5.0 WATER REGION # 3 - FRENCH CREEK

5.1 Regional Overview

The French Creek water region (WR3 (FC)) is defined as the area extending from Qualicum Beach to Parksville along the coast to the top of the French Creek catchment in the southwest (Figure 35). It is one of the smallest water regions within the RDN covering an area of approximately an area of approximately 121 km^2. The region includes several major watersheds as listed in the Table 21. The largest watershed is associated with French Creek. Two hydrometric stations, five climate stations, and approximately 68 surface water diversion licenses exist within the region (Figure 35, and Table 21). Not all 68 points are visible on the figure since many plot over each other at this scale. The locations however are included in the ARC GIS Geodatabase which will be provided to the RDN.

Table 21: WR3 (FC) - Watersheds, Wells and Surface Water Licenses

Total Water Region Area	***121 km^2**
Major Watersheds	**Drainage Area[1] (km^2)**
Grandon Creek	7.2
French Creek	69.7
Morningstar Creek	15.1
Carey Creek (including Romney Creek)	8.9
Romney Creek (Tributary of Carey Creek)	6.4
Wells and Surface Water Diversion Points	**No.**
# Water Wells listed in MOE DB	895
Surface water diversion licenses	68

Note: Drainage Areas are based on 1:50,000 BC Watershed Atlas. *Total Water Region area includes areas that drain directly to the ocean and are not part of a major watershed.

According to the MOE Wells Database (BCGOV ENV Water Protection and Sustainability Branch, 2008) WR3 (FC) has the 3rd largest number of water wells (895 wells) of the six water regions in the RDN. Although this may provide a qualitative sense of groundwater use in the region, the MOE database likely only represents a fraction of the actual wells currently in use. Many well records may not have been entered into the database and some wells may simply not be in use or have been abandoned. As there is no mandatory requirement for submitting well logs or well abandonment records, it is not possible to determine the groundwater demand from private wells with any degree of certainty, nor is it possible to assess the vulnerability that may exist with improperly abandoned or standing water wells.

5.2 Surface Water Assessment

5.2.1 Terrain, Topography and Land Use

The French Creek Water Region (#3) covers the North-Central section of the Regional District of Nanaimo. The west part region of the region runs along the edge of the Beaufort Mountains and consists of steep forested terrain. The rest of the region consists of the mild topography of the Nanaimo lowlands.

Water flows to the east in the region from its highest point in the French Creek catchment (1,080m) and out to the Strait of Georgia. The most significant water feature in the region is

French Creek and Hamilton Marsh. The major watersheds in the region from north to south are shown in Figure 35.

The majority of the land use in the upper water region is privately managed forest lands. The coastal sections of the water region are a mixture of rural development with agriculture and low density residential. Some commercial and light industrial development is located in Coombs. Both the Town of Qualicum Beach and the north-western potion of the City of Parksville, lie within this water region. These areas consist of high density development.

5.2.2 Climate

The climate for the Little Qualicum Water Region is similar to the rest of the RDN with cool wet winters and mild dry summers. In general, climate records indicate that this region tends to follow the average precipitations totals of the other low-lying regions due to the lack of influence of the mountain range. The total annual precipitation for the 1971 to 2000 Climate Normal Period of Coombs is 1126.4 (see Figure 36 for monthly distributions). This compares with recorded average total annual precipitation of 1,162.7 mm at the Nanaimo Airport.

Climate station locations are shown as green squares on Figure 35. Maps showing the distribution of annual precipitation and average temperature over the water region are shown in Figure 37 and Figure 38, respectively. Maximum total annual precipitation amounts are approximately 2,500 mm in the upper reaches of French Creek.

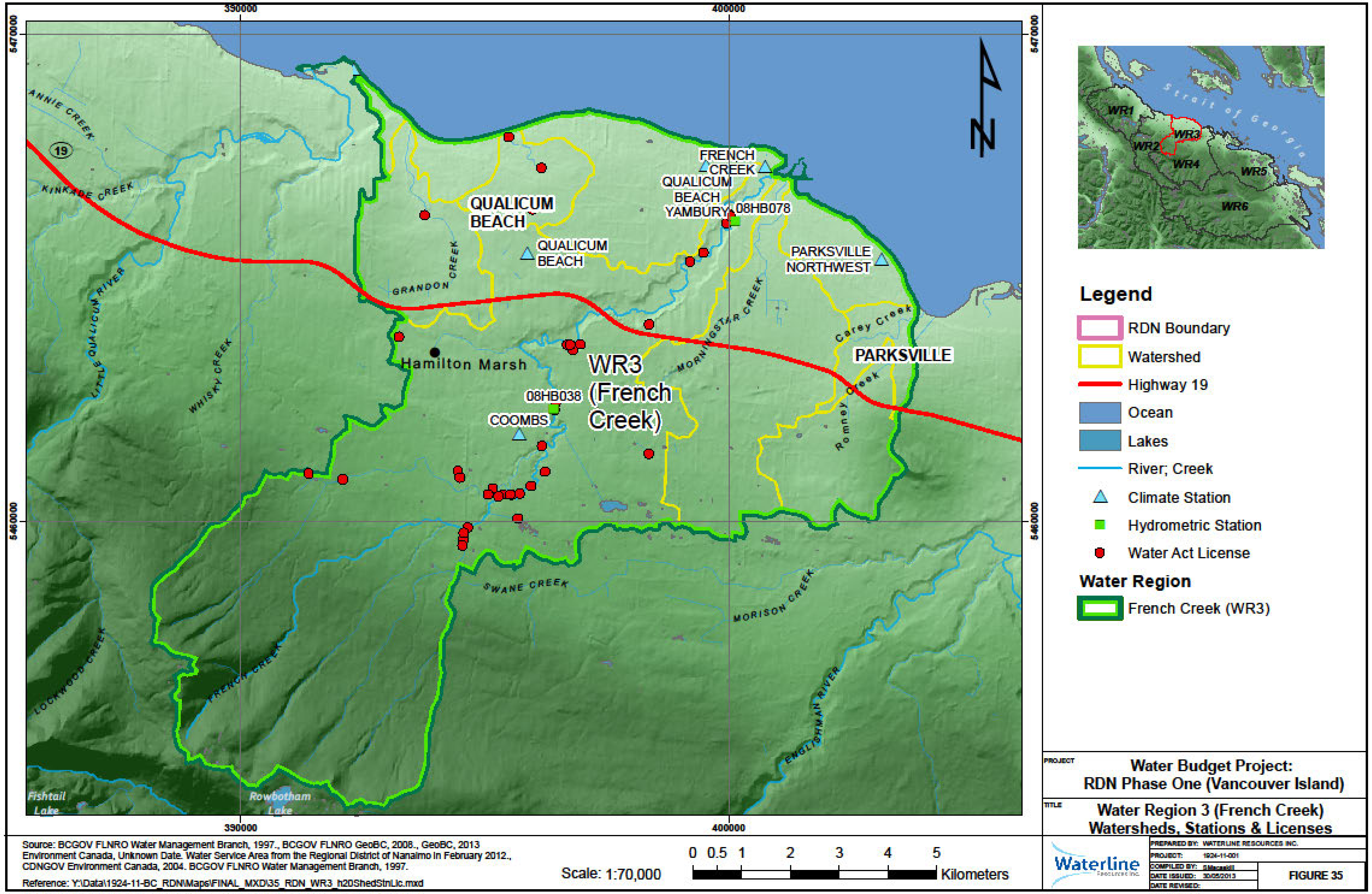

Figure 35: WR3 (FC) – Watersheds, Stations & Licenses.

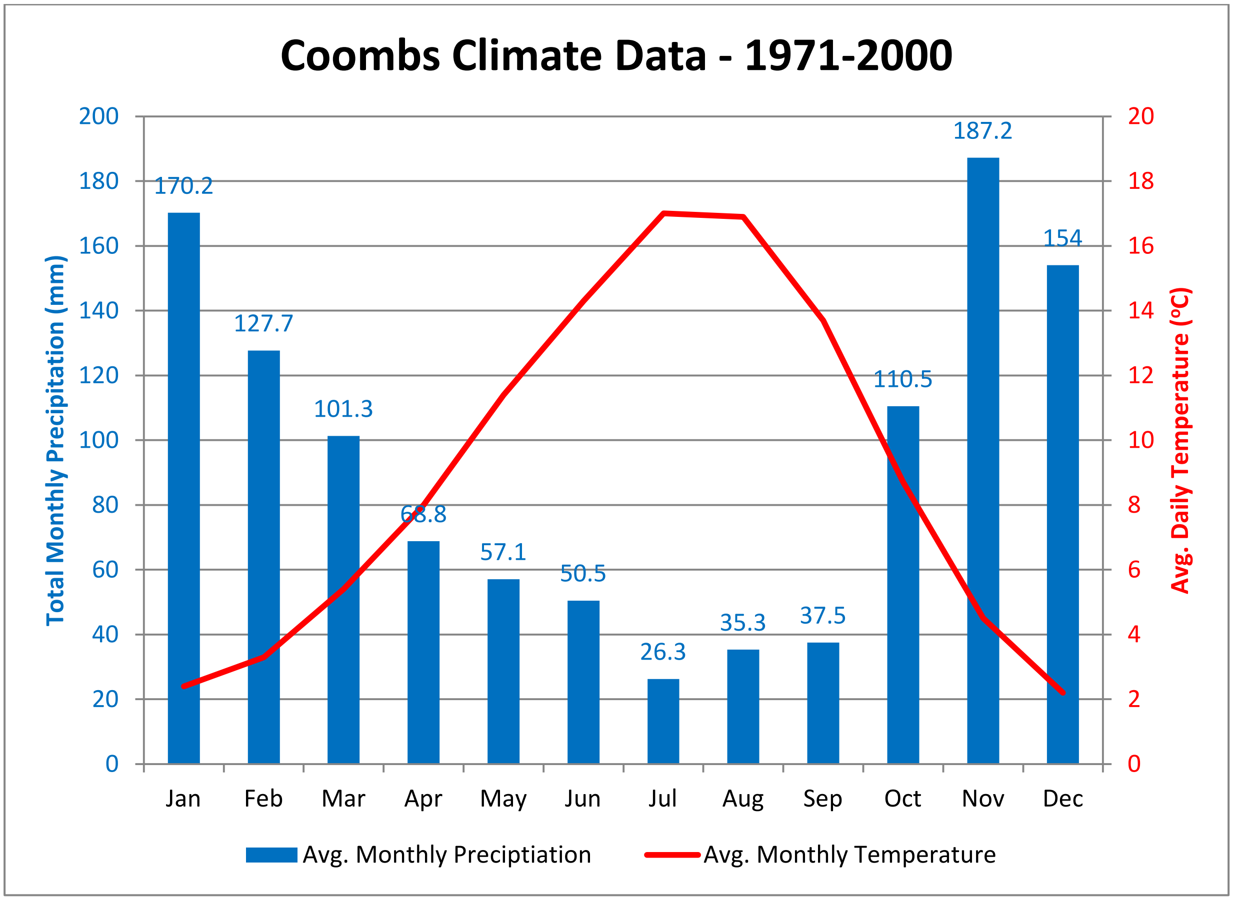

Figure 36: WR3 (FC) – Coombs Monthly Climate (1971 to 2000 Normal Period)

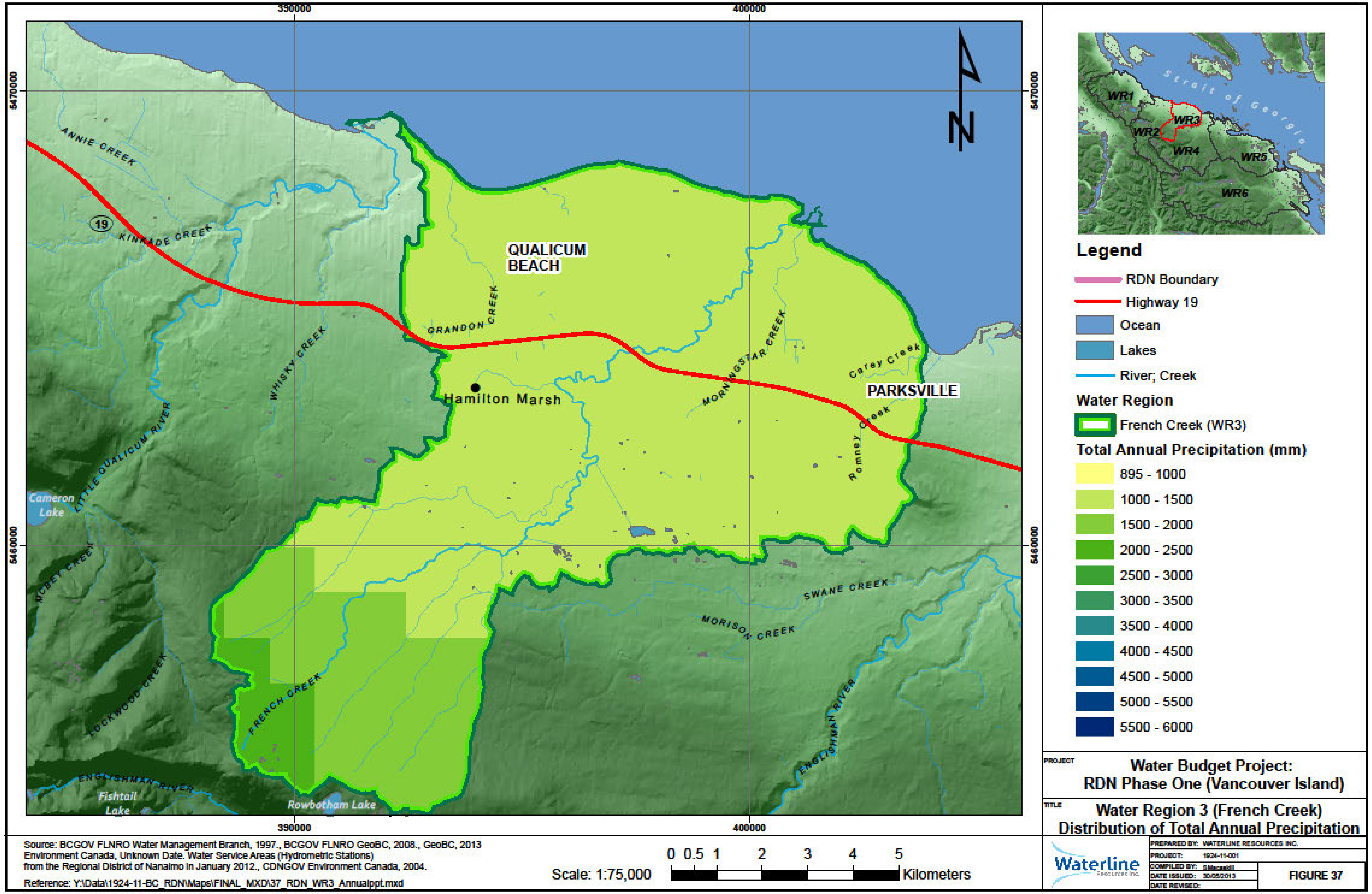

Figure 37: WR3 (FC) – Distribution of Total Annual Precipitation

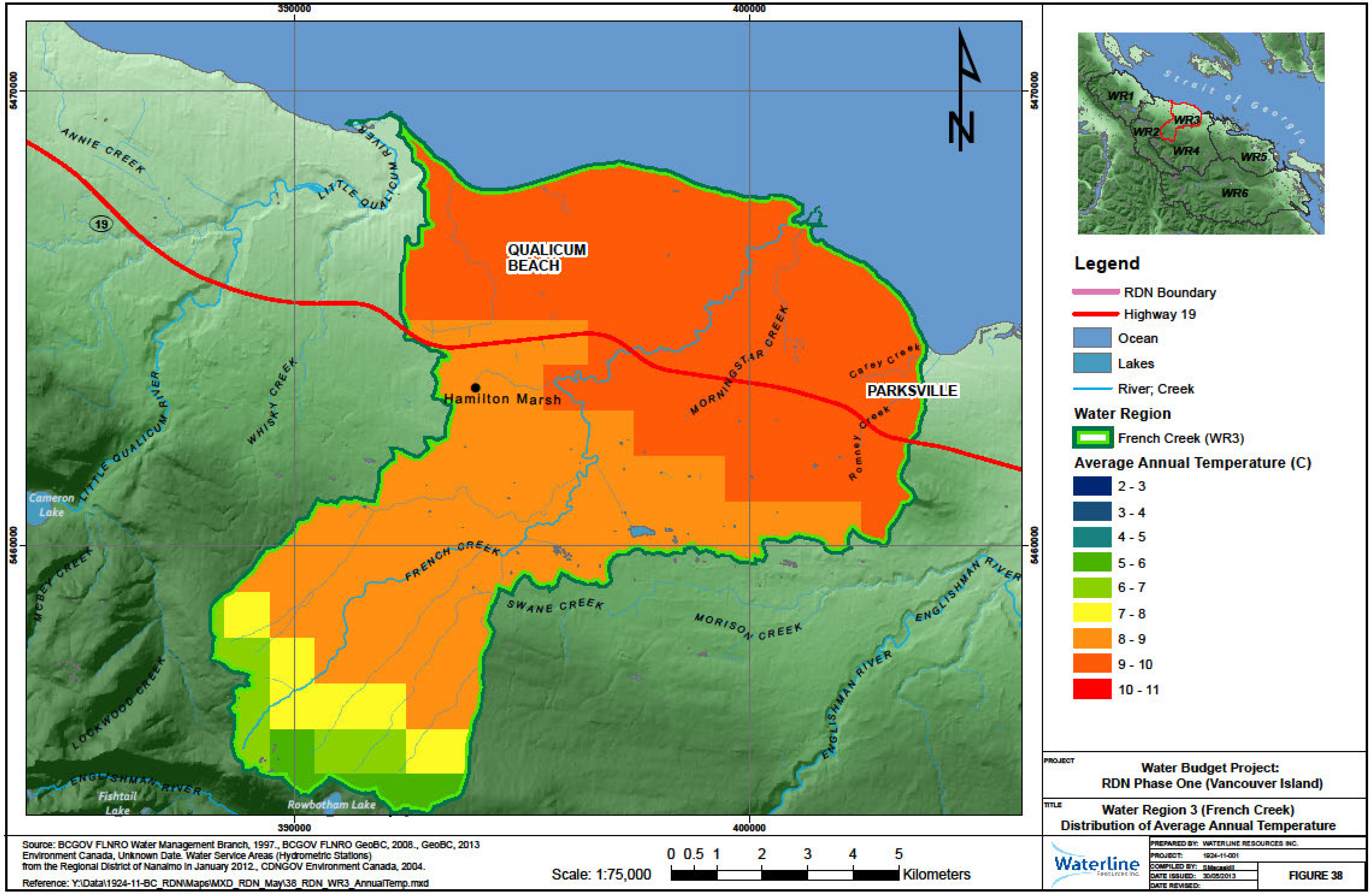

Figure 38: WR3 (FC) – Distribution of Average Annual Temperature

5.2.3 Stream Gauging and Monitoring

Table 22 lists the names of the hydrometric stations are located in the WR 3 (FC) and they are shown on Figure 35.

Table 22: WR3 (FC) – Water Survey of Canada Records

Station Name (WSC Number)	Period of Record	Natural or Regulated	Drainage Area to Gauge (km^2)	Mean Annual Discharge (m^3/s) and Volume (million m^3)	Mean Summer Discharge (m^3/s) and Volume[1] (million m^3)
French Creek above Pump house (08HB078)	1990 to 1996	Natural	79.1	2.35 m^3/s 74.2 million m^3	0.06 m^3/s 0.5 million m^3
*French Creek at Coombs[2] (08HB038)	1969-1971 1983-1989	Natural	58.3	Summer Only	0.04 m^3/s 0.4 million m^3

Notes: 1 – Summer Period Jul to Sep (three lowest average months). MAD for French Creek above the Pump House are based on only Records for French Creek at Coombs are summer only (April to September) so MAD cannot be determined.

5.2.4 Hydrology and Surface Water Resources

The hydrological model has provided estimates of average available surface water resources for the major watersheds in the region for the year and the summer (Table 23).

Table 23: WR3 (FC) – Available Surface Water Resources (Avg. for 1971 to 2000 period)

Watershed	Drainage Area (km^2)	Mean Annual Discharge (m^3/s) and Volume (million m^3)	Mean Summer Discharge (m^3/s) and Volume (million m^3)	Previous Estimate of MAD (m^3/s)
Grandon Creek	7.2	0.16 m^3/s 5.1 million m^3	0.00 m^3/s 0.0 million m^3	0.251 m^3/s
French Creek	69.7	2.25 m^3/s 71.0 million m^3	0.18 m^3/s 1.4 million m^3	2.167 m^3/s
Morningstar Creek	15.1	0.31 m^3/s 9.7 million m^3	Less than 0.1 m^3/s	0.216 m^3/s
Carey Creek	8.9	0.18 m^3/s 5.6 million m^3	Less than 0.1 m^3/s	0.095 m^3/s
Romney Creek (Tributary of Carey Creek)	6.4	0.12 m^3/s 3.6 million m^3	Less than 0.1 m^3/s	0.179 m^3/s

Notes: Previous estimates of MAD from the BC Ministry of Environment Water Allocation Plans (Bryden et. al., 1994) have been included for reference.

5.2.5 Surface Water Demand

Table 24 summarizes the surface water licences in WR3 (FC) from the BC Surface Water Licence Database. Table 24 summarizes the surface water storage in WR3 (FC. The locations of the surface water licences for WR3 (FC) are shown on Figure 35.

Table 24: WR3 (FC) – Surface Water Demand (m^3)

Type of Demand	Monthly	Annual	Summer (Jul-Sept)
Consumptive Demand			
Agriculture	8,437	101,240	75,930
Domestic	4,848	58,177	19,198
Industrial	-	-	-
Institutional	-	-	-
WaterWorks	17,285	207,415	68,447
Total Consumptive	30,569	366,833	163,576
Non- Consumptive Demand			
Power	-	-	
Conservation	36,288	435,456	108,864
Total Non-Consumptive	36,288	435,456	108,864

Table 25: WR3 (FC) – Surface Water Storage (m^3)

Type of Storage	Total
Storage	617
Conservation Storage	109903
Other Storage	9435
Total Storage	119955

The largest licensed water user in WR3 (FC) is the Parksville-Qualicum is Epcor Water Inc. for the French Creek water system. It is understood that Epcor plan to abandon the surface water intake in the near future and rely on new production wells. There is only a relatively small amount of surface water storage within the water region.

5.2.6 Surface Water Stress Analysis

As outlined in Section 2.5.2, a surface water stress analysis for French Creek has been completed. Water budget analysis for other smaller ungauged subwatersheds within WR3 (FC) should be completed when data is available and as part of a more detailed Tier 1 or Tier 2 water budget assessment (OMNR 2011). The results of the stress analysis for the watersheds in WR3 (FC) are shown in Table 26. A map showing the relative stress for French Creek is shown in Figure 39.

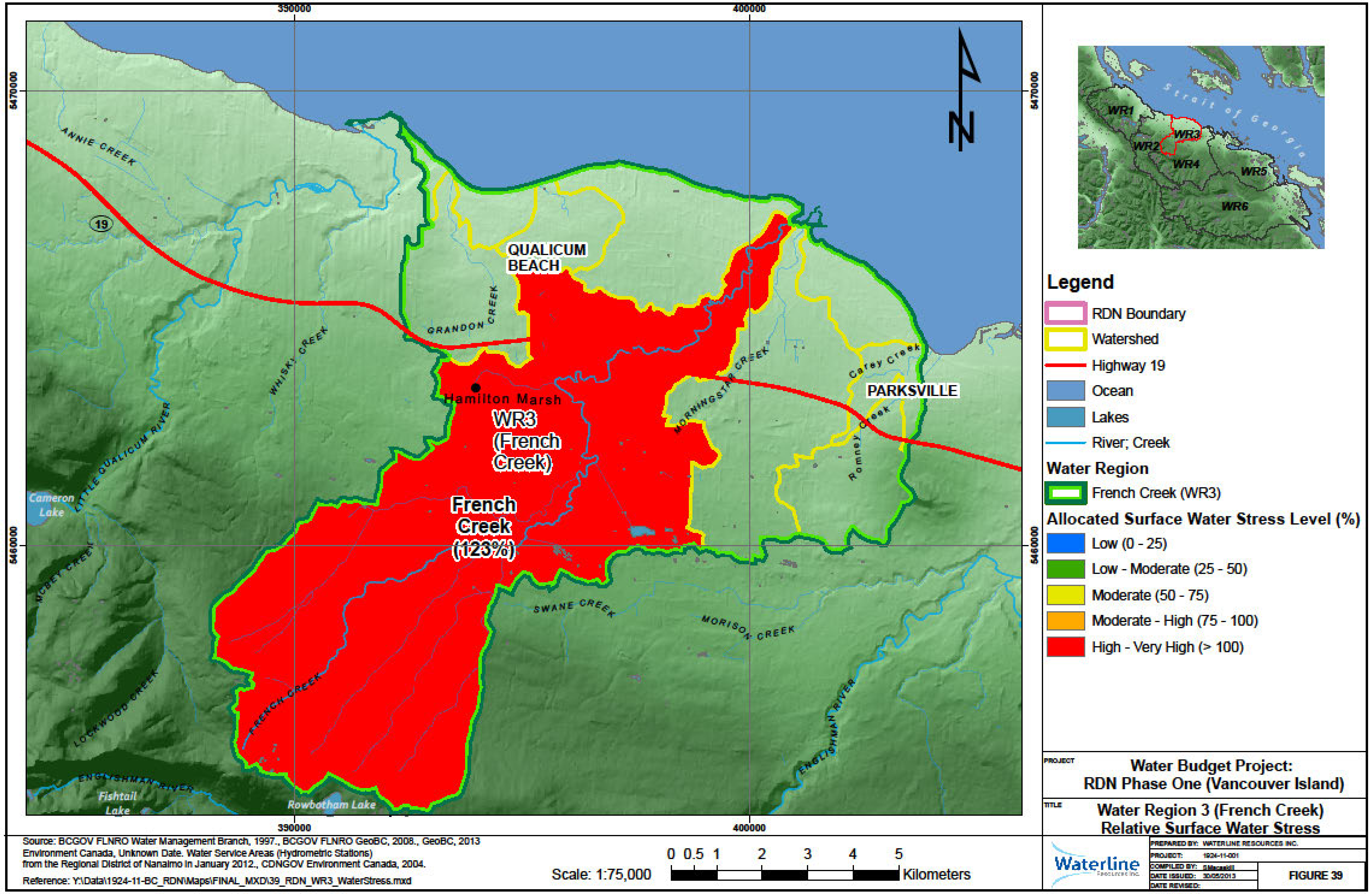

Figure 39: WR3 (FC) – Relative Surface Water Stress

Table 26: WR3 (FC) – Relative Surface Water Stress Assessment Results

Watershed	Average Natural River Flow Supply (million m^3)	Storage (million m^3)	Conservation Flow (10% of MAD) (million m^3)	Licensed Demand (million m^3)	Allocation Stress	Stress Level
French Creek	1.40	0.11	1.75	0.10	123%	High

Note: Volumes indicated in the table are average volumes for summer period (Jul to Sep). Average natural river flow is the estimated or recorded unregulated flow in the watershed. Total storage is based on licenced storage volume and assumes all storage is available to support conservation flow and licenced demand for the Jul to Sep period. The 10% of Mean Annual Discharge (MAD) conservation flow is based on current Ministry of Forest, Lands and Natural Resource Operations (MELP, 1996) minimum conservation flow policies for the east coast of Vancouver Island. Licenced demand is the total licenced volume for summer based on consumptive water licences. Allocation stress = (Average Natural supply + storage) / (Conservation Flow + Licenced Demand) Surface water stress color codes: : blue=low, green =low to moderate, yellow =moderate, brown =moderate to high, red=high to very high. Values reflect average flow conditions and do not consider drought years.

5.3 Groundwater Assessment

5.3.1 Existing Groundwater Studies and Data – WR3 (FC)

Given the regional scale of the Phase One Water Budget Assessment, the most important data compiled and geo-referenced by Waterline was the water well information, elevation data, soil and geology maps, land cover, aggregate resource map, mapped aquifers, and water service areas. Other maps were generated using the input data as part of Waterline's work and some samples are provided in Appendix C for illustration purposes (Eg: overburden thickness (Map C7), piezometric contour maps (Maps C8 and C9), air temperature (Map C14), precipitation (Map C15), runoff (Map C16 and C17), evapotranspiration (Map C18), infiltration (Map C19), Water Service Areas (Map C20), and Water Demand Assessment in Non-service areas (Map C21). All of these maps are provided in Appendix C for the entire RDN study area with an explanation of how the map was geo-reference or created by Waterline. These data and layers are now available in the ARC GIS Geodatabase at the RDN Scale, water region scale, watershed scale, on other local scale needed for site specific assessments. These data will be provided to the RDN in electronic format as part of the ARC GIS Geodatabase system which was constructed by Waterline for use by the RDN. These regional datasets form the framework for construction of the conceptual hydrogeologyical model.

Although only some of the data in certain reports may have been incorporated into Waterline's Geodatabase, the primary studies in the region were used in Waterline's water budget assessment to provide local hydrogeological context are provided in Table 27.

Table 27: WR3 (FC) – Hydrogeology Reference Reports

Author	Year	Study Title
AGRA Earth & Environmental Ltd.	1998	Well and Aquifer Evaluation for Surfside Well
EBA Engineering Consultants	2001	Aquifer Identification – Parksville Area
EBA Engineering Consultants Ltd.	2005	Final Mt. Arrowsmith Modeling Project Parksville Area, BC
Gilles Wendling, Sr. Hydrogeologist	1998	Aquifer Management Breakwater Enterprises Ltd. – Public Utility
Koers & Associates Engineering Ltd.	1994	Town of Qualicum Beach - Water Study Update
Kohut, A.P.	2003	Long Term Sustainability of Groundwater Sources, French Creek and Breakwater
Levelton	1997	Pumping Test Review Pintail Estates Wells 1-94 & 2-95 Qualicum Beach, B.C.
Lowen Hydrogeology	2011	Observation Well Drilling Program 2011 Phase 1
Ministry of the Environment	1994	French Creek Water Allocation Plan
Pacific Hydrology Consultants Ltd.	1990	Pump Testing and Capacity of Hills of Columbia Well No 7
Pacific Hydrology Consultants Ltd.	1994	Construction and Testing of New Test Wels R-1 and R-4 and Testing of Existing Anderson Test Well I-88 for French Creek Estates in the French Creek Area of Vancouver island
Pacific Hydrology Consultants Ltd.	1994	Completion Report: Test-Production Drilling/Well Construction and Capacity Testing of Hills of Columbia Well 11-94 in the French Creek Area of Nanoose District
Pacific Hydrology Consultants Ltd.	1994	Construction and Testing of Test Wells R-5 and R-8 for French Creek Estates in the French Creek Area of Vancouver Island
Pacific Hydrology Consultants Ltd.	1995	Construction and Testing of Test Wells R-7 and R-7A for French Creek Estates in the French Creek Area of Vancouver Island
Ministry of Water, Land and Air Protection Ministry of Sustainable Resource Management Nanaimo Regional Office	2002	French Creek Watershed Study
Lowen Hydrogeology Consultants	2010	Arrowsmith Water Service Englishman River Water Intake Study Groundwater Management. Discussion Paper 5-1. Existing Groundwater Supply Evaluation and Aquifer Yield Assessment, Prepared by Dennis Lowen, Alan Kohut and Bill Hodge, January 25, 2010.

5.3.2 Description of Aquifers and Water Wells

Two unconsolidated, sand and gravel aquifers, and two bedrock aquifers have been mapped within WR3 (FC) (Figure 40 and Figure 41, respectively). Table 28 provides a summary of information on mapped aquifers within WR3 (FC). Quadra sand aquifers (216 & 217) are moderately productive are generally confined to semi-confined with moderate vulnerability and heavy use. Bedrock aquifers 220 and 212 are low productivity aquifers and are generally confined with moderate vulnerability. Aquifer 220 has heavy use while Aquifer 212 along the coast is only lightly used (BCGOV ENV Water Protection and Sustainability Branch, 2012). It is important to note that there are many well records missing (unmapped) in aquifers 217 and 209 as they were mapped in the mid-nineties and a lot of well records were added to the WELLS database after 2005 (Pat Lapsevic, Pers. Comm., 2013). This illustrates the limitation of the aquifer classification designation for this area.

Table 28: WR3 (FC) – Summary of Mapped Aquifers

Aquifer Tag No.	Aquifer Lithology	Location Within Water Region	Potential Groundwater-Surface water or Aquifer to Aquifer Interaction	Developed Aquifer surface Area	Confined, Semi, or unconfined, Aquifer Vulnerability Code	Yield
				(m^2)		**(L/M/H)**
220	Haslam	FC and Alberni Hwy.	FC	3.35E+07	Confined, IB	L
216	Quadra	Daylights in FC below Albernie Hwy	FC	1.84E+07	Semi-Confined, 1B	M
217	Quadra	Lower FC	FC and Ocean	3.79E+07	Confined, IB	M
212	NG	FC Mouth	Ocean	5.90E+06	Confined, IIIC	L

Notes: A/B/C is high/moderate/low vulnerability, I/II/III is heavy/moderate/light use, H/M/L means high/medium/low productivity/yield. All aquifer classification parameters, codes and yield are defined at the following MOE web address http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/Aq_Classification/Aq_Class.html#class. NG means Nanaimo Group.

The majority of supply wells are completed along the coast in unconsolidated Quadra sand aquifers (Figure 40). Aquifer 212 and 220 appear to be less developed (Figure 41). There are a total of 895 overburden and bedrock wells listed in the MOE data base in WR3 (FC) (Table 21), however; aquifer 220 is a low yield aquifer as indicated in Table 28 and is under some stress locally. As there are no regulatory requirements in BC to submit wells logs to MOE for capture in the BC Wells Database, the water wells shown on Figure 40 and Figure 41 likely represents only a fraction of wells actually drilled.

5.3.3 Groundwater-Surface Water Interaction - Conceptual Hydrogeological Model

A conceptual hydrogeological model of each aquifer with WR3 (FC) was developed in order to understand the key elements and linkages between surface water and groundwater systems required to complete the water budget assessment. Although conceptual hydrogeological model developed by Waterline includes numerous cross-sectional views developed within the Waterline Geodatabase, only one 3D view into the subsurface will be presented here. Figure 42 shows a 3D block diagram illustrating the relationship between surface and subsurface geology in WR3 (FC). The Quadra sand deposit extends across the French Creek Valley and is mapped as aquifer 217 to the north and aquifer 217 to the south.

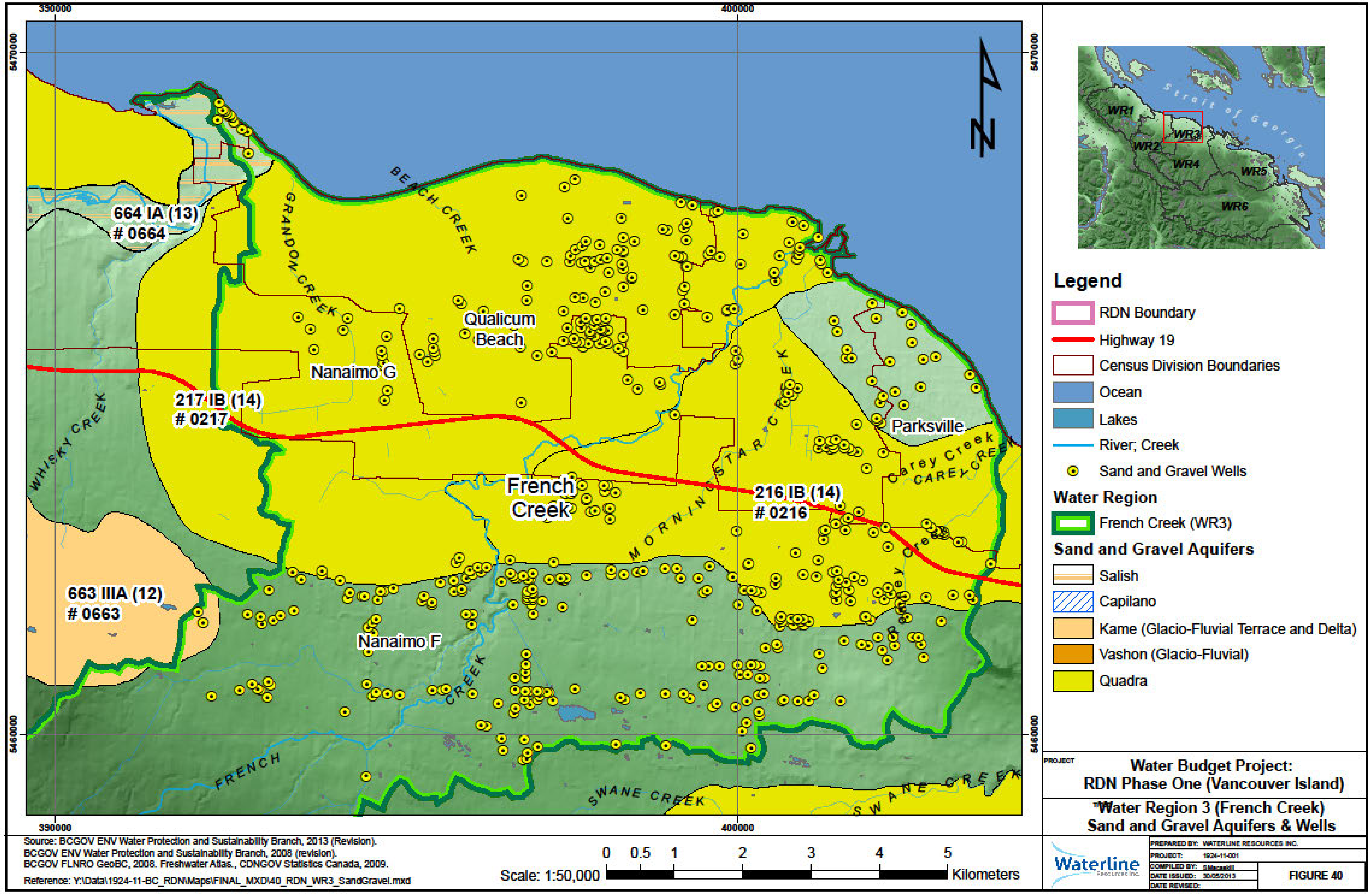

Figure 40: WR3 (FC) – Mapped Sand and Gravel Aquifers & Wells

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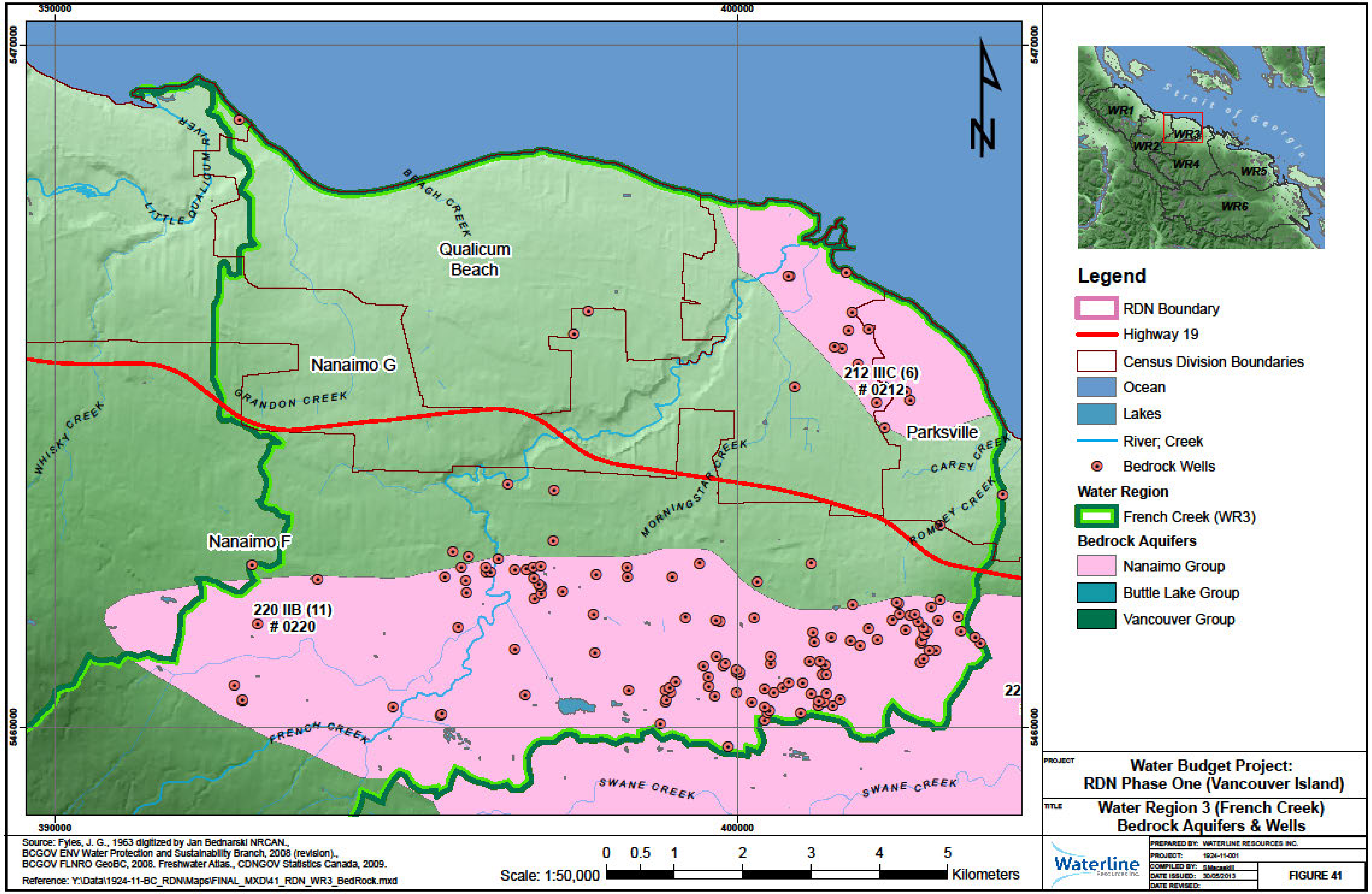

Figure 41: WR3 (FC) – Mapped Bedrock Aquifers & Wells

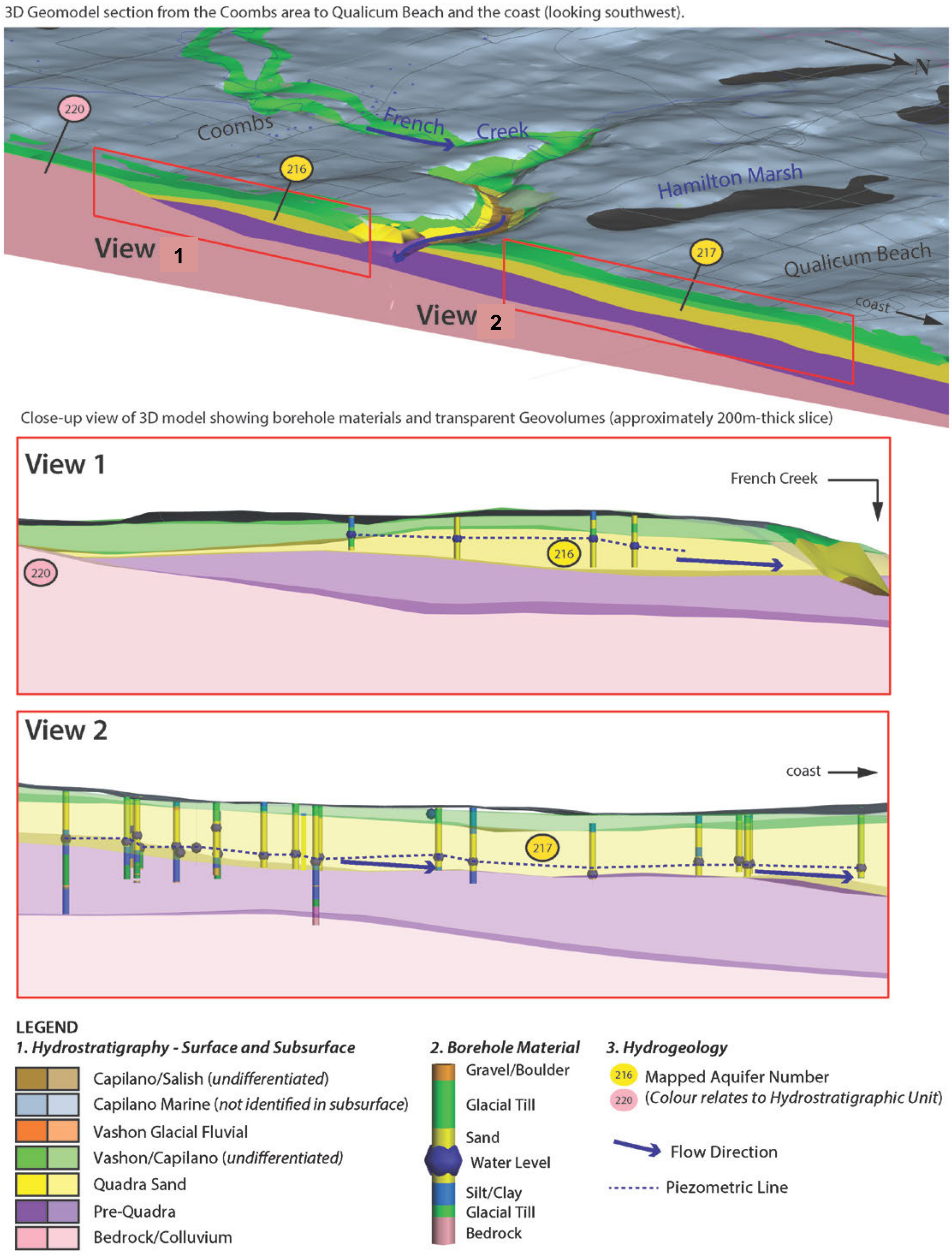

Figure 42: WR3 (FC) – Hydrogeological Conceptual Model – French Creek

View 1 shows how Quadra sand aquifer (216) is exposed in French Creek and the aquifer likely contributes important baseflow to the creek. View 2 shows Quadra sand aquifer (217) has a strong component of flow towards the ocean. The model also shows the underlying Haslam bedrock aquifer (220) which is highly developed further to the southwest of this location. Exchange of groundwater with the surface water system in French Creek is apparent based on the physical model and previous studies completed in French Creek. Further verification of actual water volumes being exchanged between the creek and the aquifers is required.

5.3.4 Significant Recharge Areas

Significant recharge areas within WR3 (FC) were determined as part of the assessment of infiltration across the region base on topography, mapped textural soil characteristics, land cover (bare land, vegetation, impermeable surfaces), and leaf area index. These areas are important for maintaining recharge to aquifers and base flow to creeks and rivers. The preliminary assessment presented herein is based on the integration of numerous datasets which may be incomplete and therefore will require further field verification. Figure 43 shows significant recharge areas mapped within WR3 (FC) as part of the water budget project.

Significant recharge areas extend to the upper reaches of WR3 (FC) all the way to coastal areas near the Town of Qualicum Beach. Better definition of these areas should be completed as the current modelling completed by Waterline and KWL was done on a 1 km square grid. Some of the areas indicated are highly developed and others are less developed. Future development planning need to consider these areas to ensure aquifer recharge continues to be maintained. As noted, the recharge catchment area is relatively small compared with the other water region. The following sections of this report show that water levels measured in many MOE observation wells completed in mapped aquifers within WR3 (FC) are in decline. Therefore, the protection of areas contributing recharge to aquifers is imperative to the future sustainability of groundwater resources in this region.

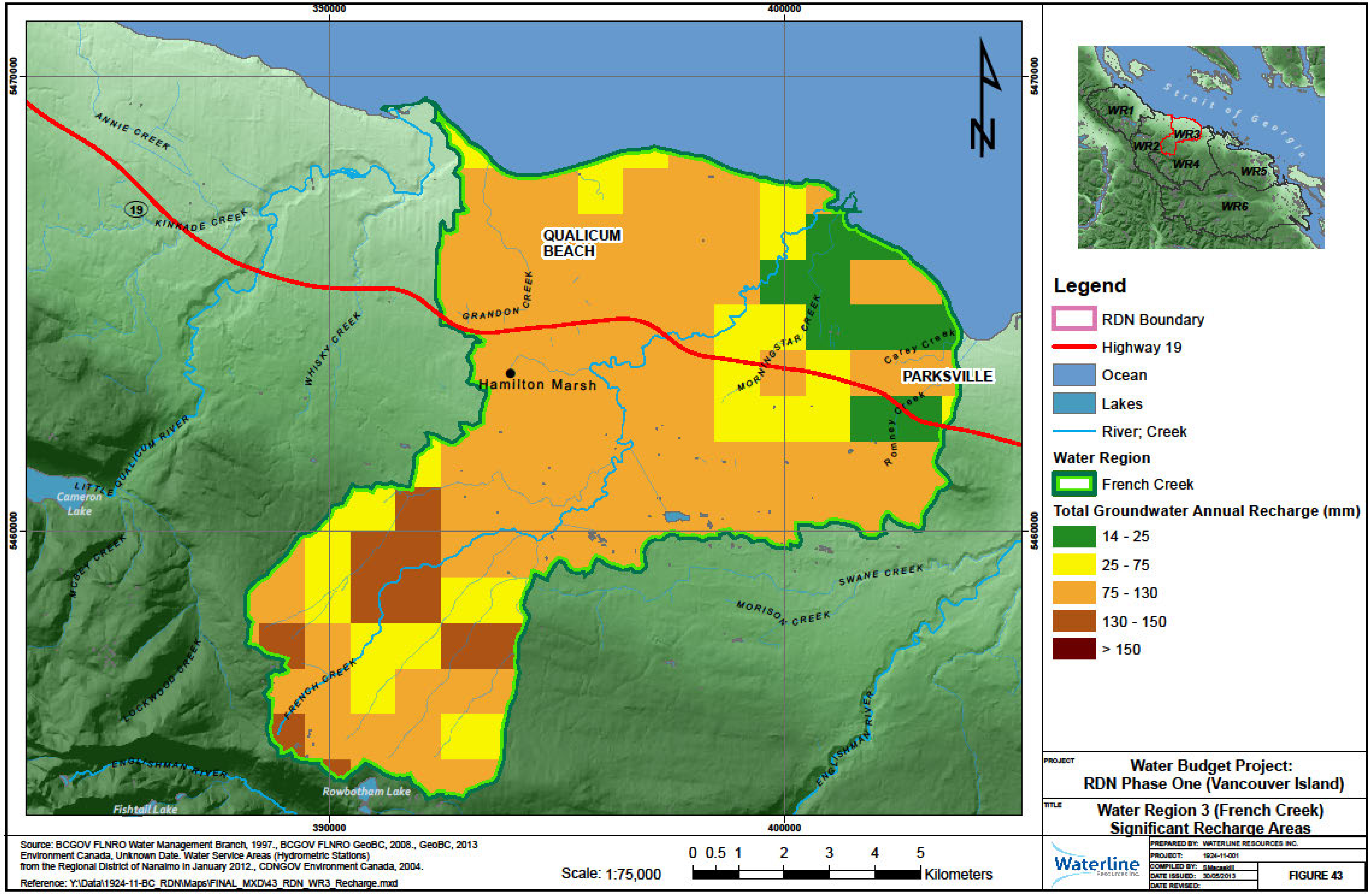

Figure 43: WR3 (FC) – Significant Recharge Areas

5.3.5 Groundwater Level Monitoring – BC MOE Observation Well Network

Long-term water level monitoring data provides an indication of an aquifer's response to global, regional, and local environmental changes in climate, groundwater pumping, and the impacts (if any) of other activities related land development. Long-term records also allows for establishing hydraulic linkages between the groundwater and surface water systems.

Figure 44 shows the locations of MOE observation wells and long-term water level monitoring records in relation to community water supply wells identified from the MOE Wells Database (E.g.: Large municipal users, the RDN, private utilities wells). Although numerous community wells are listed in the database, Waterline understands that not all of these wells shown on Figure 44 are currently active.

One of the problems encountered by Waterline during the water budget project was that community well owners generally do not cross reference active production wells to respective well logs in the MOE database. Often wells are referred to by local names (E.g.: RDN well # 1, #2, etc…). As water budget calculations required that production wells be assigned to specific aquifers, it is important that cross-referencing with the MOE well logs be done. Well owners are encouraged to report the MOE Well tag number so that accurate water level and groundwater extraction volumes can be allocated to the corresponding well and aquifer.

Water level monitoring records are available for six MOE observation wells in WR3 (FC) (Figure 45 to Figure 50, inclusive. MOE well 287 is completed in Aquifer 220 (Figure 45), MOE well 314 in Quadra sand Aquifer 216 (Figure 46), and four MOE wells in Quadra Sand aquifer 217 (Well # 295, 304, 303, and 321). Water levels in MOE observation wells were plotted along with the Coombs, Winchels Elementary, or Springwood Elementary precipitation record, the Englishman River Stage (level, # 08HB0034) and the PDO trend where appropriate.

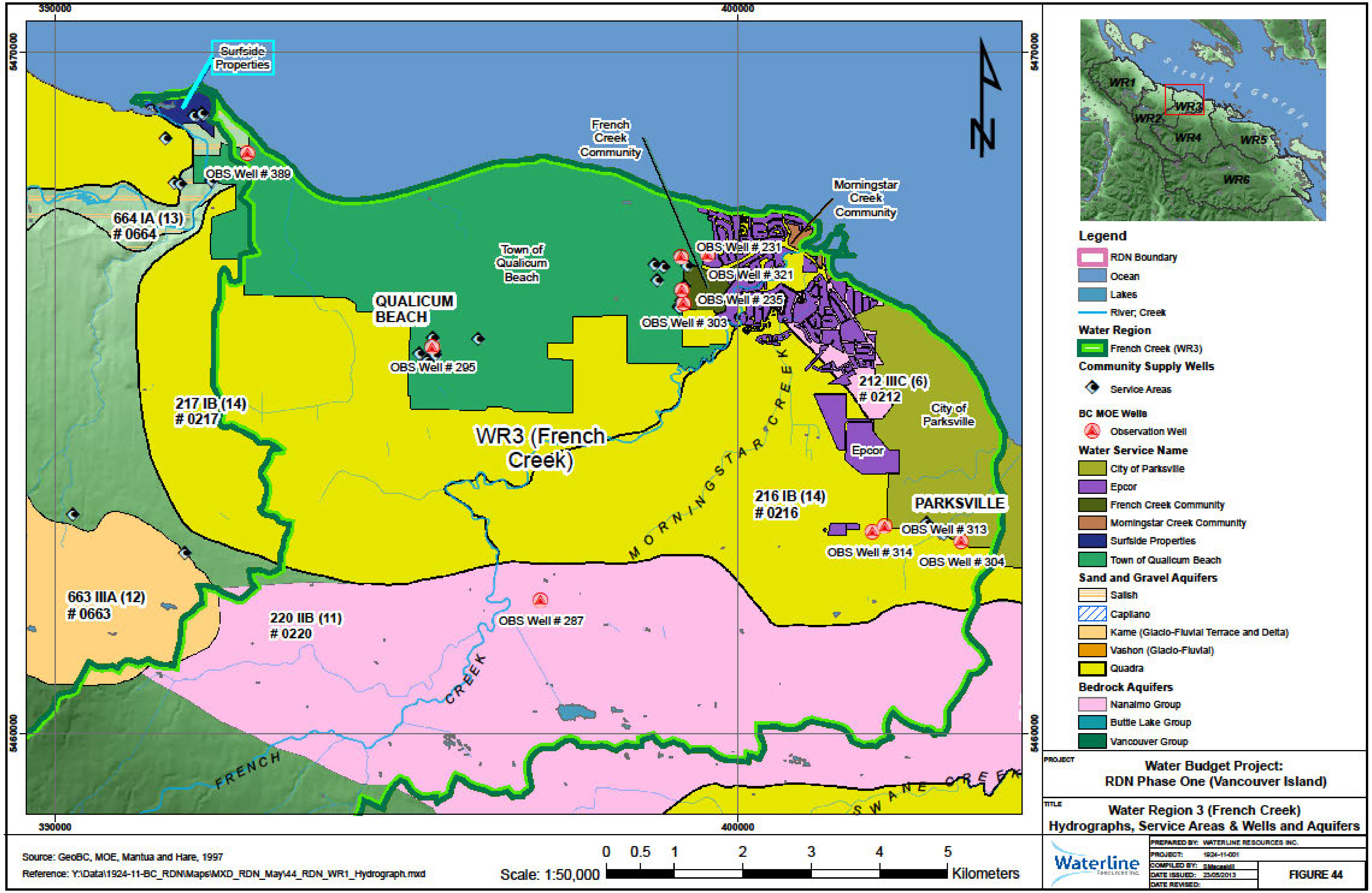

Figure 44: WR3 (FC) – MOE Well Hydrographs, Service Areas & Wells, and Aquifers.

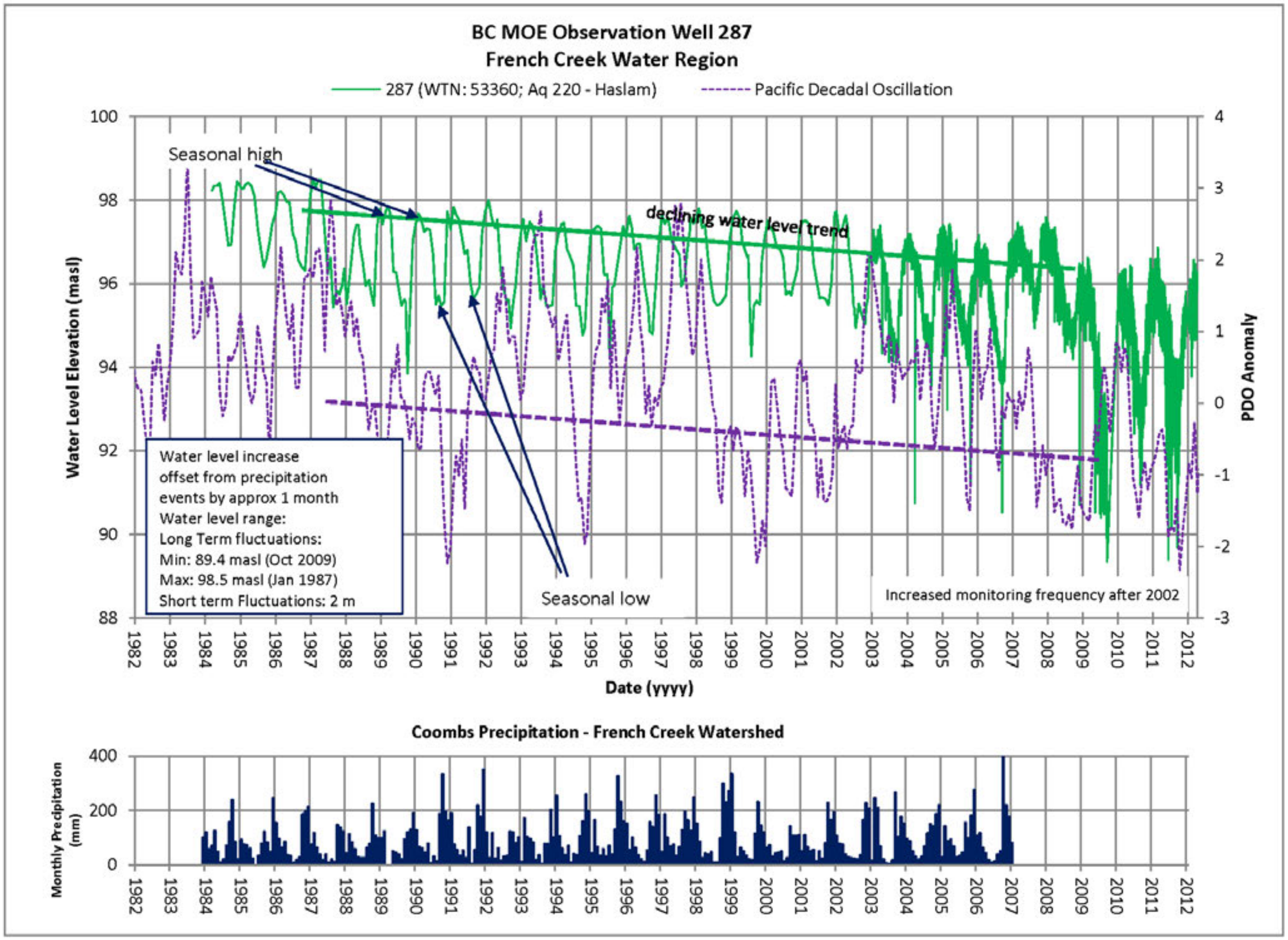

Figure 45: WR3 (FC) – Water Level Hydrograph BCMOE 287.

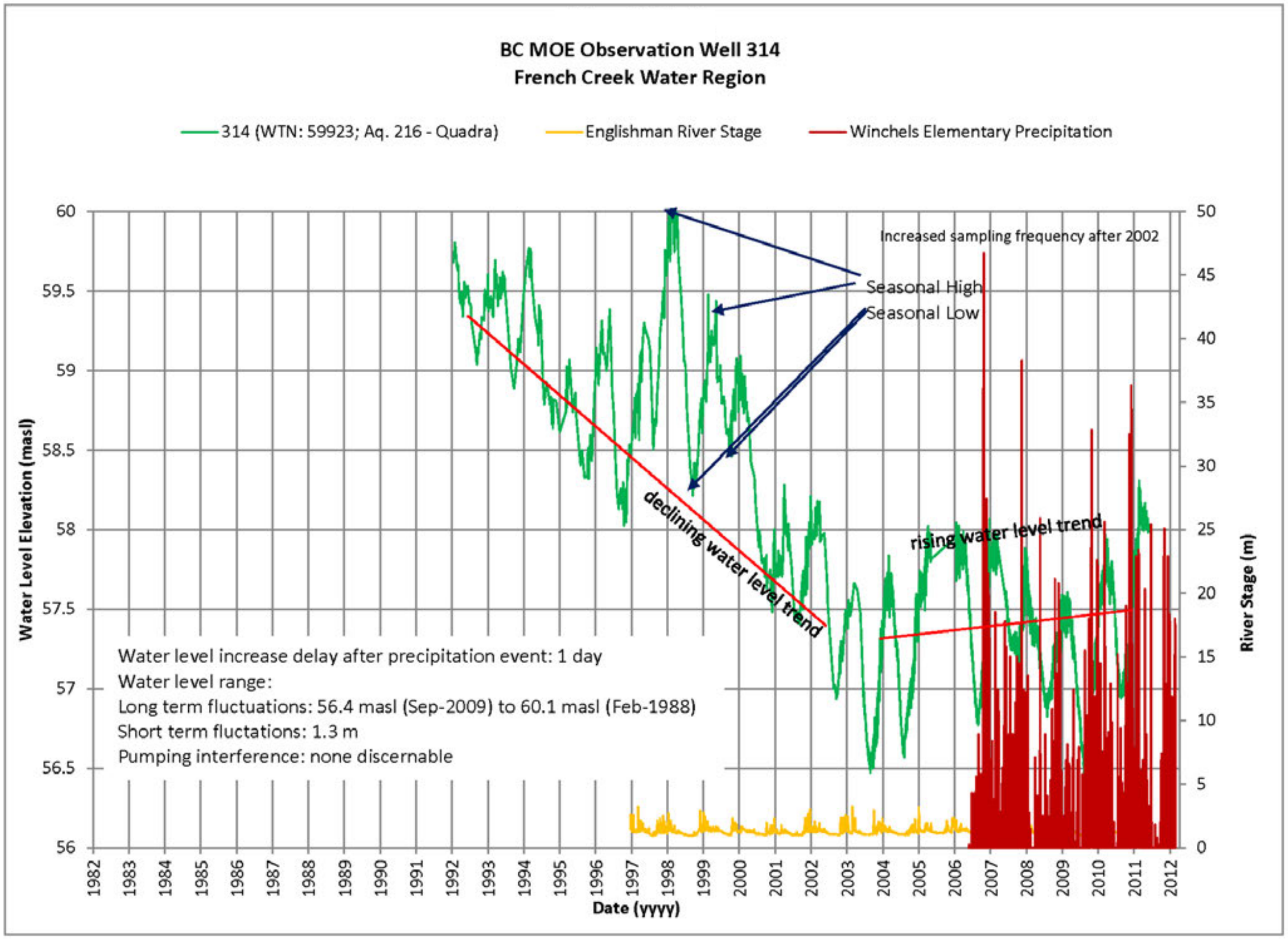

Figure 46: WR3 (FC) – Water Level Hydrograph BCMOE 314.

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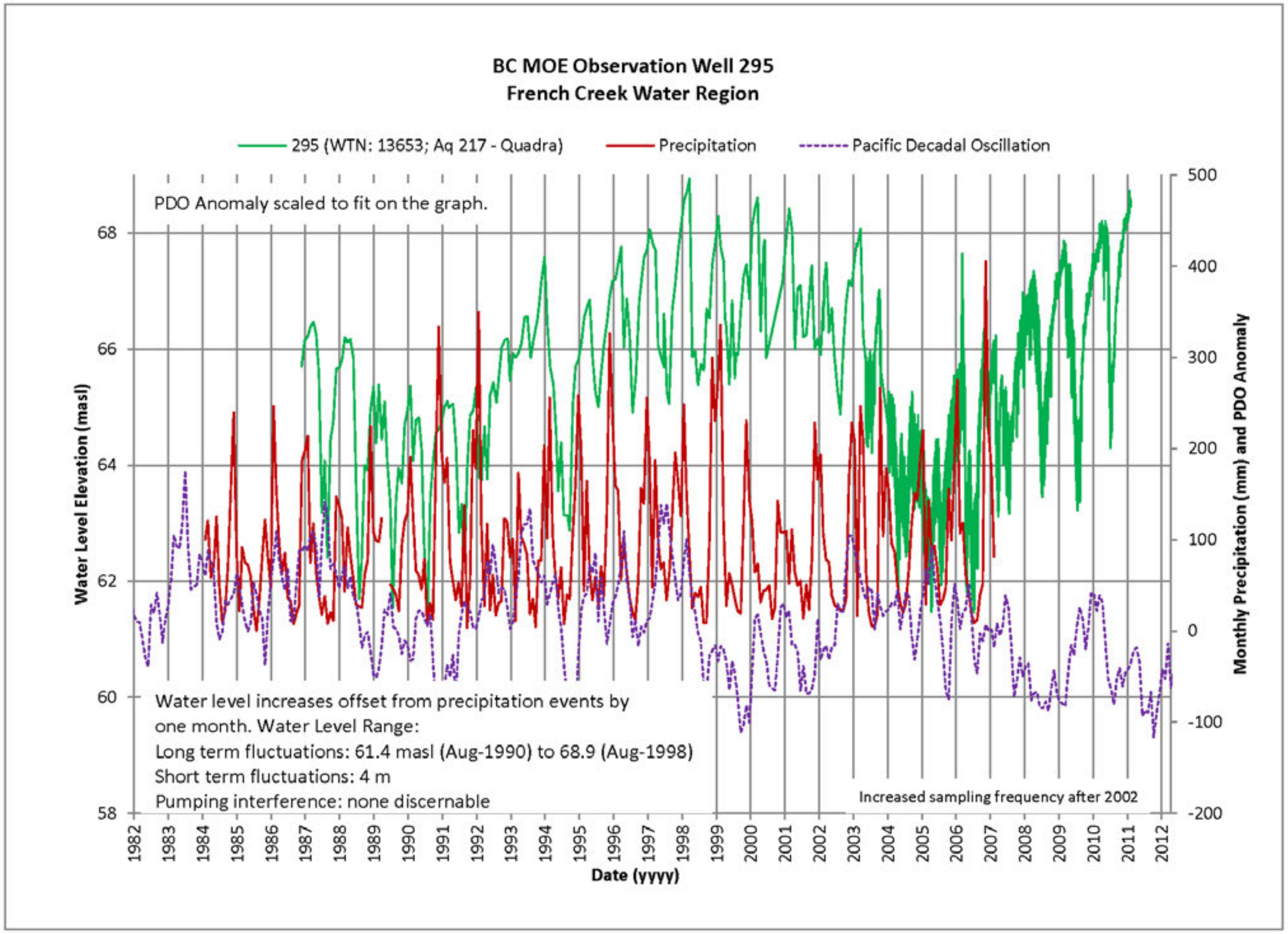

Figure 47: WR3 (FC) – Water Level Hydrograph BCMOE 295.

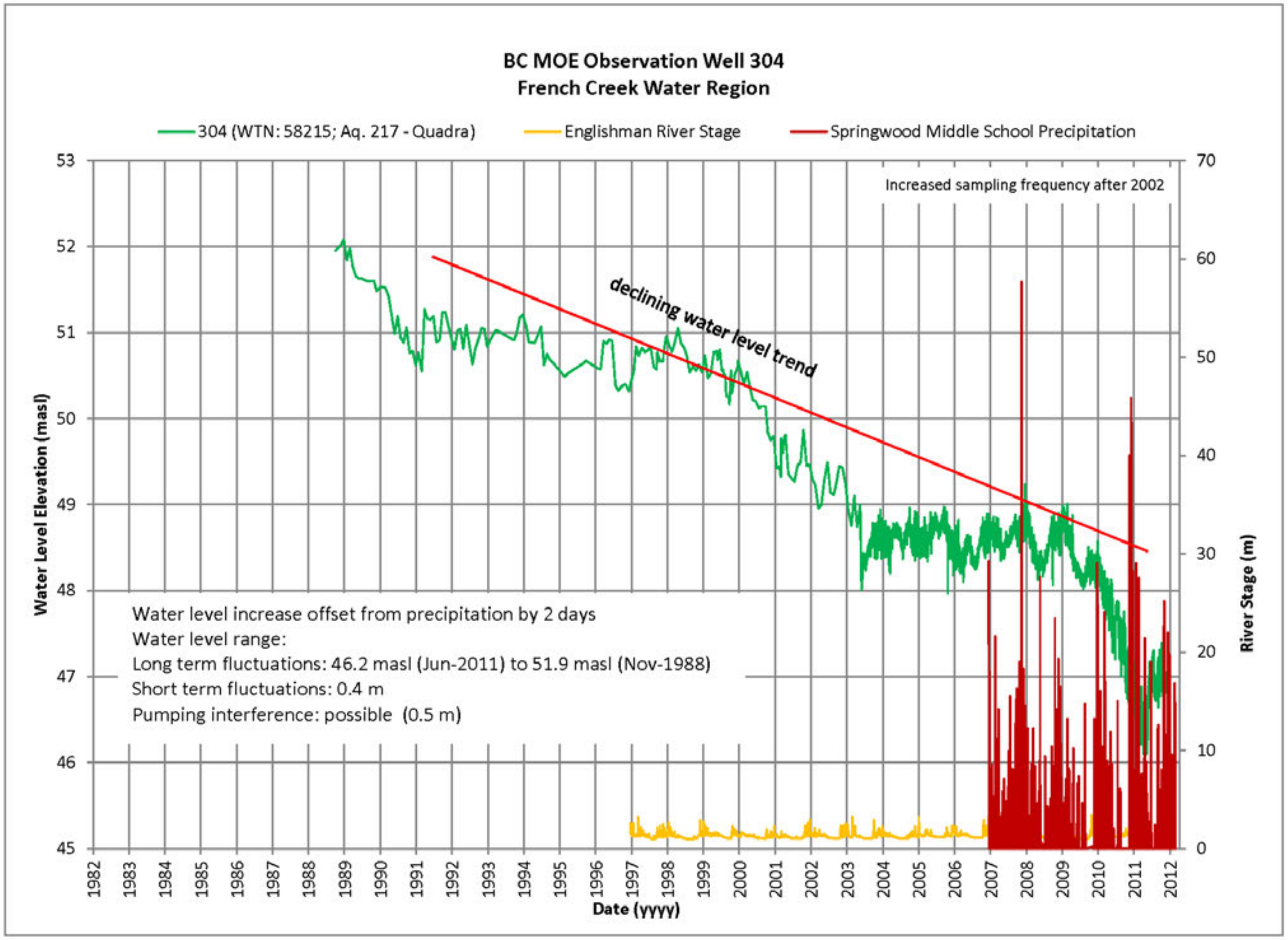

Figure 48: WR3 (FC) – Water Level Hydrograph BCMOE 304.

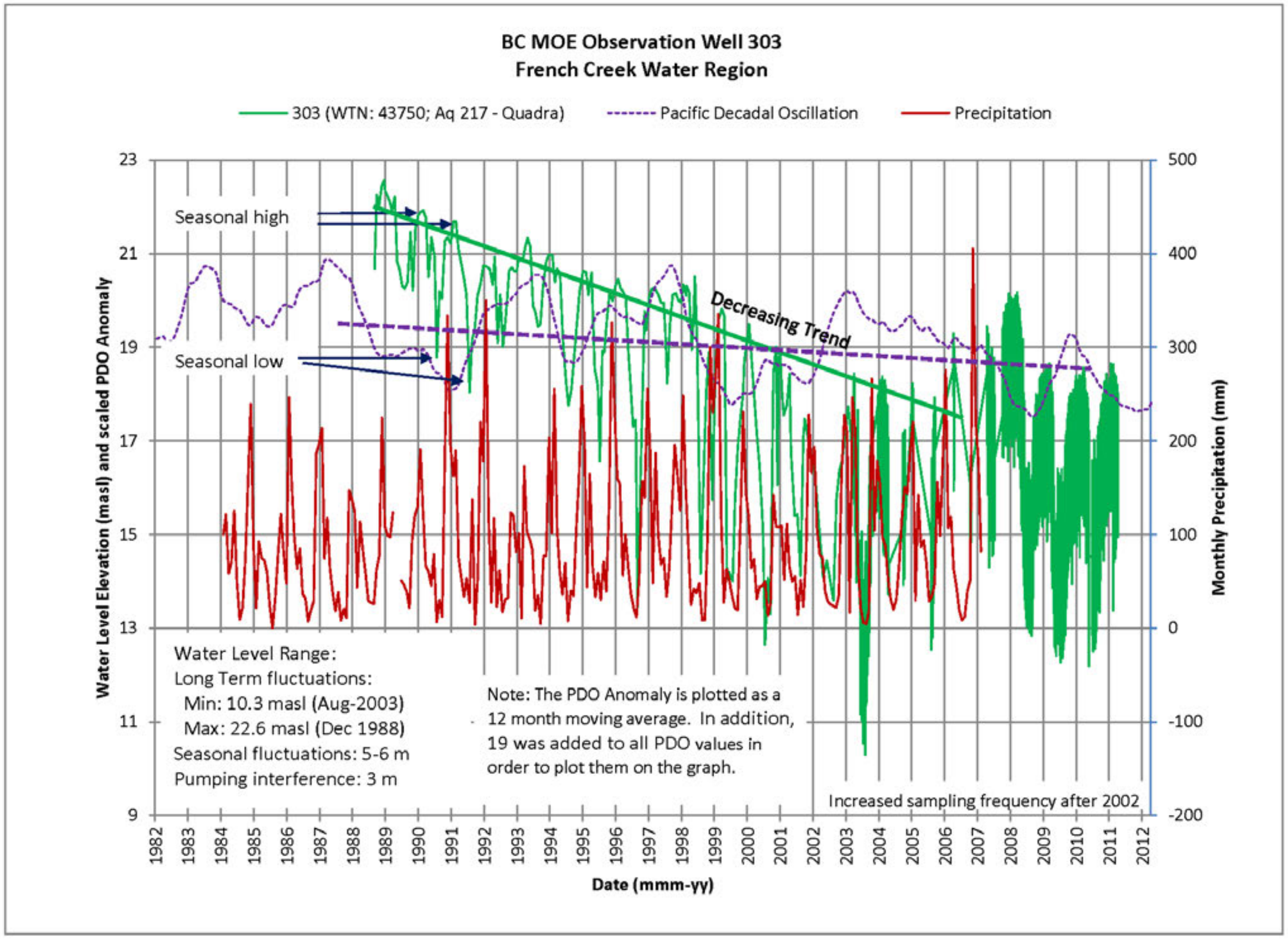

Figure 49: WR3 (FC) – Water Level Hydrograph BCMOE 303.

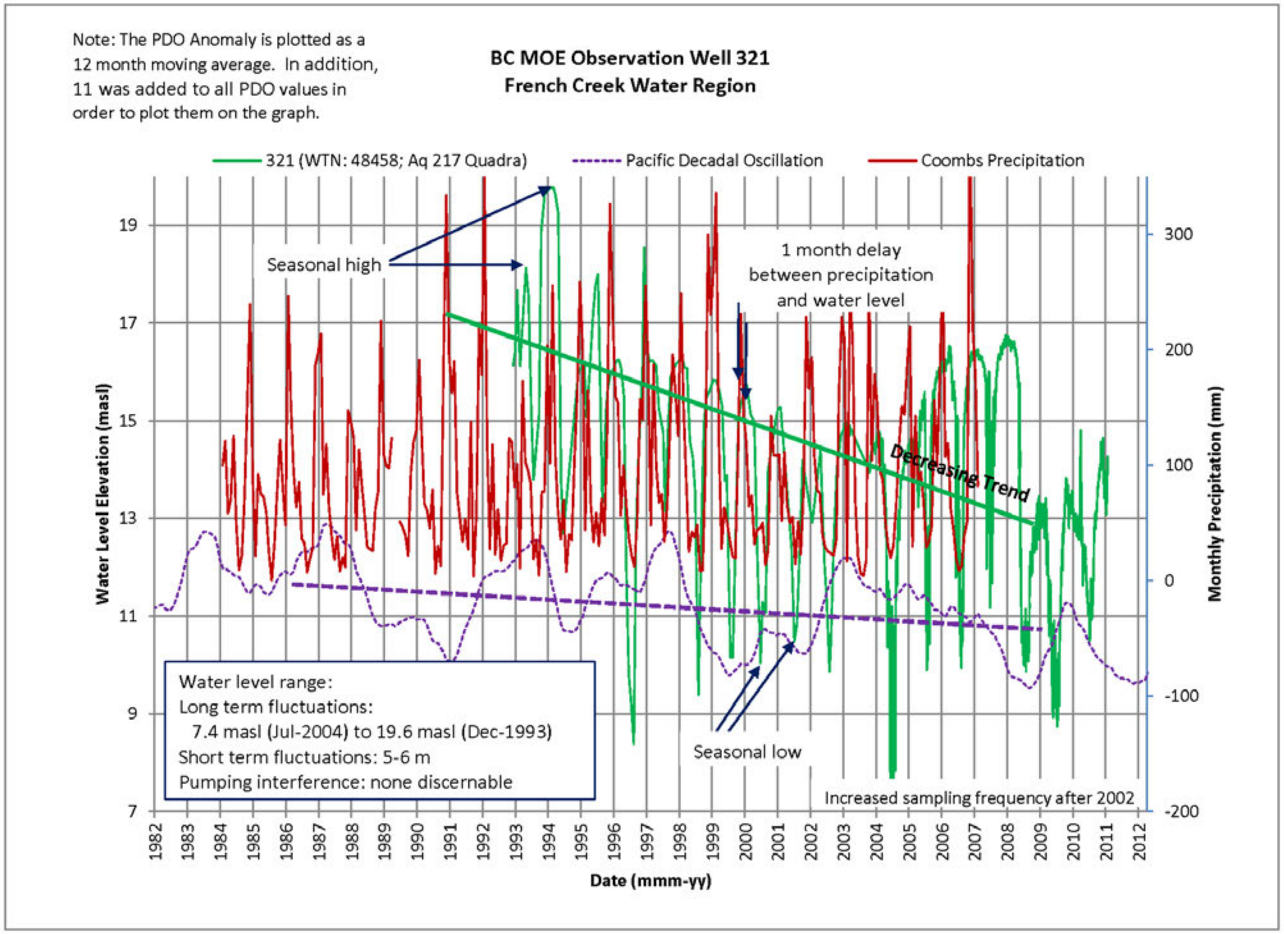

Figure 50: WR3 (FC) – Water Level Hydrograph BCMOE 321.

All MOE observation wells in WR3 (FC), with the exception of MOE well 295 (Figure 44), show significant water level declines from about 1993 to present day. This is likely caused the result of a combination of factors as follows:

- It is understood that MOE observation wells are impacted by the City of Parksville water supply wells. Specifically, the decline observed in MOE well 304 (Figure 48) in early 2010 is related to the operation of a new pumping well that was commissioned by Parksville at that time;
- WR3 (FC) has the smallest catchment area of all water regions in RDN;
- Significant recharge areas are located in the mid to lower part of the water region, which is where much of the development is located. This means that there is limited opportunity for recharge to aquifers in comparison to other larger water regions;
- There is also a limited areal extent of Quadra sand in this region. Overburden thickness maps have been developed and presented in Appendix C (Map C7). The data shows that the thickness and extent of overburden sediment in the coastal area is less and that aquifers likely have narrow boundaries and limited storage capacity for water;
- The area is densely populated and the demand for water supply in this region is higher than surrounding areas. In addition, increased development may have also resulted in increased impermeable surfaces which are known to result in less recharge; and
- MOE wells 287, 295, 303, and 321 appear to follow the PDO trend which indicates that that long-term climate variability (PDO) related to changes in sea surface temperature in the North Pacific has caused reduced precipitation and aquifer recharge over the last 35 years. This could also account for a portion of the water level decline in aquifers with WR3 (FC).

The lack of regulatory guidance on groundwater use in BC has created a situation where the cumulative effects of groundwater extraction, combined with climate variability, may have exceeded the aquifer recharge capacity within the region or in a given area (more local). Typical groundwater studies submitted for subdivision approval in BC involves a 100 day predictive calculation to assess seasonal water level fluctuations. The situation in WR3 (FC) is a good example of how such short-term predictive assessment is inadequate for planning community water supply that extend over a lifetime (100 years or more).

It is imperative that regulatory agencies implement requirements for cumulative effects analysis as a standard practice for confirming groundwater supply in advance of development approval. Submission of groundwater monitoring and aquifer performance data to a centralized database once a water supply system is operational is also required to confirm theoretical cumulative effects estimates. In the absence of regulatory guidance, at either the provincial or municipal level, there is limited opportunity to properly manage water resources in WR3 (FC) and other regions within the RDN such that sustainable groundwater use can be truly achieved.

5.3.6 Anthropogenic Groundwater Demand

Table 29 summarizes the available groundwater demand data available for WR3 (FC).

Table 29: WR3 (FC) – Summary of Anthropogenic Groundwater Demand Analysis

Aquifer Tag No.	Parksville Spring wood Wells	Town of Qualicum Beach Berwick Wells	Town of Qualicum Beach River Wells	RDN French Creek Water System	Epcor	Epcor - Hills of Columbia (Church Rd, Spring Hill Rd)?	Pintail Estates	Epcor (French Creek Estates)	Other Private Wells (From RDN Water Use Est. based on Zoning compiled on GIS)	Total Ground Water Use Estimate (ANTHout)
	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)	(m^3/yr)
220	NA	NA	NA	NA	NA	NA	NA	NA	2.2E+06	2.2E+06
216	2.8E+06	NA	NA	NA	2.0E+05	NA	NA	NA	1.1E+06	4.1E+06
217	NA	8.2E+05		8.0E+04	2.0E+05	NA	NA	1.9E+06	1.7E+06	4.7E+06
212	NA	NA	NA	NA	2.0E+05	NA	NA	NA	3.1E+05	5.0E+05

Notes: NA means not applicable, ? Means not known or unavailable, ANTHout means anthropogenic water extraction from aquifer.

The annual water use for serviced areas within the RDN (large municipal users, RDN wells, and private utilities) is typically measured and was provided by the RDN or taken from annual reports for 2010. The groundwater demand estimate for non-service areas was calculated from water use data provided by the RDN for serviced areas, and then applied to non-serviced areas based on civic addresses and zoning classification. The method of assessment is further described in Appendix C (Map C21) and Appendix D.

There may also be groundwater discharging from aquifers that is required for conservation of flow in creeks and rivers based on the physical model developed by Waterline. The total groundwater demand for each aquifer, including conservation flow requirements, was compared against the total estimated aquifer recharge to assess the stress on each aquifer. The results are presented in the following section.

5.3.7 Aquifer Water Budgets and Stress Analysis

Table 30 provides a summary of final water budget calculations for each aquifer mapped within WR3 (FC). Detailed water budget calculations are provided in Appendix D (Tables D7 and D8). Water budgets for aquifers that extend from one water region to an adjacent water region (E.g.: Aquifer 217 and 220, Figure 40 and Figure 41) were completed on the portion of the aquifer which lies within each region. The water budget calculations were also designed to be additive so that a complete water budget of an entire mapped aquifer that extends across a water region boundary could be easily developed.

As indicated above, there are a total of 895 overburden and bedrock wells listed in the MOE data base in WR3 (FC) which represents the third largest number of wells in all of the 6 water regions across the RDN on Vancouver Island. It is also recognized that this number may only represent as little as 50% of water wells actually in operation in this region. Given that the French Creek water region is the smallest of the 6 regions and generally receives less recharge, the cumulative effect of the relatively high number of groundwater users per water region area results in increase aquifer stress. There is an urgent need to better manage groundwater extraction in this region.

Based on the water budget estimates for mapped aquifers within WR3 (FC); conditions in Quadra aquifers 216 and 217 indicate a high degree of stress. The water budget assessment agrees with observed water levels monitoring in MOE observation wells where substantial water level declines have been measured although some recovery has been observed since water use demands within the RDN French Creek service area decreased in the mid-2000s.

The water budget estimates for bedrock aquifer 212 indicates a moderate level of stress. Although the water budget assessment for aquifer 220 indicates low to moderate stress, local water level monitoring indicates otherwise. In low productivity aquifers, well to well interference can have a strong local effect that is not necessarily reflected at the water region scale water budget assessment. The reason for this is with the limitation of the water budget calculations to low productivity/yield aquifers where the aquifer recharge calculation is applied to the entire surface area of the aquifer. The problem with this approach is that closely spaced supply wells will inherently cause greater local interference. Again, cumulative effects analysis is required to assess the long-term viability/sustainability of this (and other) low yield aquifers within the RDN.

Table 30: Summary of Water Budget and Stress Analysis – WR3 (FC)

Aquifer Tag No.	Aquifer Lithology	Potential Ground Water-Surface water or Aquifer to Aquifer Interaction	MOE Obs Well	Seas. Fluc.	Long Term Fluc.	WL Trend (up or down)	Total Est. AQ. Rec. (TRin) (Rp/l + Rmb)	Est. Ann. Disch to Cr. & Down Grad Aquifer (Tc out)	Ground Water Use Estimate (ANTHout)	Total Out [TcOut + $ANTH_{out}$]	Stress Anal. % GW Use of the avail. AQ. Rec.	Relative Stress Assess.
			ID	(m)	(m)	U/D	(m^3/yr)		(m^3/yr)	(m^3/yr)	(%)	Lo, Mod, Hi
220	Haslam	FC	287		9.1	D	6.4E+06	5.1E+05	2.2E+06	2.7E+06	42	Lo-Mod
216	Quadra	FC	314	1.60	3.60	D/L	4.5E+07	4.1E+07	4.1E+06	4.5E+07	100	Hi
217	Quadra	FC and Ocean	321, 325, 303	5	12	D/L	8.3E+06	6.3E+06	4.7E+06	1.1E+07	133	Hi
212	NG	Ocean	NA	NA	NA	NA	8.8E+05	0.0E+00	5.0E+05	5.0E+05	58	Mod

Notes: FC means French Creek, NA means not applicable, AQ means aquifer, Seas. Fluc. means seasonal fluctuation, PDO means Pacific Decadal Oscillation, WL means water level, Est means estimated, Disch. means discharge, Rec. means recharge ,Cr. Means creek, TRin means total recharge into aquifer, Rp/l means total recharge from precipitation and/or leakage from overlying aquifer, Rmb means total lateral recharge from upgradient aquifer or mountain block, Tc out means total aquifer groundwater discharge to creek, assess. means assessment , Total out means total discharge from aquifer (not including discharge to ocean), ANTH out mean total groundwater Anthropogenic groundwater extraction from aquifer, aquifer stress color codes: blue=low, green =low to moderate, yellow =moderate, brown =moderate to high, red=high to very high.

More accurate water budget and aquifer stress estimates could only be accomplished using a computer modelling approach, but again the lack of aquifer data would likely render this exercise inconclusive as well. Rigorous testing requirements and complete aquifer test analysis by groundwater practitioners to determine aquifer transmissivity and storativity properties, in addition to long-term groundwater monitoring data in each aquifer would be required to fully assess the actual stress on each aquifer in this region.

5.4 Water Management Planning Within WR3 (FC)

General guidance on water management planning for all water regions is provided in later sections of this document. Specific to WR3 (FC), the following recommendation are presented for consideration by RDN to improve the state of knowledge in the water region:

- At least one observation well should be installed in each mapped aquifer. The only aquifer that does not have an MOE/RDN observation well is Aquifer 212. Waterline understands that MOE is currently planning to install additional observation wells in bedrock aquifer 220 and Quadra aquifer 217;
- Well owners should identify the MOE well plate and tag numbers for each of their active water wells. In this manner, water use and monitoring data can be easily cross-referenced with the BC MOE well records. These include Parksville Springwood wells, the Town of Qualicum Beach Berwick Wells, the Town of Qualicum Beach River Wells, French Creek Water System wells, Epcor Hills of Columbia (Church Road and Spring Hill Road) wells, Pintail Estates wells, and Epcor French Creek Estates wells;
- The significant recharge area map needs to be further updated by further processing of the NRCAN remote sensing data and by field verification;
- Further mapping of the groundwater-surface water interactions is also required in French Creek to confirm the preliminary assessment; Waterline recommends specialized analysis (E.g.: isotopes[27], noble gases) of groundwater samples in this region to assist in determining groundwater age and origin. Thermal imaging of the river during high and low flow many help to quickly pinpoint areas where more detailed studies may be required;
- Reactivation of one of the WSC surface water gauging stations on French Creek is recommended; and
- Weekly flow measurements during the summer period (June to Sept) should be collected as part of the Community Watershed Monitoring Network program for Morning Star Creek, Grandon Creek and Carrey Creek to better understand summer low flows in these smaller watersheds.

[27] Elements of the same family but with different atomic weights. Technique is used to assess recharge elevation and age of water.