WATER SCIENCE SERIES

Analysis of Current Groundwater Use in the West Coast Region, British Columbia

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EXECUTIVE SUMMARY

A desktop study was completed to estimate groundwater demand by water use purpose and aquifer, and to estimate the number of properties which may require groundwater licences, for water management precincts within the West Coast Region of British Columbia.

This study is an update of a previous study completed in 2015 on behalf of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR). The aim of the original study was to gain an understanding of groundwater usage in the West Coast Region in advance of new *Water Sustainability Act* (*WSA*) requirements for groundwater licensing of non-domestic users. Pertinent information was compiled and integrated from a variety of data sources including: BC Assessment Authority Data (parcel/property information), municipal water service areas, groundwater and surface water licences, Island Health water supply system data, inventory of land-based aquaculture (hatcheries) facilities, registered groundwater wells, and mapped aquifers. In this study, an *inferred* groundwater user was defined as a groundwater user on an occupied lot with one or more registered wells and no other identified source of water (e.g., outside of a municipal water source and does not have an existing surface water licence). A *potential* groundwater user was defined as a groundwater user on an occupied lot that does not have any registered wells, and no identified alternate water source (e.g., outside of a municipal water source and does not have an existing water licence).

The results indicate that there are 3,306 inferred groundwater users potentially requiring groundwater licences within the West Coast Region. These groundwater users include 2,775 individual non-vacant, non-residential lots with registered wells and no other identified water source (out of 307,000 lots within the Region). An estimated additional 513 and 18 transitioning groundwater licences may be expected for water supply systems and aquaculture, respectively. Over 90% of the anticipated number of groundwater applications are in the following five water management precincts: Nanaimo, Victoria, Duncan, Shawnigan and Courtenay. Over 50% of these applications would be expected to be for agricultural uses.

Water use purposes associated with the largest groundwater demands estimated in the region (by volume) are aquaculture (39%), followed by water supply systems (34%) and agriculture (20%). If supplied solely by groundwater, these uses could constitute at least 90% of the total anticipated groundwater demand in the West Coast Region. The water management precincts with the highest groundwater demand are Nanaimo and Duncan, followed by Courtenay and Alberni. Approximately 75% of the total groundwater demand in the Region is found in these four precincts.

Finally, in 38 out of the 229 classified aquifers in the Region the potential annual groundwater demand exceeds more than 50% of the estimated annual recharge volume to the aquifer. In these aquifers, more detailed information and analysis (e.g. development of an aquifer water budget) will be required prior to authorizing the use of additional groundwater to ensure that long-term impacts to the groundwater resource are understood.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

Groundwater is an important resource in the West Coast Region of British Columbia (BC). The Region consists of Vancouver Island, Haida Gwaii, the Gulf Islands, numerous smaller islands and a portion of the central coast of mainland BC (Figure 1). Dug and drilled wells are used throughout the region to supply groundwater for several purposes including urban and rural residential water supply, aquaculture, agricultural, commercial, and industrial uses. In areas like the Gulf Islands, groundwater is often the only viable source of freshwater. Additionally, groundwater provides base-flow to streams in the region and ensures aquatic habitat is sustained during the dry season. Prior to 2016, groundwater extraction did not require a water licence and only large users (75 L/s or more) were required to complete an environmental assessment. Beginning in 2016 with the implementation of the *Water Sustainability Act*, existing users of groundwater for all purposes except domestic (i.e., private homes) are required to obtain a licence from the Province to continue extracting and using groundwater. Our current understanding of the number of users and the volume of groundwater extraction from aquifers in the region is limited. As demand for groundwater increases, we are particularly interested in understanding the amount of groundwater currently being extracted from aquifers in the region and whether this volume is sustainable. Additionally, groundwater extraction can reduce the amount of base-flow in some streams and impact aquatic habitat.

This study is an updated version of an analysis conducted in 2015, which was completed to provide a preliminary quantitative estimate of existing demand for groundwater in the West Coast Region, on behalf of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR). This study considers updated provincial data on lot occupancy and use, the results of recent water use studies, additional Provincial data on the appurtenancy of surface water and groundwater licences, and individual large groundwater users (i.e., aquaculture) in the Region.

The outcomes of this study include:

- Development of a methodology to estimate groundwater use using assessment data;
- Development of an updated GIS database which compiles groundwater use information in the Region;
- Identification of lots with inferred and potential groundwater use and the type of use;
- Estimation of potential total groundwater demand, by aquifer and water precinct;
- Estimation of the ratio of groundwater demand to inferred recharge, by aquifer; and
- Quantification of the inferred and potential existing groundwater users requiring a transitioning groundwater licence.

1.1 Background

The *Water Sustainability Act* (WSA) became legislation in BC in the spring of 2016. Under the WSA, as of February 2016 all non-domestic users of groundwater in BC require an authorization to extract or divert groundwater. Prior to the WSA being enacted, groundwater extraction and use was not regulated and did not require a licence. The Water Sustainability Regulation requires existing groundwater users to apply for a water licence prior to March 1, 2022. Up to this date, existing groundwater users can apply for a “transitioning” water licence and obtain a precedence date based on the date they first began using groundwater. This is important because BC assigns water rights based on a First-in-Time-First-in-Right (FITFIR) system and enables groundwater users to be incorporated into the surface water licensing system in a fair manner. The legislation excludes “domestic” groundwater users from the requirement to apply for a water licence. A “domestic” groundwater user generally refers to a property owner that

uses water for household purposes such as drinking water, food preparation, sanitation, fire prevention, animals kept for household use or as pets, and irrigation of a garden no more than 1000 m^2 (Province of BC, 2016).

In advance of groundwater licensing for non-domestic users FLNR commissioned a study to better understand groundwater use in the West Coast Region. The aim of that study was to provide a preliminary (relative) indication of groundwater demand in different sectors, water precincts, and aquifers, and to estimate the number of potential applications for a groundwater licence from existing users. Completed in 2015, the study involved a Geographic Information System (GIS) analysis to identify lots which may be using groundwater in the West Coast Region based on information from a variety of data sources (e.g., BC Assessment Authority Data, municipal water service areas, surface water licence data, Island Health water supply system data, and documented groundwater wells and aquifers). Inferred groundwater demand was determined based on lot use and was used to estimate groundwater demand to recharge ratios by aquifer. Finally, the number of expected groundwater licence applications was estimated based on the number of non-domestic and non-vacant lots which were inferred to rely on groundwater for their water supply.

This study represents an update to the original (2015) study and incorporates data that is accurate up to November 2018.

2. STUDY AREA

FLNR's West Coast Natural Resource Region and the Study Area are shown in Figure 1. The West Coast Natural Resource Region encompasses Vancouver Island, Gulf Islands, Haida Gwaii, and a portion of the western British Columbia mainland (shown in red in Figure 1). The Study Area comprises the Water Management Precincts within the West Coast Region, which the exception of those precincts that are only partially within the West Coast Natural Resource Region (i.e., Jervis, Burns Lake, Kitimat, Terrace, and Chilcotin, because some of the Water Management Precinct boundaries are not consistent with the Natural Resource Region boundary).

The population of the Study Area is approximately 800,000 residents, with most residents residing in the cities of Victoria, Nanaimo, and Duncan.

Figure 1: FLNR West Coast Region Administrative Boundaries.

3. METHODOLOGY

The study approach included:

- Development of a GIS inventory of parcel lots with inferred or potential groundwater use;
- Assignment of groundwater demand by type of water use, and estimation of total groundwater demand (by Region, water precinct, and aquifer);
- Determination of the relative groundwater demand to potential available supply in each aquifer; and
- Identification of the potential number of lots requiring a transitioning groundwater licence.

Where information was limited, a conservative approach was applied to estimate the number of lots, users, and groundwater demand. These steps are outlined in greater detail below.

3.1 Development of a GIS Inventory of Groundwater Users

A GIS inventory of parcel lots with inferred or potential groundwater use, and the estimated type of water use, was developed by:

- Compiling data pertinent to lot use and associated water sources; and
- Applying a geospatial workflow to identify occupied lots with registered wells, or without registered wells and no alternate documented source of water supply.

3.1.1 Data Sources and Compilation

Several data sources were acquired and compiled as input to conduct the GIS analysis. Some of the primary datasets and/or data source types are listed below and described in the following sections:

- BC Assessment Authority Data (BCAA);
- Water precinct boundaries;
- Regional District/Municipal Water Service Areas;
- Surface and groundwater licences and pending applications;
- Documented groundwater wells (Provincial GWELLS database);
- Mapped BC aquifers (as of 2018);
- Island Health water supply systems data; and
- Inventory of land-based freshwater aquaculture facilities (hatcheries) registered with the Ministry of Environment under the Land Based Fin Fish Waste Control Regulation.

The datasets mentioned above, except for the Island Health water supply system data, were all provided by FLNR in March 2018. It is noted that some of the datasets utilized in this study are living datasets which are revised and updated continuously. The Island Health and aquaculture dataset are current as of October 2018.

BC Assessment Authority Data

British Columbia's Assessment Authority (BCAA) maintains a dataset based on the province's legal cadastral fabric (i.e., property boundaries). This study utilized the attribute information from this dataset to identify individual lots based on their associated land use. Primary Actual Use Codes (AUCs) were used to separate the parcel fabric into specific categories of land use, and to identify occupied lots. The listing of AUCs is extensive and is attached as Appendix A1. A sampling of the AUC descriptions is listed in Table 1.

AUCs influenced the geospatial workflow and results significantly, so many of the assumptions and limitations associated with these analyses are associated with the BCAA dataset. The workflow relies on the codes for determinations such as excluding parcels (e.g., all "vacant" coded parcels), assigning groundwater demand estimates, and estimating the number of expected groundwater licence applications. However, these codes can be missing for some parcels (not included in the BCAA dataset or not able to be linked to the cadastral fabric), and land use may be misrepresented or not fully described. For example, AUCs denote the primary purpose or activity for which a property is being used for, but there may be other uses on the property not captured in the single AUC identified for each parcel (e.g., a "residential" coded parcel may also have uses that would require a groundwater licence).

Table 1: Examples of BC Assessment Authority (BCAA) primary and actual use code descriptions.

Use Category	Primary Actual Use Code	Description
Residential	000	Single Family Dwelling
	032	Residential Dwelling with Suite
	050	Multi-Family (Apartment Block)
	057	Stratified Rental Townhouse
	070	2 Acres or More (Outbuilding)
Farm	111	Grain & Forage (Vacant)
	140	Small Fruits
	170	Poultry
Commercial	200	Store(s) And Service Commercial
	205	Big Box
	213	Shopping Centre (Regional)
	220	Automobile Dealership
	276	Lumber Yard or Building Supplies
	240	Greenhouses and Nurseries (Not Farm Class)
Unknown	300	Stratified Operational Facility Areas
Industrial	402	Meat & Poultry
	417	Plywood Mills
	446	Cement Plants
Transport / Utilities	560	Water Distribution Systems
	570	Irrigation Systems
Civic, Institutional & Recreational	610	Parks & Playing Fields
	612	Golf Courses
	650	Schools & Universities, College or Technical Schools

Regional District/Municipal Water Service Area (MSA) Data

Several regional districts and municipalities were approached to obtain data regarding their Municipal Water Service Areas (MSAs). All data made available by municipalities or regional districts were gathered and compiled into a single reference water service area dataset (Figure 2). The water service area dataset is limited and incomplete, as not all municipal data could be obtained.

Where the areal extent of the water service area was unavailable (e.g., not readily available, compiled, or in digital format for some municipalities), the water service area for that municipality was inferred from the extent of identified residential areas on 1:50,000 scale National Topographic Data Base mapping. This dataset served as a proxy to the actual water service area, but it is recommended that this dataset be replaced with actual MSA boundaries in future analyses. The light pink areas depicted in Figure 2 provide an illustration of compiled water service areas for the southern portion of the West Coast Region.

All lots within a water service area were excluded as a potential groundwater user or licensee based on their inferred access to an established water supply, which may underestimate the actual groundwater use. However, water suppliers (including private, municipal, or regional districts) whose water source includes groundwater were captured as a large groundwater user or potential licensee. Water suppliers and their potential for groundwater use were evaluated by considering Island Health (IH) data (see subsequent section on IH potable water sources).

Provincial Surface Water Point of Diversions and Groundwater Licence Data

FLNR provided three spatial datasets containing water licence information (points of diversions [PODs], groundwater licences, and groundwater licence applications; Figure 3). The PODs were associated with land parcels (via Parcel Identification Number), and the groundwater points represent wells or well fields (by Well Tag Number [WTN]) or other groundwater diversion (e.g., dugouts). Land parcels associated with a groundwater or surface water licence were assumed to not require a groundwater licence. The surface water licence database only included ‘active’ licences.

FLNR also provided a dataset of parcels to which a surface water licence is appurtenant. This dataset assists in identifying parcels supplied with water from a source outside of the lot boundary. This dataset was incomplete at the time of this study’s analysis.

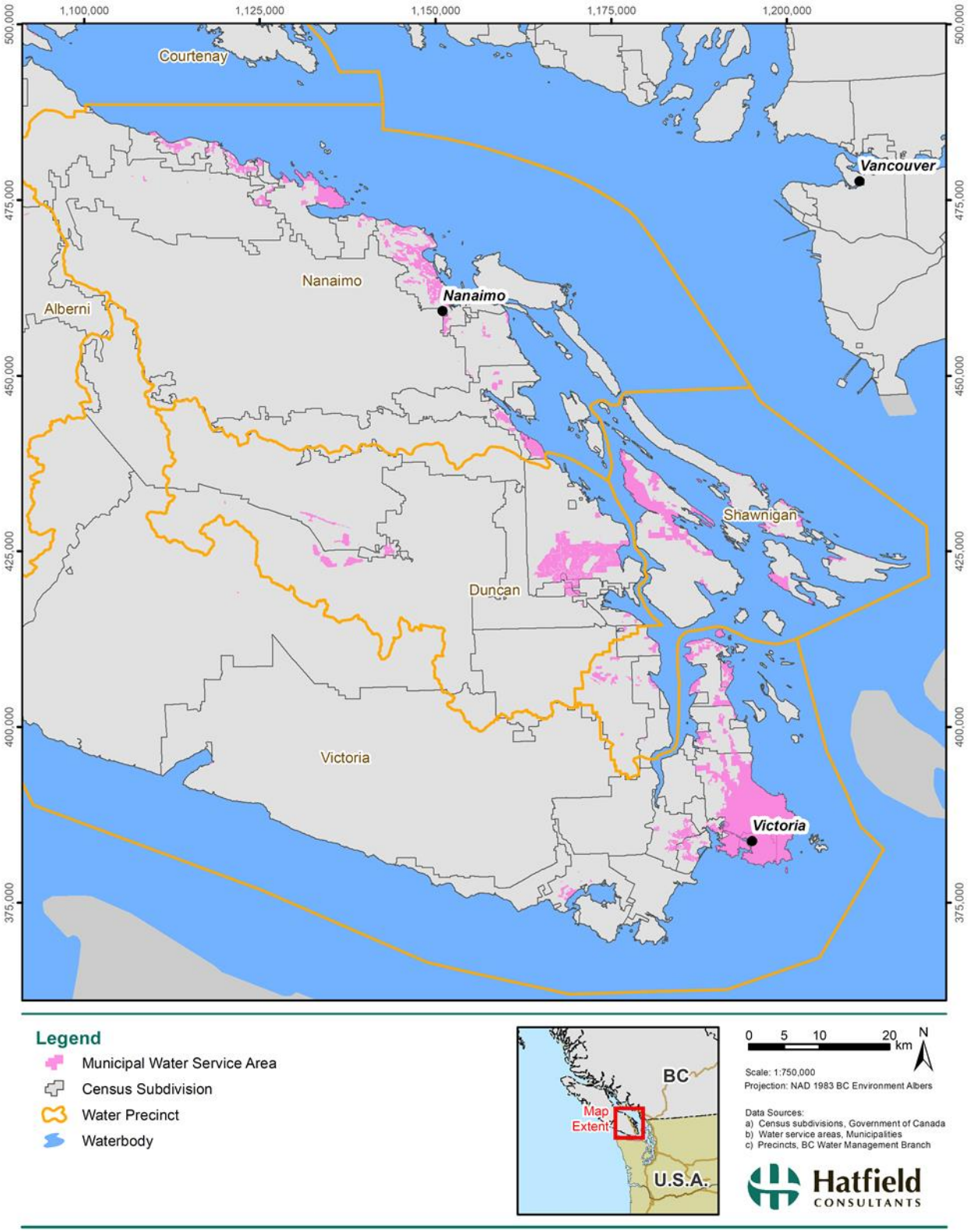


Figure 2: Identified municipal water service area (MSA) data for the South Vancouver Island and the Southern Gulf Islands.

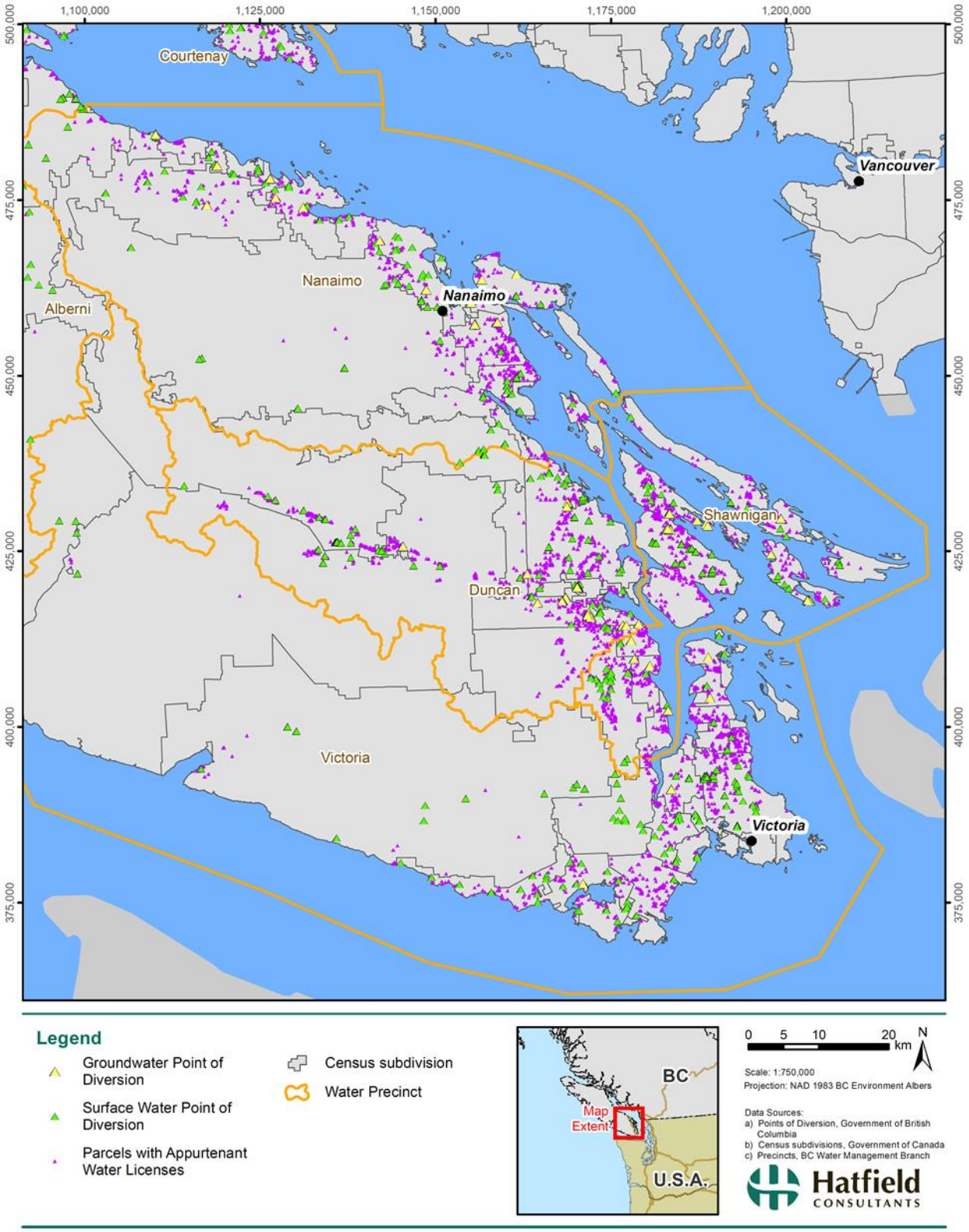


Figure 3: Distribution of surface water and groundwater licence points of diversion in a portion of the study area.

Provincial GWELLS Data

The GWELLS database provides a record of registered wells in the province, along with general information about those wells largely based on drillers' well construction reports (e.g., well location, static water level, well yield, etc.). The Province provided a filtered point dataset from this database, which excluded duplicate wells with overlapping coordinates. This dataset was generated on March 8, 2018 and at the time included over 35,000 unique wells within the West Coast region. This dataset was incorporated into the GIS methodology to correlate the location of registered wells to lots (BC Ministry of Environment, 2011). Figure 4 provides an illustration of the registered well locations within the southern portion of the study area. The known limitations of the GWELLS dataset include: the database may underestimate the number of wells in the region because well record submission by drillers and well owners has been voluntary until 2016; well location information varies in degree of accuracy (e.g., in some cases the well may be located incorrectly); and, the database may not represent the current status of wells that may be deactivated or no longer in use. The dataset did not include information regarding the well use (e.g., commercial, industrial, domestic, irrigation, etc.) because this data field was not populated historically. As a result, the type of well use was assigned based on the parcel's BCAA Primary Actual Use Code.

Properties with one or more registered wells were considered inferred groundwater users, unless the property fell within an MSA.

Island Health Water Supply Systems Data

Under the *Drinking Water Protection Act*, water supply systems are defined as domestic water systems other than those serving a single-family residence and those excluded by regulation. Island Health (IH) maintains a database of registered water supply systems ranging from small (e.g., a small commercial facility) to large systems (e.g., hotels, municipal water supply). The IH dataset provided is current as of November 28, 2018 and includes information such as the location of well or surface water diversion, water source (e.g., surface water, groundwater) and the number of connections (e.g., 2-14, 15-300, 301-10,000, 10,001-20,000 and > 20,000). The 2018 IH dataset was incomplete, with numerous systems identified but without detailed information regarding source, number of connections, or location.

Missing information from the 2018 dataset (e.g., water source, coordinates) was supplemented with additional data from the following sources: the 2015 VIHA water supply system data, web searches for the location of facilities with large connections (>300 connections), and a FLNR spreadsheet that associates groundwater wells to drinking water systems created as part of a project in the 2000's known as the Drinking Water Inventory Management Project (DWIMP). The final improved dataset had 513 groundwater systems with known locations, which were incorporated into the analysis.

Figure 5 illustrates a portion of the locations and sources of water supply systems in the Southern Vancouver Island study area. The point data shows the location and its attributes indicate type of source and the number of water supply systems of various sizes. This dataset does not directly indicate which properties are connected to the water source. It was noted that in more densely populated areas the systems are often larger and/or more numerous. For the purposes of quantifying groundwater use associated with the water supply systems, it was assumed that the water supply systems serve lots within identified MSAs.

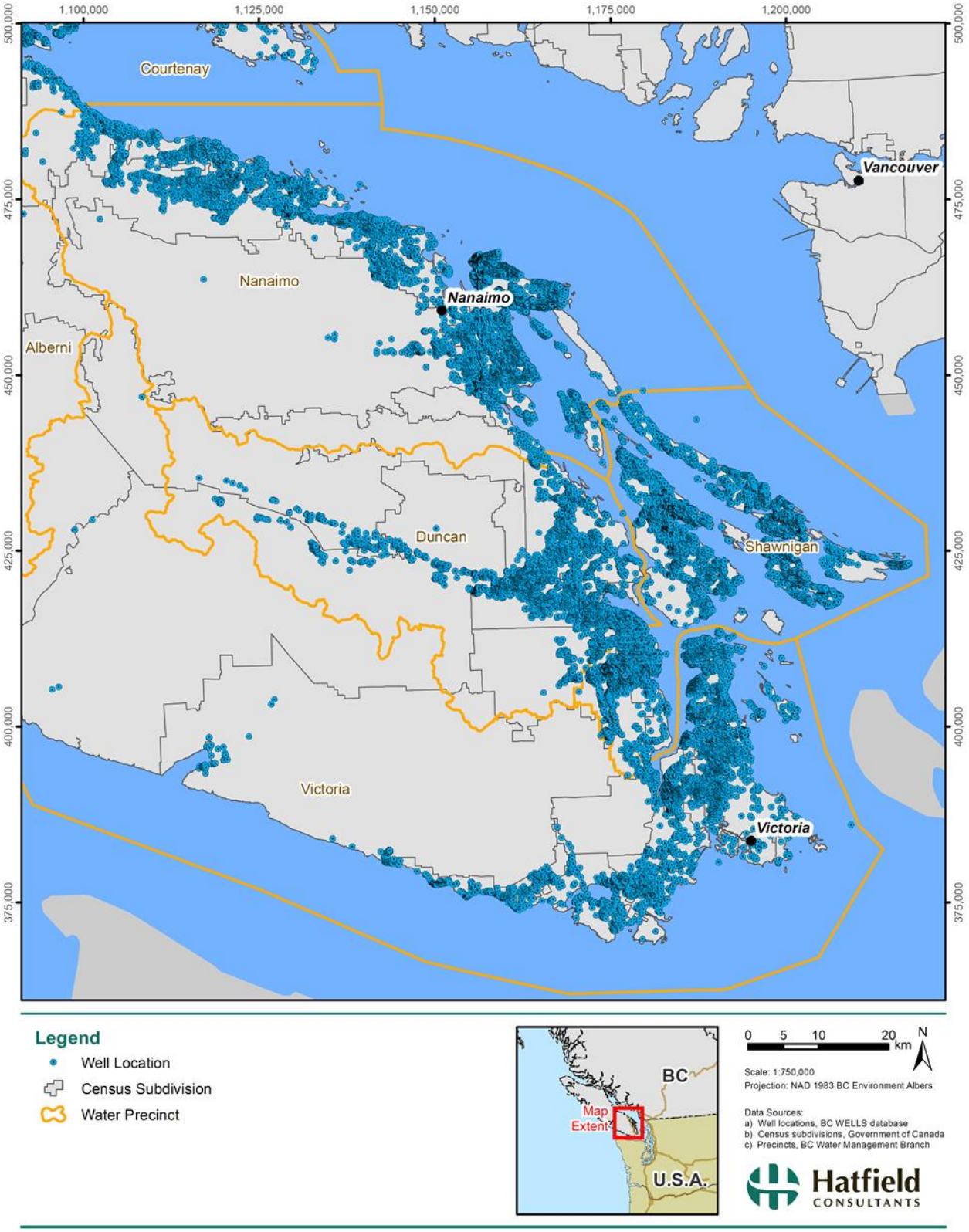


Figure 4: Locations of registered wells from the GWELLS database in a portion of the study area.

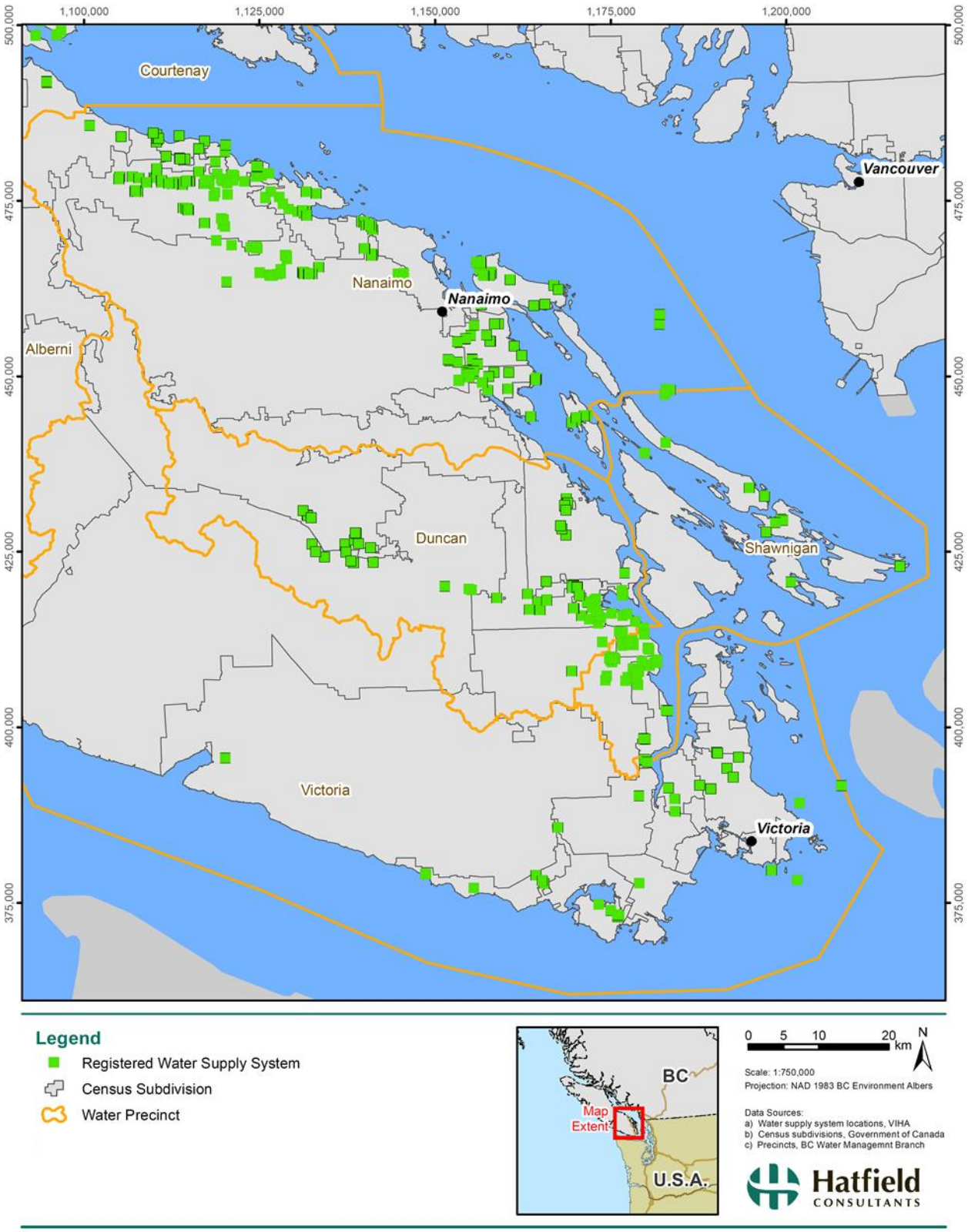


Figure 5: Example of registered, potable water supply systems with groundwater sources.

Provincial Water Precincts Data

Water precincts represent jurisdictional areas within a provincial Water District and were created by BC's Water Management Branch for administrative purposes. The precincts dataset was used to group the results (e.g., groundwater demand, number of potential water licence applicants, etc.).

Provincial Aquifer Dataset

The provincial dataset includes mapped and classified aquifers in the region (Figure 6). Most aquifer boundaries are delineated based on area of development at the time they are mapped, inferred presence of groundwater divides, or mapped or inferred boundaries of the geologic units. It is important to note that aquifers exist in three dimensions and overlying multi-aquifer systems may result in overlapping aquifer boundaries when displayed on a two-dimensional map or landscape. The dataset used was provided by FLNR in March 2018, but there have been many new aquifers mapped in the Region since that time (e.g., in the Queen Charlotte precinct) that are not included in this study.

Aquifers are classified in accordance with provincial methodology (Kreye et al. 1994; Berardinucci and Ronneseth 2002). The dataset attributes correspond to the classification scheme and include aquifer boundaries and areal extent, degree of aquifer development, vulnerability, aquifer productivity, and aquifer demand. From this dataset, the aquifer areal extents were used to estimate potential recharge to each aquifer. A groundwater demand vs potential aquifer recharge ratio was estimated on an aquifer basis. Under the BC Aquifer Classification System, aquifer demand is subjectively and qualitatively based on the density and distribution of wells at the time of mapping. In this study, groundwater demand is quantitatively estimated using a GIS exercise which may differ from the BC Aquifer Classification System.

BC aquifers have also been assigned a subtype based on depositional environment and aquifer properties (Wei et al., 2009). The descriptions of the subtype codes can be found in Appendix A2.

Provincial Aquaculture Data

Hatcheries in the West Coast Region are known to be large groundwater users for their operations. FLNR conducted a desktop review of 46 land-based hatcheries and provided tabular data which included licensed and application volumes, associated aquifer numbers (where known), and estimated groundwater consumption volumes for hatcheries presumed to be in operation (Wainwright, 2019). The review found an estimated 25 active land-based hatcheries that are assumed to be using groundwater. Hatcheries with associated surface water licences were not considered in the assessment of groundwater demand. This dataset is unverified (i.e., hatchery facilities were not contacted to confirm current groundwater use), and may have changed since this analysis was conducted.

Agricultural Water Demand Model Studies

Agricultural water demand models have been completed for the regional districts of Comox Valley, Cowichan Valley, Nanaimo, and Salt Spring Island (van der Gulik et al., 2013a; van der Gulik et al., 2013b; van der Gulik et al., 2014; Tam and van der Gulik, 2017). These reports model agricultural water demand on a parcel basis within a given district by incorporating soil, climate, crop type, and irrigation data. The modelling reports provide surface water and groundwater irrigation demands in a dry (2003 data) and wet (1997 data) year on an aquifer basis. For the purpose of this study, the groundwater irrigation demands in a dry year are matched to our inventory of aquifers. It is noted that these groundwater irrigation demand values were calculated based on aquifer information at the time. The reports referred to aquifer locations and not aquifer numbers or names, so the demands were matched as best as possible to one or more aquifers when aquifer locations could not be further verified. As such, the estimated demands in some aquifers may be over-estimated (adopting a conservative approach).

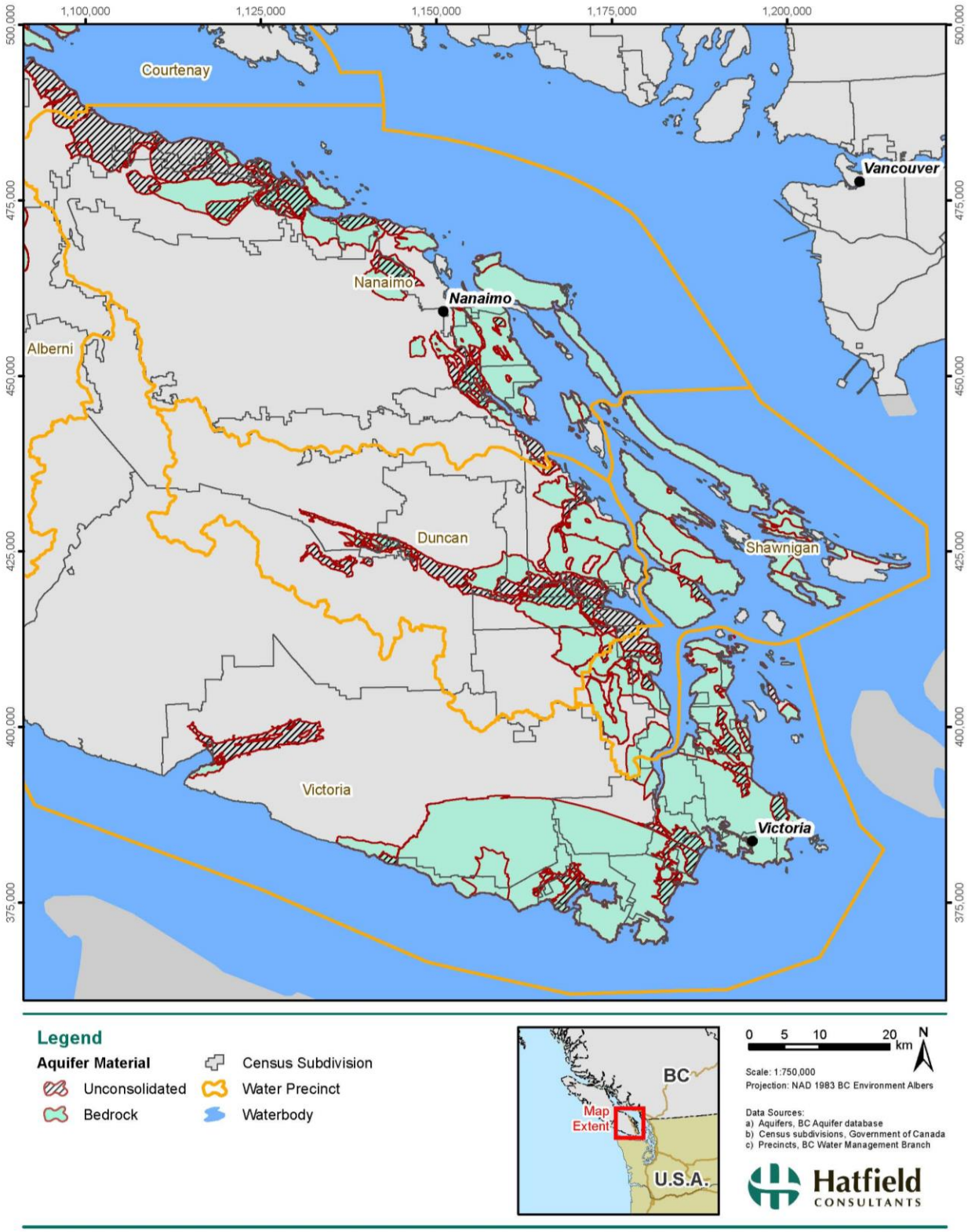


Figure 6: Example showing mapped aquifers in Southern Vancouver Island and the Gulf Islands.

3.1.2 Geoprocessing Workflow

A GIS workflow was developed within the ArcGIS 10.5 environment to establish a relationship between the cadastre and water use information. This workflow forms the linkage between cadastre, lot occupancy, lot area, type of lot and inferred water use, lots with registered wells, lots that a surface water or groundwater licence is appurtenant to, and lots within a water service area. The results from this process generated a large data file in .csv format which summarized this information for all lots in the study area.

The workflow began with a process that appends a BCAA AUC to each parcel in the cadastre feature class and prepared the database for further analysis, including removing features outside the West Coast Project area. There was an intermediate step performing a spatial join between the parcel data and four separate datasets which represented both surface and groundwater licences (surface water point of diversions, groundwater licences, groundwater licence applications and land parcels with water licences). This new integrated dataset contained information representative of the current water licences and was used to identify parcels with no associated water licences. Subsequent steps involved performing a spatial join between the cadastral layer and each thematic layer within the study area – groundwater or surface water licences, water service area, and groundwater wells. As a result, the target parcel dataset inherited the attributes from the other key thematic layers based on a common spatial reference.

When this workflow was complete, the resulting dataset contained an explicit relationship for each parcel, well, water service area, and surface or groundwater water right that could be queried and summarized using Structure Query Language (SQL) commands. Data summaries generated through SQL queries provide additional insight and characterization of the parcels by grouping the results thematically (i.e., group inferred parcels by water precinct or by regional district, etc.). For this study, water precincts were used to group the output results (i.e., the number of inferred lots per water precinct), and the outputs from the SQL queries were used in further quantitative analysis.

In summary, the geoprocessing workflow was as follows:

- Create an empty table schema and join the AUC table and cadastre fabric;
- One-to-many records spatial join of output table with Aquifers spatial table;
- One-to-one record spatial join with Water Service Areas spatial table;
- One-to-one record spatial join with unique locations of Wells spatial table;
- One-to-one record spatial join with Points of Diversion spatial table; and
- SQL database queries on attribute tables to return counts by aquifer, and totals (sums) by aquifer.

The GIS exercise demonstrated the advantage of using the cadastre fabric as the basis of the analysis, which allowed additional attributes (which may be incomplete, e.g., the GWELLS database) from seemingly disparate layers to be added spatially. The resultant dataset is an inventory of lots with inferred water use information, which can be used to identify candidate parcels for future groundwater licensing.

3.2 Groundwater Demand Quantification

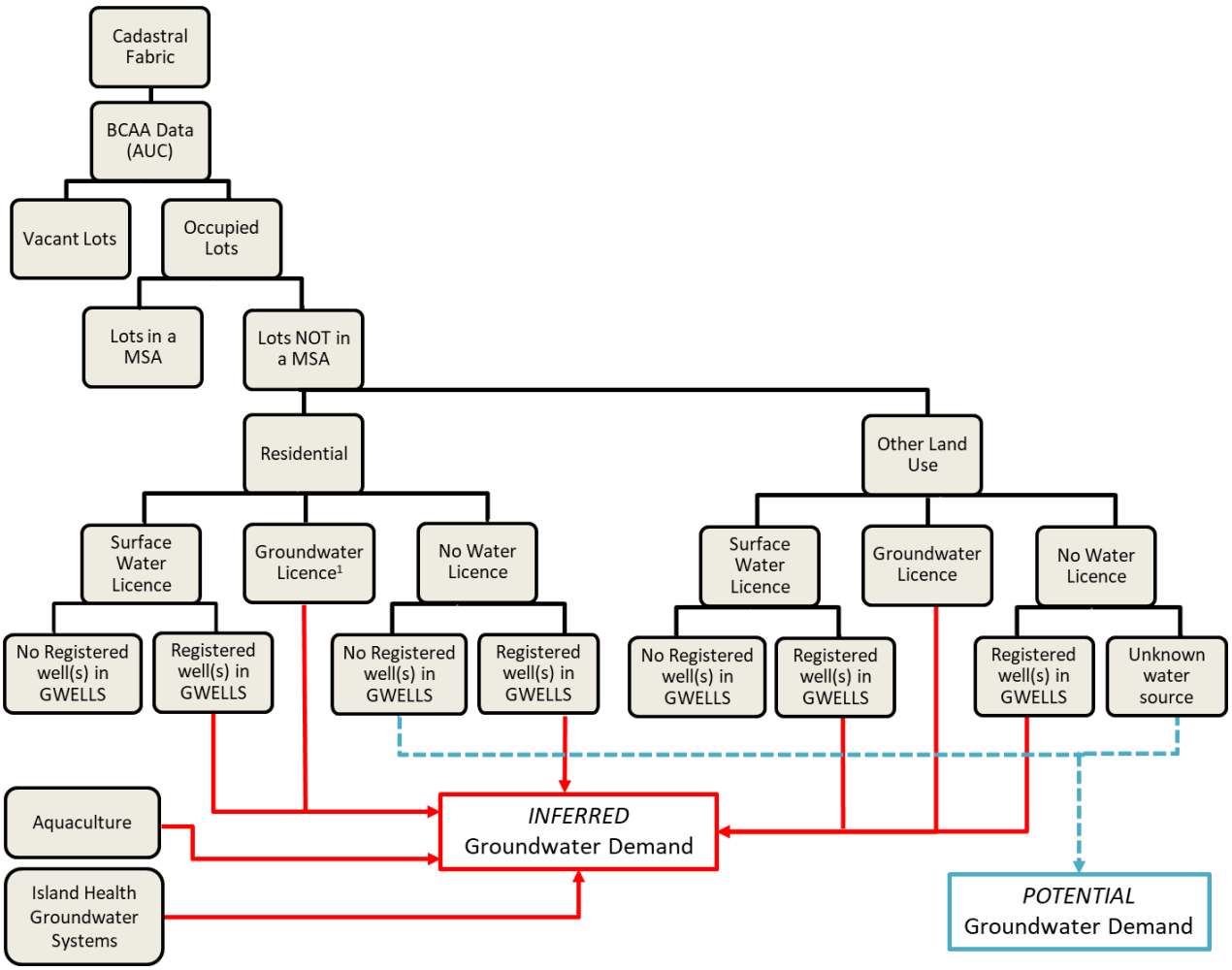
The groundwater demand within each water precinct and mapped aquifer was quantified to estimate the ratio between groundwater demand and recharge on an aquifer basis. The total groundwater demand (i.e., annual groundwater volume used) was calculated for all lots that are inferred or potential groundwater users, based on individual lot use and known or estimated water use for specific major water users (e.g., aquaculture, water supply), as described below. It should also be noted that domestic

groundwater users are included in the estimation of groundwater demand, whereas they are not included in the estimation of potential number of groundwater licence applicants (e.g., licensing workload characterization, discussed in subsequent sections).

3.2.1 Inferred and Potential Groundwater Users

Inferred groundwater users include those occupied lots with one or more registered well, and are not within a MSA (it is assumed that if a surface water licence is appurtenant to a lot with a registered well, the lot is drawing water from both surface and groundwater sources; Figure 7).

Potential groundwater users include those occupied lots that do not have registered wells, but have no alternate documented water source (i.e., no surface water licences and they are outside of a MSA; Figure 7).



Note: While the Water Sustainability Act does not authorize domestic groundwater use (i.e. private well owners using groundwater for their home), it is possible to have a non-domestic user of groundwater source their water from a residential lot.

Figure 7: Flowchart illustrating process to estimate which lots inferred and potential groundwater demand.

3.2.2 Assigned Groundwater Demand by Lot Use

Groundwater demand for each water precinct or mapped aquifer was calculated based on the AUCs assigned to each lot and associated groundwater consumption values estimated for those land uses. The total groundwater demand was calculated for each occupied lot, irrespective of the number of wells on the lot, as it was assumed that all wells provide water associated with the land use.

In addition to vacant lots, several land use types were assumed to have no associated water demand and were assigned a groundwater demand of 0 m^3/d. These land use types (and their AUC codes) are listed below:

- *Residential* –residential or 2-acre outbuilding (20, 70), and parking (43);
- *Commercial* – parking lots (260), garages (262), storage and warehouses (272, 273, 274, 275), marine facilities (280), sign or billboards (288);
- *Industrial* – storage plants (434, 435), pipelines (436), logging related land uses (426, 427), sand and gravel (445), docks and wharves (478), and parking lots (490);
- *Civic, Institutional and Recreational category* – government reserves (615), cemeteries (642), ranger stations (632), and recreational land (660); and
- Unknown land use (unknown AUC).

In addition, lots associated with AUC 403 (seafood) were not assigned a standard water demand, as the consumption values for seafood-related industries (e.g., hatcheries) vary considerably with the size and type of operation. It is assumed that these facilities are captured in the Aquaculture dataset.

Groundwater demand values assigned to the remaining lots (based on land use) and the total number of those lots, are summarized in Table 2 below. The rationale for these assigned water quantities are described in greater detail in the following sections.

Table 2: Assigned groundwater demand by primary actual use code (AUC).

Use Category	Primary AUC (Number)	Number of Non-vacant Lots		Water Consumption Value	Units
		Inferred groundwater user [(1)]	Potential groundwater user [(2)]		
Residential	Single family dwelling (0), residential dwelling with suite (32), 2 acre or more (single family dwelling or duplex) (60)	12,757	49,360	2	m^3/d
	Other multi-family	25	663	0.65	m^3/d
	Duplex (33, 34, 35, 41)	7,053	8,695	1.30	m^3/d
	Triplex (47)	4	11	1.95	m^3/d
	Fourplex (49)	0	17	2.6	m^3/d
	Row Housing (39, 52), condominiums (30), apartment blocks (50)	6	102	9.7	m^3/d
	High-rise (54)	0	0	32.6	m^3/d

Table 2: (Cont'd.)

Use Category	Primary AUC (Number)	Number of Non-vacant Lots		Water Consumption Value	Units
		Inferred groundwater user [(1)]	Potential groundwater user [(2)]		
Farm	Grain & forage (110), mixed (180), other (190), small fruits (140), tree fruits (130), vegetable (120)	1,075	914	18.4[(3)]	m^3/ha/d
	Beef (150), dairy (160)	174	158	5	m^3/d
	Poultry (170)	86	77	5	m^3/d
Commercial	Mixed commercial and administration e.g., stores and service commercial (200), stores and living quarters (202), stores and/or offices with apartments (203), stores and offices (204), office buildings (208)	81	448	30	m^3/d
	Shopping centers e.g., regional shopping centres (213), retail strips (214), big box (205)	20	68	30	m^3/d
	Rental units e.g., hotels (230), motels (232, 223), manufactured home park (224), campgrounds (236), bed & breakfasts (4+ units) (237), resorts (238)	116	302	20	m^3/d
	Bed & breakfasts (<4 units) (239)	44	169	2	m^3/d
	Other commercial lots e.g., food markets (215), theatres (250), storage (272, 273, 274, 275), senior's homes (285, 286)	181	830	5	m^3/d
Industrial	Mining (coal) (440)	0	1	5,000	m^3/d
	Seafood (403)	2	19	- [(4)]	m^3/d
	Mining (non-coal) (442, 443)	2	3	3,000	m^3/d
	Other industrial uses e.g., sawmill (415), cement plants (446), metal fabrication (464)	57	468	100	m^3/d

Table 2: (Cont'd.)

Use Category	Primary AUC (Number)	Number of Non-vacant Lots		Water Consumption Value	Units
		Inferred groundwater user (1)	Potential groundwater user (2)		
Transportation, communication and utilities	Marine and navigational facilities (505), bus company (510), airports and heliports (515)	15	52	30	m^3/d
	Other e.g., railway (500), telephone (520), gas distribution systems (550), electrical power systems (580)	56	585	5	m^3/d
Civic, institutional & recreational	Parks and playing fields (610)	593	15,830 (7)	40 (5)	m^3/d
				2.1 (6)	$m^3/d/ha$
	Schools and universities (650), churches & bible schools (652)	58	253	15	m^3/d
	Government buildings (620) and recreational and cultural buildings (600)	56	203	30	m^3/d
	Golf courses (612)	15	13	160	m^3/d
	Hospitals (640)	1	16	150	m^3/d
	Other e.g., campgrounds (614), works yards (630)	52	111	5	m^3/d

Notes:

1. Lots with registered wells or active licences, outside of an MSA and non-vacant.
2. Lots with unknown water sources, outside of an MSA and non-vacant (not used in demand calculations)
3. Farm irrigation category assigned values based on standard irrigation duty, except where data was available for specific aquifers from the Agricultural Water Use Demand Models.
4. Water consumption assigned by FLNR estimates for individual facilities. Number of lots shown for reference only.
5. Lots with unknown area size were assigned an average calculated water consumption value.
6. Lots with known area size were assigned a demand of 2.1 $m^3/d/ha$ to 35% of the lot area.
7. Although these are potential groundwater users, it is assumed that the majority of these would not be not irrigated.

Residential

Residential water use was estimated to be 2 m^3/d for single family residential lots, and for other multifamily residential lots the water use ranged from 0.65 to 32 m^3/d. The single-family dwelling value of 2 m^3/d was based on discussion with FLNR West Coast Region water allocation staff (i.e., 2 m^3/day is typically allocated for domestic purpose). Domestic purpose (as defined in the WSA), includes household purposes and fire prevention, water for animals or poultry for household use or as pets, and irrigation of a garden not exceeding 1000 m^2.

The multifamily residential lot value of 0.651 m^3/d was based on an average household size of 2.2 people as per the 2016 census (Statistics Canada, 2017), and average residential water consumption of 261 Litres per day per person (Statistics Canada, 2013).

The water consumption value (0.651 m^3/d) was multiplied by two (2) for duplexes, three (3) for triplexes, four (4) for fourplexes, fifteen (15) for row housing, condominiums and apartment blocks, and fifty (50) for high-rises. Under the BC *Homeowner Protection Act*, the average number of units per new registered multifamily residential buildings was 14.5 in 2016 (BC Housing, 2016). The Capital Regional District (Victoria) saw one of the largest increases in BC of registered buildings with 50+ units in 2017 (BC Housing, 2017). The water consumption value was multiplied by 50 for the minimum number of units in a high-rise multifamily building.

Farm (irrigation)

For the assessment of aquifer-specific groundwater demand, irrigation demand was obtained from the agricultural water demand models completed for the Districts of Nanaimo, Cowichan, Comox and Salt Spring Island (van der Gulik, et al., 2013a; van der Gulik, et al., 2013b; van der Gulik, et al., 2014; Tam and van der Gulik, 2017).

For the assessment of precinct groundwater demand and for aquifers not included in the agricultural water demand model studies, an irrigation rate of 18.4 m^3/ha/d was used. This rate was based on the modelled irrigation demand of the total area irrigated (from both groundwater and surface water sources) in each study region (i.e., Districts of Nanaimo, Cowichan, Comox and Salt Spring Island), based on a dry year (2003). In the modelling studies the total irrigated area is assumed to be the crop (irrigable) area, not the total lot size. In addition, the length of the growing season for several crop types was considered. This calculation is conservative and may overestimate demand because a dry year (2003) was used, and it was assumed that all cropland is irrigated. The water consumption rate (18.4 m^3/ha/d) was then used to estimate water use for lots assumed to be irrigating crops with groundwater by multiplying the rate by 65% of the total lot area. This calculation assumes that on average, only 65% of the lot area is used for agricultural irrigation. This value was based on a preliminary review of aerial imagery for randomly selected agricultural areas in the region.

Farm (other uses)

Beef and dairy farm lots were assigned a value of 5 m^3/d, based on an assumed average water use of 45 Litres per day (Lpd) per cow (between 12.5 and 85 Lpd each) and an average BC ranch size of 109 cows (Canadian Beef, 2016; van der Gulik, et al., 2013a; van der Gulik, et al., 2013b; van der Gulik, et al., 2014; Tam and van der Gulik, 2017).

Poultry water use values were assigned a value of 5 m^3/d. This is an average value based on as assumed average water use of 0.225 Lpd per chicken (between 0.09 – 0.36 Lpd/chicken) and an average flock size of approximately 22,000 chickens (Agricultural and Agri-Food Canada, 2017; van der Gulik, et al., 2013a; van der Gulik, et al., 2013b; van der Gulik, et al., 2014; Tam and van der Gulik, 2017).

Commercial

The majority of occupied commercial properties (over 90%) with inferred or potential groundwater use include the following AUCs:

- Stores and commercial services, stores and living quarters, stores and/or offices with apartments, office buildings;
- Automobile paint shops and garages, dealerships and lots; and
- Bed and breakfasts (<4 units and >4 units), campgrounds, seasonal resorts, hotels and motels.

Stores and office buildings were assigned a water use of 30 m^3/d. This was based on a water consumption of 60 L/ft^2/year and average size of 175,000 ft^2 (Real Property Association of Canada, 2011, 2013.

'Bed and breakfast' style properties with less than 4 units (comprising 20% of the lots) were assigned a water use of 2 m^3/d, based on an assumed occupancy of 8 full time residents and average water consumption per person in Canada of 251 Lpd.

Larger rental properties (bed and breakfasts with 4 or more units, hotels, motels, resorts, etc.) were assigned a water use of 20 m^3/d. This was based on an estimated average of 50 rooms per property, 65% double occupancy rate, and 251 Lpd per person water consumption.

Shopping centres and senior assisted-living residences were assigned specific water use values based on a large anticipated water use, although there are limited number of lots (Table 2).

Shopping centres were assigned a water use of 30 m^3/d. This is based on an average daily water consumption of 7,000 Gallons (EPA, 2007).

Senior's residences were assigned a water use of 20 m^3/d. This is based on British Columbia's median size of senior's residences of 62 spaces (Canada Mortgage and Housing Corporation, 2014), and average water consumption per person in Canada of 251 Lpd.

Other commercial properties, which only account for less than the remaining 10% of commercial lots, were assigned a water use value of 5 m^3/d.

Industrial

Specific industrial operations anticipated to have high water demands were assigned a water consumption value based on an assessment of volumes allocated in surface water licences. The water consumption value was based on the median licensed quantity for all surface water licences within BC with the same purpose and/or licensees in the industry of interest. For example, the water consumption value assigned to coal mining was based on the median quantity allocated in BC surface water licences for 'Mining (coal)' purpose.

Seafood AUC parcels are shown in Table 2, however many of the parcels were assumed to overlap with the Aquaculture dataset (see Section 3.2.3). In a separate analysis, water consumption values were estimated by FLNR for 25 individual land-based hatcheries (i.e., groundwater demand was estimated for each facility).

Median quantities selected as average values are weighted (biased) by the water use associated with the largest licensed users. Surface water licence quantities associated with those specific industrial operations and purposes are summarized in Table 3. Other industrial land uses (e.g., sawmill, cement plants, wineries) were assigned a water consumption value of 100 m^3/d.

Table 3: Surface water licence quantities associated with specific industrial operations in BC.

Industry	BCAA Land Use Code Category	Number of Operations (1)	Surface Water Licence Purpose	Surface Water Licence Quantity (m^3/d)		
				Range	Median	Average
Mining	Mining (coal)	7	Mining-Washing (Coal)	2,000 – 1,200,000	5,000	175,000
	Mining (non-coal)	94	Mining-Processing Ore	2 – 36,000	3,000	4,400

1. The number of operations was estimated based on an evaluation of licences, purposes and licensees. For example, some water licence quantities were consolidated and assumed to correspond to a single operation/facility based on the location and licensee.

Transportation, Communication and Utilities

Most of the occupied transportation, communication and utility properties with inferred or potential groundwater use comprise the following AUCs:

- Railways;
- Electrical power systems;
- Water distribution systems;
- Telephone;
- Marine and navigational facilities;
- Airport and heliports; and
- Miscellaneous.

The majority of these AUCs are assumed to have no water use as mentioned in Section 3.2.2, with the remainder of AUCs assigned a water use of 5 m^3/d.

Marine and navigational facilities, airports, and heliports were assigned a water use value of 30 m^3/d, similar to the commercial building use.

Civic, Institutional and Recreational

The majority of occupied civic, institutional and recreational properties (over 90%) with inferred or potential groundwater use include the following AUCs:

- Parks and playing fields;
- Schools and universities;
- Government buildings;
- Churches and bible schools;
- Recreational and cultural buildings;
- Campgrounds;
- Golf courses; and
- Hospitals.

Where the lot areas of parks and playing fields were not known, a water consumption value of 40 m^3/d was assigned. Otherwise, the water consumption value used was 2.1 m^3/ha/day multiplied by 35% of the lot area. The modelled annual water consumption for 'Golf and Recreational Turf' in the Districts of Nanaimo, Cowichan and Comox were used to calculate the average water consumption value of 2.1 m^3/ha/day (van der Gulik, et al., 2013a; van der Gulik, et al., 2013b; van der Gulik, et al., 2014). This water use value was applied to 35% of the lot area assuming an average park size of 0.6 km^2. This calculation assumed that 35% of the park areas are irrigated, similar to a GIS exercise which had estimated that 35% of the parks and playing fields at City of Vancouver are irrigated (Klein, pers. communication).

Schools and universities, churches, and bible schools were assigned an average water use of 15 m^3/d. Student water consumption at schools ranged between 0.011 and 0.1 m^3/d (3 and 23.6 Gallons per day) (Dziegielewski, et al., 2000; Santa Fe Water Division, 2009). School water usage is 7 m^3/day based on an average 0.038 m^3/d (10 Gallons per day) for an average of 173 students per school on Vancouver Island. University of Victoria (2011) reported a water consumption of nearly 700,000 m^3/year from April 2009 to March 2010. Based on this, a university is expected to consume approximately 1,900 m^3/d. Unfortunately, universities were not separated within the dataset so an average water use value of 15 m^3/d was applied to all educational institutions.

Government, recreational and cultural buildings were assigned a water use value of 30 m^3/d, similar to the commercial building value.

Golf courses were assigned a water consumption of 160 m^3/d, based on an average golf course size of 50 acres (reported golf course areas range from 30 to 200 acres) and assumed irrigation of 8.4 m^3/ha/year (equivalent to 1 acre-ft/acre/year).

Hospitals were assigned a water use of 150 m^3/d, based on an estimated 2,400 hospital beds in BC, and a water consumption of 44.8 m^3/year (118,500 US Gallons/year) per hospital bed (Ontario Health Coalition, n.d., US Energy Information Administration, 2012). This water consumption value is for hospitals ranging in size from 18,580 to 46,450 m^2 (200,000 to 500,000 ft^2), which is suitable as the size of Nanaimo Regional General Hospital is currently 35,520 m^2 (382,815 ft^2) (Island Health, 2012). With 20 lots assigned an AUC code (640) corresponding to hospitals, this corresponds to approximately 150 m^3/d/hospital.

With the exception of the AUCs mentioned in Section 3.2.2 with a 0 m^3/d, the remaining civic, institutional, and recreational use AUCs (i.e., campgrounds (614), work yards (630) and ski hills (654)) were assigned a value of 5 m^3/d.

3.2.3 Potential Groundwater Demand for Major Users

Aquaculture

Aquaculture operations are one of the largest water users in the West Coast Region. Relatively high water demands for aquaculture operations often include a groundwater source. Groundwater is often preferentially selected (even when surface water is available) due to more desirable temperature and water quality parameters (which can include high salinity).

Potential groundwater demand for aquaculture was assigned from tabulated data provided by FLNR. The tabulated data was based on the inventory of land-based freshwater aquaculture facilities (hatcheries) registered with the Ministry of Environment under the *Land Based Fin Fish Waste Control Regulation*, and did not include net pen facilities or hatcheries that use salt water in their operations or facilities that did not appear to be associated with water licences. Available information for each hatchery was reviewed and cross-referenced with hatchery discharge permit data, water licence information, well and aquifer data, aerial imagery, and web queries to assess and refine the groundwater withdrawal estimate for each hatchery. A dataset containing all Environmental Management Act (EMA) authorizations downloaded from the ENV website and groundwater application forms submitted by hatcheries provided supplementary information for the review. Factors used to indicate which hatcheries are likely withdrawing groundwater included whether the facility has a waste discharge permit, has at least one well on or near the property assumed to be associated with the hatchery (e.g., as indicated by information contained in the well drilling report), whether it appears their surface water licence may not provide sufficient volume for operations given the discharge permit volume (i.e., the facility is likely using a mix of groundwater and surface water), whether the facility has

submitted a groundwater application, and whether the facility appears to be operational according to aerial imagery and web-based information. Data for the Duncan area hatcheries was obtained from an analysis of groundwater use conducted in 2011 (Lapcevic et al., 2021).

Water Supply Systems

Groundwater demand for water supply systems regulated by Island Health (IH) within each water precinct or aquifer was inferred from information provided by IH. This information included the source type (e.g., surface water or groundwater, location, and number of connections).

The groundwater demand for each groundwater supply system was estimated by multiplying the assumed number of connections (listed in Table 4) by 606 L/day (Environment Canada, 2011). The 606 L/day water consumption rate is based on the total volume of water delivered to BC municipal water distribution systems, divided by the residential population served (Environment Canada, 2011). Several sources in the IH dataset did not contain spatial coordinates, which were not included in the GIS analysis. Sources of uncertainty with this dataset include possibly underrepresentation of total groundwater demand for a system because of the assumed number of connections and missing water system locations, and overrepresentation of groundwater demand from using the 606 L/day value (e.g., actual use is likely much lower in areas like the Gulf Islands).

The number of groundwater water supply systems is summarized in Table 4, below.

Table 4: Summary of water systems regulated by Island Health using groundwater

Number of Connections	Assumed Actual Number of Connections[1]	Number of Systems Identified as Using Groundwater Sources[2]
1	1	77
2 – 14	5	176
15 – 300	100	164
301 – 10,000	2000	89
10,001 – 20,000	10,001	0
> 20,000	20,001	0
	Total	**513**

[1] These numbers were generated based on the average number of connections for municipal water systems in Cowichan and Nanaimo Regional Districts (CVRD, n.d.; RDN, n.d.)

[2] Some systems comprise of multiple wells, and the total number of wells supplying groundwater to municipal water systems is 593 (Island Health, 2014).

3.2.4 Water Precinct and Aquifer Ranking by Groundwater Demand

Water precincts and aquifers were ranked based on total estimated annual groundwater demand.

Aquifers were also ranked for potential supply-demand issues (i.e., potential for unsustainable extraction or groundwater shortage) and potential impacts to surface water baseflows and instream flow needs.

Lots with inferred groundwater use that do not fall within an aquifer boundary were not accounted for in the aquifer ranking. However, these parcels are included in the precinct ranking.

Possible Supply-Demand Issues

The ranking for possible supply-demand issues was based on a simple assessment of: i) the total groundwater demand within a water precinct; and ii) the ratio of groundwater demand to supply within an area overlying an aquifer(s). Groundwater demand was calculated for lots overlying each aquifer, as described in the preceding sections. Except for aquaculture data (see Section 3.1.1), groundwater demand in stacked aquifer systems is over-estimated because demand was attributed to all overlapping aquifers (i.e., because it is not known which aquifer is potentially being drawn from). This assumption is intended to provide a worse-case indication of where aquifer demand may exceed recharge.

Groundwater supply within an aquifer was conservatively calculated based on an assumed regional precipitation of 1,500 mm/year (Environment Canada, 2017) and an assumed aquifer recharge rate (15% of annual precipitation) over the areal extent of the aquifer. This recharge rate is consistent with the lower end of the expected range of aquifer recharge rates (e.g., 10% to 25% of precipitation; Foster and Allen, 2015), and estimated vertical infiltration rates reported in groundwater studies in the study area (e.g., average vertical infiltration of approximately 255 mm/year [Regional District of Nanaimo, 2013]). However, this is a conservative estimate of the overall aquifer recharge rate because it neglects lateral groundwater flow from upgradient units and may be based on aquifer extents defined by historic areas of development (as opposed to actual extent based on geologic/hydrogeologic properties). In this analysis, sustainable supply is defined as the groundwater in an aquifer which is recharged on an annual basis and available for groundwater extraction and use.

The aquifer demand versus recharge ratio was calculated for each mapped aquifer by dividing the total annual groundwater demand by total annual recharge. Where the groundwater demand is estimated to exceed the annual recharge to the aquifer, the possibility of groundwater mining or unsustainable extraction is possible. Aquifers where potential demand is estimated to be close to (or exceed) supply can be considered 'priority aquifers' warranting further assessment.

This simple estimate of demand, and demand versus supply ratios, was intended to provide an indication of the relative potential for unsustainable extraction or water shortage among water precincts and aquifers. It is not intended to provide an accurate depiction of available supply, demand or actual risk. The following assumptions and potential sources of error in this assessment should be considered:

- The average precipitation is assumed to be 1,500 mm/yr. Actual precipitation can vary significantly across the region (e.g., less than 1,000 mm/yr at the coast, to over 3,500 mm/yr in central mountainous areas of Vancouver Island (Environment Canada, 2017);
- It assumes that 15% of precipitation infiltrates the ground and recharges each underlying aquifer units/areas. This value may be consistent with values calculated in other studies in the Nanaimo area, but it may underrepresent infiltration in other areas of the West Coast region;
- The inferred groundwater recharge rate is only based on vertical infiltration, and neglects lateral groundwater inflow to an aquifer from upgradient geologic units;

- The groundwater recharge rate also neglects that some aquifers overlap in lateral extent, and as such may overestimate infiltration to some (e.g., underlying) aquifers; and
- Groundwater demand overlying / within aquifers may be overestimated, as groundwater demand within lots overlying aquifers are attributed to all underlying aquifer units.

3.3 Transitioning Groundwater Licensing Workload

The number of non-domestic groundwater users who were using water prior to February 29th, 2016 and therefore now require a groundwater licence, was estimated from the number of lots with the following characteristics listed below (Figure 8):

- Occupied lots;
- Non-residential land use (based on BCAA use categories);
- Outside of municipal water service areas; and
- Having documented wells or no known source of water supply.

These lots were further screened to exclude lots with land uses where no current water use might be expected (e.g., vacant land, crown land, parks, managed forest units, etc.). Examples of excluded lots include those with the following land uses (i.e., BCAA AUCs):

- Outbuildings only;
- Parking;
- Storage;
- Docks and wharves;
- Logging and lumber operations;
- Lumber and work yards;
- Infrastructure related operations (roads and bridges, pipelines, railways, telecommunications, distribution systems); and
- Miscellaneous civic, institutional and recreational facilities (parks and playing fields, government reserves, garbage dumps, landfills, ranger stations, government research centres, cemeteries, recreational use).

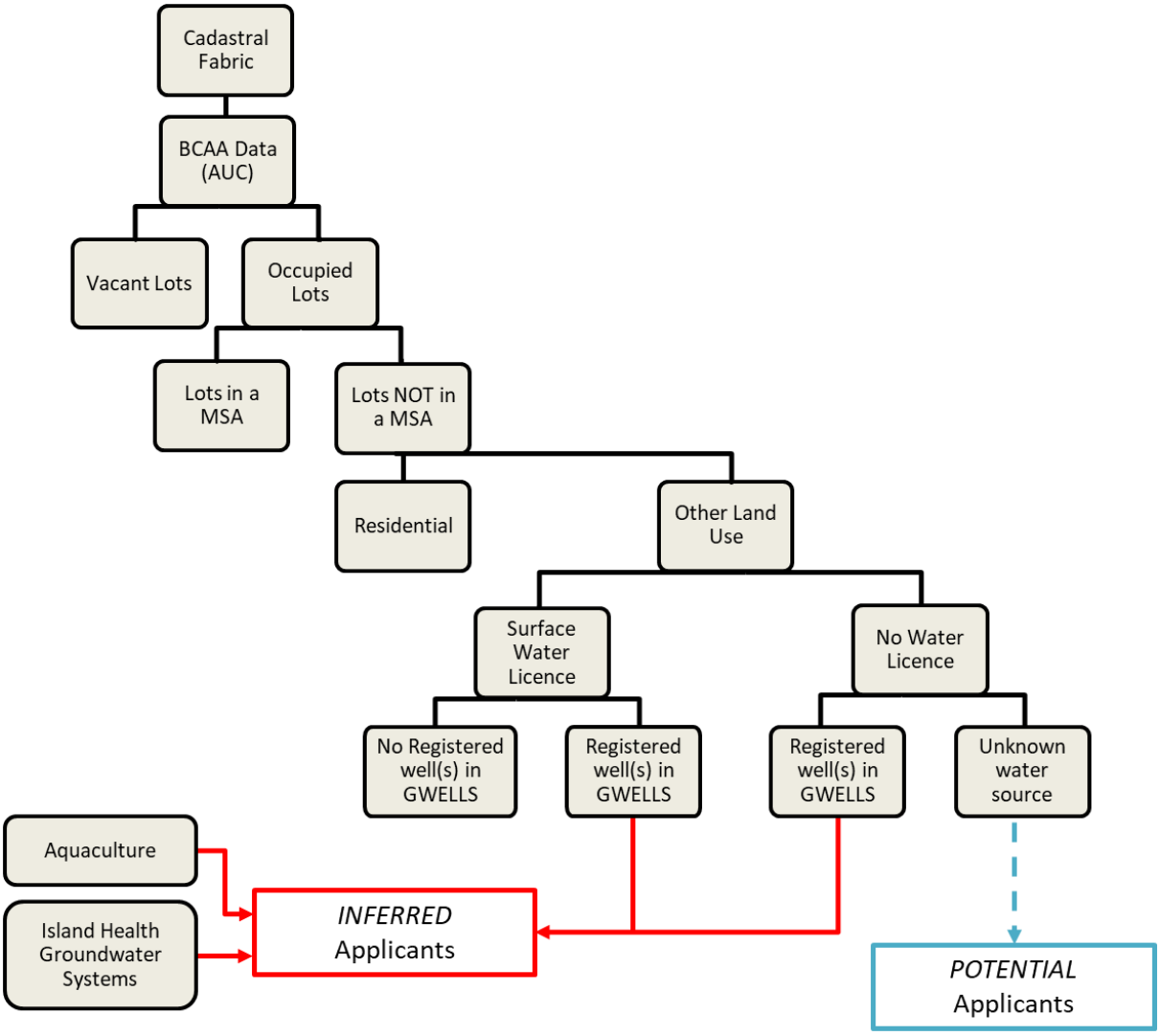


Figure 8: Flowchart illustrating work process to estimate number of inferred and potential groundwater users requiring a groundwater licence.

4. RESULTS AND DISCUSSION

4.1 Groundwater Demand

Table 5 summarizes the annual inferred groundwater demand within each water precinct and water use sector, based on the number of lots known to contain wells (Inferred Groundwater Users). It does not include potential groundwater users (e.g., lots with no documented alternate source of water).

The largest by volume use of groundwater in the region is expected to be for aquaculture operations (39%), followed by water supply systems (33%) and agriculture (20%). Together, these sectors constitute approximately 90% of the total anticipated groundwater demand in the West Coast Region. The remaining land uses (residential, civic, institutional and recreational, industrial, commercial, and transportation, communication and utility) use a much smaller proportion of the overall demand (less than 10%).

The data also suggested the water precincts with the highest relative groundwater demand are Nanaimo and Duncan, followed by Courtenay and Alberni (Table 5). Approximately 75% of the total groundwater demand in the Region is found in these four precincts.

Table 5: Inferred groundwater demand, by water precinct and water use sector (West Coast Region).

	ANNUAL DEMAND BY WATER USE PURPOSE (Millions m^3/year)									
Water Precinct	**Water Supply Systems**	**Aquaculture**	**Industrial**	**Farm (Irrigation)**	**Farm (Other Uses)**	**Residential**	**Civic, Institutional and Recreational**	**Commercial**	**Transportation, Communication and Utility**	**TOTAL**
Duncan	27.063	31.602	0.475	9.641	0.348	0.833	0.246	0.183	0.026	70.416
Alberni	0.049	31.260	0.037	1.060	0.019	0.069	0.349	0.045	0.016	32.904
Nanaimo	47.637	5.840	2.446	15.294	0.185	2.795	1.256	0.744	0.053	76.249
Shawnigan	4.945	0.715	0.219	11.599	0.152	1.830	0.948	0.503	0.029	20.941
Courtenay	6.179	21.760	2.044	8.794	0.230	0.861	0.511	0.274	0.015	40.668
Victoria	0.386	-	0.110	7.424	0.166	1.493	1.223	0.315	0.057	11.173
Sayward	7.365	13.758	0.146	0.880	0.007	0.202	0.505	0.222	0.040	23.125
Queen Charlotte	-	-	-	0.941	0.002	0.040	0.433	0.108	0.037	1.560
Bella Coola	-	-	-	0.231	0.004	0.020	0.142	0.022	0.013	0.430
Quatsino	2.971	6.328	-	-	-	0.005	0.138	0.007	-	9.449
Coast	-	-	-	-	-	-	0.007	-	-	0.007
TOTALS	96.596	111.264	5.475	55.863	1.112	8.149	5.757	2.422	0.285	286.923

Notes:

1. All demand values are based on number of non-vacant lots (BCAA dataset) with wells registered in the WELLS database.
2. Farm (Irrigation) demand is based on BCAA data and not Agricultural Water Use Models (see Section 3.2.3), as the latter data is limited to specific aquifers.
3. Water Supply system demand is based on an assigned minimum number of connections (VIHA data) and assumed household size and water use.
4. Other demand values are based on designated land use (BC Assessment AUC codes) and estimated demand as noted in Table 2.

4.2 Aquifer Demand

Table 6 summarizes the estimated groundwater demand by land use type, estimated supply in each mapped aquifer (recharge as a percentage of precipitation) and the demand vs recharge ratio each aquifer. It also includes aquifer characteristics, such as the aquifer sub-type and area. Aquifer sub-type describes the aquifer material and depositional environment for each aquifer (Appendix A2; Wei et al., 2009). In addition, total groundwater demand from unmapped areas are indicated in Table 6 for each precinct.

In more than half of the aquifers (i.e., 59%) in the West Coast Region, groundwater demand is estimated to be less than 15% of annual recharge. In 38 aquifers (i.e., 16 %) estimated groundwater demand exceeds 50% of the estimated recharge.

Nearly every precinct has at least one aquifer that has a high groundwater demand compared to recharge (i.e., demand calculated to exceed 50% of the estimated aquifer recharge), except for Bella Coola and Quatsino. In several of these aquifers, demand is estimated to exceed available supply. However, the methodology used in this analysis likely over-estimates the ratio of demand to recharge, particularly in smaller aquifers. For example, this analysis uses only a percentage of annual precipitation to calculate aquifer recharge and neglects groundwater inflow from upgradient geologic units, other aquifers, and hydraulically connected surface water bodies. Additionally, some of these aquifers are part of a layered aquifer system. In this study demand was conservatively attributed to all aquifers in layered systems, resulting in double (or even triple) accounting of water use estimates for some lots.

Table 6: Groundwater supply and demand, by aquifer.

Precinct	Aquifer Name	Annual Groundwater Demand, by purpose (m^3/yr)										Aquifer Type	Aquifer Area (km^2)	Recharge Volume (m^3)	Demand/ Recharge (%)
		Residential	Commercial	Civic, Institutional and Recreational	Farm (Irrigation)	Farm (Other Uses)	Aquaculture	Industrial	Transportation, Communication and Utility	Water Supply	TOTAL				
Alberni	693 IIA (12)	-	-	1,825	-	-	1,825,000	-	-	-	1,826,825	4a	0.274	61,601	2966%
Alberni	695 IIIC (7)	-	-	1,825	278,063	-	-	-	-	-	279,888	4b	1.225	275,703	102%
Alberni	692 IIIA (7)	-	-	-	287,910	13,432	-	-	-	-	301,342	4a	1.567	352,549	85%
Alberni	705 IIIC (6)	-	-	16,699	-	-	-	-	-	-	16,699	3	0.244	54,840	30%
Alberni	696 IIC (8)	1,324	-	10,950	228,299	13,432	-	-	-	-	254,005	5a	4.309	969,611	26%
Alberni	707 IIIC (5)	-	-	-	-	-	-	36,500	-	-	36,500	4b	0.632	142,228	26%
Alberni	698 IIC (10)	4,652	-	1,825	278,063	-	-	-	-	-	284,540	6b	5.610	1,262,149	23%
Alberni	703 IIIB (8)	-	-	26,828	-	-	-	-	-	-	26,828	4b	0.706	158,848	17%
Alberni	708 IIB (10)	-	-	5,977	-	-	-	36,500	-	-	42,477	6b	1.558	350,517	12%
Alberni	702 IB (11)	33,802	-	32,963	217,252	1,825	-	-	-	-	285,842	6b	18.035	4,057,768	7%
Alberni	699 IIIC (6)	-	-	13,174	-	-	-	-	-	-	13,174	6b	1.208	271,728	5%
Alberni	159 IIA (14)	-	-	73,740	-	-	-	-	1,825	48,662	124,227	2	12.394	2,788,755	4%
Alberni	865 IA (13)	-	-	1,697	-	-	-	-	-	-	1,697	1b	0.292	65,710	3%
Alberni	701 IIB (11)	9,965	730	-	-	-	-	-	1,825	-	12,520	6b	2.425	545,594	2%
Alberni	700 IIIC (7)	1,800	-	-	-	-	-	-	-	-	1,800	4b	0.383	86,079	2%
Alberni	704 IIIB (7)	1,426	-	-	-	-	-	-	-	-	1,426	4b	0.612	137,754	1%
Alberni	697 IIB (12)	3,463	-	1,944	25,419	1,825	-	-	-	-	32,651	5a	42.213	9,497,842	0%
Alberni	691 IIIB (7)	-	-	-	-	-	-	-	-	-	-	5a	29.308	6,594,275	0%
Alberni	694 IIB (8)	-	-	-	-	-	-	-	-	-	-	4b	0.194	43,593	0%
Alberni	Unmapped	14,312	44,530	188,177	23,268	1,825	29,434,565	-	12,775	-	29,719,886	-	-	-	-
Bella Coola	831 IIA (12)	-	-	12,775	-	-	-	-	-	-	12,775	3	1.115	250,931	5%
Bella Coola	830 IIA (10)	2,615	-	26,828	-	-	-	-	-	-	29,442	3	2.747	618,011	5%
Bella Coola	832 IIA (11)	8,964	7,300	12,775	-	-	-	-	-	-	29,039	3	3.523	792,674	4%
Bella Coola	833 IIA (9)	4,058	-	4,089	-	-	-	-	-	-	8,146	1b	2.185	491,704	2%
Bella Coola	Unmapped	4,193	14,600	85,233	230,516	3,650	-	-	12,775	-	350,968	-	-	-	-
Courtenay	414 IIA (13)	2,988	-	28,653	34,627	-	6,504,300	36,500	-	-	6,607,068	2	1.454	327,230	2019%
Courtenay	419 IIIB (12)	17,436	10,950	117	2,569	-	10,512,000	-	1,825	49,148	10,596,614	2	4.326	973,361	1089%
Courtenay	411 IIC (9)	8,336	-	-	434,813	-	-	-	-	-	877,962	5a	4.832	1,087,192	81%
Courtenay	416 IIB (12)	16,672	51,100	27,375	8,948	-	-	-	-	973,236	1,086,279	4b	13.736	3,090,662	35%
Courtenay	417 IIIA (10)	730	1,825	-	-	-	-	-	-	975,669	978,224	4a	14.931	3,359,393	29%
Courtenay	437 IIIA (11)	6,553	21,900	-	114,457	-	-	-	-	-	142,910	5a	2.202	495,520	29%
Courtenay	408 IIC (13)	267,171	54,750	88,355	2,893,949	132,756	15,914	36,500	1,825	111,922	6,497,091	4b	147.722	33,237,551	20%
Courtenay	410 IIA (11)	730	7,300	58,400	-	-	-	-	-	-	66,430	2	1.691	380,556	17%
Courtenay	407 IIA (10)	44,378	-	347	24,760	44	-	-	-	-	69,528	2	1.868	420,272	17%
Courtenay	857 IIIC (9)	-	10,950	70,882	-	-	-	-	-	-	81,832	4b	2.403	540,677	15%
Courtenay	436 IIA (13)	27,911	9,125	-	14,463	5,519	-	36,500	-	53,528	161,508	5a	5.174	1,164,131	14%
Courtenay	418 IIIC (8)	9,932	-	-	1,574	6,716	-	-	-	-	19,796	4b	0.749	168,460	12%
Courtenay	435 IA (15)	52,832	-	23,318	2,276	-	-	-	-	-	80,702	5a	3.789	852,416	9%
Courtenay	438 IIA (15)	193,079	23,725	37,257	30,983	5,475	-	36,500	-	5,353	363,355	5a	18.756	4,220,140	9%
Courtenay	975 IIA (10)	475	-	37,727	-	-	-	-	10,950	-	49,152	4a	3.465	779,672	6%
Courtenay	413 IIB (10)	11,188	-	1,825	195,011	35,405	-	36,500	-	-	474,940	5a	35.210	7,922,256	6%
Courtenay	739 IIB (8)	14,651	-	1,825	11,643	1,825	-	-	-	487	42,074	4b	3.958	890,613	5%
Courtenay	740 IIA (13)	126,669	51,100	49,631	20,255	7,431	-	36,500	-	48,662	360,502	5a	47.699	10,732,202	3%
Courtenay	415 IIIA (10)	-	-	-	1,550	-	-	-	-	-	3,100	2	0.800	179,933	2%

Table 6 (Cont'd.)

Precinct	Aquifer Name	Annual Groundwater Demand, by purpose (m^3/yr)										Aquifer Type	Aquifer Area (km^2)	Recharge Volume (m^3)	Demand/ Recharge (%)
		Residential	Commercial	Civic, Institutional and Recreational	Farm (Irrigation)	Farm (Other Uses)	Aquaculture	Industrial	Transportation, Communication and Utility	Water Supply	TOTAL				
Courtenay/ Nanaimo	665 IIIB (9)	9,286	14,600	26,778	15,274	1,825	-	-	1,825	-	69,589	4b	22.787	5,127,129	1%
Courtenay	952 IIA (9)	2,377	-	-	402	6,716	-	-	-	-	9,897	4a	3.576	804,711	1%
Courtenay	951 IIA (13)	2,971	-	-	25,617	-	-	-	-	2,433	31,021	4a	12.734	2,865,096	1%
Courtenay	950 IIIA (9)	5,959	-	1,646	-	-	-	-	-	-	7,605	5a	4.071	915,977	1%
Courtenay	421 IIIB (8)	4,448	-	5,475	-	-	-	-	-	-	9,923	4b	6.161	1,386,208	1%
Courtenay	976 IIC (7)	1,426	-	-	-	-	-	-	-	-	1,426	4b	0.893	200,938	1%
Courtenay	412 IIA (11)	2,037	-	-	-	1,825	-	-	-	-	3,862	2	3.229	726,598	1%
Courtenay	854 IIC (8)	238	-	-	-	-	-	-	-	-	238	4b	1.298	292,143	0%
Courtenay	847 IIB (8)	730	-	-	-	-	-	-	-	-	730	4b	14.295	3,216,324	0%
Courtenay	852 IIB (9)	-	-	-	-	-	-	-	-	-	-	4b	1.312	295,228	0%
Courtenay	420 IIB (9)	-	-	-	-	-	-	-	-	-	-	5a	0.379	85,270	0%
Courtenay	853 IIB (8)	-	-	-	-	-	-	-	-	-	-	4b	3.393	763,334	0%
Courtenay	409 IIIA (8)	-	-	-	-	-	-	-	-	-	-	2	1.291	290,502	0%
Courtenay	Unmapped	56,467	23,725	78,452	2,130,368	31,142	4,727,845	1,825,000	-	3,958,637	12,831,636	-	-	-	-
Duncan	948 IIIC (8)	-	-	-	-	-	-	-	-	973,236	973,236	4b	0.322	72,380	1345%
Duncan	174 IIC (8)	4,312	12,775	-	1,688,642	-	-	-	-	2,433	3,396,804	4b	1.475	331,957	1023%
Duncan	187 IIB (12)	3,582	12,775	31,557	331,566	44	12,453,280	36,500	1,825	975,669	14,178,364	1b	11.395	2,563,987	553%
Duncan	172 IA (14)	17,622	23,725	5,645	345,373	37,858	6,296,250	-	-	976,156	8,048,002	1b	7.526	1,693,254	475%
Duncan	186 IA (14)	15,670	12,775	37,032	331,566	22,017	12,453,280	36,500	1,825	978,102	14,220,332	1b	16.952	3,814,295	373%
Duncan	190 IIIA (9)	-	-	-	-	-	-	-	-	973,236	973,236	2	2.758	620,438	157%
Duncan	188 IIIC (10)	3,582	1,825	31,557	331,566	44	-	36,500	1,825	975,669	1,714,134	4b	8.671	1,951,016	88%
Duncan	197 IIC (11)	318,814	114,610	171,295	2,687,659	180,032	-	255,500	9,125	1,126,521	7,551,215	4b	39.478	8,882,555	85%
Duncan	198 IIIC (7)	42,833	3,650	16,429	840,920	56,721	-	109,500	3,650	487	1,074,191	5a	6.182	1,390,996	77%
Duncan	199 IIC (9)	12,801	-	5,475	161,704	28,689	-	73,000	1,825	487	445,684	4b	3.396	763,999	58%
Duncan	181 IC (8)	20,577	730	-	43,368	-	-	36,500	-	487	145,030	5a	1.268	285,376	51%
Duncan	175 IIB (10)	20,373	-	2,236	1,688,642	7,344	-	-	3,650	487	3,411,374	5a	42.912	9,655,226	35%
Duncan	945 IIC (8)	44,396	-	13,283	4,878	-	-	-	5,475	1,073,479	1,141,511	5a	15.625	3,515,651	32%
Duncan/ Nanaimo	170 IB (10)	28,844	-	478	47,523	6,716	-	-	-	-	131,084	6b	1.924	432,922	30%
Duncan	185 IIC (10)	57,010	12,775	4,075	236,332	27,492	-	36,500	-	2,433	612,948	4b	14.920	3,356,892	18%
Duncan	191 IIA (10)	20,729	-	13,283	-	-	-	-	1,825	97,810	133,647	2	3.394	763,659	18%
Duncan	171 IIIC (8)	36,383	7,300	-	244,318	30,514	-	-	-	-	562,833	5a	14.535	3,270,336	17%
Duncan	183 IIC (9)	46,196	10,950	10,950	43,368	14,016	-	-	-	48,662	217,509	4b	6.281	1,413,183	15%
Duncan	946 IIB (8)	22,019	-	7,642	-	-	-	-	-	51,582	81,243	6b	3.743	842,118	10%
Duncan	196 IIIC (8)	116,464	12,775	9,324	324,056	57,349	-	36,500	-	9,732	890,257	5a	45.983	10,346,170	9%
Duncan	180 IIC (9)	98,232	1,825	11,776	16,221	3,650	-	-	-	-	147,925	4b	8.420	1,894,392	8%
Duncan	179 IIIA (10)	20,509	-	22,446	16,221	1,825	-	-	-	49,148	126,370	1b	7.586	1,706,866	7%
Duncan	184 IIIA (9)	475	-	-	-	-	-	-	-	-	43,843	4a	2.649	595,952	7%
Duncan/ Shawnigan	189 IIA (12)	-	-	3,621	52,671	-	-	-	-	53,528	162,491	2	10.467	2,355,084	7%
Duncan	182 IIIC (9)	88,164	1,825	31,123	14,509	15,841	-	36,500	3,650	487	206,607	5a	31.643	7,119,619	3%
Duncan	173 IIIA (10)	52,410	20,075	25,317	14,409	26,251	-	-	-	51,582	204,452	6b	34.063	7,664,124	3%
Duncan	176 IIIA (9)	27,214	10,950	22	1,205	-	-	-	-	48,662	89,258	5a	15.547	3,498,034	3%
Duncan	949 IIA (10)	8,930	7,300	-	-	-	-	-	-	-	16,230	1b	2.928	658,874	2%

Table 6 (Cont'd.)

Precinct	Aquifer Name	Annual Groundwater Demand, by purpose (m^3/yr)										Aquifer Type	Aquifer Area (km^2)	Recharge Volume (m^3)	Demand/ Recharge (%)
		Residential	Commercial	Civic, Institutional and Recreational	Farm (Irrigation)	Farm (Other Uses)	Aquaculture	Industrial	Transportation, Communication and Utility	Water Supply	TOTAL				
Duncan	192 IIIC (9)	20,186	-	12,775	-	-	-	-	5,475	2,433	40,869	4b	8.910	2,004,687	2%
Duncan	178 IIIC (8)	29,235	-	-	17,370	44	-	-	1,825	487	48,961	4b	17.892	4,025,746	1%
Duncan	200 IIIB (9)	31,986	-	21,298	882	3,650	-	-	-	-	58,698	6b	26.940	6,061,476	1%
Duncan	177 IIIA (9)	12,054	-	-	1,205	-	-	-	-	-	14,464	5a	7.720	1,736,980	1%
Duncan	947 IIIC (7)	951	-	-	-	-	-	-	-	-	951	4b	1.160	260,913	0%
Duncan	Unmapped	32,087	24,455	22,560	442,866	1,825	399,456	36,500	-	18,590,267	19,550,017	-	-	-	-
Nanaimo	221 IIA (11)	2,411	14,600	17,253	824,610	1,825	-	-	-	97,324	1,782,632	2	4.029	906,513	197%
Nanaimo	661 IIIA (10)	9,032	-	17,036	-	-	-	1,095,000	-	-	1,123,561	4a	3.753	844,458	133%
Nanaimo	212 IIIC (6)	16,230	21,900	68,651	-	-	-	-	-	2,433	933,824	5a	5.908	1,329,219	70%
Nanaimo	210 IIB (10)	23,208	1,825	20,442	667,472	44	-	-	-	2,433	715,425	5a	5.363	1,206,599	59%
Nanaimo	216 IB (14)	61,543	41,975	83,417	824,610	15,301	-	36,500	9,125	981,022	2,878,103	4b	25.481	5,733,244	50%
Nanaimo	729 IA (13)	21,119	1,825	52	-	-	-	-	-	48,662	71,658	5a	0.644	144,815	49%
Nanaimo	167 IIIC (9)	42,953	22,630	45,537	140,367	5,475	-	1,095,000	-	51,582	1,543,910	4b	14.632	3,292,150	47%
Nanaimo	162 IA (16)	386,659	57,670	80,210	345,878	88,417	5,840,000	73,000	12,775	1,127,494	8,357,981	5a	84.198	18,944,568	44%
Nanaimo	215 IIC (10)	127,667	31,025	79,213	65,186	7,344	-	-	7,300	1,021,898	1,404,819	4b	14.339	3,226,226	44%
Nanaimo	160 IIC (9)	65,702	23,725	23,146	173,034	7,300	-	36,500	21,900	152,311	676,652	4b	8.874	1,996,607	34%
Nanaimo	963 IIA (12)	15,467	-	1,084	316,510	-	-	-	-	-	333,061	5a	5.110	1,149,780	29%
Nanaimo	214 IIB (10)	62,986	76,650	101,271	1,489,276	3,737	-	-	-	204,380	1,938,299	5a	30.403	6,840,703	28%
Nanaimo	1098 IIC (12)	57,129	62,050	32,000	1,256,647	1,912	-	-	-	58,394	1,468,132	UNK	24.415	5,493,273	27%
Nanaimo	662 IIC (12)	112,746	730	126,569	491,408	2,087	-	1,095,000	1,825	2,920	2,324,693	4b	53.022	11,929,868	19%
Nanaimo	211 IIB (12)	81,560	8,030	32,758	22,956	5,475	-	1,095,000	-	2,920	1,271,654	6b	29.574	6,654,166	19%
Nanaimo	209 IIC (9)	34,634	7,300	13,299	124,190	-	-	-	-	145,985	449,599	4b	10.678	2,402,636	19%
Nanaimo	213 IIC (11)	238,459	71,175	82,750	223,909	12,862	-	-	7,300	1,024,818	1,661,274	6b	41.953	9,439,330	18%
Nanaimo	220 IIB (11)	200,181	102,200	53,365	282,038	17,126	-	36,500	-	1,335,766	2,309,214	5a	59.235	13,327,938	17%
Nanaimo	962 IIA (7)	9,456	10,950	78	2,744	-	-	-	-	-	23,229	4a	0.602	135,360	17%
Nanaimo	169 IIIC (8)	2,156	-	-	175,946	13,432	-	-	1,825	-	369,305	4b	9.940	2,236,565	17%
Nanaimo	706 IA (15)	160,432	33,580	8,655	3,716	-	-	-	-	2,433	212,532	5a	5.871	1,321,011	16%
Nanaimo	730 IIB (10)	23,259	-	5,432	54,118	-	-	-	-	4,866	87,674	5a	2.658	598,151	15%
Nanaimo	161 IIA (15)	100,828	33,580	38,499	173,034	19,491	-	109,500	25,550	253,041	926,557	1b	31.188	7,017,207	13%
Nanaimo	217 IB (14)	95,853	20,075	214,993	407,986	12,191	-	-	3,650	60,827	1,223,561	4b	42.014	9,453,157	13%
Nanaimo	709 IIA (15)	828,510	71,175	123,115	25,734	7,562	-	-	-	62,774	1,144,603	5a	46.778	10,525,095	11%
Nanaimo	732 IA (12)	18,624	-	10,950	-	-	-	-	-	-	29,574	5a	1.242	279,344	11%
Nanaimo	163 IIB (9)	5,942	-	15,336	7,480	1,825	-	-	-	-	38,064	4b	1.642	369,353	10%
Nanaimo	964 IIB (10)	69,063	23,725	23,146	10,828	7,300	-	73,000	21,900	152,311	392,101	5a	17.309	3,894,583	10%
Nanaimo	165 IIB (10)	131,521	45,625	25,430	47,776	7,300	-	36,500	1,825	5,353	349,106	5a	17.441	3,924,164	9%
Nanaimo	219 IIC (9)	87,246	80,300	110,263	104,369	3,737	-	-	-	204,866	695,151	4b	37.785	8,501,670	8%
Nanaimo	731 IIA (12)	20,033	25,550	7,300	19,261	-	-	-	-	51,095	123,239	5a	6.759	1,520,852	8%
Nanaimo	663 IIIA (12)	11,443	-	11,025	-	-	-	36,500	-	97,324	158,009	4a	9.794	2,203,572	7%
Nanaimo	164 IIB (8)	41,968	-	15,639	10,065	7,300	-	-	-	-	74,973	5a	6.251	1,406,522	5%
Nanaimo	968 IA (10)	13,412	-	6,679	-	-	-	-	-	-	20,091	5a	1.972	443,593	5%
Nanaimo	218 IIB (9)	20,186	-	1,916	17,301	1,825	-	-	-	48,662	107,191	5a	15.779	3,550,243	3%
Nanaimo	742 IB (9)	475	-	-	-	-	-	-	-	-	475	5a	0.074	16,577	3%
Nanaimo	664 IA (13)	6,604	7,300	12,775	-	-	-	-	-	-	26,679	1b	4.958	1,115,608	2%
Nanaimo	168 IIIB (6)	21,900	10,950	136	2,744	-	-	-	-	-	35,731	5a	6.728	1,513,819	2%

Table 6 (Cont'd.)

Precinct	Aquifer Name	Annual Groundwater Demand, by purpose (m^3/yr)										Aquifer Type	Aquifer Area (km^2)	Recharge Volume (m^3)	Demand/ Recharge (%)
		Residential	Commercial	Civic, Institutional and Recreational	Farm (Irrigation)	Farm (Other Uses)	Aquaculture	Industrial	Transportation, Communication and Utility	Water Supply	TOTAL				
Nanaimo	741 IB (9)	730	-	-	-	-	-	-	-	-	730	5a	0.150	33,759	2%
Nanaimo	166 IIIB (7)	8,658	10,950	35,002	-	-	-	-	-	-	54,610	6b	12.023	2,705,139	2%
Nanaimo	734 IIB (8)	475	-	-	-	-	-	-	-	-	475	5a	0.142	31,879	1%
Nanaimo	965 IIA (9)	1,443	-	-	-	-	-	-	-	-	1,443	5a	0.970	218,201	1%
Nanaimo	966 IIB (8)	594	-	9,526	-	-	-	-	-	-	10,120	5a	24.525	5,518,092	0%
Nanaimo	Unmapped	80,709	85,775	205,397	356,819	1,825	365	-	-	40,433,090	41,163,980	-	-	-	-
Quatsino	907 IIIB (8)	-	-	10,950	-	-	-	-	-	-	10,950	5a	1.103	248,269	4%
Quatsino	Unmapped	5,263	7,300	126,986	-	-	6,328,005	-	-	2,970,803	9,438,357	-	-	-	-
Sayward	1096 IC (9)	-	-	29,821	-	-	4,015,000	-	-	-	4,044,821	UNK	2.157	485,404	833%
Sayward	1087 IC (11)	832	-	53,655	66,978	-	7,153,416	-	-	-	7,274,881	UNK	4.764	1,071,980	679%
Sayward	902 IIIB (10)	-	-	1,825	-	-	-	36,500	1,825	973,236	1,013,386	4b	1.047	235,626	430%
Sayward	752 IIC (9)	9,236	-	-	230,971	-	-	36,500	-	-	276,707	4b	1.142	256,941	108%
Sayward	759 IB (9)	10,356	-	17,225	-	-	-	-	-	-	27,581	6b	0.223	50,137	55%
Sayward	760 IIB (9)	7,012	1,825	38,792	-	-	-	-	-	-	47,628	6b	0.509	114,530	42%
Sayward	754 IB (9)	24,056	45,625	39,648	-	-	-	-	-	48,662	157,992	6b	2.270	510,726	31%
Sayward	762 IC (10)	40,235	38,325	22,700	-	-	-	-	-	-	101,261	4b	1.592	358,100	28%
Sayward	1115 IIIC (8)	3,837	-	-	331,698	-	-	-	-	2,433	337,968	4c	6.168	1,387,736	24%
Sayward	757 IIB (8)	4,855	-	11,148	-	1,825	-	-	-	-	17,828	6b	0.350	78,763	23%
Sayward	758 IB (9)	8,251	-	-	-	-	-	-	-	-	8,251	6b	0.163	36,649	23%
Sayward	753 IIB (11)	22,070	36,500	56,080	-	-	-	-	-	-	114,650	4b	3.109	699,533	16%
Sayward	904 IIA (9)	-	22,630	10,950	-	-	-	-	-	-	33,580	5a	0.950	213,724	16%
Sayward	764 IIB (11)	15,789	1,825	74,370	3,886	-	-	-	12,775	487	109,131	4b	3.556	799,996	14%
Sayward	901 IIIB (8)	951	7,300	-	-	-	-	-	-	-	8,251	4b	0.302	68,013	12%
Sayward	974 IIB (9)	3,803	-	10,950	-	1,825	-	-	-	-	16,578	4b	0.695	156,355	11%
Sayward	756 IIB (9)	43,750	45,625	33,848	-	1,825	-	-	-	-	125,048	6b	5.740	1,291,543	10%
Sayward	1051 IIIA (9)	2,632	10,950	-	134,813	3,650	-	-	-	53,528	205,573	UNK	9.674	2,176,738	9%
Sayward	858 IB (12)	475	-	37,778	-	-	-	-	-	48,662	86,915	4b	4.468	1,005,278	9%
Sayward	906 IIB (8)	8,488	-	20,568	-	-	-	-	10,950	-	40,007	4b	2.219	499,303	8%
Sayward	751 IIB (9)	10,628	-	-	8,280	-	-	-	-	-	18,908	4b	1.127	253,483	7%
Sayward	905 IIB (9)	5,585	-	20,568	-	-	-	-	-	-	26,154	5a	4.821	1,084,733	2%
Sayward	755 IIC (8)	7,742	-	-	-	-	-	-	-	-	7,742	4b	2.146	482,780	2%
Sayward	900 IIIC (7)	3,582	7,300	-	-	-	-	-	-	-	10,882	4b	3.286	739,410	1%
Sayward	763 IIB (7)	2,258	-	-	-	-	-	-	-	-	2,258	5a	0.830	186,736	1%
Sayward	859 IIIC (7)	4,058	-	-	-	-	-	-	-	-	4,058	4b	2.731	614,531	1%
Sayward	1055 IIIC (8)	5,721	-	-	-	-	-	-	-	-	5,721	UNK	5.841	1,314,142	0%
Sayward	761 IIA (11)	-	-	-	-	-	-	-	-	-	-	3	0.101	22,777	0%
Sayward	Unmapped	46,026	87,600	212,493	238,435	1,825	2,589,310	73,000	14,600	6,238,443	9,501,732	-	-	-	-
Shawnigan	155	36,296	-	4	295,289	-	715,400	-	-	-	1,046,989	4b	0.316	71,107	1472%
Shawnigan	712 IIA (13)	39,387	12,775	1,874	919,690	-	-	-	-	-	973,727	5a	6.288	1,414,788	69%
Shawnigan	620 IB (13)	39,031	10,950	43,883	914,231	1,825	-	-	-	487	1,010,406	5a	7.739	1,741,221	58%
Shawnigan	205 IIC (9)	27,486	2,555	-	55,601	28,689	-	73,000	-	97,324	340,256	4b	2.729	613,973	55%
Shawnigan	619 IIB (13)	37,129	53,655	50,553	770,511	3,694	-	-	3,650	2,433	921,624	5a	7.989	1,797,548	51%
Shawnigan	711 IIA (13)	98,841	43,435	107,737	867,301	1,825	-	-	-	-	1,119,138	5a	11.337	2,550,921	44%

Table 6 (Cont'd.)

Precinct	Aquifer Name	Annual Groundwater Demand, by purpose (m^3/yr)										Aquifer Type	Aquifer Area (km^2)	Recharge Volume (m^3)	Demand/ Recharge (%)
		Residential	Commercial	Civic, Institutional and Recreational	Farm (Irrigation)	Farm (Other Uses)	Aquaculture	Industrial	Transportation, Communication and Utility	Water Supply	TOTAL				
Shawnigan	632 IIB (10)	17,232	7,300	630	328,370	44	-	-	-	2,433	356,009	5a	3.898	876,960	41%
Shawnigan	447 IIA (11)	10,017	-	13,342	302,173	1,825	-	-	1,825	-	329,182	5a	3.736	840,602	39%
Shawnigan	1148	4,278	-	-	35,759	-	-	-	-	-	75,796	0	1.021	229,776	33%
Shawnigan	204 IIB (11)	206,596	29,930	39,090	236,911	48,808	-	36,500	-	51,095	885,840	6b	16.580	3,730,499	24%
Shawnigan / Duncan / Victoria	201 IIC (8)	7,844	-	-	28,531	15,257	-	-	-	-	80,163	4b	2.113	475,342	17%
Shawnigan	710 IIB (11)	62,730	-	65,522	211,490	3,650	-	-	-	-	343,392	5a	9.126	2,053,260	17%
Shawnigan	207 IIB (12)	152,710	28,105	85,863	100,596	55,553	-	109,500	1,825	197,080	831,828	6b	25.104	5,648,341	15%
Shawnigan	206 IIA (11)	14,770	23,725	27,643	4,532	-	-	-	1,825	-	72,495	4a	2.574	579,040	13%
Shawnigan	157	26,094	-	10,950	50,115	5,519	-	-	1,825	-	144,618	4b	5.568	1,252,799	12%
Shawnigan	735 IA (11)	23,785	7,300	934	-	-	-	-	-	2,433	34,451	5a	1.373	308,890	11%
Shawnigan	720 IIB (11)	30,763	20,440	10,010	98,094	-	-	-	-	48,662	207,969	5a	9.498	2,137,036	10%
Shawnigan	737 IB (11)	12,716	-	-	37,751	-	-	-	-	-	50,467	5a	2.870	645,744	8%
Shawnigan	320 IIB (14)	247,732	140,890	249,117	352,612	3,737	-	-	5,475	5,353	1,004,916	5a	58.150	13,083,788	8%
Shawnigan	203 IIA (12)	171,247	22,630	24,417	6,458	8,541	-	-	1,825	145,985	387,562	6b	31.017	6,978,785	6%
Shawnigan	721	243,402	27,740	2,808	142,844	9,125	-	-	10,950	-	579,712	5a	48.930	11,009,311	5%
Shawnigan / Duncan	202 IIB (10)	72,867	9,125	8,063	6,458	30,514	-	-	-	48,662	182,147	6b	20.997	4,724,337	4%
Shawnigan	722	106,245	9,490	20,765	60,937	3,694	-	36,500	-	-	298,568	6b	36.395	8,188,987	4%
Shawnigan / Victoria	208 IIA (12)	30,611	51,100	47,991	9,540	-	-	-	1,825	97,324	238,390	6b	31.891	7,175,480	3%
Shawnigan	156	9,932	-	-	2,710	-	-	-	-	-	15,352	4b	2.293	515,824	3%
Shawnigan	1147	133,970	1,460	87,265	42,930	7,387	-	-	-	-	315,943	0	48.770	10,973,206	3%
Shawnigan	750 IIC (7)	832	-	-	-	-	-	-	-	-	832	4b	0.135	30,448	3%
Shawnigan	723	51,374	730	29,658	76,839	5,519	-	-	1,825	-	242,784	6b	51.398	11,564,579	2%
Shawnigan	736 IIB (8)	3,463	7,300	-	-	-	-	-	-	-	10,763	5a	2.610	587,301	2%
Shawnigan	733 IB (9)	475	-	-	-	-	-	-	-	-	475	5a	0.135	30,484	2%
Shawnigan	967 IIA (10)	3,328	-	-	-	-	-	-	-	-	3,328	5a	0.971	218,466	2%
Shawnigan	738 IIB (8)	-	-	-	-	-	-	-	-	-	-	5a	0.275	61,872	0%
Shawnigan	Unmapped	23,225	-	47,512	230,431	1,825	-	-	-	4,246,229	4,549,221	-	-	-	-
Victoria	617 IIC (7)	4,058	-	-	43,267	1,825	-	-	-	-	49,150	4b	0.114	25,619	192%
Victoria	613 IIB (8)	6,231	10,950	5,475	185,305	-	-	-	-	-	207,961	4b	0.540	121,554	171%
Victoria	783 IIA (8)	-	-	-	305,018	-	-	-	-	-	305,018	5a	1.407	316,666	96%
Victoria	615 IIIB (8)	6,757	-	90	627,661	12,366	-	-	-	-	646,874	4b	3.393	763,352	85%
Victoria	609 IIIB (7)	5,042	-	-	70,723	44	-	-	10,950	-	86,759	4b	0.547	123,108	70%
Victoria	612 IIB (9)	18,301	45,625	980	1,161,703	7,693	-	-	-	2,920	1,237,223	4b	8.510	1,914,859	65%
Victoria	604 IIIC (6)	17,249	-	1,825	174,812	-	-	-	-	2,920	196,806	4b	2.032	457,172	43%
Victoria	610 IIB (9)	14,974	10,950	7,300	29,871	3,650	-	-	10,950	-	77,694	4b	1.036	233,047	33%
Victoria	608 IIB (14)	266,287	90,155	270,740	4,260,555	88,794	-	-	23,725	487	5,000,742	6b	79.720	17,937,013	28%
Victoria	611 IIB (8)	7,198	-	58,439	40,243	3,781	-	-	-	-	109,661	4b	2.106	473,836	23%
Victoria	614 IIIB (10)	77,807	10,950	41,522	676,926	12,950	-	-	-	51,095	871,250	6b	17.261	3,883,699	22%
Victoria	683 IIIC (8)	22,631	1,825	116,800	198,762	1,825	-	-	-	-	341,843	4b	8.962	2,016,455	17%
Victoria	607 IIIB (8)	51,814	730	-	240,087	3,650	-	-	10,950	-	307,231	5a	9.060	2,038,528	15%
Victoria	681 IA (11)	101,132	-	40,611	89,432	-	-	-	-	-	231,174	6b	7.866	1,769,902	13%

Table 6 (Cont'd.)

Precinct	Aquifer Name	Annual Groundwater Demand, by purpose (m^3/yr)										Aquifer Type	Aquifer Area (km^2)	Recharge Volume (m^3)	Demand/ Recharge (%)
		Residential	Commercial	Civic, Institutional and Recreational	Farm (Irrigation)	Farm (Other Uses)	Aquaculture	Industrial	Transportation, Communication and Utility	Water Supply	TOTAL				
Victoria	605 IIIC (6)	3,616	-	-	-	-	-	-	-	-	3,616	4b	0.133	30,029	12%
Victoria	786 IIIB (11)	-	-	56,259	-	-	-	-	-	-	56,259	4b	2.289	515,044	11%
Victoria	944 IIB (11)	7,419	-	50,690	-	-	-	-	-	-	58,109	4b	2.617	588,852	10%
Victoria	599 IIIA (11)	42,817	1,825	79,707	293,581	1,825	-	-	-	2,920	422,674	4b	19.251	4,331,525	10%
Victoria	778 IIB (7)	475	-	-	-	-	-	-	-	-	475	5a	0.028	6,371	7%
Victoria	680 IB (14)	497,860	60,225	383,629	908,416	38,500	-	36,500	18,250	50,122	1,993,502	6b	209.014	47,028,069	4%
Victoria	787 IIIC (9)	2,411	-	34,679	-	-	-	-	-	-	37,090	6b	4.133	929,900	4%
Victoria	781 IA (10)	119	-	-	-	-	-	-	-	-	119	5a	0.014	3,054	4%
Victoria	782 IIA (8)	475	-	-	-	-	-	-	-	-	475	5a	0.060	13,592	3%
Victoria	616 IIC (11)	4,058	-	-	4,065	1,825	-	-	-	48,662	58,609	4b	7.852	1,766,798	3%
Victoria	682 IIIB (11)	18,369	34,675	68,722	31,001	1,869	-	-	-	-	154,636	4a	24.084	5,418,963	3%
Victoria	942 IIA (11)	10,492	-	10,732	3,530	-	-	-	-	-	24,754	6b	5.676	1,277,024	2%
Victoria	606 IIIA (12)	465,233	100,375	287,458	1,201,922	27,462	-	73,000	3,650	10,219	2,169,319	6b	537.614	120,963,236	2%
Victoria	943 IIB (8)	12,835	-	50,690	-	-	-	-	-	-	63,525	6b	16.255	3,657,276	2%
Victoria	618 IIIC (8)	1,307	16,425	593	-	-	-	-	-	-	18,325	6b	5.844	1,314,789	1%
Victoria	780 IIC (6)	475	-	-	-	-	-	-	-	-	475	5a	0.153	34,331	1%
Victoria	785 IIA (8)	119	-	-	-	-	-	-	-	-	119	5a	0.050	11,273	1%
Victoria	784 IIA (8)	475	-	-	-	-	-	-	-	-	475	5a	0.245	55,126	1%
Victoria	685 IIIA (14)	730	-	21,624	-	-	-	-	-	48,662	71,016	1b	41.185	9,266,617	1%
Victoria	449 IIIC (10)	21,748	8,030	5,455	-	3,650	-	-	-	-	38,883	5a	28.132	6,329,621	1%
Victoria	779 IIB (7)	119	-	-	-	-	-	-	-	-	119	5a	0.147	33,123	0%
Victoria	684 IIIA (10)	-	-	-	-	-	-	-	-	-	-	1c	0.255	57,310	0%
Victoria	686 IIIC (7)	-	-	-	-	-	-	-	-	-	-	4b	7.288	1,639,896	0%
Victoria	Unmapped	3,107	-	81,929	-	-	-	-	-	167,883	252,919	-	-	-	-

Notes:

1. The groundwater demands are calculated based on BCAA dataset and the estimated groundwater demands, with the exception of Aquaculture and Water Supply. These groundwater demands were sourced from external datasets provided by FLNR and IH.
2. The total groundwater demand may be slightly higher than presented in Table 5 due to groundwater demand assigned to all stacked aquifers, thus over-estimating the groundwater demand.
3. Several aquifers cross boundaries between several precincts, and the groundwater demand and recharge shown, is calculated based on the whole aquifer extent.

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4.3 Transitioning Groundwater Licence Workload

The BC Authority Assessment data indicated that there are approximately 307,000 individual lots within the West Coast Region. Within the BCAA dataset, the lots were categorized into one of six primary use codes (Residential; Commercial; Civic, Institutional and Recreational; Farm; Transportation, Communication and Utility; and Industrial). The BCAA dataset does not link to all cadastre parcels within the West Coast Region (e.g., where parcels have been subdivided, etc.), and approximately 19,300 lots (6.5%) have no land use information. These lots are assumed to be vacant for the purpose of this exercise.

Of the 307,000 lots, approximately 292,000 lots were considered to not require a groundwater licence as they are associated with a water service area, surface water licence, vacant lot, residential lot, or an excluded land use (Figure 8). Non-vacant lots having an existing surface water licence and unlicensed wells may require a groundwater licence, however for this exercise it was assumed that those wells were back-up water source only. This assumption was applied to 555 lots of which 413 lots have predominantly farm use categories.

Coupling the GWELLS database with the BCAA dataset indicates there are 2,775 non-residential occupied lots with registered wells outside of municipal water service areas. Over 90% of the 2,775 lots are located in Nanaimo, Victoria, Duncan, Shawnigan and Courtenay (Table 7). These lots are also anticipated to require groundwater licences. Additionally, there are nearly 12,000 lots with an 'unknown' land use and unknown water source (i.e., occupied lots outside of a municipal water service area, with no registered wells or water licences). It is expected that some proportion of these lots may also use groundwater and require a groundwater licence.

There are about 3,500 lots that are inferred to require a groundwater licence, based on the presence of groundwater wells on non-vacant, non-domestic parcels (indicated by BCAA land use codes) and supplementary data on water supply system and aquaculture. This number quantifies the lots with potential groundwater use while excluding residential and unknown land uses (Table 8).

This assessment may under- or overestimate the total number of transitioning groundwater users for the following reasons:

- Estimated land use was based solely on the BCAA data.
- The BCAA data indicated that only 225 lots are assigned a land use code for water distribution, whereas the Island Health data indicates that up to 513 water supply systems use groundwater. Although it is possible that water supply systems may also be captured under another land use code, there may be water supply systems that are not captured within the BCAA data and also require a groundwater licence.
- Large industrial or agricultural water users within water service areas may use water from a water distribution system for human uses but maintain a separate groundwater system for their industrial operations. An example of this is seen in the aquaculture industry in Duncan where several operations within the City of Duncan service area have their own wells.
- The dataset of service areas is incomplete. We suspect that many of the lots which do not identify a source of water are being supplied from a community system. In other words, while it was assumed that each lot with inferred or potential groundwater use would require its own well, it is likely that there are a number of water supply systems supplying several lots from a single well or well field on a single parcel.
- The entries in the GWELLS database are largely based on construction records completed at the time of well drilling and are rarely updated when the status of well changes (e.g., an inactive well could be activated, or an active well deactivated).

- Landowners with both groundwater and surface water sources on their properties were not included in the assessment, though they may use groundwater to supplement their surface water needs during low flows or use groundwater for non-domestic purposes (e.g., irrigation). Some water users likely did not abandon their surface water rights when they started using groundwater.
- A total of 1,717 lots have both a registered well and an active surface water licence. It is unknown as to what portion of their water demand (e.g., partial or full) could be or is being met by their surface water licence, and whether these landowners would apply for a transitioning groundwater licence or abandon their well.

The number of groundwater supply systems (IH data) and non-vacant lots with registered wells, by land use (sector), within each precinct are summarized in Table 8. These numbers provide an indication of the number of groundwater licences expected in each water use sector.

Table 7: Number of lots with registered wells and unknown water sources, by precinct.

Precinct	Total number of lots with registered wells [1]	Total number of non-vacant, non-residential lots	
		with registered wells [2]	with unknown water source [3]
Nanaimo	9,714	687	2,148
Victoria	6,767	595	4,128
Duncan	4,286	457	1,429
Shawnigan	7,691	511	608
Courtenay	3,674	331	889
Sayward	812	87	1,149
Alberni	487	43	1,406
Queen Charlotte	242	47	2,760
Bella Coola	104	8	144
Quatsino	59	8	458
Coast	5	1	73
Totals	33,841	2,775	15,192

Notes:

1. All wells included in the GWELLS database including domestic wells, and there is potential for multiple wells on a lot.
2. Lots with well(s) registered in the BC Wells database and non-residential land use.
3. Occupied lots outside of a known municipal water service area, with no registered wells or water licence (excluding residential and unknown primary uses).

Table 8: Anticipated number of transitioning groundwater licence applicants, by precinct and water use.

	IH Data	Ministry of Environment Data	BCAA Data						TOTAL [1]
Water Precinct	**Water Supply Systems [2,3]**	**Aquaculture**	**Industrial [4]**	**Farm (All Uses)**	**Civic, Institutional and Recreational**	**Commercial**	**Transportation, Communication and Utility**	**Unknown**	
Nanaimo	229	2	14	398	51	121	4	99	930
Shawnigan	49	1	12	308	37	81	1	72	550
Victoria	31	-	5	445	30	47	4	64	631
Duncan	67	2	18	327	21	30	2	59	536
Courtenay	81	4	7	234	16	38	1	35	369
Sayward	41	3	12	13	14	32	3	13	116
Alberni	10	5	2	14	4	8	1	14	49
Queen Charlotte	-	-	1	6	5	14	3	18	47
Bella Coola	-	-	-	3	1	3	1	-	8
Quatsino	5	1	3	-	3	1	-	1	14
Coast	-	-	-	-	-	-	-	1	1
TOTALS	**513**	**18**	**74**	**1,748**	**182**	**375**	**20**	**376**	**3,306**

Notes:

1. Number of transitioning groundwater licences based on IH data, aquaculture data, and non-vacant, non-residential lots with registered wells.
2. Number of groundwater licences based on number of water supply systems whose source includes groundwater (IH data).
3. The total number of licences associated with water supply systems may be overestimated as the BCAA data includes 29 lots with registered wells used for water distribution.
4. The location of the 25 'Sea food' lots included in the industrial category could not be verified, and there is a chance they are double counted with Aquaculture.

The number of transitioning groundwater licence applicants based on land use/sector is expected to be 3,306 (Table 8). This number does not include lots that have either an existing groundwater or surface water licence (592 lots), un-serviced lots with an unknown water supply, or the 95 lots with groundwater licences issued or pending approval from 2016 to 2018. This number is based on lots inferred to be using groundwater and does not account for licences that could be appurtenant to multiple lots.

The three land uses (sectors) which correspond to the largest number of possible groundwater licence applications are Farm, Water Supply Systems and Commercial (Table 8). These land uses corresponded to approximately 80% of the expected number of groundwater licences. Of the commercial lots approximately 27% corresponded to offices and/or stores, 25% corresponded to hotels, motels, bed and breakfast operations, campgrounds, and resorts, and 5% corresponded to restaurants, pubs, and halls.

Table 9 ranks the top five Water Precincts based on highest groundwater demand, highest number of expected groundwater licences, and potential for high groundwater demand compared to recharge.

Table 9: Top five water precincts, ranked by demand, potential for high demand compared to recharge, and expected number of licences.

Total Potential Groundwater Demand[1]	Number of Aquifers where Demand Greatly Exceeds Recharge[2]	Number of Potential Transitioning Groundwater Licences[3]
Alberni	Nanaimo	Nanaimo
Nanaimo	Duncan	Victoria
Duncan	Sayward	Shawnigan
Courtenay	Alberni	Duncan
Sayward	Victoria	Courtenay

1. Total groundwater demand by volume (based on results shown in Table 5).
2. Based on number of aquifers classified as having groundwater demand vs supply ratios exceeding 50% (Table 6).
3. Number of transitioning groundwater licences based on number of lots with registered wells (Table 7).

4.4 Analysis Limitations

This assessment was intended to be a high-level screening study and only provides an indication of potential groundwater demand, relative demand within each water precinct and aquifer, and number of expected groundwater licence applications. The results should not be construed as a detailed or accurate estimate due to several limitations, including:

- The estimate of inferred groundwater licence applications was partly based on the number of lots with registered wells, however the GWELLS database is not expected to fully capture all existing active wells;
- The IH input data set did not provide enough detail to quantify actual number of groundwater users or demand. For example, the IH data only provides coarse categorization of number of connections within the IH dataset, and the number of connections may not necessarily correspond (correlate) to the actual groundwater demand (e.g., some single connection water supply systems may correspond to bulk groundwater providers);
- The water supply/service area dataset used in this analysis was incomplete;
- The actual use codes assigned in the BCAA data may not represent all land uses on a lot, and AUCs are missing for many parcels due to incomplete record joins during the geoprocessing workflow and lack of AUC data for some parcels;

- The assigned groundwater demand values were based on estimates from other datasets or reports and does not represent actual groundwater usage;
- Groundwater demand for parcels located above overlapping aquifers was conservatively assigned to all underlying aquifers. While this provides a conservative indication of unsustainable groundwater use, it overestimates (e.g., duplicates) groundwater demand for lots in these areas;
- Aquifer recharge was based solely on a percentage of precipitation and neglected lateral groundwater movement and the connection of surface water;
- The inferred groundwater demand associated with specific land uses and assumed irrigation or watering areas may not be representative of all lots. Our analysis is based on assumed average water use rates and/or assumed percentage areas of use (e.g., some parks and playing fields or farms, with a well, may use groundwater at a greater or lesser rate over a different proportion of the total lot area); and
- There were discrepancies between the lot boundaries and identifiers defined in the differing datasets (e.g., BCAA and cadastral layers), which may affect the identification of lots and lots with wells.

5. CONCLUSIONS

This study compiled several datasets to estimate existing groundwater demand at the lot level. Various data sources were integrated and then utilized to rank the relative groundwater demand and identify precincts and/or aquifers of potential concern. The data suggests that existing groundwater demand in several aquifers may be unsustainable and/or result in potential impacts to baseflows and instream flow needs.

The total number of inferred transitioning groundwater licence applicants, based on identified groundwater supply systems and non-residential lots with registered wells, was expected to be around 3,300. However, this does not include lots with both registered wells and surface water licences (i.e., 590 lots) or 15,192 un-serviced lots with unidentified sources of water supply.

5.1 Recommendations

The following recommendations are suggested to improve the estimate of transitioning groundwater licences and potential groundwater demand:

- Focus on completeness of the water supply system dataset. This improved dataset should incorporate Island Health and municipal data, and confirm service areas and groundwater use;
- Incorporate additional government datasets, where available and as they are updated, to further refine potential or inferred groundwater use and demand;
- Identify and investigate specific high demand water users or lots of interest (e.g., pulp and paper, aquaculture, mining, farm, parks and playing fields) to confirm actual groundwater use. These water users may require very high volumes of water relative to other users and may significantly impact estimates of supply and demand assessments; and
- Refine the groundwater demand assessment in consideration of groundwater extraction from specific aquifers, particularly where there are layered aquifer systems or aquifer complexes.

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APPENDICES

Appendix A1: British Columbia Assessment Authority (BCAA) Actual Use Codes (AUC)

Residential	**0-100**
Farm	**100s**
Commercial	**200s**
Unknown	**300s**
Industrial	**400s**
Transport/utilities	**500s**
Civic institution	**600s**

BC Assessment Codes	Description	AUC_Code	PRIMARY_AC
000 Single Family Dwelling	Single Family Dwelling	000	Residential
001 Vacant Residential Less Than 2 Acres	Vacant Residential Less Than 2 Acres	001	Residential
002 Property Subject To Section 19(8)	Property Subject To Section 19(8)	002	Residential
020 Residential Outbuilding Only	Residential Outbuilding Only	020	Residential
029 Strata Lot (Parking Residential)	Strata Lot (Parking Residential)	029	Residential
030 Strata-Lot Residence (Condominium)	Strata-Lot Residence (Condominium)	030	Residential
031 Strata-Lot Self Storage-Res Use	Strata-Lot Self Storage-Res Use	031	Residential
032 Residential Dwelling with Suite	Residential Dwelling with Suite	032	Residential
033 Duplex, Non-Strata Side by Side or Front / Back	Duplex, Non-Strata Side by Side or Front / Back	033	Residential
034 Duplex, Non-Strata Up / Down	Duplex, Non-Strata Up / Down	034	Residential
035 Duplex, Strata Side by Side	Duplex, Strata Side by Side	035	Residential
036 Duplex, Strata Front / Back	Duplex, Strata Front / Back	036	Residential
037 Manufactured Home (Within Manufactured Home Park)	Manufactured Home (Within Manufactured Home Park)	037	Residential
038 Manufactured Home (Not In Manufactured Home Park)	Manufactured Home (Not In Manufactured Home Park)	038	Residential
039 Row Housing (Single Unit Ownership)	Row Housing (Single Unit Ownership)	039	Residential
040 Seasonal Dwelling	Seasonal Dwelling	040	Residential
041 Duplex, Strata Up / Down	Duplex, Strata Up / Down	041	Residential
042 Strata-Lot Seasonal Dwelling (Condominium)	Strata-Lot Seasonal Dwelling (Condominium)	042	Residential
043 Parking (Lot Only, Paved Or Gravel-Res)	Parking (Lot Only, Paved Or Gravel-Res)	043	Residential
047 Triplex	Triplex	047	Residential
049 Fourplex	Fourplex	049	Residential
050 Multi-Family (Apartment Block)	Multi-Family (Apartment Block)	050	Residential
051 Multi-Family (Vacant)	Multi-Family (Vacant)	051	Residential
052 Multi-Family (Garden Apartment & Row Housing)	Multi-Family (Garden Apartment & Row Housing)	052	Residential
053 Multi-Family (Conversion)	Multi-Family (Conversion)	053	Residential
054 Multi-Family (High-Rise)	Multi-Family (High-Rise)	054	Residential
055 Multi-Family (Minimal Commercial)	Multi-Family (Minimal Commercial)	055	Residential
056 Multi-Family (Residential Hotel)	Multi-Family (Residential Hotel)	056	Residential
057 Stratified Rental Townhouse	Stratified Rental Townhouse	057	Residential
058 Stratified Rental Apartment (Frame Construction)	Stratified Rental Apartment (Frame Construction)	058	Residential
059 Stratified Rental Apartment (Hi-Rise Construction)	Stratified Rental Apartment (Hi-Rise Construction)	059	Residential

BC Assessment Codes	Description	AUC_Code	PRIMARY_AC
060 2 Acres Or More (Single Family Dwelling, Duplex)	2 Acres Or More (Single Family Dwelling, Duplex)	060	Residential
061 2 Acres Or More (Vacant)	2 Acres Or More (Vacant)	061	Residential
062 2 Acres Or More (Seasonal Dwelling)	2 Acres Or More (Seasonal Dwelling)	062	Residential
063 2 Acres Or More (Manufactured Home)	2 Acres Or More (Manufactured Home)	063	Residential
070 2 Acres Or More (Outbuilding)	2 Acres Or More (Outbuilding)	070	Residential
110 Grain & Forage	Grain & Forage	110	Farm
111 Grain & Forage (Vacant)	Grain & Forage (Vacant)	111	Farm
120 Vegetable & Truck	Vegetable & Truck	120	Farm
121 Vegetable & Truck (Vacant)	Vegetable & Truck (Vacant)	121	Farm
130 Tree Fruits	Tree Fruits	130	Farm
131 Tree Fruits (Vacant)	Tree Fruits (Vacant)	131	Farm
140 Small Fruits	Small Fruits	140	Farm
141 Small fruits (Vacant)	Small fruits (Vacant)	141	Farm
150 Beef	Beef	150	Farm
151 Beef (Vacant)	Beef (Vacant)	151	Farm
160 Dairy	Dairy	160	Farm
161 Dairy (Vacant)	Dairy (Vacant)	161	Farm
170 Poultry	Poultry	170	Farm
171 Poultry (Vacant)	Poultry (Vacant)	171	Farm
180 Mixed	Mixed	180	Farm
181 Mixed (Vacant)	Mixed (Vacant)	181	Farm
190 Other	Other	190	Farm
191 Other (Vacant)	Other (Vacant)	191	Farm
200 Store(S) And Service Commercial	Store(S) And Service Commercial	200	Commercial
201 Vacant IC&I	Vacant IC&I	201	Commercial
202 Store(S) And Living Quarters	Store(S) And Living Quarters	202	Commercial
203 Stores And/Or Offices With Apartments	Stores And/Or Offices With Apartments	203	Commercial
204 Store(S) And Offices	Store(S) And Offices	204	Commercial
205 Big Box	Big Box	205	Commercial
206 Neighbourhood Store	Neighbourhood Store	206	Commercial
208 Office Building (Primary Use)	Office Building (Primary Use)	208	Commercial

Appendix A2: BC Aquifer Subtype Descriptions

Aquifer Subtype Code	Description
1a	Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along major rivers of higher stream order with the potential to be hydraulically influenced by the river.
1b	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.
1c	Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along lower order (< 3-4) streams in confined valleys with relatively undeveloped floodplains, where aquifer thickness and lateral extent are more limited.
2	Predominantly unconfined deltaic sand and gravel aquifers are commonly found in deltas where a stream or smaller river flows into a standing body of water.
3	Alluvial or colluvial fan sand and gravel aquifers typically occur at or near the base of mountain slopes, either along the side of valley bottoms, or if formed during the last period of glaciation, raised above the valley bottoms.
4a	Unconfined glacio-fluvial outwash or ice contact sand and gravel aquifers generally formed near or at the end of the last period of glaciation.
4b	Confined Glacio-fluvial sand and gravel aquifers underneath till, in between till layers, or underlying glacio-lacustrine deposits.
4c	Confined sand and gravel aquifer associated with glacio-marine environments near the coast.
5a	Fractured sedimentary rock aquifers primarily found in association with old sedimentary basins.
5b	Karstic limestone aquifers
6a	Crystalline bedrock aquifers associated with flat-lying to gently-dipping volcanic flows.
6b	Fractured crystalline (igneous intrusive or metamorphic, meta-sedimentary, meta-volcanic, volcanic) rock aquifers
UNK	Unknown

Adapted from Wei M. et al., 2009