detailed design and refinement of a development proposal.

2.3.1 Working Within the Development Permit Area

- (a) Development within the Development Permit Area will generally be considered only where:
 - (i) historical subdivision or construction has occurred before the DPA was designated;
 - (ii) the DPA occupies so much of a pre-existing lot that it makes the lot undevelopable for the use permitted under its existing zoning;
 - (iii) because of topographic, natural hazard or other environmental constraints on the lot, there is no acceptable building site outside the DPA; and
 - (iv) all opportunities to relax other development requirements (such as setbacks, minimum lot size, parking) have been exhausted.
- (b) Encroachment into the DPA by all development activities must not exceed what is indicated in the site plan approved for the Development Permit. All development activities must avoid causing disturbance in the DPA beyond the building footprint. This may mean adjusting conventional practices with respect to locating machinery and stockpiles and using alternatives such as hand labour as opposed to machinery.
- (c) The onus lies with the applicant to demonstrate that encroaching into a DPA is necessary to establish a permitted use that might not ‘fit’ on the land outside of the DPA.

2.3.2 Environmentally Sensitive Protection Areas

Environmentally Sensitive Areas are deemed to be areas of significant ecological value and susceptible to disturbance, as determined by a Qualified Environmental Professional or other professional (see below).

- (a) All Environmentally Sensitive Areas must be maintained free of development and conserved in a natural vegetated state or remediated to return to a natural state (except as otherwise allowed under a Development Permit issued under these guidelines).
- (b) Development activity taking place outside an Environmentally Sensitive Area must make every effort through site design to avoid encroaching into the protected area and negatively affecting its natural features, functions and conditions.
- (c) **Prohibited Activities:** The following development activities are not permitted in a Protection Area unless there is proven hardship:
 - (i) construction of septic tanks, drainage and deposit fields;
 - (ii) irrigation or drainage improvements; and
 - (iii) installation of water systems.
- (d) **Relaxation of Other Land Use Regulations:** Varying or relaxing other bylaw requirements (e.g. by allowing variances to front, side and rear yard setbacks, building height or parking requirements) will be considered to facilitate safeguarding an Environmentally Sensitive Area, particularly where the relaxation can make possible the development of the remainder of the lot.
- (e) **Varying the Boundaries of Environmentally Sensitive Protection Areas:** Varying the boundaries of a Protection Area is generally not allowed and will only be considered where:
 - (i) the Protection Area occupies so much of the property as to render it undevelopable for the use for which the property is zoned;
 - (ii) because of topographic, natural hazard or other environmental constraints, there is little or no acceptable development site on the property outside the Protection Area;
 - (iii) by averaging the width of the Protection Area over a property, an equal or greater area of ecological value, acceptable to the Municipality, is provided;
 - (iv) in the case of the Watercourse Protection Development Permit Area: an assessment has been undertaken by a Qualified Environmental Professional in accordance with the Riparian Area Regulation, the assessment supports any proposed boundary change; and the Department of Fisheries and Oceans and the provincial Ministry of Environment agree that there will no harmful alteration or destruction of fish habitat;
 - (v) in the case of other environmentally sensitive areas, an assessment prepared by a Qualified Environmental Professional demonstrates to the satisfaction of the Municipality that the natural features, functions and conditions of the Protection Area will be preserved, protected and/or enhanced by the proposed development design.
- (f) **Buffer Areas:** Buffers must be established around the Protection Area in keeping with the following guidelines:
 - (i) Buffers must be wide enough to protect the ecological integrity of the resource.
 - (ii) Riparian buffers must consider the needs of all species, not just fish.
 - (iii) Light penetration into a buffer area must be minimized.
 - (iv) The long-term protection of buffer areas must be secured through dedication, donation, covenant or other legal mechanisms.
 - (v) Permanent barriers may be required to be installed to discourage access.

- (vi) Invasive plant species within the buffer must be removed and replaced with native species.
 - (vii) Buffer areas must be physically located on the ground by a B.C. Land Surveyor or Qualified Environmental Professional before any development, land alteration or vegetation removal occurs.
 - (viii) For developments not subject to subdivision, the limit of a Protection Area may be determined and flagged on-site in cooperation with the Municipality.
 - (ix) Temporary barrier fencing, to demarcate the area of no disturbance, must be installed along all buffer areas before any development activities begin.
 - (x) Permanent fencing may be required to be installed to demarcate the Protection Area over the long term. Where required, it must be designed to allow for free and uninterrupted movement of organisms between the Protection Area and upland ecosystems and must be maintained in good order.
 - (xi) Signage may be required to be installed. Where required, it must be in a clearly visible location a minimum of every 10 m, and at least one sign must be installed on each proposed lot adjacent to the Protection Area.
- (g) **Subdivision:** When land containing a Protection Area is to be subdivided all lots smaller than 1.0 ha (2.47 acres) within the Urban Containment Boundary must meet the minimum lot size and dimensions required under the Zoning Bylaw exclusive of the Protection Area.
- (h) **Dedication:** Where possible, Protection Areas should be dedicated for conservation purposes using one of these mechanisms:
- (i) reversion to the Province (a "Return to Crown");
 - (ii) dedication to the municipality where the land would be managed primarily to protect the environmental values;
 - (iii) dedication to a private land trust where the land is managed for conservation purposes;
 - (iv) registration of a section 219 (conservation) covenant in favour of the municipality, provincial agency, recognized stewardship group or land trust; or
 - (v) other suitable mechanism as determined by the Municipality.
- (i) **Sediment and Erosion Control:**
- (i) All development within this Development Permit Area (DPA-3 Natural Environment) must be undertaken and completed in such a manner as to prevent the release of sediment to any watercourse, storm sewer or over land.
 - (ii) An erosion and sediment control plan may be required as part of the Development Permit application and should include actions to be taken before land clearing and site preparation, and the proposed timing of development activities to reduce the risk of erosion.
 - (iii) Sediment containment and erosion control measures must be installed before any land development activity begins.
 - (iv) Development must be avoided on slopes greater than 20% because of the high risk of erosion and bank slippage.
 - (v) The standards for sediment and erosion control outlined in the *Land Development Guidelines for the Protection of Aquatic Habitat* (jointly published by BC Ministry of

Environment and Department of Fisheries and Oceans) must be adhered to.

- (j) **Monitoring:** The Municipality may require a qualified environmental professional to monitor and ensure that implementation of environmental mitigation, restoration or enhancement measures approved under a Development Permit are being done.
- (k) **Unauthorized Development Activity in a Protection Area or Development Permit Area:** Where land alteration has occurred within any Protection Area or Development Permit Area without prior Municipality approval, the Municipality will require:
 - (i) an environmental impact assessment report to be completed by a Qualified Environmental Professional to identify mitigation and restoration requirements;
 - (ii) the owner to apply for a Development Permit and to meet the conditions established to mitigate and restore the environmentally sensitive area; and
 - (iii) the owner to post a financial security in an amount that is equal to the amount required to pay for:
 - the cost of rehabilitating and/or restoring an environmentally sensitive area;
 - the cost of repairing damage caused by construction or site disturbance; and
 - the cost of restoring fish habitat.
- (l) **Performance Bonding:** The Municipality may require the applicant to submit an estimate, prepared by a qualified professional and accepted by the Municipality, of the total cost to rehabilitate and/or restore the environmentally sensitive area and to ensure the conditions of the permit and these DP guidelines are met. Financial security, based on the cost estimate approach outlined above, must be provided to the Municipality before any approval for construction, land alteration or vegetation removal will be issued. For example, security may be required, and applied against, erosion control works, site grading, phased clearing, barrier fence installation, habitat restoration works, post-development success of revegetation and restoration works, or any other requirements of a Development Permit.

2.3.3 Best Management Practices

Development design must reflect the objectives and guidelines of “Best Management Practices” outlined in the following documents and others that may be developed, updated and or amended from time to time. As stated in the preamble of this document, there are numerous references to documents, guidelines, plans and strategies developed and administered by other government agencies and organizations throughout this document. While these documents are relevant and useful as of the date of adoption of this document, it is always advisable to confirm with Municipal Planning staff that specific documents and information remains up-to-date and supported by the Municipality.

- (a) *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia*
- (b) *Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia*
- (c) *Instream Flow Guidelines for British Columbia*
- (d) *Standards and Best Management Practices for Instream Works*
- (e) *Riparian Area Regulation Assessment Methods*
- (f) *Best Management Practices for Lakeshore Stabilization*
- (g) *Stream Stewardship: A Guide for Planners and Developers*
- (h) *Access Near Aquatic Areas: A Guide to Sensitive Planning, Design and Management*
- (i) *Stormwater Planning: A Guidebook for British Columbia*
- (j) *Community Green Ways Linking Communities to Country and People to Nature*
- (k) *Guidelines to protect fish and fish habitat from treated wood used in aquatic environments in the Pacific Region*

- (l) *Land Development Guidelines for the Protection of Aquatic Habitat*
- (m) *Living by Water*
- (n) *Marina Development Guidelines for the Protection of Fish and Fish Habitat*
- (o) *Riparian Revegetation*
- (p) *The Shore Primer – A Cottagers Guide to a Healthy Waterfront; and*
- (q) *Other Fisheries and Oceans best practices materials for docks, wharves and retaining structures or other waterfront development.*

2.3.4 Vegetation Management, Restoration and Enhancement

- (a) Existing, native vegetation must be retained wherever possible to minimize disruption to habitat and to protect against erosion and slope failure.
- (b) To ensure their long-term health, existing trees and shrubs that are retained must be clearly marked before development, and temporary fencing must be installed at the drip line (at a minimum) to protect the trees during clearing, grading and other development activities.
- (c) If the area has been previously cleared of native vegetation, or is cleared during the process of development, replanting must be done in keeping with these guidelines or with requirements specified in the Development Permit. Areas of undisturbed bedrock exposed at the surface or natural sparsely vegetated areas shall not require planting.
- (d) Where existing trees and vegetation are retained, the following actions are allowed:
 - (i) pruning or removing of hazardous trees (as determined by an arborist), but leaving wildlife trees and snags (dead, upright trees, or stumps) wherever safe;
 - (ii) pruning of undergrowth within 1 m of existing or proposed public trails to avoid injury to users; and
 - (iii) supplementing existing vegetation with planted stock as needed to landscape bare or thin areas, following specifications noted below.
- (e) Invasive plants (e.g. blackberry, Scotch broom, English ivy) and noxious weeds may be required to be removed from the lands and areas replanted in keeping with these guidelines.
- (f) Plant species selected for replanting, restoration or enhancement should: suit the soil, light and groundwater conditions of the site; be native to the district; and be suitable for erosion control and, as needed, for fish and habitat wildlife habitat.
- (g) Replanting requirements will be set out in plans developed as part of the Development Permit application and approved by the Municipality, or will be expected to meet the guidelines provided by the Municipality and will form part of the Development Permit.
- (h) All replanting must be maintained by the property owner for a minimum of two years from the date of completion of the planting. This may require removal of invasive plants and maintenance of irrigation systems. Unhealthy, dying or dead stock will be replaced at the owner's expense within that time in the next regular planting season.

2.3.5 Rainwater Management Strategies

- (a) Rainwater management systems should be designed in accordance with the following principles:
 - (i) Development practices shall not increase nutrient inputs to waterways beyond natural levels.
 - (ii) Development must not increase or decrease the amount and quality of surface and groundwater.
- (b) Rainwater management systems should be designed with reference to the provincial Ministry of

Environment's document *Stormwater Planning: A Guidebook for British Columbia*, and should consider the following guidelines:

- (i) Manage rainwater on site so that post-development rainwater flow levels from the site are equal to pre-development levels.
- (ii) Use rain gardens, vegetated swales, reduced impervious surfaces, increased soil depths and other technologies for managing rainwater on site.
- (iii) Install features for controlling erosion and rainwater quality and quantity to the Municipality's satisfaction, to minimize impacts of outflow on slope stability, fish habitat and downstream impacts.
- (iv) Make provision, and undertake works, to provide for the disposal of surface run-off and stormwater flowing over the land which may stem from later development. Such works must divert drainage away from areas subject to sloughing.

2.4 Development Permit Guidelines "B": Specific Guidelines

Development Permits will only be issued in this Development Permit Area (DPA-3 Natural Environment) subject to consideration of the following specific design practices. These guidelines should be carefully considered from conceptual design through to detailed design and refinement of a development proposal.

2.4.1 Watercourse Protection Areas

The layout and design of development proposed within DPA-3 (a. Stream and Watercourses), or any associated Environmentally Sensitive Protection Areas as defined in section 2.3.2, must strive to:

- (a) preserve and protect sensitive riparian and aquatic ecosystems;
- (b) preserve and protect water quality within aquatic ecosystems;
- (c) ensure riparian and watercourse protection areas remain large enough to protect habitat, prevent flooding, control erosion, reduce sedimentation and recharge groundwater.
- (d) connect environmentally sensitive areas by retaining wildlife corridors wherever possible;
- (e) design development layout to allow flooding, streambank erosion and other natural processes to continue unimpeded;
- (f) protect the ecological values of riparian areas and watercourses during and after development;
- (g) restore degraded ecosystems where possible;
- (h) ensure that all planning and development in the DPA occurs according to the requirements of the Riparian Area Regulation and other environmental protection regulations;
- (i) maintain hydrologic regimes, including not dyking or damming inflow and outflow streams; and
- (j) maintain normal wetland and water processes such as flooding, seasonal drawdown and groundwater recharge.

2.4.2 Terrestrial Habitat and Endangered Species Protection Areas

Habitat Protection Area boundaries should be located, with the assistance of a professional environmental professional, to maximize the inclusion within them of one or more of their natural features, functions or conditions. The layout and design of development proposed within DPA-3 (b. Environmentally Sensitive Areas), or any associated Environmentally Sensitive Protection Areas as defined in section 2.3.2, must strive to:

- (a) develop away from the most pristine and least disturbed habitat areas;

- (b) ensure development results in no net loss to environmentally sensitive terrestrial ecosystems;
- (c) protect endangered Douglas-fir forests and the critical habitat contained in them from disturbance;
- (d) protect endangered Garry oak meadow ecosystems, including their spring wildflowers, grasses, mosses, shrubs, lichens and fungi, as well as the variety of animal and insect species that thrive in this unique environment;
- (e) maintain connectivity and linkages between sensitive ecosystems and habitat areas, and minimize fragmentation within one property and among adjacent properties;
- (f) favour maintaining fewer larger undisturbed areas rather than many small but isolated areas;
- (g) maintain and establish more complex areas of habitat that contain a variety of plant species, ages and multi-storey vegetation;
- (h) protect and enhance biodiversity within terrestrial ecosystems;
- (i) design habitat areas without creating barriers to wildlife passage (e.g. walls, solid fences, roads);
- (j) protect the ecological values of terrestrial areas during and after development; and
- (k) restore degraded ecosystems where possible.

2.4.3 Shoreline Protection Areas

- (a) Development in a Shoreline Protection Area is restricted generally only to those uses necessitating shoreline access, and then only with appropriate environmental assessment and mitigation measures.
- (b) The layout and design of development proposed within DPA-3 (c. Marine Riparian Areas), or any associated Environmentally Sensitive Protection Areas as defined in section 2.3.2, must strive to:
 - (i) minimize erosion, retain wildlife habitat and maintain water quality, slope stability and natural vegetation along shorelines;
 - (ii) avoid areas with poor slope stability and locate foreshore accesses/structures sensitively;
 - (iii) maintain existing marine habitat (e.g. eelgrass beds, shell fish beds) in their natural state to protect the resource;
 - (iv) establish water views selectively by pruning branches of shoreline trees instead of topping or removing healthy trees; and
 - (v) maintain public access.
- (c) Installation of hard structural shore protection measures (e.g. riprap structures, lock block walls, concrete walls) to address shoreline erosion is strongly discouraged. The use of non-structural options is preferred, such as using bio-engineering techniques, locating new buildings/structures farther from the shoreline, or installing on-site drainage improvements are preferred.
- (d) Before any shore protection measure is taken, an appropriate qualified coastal professional must provide conclusive evidence that the development structure is at risk from shoreline erosion caused by tidal action, currents, or waves. Evidence of normal sloughing, erosion of steep bluffs or shoreline erosion itself without a scientific or geotechnical analysis is not a sufficient demonstration of need. Confirmation is required that the erosion is not being caused by upland conditions, such as the loss of vegetation and drainage.
- (e) All shore protection measures must be designed by an appropriate qualified coastal professional.
- (f) Shore protection measures that could cause erosion or other physical damage to adjacent or down-current properties or that impedes public access are not supported.
- (g) The size of any shore protection device must be limited to the minimum size necessary.

- (h) All structural shore protection measures should be installed within the property line or upland of the natural boundary, whichever is farther inland.
- (i) Backfilling to extend the existing top of bank is not permitted unless it can be clearly demonstrated that the fill is necessary to prevent further erosion or sloughing of the bank that would potentially endanger existing buildings/structures.
- (j) A geotechnical assessment of the site and shoreline characteristics may be required to establish safe setbacks from the top of bank and to identify measures to ensure safe building site areas or usable lots. Such assessment must consider rising sea levels. [See also DPA 4 – Hazard Lands, Sea Level Rise]
- (k) Where a Shoreline Protection Area includes native plant species or plant communities that are identified as sensitive, rare, threatened or endangered, or have been identified by a Qualified Environmental Professional as worthy of particular protection, their habitat areas must be left undisturbed. If disturbance cannot be entirely avoided, development and mitigation/compensation measures must be undertaken under the supervision of the Qualified Environmental Professional and may require additional advice from applicable senior governmental agencies.

2.4.4 Nest Tree Protection Areas

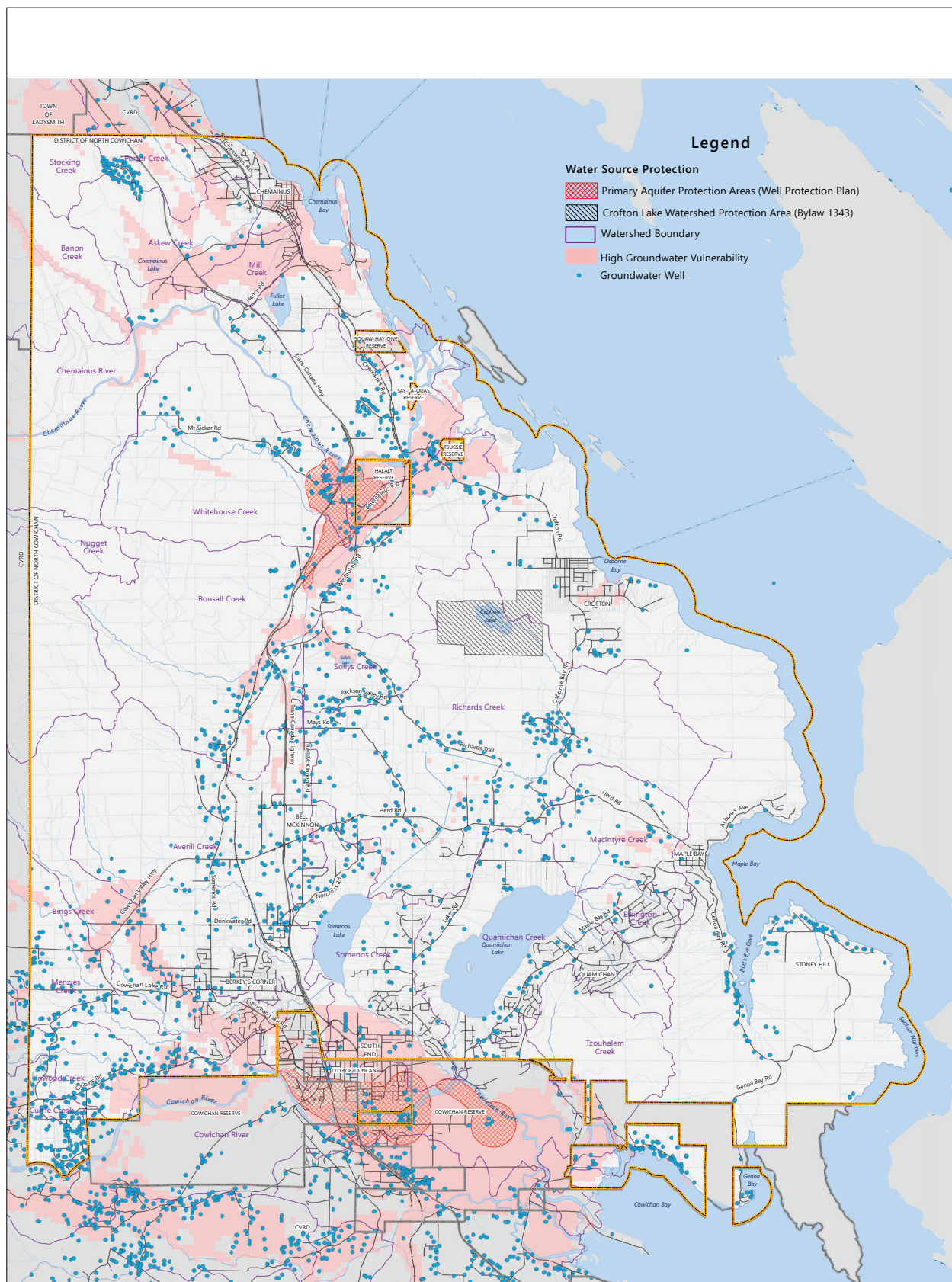
All nest trees are protected under the provincial *Wildlife Act*. Therefore, notifying the Municipality of these nest trees before and during construction and adhering to these guidelines will protect an applicant, landowner or developer from potential prosecution under the *Wildlife Act* and or under this bylaw.

- (a) The layout and design of development proposed within a DPA-3 (b. Environmentally Sensitive Areas), or any associated Environmentally Sensitive Protection Areas as defined in section 2.3.2, should ensure that buffer areas are established based on the Ministry of Environment's best practices, as detailed in *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia*, and strive to:
 - (i) identify: areas to be maintained free of development and in a naturally vegetated state; areas of no disturbance and with noise control during the breeding season (usually January 30 to June 30), including areas around a nest tree in which no blasting should occur during the breeding season;
 - (ii) retain wildlife trees (including fallen trees and snags, trees with cavities), leaf litter, fallen debris and natural vegetation; and
 - (iii) locate artificial snags to help improve habitat.

2.4.5 Aquifer Protection Areas

- (a) Developments found to have the potential to pose detrimental impacts on either the quality or quantity of groundwater will not be supported.
- (b) The use or disposal of substances or contaminants that may be harmful to area aquifers is prohibited and, wherever practical, steps must be taken to ensure the proper disposal of such contaminants.
- (c) Where the possibility of a development impacting an aquifer exists, the applicant must submit to the Municipality a report from a registered professional that includes:
 - (i) an assessment of the characteristics of the aquifer and its ability to accommodate the additional groundwater demand proposed by the development, including an assessment of the anticipated demand given the development potential of the subject property based on its current zoning, and given potential impacts on adjacent properties;
 - (ii) a statement backed by a professional assessment that the proposed development will not

- have a negative impact on the aquifer; and
 - (iii) recommendations of measures required to ensure the aquifer is protected.
- (d) The layout and design of development proposed within DPA-3 (d. Aquifer Protection), or any associated Environmentally Sensitive Areas as defined in section 2.3.2, must strive to:
- (i) ensure that drainage from all impervious surfaces and areas where vehicles are parked is directed through an appropriately sized and engineered sedimentation, soil, water and grease separator, or is managed with another engineered solution;
 - The engineer must provide an appropriate maintenance schedule.
 - A section 219 covenant may be required to be registered on the title of the land, outlining the maintenance schedule and a commitment to maintain the sedimentation, oil, water and grease separator in keeping with the engineer's recommendations.
 - (ii) make provision for grease, oil, and sedimentation removal facilities and the ongoing maintenance of these facilities to handle treated effluent and diverted rainwater collection and discharge systems on development sites (commercial, industrial, multi-residential and others) where there is potential for silt and petroleum-based contaminants to enter a watercourse or infiltrate into the ground; and
 - (iii) use permeable paving and other methods to reduce rainwater run-off.



Map 5

Water Source Protection

Source: District of North Cowichan, Province of BC, Ministry of Environment, Thurber Engineering, March 2001, Well Protection Plan Lower Cowichan River Aquifer Chemainus River Aquifer Primary Wells.

MUNICIPALITY OF
NORTH
Cowichan



1 0.5 0 1
KM

March 30, 2022

6.2 LIMITING HUMAN IMPACTS: SOIL AND WATER QUALITY AIR, NOISE & LIGHT POLLUTION

SOIL

Soil is one of the primary sources of productivity, both for wildlife and agriculture. Preserving and increasing the quality of North Cowichan's soils is therefore an important aim. Overloading soils with pesticides, herbicides and fertilizer may temporarily increase short-term crop yields, but leads to long-term deterioration in soil and water quality. The Municipality can encourage regenerative agriculture practices and regulate soil deposition and removal through its bylaws. Soil and water quality are closely linked, with storm/flood waters mediating chemical exchanges between the land and the lakes and watercourses.

WATER

At present, Somenos Lake and Quamichan Lake share a common set of conditions and threats:

- Excessive nutrient loading from the farms and homes that surround the lakes (eutrophication).
- Historic nutrient loading, contained and released from the sediments.
- Insufficient "flushing" in summer due to reduced inflows and truncated outflows.
- Increased algae growth (blue-green algae blooms from phosphorous).
- Hypoxia (reduced oxygen levels as the vegetation decomposes).
- Intensified warming.

The combination of oxygen reduction at the bottom and temperature increases at the surface forces indigenous fish into the middle layer, where there is still some oxygen and temperatures are not too warm. In most recent summers, even that habitable middle layer has disappeared, resulting in fish-kills. Both lakes are now embraced by stewardship organizations, the Somenos Marsh Wildlife Society and the Quamichan Watershed Stewardship Society. Both are governed by watershed management plans.

AIR

Poor air quality has detrimental impacts on the health of residents and the natural environment. While North Cowichan's air quality is generally excellent, it sometimes falls below acceptable levels.

During periods with stable high pressure air cells, smoke and other pollutants can be trapped in valley lowlands. Because North Cowichan is part of a larger air shed, air quality concerns in neighbouring jurisdictions also affect us. In recent years, the vast majority of North Cowichan's poorest air quality days occur in the summer due to the movement of air from forest fires on the mainland. Changing our practices to reduce emissions is a responsible approach to minimize the impacts of air pollution on human and ecological health.

Trees and vegetation improve air quality and remove particulate matter. Managing for healthy ecosystems and tree canopy cover will help to improve long term air quality. Wildfires can also be a significant source of fine particulate matter. Managing for the risk of wildfires will be important not only for North Cowichan but also for neighbouring communities to maintain good air quality during the wildfire season.



Meets the social justice and equity principle by ensuring access for clean air for all means that those who don't have temperature controlled homes with air filters are still able to breathe healthy air.

SOUND

Another environmental irritant of concern to North Cowichan residents is noise pollution. Loud discordant sound (and vibration) emitted on a regular, repetitive basis can adversely affect the health and well-being of humans and animals (on land and in water) and are even capable of damaging physical structures over time. Efforts will be made to prevent the creation of new sources of noise pollution and to identify and mitigate the impact of current sources.

LIGHT & VISUAL

There also exist concerns about other effects of development such as:

- Light pollution which reduces the visibility of the stars in the night sky and can be disruptive to nocturnal and migratory species.
- Visual interruptions in forested mountain ridgelines resulting from development, forest operations and other human activity.

SOIL AND WATER QUALITY

6.2.1 Defining Success | Objectives

Objective: Pursue policies and practices that lead to long-term regeneration and improvements in soil and water quality, including reductions in contaminants and invasive species.

Progress can be measured by:

- Improvements in water quality, particularly in Quamichan and Somenos Lakes.
- Improvements in soil quality and productivity.

6.2.2 The Municipality will strive to:

- a. Retain native soils when possible and continue to implement and update regulations as necessary to reduce negative impacts from soil removal and deposit. Soil deposits should be free of invasive species and covered when not in use.
- b. Protect surface water, aquifers, groundwater quality and quantity through the Natural Environment Development Permit approval process.
- c. Ensure land use and growth consider the limits of water supply.
- d. Ensure that development and land use activities support the natural hydrologic cycle, including groundwater recharge.
- e. Work to retain the historic natural water balance by:
 - Protecting and restoring watercourses, waterbodies, wetlands and aquifers.
 - Preserving and restoring riparian plant communities.
 - Encouraging rainwater infiltration, including the use of green infrastructure
 - "Daylighting" (opening, to expose natural light) and restoring creeks and waterways that have been channelized, piped, or buried.
 - Designing developments to allow flooding, stream-bank erosion and other natural ecological processes to continue unimpeded while considering the expected impacts of climate change.
- f. Work to eliminate algae bloom and fish kills by restoring water quality in Quamichan and Somenos Lake. Reduce phosphorus levels in the lake by managing the watersheds and the streams that drain agricultural/rural and residential lands, and addressing internal loading of phosphorous.
- g. Apply a systems approach to watersheds, and explore options to map protected riparian area setbacks from creeks, foreshore and other waterbodies. These setbacks should consider the size and shape of the watercourse, bank characteristics, and use by fish and other aquatic species and should meet, or exceed, provincial and federal protection requirements.
- h. Recognize the benefits and impacts of seasonally flooded agricultural lands. These lands can play an important role managing stormwater flows. They can, however, also be significant sources of nutrients that contribute to eutrophication of our water bodies.
- i. Recognize the value of and promote the use of green infrastructure (e.g. bio swales, rain gardens, wetlands, tree trenches, and storm detention ponds).
- j. Adopt roadside maintenance procedures that preserve the treatment function of verges and ditches leading to natural areas.

6.2.3 The Municipality will ask developers and landowners to:

- a. Utilize best practices to mitigate surface water run-off entering natural surface and groundwater from projects requiring municipal approval and prohibit discharge of unmanaged rainwater into watercourses. Measures will include the use of green infrastructure.

6.2.4 The Municipality will work with others to:

- a. Support societies and neighbourhood associations that have tractable plans for work within watersheds that regenerate sensitive ecosystems and lead to improved water quality.
- b. Work with landowners, the regional district and provincial agencies on watershed management plans designed to protect the integrity of fishery and agricultural use, while ensuring that environmental values are not unduly compromised.
- c. Discourage or ban the use of cosmetic pesticides within North Cowichan.
- d. Support 'green shore' initiatives to restore physical processes such as the natural actions of water, enhance habitat function and diversity and reduce pollutants entering the aquatic environments.

Manage risk to public health from noise pollution and reduce impact from light pollution

- e. Acknowledge that noise can be an environmental health issue and/or a nuisance and seek to reduce noise pollution wherever possible.
- f. Advocate for provincial regulations and enforcement clamping down on vehicles designed or modified to be intentionally noisy.
- g. Consider the development of more comprehensive regulations related to the management of noise on private property.
- h. Work to protect night sky values by minimizing sources and effects of light pollution, implementing dark sky principles in development and capital projects, and avoiding shining bright lights on habitat areas.
- i. Create standards for roadway and area lighting combining CPTED (Crime Prevention Through Environmental Design) and dark skies approaches.

AIR, NOISE AND LIGHT POLLUTION

6.2.5 Defining Success | Objectives

Objective: Pursue practices that sustain good air quality to reduce the immediate and long-term health impacts to residents. Identify and mitigate sources of noise and light pollution.

Progress can be measured by:

- Improvement in air and water quality.
- Reduction in litter and plastic waste.
- Reduction in light pollution in the rural areas.

6.2.7 The Municipality will ask developers and landowners to:

Manage risk to public health from noise pollution and reduce impact from light pollution

- a. Take into consideration the potential for noise pollution posed by an applicant's operation or activity and accept additional requirements to ensure that any potential disturbances are minimized.
- b. Submit lighting plans as part of site design, demonstrating measures to minimize light spill into natural areas or the night sky.

6.2.6 The Municipality will strive to:

Manage risk to public health from air pollution

- a. Recognize the importance of clean air to the health and well-being of residents and work to protect clean air in North Cowichan.
- b. Monitor regulations related to the management of outdoor burning.
- c. Implement a wildfire development permit area policy to reduce the risk from wildfires.
- d. Provide public information and education regarding the health hazards associated with particulate matter in the air.

6.2.8 The Municipality will work with others to:

Minimize the risk to public health from air pollution

- a. Support initiatives to reduce vehicle emissions, such as discouraging idling, electrifying the municipal fleet where possible, and promoting alternative forms of transportation.
- b. Address impacts of wood stoves and backyard burning in collaboration with the CVRD.

APPENDIX B

Conceptual Layout of the Proposed Development

APPENDIX C

Summary of Available Water Well Information within 1 km of Subject Property

Summary of Wells in AQ 168 Within 1 KM of Subject Property

No.	Well Tag Number	Easting	Northing	Well Depth (m)	Static Water Level (m)	Bedrock Depth (m)	Well Yield (L/s)	Aquifer ID	Date of Construction	Licensed
			count >>	58	28	7	32.00			
			max >>	131.06	5.18	23.47	200.19			
			min >>	2.74	0.30	1.52	0.11			
			geomean >>	20.00	1.69	4.93	4.57			
1	104690	449593	5402558	28.96	2.41		200.19	186	31-May-1991	Unlicensed
2	104689	449559	5402687	30.63	2.07		191.54	186	31-May-1991	Unlicensed
3	120506	450308	5403554	42.67	4.57	3.66	0.35		9-Mar-2020	Unlicensed
4	111452	449296	5403796	16.76	1.52		3.15	186	24-May-2016	Licensed
5	104706	448072	5403151	5.20	4.51			186	25-Jan-2010	Unlicensed
6	104705	448121	5402910	6.30	2.71			186	25-Jan-2010	Unlicensed
7	22175	449690	5402430	38.10			11.36	187	1-Feb-1969	Unlicensed
8	59652	449595	5402559	30.48			29.21	186	1-May-1991	Unlicensed
9	59654	449630	5402557	30.48	2.44		6.31	186	1-May-1991	Unlicensed
10	85198	449555	5402687	26.82				186		Unlicensed
11	23138	449742	5402718	24.38	1.52		189.27	187	1-Jan-1970	Unlicensed
12	87376	449368	5403540	30.18	0.61		7.57	186		Unlicensed
13	96482	449634	5403566	11.28			1.26	186	2-Feb-1983	Unlicensed
14	39444	449309	5404744	131.06	3.05	3.05	0.19	175	1-Apr-1978	Unlicensed
15	39443	449254	5404758	112.78	3.05	2.74	0.13	175	1-Apr-1978	Unlicensed
16	65449	449421	5405022	91.44						Unlicensed
17	84608	447871	5403665	12.80			1.89	186	25-Sep-1997	Unlicensed
18	77195	448482	5403052	16.76				186	14-Sep-1999	Unlicensed
19	84142	448614	5403194	8.38			2.52	186	21-Jul-2004	Unlicensed
20	22854	448760	5402502	17.07	2.74		126.18	186	1-Oct-1969	Unlicensed
21	24393	448804	5402423	11.89	2.44		3.15	186	1-Jan-1971	Unlicensed
22	36264	448828	5402657	10.06				186	1-Jan-1977	Unlicensed
23	39849	448950	5402385	21.34	3.05		133.75	187	9-Jun-1978	Unlicensed
24	39695	448977	5402391	24.38	2.13		27.57	187	12-May-1978	Unlicensed
25	4162	449667	5404611	21.34				175	1-Jan-1950	Unlicensed
26	4121	449722	5405215	36.58				175	1-Jan-1950	Unlicensed
27	4144	449903	5405117	50.29				175	1-Jan-1950	Unlicensed
28	4069	450163	5404024	2.74					1-Jan-1950	Unlicensed
29	19936	449609	5403809	7.92	0.61		41.01	186	1-May-1966	Unlicensed
30	4052	449838	5403314	3.05				186	1-Jan-1950	Unlicensed
31	19415	450453	5403146	6.10	2.44		0.76	186	1-Sep-1965	Unlicensed
32	18123	448925	5402494	15.09	1.83		126.18	186	1-Jul-1963	Unlicensed
33	21166	448886	5402503	14.02				186	1-Jan-1968	Unlicensed
34	4214	448859	5402505	12.19				186	1-Jan-1950	Unlicensed
35	4086	448478	5403120	9.14				186	1-Jan-1950	Unlicensed
36	14551	448118	5403144	91.74	2.44	8.53	0.13		1-Aug-1955	Unlicensed
37	21921	449263	5403447	21.34	0.30		12.62	187	1-Nov-1968	Unlicensed
38	4055	448764	5403719	7.62				186	1-Jan-1950	Unlicensed
39	4060	448764	5403738	10.67	0.61			186	1-Jan-1950	Unlicensed
40	16683	447830	5403798	63.09		23.47	0.19		1-Jan-1961	Unlicensed
41	16963	447877	5403806	121.01	0.91	7.62	0.19		1-Feb-1961	Unlicensed
42	19623	448711	5403834	7.62	0.61		3.79	186	1-Jan-1966	Unlicensed
43	20954	448435	5403849	26.21				186	1-Oct-1967	Unlicensed
44	19622	449419	5403815	7.62	0.61			186	1-Jan-1966	Unlicensed
45	20955	448437	5403910	26.82				186	1-Oct-1967	Unlicensed
46	19801	448716	5403905	12.19	0.61		11.36	186	1-Jan-1966	Unlicensed
47	20957	448438	5403971	29.87					1-Oct-1967	Unlicensed
48	20958	448440	5404032	28.65					1-Oct-1967	Unlicensed
49	20959	448440	5404092	29.26					1-Oct-1967	Unlicensed
50	20956	448441	5404153	14.33					1-Oct-1967	Unlicensed
51	4154	448903	5404304	55.78				175	1-Jan-1950	Unlicensed

Summary of Wells in AQ 168 Within 1 KM of Subject Property

No.	Well Tag Number	Easting	Northing	Well Depth (m)	Static Water Level (m)	Bedrock Depth (m)	Well Yield (L/s)	Aquifer ID	Date of Construction	Licensed
			count >>	58	28	7	32.00			
			max >>	131.06	5.18	23.47	200.19			
			min >>	2.74	0.30	1.52	0.11			
			geomean >>	20.00	1.69	4.93	4.57			
52	19833	448990	5404949	64.01		1.52	0.19	175	1-Feb-1966	Unlicensed
53	1308	449213	5404955	44.50			0.11	175	1-Jan-1916	Unlicensed
54	4143	449400	5405025	91.44				175	1-Jan-1950	Unlicensed
55	64104	448045	5403283	8.84	5.18		0.50	186	31-Aug-1988	Unlicensed
56	29631	448338	5403544	7.62	2.13		22.40	186	1-Jan-1974	Unlicensed
57	29633	448351	5403542	7.62	2.13		22.40	186	1-Jan-1974	Unlicensed
58	27433	448702	5403673	11.28				186	30-Dec-1972	Unlicensed

APPENDIX D

Aquifer Factsheet, Classification Report and Plan of Direction of
Groundwater Flow for AQ 186 AQ 186

Aquifer #186

Lower Cowichan River A



Legend

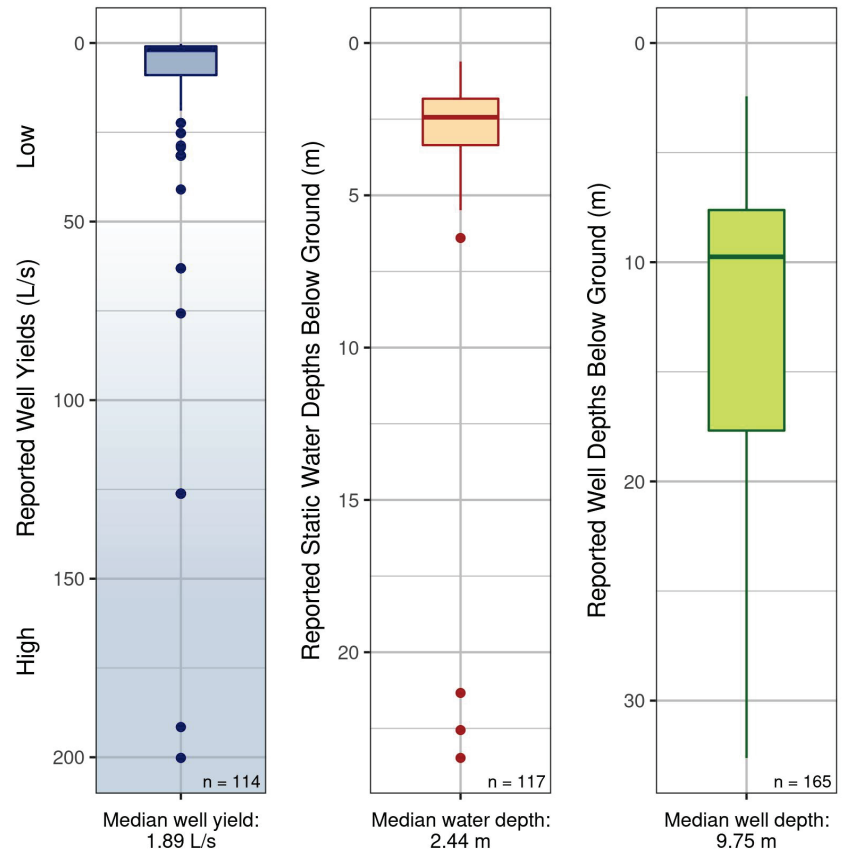
- Registered Water Well - Artesian
- Registered Water Well
- Active Observation Well
- Inactive Observation Well
- Aquifer Boundary



Aquifer Description (Mapping Report - 2020):

Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along rivers of moderate stream order with the potential to be hydraulically influenced by the river (subtype = 1b).

Aquifer Details	
Region	West Coast
Water District	Victoria
Aquifer Area	17.4 km ²
No. Wells Correlated	168
Vulnerability to Contamination	High
Productivity	High
Aquifer Classification	IA
Hydraulic Conductivity *	3.2x10 ⁻³ - 2.2x10 ⁻¹ m/s (n=4)
Transmissivity *	3.9x10 ⁻³ - 1.2e+00 m ² /s (n=4)
Storativity *	3x10 ⁻⁴ - 3.8e+00 (n=2)
No. Water Licences Issued to Wells	3
Observation Wells (Active, Inactive)	204, 211, 318, 205, 208, 298



* min - max

For Hydraulic Connection see guidance document

Disclaimer: Use of information from Aquifer factsheets (accessed by BC government website) is subject to limitation of liability provisions (further described on that website). That information is provided by the BC government as a public service on an "as is" basis, without warranty of any kind, whether express or implied, and its use is at your own risk. Under no circumstances will the BC government, or its staff, agents and contractors, be responsible or liable to any person or business entity, for any direct, indirect, special, incidental, consequential or any other loss or damages to any person or business entity based on this factsheet or any use of information from it.

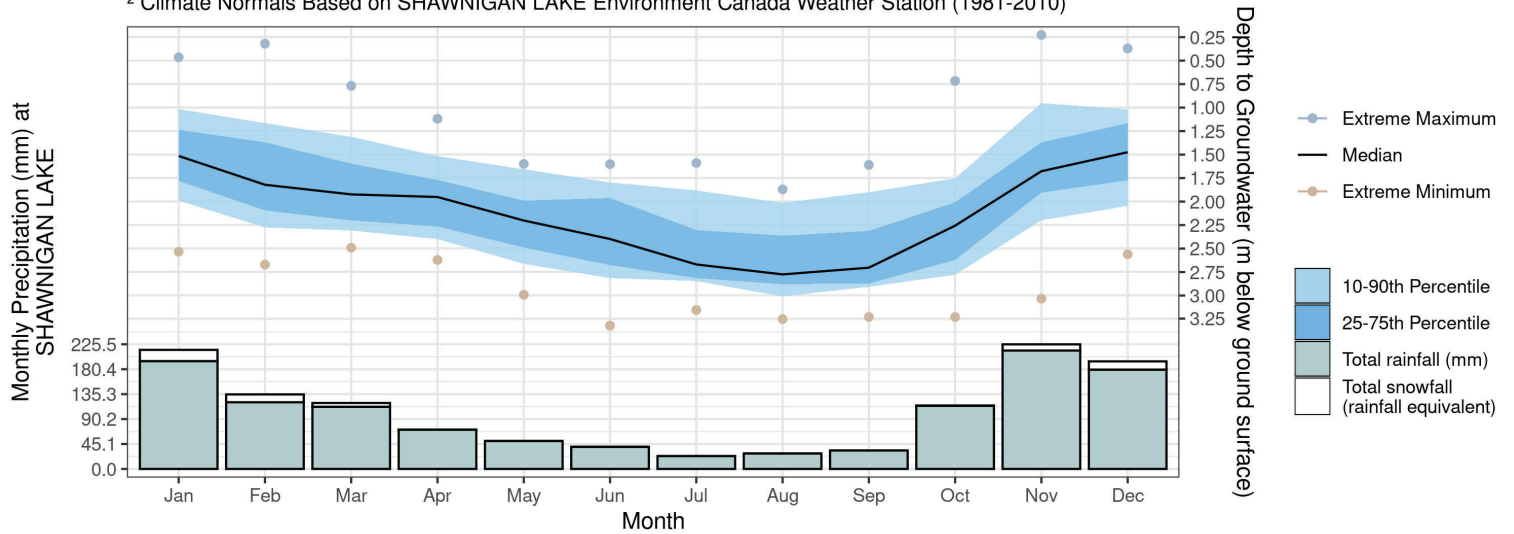
Detailed methods for all figures are described in the companion document ([Aquifer Factsheet - Companion Document.pdf](#)).

Factsheet generated: 2022-07-27. Aquifers online: <https://apps.nrs.gov.bc.ca/gwells/aquifers>.

Monthly Groundwater Level¹ with Precipitation from Climate Normals²

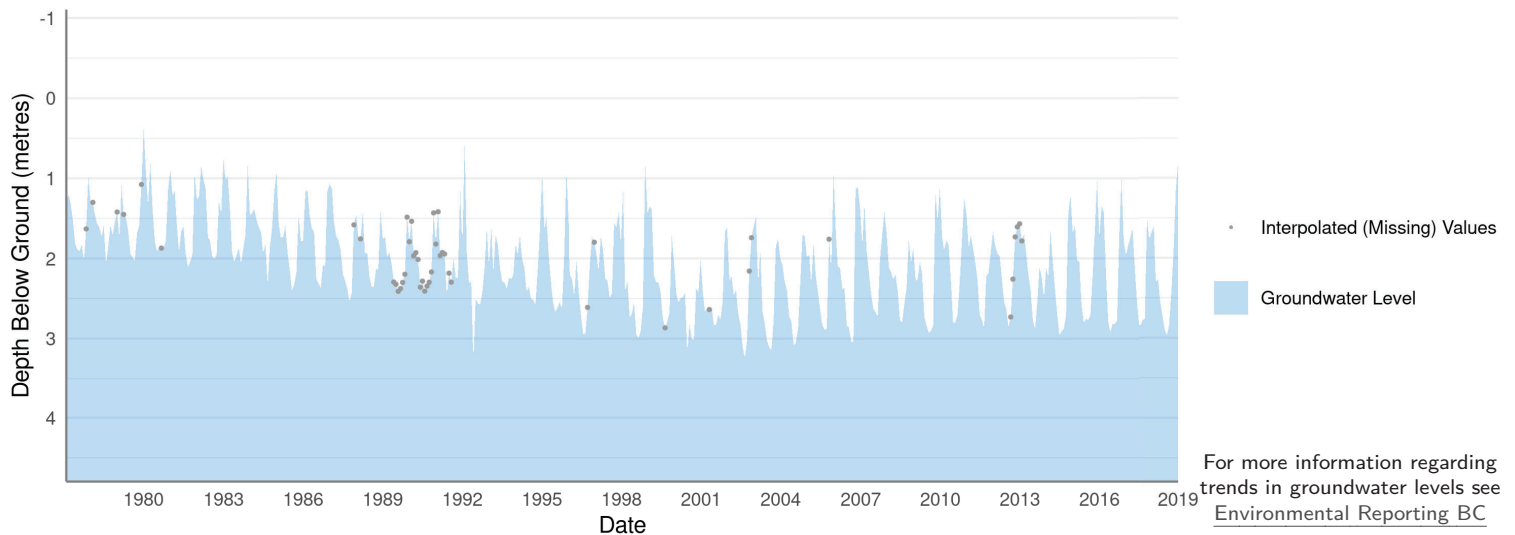
¹ Full Monthly Water Level Summary (45 years of data; 1977-2022)

² Climate Normals Based on SHAWNIGAN LAKE Environment Canada Weather Station (1981-2010)

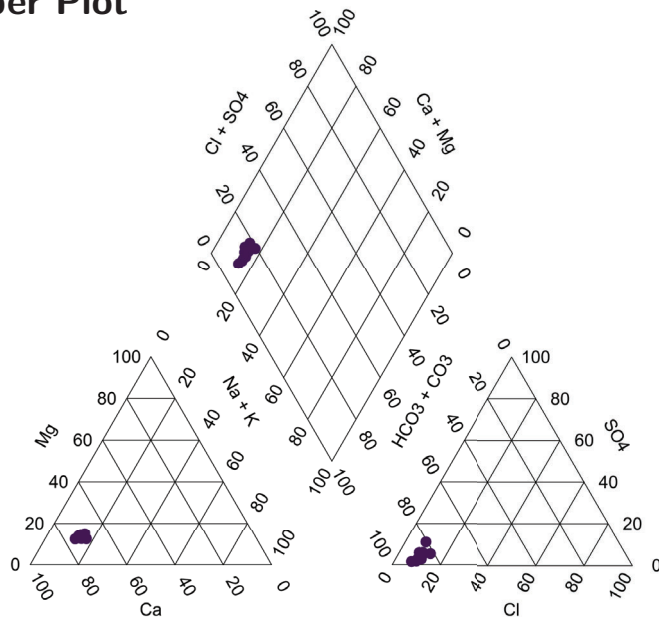


Groundwater Levels and Long-term Trend

Category: Stable



Piper Plot

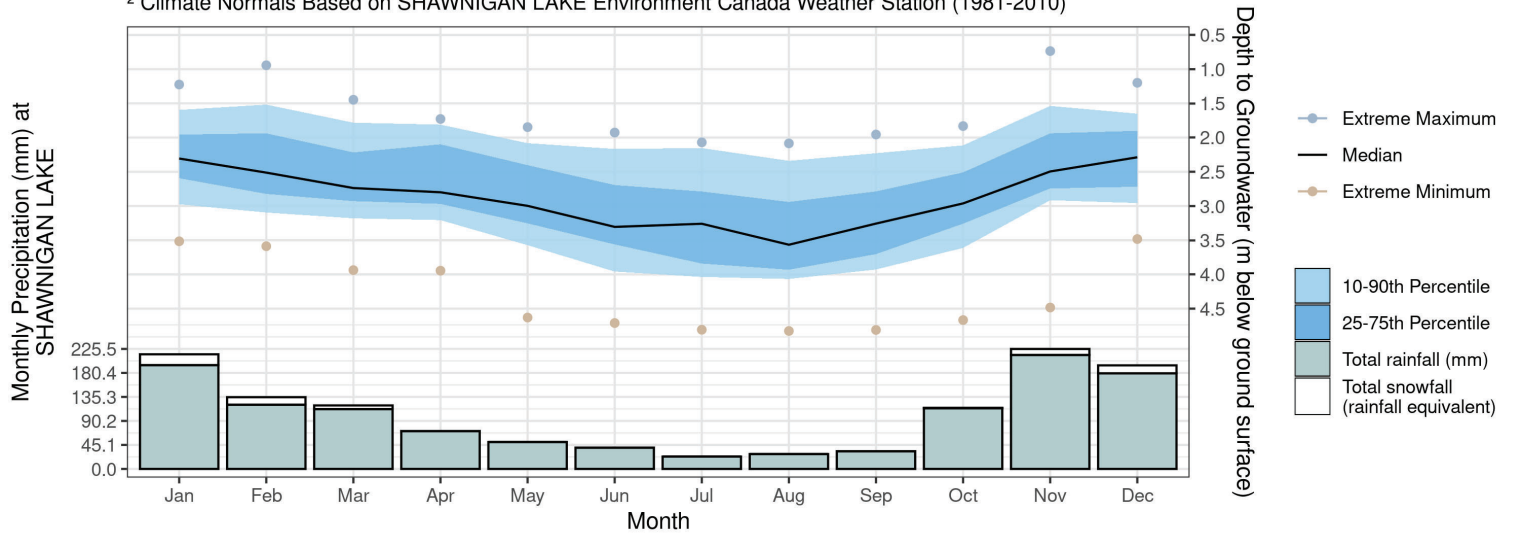


The groundwater samples are typically of the Ca-HCO₃ type. Ca is the dominant cation, which indicates a less evolved/short flow path recharge area type of groundwater. The fact that HCO₃ is the dominant anion shows the source is primarily recent precipitation in the deltaic and fluvial sand and gravel aquifer #186. For EMS water chemistry data, see [EMS ID 1400120](#).

Monthly Groundwater Level¹ with Precipitation from Climate Normals²

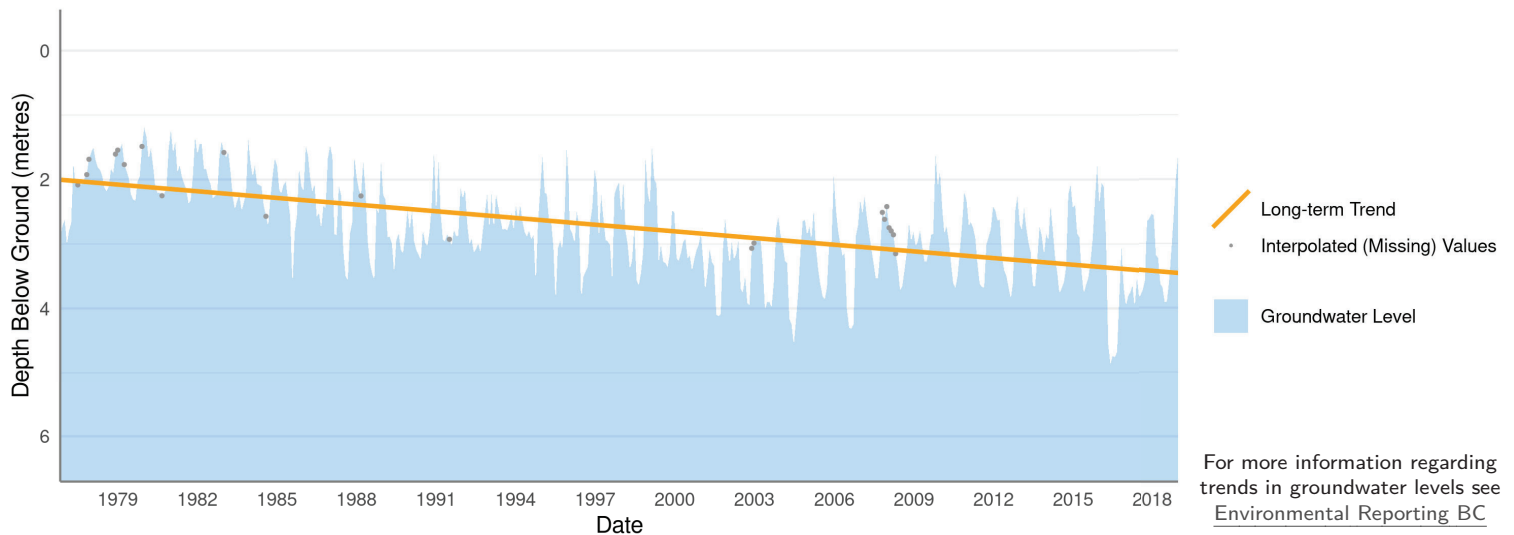
¹ Full Monthly Water Level Summary (46 years of data; 1976-2022)

² Climate Normals Based on SHAWNIGAN LAKE Environment Canada Weather Station (1981-2010)

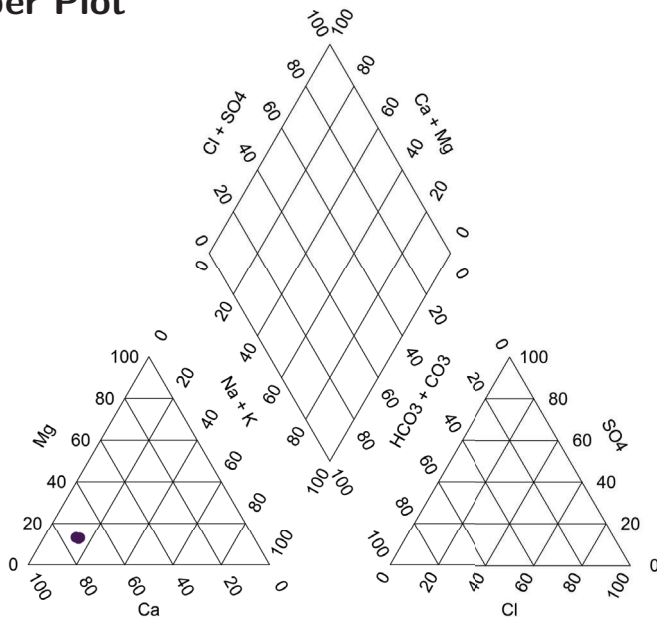


Groundwater Levels and Long-term Trend

Category: Moderate Rate of Decline (-0.035 m/year)



Piper Plot



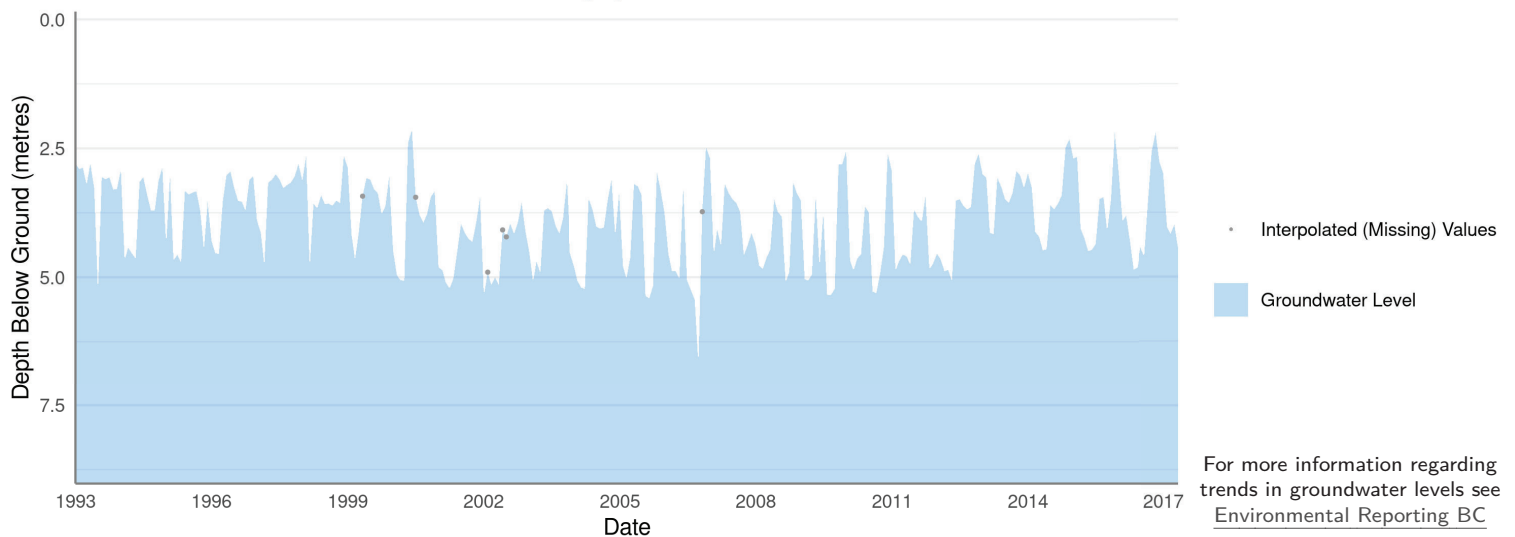
The groundwater samples are typically of the Ca-HCO₃ type. Ca is the dominant cation, which indicates a less evolved/short flow path recharge area type of groundwater. The fact that HCO₃ is the dominant anion shows the source is primarily recent precipitation in the deltaic and fluvial sand and gravel aquifer #186. For EMS water chemistry data, see [EMS ID 1400131](#).

Monthly Groundwater Level¹ with Precipitation from Climate Normals²

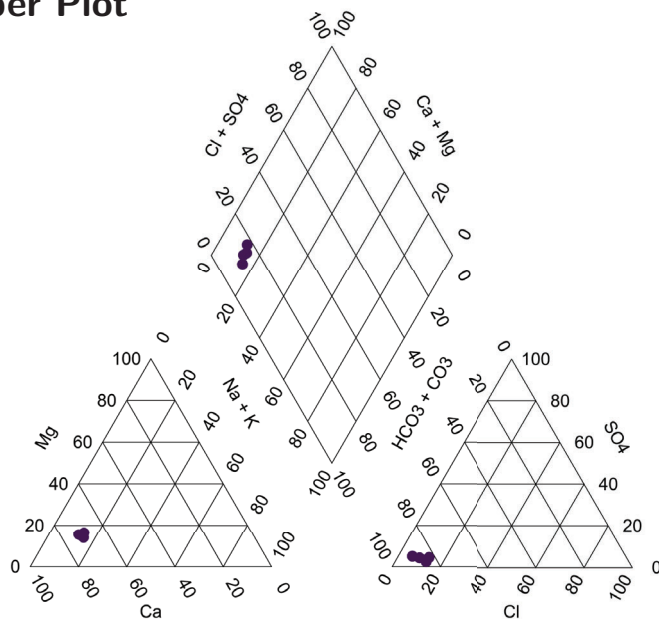
Graph not available
(no precipitation data)

Groundwater Levels and Long-term Trend

Category: Stable



Piper Plot



The groundwater samples are typically of the Ca-HCO₃ type. Ca is the dominant cation, which indicates a less evolved/short flow path recharge area type of groundwater. The fact that HCO₃ is the dominant anion shows the source is primarily recent precipitation in the deltaic and fluvial sand and gravel aquifer #186. For EMS water chemistry data, see [EMS ID E218238](#).

1. AQUIFER DESCRIPTION FOR AQUIFER TAG 186

1.1 Conceptual Understanding of Hydrostratigraphy

In this update, Aquifers 186 and 187 (Gallo, 1995a and 1995b) have been combined as one – Aquifer 186.

The previously held concept of three aquifers in the lower Cowichan valley (from the Town of Duncan to the Cowichan Estuary) was based, in part, on Wei (1985)'s and Zubel (1978)'s conceptual model of the Cowichan Estuary. In contrast, Kohut's (1981) schematic cross-section at the estuary shows only 2 aquifers.

The concept of an upper, middle and lower aquifer was originally conceptualized by Foweraker (1976) in his study on the drilling of test wells in the Boys Road area. The upper and middle became more formally known as Aquifer 186 and 187, respectively.

A review of the available well records in the lower Cowichan valley caused us to combine Aquifers 186 and 187 into one aquifer. Our reasons for doing this is as follows:

- The confining layer separating Aquifers 186 and 187 appears to comprise silt, silty sand and silty sand and gravel; the permeability contrast between the confining layer and the sand and gravel sediments in the over-lying Aquifer 186 and underlying Aquifer 187 is not expected to be great (see photo in Figure 1);
- This lithology is either absent or indistinct in many of the well records (e.g., WTN 86104, 63845) further upstream from the estuary, which makes mapping this unit challenging.



Figure 1: Core drilling in the Boys Road area in March, 2014; photo from well CR-5 from 12-15 m below ground surface (38-48 ft below ground surface) showing the silty gravel and coarse sand layer between the “upper” and “middle” aquifers, believed to be associated with lithology historically described in drill logs as “silty sand and gravel”. The sediments appear to have sufficient permeability to persuade us to combine Aquifer 186 and 187 together as one aquifer. (Photo from S. Barroso, Ministry of Forests, Lands and Natural Resource Operations and Rural Development).

1.2 Aquifer Extents

The boundary of Aquifer 186 largely follows the surficial geology boundary of Blyth and Rutter (1993)'s fluvial deposits (sgF, \$sFf). The aquifer terminates at the Allenby Bridge where the Cowichan River floodplain narrows significantly (the fluvial deposit does continue upstream along the Cowichan River channel). The aquifer is interpreted to extend upstream from the mouth of the Koksilah River to the confluence with Kelvin Creek (the fluvial deposit mapped by Blyth and Rutter (1993) and Blyth et al (1993) extends into this area). In this lower reach of the Koksilah, the aquifer boundary has been mapped to roughly follow the 10 m elevation contour. The fluvial deposit along the Koksilah River does extend a bit further upstream but wells along the Koksilah River are not drilled into the fluvial deposit (likely too thin and discontinuous) and therefore, Aquifer 186 appears to be absent upstream of Kelvin Creek.

1.2.1 Geologic Formation (Overlying Materials)

Fluvial sand, gravel and silt deposited by the Cowichan (and locally Koksilah) River. There is also fill material where the land has locally been built up and developed.

1.2.2 Geologic Formation (Aquifer)

Fluvial sand, gravel and silt deposited by the Cowichan (and locally Koksilah) River. According to Wei et al (2009), this is a type 1b unconfined, unconsolidated sand and gravel aquifer.

1.2.3 Vulnerability

The DRASTIC method was used to complete intrinsic groundwater vulnerability mapping as part of the Vancouver Island Water Resources Vulnerability Mapping Project (Newton and Gilchrist, 2010). A high intrinsic vulnerability was calculated for a majority of the aquifer area. Well records indicate Aquifer 186 is unconfined and highly transmissive (high well yields), ranging to a depth of 30 m. The median and average reported static water level is shallow, 2.4 m and 2.7m, respectively.

Excessive pumping at the Cowichan estuary can increase the risk of saltwater intrusion (see previous studies of concern for saltwater intrusion in the estuary by Chwojka, 1997 and Wei, 1985).

1.3 Conceptual Understanding of Flow Dynamics

1.3.1 Groundwater Levels and Flow Direction

Groundwater gradients and flows have not been mapped but groundwater flow is interpreted to be driven by topography. Ambient groundwater flow is expected to be to the southeast along the general direction of river flow.

Flow is also locally influenced by heavy well pumping in the well fields bordering the river in the Boys Road and Wharncliffe Road areas, by the Cowichan River (gaining and losing along its reach and seasonally), as well as groundwater inflow from the Quamichan Lake and Somenos Lake areas.

1.3.2 Recharge

The following are the likely main sources of natural recharge to Aquifer 186:

- Infiltration from precipitation falling directly on the aquifer;
 - Discharge possibly from the underlying Aquifer 188 and bedrock (Aquifers 176 and 198) where windows in the confining layer occur;
 - Lateral inflow from adjacent aquifers (Aquifers 185, 199, and 197)
 - Groundwater inflow from the Cowichan River and locally from the Koksilah River;
-

- Groundwater inflow from the Quamichan Lake and Somenos Lake areas.

Induced infiltration of river water can also occur locally by pumping of high production wells along the Cowichan River (Foster, 2008).

1.3.3 Potential for Hydraulic Connection

Hydraulic connection likely exists along the Cowichan River. Foster (2008) modelled the surface and groundwater inter-action along the Cowichan River from Cowichan Lake to the mouth. More local studies of surface water-groundwater interaction have also been done by others (e.g., Foweraker, 1976; Lapcevic et al, 2020) along the Boys Road area where heavy pumping occurs. Hydraulic connection also exists along the lowest reaches of the Koksilah River because of the shallow groundwater level and the lack of significant confining sediments between the river and the aquifer.

The Cowichan River likely loses water to the aquifer in the following situations:

- Along reaches where there is drawdown from heavy well pumping (see for example the model results in Foster, 2008)
- During periods of high winter river levels and
- Where the Cowichan River flows into the broader floodplain at Allenby Bridge.

The likelihood of hydraulic connection between Aquifer 186 and underlying Aquifer 188 is not well understood. Connection is assumed where the confining layer separating the two aquifers is absent but these windows in the confining layer have not been mapped.

Aquifers 186 also likely receives inflow from the unmapped surficial sediments underlying the Quamichan Lake and Somenos Lake areas, contributing groundwater flow from those two watersheds to the Cowichan River floodplain at and just downstream of the Town of Duncan. Foster (2008)'s model shows both areas to be up-gradient from Aquifer 186.

Finally, excessive pumping at the Cowichan estuary (among other factors – see Kohut (1981)) can lower hydraulic gradients locally and increase the risk of saltwater intrusion.

1.4 Additional Information on Water Use and Management

A Cowichan-Koksilah Water Management Plan was approved in 1986 (Ministry of Environment and Parks, 1986):

- [Ministry of Environment and Parks, 1986. *Cowichan-Koksilah Water Management Plan*. Province of BC, 273 pp.](#)

This is an operational plan to inform water management within the Cowichan-Koksilah basin. Note: The plan does not have legal authority as a water sustainability plan under the *Water Sustainability Act*.

A number of studies have also been completed on water use:

- Lapcevic, P., C. Gellein, S. Barroso, and R. Ormond. 2020. *Groundwater in the Cowichan River Watershed, Vancouver Island British Columbia*. WSS 2020-XX. Water Science Series. Province of B.C.
- Pike, R. E. Young, J. Goetz and D. Spittlehouse. 2017. [Cowichan River: Summary of Historical Disturbances, Water Use Pressures and Streamflow Trends](#). Water Science Series, WSS2017-05. Province of B.C. http://a100.gov.bc.ca/appsdata/acat/documents/r54179/2017-05_CowichanRiver_Disturbances_PressuresTrend_1521740164642_1738808548.pdf.

1.5 Additional Assessments or Management Actions:

The following groundwater characterization studies have been completed:

- Lapcevic, P., C. Gellein, S. Barroso, and R. Ormond. 2020. *Groundwater in the Cowichan River Watershed, Vancouver Island British Columbia*. WSS 2020-XX. Water Science Series. Province of B.C.
- Foster, S. and D.M. Allen. June 2015. *Results of Coupled Groundwater-Surface Water Model of the Cowichan Valley Watershed Final Report*. Department of Earth Sciences, Simon Fraser University. Prepared for B.C. Ministry of Forests, Lands and Natural Resource Operations, Cowichan Valley Regional District, Cowichan Watershed Board.
- Foster, S. B., 2014. *Characterizing Groundwater – Surface Water Interactions within a Mountain to Ocean Watershed, Lake Cowichan, British Columbia*. Simon Fraser University, MSc Thesis, 222 pp.
- Barroso, S. R. Ormond, G. Henderson, and P. Lapcevic. 2013. *Groundwater quality in the Lower Cowichan River Aquifer Complex*. Ministry of Forests, Lands, and Natural Resources Operations. Nanaimo, B.C.
http://a100.gov.bc.ca/appsdata/acat/documents/r36576/2013DuncanWaterQualityStudy_1369685558278_4c91d45b15065e9a55fdff45ad66c8819560a759dd4c7968a04ee2d744b9173a.pdf.
- Chwojka, F., 1997. *Assessment of Water Quality and Identification of Water Quality Concerns and Problem Areas Cowichan-Koksilah Estuary*. Ministry of Environment, Lands and Parks, 43 pp.
- Kohut, A. P., 1981. *Salt Water Intrusion Problem – Cowichan Bay*. Ministry of Environment, 6 pp.
- Foweraker, J.C., 1976. *Groundwater Research Project Cowichan River Aquifers Near Duncan, British Columbia*. Department of Environment, Water Resources Service, Hydrology Division, Groundwater Section. Groundwater Section NTS Report 092B/13 No. 30. 31 pp.

1.6 Aquifer References

Blyth, H. E. and N. W. Rutter, 1993. *Surficial Geology of the Duncan Area, NTS 92B/13 Open File 1993-27*, Ministry of Energy, Mines, and Petroleum Resources, British Columbia.

Blythe, H.E., Rutter, N.W., Sankerelli, L.M. 1993. *Surficial Geology of the Shawnigan Lake Area (92B/12)*. 1:50,000. British Columbia Geological Field Survey. Open File 1993-26.

Foster, S. B., 2014. *Characterizing Groundwater – Surface Water Interactions within a Mountain to Ocean Watershed, Lake Cowichan, British Columbia*. Simon Fraser University, MSc Thesis, 222 pp.

Foweraker, J.C., 1976. *Groundwater Research Project Cowichan River Aquifers Near Duncan, British Columbia*. Department of Environment, Water Resources Service, Hydrology Division, Groundwater Section. Groundwater Section NTS Report 092B/13 No. 30. 31 pp.

Gallo, M., 1995a. *Aquifer Classification Work Sheet Aquifer 186*. Ministry of Environment. 4 pp.

Gallo, M., 1995b. *Aquifer Classification Work Sheet Aquifer 187*. Ministry of Environment. 5 pp.

Kohut, A. P., 1981. *Salt Water Intrusion Problem – Cowichan Bay*. Ministry of Environment, 6 pp.

Lapcevic, P., C. Gellein, S. Barroso, and R. Ormond. 2020. *Groundwater in the Cowichan River Watershed, Vancouver Island British Columbia*. WSS 2020-XX. Water Science Series. Province of B.C.

Newton, P. & A. Gilchrist, April 2010. *Technical Summary of Intrinsic Vulnerability Mapping Methods for Vancouver Island; Vancouver Island Water Resources Vulnerability Mapping Project – Phase 2*. Vancouver Island University, Nanaimo, BC, 51 pp.

Wei, M. 1985. *Groundwater Quality Monitoring and Assessment Program 1985/86 - Cowichan - Koksilah Estuary - Fall, 1985 Field Survey*. Ministry of Environment, Water Management Branch, Groundwater Section, Victoria, B.C.

Wei, M., D. Allen, A. Kohut, S. Grasby, and K. Ronnesth, 2009. Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater. In *Streamline Watershed Management Bulletin*, vol 13, no. 1, P. 10-18.

1.7 Revision History

Date	Version	Revision Class	Comments	Author
November 29, 1995 (Aquifer 186) and December 5, 1995 (Aquifer 187)	1	Major	Initial mapping of aquifer	Mike Gallo
June 18, 2020	2	Major	Combined Aquifers 186 and 187 and co-related wells in GWELLS to aquifer.	Mike Wei, P. Eng. and Sylvia Barroso, P. Geo.

APPENDIX E

Copies of Well Records for 5 Wells in Area of Subject Property

Well Summary

Well Tag Number: 111452
Well Identification Plate Number: 40525
Owner Name: COWICHAN GREEN COMMUNITY
Intended Water Use: Irrigation
Artesian Condition: No

Well Status: New
Well Class: Water Supply
Well Subclass: Not Applicable
Aquifer Number: 186
Technical Report: N/A

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No

Licensing Information

Licensed Status: Licensed

Licence Number:

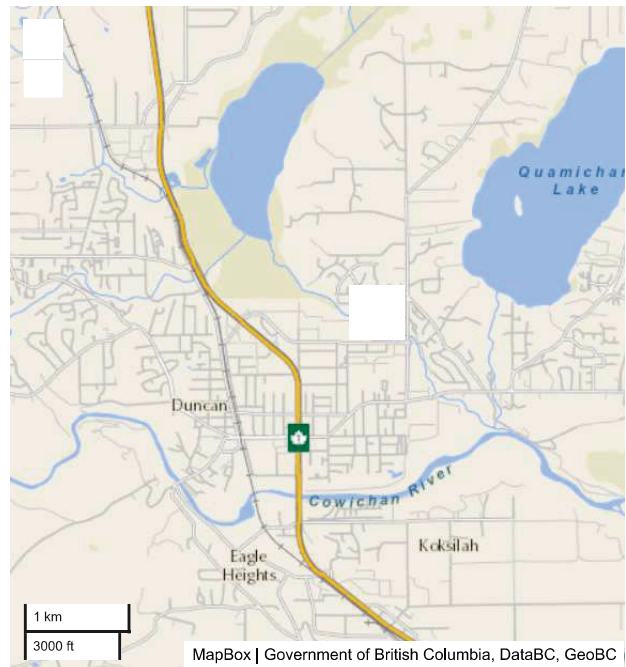
Location Information

Street Address: 2431 Beverly Street
Town/City: North Cowichan

Legal Description:

Lot	1
Plan	EPP 35195
District Lot	
Block	
Section	19
Township	
Range	7
Land District	45
Property Identification Description (PID)	029237424

Description of Well Location: NOTHING ENTERED.



Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 48.785095
UTM Easting: 449296
Zone: 10

Longitude: -123.690259
UTM Northing: 5403796
Coordinate Acquisition Code: (10 m accuracy) Handheld GPS with accuracy of +/- 10 metres

Well Activity

Activity	↕ Work Start Date	↕ Work End Date	↕ Drilling Company	↕ Date Entered	↕
Legacy record	2016-05-24	2016-05-25	Drillwell Enterprises	June 29th 2016 at 5:07 PM	

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
2016-05-24	2016-05-25				

Well Completion Data

Total Depth Drilled: 55 ft bgl	Estimated Well Yield: 50 USgpm	Static Water Level (BTOC): 5 feet btoc
Finished Well Depth: 55 ft bgl	Well Cap: WELDED LID	Artesian Flow:
Final Casing Stick Up: 18 inches	Well Disinfected Status: Disinfected	Artesian Pressure (head):
Depth to Bedrock:	Drilling Method: Dual Rotary	Artesian Pressure (PSI):
Ground elevation: 9 feet	Method of determining elevation: Unknown	Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Water Bearing Flow Estimate (USGPM)
0	8	SILT, CLAY, TRACE OF GRAVEL			brown	Soft	
8	39	SILT, SOME SAND LAYERS			grey	Soft	
39	42	GRAVEL, SILTY, VERY SANDY			grey	Medium	WB
42	50	GRAVEL, SANDY			grey	Medium	WB
50	55	SAND, COARSE, SOME WOOD, TRACE OF GRAVEL			grey	Loose	WB

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
0	15	Steel Removed		10		Not Installed
0	55		Steel	6	0.219	Installed

Surface Seal and Backfill Details

Surface Seal Material: Bentonite clay	Backfill Material Above Surface Seal:
Surface Seal Installation Method: Poured	Backfill Depth:
Surface Seal Thickness: 2 inches	
Surface Seal Depth: 15 feet	

Liner Details

Liner Material:	Liner perforations
Liner Diameter:	From (ft bgl)To (ft bgl)
Liner from:	Liner Thickness: Liner to:
	There are no records to show

Screen Details

Intake Method: Screen	Installed Screens
Type: Telescope	From (ft bgl)To (ft bgl)Diameter (in)Assembly TypeSlot Size
Material: Stainless Steel	48.5050.505.00K_RISER
Opening: Continuous Slot	50.5055.005.00SCREEN25.00
Bottom: Plug	

Well Development

Developed by: Air lifting	Development Total Duration: 2 hours
---------------------------	-------------------------------------

Well Yield

Estimation Method: Bailing	Estimation Rate: 50 USgpm	Estimation Duration: 2 hours
Static Water Level Before Test:	Drawdown:	
Hydrofracturing Performed: No	Increase in Yield Due to Hydrofracturing:	

Well Decommission Information

Reason for Decommission:	Method of Decommission:
Sealant Material:	Backfill Material:
Decommission Details:	

Comments

WELL RECORD X-REF'D & ASSOCIATED W/GW LICENSE APPLICATION.

Documents

No additional documentation available for this well.

Disclaimer

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Well Summary

Well Tag Number: 19936
 Well Identification Plate Number:
 Owner Name: DISTRICT OF NORTH COWICHAN
 Intended Water Use: Unknown Well Use
 Artesian Condition: No

Well Status: New
 Well Class: Unknown
 Well Subclass:
 Aquifer Number: 186
 Technical Report: N/A

Observation Well Number:
 Observation Well Status:
 Environmental Monitoring System (EMS) ID:
 Alternative specs submitted: No
 Drinking Water Area Indicator: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

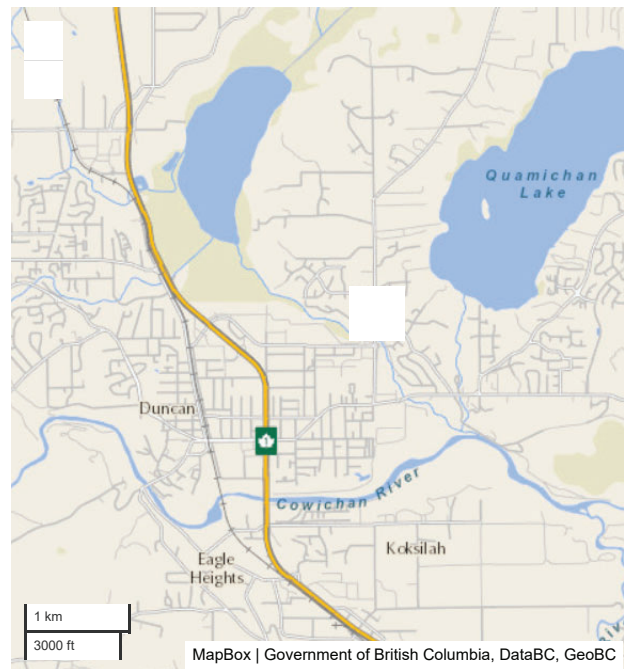
Location Information

Street Address: BEVERLY ST
 Town/City:

Legal Description:

Lot	
Plan	
District Lot	
Block	
Section	19
Township	
Range	7
Land District	45
Property Identification Description (PID)	

Description of Well Location:



Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 48.785237

Longitude: -123.686

UTM Easting: 449609

UTM Northing: 5403809

Zone: 10

Coordinate Acquisition Code: (100 m accuracy) Digitized from old Dept. of Lands, Forests and Water Resources maps

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1966-05-01	1966-05-01	Drillwell Enterprises	August 13th 2003 at 5:16 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1966-05-01	1966-05-01				

Well Completion Data

Total Depth Drilled:	Estimated Well Yield: 650 USgpm	Static Water Level (BTOC): 2 feet btoc
Finished Well Depth: 26 ft bgl	Well Cap:	Artesian Flow:
Final Casing Stick Up:	Well Disinfected Status: Not Disinfected	Artesian Pressure (head):
Depth to Bedrock:	Drilling Method: Other	Artesian Pressure (PSI):
Ground elevation:	Method of determining elevation: Unknown	Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	6	Brown silty clay						
6	8	Blue silty clay						
8	10	Block organic clay -wood						
10	12	Blue silty gravel						
12	23	Clean coarse gravel						
23	26	Coarse gravel with lenses of clay						

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
There are no records to show						

Surface Seal and Backfill Details

Surface Seal Material:	Backfill Material Above Surface Seal:
Surface Seal Installation Method:	Backfill Depth:
Surface Seal Thickness:	
Surface Seal Depth:	

Liner Details

Liner Material:	Liner perforations	
Liner Diameter:	Liner Thickness:	
Liner from:	Liner to:	
There are no records to show		

Screen Details

Intake Method:	Installed Screens				
Type:	From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
Material:	There are no records to show				
Opening:					
Bottom:					

Well Development

Developed by:	Development Total Duration:
---------------	-----------------------------

Well Yield

Estimation Method:	Estimation Rate:	Estimation Duration:
Static Water Level Before Test:	Drawdown:	
Hydrofracturing Performed: No	Increase in Yield Due to Hydrofracturing:	

Well Decommission Information

Reason for Decommission:	Method of Decommission:
Sealant Material:	Backfill Material:
Decommission Details:	

Pumping Test Information and Aquifer Parameters

Start Date	Pumping Test	Test	Boundary		Transmissivity	Hydraulic		Specific		
Pumping Test	Description	Duration (min)	Effect	Storativity	(m²/day)	Conductivity (m/day)		Capacity (L/s/m)	Analysis Method	Comments
There are no records to show										

Comments

YIELD 650 GPM FOR 17 FT. OF DRAWDOWN. METHOD OF DRILLING = DRILLED

Documents

- [WTN 19936 Well Record.pdf](#)

Disclaimer

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Well Summary

Well Tag Number: 19622
 Well Identification Plate Number:
 Owner Name: DISTRICT OF NORTH COWICHAN
 Intended Water Use: Unknown Well Use
 Artesian Condition: No

Well Status: New
 Well Class: Unknown
 Well Subclass:
 Aquifer Number: 186
 Technical Report: N/A

Observation Well Number:
 Observation Well Status:
 Environmental Monitoring System (EMS) ID:
 Alternative specs submitted: No
 Drinking Water Area Indicator: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

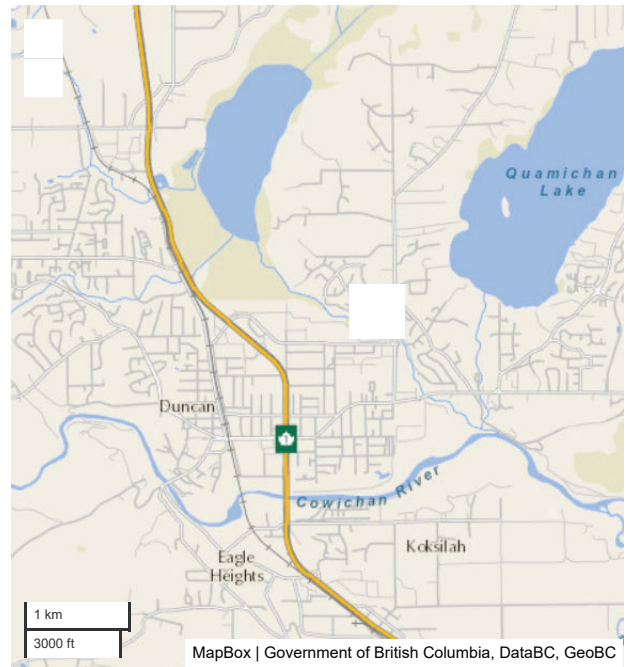
Location Information

Street Address:
 Town/City: DUNCAN

Legal Description:

Lot	
Plan	
District Lot	
Block	
Section	19
Township	
Range	7
Land District	45
Property Identification Description (PID)	

Description of Well Location:



Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 48.785276

Longitude: -123.688587

UTM Easting: 449419

UTM Northing: 5403815

Zone: 10

Coordinate Acquisition Code: (100 m accuracy) Digitized from old Dept. of Lands, Forests and Water Resources maps

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1966-01-01	1966-01-01	Unknown	August 13th 2003 at 5:16 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1966-01-01	1966-01-01				

Well Completion Data

Total Depth Drilled:	Estimated Well Yield: 0 USgpm	Static Water Level (BTOC): 2 feet btoc
Finished Well Depth: 25 ft bgl	Well Cap:	Artesian Flow:
Final Casing Stick Up:	Well Disinfected Status: Not Disinfected	Artesian Pressure (head):
Depth to Bedrock:	Drilling Method:	Artesian Pressure (PSI):
Ground elevation:	Method of determining elevation: Unknown	Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	0	brown silt						
0	2	Topsoil						
2	4	Silty sand (W.B.)						
4	8	Brown silt with layers of blue sand						
8	25	Blue silty clay with lenses of fine						

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
There are no records to show						

Surface Seal and Backfill Details

Surface Seal Material:	Backfill Material Above Surface Seal:
Surface Seal Installation Method:	Backfill Depth:
Surface Seal Thickness:	
Surface Seal Depth:	

Liner Details

Liner Material:	Liner perforations	
Liner Diameter:	Liner Thickness:	
Liner from:	Liner to:	
From (ft bgl)		To (ft bgl)
There are no records to show		

Screen Details

Intake Method:	Installed Screens				
Type:	From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
Material:	There are no records to show				
Opening:					
Bottom:					

Well Development

Developed by:	Development Total Duration:
---------------	-----------------------------

Well Yield

Estimation Method:	Estimation Rate:	Estimation Duration:
Static Water Level Before Test:	Drawdown:	
Hydrofracturing Performed: No	Increase in Yield Due to Hydrofracturing:	

Well Decommission Information

Reason for Decommission:	Method of Decommission:
Sealant Material:	Backfill Material:
Decommission Details:	

Pumping Test Information and Aquifer Parameters

Start Date	Pumping Test	Test	Boundary		Transmissivity	Hydraulic		Specific		
Pumping Test	Description	Duration (min)	Effect	Storativity	(m²/day)	Conductivity (m/day)	Specific Yield	Capacity (L/s/m)	Analysis Method	Comments
There are no records to show										

Comments

No comments submitted

Documents

- [WTN 19622 Well Record.pdf](#)

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Well Summary

Well Tag Number: 96482
Well Identification Plate Number:
Owner Name: STAN HOLMAN
Intended Water Use: Private Domestic
Artesian Condition: No

Well Status: New
Well Class: Water Supply
Well Subclass: Not Applicable
Aquifer Number: 186
Technical Report: N/A

Observation Well Number:
Observation Well Status:
Environmental Monitoring System (EMS) ID:
Alternative specs submitted: No
Drinking Water Area Indicator: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

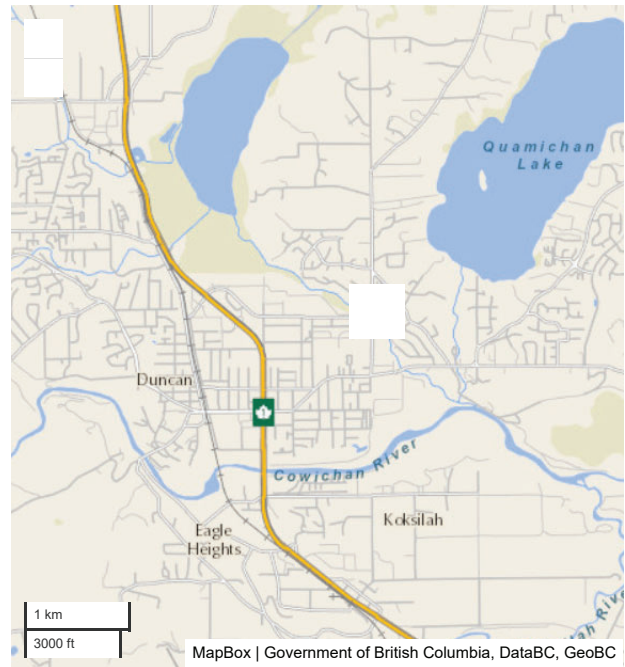
Location Information

Street Address: 5860 LAKES ROAD
Town/City: DUNCAN MAPLE BAY AREA

Legal Description:

Lot	1
Plan	11639
District Lot	
Block	
Section	18
Township	
Range	7
Land District	45
Property Identification Description (PID)	

Description of Well Location: NOT PROVIDED



Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 48.78305

Longitude: -123.68563

UTM Easting: 449634

UTM Northing: 5403566

Zone: 10

Coordinate Acquisition Code:
unknown, accuracy based on parcel
size) ICF cadastre, poor or no
location sketch, arbitrarily located in
center of parcel

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record	1983-02-02	1983-02-02	Drillwell Enterprises	December 22nd 2009 at 8:00 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
1983-02-02	1983-02-02				

Total Depth Drilled:	Estimated Well Yield: 20 USgpm	Static Water Level (BTOC):
Finished Well Depth: 37 ft bgl	Well Cap:	Artesian Flow:
Final Casing Stick Up:	Well Disinfected Status: Not Disinfected	Artesian Pressure (head):
Depth to Bedrock:	Drilling Method: Air Rotary	Artesian Pressure (PSI):
Ground elevation:	Method of determining elevation: Unknown	Orientation of Well: VERTICAL

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	4	GRAVEL FILL						
4	33	VERY SILTY SAND						
33	37	SAND & GRAVEL						

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
				6		

Surface Seal Material:	Backfill Material Above Surface Seal:
Surface Seal Installation Method:	Backfill Depth:
Surface Seal Thickness:	
Surface Seal Depth:	

Liner Material: Liner Diameter: Liner from:		Liner Thickness: Liner to:		Liner perforations	
				From (ft bgl)	To (ft bgl)
				There are no records to show	

Intake Method:	Installed Screens				
Type:	From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
Material:					
Opening:	There are no records to show				
Bottom:					

Developed by:	Development Total Duration:
---------------	-----------------------------

Estimation Method:	Estimation Rate:	Estimation Duration:
Static Water Level Before Test:	Drawdown:	
Hydrofracturing Performed: No	Increase in Yield Due to Hydrofracturing:	

Reason for Decommission:	Method of Decommission:
Sealant Material:	Backfill Material:
Decommission Details:	

Start Date	Pumping Test	Test Duration	Boundary		Transmissivity	Hydraulic Conductivity	Specific Yield	Specific Capacity	Analysis Method	
Pumping Test	Description	(min)	Effect	Storativity	(m ² /day)	(m/day)		(L/s/m)		Comments
There are no records to show										

Comments

unpublished duplicate record WTN 64999

Documents

- [WTN 96482 Well Record.pdf](#)

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Well Summary

Well Tag Number: 87376

Well Identification Plate Number: 16589

Owner Name: COWICHAN SPORTSPLEX

Intended Water Use: Irrigation

Artesian Condition: No

Well Status: Closure

Well Class: Water Supply

Well Subclass: Not Applicable

Aquifer Number: 186

Technical Report: N/A

Observation Well Number:

Observation Well Status:

Environmental Monitoring System (EMS) ID:

Alternative specs submitted: No

Drinking Water Area Indicator: No

Licensing Information

Licensed Status: Unlicensed

Licence Number:

Location Information

Street Address: 5847 CHESTERFIELD AVENUE

Town/City: COWICHAN

Legal Description:

Lot	1
Plan	5261
District Lot	
Block	
Section	18
Township	
Range	7
Land District	45
Property Identification Description (PID)	

Description of Well Location:



Geographic Coordinates - North American Datum of 1983 (NAD 83)

Latitude: 48.7828

Longitude: -123.68925

UTM Easting: 449368

UTM Northing: 5403540

Zone: 10

Coordinate Acquisition Code:

unknown, accuracy based on parcel size) ICF cadastre, poor or no location sketch, arbitrarily located in center of parcel

Well Activity

Activity	Work Start Date	Work End Date	Drilling Company	Date Entered
Legacy record			Drillwell Enterprises	October 29th 2007 at 7:54 AM

Well Work Dates

Start Date of Construction	End Date of Construction	Start Date of Alteration	End Date of Alteration	Start Date of Decommission	End Date of Decommission
				2006-02-01	2006-02-01

Well Completion Data

Total Depth Drilled: 270 ft bgl	Estimated Well Yield: 120 USgpm	Static Water Level (BTOC): 2 feet btoc
Finished Well Depth: 99 ft bgl	Well Cap: WELDED	Artesian Flow:
Final Casing Stick Up:	Well Disinfected Status: Not Disinfected	Artesian Pressure (head):
Depth to Bedrock:	Drilling Method: Air Rotary	Artesian Pressure (PSI):
Ground elevation:	Method of determining elevation: Unknown	Orientation of Well: VERTICAL

Lithology

From (ft bgl)	To (ft bgl)	Raw Data	Description	Moisture	Colour	Hardness	Observations	Water Bearing Flow Estimate (USGPM)
0	4	GRAVEL						
4	9	LOAMY SOIL, PEAT						
9	14	GRAVEL, BROWN, RUSTY			brown			
14	27	GRAVEL, GREY			grey			
27	45	CLAY, SILT, GREY			grey			
45	58	CLAY, BROWN			brown			
58	82	CLAY WITH SILTY SAND SEAMS	silty					
82	84	SAND GREY, FINE SILTY TRACE GRAVEL	gravel streaks		grey			
84	99	SAND AND FINE GRAVEL- VERY WET AND BROWN			brown			
99	108	WOOD - SILT - TIGHT SILTY SAND						
108	111	GRAVEL	water-bearing				WATER BEARING	
111	117	SILT, SILTY CLAY						
117	136	CLAY, GREY WHITE						
136	165	SILT, GREY-WHITE						
165	180	CLAY, LIGHT GREY			grey			
180	270	CLAY, SMALL SILTY SAND SEAMS	sand streaks					

Casing Details

From (ft bgl)	To (ft bgl)	Casing Type	Casing Material	Diameter (in)	Wall Thickness (in)	Drive Shoe
0	17		Steel	10		Not Installed
0	87.6		Steel	8	0.322	Installed

Surface Seal and Backfill Details

Surface Seal Material: Bentonite clay	Backfill Material Above Surface Seal:
Surface Seal Installation Method:	Backfill Depth:
Surface Seal Thickness:	
Surface Seal Depth:	

Liner Details

Liner Material:		Liner perforations	
Liner Diameter:	Liner Thickness:	From (ft bgl)	To (ft bgl)
Liner from:	Liner to:	There are no records to show	

Screen Details

Intake Method: Screen

Type: Telescope

Material: Stainless

Steel

Opening: Continuous

Slot

Bottom:

Installed Screens

From (ft bgl)	To (ft bgl)	Diameter (in)	Assembly Type	Slot Size
86.00	88.00	7.00	K_PACKER	
88.00	93.60	7.00	K_PACKER	0.03
93.60	99.00	7.00	K_PACKER	0.03

Well Development

Developed by:

Development Total Duration:

Well Yield

Estimation Method:

Static Water Level Before Test:

Hydrofracturing Performed: No

Estimation Rate:

Drawdown:

Increase in Yield Due to Hydrofracturing:

Estimation Duration:

Well Decommission Information

Reason for Decommission: UNKNOWN

Sealant Material: BENTONITE

Decommission Details: BACKFILLED & BENTONITE

SEALED TO 104 CUT CASING (SHOE) AT 104 FEET.

Method of Decommission:

Backfill Material:

Pumping Test Information and Aquifer Parameters

Start Date	Pumping Test	Test	Boundary		Transmissivity	Hydraulic		Specific	Specific	Analysis	
Pumping Test	Description	Duration (min)	Effect	Storativity	(m²/day)	Conductivity (m/day)		Yield	Capacity (L/s/m)	Method	Comments
There are no records to show											

Comments

No comments submitted

Documents

- [WTN 87376 Well Record.pdf](#)

Disclaimer

The information provided should not be used as a basis for making financial or any other commitments. The Government of British Columbia accepts no liability for the accuracy, availability, suitability, reliability, usability, completeness or timeliness of the data or graphical depictions rendered from the data.

APPENDIX F

Well Capture Zone Calculations for Subject Property Well (WTN 111452)

Cowichan Green Well Approximate Estimate of Time-of-Travel Capture Zone

Reference: Ceric, A., and Haitjema, H., 2005. **On Using Simple Time-of-Travel Capture Zone Delineation Methods.** *Ground Water* Vol 43, No. 3 pp 408-412.
 note...60 days = 5184000s, 1yr = 31557600, 5 yrs = 157788000s Porosity is usually 0.25

Step 1: Calculate T^* (dimensionless time of travel parameter)

Given	Parameter Description	Symbol	Value	Unit	Assumptions
	Pumping rate	Q	0.00221	m ³ /s	aquifer of infinite areal extent
	Time-of-Travel Zone Required (1 yr)	T	8640000	s	aquifer of constant uniform thickness
	Ambient groundwater flow rate ($Q_0 = kHi$)	Q_0	1.50E-05	m ² /s per unit width of aquifer	constant effective porosity
	regional gradient	i	0.00	-	constant isotropic hydraulic conductivity
	hydraulic conductivity	k	3.00E-03	m/s	steady state conditions
	aquifer thickness	H	5	m	
	porosity	n	0.25	-	

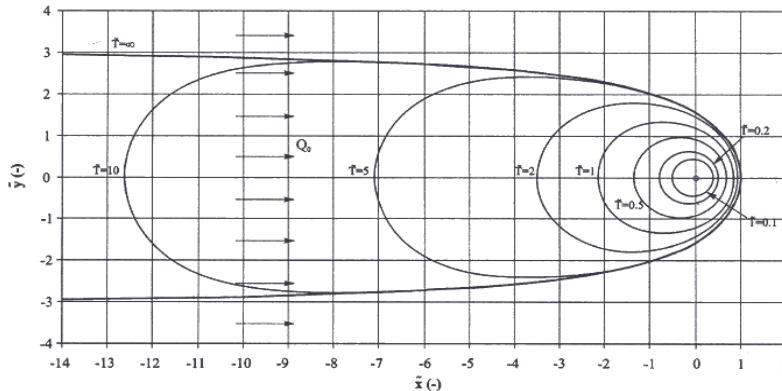
WARNING: INPUT DATA ONLY WHERE BLUE FONT APPEARS

Solution

$$T^* = \frac{2\pi Q_0^2 T}{nHQ} \text{ or } \frac{2\pi (kHi)^2 T}{nHQ}$$

where $T^* < 0.1$ indicates time-of-travel capture zones concentric (circular) around the well
 where $0.1 < T^* < 1$ indicates time-of-travel capture zones which resemble circles but are shifted in the direction of upgradient regional groundwater flow
 where $T^* > 1$ the time-of-travel capture zones are like ellipses and cannot reasonably be approximated by circles

Dimensionless time of travel parameter $T^* = 4.43$ -



Step 2: If $T^* < 0.1$, then calculate Centric Circular Capture Zone

(this case typically occurs when ambient gw flow is small compared to well pumping rate)

Solution

$$R = 1.1543 \sqrt{\frac{QT}{\pi H n}}$$

where R is the approximate but conservative (15% larger than exact radius by volumetric method alone) fixed-radius capture zone (m)

Approximate conservative fixed-radius $R = 80.46$ m

If $0.1 < T^* < 1$, then calculate Eccentric Circular Capture Zone

(the capture zone circle in this case is shifted upgradient)

Solution

$$L_s = \frac{Q}{2\pi Q_0} \text{ or } \frac{Q}{2\pi kHi}$$

$$R^* = 1.161 + \ln(0.39 + T^*)$$

$$R = R^* L_s$$

$$\delta = (R - L_s) / 2$$

where L_s is the distance from the well to the well's stagnation point (m),
 R is the approximate fixed-radius capture zone (m),
 δ is the eccentricity (amount of shift) of the circle centre upgradient (m)

Distance from well to well's stagnation point (x at y = 0)
 Approximate fixed-radius capture zone
 Amount of upgradient shift of the circle centre

$L_s = 23.43$ m
 $R = 64.03$ m
 $\delta = 20.30$ m

$R^* = 2.73$
 $\delta^* = 2.89$

Cowichan Green Well Approximate Estimate of Time-of-Travel Capture Zone

If $T^* > 1$, then calculate Boat-Shaped Capture Zone

(capture zone cannot reasonably be approximated by circle; propose replacement of actual time of travel capture zone by envelope of all capture zones.

Solution

$$L_u^* = T^* + \ln(T^* + e)$$

$$L_u = L_u^* L_s$$

where L_u is the distance from the well to the furthest upgradient point of the time of travel capture zone (m),

$$-x = \frac{-y}{\tan(2\pi k H i y / Q)}$$

Equation to describe the edge of the **steady-state capture zone** for a confined aquifer when steady state conditions have been reached (Todd 1980; Grubb 1993)
where $\tan(y)$ in radians

Distance to furthest upgradient point of the time of travel capture zone

Distance to the furthest downgradient point of the time of travel capture zone (L_s) (x at y = 0)

Half width of capture zone at well location (y at x=0)

Maximum half width of capture zone (y at -x=infinity)

$L_u^* = 6.39$

$L_u = 149.75$ m

<WARNING, DOES NOT EQUATE TO X AT 99%Ymax

$L_s = 23.43$ m

< stagnation point

$Y_1 = 36.80$ m

< symmetrical about the x-axis

$Y_{max} = 73.61$ m

< symmetrical about the x-axis

5% Y_{max} or y=	3.68	x =	23.24 m	< downgradient of well (positive side of x axis on figure below)
25% Y_{max} or y=	18.40	x =	18.40 m	
50% Y_{max} or y=	36.80	x =	0.00 m	< x at origin (see figure below)
60% Y_{max} or y=	44.16	x =	-14.35 m	< upgradient of well (negative side of x axis on figure below)
70% Y_{max} or y=	51.52	x =	-37.43 m	< upgradient of well (negative side of x axis on figure below)
75% Y_{max} or y=	55.21	x =	-55.21 m	< upgradient of well (negative side of x axis on figure below)
80% Y_{max} or y=	58.89	x =	-81.05 m	< upgradient of well (negative side of x axis on figure below)
85% Y_{max} or y=	62.57	x =	-122.79 m	< upgradient of well (negative side of x axis on figure below)
90% Y_{max} or y=	66.25	x =	-203.88 m	< upgradient of well (negative side of x axis on figure below)
95% Y_{max} or y=	69.93	x =	-441.50 m	< upgradient of well (negative side of x axis on figure below)

Calculate half width of time of travel capture zone (y at -x \approx Lu):

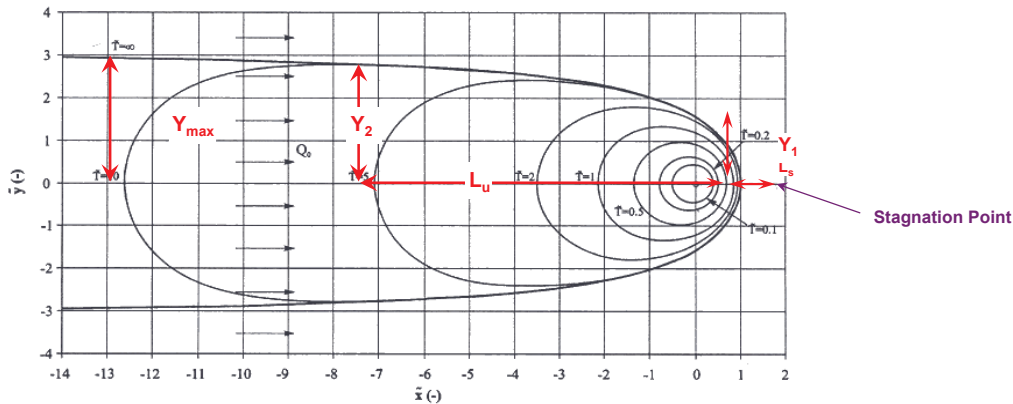
Use "trial-and-error" approach by changing %Ymax or y below until '-x' \approx Lu

87.00% Y_{max} or $Y_2 = 64.04$

x = -147.98 m

< where -x \approx Lu

< half width @ L_u



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