Associated Environmental

REPORT

Sunshine Coast Regional District

Well Protection Plan

July 2017

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1 Introduction

1.1 PROJECT BACKGROUND

The Sunshine Coast Regional District (SCRD) operates five water supply systems in the Gibsons area. The systems, which include Chaster, Soames, Granthams, Langdale, and Eastbourne, are sourced by eight groundwater wells. The SCRD is required to complete a Well Protection Plan for those wells as one of the conditions of the Permit to Operate a Water Supply System with Vancouver Coastal Health.

In October 2016, Associated Environmental Consultants Inc. (Associated) was retained by the SCRD to complete the Well Protection Plan in accordance with the BC Ministry of Health Living and Sport (MHLS) Comprehensive Drinking Water Source-to-Tap Assessment Guideline (Source-to-Tap Guideline) Modules 1, 2, 7, and 8 (MHLS 2010). This Well Protection Plan addresses those four modules.

1.2 PROJECT OBJECTIVES

The overall goal of the Well Protection Plan is to improve the safety of the drinking water systems. The objectives of developing a Well Protection Plan are to:

- Identify the hazards that may threaten the quality of the groundwater supply source;
- Rank the hazards according to risk;
- Develop recommendations to either reduce the chances that the hazards will occur, or mitigate the risk from the hazards if unavoidable; and
- Provide costs and timelines associated with the recommendations.

All eight wells in the five water supply systems are addressed in this Well Protection Plan. This approach recognizes that the SCRD manages each system; therefore, similarities exist in management, system operation, land use planning, and emergency response coordination.

1.3 PROJECT SCOPE AND GENERAL PROJECT APPROACH

The Source-to-Tap Guideline provides a structured and consistent approach to evaluating risks to drinking water (MHLS 2010). It serves as a tool for water systems to: (a) develop a more comprehensive understanding of risks to drinking water safety and availability, (b) operate effectively, and (c) produce the best possible water quality. The four Source-to-Tap Guideline modules are:

- Module 1: Delineate and characterize drinking water sources
- Module 2: Conduct contaminant source (‘hazard’) inventory
- Module 7: Characterize risks from source to tap
- Module 8: Recommended actions to improve drinking water protection.

As mentioned above, the scope of this Well Protection Plan includes Modules 1, 2, 7, and 8. Modules 3, 4, 5, and 6 are related to engineering and governance, and are not required by the SCRD at this time.

The general approach of the Well Protection Plan is summarized in Table 1-1. The methods used for each module, including details on the risk analysis procedure, are described in Sections 2 through 5.

Table 1-1
General approach of the Well Protection Plan

Module Number	Module Name	Tasks
1	Delineate and Characterize Drinking Water Sources	• Characterized the water source by collecting and reviewing available data including previous groundwater reports, geological and groundwater mapping, flow records, and water quality data • Delineated the 200-day and 10-year well capture zones
2	Conduct Contaminant Source (Hazard) Inventory	• Reviewed existing records to identify potential hazards • Conducted a field survey to identify hazards and inspect the well heads • Lead a workshop with the TAC (Workshop 1) to identify hazards not found during the records review • Created maps showing all identified hazards
7	Characterize Risks from Source to Tap	• Lead a second workshop with the TAC (Workshop 2) to complete a hazard assessment of each identified hazard and ranked each as low risk, moderate risk, high risk, or very high risk • Completed a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis with the SCRD
8	Recommend Actions to Improve Drinking Water Protection	• Provided recommendations for all identified moderate, high, and very high risk hazards • Summarized the results of Modules 1, 2, 7, and 8 in the Well Protection Plan • Reviewed the SCRD emergency response plans and provided some hydrogeology related suggestions for improvements

1.4 TECHNICAL ADVISORY COMMITTEE

The Source-to-Tap Guideline recommends assembling a multi-disciplinary Technical Advisory Committee (TAC) to identify potential hazards to the drinking water system and assess the associated risks. In partnership with the SCRD, Associated facilitated the formation of a TAC whose members are listed in Table 1-2.

Table 1-2
Technical Advisory Committee members

Organization	Name	Title
SCRD	Dave Crosby	Manager of Utility Services Special Projects
SCRD	Kevin Johnson	Senior Water Operator
SCRD	Trevor Rutley	Engineering Technician
SCRD	Beth Brooks	Environmental Technician
Associated	Marta Green	Hydrogeologist
Vancouver Coastal Health	Darren Molder	Senior Environmental Health Officer

Additional SCRD staff (planners, operators) contributed to various components of the workshops. Records of meetings are in Appendix A.

1.5 DEFINITIONS

The following definitions are reproduced from the BC Well Protection Toolkit (BC MOE 2000). The planning team should become familiar with technical terms that will be used throughout the development of the Well Protection Plan. Figure 1-1 is a general model that shows many of these concepts.

Hydrogeology: Hydrogeology is the study of the flow of water and chemicals through the geological formations.

Aquifer: An aquifer is a permeable geological deposit (such as sand and gravel or fractured bedrock) that holds and yields a supply of water (Figure 1-1). The well may draw water from a large portion of the aquifer or only part of it.

Aquifer Protection Area: The aquifer protection area is the land area on which protection measures are taken. In most cases, this will be the area defined as the capture zone. However, it may include an area larger than the capture zone (e.g., the water district boundary). The aquifer protection area should be reviewed every year and revised as necessary.

Aquifer Transmissivity: Aquifer transmissivity refers to the rate that water can be transmitted to a pumping well.

Aquitard: An aquitard is a geological formation that does not transmit a significant amount of water to wells and springs. Some examples of aquitards are layers of finer grained sediments such as silts, clays, and compact tills.

Confined Aquifer: A confined aquifer occurs when an aquitard overlies an aquifer. The low permeability of the aquitard can help in protecting the underlying aquifer from impacts of human activities at the land surface. In those cases, an aquifer is said to be “confined.”

Unconfined Aquifer: Where no aquitards overlie the aquifer, the aquifer is said to be “unconfined” and is vulnerable to impacts from human activities at the land surface, particularly if the water table is shallow. Knowing which areas of the aquifer are most vulnerable can help in focusing the greatest effort into the areas that need most protection.

Water Table: The water table is the level of standing water in the ground (Figure 4-1) and is the upper boundary of the unconfined aquifer. Where the water table comes to the surface, lakes and wetlands form.

Drawdown Cone: When water is pumped from a well, the water table close to the well drops in a cone-shape (Figure 4-1). The area influenced by the pumping well is called the “drawdown cone.” Its shape will vary; it is circular only where the geology is uniform and the water table is level.

Time of Travel: The time it takes for a particular contaminant to be transported through groundwater flow to a specified location. Time of travel is commonly used to relate the distance of a contaminant source to a drinking water well (e.g. “that gas station is located within a one-year time of travel distance from the community well”).

Capture Zone: The capture zone is the land area that contributes water to the community well. A generic example of capture zone is shown in Figure 1-1. Any precipitation (rain or snow) that lands in this area may eventually end up in your well water. So may any fertilizers, oils, spills, or other contaminants.

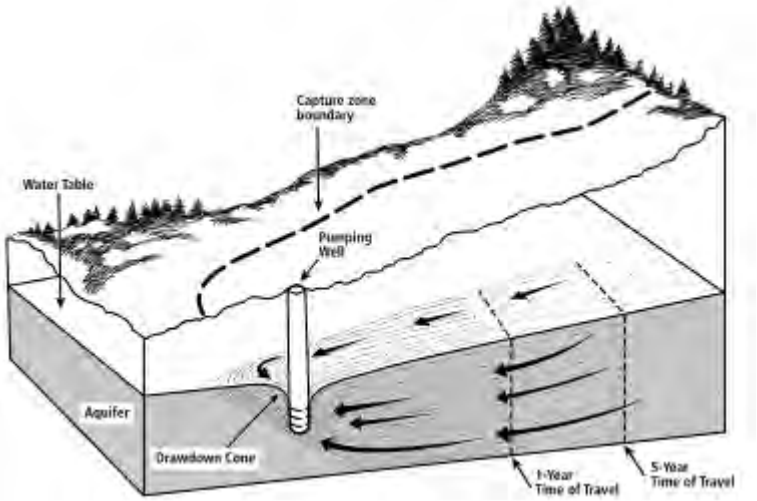

Figure 1-1
Schematic of a capture zone

2 Module 1: Delineation and Characterization of Water Source

Module 1 includes characterizing the water source and delineating the capture zones. The key outcome of Module 1 is a definition of the capture zones for the wells during regular operating conditions. The capture zone is the area around a well that contributes water to the well. To determine this area, an understanding of the water source (including a description of the wells, well sites, and hydrogeological setting) is first required.

2.1 CHARACTERIZATION OF WATER SOURCE

Table 2-1 lists the five water supply systems and eight wells that are included in this Well Protection Plan. The Soames, Granthams, and Langdale systems serve between 80 and 220 connections each. The Chaster system is part of the larger Chapman system, whose main supply is Chapman Creek, but up to 1500 connections within the Chapman system are supplemented by the Chaster well in summer. The Eastbourne system serves 160 connections.

Table 2-1
Well systems, wells, and associated aquifers

System	Well	General Location
Chaster	Chaster Road Well	Gower Point area
Granthams	Granthams Well	Soames Point and Granthams Landing (because the capture zones for these two wells overlap [Section 2.2], they are discussed together in this report).
Soames	Soames Well	
Langdale	Langdale Well	Langdale Ferry Terminal
Eastbourne (on Keats Island)	Drilled Well Gordon Well Collector Well Old East Well	Keats Island

2.1.1 Hydrogeological Setting

All groundwater is recharged from water that falls on the surface of the earth as rain or snow. The hydrogeological setting in which water supply wells are installed will dictate the vulnerability of the wells to contamination from surface, and the time it will take for contaminants to transport through the aquifer.

In confined aquifers, there is a layer of less permeable material, such as clay or silt, overlying the aquifer. This layer helps to protect the aquifer from contamination directly above because contaminants will take a very long time to percolate through, if at all. Unconfined aquifers do not have this overlying layer of less permeable material and are therefore more susceptible to contamination from the surface.

The rate of transport for contaminants in groundwater is dependent upon several factors, but primarily on the aquifer characteristics. Groundwater and contaminants will move quicker through coarse-grained sediments such as sand and gravel than through fine-grained sediments.

Provincial mapping occurred in 2002. The Chaster well is mapped within the Gibsons Lower Aquifer (MOE aquifer 560IIC), an aquifer within Pre-Vashon gravel, sand, and silt sediment. Langdale is mapped within the Langdale/Hopkins Landing Aquifer (MOE aquifer 552IIB), which is composed of more recent fluvial sand and gravel of the Salish sediments. Both aquifers are confined, with moderate productivity, low vulnerability to contamination, and moderate demand. Granthams and Soames are not within any MOE mapped aquifer. The three shallow wells of the Eastbourne system (Gordon, Old East, and Collector) are situated in MOE aquifer 547IIIB, which is a confined sand and gravel aquifer associated with glacio-marine environments (mostly shallow dug wells in till). The Drilled Well on Keats Island indicates 4.6 m of sand and gravel overlying 8.8 m of till, which overlies bedrock. The bedrock aquifer (MOE aquifer 548IIIB) is composed of igneous intrusive or metamorphic fractured rock. Both aquifers on Keats Island are low in productivity, with moderate vulnerability to contamination, and low demand (MOE 2017).

In 2013, a large aquifer mapping study was completed in the Gibsons area (Waterline 2013). Based on our review of the study and our understanding of the lithology of the SCRD wells, the Gibsons Lower Aquifer likely extends even farther than what was mapped by MOE, and likely extends from the base of Mt. Elphinstone to the west and all along the Sunshine Coast from north of Langdale well to south past Chaster well. Based on our review of available reports and well logs, all four wells (not including the four Eastbourne system wells) are likely situated in this larger, regional, confined aquifer.

The majority of recharge to the Gibsons Lower Aquifer is likely occurring at the base of Mt. Elphinstone, where the confining layer is not present (Waterline 2013). However, recharge is also possible at other locations closer to the well sites, including stratigraphic windows (i.e., where the confining layer is absent or thin), “losing” streams, and, to a lesser extent (orders of magnitude less), from confining layers “leaking” water to the aquifer.

Figure 2-1 shows the boundaries of the MOE mapped aquifers. However, based on the limitations on the MOE mapped aquifers described above, MOE mapped aquifers are not shown on figures after Figure 2-1.

2.1.2 Description of Wells and Well Sites

Tables 2-2 and 2-3 summarize the wells on the mainland and Keats Island, respectively. Available well logs are provided in Appendix B and well locations are shown on Figure 2-1.

Table 2-2
Summary of wells on Mainland

Well ID		Chaster Road Well	Soames Point Well	Granthams Landing Well	Langdale Well
Well Tag Number (WTN)		23421	65967	78231	24390
Well Plate ID (WPID)		n/a	n/a	n/a	n/a
Year of Construction		1970	1979	1990	1971
Maximum Supply Capacity (L/s)		17[A]	41[B]	2.8[C]	23[D]
Location	Easting (m) (Zone 10 U))	460374	464290	464236	465350
	Northing (m) (Zone 10 U)	5471238	5473657	5473615	5475842
	Ground Elevation (masl)	100	37	31	30
Construction Data	Static Water Level (m btoc)	70.7	9.4	flowing artesian	0.9
	Well Depth (m bgs)	108.2	36.9	15.8	44.5
	Screened Interval(s) (m bgs)	99.1 to 108.2	unknown	12.6 to 15.8	35.4 to 44.5
	Casing Diameter (mm)	203.2	254.0	203.2	304.8
	Screen Diameter (mm)	177.8	unknown	177.8	203.2

Notes:
masl – metres above sea level. Source: Google Earth digital elevation model.
m btoc – metres below top of casing
m bgs – metres below ground surface
A – Sustainable yield from the March 2014 flow test (Rutley, personal communication, 2016).
B – Alluvia (2004a). Reported maximum pumping rate at 650 US gpm.
C – Alluvia (2004b). Well is flowing artesian at 45 US gpm; well is not pumped
D – Alluvia (2004c). Well is pumped at 223 US gpm when operating at 60% capacity. Pumping rate at 100% was extrapolated from this value.
E - Langdale construction details source: Dayton Knight (1971). All other well construction details from well logs.

Table 2-3
Summary of Eastbourne wells (Keats Island)

Well ID		Gordon Well	Old East Well	Collector Well	Drilled Well
Well Tag Number (WTN)		749	7997	n/a	92987
Well Plate ID (WPID)		n/a	n/a	n/a	n/a
Year of Construction		unknown	unknown	unknown	2004
Maximum Supply Capacity (L/s)		unknown	unknown	unknown	0.13
Location	Easting (m) (10 U)	468270	468411	468379	468406
	Northing (m) (10 U)	5471445	5471739	5471743	5471762
	Elevation (masl)	40	63	70	65
Construction Data	Static Water Level (m bgs)	unknown	2.4	n/a	unknown
	Well Depth (m bgs)	6.1	6.1	n/a	74.7
	Screened Interval(s) (m bgs)	open hole - unknown interval	open hole from 1.2 to 6.1	n/a	open hole from 17.7 to 74.7
	Casing Diameter (mm)	1524	2134	n/a	152.4
	Screen Diameter (mm)	n/a	n/a	n/a	n/a

Notes:
masl – metres above sea level. Source: Google Earth digital elevation model.
m btoc – metres below top of casing
m bgs – metres below ground surface
Drilled well construction details source: Piteau (2005). All other well construction details from well logs.

2.1.3 Water Quality

Associated reviewed water quality data provided by the SCRD. The available data, average concentrations of key parameters, and comments about any noted increases in concentrations are provided in Table 2-4

Table 2-4
Summary of available water quality data

Well	Available Data	Average Concentrations		Raw water bacteria results	Comments
Chaster Road Well	General parameters, nutrients, and total metals: June 2008, May 2009, June 2010, May 2012, and May 2015. Additional nitrate, nitrite, and total phosphorus data from 2001 and 2002.	Chloride = 4.6 mg/L Sodium (total) = 8.24 mg/L Sulphate = 5.2 mg/L TDS = 114 mg/L	Turbidity = 1.6 NTU Nitrate = 0.71 mg/L Hardness = 45.0 mg/L	None available	• Minor indication of increasing nitrate-N. Between 2001 and 2002, nitrate-N was around 0.6 mg/L. Between 2008 and 2012, it was around 0.7 mg/L. In the most recent sample (2015), it was 1.01 mg/L. Also minor increase in chloride (4 mg/L in 2008 to 6 mg/L in 2016). • One sample (2008) of total iron (0.576 mg/L) was above the aesthetic objectives (0.3 mg/L) out of five samples collected.
Soames Point Well	General parameters, nutrients, and total metals tested yearly or bi-annually from 2008 to 2016. Additional nitrate, nitrite, and total phosphorus data from 2001, 2002, 2003, and 2007. Total coliforms and *E. coli* tested twice monthly in 2011 and 2013.	Chloride = 3.8 mg/L Sodium (total) = 5.8 mg/L Sulphate = 7.5 mg/L TDS = 98 mg/L	Turbidity = 0.2 NTU Nitrate = 0.66 mg/L Hardness = 39.6 mg/L	Neither total coliforms nor *E. coli* were detected in any of the 46 samples from 2011 and 2013.	• Minor indication of increasing chloride (3.2 mg/L in 2008 to 4.8 mg/L in 2016) and sodium (5.11 mg/L in 2008 to 6.8 mg/L in 2016).
Granthams Landing Well	General parameters, nutrients, and total metals tested yearly or bi-annually from 2009 to 2015. Total coliforms and *E. coli* tested monthly (occasionally twice per month) in 2013. Some additional data from 2011.	Chloride = 3.2 mg/L Sodium (total) = 5.3 mg/L Sulphate = 7.8 mg/L TDS = 92.5 mg/L	Turbidity = 0.8 NTU Nitrate = 0.45 mg/L Hardness = 35.6 mg/L	Total coliforms were detected in four of 18 samples in 2013 (at 3 counts maximum) and *E. coli* were not detected. Neither *E. coli* nor total coliforms were detected in the six samples from 2011.	• Turbidity exceeded 1 NTU periodically (2011, 2012).
Langdale Well	General parameters, nutrients, and total metals tested yearly or bi-annually from 2008 to 2016. Additional nitrate, nitrite, and total phosphorus data from 2001, 2002, 2003, 2005, and 2007. Total coliforms and *E. coli* tested twice monthly in 2011 and 2013.	Chloride = 2.9 mg/L Sodium (total) = 5.9 mg/L Sulphate = 10.0 mg/L TDS = 81.4 mg/L	Turbidity = 0.4 NTU Nitrate = 0.34 mg/L Hardness = 34.5 mg/L	Neither total coliforms nor *E. coli* were detected in any of the 24 samples from 2013. In 2011, total coliforms were detected once out of 23 samples (at 1 count) and *E. coli* were not detected.	• Total copper and iron have increased. Total copper increased from 1.9 µg//L in 2008 to 2.33 µg/L in 2016. Total iron increased from 0.053 mg/L to 0.0908 mg/L in 2016. • Total sodium increased from 5.43 mg/L in 2008 to 6.99 mg/L in 2016. • One elevated nitrate result (2.19 mg/L in 2005). Otherwise, nitrate remained below 0.4 mg/L.

Table 2-4
Summary of available water quality data

Well	Available Data	Average Concentrations		Raw water bacteria results	Comments
Eastbourne Drilled Well	General parameters, nutrients, and total metals tested yearly to three times annually from 2007 to 2016. Total coliforms and *E. coli* tested twice monthly in 2011 and 2013.	Chloride = 7.9 mg/L Sodium (total) = 67.8 mg/L Sulphate = 24.5 mg/L TDS = 231.1 mg/L	Turbidity = 0.4 NTU Nitrate = 0.042 mg/L Hardness = 26.2 mg/L	Neither total coliforms nor *E. coli* were detected in any of the 26 samples from 2013. In 2011, total coliforms were detected in three of 22 samples (at 36.4 counts maximum). *E. coli* were not detected.	• Total arsenic frequently exceeded the MAC guideline of 10 µg/L. Total manganese exceeded the AO guideline of 50 µg/L once. The well is treated for arsenic. • Chloride increased from 4.2 mg/L in 2007 to 10 mg/L in 2016. Total sodium also increased from 27.1 mg/L in 2007 to 74.3 mg/L in 2016, with the exception of 79 mg/L in 2008.
Mixed raw water (Eastbourne System)	General parameters, nutrients, and total metals tested yearly to three times annually from 2007 to 2016. Total coliforms and *E. coli* tested twice monthly in 2011 and 2013 in the Collector Well, Old East Well, and Gordon Well.	Chloride = 7.4 mg/L Sodium (total) = 16.8 mg/L Sulphate = 9.9 mg/L TDS = 84.7 mg/L	Turbidity = 0.2 NTU Nitrate = 0.6 mg/L Hardness = 20 mg/L	**Collector Well** – Total coliforms were detected in four of 26 samples in 2013 (at 10 counts maximum) and six of 27 samples in 2011 (at 410.6 counts maximum). *E. coli* were not detected in 2013, but were detected once in 2011 (at 1 count). **Old East Well** – total coliforms were detected frequently (over 75% of the time) in 2011 and 2013. *E. coli* was detected once each in 2011 and 2013, at 2 counts and 1 count, respectively. **Gordon Well** – total coliforms were detected over frequently (over 80% of the time) in 2011 and 2013. *E. coli* was detected twice in 2013 and once in 2011 (at 2 counts maximum)	• Lead exceeded the MAC guideline of 10 µg/L once in September 2013 (14.7 µg/L).

Notes:
TDS = Total dissolved solids

2.2 DELINEATION OF CAPTURE ZONES

Table 1-4 in Module 1 of the Source-to-Tap Guideline summarizes the different capture zone delineation methods, from simple to more complex, and recommends which one to follow depending on the size of the water system and the hydrogeologic setting (MHLS 2010). The number of connections each well is used for ranges from 80 (Soames Well) to 1,500 (the Chapman water system up to Gower Point, which is augmented by the Chaster well in summer only). For water systems with 100 to 10,000 connections, the Source-to-Tap Guideline recommends using analytical equations and hydrogeological mapping to delineate the capture zones. Therefore, we used a combination of hydrogeological mapping and the analytical equation method outlined by Ceric and Haitjema (2005), which includes a mathematical approach to justify the method selection between the circular, eccentric circular, and boat-shaped capture zone analytical equations that are presented in the BC Well Protection Toolkit (MOE 2000). The analytical equations required estimating the aquifer's hydraulic conductivity (m/s), thickness (m), hydraulic gradient (unitless), and porosity (unitless) as well as the pumping rate of the well (m^3/s) and the timeframe of interest.

For this assignment, capture zones are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate. This is to allow for an increase in pumping rate, if the SCRD so chooses, without re-doing the capture zones. Following this approach, we mapped the 200-day and 10-year capture zones for each well. A 200-day capture zone represents the survival time of pathogens (including viruses) and is consistent with the new version of the BC Ministry of Health's Guideline for Determining Groundwater at Risk of Containing Pathogens (MoH 2015)[1]. A 10-year capture zone represents the time it would take to remediate a chemical spill or leak. In addition to 200-day and 10-year capture zones, well protection zones of 100 m were applied to all wells. The well protection zone represents the area of greatest risk to source water, and is a recommendation from the Source-to-Tap Guideline. Herein, the capture zones are referred to as Aquifer Protection Areas (APAs). The 100 m well protection zone is referred to as APA A, the 200-day capture zone is referred to as APA B, and the 10-year capture zone is referred to as APA C. An overview of the delineated APAs for all wells is shown on Figure 2-1, and Table 2-5 lists the parameters that were used to delineate the capture zones.

[1] Pathogens are disease causing organisms. There are three types of water-born pathogens of concern to humans: viruses, bacteria, and protozoa, each with different sizes, life cycles, and characteristics.

Table 2-5
Parameters used to delineate the capture zones for Chaster, Soames, Grantham, and Langdale Wells

		Chaster Well (WTN 23421)	Soames Well (WTN 65967)	Granthams Well (WTN 78231)	Langdale Well (WTN 24390)
Aquifer description based on well logs		Confined, fine sand aquifer	Confined, coarse sand and gravel aquifer		Confined, fine sand aquifer
Analytical equation used	200-day	Eccentric circular	Boat-shaped	Boat-shaped	Circular
	10-year	Boat-shaped	Boat-shaped	Boat-shaped	Eccentric circular
Hydraulic conductivity (m/s)[1]		$3x10^{-5}$	$2x10^{-3}$ m/s	$2x10^{-3}$ m/s	$1x10^{-5}$ m/s
Aquifer thickness (m)[2]		32.3	7.3	8.2	22.3
Porosity[3]		0.25	0.25	0.25	0.25
Hydraulic gradient[4]		0.02	0.02	0.02	0.035
Pumping rate		270 US gpm (17 L/s) [5]	650 US gpm (41 L/s) [6]	45 US gpm (2.8 L/s) [7]	373 US gpm (23 L/s) [8]
Changes to analytical equation results based on hydrogeological mapping		No changes made to the analytical equation results.	The individual capture zones coincided, so the 200-day and 10-year zones were combined. These capture zones were large and extended beyond Mt. Elphinstone so they were ended at what is estimated to be the contact of the bedrock and the surficial sediments.		No changes made to the analytical equation results.

Source:
[1] Waterline (2013) for Chaster and Soames Point. Granthams is assumed to be the same as Soames Point. For Langdale, the hydraulic conductivity was estimated based on the well lithology and values in Freeze and Cherry (1979).
[2] Waterline (2013) and the well log for Chaster, and from the well logs for Soames Point, Granthams, and Langdale.
[3] Freeze and Cherry (1979) for all wells.
[4] Waterline (2013) and topography for Chaster, Soames Point, and Granthams and from topography for Langdale.
[5] Sustainable yield from the March 2014 flow test (Rutley, personal communication, 2016).
[6] Alluvia (2004a). Reported maximum pumping rate at 650 US gpm.
[7] Alluvia (2004b). Well is flowing artesian at 45 US gpm; well is not pumped
[8] Alluvia (2004c). Well is pumped at 223 US gpm when operating at 60% capacity. Pumping rate at 100% was extrapolated from this value.

The Drilled Well (WTN 92987), Old East Well (WTN 7997), and Collector Well (no WTN) are located around the Eastbourne water treatment plant. The Drilled Well is 74.7 m deep and installed in fractured granite. Piteau (2005) estimated the hydraulic conductivity of the aquifer to be $1x10^{-7}$ m/s. The porosity of fractured rock aquifers is assumed to be 0.1 (Freeze and Cherry 1979). Based on topography, the hydraulic gradient is approximately 0.08. Piteau (2005) indicated that the sustainable well yield was approximately 2 US gpm ($1.3x10^{-4}$ m^3/s). These variables indicated that an eccentric circular method would be the most suitable for the 10-year capture zone. The result was a circle with a radius of 50 m shifted upgradient 4 m. Since this area is smaller than the well protection zone (100 m radius), the well protection zone was used for the 10-year capture zone. The Collector Well is a shallow, dug trench lined with drain rock that collects surface

water and pumps it into raw water tanks for treatment. Because this trench collects surface water, the capture zone is ultimately the catchment area for surface water. For the 1 and 10-year aquifer protection areas, we therefore delineated the catchment area of the 100m well protection zone (Figure 2-1). The Old East Well is a shallow dug well (6.1 m deep) about 30 m from the Collector Well. Therefore, the aquifer protection areas for the Old East Well is combined with those of the Collector Well.

The Gordon Well (WTN 749) is located approximately 350 m south of the Eastbourne water treatment plant. It is a dug well approximately 6.1 m deep. Very little information exists regarding the lithology or construction of the well. Similar to that used for the Collector Well, and because the well is so shallow, the 1 year and 10-year aquifer protection areas for the Gordon Well is the catchment area for surface water of the well protection zone (100 m radius around the well).

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Well Location

SCRD Water Mains

MOE Aquifer

Aquifer Protection Area

A - 100m Well Protection Zone

B - 200 Day Time of Travel

C - 10 Year Time of Travel

Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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DRAWN BY: DA

FIGURE 2-1: CAPTURE ZONE OVERVIEW - ALL WELLS

Sunshine Coast Regional District

Well Protection Planning

3 Module 2: Contaminant Source Inventory

Module 2 includes a contaminant source inventory that identifies the inherent risks to water quality as well as describing land uses, human activities, and other potential hazards that could affect source water quality within the APAs. In this Well Protection Plan, potential contaminant sources are referred to as "hazards."

3.1 TYPES OF HAZARDS

3.1.1 Point Source and Non-Point Source Hazards

The term hazards are defined in the Source-to-Tap Guideline to mean both actual/existing and potential hazards. Hazards are typically categorized as point source or non-point source. Point sources of contamination arise from a single, identifiable location (e.g., a wastewater treatment plant). Non-point sources arise from multiple diffuse sources over an area (e.g., runoff from agricultural land, septic tanks).

There are seven main types of land uses that can cause a point source or non-point source hazard. Examples of hazards from each type of land use are as follows:

- Naturally occurring: pathogens from wildlife including bacteria (*E. coli*), and protozoa such as *Giardia lamblia.* Bacteria die off in a matter of weeks, but protozoa can remain active for months because of a protective shell.
- Agricultural: nitrates, phosphates, pesticides, automotive wastes from farm machinery
- Forestry-related: phenolics from decomposing woodwaste, turbidity, nitrates, motor fuel and pathogens from camp wastewater
- Municipal: fertilizers and pesticides from fields/parks, stormwater run-off, salt (sodium chloride)
- Commercial: contaminants from airports, auto repair shops, dry cleaners
- Industrial: specific contaminants from specific industrial land uses
- Residential: pathogens from septic tanks, heating oil, pesticides, solvents

3.1.2 Climate Change

In recent years we have experienced extreme weather and weather-related events across Canada, including storms, flooding, drought, wind, and wildfires. Water system infrastructure, including water quality from water supply wells, is vulnerable to the changing climate. For example, virus detection and concentrations appear to be associated with groundwater recharge events (Bradbury et al. 2013), and more precipitation systematically increased childhood gastrointestinal illness in municipalities accessing untreated water, including both groundwater and surface water sources (Uejio et al 2014). In that case, the relative risk of contracting gastrointestinal illness was 240% higher in very wet weeks with 12 cm of precipitation (Uejio et al 2014). This suggests that with a changing climate and more extreme storm events, groundwater supplies may not be as protected from surface contaminants as once thought.

3.2 HAZARDS INVENTORY

To determine potential hazards, the following tasks were conducted:

1. A review of existing records, including:
   - MOE Site Registry of contaminated sites
   - Historical aerial photographs of the area
   - Zoning maps
   - Utility maps
   - MOE waste management database
   - BC Water Resource Atlas to identify all registered wells
   - Relevant past reports
2. A field survey; and
3. A workshop (Workshop 1) with the TAC members who added and removed hazards based on their knowledge of the water supply systems.

3.2.1 Records Review

3.2.1.1 Site Registry

The Site Registry is a database administered by the MOE that pertains to the environmental condition of land in the province (MOE 2016b). This registry is not a complete database of contaminated sites in BC, but it does provide a record of sites that the MOE has documented as contaminated or as having undergone a contaminated sites investigation. Search results typically provide a record of current or past contamination, spills, or environmental works at registered sites.

Associated conducted a large area search (i.e., 100 km^2 from the approximate centre of the study area), which returned 23 records of surrounding properties. Of these 23 records, only four were for properties within the designated capture zones (Site IDs 8414, 9116, 9449, and 18124). Detail Reports were obtained for these four properties and are summarized below. The Site Registry search and Detail Reports are provided in Appendix C.

Langdale Ferry Terminal (Site ID 8414): Located in the Langdale Well Capture Zone
This site has been registered with the MOE since 2003. The Detail Report indicates that a Notice of Independent Remediation Completion was submitted to the MOE in 2003. The owner of the site was listed as BC Ferries. The site is currently listed as Inactive- No Further Action.

1281 Marine Drive, Gibsons (Site ID 9116): Located in the Langdale Well Capture Zone
This site has been registered with the MOE since 2004. The Detail Report indicates that a Certificate of Compliance (COC) was issued by the MOE in 2014. This COC was issued after remediation was undertaken and completed following the decommissioning of the former Hopkins Landing Bulk Plant. The site is currently listed as Active- Remediation Complete. Based on this information, it is unlikely that this site will pose environmental concern in the capture zone.

1170 Stewart Road, Gibsons (Site ID 9449): Located in the Granthams and Soames Well Capture Zone
This site has been registered with the MOE since 2005. The Detail Report indicates that a Site Profile was submitted to the MOE in 2004 for a property that was used for ship building or boat repairs. It was

determined by the MOE that no further investigation was required. The site is currently listed as Inactive- No Further Action. Based on this information, this site is not expected to pose significant environmental concern for the capture zone.

1196 Stewart Road, Gibsons (Site ID 18124): Located in the Granthams and Soames Well Capture Zone
This site has been registered with the MOE since 2015. The Detail Report indicates that a Site Profile was submitted to the MOE in 2015 for a welding and machine shop and industrial wood waste disposal operation. The Site Profile indicated that the site had fill material that could potentially have come from a contaminated source, and that there were above-ground fuel or chemical storage tanks present at the site. This triggered the MOE to determine that further investigation was required. This determination does not necessarily mean there is contamination present at the site, but rather that the operations at the site warrant further investigation (i.e. a Stage 1 or 2 Preliminary Site Investigation). There is no other information available in the Detail Report as to whether any further investigative work has been conducted at the site. The site is currently listed as Active- Under Assessment. To date, there have been no updates to the status of this report since it was registered in 2015. Associated spoke with Ms. Jennifer Samways, Site Information Advisor with the MOE on March 14, 2017. She indicated that there is no further information available for this site, and if there have been updates to the status of the site (i.e. notice of contamination, or migration of contamination off-site) that it would have been listed in the Detail Report (J. Samways, pers. comm. 2017). She also stated that any changes to the status of sites is updated once a week. Since there have been no updates to this report since 2015, it is difficult to definitively conclude whether the site poses a risk of contamination in the capture zone or not. However, new information on this site may become available over time, which could help determine the level of risk (if any) that the site poses to the drinking water supply wells.

3.2.1.2 Historical Aerial Photographs

Associated reviewed historical aerial photographs and Google Earth images for the area dating back to 1967. A summary of the findings of the review is provided in Table 3-1.

Table 3-1
Historical aerial photograph review

Date	Description			
	Chaster	Granthams and Soames	Langdale	Eastbourne
1967, 1968, 1972, 1978	The capture zone is mainly undeveloped forested land.	The capture zone is mainly undeveloped or small-scale residential and agricultural properties. An industrial area is being developed in the north portion of the capture zone	The capture zone is mainly undeveloped land and small-scale residential properties. The Langdale Ferry Terminal is located in the centre of the capture zone.	The capture zone is mainly undeveloped forested land.
1982, 1986, 1990, 1994, 1998	The capture zone is mainly small-scale residential properties or undeveloped forested land. There is a cleared area in the northwest portion of the capture zone, which appears to be used as a cement plant. Arial photographs were not available for 1986 for this capture zone.	The capture zone is generally the same as 1978, except the industrial zone in the north is more developed and there are more residential properties in the south and central portions of the capture zone. Aerial photographs were not available for 1986 or 1982 for this capture zone.	The capture zone is generally the same as 1978, except for slightly more development of residential properties. Prior to the 1998 air photo, the highway ran directly east of the Langdale Well, by the Langdale Ferry Terminal. Between 1994 and 1998, it appears that a highway bypass was constructed further west of the well. The area between the old highway and the new bypass was converted into a paved parking lot.	The capture zone is generally the same as 1978 except for a small increase in residential properties.

Date	Description			
	Chaster	Granthams and Soames	Langdale	Eastbourne
2005, 2009, 2012, 2013, 2014, 2016	The capture zone is generally the same as in 1998, except there is more development of residential properties in the south end of the capture zone. The cement plant is still visible in the northwest corner.	The capture zone is a mixture of commercial, industrial, and residential properties. The industrial area is in the north portion of the capture zone, while the main residential areas are in the south and centre portions of the capture zone.	The capture zone is a mixture of medium-density residential properties and undeveloped forested land. The Langdale Ferry Terminal is located in the centre of the capture zone.	The capture zone is mainly undeveloped forested land. There are some small-scale residential properties and unpaved access roads located throughout.

3.2.1.3 Zoning Information

Current (2016) zoning information was publicly available through the SCRD's and Islands Trust website. The zoning in the capture zones are mainly agricultural, residential, and parkland land use. However, some commercial and industrial land use is present, specifically in the Granthams and Soames well capture zone. Areas within the capture zones that are zoned for commercial and industrial land use present a higher risk for contamination to occur. An overview of the zoning for each of the capture zones is summarized below:

- Chaster – Zoning is a mixture of residential, park/assembly, and rural. There are no areas with commercial or industrial zoning.
- Granthams and Soames – There is an industrial area located in the north portion of the capture zone, where there are a number of potential hazards. The remaining area is zoned for rural, residential, and park/assembly land use.
- Langdale – The capture zone is a mixture of residential, park/assembly, and rural zoning. The Langdale Ferry Terminal is located in this capture zone, which could be considered as commercial or light industrial land use.
- Keats Island – The capture zone is a mixture of residential, institutional, and rural zoning.

Zoning information of interest is shown on Figures 3-1, 3-2, 3-3, and 3-4.

3.2.1.4 Utility Maps

The SCRD provided maps of water lines (Figures 3-1, 3-2, 3-3, and 3-4). Some information was provided for two private sanitary systems, and any relevant information was added to the list of hazards. No other utility information was provided. We assume that there are private utilities in the area (e.g., natural gas and cable), and have made some assumptions based on their location when developing recommendations.

3.2.1.5 Waste Management Database

A search of the Waste Management Database (MOE 2016c) included the Authorization Management System Database (AMS) and the Environmental Violations Database (EVD). All relevant information was included during Module 7, Characterization of Risk.

3.2.1.6 BC Water Resource Atlas

A search of the BC Water Resource Atlas revealed all registered water wells within the water supply systems (MOE 2016a). Registered water wells are shown on Figures 3-1, 3-2, 3-3, and 3-4.

3.2.1.7 Review of Relevant Reports

Associated reviewed the following previous reports to identify potential water well hazards:

- Alluvia Environmental Services. 2004. Sunshine Coast Regional District Langdale Water System: Drinking Water Source Assessment Report. Prepared for: Coast Garibaldi Health, Vancouver Coastal Health Authority.
- Alluvia Environmental Services. 2004. Sunshine Coast Regional District Soames Point Water System: Drinking Water Source Assessment Report. Prepared for: Coast Garibaldi Health, Vancouver Coastal Health Authority.
- Dayton & Knight. 1996. Aquifer Protection Plan. Sunshine Coast Regional District. This includes a report from Piteau Associates. 1996. Re: West Howe Sound Public Water Supply Well's Capture Zones.
- Opus Dayton Knight Consultants Ltd. 2013. Comprehensive Regional Water Plan. Prepared for: Sunshine Coast Regional District.
- Piteau Associates. 1998. Sunshine Coast Aquifer Protection Plan, Monitoring Well Installation.
- Piteau Associates. 1999. Sunshine Coast Aquifer Protection Plan, Monitoring Well Update and SCRD Production Well Instrumentation Costs
- Piteau Associates Engineering Ltd. 2005. Eastbourne Well Protection Study. Prepared for: Sunshine Coast Regional District.
- Sunshine Coast Regional District and Enerficiency Consulting. 2012. Sunshine Coast Renewable Energy Atlas.

All relevant information is included in the appropriate table list of hazards.

3.3 FIELD SURVEY

Marta Green, P.Geo., of Associated performed the field survey on November 14 and 15, 2016. Ms. Green was accompanied by Trevor Rutley, Codi Abbott, and Kevin Johnson on November 14, and by Paul Sheridan on November 15. At the Eastbourne sites, we were joined by water operators Alex Laidlaw, Andrew Nadler, and Scott Benson. All relevant information was included during Module 7, Characterization of Risk.

3.4 TAC WORKSHOP 1

On November 14, 2016, Associated led TAC Workshop 1 to identify hazards not found during the records review and to obtain more information on the hazards that were identified by Associated during the records review. The workshop was attended by TAC members (Table 1-1). The TAC reviewed the hazards identified during the records review. The TAC then added and removed hazards based on local knowledge. In total, 26 potential point-source hazards and 8 non-point source hazards were identified. The hazards are separated into point sources and non-point sources.[2]

The hazards identified during the records review, field survey, interviews, and TAC Workshop 1 were used to produce the list of hazards (Table 3-2). The locations of the identified point source contaminants are shown in Figure 3-1.

[2] Point sources of contamination arise from a single, identifiable location (e.g., a wastewater treatment plant). Non-point sources arise from multiple diffuse sources over an area (e.g., agricultural land, septic tanks).

Table 3-2
Drinking water hazards – Chaster Well

Hazard No.	Hazard	Owner/ Jurisdiction	Location	Contaminants of Concern	Transport Mechanism and other notes
Point Sources					
PS-1a	Well site Hazard 1a: Well is located in a concrete pit.	SCRD	At wellhead	Pathogens	Direct to groundwater via annular space to screen intake
PS-1b	Well site Hazard 1b: Roof drain discharges to pipe - unknown where the pipe drains to.	SCRD	At wellhead	Pathogens	Short circuit to below ground surface and within 1 m of well casing.
PS-2	Lower Chaster Creek	Public	At edge of APA A and B, upgradient of well.	Pathogens, nitrates	Infiltration to groundwater
PS-3a	Gibsons Redi-Mix Ltd. gravel plant. The gravel plant is closing down soon.	Private owner	740 m north. 1327 Fitchett Road	Elevated pH from possible cement wastewater, hydrocarbons from possible above-ground storage tanks and under-ground storage tanks, antifreeze from chemical release.	Deposits and runoff to groundwater, or to Chaster Creek and then to groundwater.
PS-3b	Gibsons Redi-Mix Ltd. Redevelopment plan: subdivision and 60 trailer pads with onsite septic. Two subdivided lots, both under 22,700 L/day. However, the SCRD is requiring the wastewater treatment facility to meet the Municipal Wastewater Regulations.	Private owner	740 m north. 1327 Fitchett Road	Nitrates (pathogens are not considered a hazard because site is outside of the 200-day capture zone)	Infiltration to groundwater, or to Chaster Creek and then to groundwater.
Non-point Sources					
NPS-1	Poorly constructed existing wells in capture zone - monitoring wells, irrigation wells, domestic wells, or geoexchange wells	Various owners	Throughout all capture zones	Poorly constructed existing wells or wells drilled pre-2005 may not have been constructed with a surface seal and therefore could act as a direct pathway to the aquifer, and then the contaminant would travel horizontally through aquifer.	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200 day the concern would be on chemical contaminants.
NPS-2	Underground or above-ground residential heating oil storage tanks	Private owners	Throughout all capture zones	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	Leaks and spills, and then infiltration to groundwater
NPS-3	Residential properties	Private owners	Directly across from well	Pesticides, herbicides, household cleaners, automotive wastes	Deposits and runoff to groundwater
NPS-4	Agricultural operations	Private owners	About 25% of Aquifer Protection Area C is within the ALR	Nitrates, pesticides, herbicides, pathogens	Runoff, seepage to groundwater
NPS-5	Natural gas lines and other private utilities (preferred pathways)	Fortis BC and others	Throughout capture zone area	Utility lines and the bedding sands used to install the utility lines can act as preferred pathways carrying surface contaminants longer distances than through native ground.	Spills, runoff, leaks infiltrating to groundwater
NPS-6	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Velvet Road, directly adjacent to well	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	Spills, runoff, leaks infiltrating to groundwater
NPS-7	Animals and pests	Various owners	In green space throughout study area	Pathogens	Deposits to soil and groundwater
NPS-8	Septic systems/septic tanks	Private owners	Closest upgradient residential area is 23 m away (to front lawn). About 8 homes are within APA B.	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, and PCPs (pharmaceuticals and personal care products). Tetrachloroethylene, dichlorobenzene, and methylene chloride are present in some septic tank/cesspool cleaners.	Infiltration to groundwater

Smelt Creek
Whispering Firs
PA2
RU1
PA2
RM2
End Creek
Walker Creek
R2
Georgia Crest
R2A
R2
RM3
PS-3 a/b
Chaster Tributary
RU1
RU3
RU3A
WTN 13963
WTN 17042
WTN 17041
WTN 11480
WTN 93009
WTN 11537
WTN 17323
WTN 11628
WTN 17914
Ocean
WTN 15038
WTN 11759
WTN 17046
WTN 17040
WTN 11395
WTN 11476
R1
PA1
Cedar Meadows
WTN 17043
WTN 43984
Lower Chaster Creek
PS-2
Velvet and Knight
PA1
WTN 23421
Chaster Road Well
PS-1 a/b
WTN 19943
WTN 15037
Maryanne West
Cedar Grove Elementary
W1
RM2
C3
R1
WTN 14418
WTN 11629
Grandview Heights
PA1
N
W
E
S
Meters
0
250

ID Number	Hazard
PS-1a	Chaster Road Well construction
PS-1b	Chaster Road Well roof drain pipe
PS-2	Lower Chaster Creek
PS-3a	Gibsons Redi-Mix gravel plant (closing soon)
PS-3b	Redevelopment plan: subdivision with onsite septic

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Associated Environmental

Potential Hazard
Well Location
MOE Registered Well

SCRD Water Mains
Zoning* Boundary

ALR Land
Park

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

Aquifer Protection Area
A - 100m Well Protection Zone
B - 200 Day Time of Travel
C - 10 Year Time of Travel
Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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FIGURE 3-1: DRINKING WATER HAZARDS – CHASTER WELL

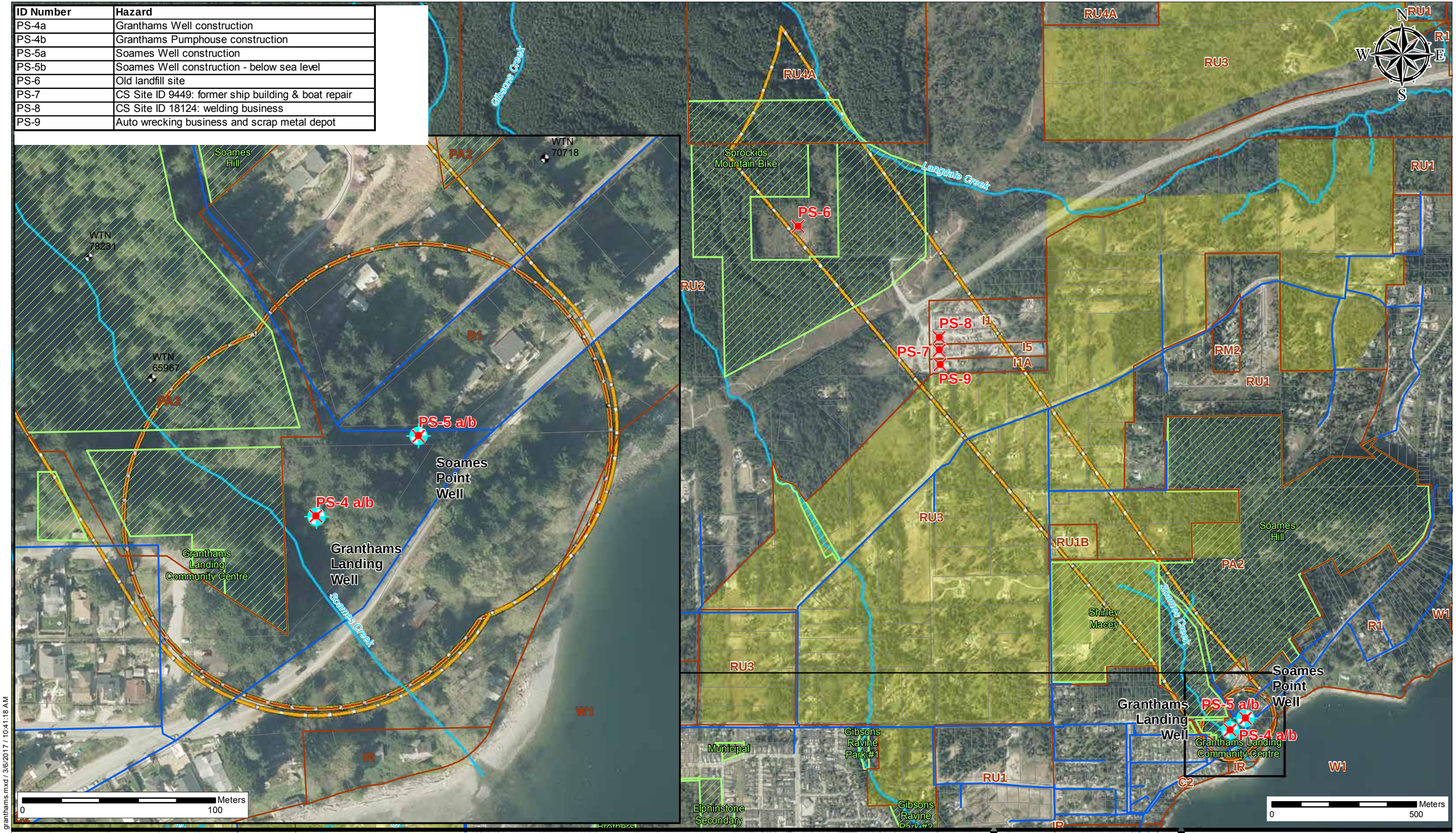
Sunshine Coast Regional District

Well Protection Planning

Table 3-3
Drinking water hazards – Granthams and Soames Wells

Hazard No.	Hazard	Owner/ Jurisdiction	Location	Contaminants of Concern	Transport Mechanism and other notes
Point Sources					
PS-4a	Granthams well construction and uncontrolled flowing artesian conditions.	SCRD	At wellhead.	Pathogens.	Annular space is present, and being held open by artesian pressure. When pump is turned on, water level drops, potentially pulling in surface contaminants along annular space and directly into the well.
PS-4b	Granthams pumphouse construction and related piping	SCRD	At wellhead.	Pathogens.	Infiltration to groundwater
PS-5a	Soames well construction - well head in an underground chamber below a road	SCRD	At wellhead.	Any surface contaminant. Most likely pathogens, and road run-off (hydrocarbons).	Directly into well
PS-5b	Soames well construction below sea level.	SCRD	At wellhead	Sodium and chloride	Horizontal migration through aquifer
PS-6	Old landfill site	Unknown	North of corner of Mountain Bike Park Road	Solvents, gasoline, diesel, oils, lubricants, paints, other chemicals	Leaks and spills at surface and then infiltration to groundwater
PS-7	CS Site ID 9449, 1170 Stewart Road: Registered with the MoE since 2005 (previous use ship building & boat repair, current use unknown).	Private owner	1170 Stewart Road. Approximately 1.5 km north	Solvents, gasoline, diesel, oils, lubricants, paints, other chemicals	Infiltration to groundwater
PS-8	CS Site ID 18124, 1196 Stewart Road: Registered with the MoE since 2015 (currently a welding business).	Private owner	1196 Stewart Road. Approximately 1.5 km north	The report from MoE indicates fill materials were brought onto this site from a contaminated source.	Leaks and spills at surface and then infiltration to groundwater
PS-9	Auto Wrecking Business and Scrap Metal Depot	Private owner	1178 Stewart Road. Approximately 1.5 km north	Solvents, gasoline, diesel, oils, lubricants, paints, other chemicals	Leaks and spills at surface and then infiltration to groundwater
Non-point Sources					
NPS-9	Poorly constructed existing wells in capture zone - monitoring wells, irrigation wells, domestic wells, or geoexchange wells	Various owners	Throughout all aquifer protection areas. Nearest is on edge of APA A/B	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200 day the concern would be on chemical contaminants.	Existing wells could act as a direct pathway to the aquifer, and then the contaminant would travel horizontally through aquifer.
NPS-10	Underground or above-ground storage tanks Granthams and Soames	Private owners	Nearest home is 200 m away	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	Leaks and spills at surface and then infiltration to groundwater
NPS-11	Residential properties Granthams and Soames	Private owners	Two homes within APA A and B for Granthams Well. About 4 homes within APA A and B for Soames well.	Pesticides, herbicides, household cleaners, automotive wastes,	Deposits and runoff to groundwater
NPS-12	Agricultural operations.	Private owners	Closest ALR is over 500 m away, within APA C. ALR land comprises about half of the APA C.	Nitrates, pesticides, herbicides, pathogens	Runoff, seepage to groundwater
NPS-13	Natural gas lines and other private utilities (preferred pathways)	Fortis BC and others	Throughout residential areas	Various contaminants	Spills, runoff, leaks infiltrating to groundwater
NPS-14	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Busy road (Marine Drive) only 27 m away from Soames Well. Storm management includes ditching is along Marine Drive 27 m away from Soames well.	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	Leaks and spills at surface and then infiltration to groundwater.
NPS-15	Animals and pests	Various owners	In green space throughout	Pathogens	Deposits to soil and groundwater
NPS-17	Septic systems/septic tanks	Private owners	Throughout aquifer protection areas. At least 4 homes are within APA B	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and Pops (pharmaceuticals and personal care products).	Leaks, spills and infiltration to groundwater

ID Number	Hazard
PS-4a	Granthams Well construction
PS-4b	Granthams Pumphouse construction
PS-5a	Soames Well construction
PS-5b	Soames Well construction - below sea level
PS-6	Old landfill site
PS-7	CS Site ID 9449: former ship building & boat repair
PS-8	CS Site ID 18124: welding business
PS-9	Auto wrecking business and scrap metal depot



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Associated Environmental

Potential Hazard
Well Location
MOE Registered Well

SCRD Water Mains
Zoning* Boundary
ALR Land
Park

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

Aquifer Protection Area
A - 100m Well Protection Zone
B - 200 Day Time of Travel
C - 10 Year Time of Travel
Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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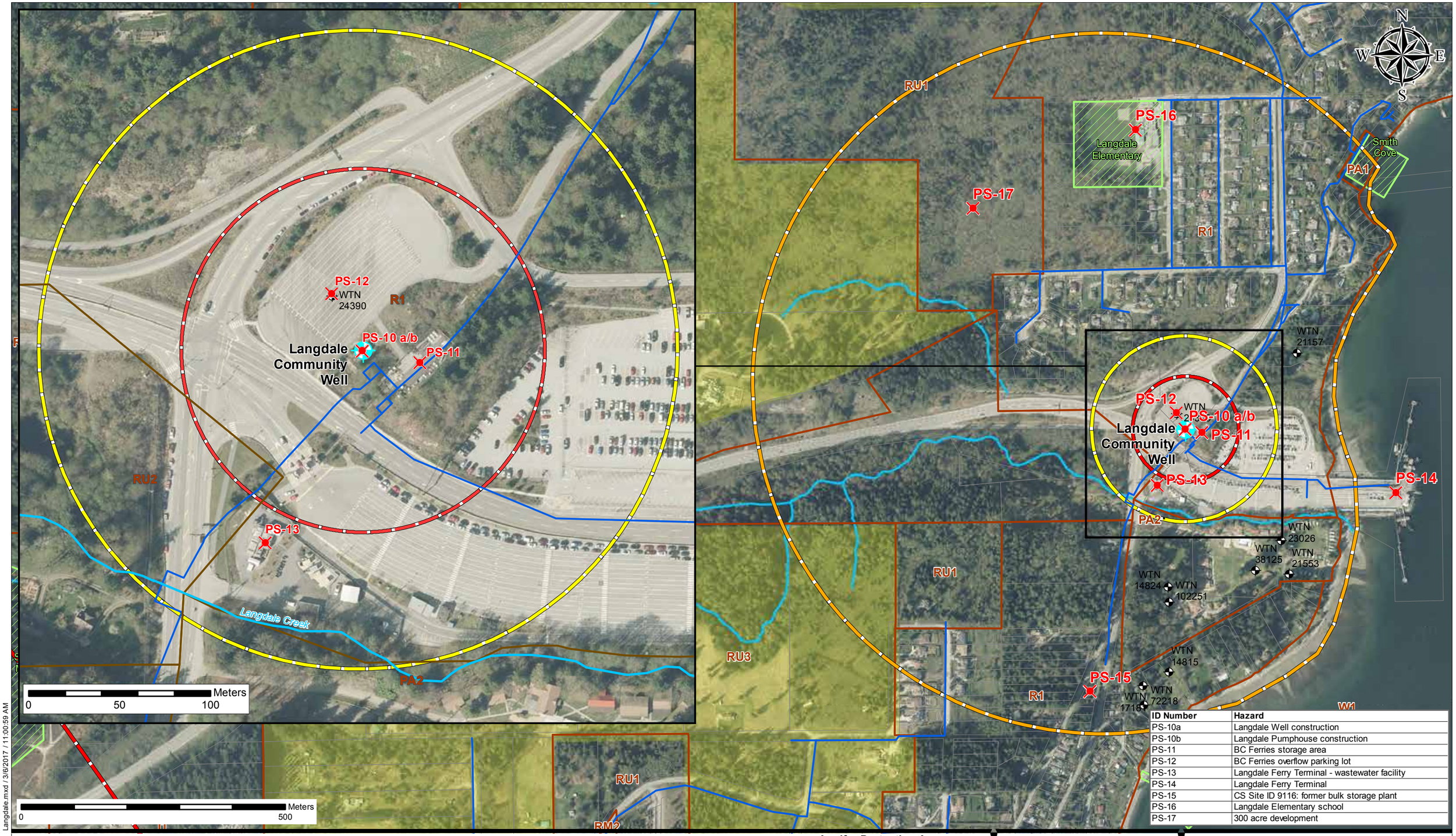
FIGURE 3-2: DRINKING WATER HAZARDS - GRANTHAMS AND SOAMES WELLS

Sunshine Coast Regional District

Well Protection Planning

Table 3-4
Drinking water hazards – Langdale Well

Hazard No.	Hazard	Owner/ Jurisdiction	Location	Contaminants of Concern	Transport Mechanism and other notes
Point Sources					
PS-10a	Saltwater Intrusion	SCRD	At wellhead	Sodium and chloride	Horizontal travel through aquifer
PS-10b	Langdale pumphouse construction	SCRD	At wellhead	Pathogens.	Direct to well from wellhead
PS-11	BC Ferries Storage Area	SCRD/MOTI/BC Ferries	18 m east of the well	Depends on what is stored	Infiltration to groundwater
PS-12	BC Ferries Overflow parking lot and ditch adjacent to pumphouse	SCRD/MOTI/BC Ferries	adjacent to well	Surface water contaminants, spills from motor vehicle accidents	Infiltration to groundwater
PS-13	Langdale Ferry terminal - wastewater facility	BC Ferries	Within APA B	Pathogens.	Infiltration to groundwater
PS-14	Langdale Ferry Terminal.	BC Ferries	Well is on edge of ferry terminal	Diesel, petroleum hydrocarbons, chlorophenols, PAHs	Spills and runoff from parking lot, and then infiltration into ground
PS-15	CS Site ID 9116: Former bulk storage plant that was decommissioned.	Private owner	1281 Marine Drive. Approximately 500 m south	BTEX, diesel, VOCs, petroleum hydrocarbons, waste oil	Infiltration to groundwater
PS-16	Langdale Elementary school	BC Government.	School is at Johnson Road. Approximately 450 m north	Fertilizer, pesticides, nitrates from septic field	Leaks and spills and then infiltration to groundwater
PS-17	300-acre proposed development	Private owner	Located outside of APA A and B but within APA C.	Nitrates if they have their own wastewater facility. Typical city run-off.	Infiltration to groundwater
Non-point Sources					
NPS-19	Poorly constructed existing wells in capture zone - either monitoring wells, domestic wells, geoexchange wells.	Various owners	Nearest is on edge of APA A/B	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200 day the concern would be on chemical contaminants.	Existing wells could act as a direct pathway to the aquifer, and then the contaminant would travel horizontally through aquifer.
NPS-20	Underground or above-ground storage tanks	Private owners	Nearest home is 200 m away, within APA C.	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	Leaks and spills, and then infiltration to groundwater
NPS-21	Residential properties	Private owners	Nearest home is 200 m away, within APA C.	Pesticides, herbicides, household cleaners, automotive wastes,	Deposits and runoff to groundwater
NPS-22	Agricultural operations.	Private owners	About 120% of APA C is within the ALR, but no current agricultural activities are evident.	Nitrates, pesticides, herbicides, pathogens	Runoff, seepage to groundwater
NPS-23	Natural gas lines and other private utilities (preferred pathways)	Fortis BC and others	Nearest home is 200 m away, within APA C.	Various contaminants	Spills, runoff, leaks infiltrating to groundwater
NPS-24	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Very busy roads (Ferry Ramp/Sunshine Coast Highway and Hwy Port Mellon) are located 30 and 80 m away from the well house, respectively.	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	Runoff, leaks, and spills will infiltrate to groundwater. Lots of ditching.
NPS- 25	Animals and pests	Various owners	In green space throughout	Pathogens	Infiltration to groundwater
NPS-26	Septic systems/septic tanks	Private owners	Nearest homes are outside of APA B but within 300 m GARP guideline screening. Only nitrates and chemicals are a concern.	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and Pops (pharmaceuticals and personal care products).	Leaks and spills at surface and then infiltration to groundwater



ID Number	Hazard
PS-10a	Langdale Well construction
PS-10b	Langdale Pumphouse construction
PS-11	BC Ferries storage area
PS-12	BC Ferries overflow parking lot
PS-13	Langdale Ferry Terminal - wastewater facility
PS-14	Langdale Ferry Terminal
PS-15	CS Site ID 9116: former bulk storage plant
PS-16	Langdale Elementary school
PS-17	300 acre development

Associated Environmental

- Potential Hazard
- Well Location
- MOE Registered Well
- SCRD Water Mains
- Zoning* Boundary
- ALR Land
- Park

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

Aquifer Protection Area

- A - 100m Well Protection Zone
- B - 200 Day Time of Travel
- C - 10 Year Time of Travel

Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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FIGURE 3-3: DRINKING WATER HAZARDS – LANGDALE WELL

Sunshine Coast Regional District

Well Protection Planning

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Table 3-5
Drinking water hazards – Eastbourne Well System

Hazard No.	Hazard	Owner/ Jurisdiction	Location	Contaminants of Concern	Transport Mechanism and other notes
Point Sources					
PS-18	Construction of Gordon Well (dug well)	SCRD	At wellhead	Any surface contaminant (chemical and pathogens)	Infiltration to groundwater or direct to well
PS-19	Construction of Collector well (near surface dug well).	SCRD	At wellhead	Any surface contaminant (chemical and pathogens)	Infiltration to groundwater or direct to well
PS-20	Construction of Old East well (dug well).	SCRD	At wellhead	Any surface contaminant (chemical and pathogens)	Infiltration to groundwater or direct to well
PS-21	Drilled well construction and saltwater intrusion.	SCRD	At wellhead	Sodium and chloride	Horizontal migration through aquifer
Non-point Sources					
NPS-25	Poorly constructed existing wells in capture zone - either monitoring wells, domestic wells, geothermal wells.	Private	Throughout all capture zones.	Existing wells could act as a direct pathway to the aquifer, and then the contaminant would travel horizontally through aquifer.	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200 day the concern would be on chemical contaminants.
NPS-26	Underground or above-ground storage tanks	Private	Throughout all capture zones.	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	Leaks and spills, and then infiltration to groundwater
NPS-27	Residential properties	Private	Nearest home is within 30 m and is within all APAs.	Pesticides, herbicides, household cleaners, automotive wastes,	Deposits and runoff to groundwater
NPS-28	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Gordon Well located adjacent to Gordon Road, other wells located adjacent to Keats Road	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	Spills and infiltration to groundwater
NPS-29	Animals and Pests	Various owners	In green space throughout study area	Pathogens	Deposits to soil and groundwater
NPS-30	Septic Systems/Septic Tanks.	Private owners	Nearest residents to each well may be around, and possibly less than, 30 m away.	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and Pops (pharmaceuticals and personal care products).	Leaks, spills and infiltration to groundwater

ID Number	Hazard
PS-18	Gordon Well construction (dug well)
PS-19	Collector Well construction (near surface dug well)
PS-20	Old East well construction (dug well)
PS-21	Drilled well construction

Potential Hazard
Well Location
MOE Registered Well
Drilled Well
Dug Well

SCRD Water Mains
Zoning* Boundary
ALR Land
Park

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

Aquifer Protection Area
A - 100m Well Protection Zone
B - 200 Day Time of Travel
C - 10 Year Time of Travel

Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

Associated Environmental

PROJECT NO.: 2016-8167.000.000
DATE: November 2016
DRAWN BY: DA

FIGURE 3-4: DRINKING WATER HAZARDS - EASTBOURNE WELL SYSTEM

Sunshine Coast Regional District

Well Protection Planning

eastbourne.mxd / 7/6/2017 / 2:44:57 PM

4 Module 7: Characterize Risks from Source to Tap

The purpose of Module 7 is to critically assess the adequacy of water protection barriers and assign risk levels to each hazard identified in Module 2. The TAC completed this step during TAC Workshop 2 (risk assessment). First, the risk matrix provided in Module 7 of the Source-to-Tap Guideline was used to assign each hazard as low risk, medium risk, high risk, or very high risk (Section 4.1). Then a SWOT (Strengths, Weakness, Opportunities, and Threats) analysis was completed (Section 4.2).

4.1 TAC WORKSHOP 2

According to the Source-to-Tap Guideline, risk is defined as, "the combination of the likelihood that a hazard will occur and cause harm, and the extent and degree of that harm" and can be quantitatively evaluated by multiplying the likelihood of a hazard occurring by the consequence of that hazard (MHLS 2010). To determine potential risks, two ratings were applied to each hazard:

1. The likelihood of occurrence (i.e., the probability the event occurs, and that if it occurs the contaminant will migrate to the well intake); and
2. The magnitude of consequence if that event was to occur.

Tables 4-1 and 4-2 summarize how each level of risk is assigned using the likelihood of occurrence and magnitude of consequence matrices, respectively.

Table 4-1
Assignment of risk categories – likelihood of occurrence

Level	Description	Probability of Occurrence in Next 10 Years
A	Almost certain – is expected to occur in most circumstances	>90%
B	Likely – will probably occur in most circumstances	71–90%
C	Possible – will probably occur at some time	31–70%
D	Unlikely – could occur at some time	10–30%
E	Rare – may only occur in exceptional circumstances	<10%

Source: Source-to-Tap Guideline (MHLS 2010)

Table 4-2
Assignment of risk categories – magnitude of consequence

Level	Description
1	Insignificant – no illness, little disruption to normal operation, and/or little or no increase in normal operating costs.
2	Minor – small population, mild illness moderately likely, some manageable operation disruption, and/or small increase in operating costs.
3	Moderate – minor impact for large population, mild to moderate illness probable, significant moderation to normal operations but manageable, operating costs increased, and/or increased monitoring.
4	Major – impact for small population, severe illness probable, systems significantly compromised and abnormal operation if at all, and/or high level monitoring required.
5	Catastrophic – major impact for large population, severe illness probable, and/or complete failure of system.

Source: Source-to-Tap Guideline (MHLS 2010)

The likelihood of occurrence and magnitude of consequence are then used to determine the risk to drinking water (Table 4-3).

Table 4-3
Risk (likelihood-consequence) matrix

Likelihood	Consequence				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely)	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

Source: Source-to-Tap Guideline (MHLS 2010)

During Workshop 2, the TAC assigned a likelihood of occurrence and magnitude of consequence score to each hazard identified in Module 2, and then determined risk using the risk matrix (Table 4-3). In total,

seven very high, seven high, seven moderate, and five low risk point-source hazards were identified. Of the seven very high point-source hazards, three each were in the Granthams and Soames and Eastbourne APAs, and one was in the Langdale APA. Of the seven high point-source hazards, one was in the Chaster APA, five were in the Langdale APA, and one was in the Eastbourne APA.

Eight non-point source hazards were also identified for the four systems. Risk rankings for the non-point source hazards vary for each well system. The Chaster, Granthams and Soames, and Langdale APAs had no very high risk non-point source hazards, and the Eastbourne APA had one. All four systems had two high risk non-point source hazards.

Table 4-4 lists each hazard, the likelihood of occurrence and magnitude of consequence score, the risk rating based on that score, and the rationale behind each assigned risk. The locations of the hazards are shown on Figures 4-1, 4-2, 4-3, and 4-4.

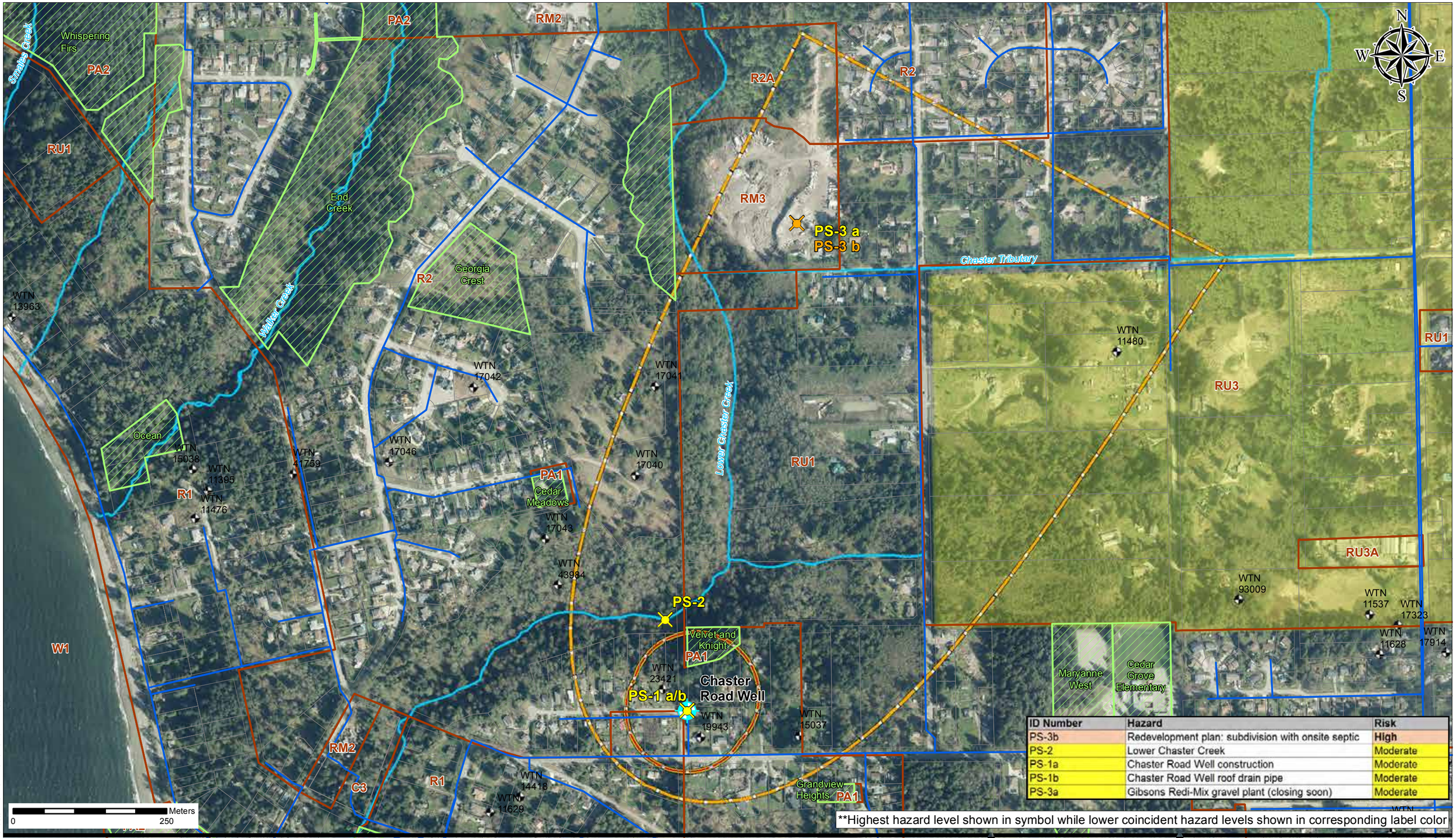
Table 4-4
Hazard risk assessment – Chaster Well

Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
Point Sources									
PS-3b	Gibsons Redi-Mix Ltd. Redevelopment plan: subdivision and 60 trailer pads with onsite septic.	Private owner	Nitrates (pathogens are not considered a hazard because site is outside of the 200-day capture zone)	D (unlikely)	Concentrations of Nitrate-N in the well have risen from 0.56 mg/L in April 2001, to 1.010 mg/L in May 2015 (compared to a drinking water guideline of 10 mg/L). Groundwater from septic fields at this location will likely discharge naturally to Lower Chaster Creek. Based on the Gibsons Aquifer Mapping project, recharge is likely from the base of Mt. Elphinstone, but other sources of recharge are possible, such as where the till layer is thin, and losing streams (Waterline 2013). The till layer is thick in this vicinity and therefore, the volume of recharge from the vicinity of this Hazard is likely low.	4	If the sanitary system is well maintained and meets the Sewerage System Regulations at a minimum, the concentrations of nitrate in Chaster Well are likely to remain similar to what they are now due to the confining layers, and the “perched” nature of Chaster Creek. Monitoring costs; however, could increase.	High	4,5,7
PS-2	Lower Chaster Creek	Public	Nitrates (pathogens are not considered a hazard because site is outside of the 200-day capture zone)	D (unlikely)	Based on the Gibsons Aquifer Mapping project, recharge is likely from the base of Mt. Elphinstone, but other sources of recharge are possible, such as where the till layer is thin, and losing streams (Waterline 2013). The till layer is thick in this vicinity and although the watershed for Chaster Creek includes residential (with septic fields) and agricultural land uses, and some recharge from “losing streams” is possible, the volume of recharge from this source is likely very low.	3	As long as the agricultural operations follow best management practices and the sanitary systems are maintained, the concentrations of nitrate are likely to remain similar to what they are now due to the confining layers, and the “perched” nature of Chaster Creek. Monitoring costs; however, will increase.	Moderate	3,4,5
PS-1a	Well site Hazard 1a: Well is located in a concrete pit.	SCRD	Pathogens	D (unlikely)	The well does not have a surface seal and is located in a well pit. The well pit cover is a metal steel lid, locked, is likely vermin proof. The top of the well casing is only about 10 cm above bottom of pit. The well pit does not appear to be water-tight: water flows into the concrete pit from the inline chlorine meter and exits the pit through a drain in the bottom of the pit, which is connected to piping that discharges away from the well at an unknown distance away from the well. Roots are visible growing in the drain, and water is ponding at the bottom of the pit at the location of the drain. There appears to be cracks in the concrete floor of the pit. There are two potential conduits: the electrical conduit to the submersible well pump inside well and the water level meter conduit (sounding tube). Pathogens could migrate directly into the well during a large rainstorm event via the annular space if the concrete pit is compromised (which it appears it may be). However, this configuration has likely been like this for a long time, and any contaminants would have already reached the well, the well is deep (allowing for many zones for the natural soils to seal tightly against the well casing) and the bacteriological water quality on this well is excellent (although no protozoa sampling has occurred).	3	If pathogens reached the well, the only protection is chlorine, which will inactive viruses and bacteria, but not protozoa.	Moderate	1
PS-1b	Well site Hazard 1b: Roof drain discharges to pipe - unknown where the pipe drains to.	SCRD	Pathogens	D (unlikely)	Roof drain is located on the closest side of the pumphouse to the well. Roof drain pipe might go right by well. Bedding sand of pipe might be coarse, acting as a preferred pathway if pipe is perforated or not well connected to roof drain. Well does not have a surface seal. If the perforated pipe is located near the well, surface water could go down the annular space of the well. However, this configuration has likely been like this for a long time, and any contaminants would have already reached the well, the well is deep (allowing for many zones for the natural soils to seal tightly against the well casing) and the bacteriological water quality on this well is excellent (although no protozoa sampling has occurred).	3	If pathogens reached the well, the only protection is chlorine, which will inactivate viruses and bacteria, but not protozoa.	Moderate	1,2
PS-3a	Gibsons Redi-Mix Ltd. gravel plant. The gravel plant is closing soon.	Private owner	Elevated pH from possible cement wastewater, hydrocarbons from possible above-ground storage tanks and under-ground storage tanks, antifreeze from chemical release.	E (rare)	No hydrocarbons have been sampled at the well. However, the earliest available air photos indicate that the area was cleared by at least 1982, and the site has likely been operating as a gravel pit since that time. The estimated travel time between the gravel plant and the Chaster well is 7-8 years, it has been in operation since the mid 80’s, and hazardous materials handling has probably improved over time. Therefore, those contaminants that are not readily attenuated would be expected to have shown up at the Chaster well by now. Based on the Gibsons Aquifer Mapping project, recharge is likely from the base of Mt. Elphinstone, but other sources of recharge are possible, such as where the till layer is thin, and losing streams (Waterline 2013). The till layer is thick in this vicinity and although some recharge from “losing streams” is possible, the volume of recharge from this source is likely very low.	3	All but the most mobile hydrocarbons (e.g. benzene, naphthalene) are attenuated short distances along the groundwater flow path. If these mobile hydrocarbons reached the well, their concentrations would be likely very low because the volumes would be very small and dilution would occur. However, very little information is known about the exact types of contaminants. Routine monitoring would be required at a minimum.	Moderate	6
Non-point Sources									
NPS-4	Agricultural operations	Private owners	Nitrates, pesticides, herbicides, pathogens	D (unlikely)	Farming operations have been known to cause nitrate-N to exceed drinking water guidelines in community wells in Canada. Nitrate-N in Chaster well has been increasing, even though the well is over 100 m deep, indicating it is susceptible to surface land uses.	4	Treatment costs are very high for nitrate. If nitrate increased to above the drinking water guideline of 10 mg/L (right now nitrate-N at Chaster Well is at 1 mg/L), the well infrastructure may be lost.	High	24

Table 4-4
Hazard risk assessment – Chaster Well

Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
NPS-8	Septic systems/septic tanks	Private owners	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and PPCPs (pharmaceuticals and personal care products).	C (possible)	Closest upgradient residential area is 23 m away (to front lawn) and upslope. The exact location of the septic field is not known. If the septic field is closer than 30 m away, the setback to a drinking water supply does not meet the Health Hazard Regulation. Well has no surface seal and a glacial till layer starts at 1.5m, meaning if the septic tank is not properly maintained, there is a potential that water from the septic tank could be passing by the well casing and travelling down annular space of the casing. The Drinking Water Protection Regulation requires that groundwater at risk of containing pathogens (GARP) must be disinfected. The Ministry of Health published a guideline document for determining GARP in December 2015, which suggests a GARP determination be completed. No GARP determination has been completed. No raw coliform data is available for Chaster well. Due to lack of data, the likelihood is possible.	3	If pathogens reached the well, the only protection is chlorine, which will inactivate viruses and bacteria, but not protozoa.	High	1,8,33
NPS-2	Underground or above-ground residential heating oil storage tanks	Private owners	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	E (rare)	Natural gas came to Sunshine Coast in the mid 1990s, since that time, most homes are heated using electricity, wood, or natural gas. Heating oil is made up of heavier hydrocarbons, which are less mobile in groundwater. Any contamination from historical use of heating oil would already have been apparent. Moreover, the screen intake is 40 m below the water table, and varying layers of glacial till are present at shallower depths: any hydrocarbon plume would stay near the surface.	4	If a contaminant reached the well, major infrastructure may be lost.	Moderate	11,22
NPS-3	Residential properties	Private owners	Pesticides, herbicides, household cleaners, automotive wastes	E (rare)	Pesticide use is not prevalent on the Sunshine Coast. Chaster Well is surrounded by larger holding residences that could allow hobby farms; therefore, small scale agricultural practices can be expected. Nitrate-N in Chaster well has been increasing, even though the well is over 100 m deep.	3	The majority of contaminants of concern related to residential homes are detectable at trace amounts, and can be observed through regular monitoring.	Moderate	23
NPS-1	Poorly constructed existing wells in capture zone (monitoring, irrigation, domestic or geoexchange wells)	Various owners	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200 day the concern would be on chemical contaminants.	D (unlikely)	There are 3 registered wells within the APAs but the BC Ministry of Environment's Wells database is a voluntary registration process and some other wells may exist; however, none are known to exist within 100 m (APA A).	2	Types of contaminants of concern would be at very low loads since residential area.	Low	20
NPS-5	Natural gas lines and other private utilities (preferred pathways)	Fortis BC and others	Any surface contaminant. Most likely pathogens, and road run-off (hydrocarbons).	E (rare)	The well is located about 5 m from the centre of the driveway of the nearest home. A natural gas connection to the home is likely, and may be present within a few meters of the well. However, the fine geological deposits provide protection confining layers between the surface and the well intake, and the surrounding land use is low density residential. Therefore, the likelihood a contaminant would reach the well intake from a preferred pathway is rare.	2	Types of contaminants of concern would be at very low loads since residential area.	Low	25
NPS-6	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	E (rare)	Typical winters are mild and do not require salt application. Lots of ditching in this area, but residential neighborhood in vicinity, with green space nearby.	2	Types of contaminants of concern would be at very low loads since residential area.	Low	26, 27, 28, 29, 30, 31
NPS-7	Animals and pests	Various owners	Pathogens	E (rare)	No main dog parks in aquifer protection area, and well intakes are set below thick protective layers. Well cover and well house adjacent to well appeared to be vermin-proof.	1		Low	32

Notes:
[1] 1 = Insignificant; 2 – Minor; 3 – Moderate; 4 – Major; 5 – Catastrophic (Section 4.1, Table 4-2)
[2] See Section 5, Table 5-2 for Action Item details.



ID Number	Hazard	Risk
PS-3b	Redevelopment plan: subdivision with onsite septic	High
PS-2	Lower Chaster Creek	Moderate
PS-1a	Chaster Road Well construction	Moderate
PS-1b	Chaster Road Well roof drain pipe	Moderate
PS-3a	Gibsons Redi-Mix gravel plant (closing soon)	Moderate

**Highest hazard level shown in symbol while lower coincident hazard levels shown in corresponding label color

Chaster Well risk.mxd / 3/15/2017 / 11:30:31 AM

Associated Environmental

Well Location

MOE Registered Well

SCRD Water Mains

Zoning* Boundary

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

ALR Land

Park

Hazard Level**

Very High

High

Moderate

Low

Aquifer Protection Area

A - 100m Well Protection Zone

B - 200 Day Time of Travel

C - 10 Year Time of Travel

Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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FIGURE 4-1: DRINKING WATER HAZARDS AND RISK LEVEL – CHASTER WELL

Sunshine Coast Regional District

Well Protection Planning

Table 4-5
Hazard risk assessment – Granthams and Soames Wells

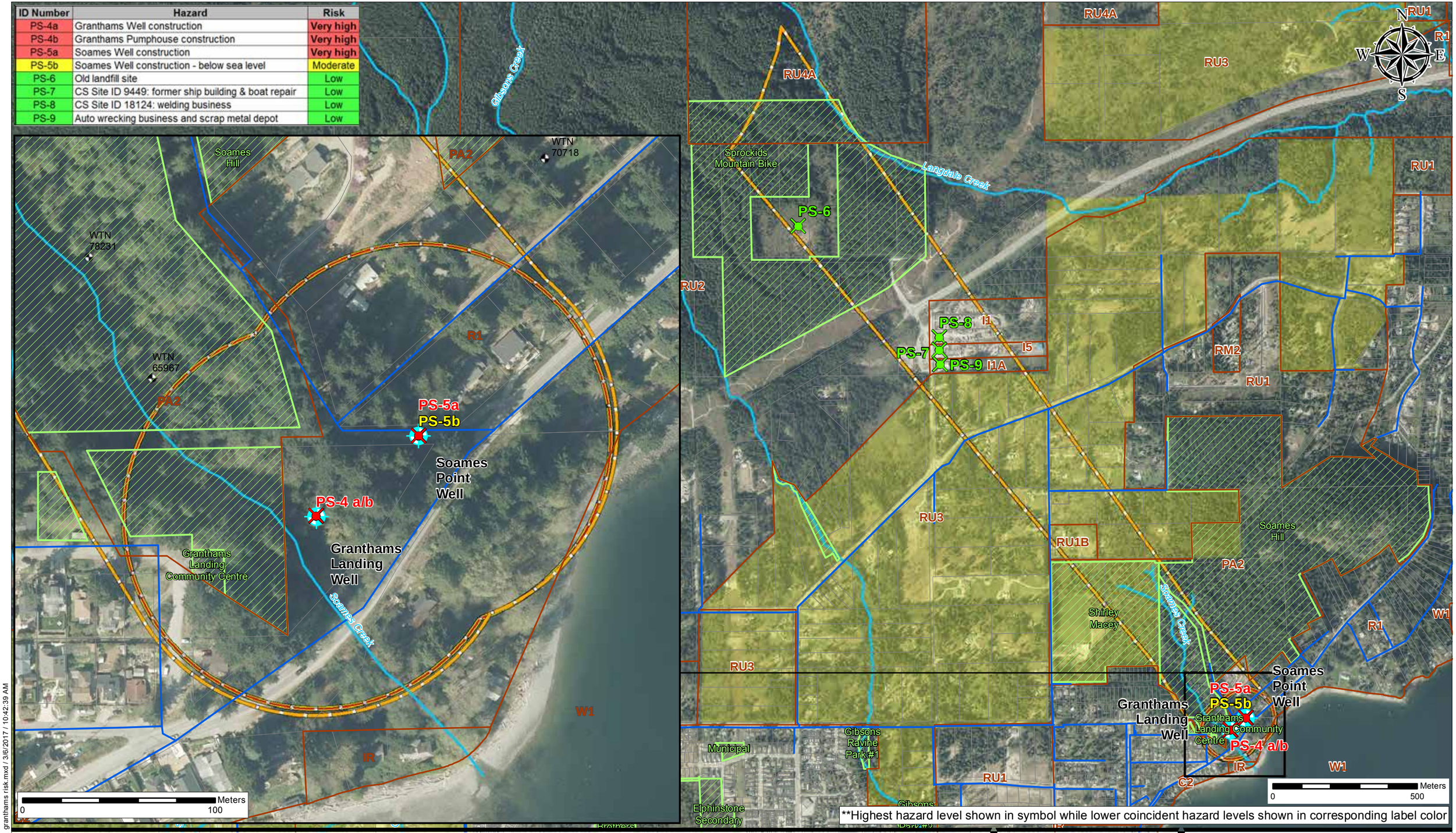
Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
Point Sources									
PS-4a	Granthams well construction and uncontrolled flowing artesian conditions.	SCRD	Pathogens.	A (almost certain)	The Granthams wellhead is a sealed above-ground steel casing located inside a locked concrete culvert above ground. The bottom of the concrete culvert box is coarse gravel. No surface seal is present and ponded water is visible around the concrete culvert. This indicates uncontrolled flowing artesian well conditions, and does not meet Groundwater Protection Regulation (must control flowing conditions). Bacteriological tests were completed monthly in 2013 and 4 samples contained total coliform out of a total of 18 samples.	4	The potential loading from surface contaminants such as pathogens is unknown, but if pathogens are found in the well, significant treatment costs or well upgrades would be required.	**Very High**	8,9
PS-4b	Granthams pumphouse construction and related piping	SCRD	Pathogens.	A (almost certain)	This is the location of an old fish hatchery. The outlets of many underground piping networks are visible, and the pumphouse has a wet well. The pumphouse is not vermin proof. Bacteriological tests were completed monthly in 2013 and 4 samples contained total coliform out of a total of 18 samples.	4	The potential loading from surface contaminants such as pathogens is unknown, but if pathogens are found in the well, significant treatment costs or well upgrades would be required.	**Very High**	8
PS-5a	Soames well construction - well head in an underground chamber below a road	SCRD	Any surface contaminant. Most likely pathogens, and road run-off (hydrocarbons).	B (likely)	The Soames wellhead is located on a steep paved road in an underground concrete box. No surface seal but well log says "casing to 20m" - this may be a surface seal. Difficult to identify the till layer by well log but appears well protected from surface: "compact sandy gravel 26-83 ft" and "very compact silty coarse gravel: from 83-94 ft, and "compact clayey gravel possibly till" 94-97 ft. Well depth 121 ft (no screen given). Water quality appears to be excellent (no total coliforms detected in when tested for in raw water in 2011 and 2013), although there have been no tests for protozoa.	4	The potential loading from surface contaminants such as pathogens is unknown, but if pathogens are found in the well, significant treatment costs or well upgrades would be required.	**Very High**	8,11
PS-5b	Soames well construction below sea level.	SCRD	Sodium and chloride	E (rare)	Bottom of well is at 0.3 m below sea level; therefore, concern with drawing in salt water. Gradient is strong; therefore, significant pumping would be required to draw in salt water and likelihood is rare.	3	Most likely contaminant to reach this far would be soluble metals. Additional minor monitoring would be required until the contaminant source is removed, but it is unlikely that the supply would be lost.	Moderate	12
PS-6	Old landfill site	Unknown	Solvents, gasoline, diesel, oils, lubricants, paints, other chemicals	E (rare)	The hazard is farther than 500m away, consistent with CSR Protocol 21 for drinking water receptors (Water Use Determination) and more than 40 m of clayey and silty deposits (till) provides protection to contaminant transport, as shown by the lithology described in well tag number 6805.	2	Most likely contaminant to reach this far would be soluble metals. Additional minor monitoring would be required until the contaminant source is removed, but it is unlikely that the supply would be lost.	Low	11
PS-7	CS Site ID 9449 - Previous use ship building & boat repair, current use unknown	Private owner	Solvents, gasoline, diesel, oils, lubricants, paints, other chemicals	E (rare)	MoE requires no further action and the hazard is farther than 500m away, consistent with CSR Protocol 21 (Water Use Determination) for a drinking water receptor. Moreover, more than 40 m of clayey and silty deposits (till) is present, provides protection to contaminant transport, as shown by the lithology described in well tag number 6805.	2	Most likely contaminant to reach this far would be soluble metals. Additional minor monitoring would be required until the contaminant source is removed, but it is unlikely that the supply would be lost.	Low	11
PS-8	CS Site ID 18124 - Currently a welding business	Private owner	The report from MoE indicates fill materials were brought onto this site from a contaminated source.	E (rare)	This is an ongoing case with MoE, they determined that further investigation was required; however, the hazard is farther than 500m away consistent with CSR Protocol 21 (Water Use Determination) for a drinking water receptor and more than 40 m of clayey and silty deposits (till) is present above the aquifer, acting as a barrier to contaminant transport, as shown by the lithology described in well tag number 6805.	2	Most likely contaminant to reach this far would be soluble metals. Additional minor monitoring would be required until the contaminant source is removed, but it is unlikely that the supply would be lost.	Low	11
PS-9	Auto Wrecking Business and Scrap Metal Depot	Private owner	Solvents, gasoline, diesel, oils, lubricants, paints, other chemicals	E (rare)	This hazard is farther than 500m away consistent with CSR Protocol 21 (Water Use Determination) for a drinking water receptor and more than 40 m of fine geological deposits (till) acting as a barrier to contaminant transport, as shown by the lithology described in well tag number 6805.	2	Most likely contaminant to reach this far would be soluble metals. Additional minor monitoring would be required until the contaminant source is removed, but it is unlikely that the supply would be lost.	Low	11
Non-point Sources									
NPS-14	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	E (rare)	Speed limit on Marine Drive is 50 km/hr. Road is narrow and winding. However, the fine geological deposits provide protection above the aquifer and any spill from a Motor Vehicle Accident would be cleaned up quickly.	4	If a hydrocarbon contaminant reached the well intake, major infrastructure may be lost.	High	26, 27, 28, 29, 30, 31

Table 4-5
Hazard risk assessment – Granthams and Soames Wells

Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
NPS-17	Septic systems/septic tanks	Private owners	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and PPCPs.	C (possible)	Nearest home from Soames well is about 30 m away. Nearest home from Granthams well is 60 m away and on other side of Soames Creek. Well has no surface seal and a glacial till layer starts at 1.5m, meaning septic water could be passing by well casing and travel down annular space outside of the casing. The Drinking Water Protection Regulation requires that groundwater at risk of containing pathogens (GARP) must be disinfected. The Ministry of Health published a guideline document for determining GARP in December 2015, which suggests a GARP determination be completed. No GARP determination has been completed. Since the risk is unknown, the likelihood is possible.	3	If pathogens reached the well, the only protection is chlorine, which will inactivate viruses and bacteria, but not protozoa.	High	1, 8, 33
NPS-10	Underground or above-ground storage tanks Granthams and Soames	Private owners	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	E (rare)	Natural gas came to Sunshine Coast in the mid 1990s, since that time, most homes are heated using electricity, wood, or natural gas. Any contamination from historical use of heating oil would already have been apparent. Moreover, the screen intake is 40 m below the water table, and varying layers of glacial till are present at shallower depths: any hydrocarbon plume would stay near the surface.	4	If a contaminant reached the well, major infrastructure may be lost.	Moderate	11, 22
NPS-11	Residential properties Granthams and Soames	Private owners	Pesticides, herbicides, household cleaners, automotive wastes,	E (rare)	See rationale for NPS-10	4	If a contaminant reached the well, major infrastructure may be lost.	Moderate	11,23
NPS-9	Poorly constructed existing wells in capture zone (monitoring, irrigation, domestic or geoexchange wells)	Various owners	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200-day the concern would be on chemical contaminants.	D (unlikely)	Right now, there are 5 registered wells within the APAs but the BC Ministry of Environment's Wells database is a voluntary registration process and some other wells may exist; however, none are known to exist within 100 m (APA A). Although there is no surface seal, many fine geological deposits are present above the aquifer which starts at 30 m. With this low number of wells in the area, and the fine formation above the aquifer, the likelihood is unlikely (could occur at some time).	2	Types of contaminants of concern would be at very low loads since residential area.	Low	20
NPS-12	Agricultural operations.	Private owners	Nitrates, pesticides, herbicides, pathogens	E (rare)	Only small scale gardens are visible.	2	The majority of contaminants of concern related to small scale gardens are detectable at trace amounts, and can be observed through routine monitoring. Therefore, the magnitude is minor.	Low	24
NPS-13	Natural gas lines and other private utilities (preferred pathways)	Fortis BC and others	Various contaminants	E (rare)	Soames Well is on a driveway and there could be a natural gas line that follows the driveway. So, a natural gas line is likely present within a few meters of the well. No underground utilities expected to be near Granthams Well. However, there are many protective confining layers between the surface and the well intakes, and the surrounding land use is low density residential. Therefore, the likelihood a contaminant would reach the well intake from a preferred pathway is rare.	2	Types of contaminants of concern would be at very low loads since residential area.	Low	25
NPS-15	Animals and pests	Various owners	Pathogens	E (rare)	Although dog owners frequent Soames Park, the well intakes are set below thick protective confining layers.	1	The concentrations of any contaminant of concern (nitrates, chlorides) will be well within acceptable limits and are easily managed through routine monitoring.	Low	32

Notes:
[1] 1 = Insignificant; 2 – Minor; 3 – Moderate; 4 – Major; 5 – Catastrophic (Section 4.1, Table 4-2)
[2] See Section 5, Table 5-2 for Action Item details.

ID Number	Hazard	Risk
PS-4a	Granthams Well construction	Very high
PS-4b	Granthams Pumphouse construction	Very high
PS-5a	Soames Well construction	Very high
PS-5b	Soames Well construction - below sea level	Moderate
PS-6	Old landfill site	Low
PS-7	CS Site ID 9449: former ship building & boat repair	Low
PS-8	CS Site ID 18124: welding business	Low
PS-9	Auto wrecking business and scrap metal depot	Low



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Associated Environmental

Well Location
MOE Registered Well
SCRD Water Mains
Zoning* Boundary
ALR Land
Park

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

Hazard Level**
Very High
High
Moderate
Low

Aquifer Protection Area
A - 100m Well Protection Zone
B - 200 Day Time of Travel
C - 10 Year Time of Travel
Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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DATE: November 2016
DRAWN BY: DA

FIGURE 4-2: DRINKING WATER HAZARDS AND RISK - GRANTHAMS AND SOAMES

Sunshine Coast Regional District

Well Protection Planning

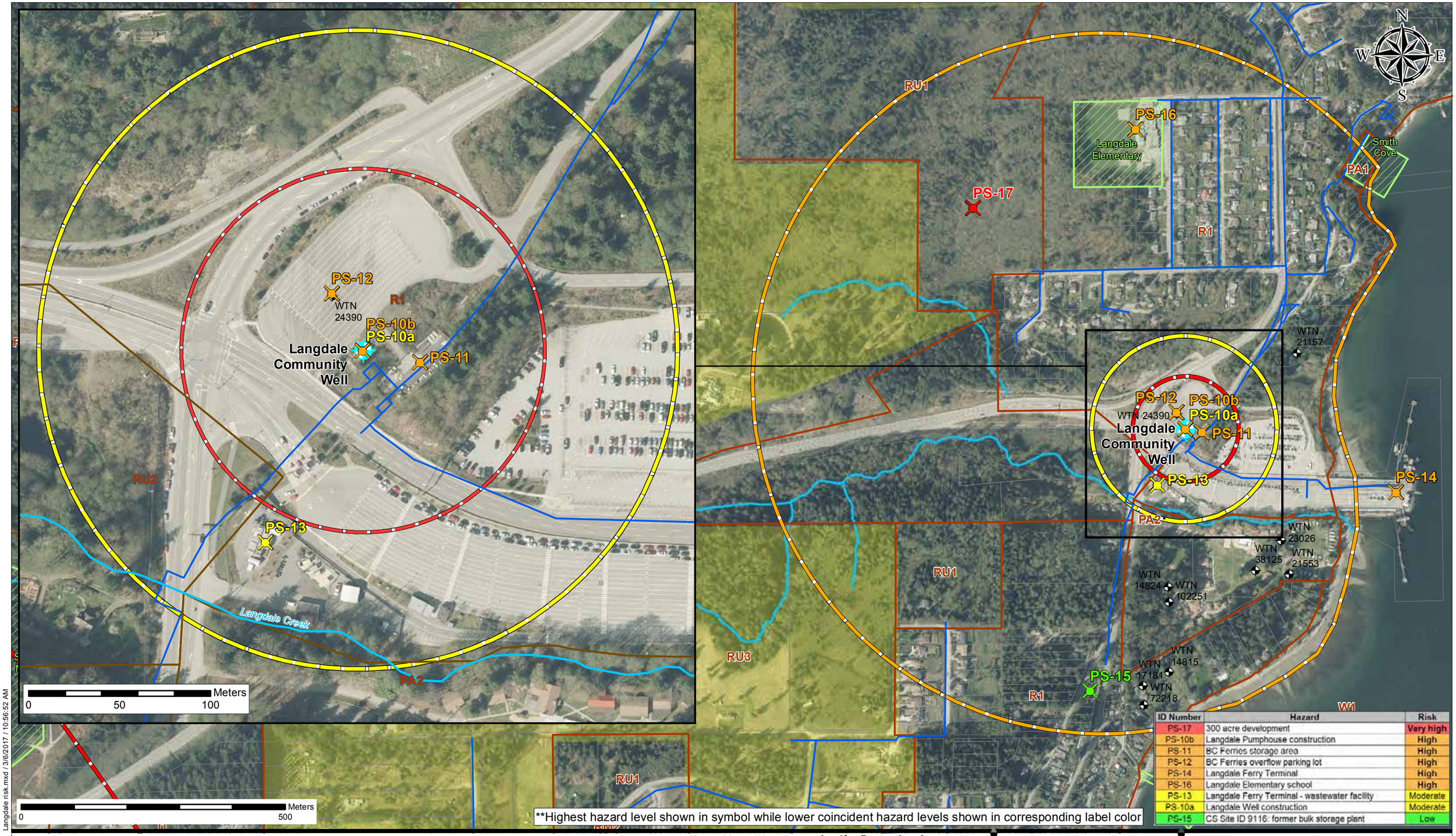
Table 4-6
Hazard risk assessment – Langdale Well

Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
Point Sources									
PS-17	300-acre proposed development	Private owner	Nitrates if they have their own wastewater facility. Typical city run-off.	C (possible)	A 300-acre proposed mixed residential and commercial development has been proposed for the hillside northwest of Langdale well. It is difficult to assess the risk at this stage, but a community sanitary system with discharge to ground may be a consideration for a large residential development.	4	Treatment costs are very high for nitrates. If nitrates increased to above the drinking water guideline of 10 mg/L (right now nitrate-N is at 1 mg/L) at the well, the well infrastructure would be lost. The Langdale well is the only supply for the Langdale community and the Langdale Ferry terminal. Although an emergency connection to the private Hopkins Landing System is possible, water shortages would be experienced.	**Very High**	11, 18, 19
PS-10b	Langdale pumphouse construction	SCRD	Pathogens.	B (likely)	During the site visit, the well cap was not sealed. The pumphouse has gaps that allow vermin to enter and there was evidence of vermin droppings. Raw bacteriological data was collected generally twice per month in 2011 and 2013. The results were 1 total coliform out of 23 samples in 2011 and zero total coliforms out 24 samples in 2013. These results indicate excellent water quality. The majority of the water is likely flowing horizontally into the well from the coarsest aquifer section at the well screen at a depth of 45 m below ground. No raw water has been collected since 2013, and no chlorination is completed.	3	If coliforms were detected, a boil water notice would be issued, until the well was flushed.	High	8,13
PS-11	BC Ferries Storage Area	SCRD/MOTI/ BC Ferries	Depends on what is stored	E (rare)	There is a large fenced and locked storage area is located very close to the well. Although no contaminants of concern were identified in this storage area, the potential for storage of hazards (road salt, waste oil, for example) exists. There are many protective layers above the well screen; however, the potential still existing for contaminants to make its way into the aquifer.	4	If a contaminant like a hydrocarbon were detected in the well, the well infrastructure would be lost for a period of time until the remediation was complete.	High	14
PS-12	BC Ferries Overflow parking lot and ditch adjacent to pumphouse	SCRD/MOTI/ BC Ferries	Surface water contaminants, spills from Motor vehicle accidents	E (rare)	The ditch along the pumphouse carries significant flow during precipitation events. The flow originates from the large parking lot, and from the highway on the other side of the parking lot. The ditch is in need of repair. Many protective layers are present above the well screen. However, if a motor vehicle accident occurred, significant fuel could flow adjacent to the well and may pond in the area next to the well.	4	If hydrocarbons were detected in the well, the well infrastructure may be lost for a period of time until the remediation was complete.	High	15
PS-14	Langdale Ferry Terminal.	BC Ferries	Diesel, petroleum hydrocarbons, chlorophenols, PAHs	E (rare)	This is a registered contaminated site CS Site ID 8414 registered as the Langdale Ferry Terminal. However, the Ferry Terminal is downslope and there are many protective layers between the surface and the aquifer.	4	If a contaminant reached the well, well infrastructure may be lost and an alternative water supply may need to be connected (connection to Hopkins is complex), or a new well drilled. Water shortages would result.	High	17
PS-16	Langdale Elementary school	BC Government.	Fertilizer, pesticides, nitrates from septic field	D (unlikely)	There is no shop at the school, but there is a large playing field with a significant population of geese that use the fields (Knight, Duncan, 2016). The school is on a septic field and there are 106 students that attend the school. The school is outside of the APA B and therefore only nitrates are a concern. Nitrate-N concentrations have been sampled once or twice a year since at least 2001 and have ranged between 0.2 to 0.3 mg/L except for one sample on November 7, 2005 that showed 2.19 mg/L. This result may be an error because it is an outlier from the other data points. No upwards trend is evident.	4	Treatment costs are very high for nitrate. If nitrate-N increased to above the drinking water guideline of 10 mg/L, the well infrastructure would be lost, and a connection with Chapman water system would need to be made through Hopkins Landing.	High	18
PS-10a	Langdale well construction and saltwater Intrusion	SCRD	Any contaminant	E (rare)	Bottom of well is about 10 m below sea level, and with quite a flat gradient estimate, the concern is that pumping could draw in salt water. However, pumping at existing rate provides very good water quality, and monitoring would pick up any indication of over pumping.	3	At current pumping rates, sodium and chloride are not elevated indicating no salt water intrusion. However, if the pumping rate is increased and saltwater is drawn into the well (evidenced by increases in sodium and chloride), the consequence would be drilling a new well.	Moderate	12
PS-13	Langdale Ferry terminal - wastewater facility	BC Ferries	Pathogens.	E (rare)	The wastewater treatment plant for the ferry terminal is located within the aquifer protection area for pathogens. A pressurized line carries raw effluent to the wastewater treatment plant and the treated effluent is discharge to the ocean. The discharge line follows the same trench as the pressurized raw effluent line. The plant was constructed in 2010, is inspected twice a week, and is registered with the Ministry of Environment. Raw water bacteriological data from the Langdale well was collected generally twice per month in 2011 and 2013and is excellent (one total coliform in 23 samples in 2011 and zero total coliforms in 2013). This indicates the fine soils above the well intake are likely providing adequate protection from pathogens.	3	If pathogens reached the well, the only protection is chlorine, which will inactivate viruses and bacteria, but not protozoa.	Moderate	8,16

Table 4-6
Hazard risk assessment – Langdale Well

Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
PS-15	CS Site ID 9116: Former bulk storage plant that was decommissioned.	Private owner	BTEX, diesel, VOCs, petroleum hydrocarbons, waste oil	E (rare)	Certificate of Compliance was issued for this site in 2014 indicating site was remediated to applicable standards.	1		Low	None
Non-point Sources									
NPS-22	Agricultural operations.	Private owners	Nitrates, pesticides, herbicides, pathogens	D (unlikely)	Agricultural land is present throughout most aquifer protection areas. Farming operations have been known to cause nitrate-N to exceed drinking water guidelines in community wells in Canada. Nitrate-N in Chaster well has been increasing, even though the well is over 100 m deep.	4	Treatment costs are very high for nitrate. If nitrate-N increased to above the drinking water guideline of 10 mg/L, the well infrastructure may be lost.	High	24
NPS-26	Septic systems/septic tanks	Private owners	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and PPCPs.	C (possible)	No GARP determination has been completed. Since the risk is unknown, the likelihood is possible.	3	If pathogens reached the well, the only protection is chlorine, which will inactivate viruses and bacteria, but not protozoa.	High	1, 8, 33
NPS-20	Underground or above-ground storage tanks	Private owners	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	E (rare)	Natural gas came to Sunshine Coast in the mid 1990s, since that time, most homes are heated using electricity, wood, or natural gas. Any contamination from historical use of heating oil would already have been apparent. Moreover, the screen intake is 40 m below the water table, and varying layers of glacial till are present at shallower depths: any hydrocarbon plume would stay near the surface.	4	If a contaminant reached the well, major infrastructure may be lost.	Moderate	11, 22
NPS-21	Residential properties	Private owners	Pesticides, herbicides, household cleaners, automotive wastes,	E (rare)	Pesticide use is not prevalent on the Sunshine Coast. Langdale Well is surrounded by larger holding residences that could allow hobby farms; therefore, small scale agricultural practices can be expected.	3	The majority of contaminants of concern related to residential homes are detectable at trace amounts, and can be observed through regular monitoring.	Moderate	23
NPS-24	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	E (rare)	Ditches carrying stormwater from the highways passes within 20 m of the well. Moreover, the Sunshine Coast Highway rises steeply away from the well, and any fuel from a MVA would quickly enter the ditch system. However, the protective confining layers above the well intake would slow the speed at which the fuel would reach the well intake.	4	If a contaminant reached the well, major infrastructure may be lost.	Moderate	26, 27, 28, 29, 30, 31
NPS-19	Poorly constructed existing wells in capture zone (monitoring, irrigation, domestic or geoexchange wells)	Various owners	Inside the 200-day capture zone, pathogens and chemical contaminants are of concern. Outside of 200 day the concern would be on chemical contaminants.	D (unlikely)	Right now, there are 5 registered wells within the APAs but the BC Ministry of Environment's Wells database is a voluntary registration process and some other wells may exist; however, none are known to exist within 100 m (APA A). Although there is no surface seal, many fine units are present above the aquifer which starts at 30 m. With this low number of wells in the area, and the fine formation above the aquifer, the likelihood is unlikely (could occur at some time).	2	Types of contaminants of concern would be at very low loads since residential area.	Low	20
NPS-23	Natural gas lines and other private utilities (preferred pathways)	Fortis BC and others	Various contaminants	E (rare)	No natural gas or other private utility lines are expected to be near the well. Moreover, there are many protective confining layers between the surface and the well intake, and the surrounding land use is low density residential.	2	Types of contaminants of concern would be at very low loads since residential area.	Low	25
NPS-25	Animals and pests	Various owners	Pathogens	E (rare)	One dog park is present in APA C, but the well intake is set below protective confining layers.	1	The concentrations of any contaminant of concern (nitrates, chlorides) will be well within acceptable limits and are easily managed through routine monitoring.	Low	32

Notes:
[1] 1 = Insignificant; 2 – Minor; 3 – Moderate; 4 – Major; 5 – Catastrophic (Section 4.1, Table 4-2)
[2] See Section 5, Table 5-2 for Action Item details.



ID Number	Hazard	Risk
PS-17	300 acre development	Very high
PS-10b	Langdale Pumphouse construction	High
PS-11	BC Ferries storage area	High
PS-12	BC Ferries overflow parking lot	High
PS-14	Langdale Ferry Terminal	High
PS-16	Langdale Elementary school	High
PS-13	Langdale Ferry Terminal - wastewater facility	Moderate
PS-10a	Langdale Well construction	Moderate
PS-15	CS Site ID 9116: former bulk storage plant	Low

**Highest hazard level shown in symbol while lower coincident hazard levels shown in corresponding label color

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Associated Environmental

Well Location
MOE Registered Well
SCRD Water Mains
Zoning* Boundary
ALR Land
Park

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

Hazard Level**
Very High
High
Moderate
Low

Aquifer Protection Area
A - 100m Well Protection Zone
B - 200 Day Time of Travel
C - 10 Year Time of Travel

Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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FIGURE 4-3: DRINKING WATER HAZARDS AND RISK – LANGDALE WELL

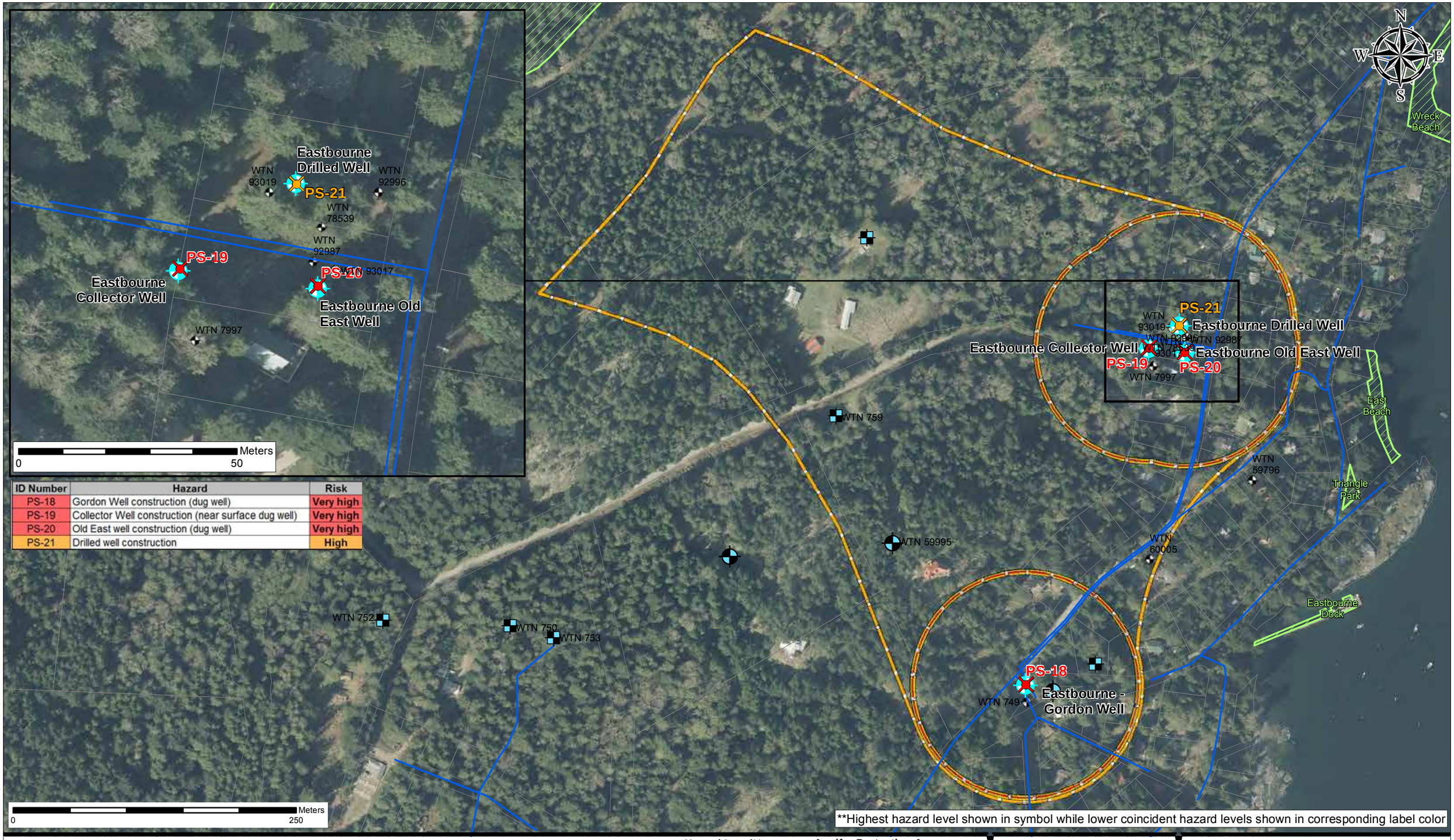
Sunshine Coast Regional District

Well Protection Planning

Table 4-7
Hazard risk assessment – Eastbourne Well System

Hazard No.	Hazard	Owner/ Jurisdiction	Contaminants of Concern	Likelihood of Occurrence		Magnitude of Consequence[1]		Risk	Preliminary Action Item No.[2]
Point Sources									
PS-18	Construction of Gordon Well (dug well)	SCRD	Any surface contaminant (chemical and pathogens)	C (possible)	Well is locked, but area is not fenced. Operators live on Keats Island and do regular inspections. Well is GARP - groundwater at risk of protozoa, and treated with chlorine and UV disinfection.	4	If a contaminant reached the well, major infrastructure may be lost.	**Very High**	21
PS-19	Construction of Collector well (near surface dug well).	SCRD	Any surface contaminant (chemical and pathogens)	C (possible)	The Collector Well is a shallow sand-filled trench with a collector pipe at the bottom of the trench that collects near-surface water that intersects with the trench. The collector pipe feeds into a shallow wet well. The water system operators live on Keats Island and do regular inspections. The trench depth is not known. That water table in the wet well during the site visit on November 14, 2016 was 0.6 m below ground. However, in wet months, the entire area can be ponded. The water is treated as surface water with both chlorinated and UV-treatment. The drilled well water also gets treated for arsenic removal.	4	If a contaminant reached the well, major infrastructure may be lost	**Very High**	21
PS-20	Construction of Old East well (dug well).	SCRD	Any surface contaminant (chemical and pathogens)	C (possible)	Well-head is located below ground surface in a wooden crib box. Well-head does not have a well cap; however, well is GARP - groundwater at risk of protozoa, and treated accordingly. Some refuse is stored next to pumphouse 5 m away from this well.	4	If a contaminant reached the well, major infrastructure may be lost.	**Very High**	21
PS-21	Drilled well construction and saltwater intrusion.	SCRD	Sodium and chloride	C (possible)	Bottom of well is 8 m below sea level, and therefore there is a potential to draw in salt water. Well is only 12 years old – it may take a few years to draw in salt water based on aquifer characteristics.	4	If a contaminant reached the well, major infrastructure may be lost, thus magnitude of consequence is major.	High	12
Non-point Sources									
NPS-30	Septic Systems/Septic Tanks.	Private owners	Pathogens (coliform and non-coliform bacteria and viruses), chloride, sulphate, nitrates, phosphate, heavy metals, tetrachloroethylene, dichlorobenzene, methylene chloride, and PPCPs.	B (likely)	Keats Island is not serviced by any municipal sanitary sewer system, so homes have either septic systems or outhouses. Nearest homes are about 20 m away, so it is difficult to assess if the well sites meet the Health Hazards Regulation (well needs to be located at 30 m away from any source of contamination, including septic fields). Bacteriological is poor based on a review of raw water in 2011 and 2013: of 105 samples collected from the wells in 2011, 3 samples contained *E. coli,* and 59 samples contained total coliforms.	4	The well is disinfected; however, it is uncertain whether the contact time meets the 4-log inactivation of viruses. If not, the small population could become ill.	**Very High**	8,32
NPS-27	Residential properties	Private	Pesticides, herbicides, household cleaners, automotive wastes,	C (possible)	Pesticide use is not prevalent however, homes on Keats Island may tend to store quantities of fuel, and other chemical hazards like unused cars and trucks. Since the wells are shallow, they are not protected by any infiltration of contaminants on the surface.	4	If a contaminant reached the well, major infrastructure may be lost.	High	23,34,35
NPS-28	Roads and other transportation infrastructure including storm drains and discharge points (like dry wells)	SCRD/MOTI?	Automotive wastes, sodium chloride, pesticides, herbicides, solid and liquid spills and runoff	E (rare)	There are minimal vehicles on Keats Island (there is no car ferry). The one road north of the Gordon Well is steep. The ditch along the road carries stormwater and the flow can sometimes be quite substantial. There is a possibility of the ditch overflowing and water running across the road and past the area immediately around the well.	4	If a contaminant reached the well, major infrastructure may be lost.	High	25, 26, 27, 28, 29, 30.
NPS-26	Underground or above-ground storage tanks	Private	BTEX, VOCs, Diesel, MTBE, petroleum hydrocarbons, waste oil	E (rare)	No natural gas is on Keats Island. The main source of heat is electrical and wood. came to Sunshine Coast in the mid 1990s, since that time, most homes are heated using electricity, wood, or natural gas. Any contamination from historical use of heating oil would already have been apparent. Moreover, the screen intake is 40 m below the water table, and varying layers of glacial till are present at shallower depths: any hydrocarbon plume would stay near the surface. Therefore, the likelihood is rare.	4	If a contaminant reached the well, major infrastructure may be lost.	Moderate	11, 22
NPS-25	Poorly constructed existing wells in capture zone - either monitoring wells, domestic wells, geothermal wells.	Private	Existing wells could act as a direct pathway to the aquifer, and then the contaminant would travel horizontally through aquifer.	E (rare)	No other wells besides the SCRD wells are registered on the Ministry of Environment's Water Resources Atlas. One non-registered well is known to exist within 30 m of Gordon Well, but is welded shut. Other non-registered wells could exist. Based on this low number of wells, and because a community water system is present and therefore new wells drilled is unlikely, the likelihood is rare.	2	Types of contaminants of concern would be at very low loads since residential area.	Low	20
NPS-29	Animals and Pests	Various owners	Pathogens	E (rare)	There are no dog parks in the area.	1		Low	31

Notes:
[1] 1 = Insignificant; 2 – Minor; 3 – Moderate; 4 – Major; 5 – Catastrophic (Section 4.1, Table 4-2)
[2] See Section 5, Table 5-2 for Action Item details.



ID Number	Hazard	Risk
PS-18	Gordon Well construction (dug well)	Very high
PS-19	Collector Well construction (near surface dug well)	Very high
PS-20	Old East well construction (dug well)	Very high
PS-21	Drilled well construction	High

**Highest hazard level shown in symbol while lower coincident hazard levels shown in corresponding label color

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Associated Environmental

Well Location
MOE Registered Well
Drilled Well
Dug Well

SCRD Water Mains
Zoning* Boundary

*Zoning Codes: R** = residential,I** = industrial, C** = commercial, P** = parks, W** = water

ALR Land
Park

Hazard Level**
Very High
High
Moderate
Low

Aquifer Protection Area
A - 100m Well Protection Zone
B - 200 Day Time of Travel
C - 10 Year Time of Travel

Aquifer protection areas are based on the maximum (sustainable) well pumping rate, not the actual well pumping rate

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FIGURE 4-4: DRINKING WATER HAZARDS AND RISK LEVEL - EASTBOURNE SYSTEM

Sunshine Coast Regional District

Well Protection Planning

4.2 STRENGTH, WEAKNESSES, OPPORTUNITIES, AND THREATS ANALYSIS

One of the major objectives of the Source-to-Tap Guideline is to incorporate information generated on the water supply system into a comprehensive assessment that identifies the strengths and weaknesses of the overall water system as an integrated whole. The TAC achieved this objective by conducting a SWOT analysis on November 15, 2016. The minutes from that meeting are included in Appendix A.

5 Module 8: Recommended Actions to Improve Drinking Water Protection

The outcome of Module 8 is a series of recommendations for each medium and high risk hazard identified in Module 7. The recommended risk management actions follow the SMART (Specific, Measurable, Achievable, Realistic, Time-bound) principles outlined in Module 8 of the Source-to-Tap Guideline and are based on the **multiple barrier** framework[3] for source protection defined by the Canadian Council of Ministers of the Environment (CCME 2004), which considers practical and cost-effective methods to improve existing barriers or implement new ones, where warranted.

The barriers introduced through source protection augment the natural barriers (or filters) that are already in place in watersheds or aquifers. For aquifers, these include the presence of confining layers and the properties of soils or bedrock that can attenuate contaminant concentrations in groundwater.

The Source-to-Tap Guideline recommends that the TAC, water supplier, and Drinking Water Officer develop risk management actions that are specific, measurable, achievable, realistic, and time-bound, following the principle outlined in Module 8 (MHLS 2010). The suggested timeframes for risk management actions are presented in Table 5-1; however, the Source-To-Tap Guideline suggests that risk level is not the only factor to consider when prioritizing actions; ease of implementation can also be a factor.

Table 5-1
Suggested time categories for risk management actions

Category	Timeframe	Type of Risk Management Action
Immediate	Within 3 months	Actions addressing regulatory violations, imminent public health threats, or water shortages.
Short Term	Within 1 year	Actions that are easy to implement or those addressing significant public health concerns or water quantity issues, enhancement or weak barriers.
Medium Term	1 to 3 years	Actions addressing moderate water quality or quantity concerns, broad systemic issues.
Long Term	3 years +	Actions addressing hazards representing chronic health implications or long-term threats to water availability, broad systemic issues.

Source: BC Ministry of Healthy Living and Sport 2010

[3] The multi-barrier approach is an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health.

The recommendations to protect drinking water are included in Table 5-2 and are designed to reduce the potential for future source water contamination. It is important to consider all of these recommendations to improve the safety of the water supply systems. To help with this, we have categorized our recommendations as: engineering/capital works, planning, or operational.

Table 5-2
Recommended actions to protect drinking water

Action No.	System	Action	Action Type and rough cost estimate if applicable	Action Timeframe
1	Chaster	Replace pit with pitless adaptor and add surface seal set 1.0 m into till, which starts at 1.5 m.	Engineering/capital works $30,000.	Medium term (1-3 years)
2		When replacing the pit with a pitless adaptor, if the storm drain is found, consider re-routing it to discharge farther away from the well.	Engineering/capital works	Medium term (1-3 years)
3		Continue to allow for a certain percentage of development be dedicated as SCRD parkland, as development occurs along Chaster Creek. This will enhance protection of the aquifer protection areas for the Chaster well.	Planning	Long term (>3 years)
4		Sample Chaster Creek and Chaster well two times per year for three years, and then re-assess frequency at that time. Test for common list of wastewater and agriculture related parameters: ammonia, nitrate, nitrite, organic nitrogen, total Kjeldahl nitrogen, total nitrogen, total phosphorus, total dissolved phosphorus, orthophosphate, chloride, sodium, pH (field), conductivity (field and lab), total coliforms, *E. coli*., biological oxygen demand, dissolved oxygen (field), and temperature (field).	Operational	Short term (within 1 year)
5		Install a datalogger in Chaster well to continuously monitor changes in water levels compared to rainfall/snowmelt events, to better assess the groundwater-surface water interaction.	Engineering/capital works	Long term (>3 years)
6		Sample for hydrocarbons three times for one year and then re-evaluate risk to hydrocarbons, and re-evaluate frequency at that time, depending on the results.	Operational	Short term (within 1 year)
7		Require development to show that it will meet water quality guidelines, including drinking water, at Chaster Creek, because Chaster Creek may be a recharge source to Chaster Road Well.	Planning	Short term (within 1 year)
8		Conduct a study to assess if the groundwater is at risk of containing pathogens (GARP) following the Ministry of Health's GARP Guideline (MOH 2015).	Engineering/capital works $5000 for four wells (Chaster, Granthams, Soames, Langdale)	Immediate (within 3 months)
9	Granthams and Soames	Bring uncontrolled flowing artesian conditions under control or close the well to meet the Groundwater Protection Regulation (BC Reg. 39/2016). Steps involved in controlling flow include drilling a dewatering well, dewatering the area, adding a closure plug using suitable materials such as bentonite and cement grout, pulling the casing, and drilling a new replacement well. Costs are ball-park and a detailed cost estimate should be developed.	Engineering/capital works $200,000+new well	Medium term (1-3 years)
10		Make the Granthams pumphouse vermin-proof.	Engineering/capital works	Immediate (within 3 months)
11		Test raw water for a wider range of contaminants twice per year for the first three years, and then assess frequency at that time. General parameters (including nutrients and wastewater) include total metals, Langelier Index, total coliforms, *E. coli*, LEPH, HEPH, PAHs, VOCs, and DOC. Once every five years, also test pesticides, herbicides, phenols, THM formation potential, cyanide, and gross alpha/beta and other isotope analysis as needed.	Operational	Short term (within 1 year)
12		Measure temperature, TDS, and conductivity in the field when doing bacteria testing and regularly review the quarterly monitoring results of sodium and chloride. Plot the results to assess trends over time.	Operational	Short term (within 1 year)
13	Langdale	Make pumphouse improvements: a) Machine a custom well cap that provides vermin-proof seal. b) Ensure the pumphouse is vermin-proof. For example, seal the gap below the door and cover windows with a finer mesh. c) Extend the roof drains further away from the well area, especially the southeast corner roof drain, which is closest to the well.	Engineering/capital works	Immediate (within 3 months)
14		Add signage to the Storage Area fence stating that this is part of an APA and that storage of chemicals including road salt is not allowed.	Operational	Short term (within 1 year)
15		Keep the ditch maintained and install a solid section of culvert to carry runoff away from the well area	Engineering/capital works	Medium term (1-3 years)
16		Provide a copy of the Source Protection Plan to BC Ferries, and ask BC Ferries for a copy of their annual reports submitted to Ministry of Environment. Review the report annually, and ask that BC Ferries report any leaks or spills immediately to the SCRD.	Operational	Short term (within 1 year)
17		Establish a connection to the Chapman water system via the Hopkins so that a connection can be done more easily in an emergency. Alternatively, install a second well in a different location in the Langdale area, to provide some redundancy to the system.	Operational	Short term (within 1 year)
18		Sample Langdale twice a year for common wastewater parameters for three years and then re-assess frequency at that time: ammonia, nitrate, nitrite, organic nitrogen, total Kjeldahl nitrogen, total nitrogen, total phosphorus, total dissolved phosphorus, orthophosphate, chloride, sodium, pH (field), conductivity (field and lab), total coliforms, *E. coli*., biological oxygen demand, dissolved oxygen (field), and temperature (field). Use a database management tool, such as Wireless Water or Watertrax, which can set up automatic alerts that email or text selected people if a concentration exceeds pre-established guidelines.	Operational	Short term (within 1 year)
19		For a new large development within the APA, implement aquifer protection measures, including: a) Provide APA maps to the developers. b) Once development plans are better understood, conduct additional studies on APA mapping to better delineate groundwater flow paths from potential hazards. The Source-to-Tap Drinking Water Assessment Guide (MOH 2010) provides guidance on different levels of scope for aquifer mapping depending on the size of the population. For 10,000 connections or more, conduct numerical modelling.	Planning	Short term (within 1 year)

Table 5-2
Recommended actions to protect drinking water

Action No.	System	Action	Action Type and rough cost estimate if applicable	Action Timeframe
20		Use planning tools to better manage installation and closure of wells. Actions could include: a) Require all wells drilled in capture zone to be registered with MOE's wells database, including detailed lithology. b) Require a surface seal to be installed on all monitoring wells, from top of screen to surface, and to be extended to at least 1 m into the first competent till layer for all water supply wells. c) Require all exploratory boreholes to be backfilled with bentonite all the way from bottom to surface (this is above and beyond the *Groundwater Protection Regulation* and *Water Sustainability Act*, but is prudent to protect the drinking water source). See Okanagan Basin Water Boards' Groundwater Bylaws toolkit for more information at http://www.obwb.ca/library/groundwater-bylaws-toolkit/. In this toolkit is an example Well Closure Bylaw that the City of Merritt put in place to increase the protection of its drinking water wells.	Planning	Medium term (1-3 years)
21	Eastbourne	Eastbourne shallow wells actions include: a) Check that contact time for 4-log inactivation of viruses and 3-log inactivation of protozoa is being met by reviewing storage capacity and chlorine concentrations. b) Continue regular inspections of well area and well itself. c) Do not store chemicals in the area of the wells including spent arsenic treatment material, and keep the area tidy. d) Share Source Protection Plan with land owners and discuss potential hazards, and consequences of spills/leaks. e) If doing underground works in the area, backfill with fill that has a finer hydraulic conductivity than surrounding area, and compact to avoid ponded areas forming. f) Add a vermin-proof well cap to the well-head within the wet well end of the Collector Well.	Operational	Immediate (within 3 months)
22	General	Improve groundwater protection from leaking fuel storage tanks through various planning tools. For example: a) In new developments, do not allow USTs, and require a permit to allow covered and contained ASTs in capture zones. b) When significant renovations occur on existing homes in capture zones, require removal of UST or AST. See Groundwater Bylaws Toolkit at http://www.obwb.ca/fileadmin/docs/groundwater_bylaws_toolkit.pdf for more ideas on how to complete this as part of planning.	Planning	Medium term (1-3 years)
23	General	Review acceptable practices for each zoning within each APA. See Groundwater Bylaws Toolkit at http://www.obwb.ca/fileadmin/docs/groundwater_bylaws_toolkit.pdf for more ideas on how to complete this as part of planning.	Planning	Medium term (1-3 years)
24	General	Improve management of groundwater at agricultural operations within APA to help protect the aquifers using various planning tools (Bylaws, Community Plans, etc.). For example: a) Provide information to farms within APA C about Source Protection and potential impacts of nutrients on drinking water if not properly managed. b) Recommend Environmental Farm Plans and Nutrient Management Plans for large-scale operations within APA A and B. b) Require an environmental assessment prior to approval of large-scale agricultural operations such as composting operations, dairies and feedlots with, for example, more than 50 cow, and intensive agricultural operations larger than 20 acres. See Groundwater Bylaws Toolkit at http://www.obwb.ca/fileadmin/docs/groundwater_bylaws_toolkit.pdf for more ideas on how to complete this as part of planning.	Planning	Medium term (1-3 years)
25	General	Consider the proximity to water supply wells when evaluating the alignment of future underground utility corridors. Provide a copy of the Source Assessment and Protection Plan to each utility company in the area.	Planning	Short term (within 1 year)
26	General	Present the Aquifer Protection Plan to First Responders and conduct regular meetings (i.e., annually) to discuss Source Protection.	Operational	Short term (within 1 year)
27	General	Improve signage at the wellhouse.	Operational	Short term (within 1 year)
28	General	Improve access to the well house for First Responders.	Operational	Short term (within 1 year)
29	General	Practice disaster response with First Responders.	Operational	Short term (within 1 year)
30	General	Keep ditches well maintained.	Operational	Short term (within 1 year)
31	General	When making improvements to roads in the APAs, consider bioswales or ditches, and avoid installing dry wells. In this way, surface water will receive some polishing from natural processes.	Engineering/capital works	Medium term (1-3 years)
32	General	Conduct frequent visits to the well site to ensure cleanliness in the pumphouse and around the vicinity of the well.	Operational	Immediate (within 3 months)
33	Eastbourne	Use planning tools to increase groundwater protection related to septic tanks in the APA. For example: a) Prepare a guide on "How to Maintain your Septic Tank" and provide to home owners within each APA. b) Consider having a grant program for maintenance and replacement of septic tanks to encourage owners to follow a maintenance plan. c) Review zoning in APA A and APA B, and move towards protecting the area or allow only low density development. d) For APA C, the contaminant of concern is nitrates. Consider requiring a nitrogen mass balance calculation and assessment of groundwater flow from the subdivision as part of the requirements of any subdivision application within all APAs.	Planning	Medium term (1-3 years)
34	Eastbourne	Present the Source Protection Plan at the annual Keats Island Owners' meeting.	Operational	Short term (within 1 year)
35	Eastbourne	Work with the homeowners in Eastbourne APA to clean up any unwanted stored fuel and other potential hazards (e.g., scrap cars).	Operational	Short term (within 1 year)

Notes: APA = Aquifer Protection Area, LEPH = Light extractable petroleum hydrocarbons, HEPH = Heavy extractable petroleum hydrocarbons, PAHs = polycyclic aromatic hydrocarbons, VOCs = volatile organic compounds, DOC = dissolved organic carbon

6 Contingency Plans

In 2016 the SCRD updated the Emergency Response Plans for each of their water supply systems including:

- Chapman Creek (including Chaster Well, which is used in summer months to augment supply)
- Granthams
- Soames
- Langdale
- Eastbourne

Each SCRD Emergency Response Plan generally follows the format of an emergency plan, as suggested in the BC Well Protection Toolkit. We reviewed the SCRD Emergency Response Plans and provide our comments in Table 6-1, organised by item from the BC Well Protection Toolkit.

Table 6-1
Review of SCRD Emergency Response Plans

Item in an Emergency Response Plan	Section Covered in SCRD ERPs	Comments
1) Roles and responsibilities of the Well Emergency Response Team within the District's overall Emergency Plan.	ERP Table 4-1 and Table 4-2	Consider adding Well Protection Consulting Team Members to the team. These are experts that understand the well and aquifer systems, and can help the SCRD and emergency responders understand the implications of a spill, for example, at different locations within the aquifer protection areas. Example additions: Well Protection Consulting Team Members • Project Hydrogeologist: Marta Green, P.Geo.. Associated Environmental Consultants Ltd., 250-545-3672 • Water System Operator Contractors: Scott Benson, Keats Island Contracting, 604-741-7561 • Engineering System: Shane Walkey, SCRD, 604-885-6806 • Pump Contractors: Pika Pump and Compressor Sales, 250-929-9401 • Drilling Contractors: Paul Anderson, Canwest Well Drilling, Powell River, 604-485-4250
2) An outline of specific response scenarios for each of the most likely and most	ERP Table 3-1	Consider adding specific response scenarios for some additional most likely and likely threats to groundwater sources. Table 6-2 provides some specific response scenarios

Item in an Emergency Response Plan	Section Covered in SCRD ERPs	Comments
significant threats to local water supplies.		for the very high risk hazards that are related to an emergency event. Consider adding Well Protection Consulting Team Members below “Contractors” to the Chain of Command Tree in Figure 4-1
3) An outline of specific response scenarios to unexpected threats and contamination events.	ERP Table 3-1	Provide a copy of aquifer protection area maps in each ERP, and provide a GIS data to each Well Emergency Response Team Member, to allow for the addition of their respective geographic information system.
4) Identification of contacts names and responsibilities for the Well Emergency Response Team, including community members that would be part of the team. For example, providing phone numbers of where to contact neighbours that are out of town in the event of an emergency.	Table 4-2	See Item 1 comments
5) Train the Well Emergency Response Team.	Section 1.5.1	When completing the next training event, provide a summary of the aquifers and wells, and how contaminants move from the surface to the well intake. Discuss the aquifer protection areas and the results of the hazard inventory.
6) Develop a specific communication plan for water contamination events.	Tab 5	Tab 2 provides a description of the engineering components of the system. In Tab 2, How the System Works, consider providing a simple explanation of how water moves through groundwater and the vulnerability at each system.
7) Prepare a schedule and process to update maps and contact information.	Not included	Consider developing a schedule to update the ERPs. Complete an annual review of existing ERPs and a detailed review once every 5 years. The last ERPs were developed in 2016, so consider a detailed review in 2021.
8) Secure alternate water supplies.	Tab 6	Consider an alternate source (a second well) for Langdale, or improve the connection to the Chapman system through Hopkins system (a private water system sourced by a well). Test the backup pump that connects Langdale to Hopkins.

Item in an Emergency Response Plan	Section Covered in SCRD ERPs	Comments
9) Identify and secure funding to implement the Well Emergency Response Plan.	Not included	See Item 7 comments.

Table 6-2 provides some specific response scenarios for the very high and high risk hazards that are related to an emergency event. Consider adding some of these to the SCRD ERPs.

Table 6-2
Response scenario of very high and high risk hazards

Very High and High Risk Hazards	Potential Triggers	Potential Contingency Activity (depends on actual event)	Contacts
Gordon Well, Collector Well, and Old East Well Construction (PS-18, 19, 20) **Examples of contaminants:** Gasoline, antifreeze, oils and solvents	• Complaint of odour • Report of fuel spill in area • Vandalism	1. Determine extent of spill/vandalism. 2. If necessary issue Public Advisory. 3. Provide alternate drinking water source. 4. Expand monitoring to pinpoint source. 5. Contact Well Protection Consulting Team for containment and/or clean up management.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business or homeowner responsible
Grantham Well and Pumphouse Construction, Soames Well Construction (PS4a, PS-4b, and PS-5) **Examples of contaminants:** Pathogens	• Coliforms in raw water samples • Reports of gastro-intestinal illness in serviced community	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact Well Protection Consulting Team for containment and/or clean up management.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business or homeowner responsible
Langdale Pumphouse Construction (PS-10b) **Examples of contaminants:** Pathogens	• Coliforms in raw water samples	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer

Very High and High Risk Hazards	Potential Triggers	Potential Contingency Activity (depends on actual event)	Contacts
		4. Contact Well Protection Consulting Team for containment and/or clean up management.	4. Well Protection Consulting Team 5. Business or homeowner responsible
Gibsons Redi-Mix Ltd. Redevelopment plan: subdivision and 60 trailer pads with onsite septic (PS-3b) **Examples of contaminants:** Pathogens, hydrocarbons, metals, salts, herbicides and pesticides	• Nitrates increasing over time in Chaster Well	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact business or homeowner responsible.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business responsible
BC Ferries Overflow Parking Lot (PS-10b) **Examples of contaminants:** Hydrocarbons, metals, salts, herbicides, and pesticides	• Flooding in the area of Langdale Pumphouse • Report of backup in stormwater system • Coliforms in well	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact Well Protection Consulting Team for containment and/or clean up management. 5. Contact MOTI and BC Ferries.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business or homeowner responsible
Poorly constructed existing Wells (either monitoring wells, domestic wells, or geoexchange wells) **Examples of contaminants:** Hydrocarbons, metals, salts, herbicides, and pesticides	• Complaint of odour in well water • Coliforms in raw water results	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact Well Protection Consulting Team for containment and/or clean up management. 5. Contact business or homeowner responsible.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business or homeowner responsible
Agricultural Operations **Examples of contaminants:** Hydrocarbons, metals, salts, herbicides, and pesticides	• Complaint of odour or colour in customer's water • Coliforms in raw water results	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact Well Protection Consulting Team for	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer

Very High and High Risk Hazards	Potential Triggers	Potential Contingency Activity (depends on actual event)	Contacts
	• Nitrates increasing over time	containment and/or clean up management. 5. Contact business or homeowner responsible.	4. Well Protection Consulting Team 5. Business or homeowner responsible
Roads and Transportation Systems including Drainage Pits and Storm Drainage Mains **Examples of contaminants:** Pathogens, hydrocarbons, metals, salts, herbicides and pesticides	• Flooding within aquifer protection areas • Report of backup in stormwater system • Coliforms in well • Incidents of dead animals reported • Incidents of illness reported • Home or business owner use of prohibited substance.	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact Well Protection Consulting Team for containment and/or clean up management. 5. Contact business or homeowner responsible.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business or homeowner responsible
Septic systems/septic tanks **Examples of contaminants:** Pathogens, hydrocarbons, metals, salts, herbicides and pesticides	• Complaint of odour or colour in customer's water • Coliforms in raw water results • Nitrates increasing over time	1. If necessary issue Public Advisory. 2. Provide alternate drinking water source. 3. Expand monitoring to pinpoint source. 4. Contact Well Protection Consulting Team for containment and/or clean up management. 5. Contact business or homeowner responsible.	1. General Manager, Infrastructure Services/Regional Manager 2. Emergency Program Coordinator 3. Drinking Water Officer 4. Well Protection Consulting Team 5. Business or homeowner responsible

Notes: Pink highlighting are very high risk hazards and orange highlighting are high risk hazards

7 Summary, Conclusions, and Recommendations

Associated completed a Well Protection Plan for the SCRD's five water supply systems (Chaster, Soames, Granthams, Langdale, and Eastbourne) in the Gibsons area. The assessment followed Modules #1, 2, #7, and #8 of the Source-To-Tap Guideline. The other modules, which relate to financial and governance areas of the water systems, are not addressed in this Well Protection Plan.

The identified potential sources of groundwater contamination (hazards) were based on our review of available information, our discussions with SCRD personnel, and our Senior Hydrogeologist's site visit to each well area. A technical advisory committee assigned a likelihood rating for each contaminant to reach the well and a consequence rating if the contaminant made it to the well. A risk rating for each hazard was based on the combination of likelihood and consequence.

Of the 26 potential point-source hazards and eight non-point source hazards, eight were rated as very high risk and 15 as high risk. The very high hazards are as follows:

- Granthams Well construction, uncontrolled flowing artesian conditions, and pumphouse construction (PS-4a/b, Granthams Well);
- Soames Well construction (PS-5a, Soames Well);
- A 300-acre proposed development (PS-17, Langdale Well);
- Gordon Well, Collector Well, and Old East Well construction (PS-18, PS-19, and PS-20, Eastbourne Well System); and
- Septic systems and tanks on Keats Island (NPS-30, Eastbourne Well system).

Based on our conclusions, Associated recommends the following:

1. The SCRD complete the action items listed in Table 5-2. To manage public health risk and to adequately maintain the SCRDs valuable infrastructure, the recommended action items should be completed within the timeframe listed in Table 5-2. Some action items do not involve capital funds, such as sharing the Well Protection Plan, which shows the aquifer protection areas, with First Responders. Others will require some level of planning and incorporation into annual capital budgets beginning in 2017. In summary, these recommendations:
    a. further assess the risk of pathogens through "Groundwater At Risk of Containing Pathogens" studies;
    b. improve emergency preparedness through better communication and training of First Responders;
    c. reduce the chance that various contaminants enter the aquifer by educating the key business owners, institution managers (schools, and BC Ferries), and SCRD staff about the aquifer protection areas, potential sources of contamination, and an understanding of how contaminants move through aquifers;

d. provide the SCRD with examples of planning tools that can be used to help minimise future land use conflicts;

e. address the management and upgrades of infrastructure in ways that reduce the risk of source water contamination; and

f. implement security and detection systems that improve protection and monitoring of the source water.

2. The SCRD update each water system's Emergency Response Plan as described in Table 6-1 and Table 6-2. Attach a copy of the Well Protection Plan to each Emergency Response Plan.

3. If groundwater supply is expanded in the future, consider developing some redundancy to Langdale well, and consider source protection when selecting future well sites. The SCRD may wish to consider reducing the number of wells used in the system, to be able to place more resources on continuously improving the safety of the remaining sources. For example, Soames and Granthams wells could be permanently closed and replaced with a new well near the Soames reservoir, which is located 50 m west of Soames well. The Soames reservoir site is ideal from a source protection point of view because it is surrounded by a large undeveloped park owned by SCRD.

4. As part of the multiple barrier approach, continue best management practices, including ongoing operator training, reviewing chlorine residual and coliform results in a timely fashion, and limiting activity around the well areas. Promoting a multi-barrier approach and continued improvement is the key to a safe water supply.

Closure

This Well Protection Plan was prepared for the Sunshine Coast Regional District to improve the safety of the water supply systems.

The services provided by Associated Environmental Consultants Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Environmental Consultants Inc.

PROFESSIONAL GEOSCIENTIST PROVINCE OF BRITISH COLUMBIA M. C. GREEN #30667

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Appendix A – Records of Meetings

Date:	November 14, 2016	**File:**	2016-8167
Time:	9am	**Page:**	1 of 3
Project:	SCRD Well Protection Plan		
Subject:	Workshop minutes		
Client:	SCRD		
Location:	SCRD Field Road Office		
Present:	Marta Green (Associated Environmental) Darren Molder, Drinking Water Officer, Coastal Health Authority (Day 2) Shane Walkey, Manager of Utility Services (part of Day 1 SWOT) Codi Abbott, Utilities Operations Superintendent Kevin Johnson, Senior Water Technician Trevor Rutley, Engineering Technician (Day 1) Beth Brooks, Environmental Technician Paul Sheridan, Water Technician (Day 2) Andrew Nadler, Keats Island Construction (Day 2) Dave Crosby, Special Projects Manager, Utility Services (Day 2) Dale Sapach, SCADA tech (Day 2) Ron Hunter, Water Technician (Day 2) Andrew Allen, Planner (part of Day 2)		
Distribution:	Those Present		

RECORD OF MEETING

This Record of Meeting is considered to be complete and correct. Please advise the writer within one week of any errors or omissions, otherwise this Record of Meeting will be considered to be an accurate record of the discussions

Action By:	**Discussion:**	
Marta	1	DAY 1: MONDAY, NOVEMBER 14, 2016: SITE VISIT AND TECHNICAL ADVISORY COMMITTEE (TAC) WORKSHOP 1 - IDENTIFY POTENTIAL CONTAMINANT SOURCES, AND SWOT ANALYSIS

Marta Green, Kevin Johnson, and Trevor Rutley visited Eastbourne and Chaster Sites. Met Alex, Scott, and Andrew Nadler from Keats Island Construction at Eastbourne. Marta discussed the goals of the project, the Source to Tap modules, an overview of groundwater flow, and introduced the SWOT exercise. In the afternoon, strengths, weakness, opportunities and threats were done for the water system as a whole and for each well system. See SWOT Memo Attached.

Action By:	Discussion:	
Marta	2	TUESDAY, NOV 15, 2016: TAC WORKSHOP 2 (HAZARD SCREENING ASSESSMENT AND RISK CHARACTERIZATION).

Introductions were completed, and then Marta discussed the goals of the project, the Source to Tap modules, an overview of groundwater flow, and introduced the Workshop 2 exercise. A table with a draft list of hazards were given out and risk assignment (see attached tables) were discussed.

Rank likelihood of occurrence

Level	Description	Probability of Occurrence in Next 10 Years
A	Almost certain - is expected to occur in most circumstances	>90%
B	Likely - will probably occur in most circumstances	71-90%
C	Possible - will probably occur at some time	31-70%
D	Unlikely – could occur at some time	10-30%
E	Rare - may only occur in exceptional circumstances	<10%

Rank magnitude of consequence

Level	Description
1	Insignificant - no illness, little disruption to normal operation, little or no increase in normal operating costs.
2	Minor - small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs.
3	Moderate - minor impact for large population, mild to moderate illness probable, significant moderation to normal operations but manageable, operating costs increased, increased monitoring.
4	Major - impact to small population, severe illness probably, systems significantly compromised and abnormal operation if at all, high level monitoring required.
5	Catastrophic - Major impact for large population, severe illness probable, complete failure of system.

Agree on risk assignments (very high, high, moderate, low).

Likelihood	Consequence				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely)	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

Associated Environmental

Date:	November 18, 2016	**File:**	2016-8167
To:	Dave Crosby		
From:	Marta Green, P.Geo		
Project:	SCRD Well Protection Planning		
Subject:	SWOT minutes		

MEMO

On November 14, 2016, we completed a SWOT of the wells and the system as a whole. In attendance were: Marta Green (Associated Environmental), Shane Walkey, Manager of Utility Services (part of Day 1 SWOT), Codi Abbot, Utilities Operations Superintendent; Kevin Johnson, Senior Water Technician; Trevor Rutley, Engineering Technician; Beth Brooks, Environmental Technician

Table 1: Strengths, weaknesses, opportunities and threats for the SCRD Wells Systems Overall

	SCRD Wells Systems Overall
Strengths	• Wells backup each other • No large industrial or agricultural sources • Good operators (8 operators, EOCP Class 1 to 4 (two level 4s) • Geology: there is a protective till layer on top of all well sites • Analyze for parameters regularly and review lab results as soon as they arrive • Complete aggressivity/corrosivity testing for all wells: this will allow SCRD to review the lead-leaching potential of its water sources • Great water quality
Weaknesses	• Natural gas arrived to the Sunshine Coast in early 2000s. Therefore, heating oil tanks may have been used up until recently as main mode of heat, although electric heat and wood is quite popular. • Cross connection between Hopkins Landing is a bit complicated, leaving Langdale having a complex back-up system. • The SCRD doesn't own all of the land that its infrastructure is on: all rights of ways from MOTI. • No education campaign.
Opportunities	• Put water quality data into a database that compares to Guidelines, and sends alerts, freeing up Operator's time. Or putting into existing Cityworks for other uses. • Water tastes really good and this is of great value to the consumers. This is an opportunity because SCRD should have an easier time selling the water at a higher price, bringing in more revenue. • There is no drill rig on the Sunshine Coast, and little intensive agriculture yet: therefore, the till aquitard remains intact for the most part. This is an opportunity to protect it now before its integrity is compromised by too many improperly closed boreholes or over application of nutrients, for example. • If completed connection to Hopkins Landing, then the entire system would have more redundancy.
Threats	• There is very little groundwater data and this makes it difficult to make sound decisions related to aquifer protection. • Many urban growth pressures.

Table 2: Strengths, weaknesses, opportunities and threats for the Chaster Well

	Chaster Well
Strengths	• Great protective layers above intake • Low population density • Great water quality • Deep well • Electrical and chlorine and piping all in separate buildings/structures • Alarmed and keyed.
Weaknesses	• Well in concrete pit: confined space: making any kind of maintenance including emergency repair very difficult and potentially dangerous. • Roof drain: where does it go? • No surface seal = annular space = direct pathway. • At least 1 septic field up-gradient within about 30 m.
Opportunities	• With a bit of work, you could have lots of improvements. • Could purchase u-g home when comes for sale. • Can develop policy around ALR land in capture zone. • If sample port is put in, can sample raw water for indicators for septic field influence and saltwater intrusion (conductivity, temperature, TDS, pH) easily when weekly bacteria samples are taken
Threats	• Lots of urban growth and ALR land pressures in the capture zone.

Table 3: Strengths, weaknesses, opportunities and threats for the Granthams and Soames Wells

	Granthams and Soames
Strengths	• SCRD owns the large park (Soames Park) that surrounds the majority of the Aquifer Protection Area, and the area in the vicinity of the wells.
Weaknesses	• Soames and Granthams are over 100 years old: therefore, there may be old contaminants. • These originally were privately run systems. Soames was taken over by SCRD in 1990, and Granthams in 2012. Therefore, original well logs, pumping tests, and engineering drawings may not be available. • Uncontrolled flowing well. • Soames well under a road. • Industrial park in upper reaches of capture zone
Opportunities	• Protecting these aquifer protection areas will be easier because the majority is a park and is owned by SCRD. Needs to be coordinated with Parks Division.
Threats	• Road.

Table 4: Strengths, weaknesses, opportunities and threats for the Langdale System

	Langdale
Strengths	• Designed by a professional Engineer and has engineering drawings • Very low density nearby
Weaknesses	• Land around the well not controlled by SCRD: controlled by MOTI or BC Ferries. • Septic fields on north and south sides: • Langdale community • Langdale school • BC Ferries wastewater treatment plant • Salvation Army • Steep slope carrying lots of stormwater from large highway sections to ditches that pass near the well.
Opportunities	• Geology still provides some protective capping but not as good as Chaster. • Backup to the well is through Hopkins Landing, another water supplier. • BC Ferries is likely to be a very good partner in aquifer protection
Threats	• A very large 300-acre residential complex development is planned upgradient of the well. • Very large relatively unused overflow parking lot right next to well: what if BC Ferries changes and starts using it more?

Table 5: Strengths, weaknesses, opportunities and threats for the Eastbourne System

	Eastbourne
Strengths	• No industrial uses, all residential. • Own lots or easements for infrastructure. • Great operators that are also local. • Advanced treatment system
Weaknesses	• These originally were privately run systems. Therefore, original well logs, pumping tests, and engineering drawings may not be available. • Septic fields nearby.
Opportunities	• 100 year lease of other community on Keats Island is coming up.
Threats	• Low water availability, climate change

Appendix B – Well Logs

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 23421

Owner: SUNSHINE COAST REGIO

Address: CHASTER ROAD

Area:

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot: 909 Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 83): 092G033343 Well: 16

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Licence General Status: UNLICENSED
Well Use: Unknown Well Use
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 12.0 inches
Casing drive shoe:
Well Depth: 364 feet
Elevation: 0 feet (ASL)
Final Casing Stick Up: inches
Well Cap Type:
Bedrock Depth: feet
Lithology Info Flag:
File Info Flag:
Sieve Info Flag:
Screen Info Flag:

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 1970-04-01 00:00:00

Driller: Rural Well Drillers
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 240 (Driller's Estimate) U.S. Gallons per Minute
Development Method:
Pump Test Info Flag: Y
Artesian Flow:
Artesian Pressure (ft):
Static Level: 232 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag:
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag:
Material:
Method:
Depth (ft):
Thickness (in):

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
MX. PUMPING RATE 240 USGPM.

LITHOLOGY INFORMATION:

From	0 to	5 Ft.	Sand and gravel
From	5 to	20 Ft.	Glacial till
From	20 to	82 Ft.	Fine - medium sand occasional gravel
From	82 to	84 Ft.	Sand and water
From	84 to	182 Ft.	Glacial till
From	182 to	235 Ft.	Medium - coarse sand
From	235 to	247 Ft.	Organic silt
From	247 to	255 Ft.	Sand with some silt
From	255 to	258 Ft.	Silt
From	258 to	291 Ft.	Fine sand (W.B.)
From	291 to	296 Ft.	Sandy silt - no water
From	296 to	316 Ft.	Sand - some silt and wood chips W.B.
From	316 to	333 Ft.	Medium clean sand, silt fraction
From	333 to	364 Ft.	Fine sand (W.B.)

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

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Report 1 - Detailed Well Record

Well Tag Number: 78231	Construction Date: 1990-08-24 00:00:00
Owner: GRANTHAMS LANDING IM	Driller: Nor-West Drilling
	Well Identification Plate Number:
Address: SOAMES CREEK	Plate Attached By:
	Where Plate Attached:
Area: GIBSONS	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 0 (Driller's Estimate)
NEW WESTMINSTER Land District	Development Method:
District Lot: 693 Plan: 1119 Lot:	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block: D	Artesian Pressure (ft):
Quarter:	Static Level: 75 feet
Island:	
BCGS Number (NAD 83): 092G043213 Well: 8	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag:
Well Use:	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method:	Water Utility:
Diameter: 8 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:

Well Depth: 52 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft): 0 feet
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	Liner from To: feet
Screen Info Flag: Y	
	WELL CLOSURE INFORMATION:
Site Info Details:	Reason For Closure:
Other Info Flag:	Method of Closure:
Other Info Details:	Closure Sealant Material:
	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size
41.5	52		40
0	0		60
0	0		0
0	0		0

Casing from	to feet	Diameter	Material	Drive Shoe
0	0	0	null	null

GENERAL REMARKS:
SOAMES CREEK GIBSONS BC

LITHOLOGY INFORMATION:

From	0 to	9 Ft.	ROCK FILL
From	9 to	19 Ft.	SILTY BROWN SAND
From	19 to	25 Ft.	STONEY HARD PAN
From	25 to	52 Ft.	WATER BEARING SAND & GRAVEL

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

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Information provided should not be used as a basis for making financial or any other commitments.

Report 1 - Detailed Well Record

Well Tag Number: 65967	Construction Date: 1979-10-17 00:00:00
Owner: SOAMES POINT WATER W	Driller: Rural Well Drillers
	Well Identification Plate Number:
Address:	Plate Attached By:
	Where Plate Attached:
Area:	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 0 (Driller's Estimate)
NEW WESTMINSTER Land District	Development Method:
District Lot: 693 Plan: Lot:	Pump Test Info Flag: Y
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 31 feet
Island:	
BCGS Number (NAD 83): 092G043213 Well: 9	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: Y
Well Use:	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 10.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:

Well Depth: 121 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft):
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	
Screen Info Flag: N	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
CASING 0.0 TO 20.0, STAINLESS STEEL,PUMP TEST RATE 51 USGM,51.39 FT AFTER 24 HRS

LITHOLOGY INFORMATION:

From	0	to	3 Ft.	SANDY GRAVEL
From	0	to	0 Ft.	UP PIPE YIELD BY BLOWING GREATER THAN 10
From	7	to	10 Ft.	BOULDERS & COMPACT GRAVEL
From	10	to	17 Ft.	COMPACT SILTY SAND & COARSE GRAVEL FEW B
From	17	to	26 Ft.	MEDIUM SAND COMPACT
From	26	to	83 Ft.	COMPACT SANDY GRAVEL WITH SOME SILT OCCA
From	0	to	0 Ft.	BOULDERS
From	83	to	94 Ft.	VERY COMPACT SILTY COARSE GRAVEL
From	94	to	97 Ft.	COMPACT CLAYEY GRAVEL POSSIBLY TILL VERY
From	0	to	0 Ft.	WATER
From	97	to	101 Ft.	LOOSE COARSE CLEAN SANDY GRAVEL VERY HIG
From	0	to	0 Ft.	WATER CLEARED IN MINUTES
From	101	to	121 Ft.	VERY COARSE CLEAN SANDY GRAVEL VERY PROD
From	0	to	0 Ft.	WATER BEARIANG CAPACITY COARSE MATERIAL

From	3 to	7 Ft.	FINE DRY SAND

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 24390	Construction Date: 1971-01-01 00:00:00
Owner: SUNSHINE COAST REGIO	Driller: Rural Well Drillers
	Well Identification Plate Number:
Address:	Plate Attached By:
	Where Plate Attached:
Area: LANGDALE	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 240 (Driller's Estimate) U.S. Gallons per Minute
NEW WESTMINSTER Land District	Development Method:
District Lot: 1401 Plan: Lot:	Pump Test Info Flag: Y
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block:	Artesian Pressure (ft):
Quarter:	Static Level: 3 feet
Island:	
BCGS Number (NAD 83): 092G043231 Well: 1	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: Y
Well Use: Unknown Well Use	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Drilled	Water Utility:
Diameter: 12.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:
Well Depth: 150 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag:
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag:	Depth (ft):
File Info Flag:	Thickness (in):
Sieve Info Flag:	

Screen Info Flag:	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

From	0 to	28 Ft.	Coarse sand and gravel
From	28 to	34 Ft.	Medium fine sand
From	34 to	38 Ft.	Coarse sand and gravel
From	38 to	44 Ft.	Silty sand and gravel
From	44 to	47 Ft.	Med. fine sands and gravel
From	47 to	77 Ft.	Silt gravel and stones - no water
From	77 to	95 Ft.	Silt gravel and stones (W.B.)
From	95 to	141 Ft.	Fine sand
From	141 to	146 Ft.	Coarse sand and gravel
From	146 to	150 Ft.	Till
From	150 to	0 Ft.	Possible bedrock

- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 749

Owner: EASTBOURNE COMMUNITY

Address:

Area:

WELL LOCATION:
NEW WESTMINSTER Land District
District Lot: 1595 Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island: KEATS
BCGS Number (NAD 83): 092G033443 Well: 6

Class of Well:
Subclass of Well:
Orientation of Well:
Status of Well: New
Licence General Status: UNLICENSED
Well Use: Commercial and Industrial
Observation Well Number:
Observation Well Status:
Construction Method: Dug
Diameter: 60.0 inches
Casing drive shoe:
Well Depth: 20 feet
Elevation: 0 feet (ASL)
Final Casing Stick Up: inches
Well Cap Type:
Bedrock Depth: feet
Lithology Info Flag:
File Info Flag:
Sieve Info Flag:
Screen Info Flag:

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date:

Driller: Unknown
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 0 (Driller's Estimate)
Development Method:
Pump Test Info Flag:
Artesian Flow:
Artesian Pressure (ft):
Static Level: 8 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag:
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag:
Material:
Method:
Depth (ft):
Thickness (in):

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
THIS WELL IS NOT CASED TO THE BOTTOM, BUT WAS OBSERVED TO BE CASED BELOW THE H2O LEVEL IN WELL.HEAVY USE ON SUMMER WEEKENDS DEPLETES WELL.

LITHOLOGY INFORMATION:

From 0 to 0 Ft. fine silty

From 0 to 0 Ft. water enters well through grey gravelly

From 0 to 0 Ft. seams in till

- Return to Main
- Return to Search Options
- Return to Search Criteria

Report 1 - Detailed Well Record

Well Tag Number: 7997	Construction Date: 1950-01-01 00:00:00
Owner: EASTBOURNE COMMUNITY	Driller: Unknown
	Well Identification Plate Number:
Address:	Plate Attached By:
	Where Plate Attached:
Area: EASTBOURNE	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 0 (Driller's Estimate)
NEW WESTMINSTER Land District	Development Method:
District Lot: 1595 Plan: 10378 Lot: 2	Pump Test Info Flag:
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block: 19	Artesian Pressure (ft):
Quarter:	Static Level:
Island: KEATS	
BCGS Number (NAD 83): 092G033443 Well: 3	WATER QUALITY:
	Character:
Class of Well:	Colour:
Subclass of Well:	Odour:
Orientation of Well:	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag:
Well Use: Commercial and Industrial	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method: Dug	Water Utility:
Diameter: 84.0 inches	Water Supply System Name:
Casing drive shoe:	Water Supply System Well Name:

Well Depth: 20 feet	
Elevation: 0 feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: inches	Flag:
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag:	Depth (ft):
File Info Flag:	Thickness (in):
Sieve Info Flag:	
Screen Info Flag:	WELL CLOSURE INFORMATION:
	Reason For Closure:
Site Info Details:	Method of Closure:
Other Info Flag:	Closure Sealant Material:
Other Info Details:	Closure Backfill Material:
	Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:
REPORTED: 7 FT.SQUARE CEDAR CRIBBED FOR 1ST 4 FT THEN OPEN HOLE GOOD QUALITY,

LITHOLOGY INFORMATION:

From 0 to 20 Ft. till, water enters in grey gravelly

From 0 to 0 Ft. seams in till

- Return to Main
- Return to Search Options
- Return to Search Criteria

Information Disclaimer

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 92987	Construction Date: 2004-07-14 00:00:00
Owner: SUNSHINE COAST REGIONAL DISTRICT	Driller: Nor-West Drilling
	Well Identification Plate Number:
Address:	Plate Attached By:
	Where Plate Attached:
Area: KEATS ISLAND	
	PRODUCTION DATA AT TIME OF DRILLING:
WELL LOCATION:	Well Yield: 2 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Land District	Development Method:
District Lot: 1595 Plan: 10378 Lot: 3	Pump Test Info Flag: N
Township: Section: Range:	Artesian Flow:
Indian Reserve: Meridian: Block: 19	Artesian Pressure (ft):
Quarter:	Static Level:
Island:	
BCGS Number (NAD 83): 092G033443 Well:	WATER QUALITY:
	Character:
Class of Well: Water supply	Colour:
Subclass of Well: Domestic	Odour:
Orientation of Well: Vertical	Well Disinfected: N
Status of Well: New	EMS ID:
Licence General Status: UNLICENSED	Water Chemistry Info Flag: N
Well Use: Private Domestic	Field Chemistry Info Flag:
Observation Well Number:	Site Info (SEAM):
Observation Well Status:	
Construction Method:	Water Utility:
Diameter: inches	Water Supply System Name:
Casing drive shoe: N	Water Supply System Well Name:
Well Depth: feet	
Elevation: feet (ASL)	SURFACE SEAL:
Final Casing Stick Up: 24 inches	Flag: N
Well Cap Type:	Material:
Bedrock Depth: feet	Method:
Lithology Info Flag: N	Depth (ft): 15 feet
File Info Flag: N	Thickness (in):
Sieve Info Flag: N	Liner from To: feet
Screen Info Flag: N	
	WELL CLOSURE INFORMATION:
Site Info Details:	Reason For Closure:
Other Info Flag:	Method of Closure:

Other Info Details:	Closure Sealant Material: Closure Backfill Material: Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe
0	58	6	null	N

GENERAL REMARKS:
RIG #: AR#1.

LITHOLOGY INFORMATION:

From	0 to	15 Ft.	SAND & GRAVEL	
From	15 to	25 Ft.	CLAY & LAYERS OF TILL	grey
From	25 to	44 Ft.	TILL & SAND, LAYERS OF GRAVEL	
From	44 to	60 Ft.	SAND & GRAVEL	
From	60 to	65 Ft.	BROKEN ROCK	
From	65 to	140 Ft.	LAYERS OF DARK GREEN	
From	140 to	160 Ft.	WITH LAYERS OF GREY GRANITE	green
From	160 to	180 Ft.	MULTI COLOURED GREY WITH LAYERS OF GREEN	
From	180 to	245 Ft.	GREYISH GREEN WITH LAYERS OF GREEN	

- Return to Main
- Return to Search Options
- Return to Search Criteria

Appendix C – BC Contaminated Site Registry Search

As Of: OCT 16, 2016 BC Online: Site Registry 16/11/02
For: PK57542 ASSOCIATED ENVIRONMENTAL CONSULTANT 13:32:33
Folio: 2016-8167 Page 1

23 records selected for 5.0 km from latitude 49 deg, 24 min, 20.1 sec
and Longitude 123 deg, 29 min, 56.7 sec

Site Id	Lastupd	Address / City
0001142	03FEB06	524 MARINE DRIVE GIBSONS
0001589	16JUN02	263 GOWER POINT RD & 1157 SCHOOL RD (MOLLYS LANE) GIBSONS
0003440	05JAN27	400 GOWER POINT ROAD GIBSONS
0004012	02OCT24	910 HIGHWAY 101 GIBSONS
0004021	04NOV30	1012 SEAMOUNT WAY GIBSONS
0007154	09JAN13	1118 SUNSHINE COAST HIGHWAY GIBSONS
0007902	14MAR25	694 GIBSONS WAY GIBSONS
0008375	04DEC13	895 GIBSONS WAY GIBSONS
0008414	13NOV12	LANGDALE FERRY TERMINAL LANGDALE
0009116	14NOV18	1281 MARINE DRVE GIBSONS
0009449		1170 STEWART ROAD GIBSONS
0009458	15DEC09	883 GIBSONS WAY GIBSONS
0009770	13NOV14	1028 GIBSONS WAY - RR7 GIBSONS
0010870		1413 SUNSHINE COAST HIGHWAY GIBSONS
0015070	14JUN12	969 KEITH ROAD GIBSONS
0016296		632 SHAW ROAD GIBSONS
0016759	16MAY20	377 TO 385 GOWER POINT ROAD GIBSONS
0016864	15APR10	875 GIBSONS WAY GIBSONS
0018124		1196 STEWART ROAD GIBSONS
0018194	16JUN02	647 SCHOOL ROAD GIBSONS
0018198	16JUN02	MOLLY'S LANE, GOWER POINT ROAD AND SCHOOL ROAD GIBSONS
0018199	16JUN02	PORTION OF SEA WALK SW OF SCHOOL ROAD GIBSONS
0018218	16JUN02	643 & 645 SCHOOL ROAD GIBSONS

```
 As of: OCT 16, 2016        BC Online: Site Registry                        16-11-03
                      For: PK57542  ASSOCIATED ENVIRONMENTAL CONSULTAN 08:42:09
 Folio: 2016-8167                                                           Page   1
                                  Detail Report
SITE LOCATION
      Site ID:      8414                                   Latitude:  49d 26m 03.3s
 Victoria File:                                           Longitude: 123d 28m 44.1s
 Regional File: 26250-20/8414
        Region: SURREY, LOWER MAINLAND

 Site Address: LANGDALE FERRY TERMINAL
         City: LANGDALE                              Prov/State: BC
  Postal Code: V0N 1V0

 Registered: SEP 24, 2003  Updated: NOV 12, 2013  Detail Removed: NOV 01, 2013

 Notations:   2  Participants:   3   Associated Sites:   0
 Documents:   0 Susp. Land Use:  0 Parcel Descriptions:  0

Location Description: LAT/LONG CONFIRMED USING GOOGLE EARTH 2013-11-01

Record Status: INACTIVE - NO FURTHER ACTION
 Fee category: UNRANKED

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NOTATIONS

  Notation Type: NOTICE OF INDEPENDENT REMEDIATION COMPLETION SUBMITTED (WMA
                 28(2))
 Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
      Initiated: SEP 16, 2003                          Approved: SEP 16, 2003

 Ministry Contact: DUNDAS, KERRI (SURREY) L

 Notation Participants                                 Notation Roles
 EBA ENGINEERING CONSULTANTS LTD (NANAIMO)             SUBMITTED BY
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Notation Type: NOTICE OF INDEPENDENT REMEDIATION INITIATION SUBMITTED (WMA
                 28(2))
 Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
      Initiated: MAR 13, 2003                          Approved:

 Ministry Contact: DUNDAS, KERRI (SURREY) L

 Notation Participants                                 Notation Roles
 EBA ENGINEERING CONSULTANTS LTD (NANAIMO)             SUBMITTED BY
 BC FERRIES (VICTORIA)                                 RECEIVED BY
 = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
SITE PARTICIPANTS

   Participant: BC FERRIES (VICTORIA)
       Role(s): PROPERTY OWNER
    Start Date: MAR 13, 2003                              End Date:
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
   Participant: DUNDAS, KERRI (SURREY) L
       Role(s): MAIN MINISTRY CONTACT
```

SITE PARTICIPANTS

Start Date: MAR 13, 2003 End Date:

- -

Participant: EBA ENGINEERING CONSULTANTS LTD (NANAIMO)
Role(s): ENVIRONMENTAL CONSULTANT/CONTRACTOR
Start Date: MAR 13, 2003 End Date:

No activities were reported for this site

End of Detail Report

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 As of: OCT 16, 2016        BC Online: Site Registry                    16-11-03
                    For: PK57542  ASSOCIATED ENVIRONMENTAL CONSULTAN 08:42:25
 Folio: 2016-8167                                                      Page   1
                                  Detail Report
SITE LOCATION
      Site ID:       9116                          Latitude:  49d 25m 47.6s
 Victoria File: 26250-20/9116                     Longitude: 123d 28m 48.9s
 Regional File: 26250-20/9116
        Region: SURREY, LOWER MAINLAND

 Site Address: 1281 MARINE DRVE
         City: GIBSONS                          Prov/State: BC
  Postal Code: V0N 1V0

 Registered: SEP 23, 2004  Updated: NOV 18, 2014  Detail Removed: NOV 13, 2014

 Notations:   9  Participants:  14   Associated Sites:   0
 Documents:   9 Susp. Land Use:   1 Parcel Descriptions:   5

Location Description: SITE CREATED BY SITE PROFILE, ENTERED 2004-09-07.
 LAT/LONG CONFIRMED USING GOAT BY MINISTRY STAFF

Record Status: ACTIVE - REMEDIATION COMPLETE
 Fee Category: UNRANKED

= = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
NOTATIONS

  Notation Type: CERTIFICATE OF COMPLIANCE ISSUED USING RISK BASED STANDARDS
 Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
      Initiated: NOV 07, 2014                    Approved: NOV 07, 2014

 Ministry Contact: LOCKHART, DAVE

 Notation Participants                           Notation Roles
 IMPERIAL OIL LTD                                RECEIVED BY
 KICKHAM, PETER                                  ISSUED BY
 GOLDER ASSOCIATES LTD.                          APPROVED PROFESSIONAL

 Note: ISSUED ON THE RECOMMENDATION OF AN APPROVED PROFESSIONAL (ROBERT
 MCLENEHAN) UNDER PROTOCOL 6 OF THE CONTAMINATED SITES REGULATION
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Notation Type: CERTIFICATE OF COMPLIANCE REQUESTED
 Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
      Initiated: OCT 01, 2014                    Approved: OCT 01, 2014

 Ministry Contact: LOCKHART, DAVE

 Notation Participants                           Notation Roles
 GOLDER ASSOCIATES LTD.                          APPROVED PROFESSIONAL
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Notation Type: NOTICE OF INDEPENDENT REMEDIATION COMPLETION SUBMITTED
 Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
      Initiated: NOV 09, 2010                    Approved: NOV 09, 2010

 Ministry Contact: SAMWAYS, JENNIFER
```

NOTATIONS

Notation Participants — Notation Roles
GOLDER ASSOCIATES — SUBMITTED BY

Note: COMPLETED: 2010-09-21

- -

Notation Type: SITE RISK CLASSIFIED - SITE IS NON-HIGH RISK
Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
Initiated: SEP 21, 2010 Approved: SEP 21, 2010

Ministry Contact: O'GRADY, TYLER

Notation Participants — Notation Roles
GOLDER ASSOCIATES — SUBMITTED BY

- -

Notation Type: NOTICE OF INDEPENDENT REMEDIATION INITIATION SUBMITTED
Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
Initiated: SEP 17, 2010 Approved: SEP 17, 2010

Ministry Contact: SAMWAYS, JENNIFER

Notation Participants — Notation Roles
GOLDER ASSOCIATES — SUBMITTED BY

Note: START: 2010-09-15

- -

Notation Type: SITE PROFILE - FURTHER INVESTIGATION REQUIRED BY THE MINISTRY
Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
Initiated: SEP 20, 2004 Approved:

Ministry Contact: HANEMAYER, VINCENT (SURREY) C

Note: SITE DECOMMISSIONING. MINISTRY PERMISSION GRANTED TO RELEASE THE DEMOLITION PERMIT BECAUSE IN THE OPINION OF THE DIRECTOR THE ISSUANCE OF THE DEMOLITION PERMIT WOULD NOT POSE SIGNIFICANT THREAT OR RISK

Required Actions: PRELIMINARY SITE INVESTIGATION REQUIRED.

- -

Notation Type: SITE PROFILE REVIEWED - FURTHER INVESTIGATION REQUIRED BY THE MINISTRY
Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
Initiated: SEP 20, 2004 Approved:

Ministry Contact: HANEMAYER, VINCENT (SURREY) C

Note: SITE DECOMMISSIONING. MINISTRY PERMISSION GRANTED TO RELEASE THE DEMOLITION PERMIT BECAUSE IN THE OPINION OF THE DIRECTOR THE ISSUANCE OF THE DEMOLITION PERMIT WOULD NOT POSE SIGNIFICANT THREAT OR RISK

Required Actions: PRELIMINARY SITE INVESTIGATION REQUIRED.

NOTATIONS

Notation Type: SITE PROFILE RECEIVED
Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
Initiated: SEP 07, 2004 Approved:

Ministry Contact: HANEMAYER, VINCENT (SURREY) C

Notation Participants	Notation Roles
IMPERIAL OIL LIMITED	SITE PROFILE SUBMITTED BY
IMPERIAL OIL LIMITED	SITE PROFILE SUBMITTED BY

Notation Type: SITE PROFILE RECEIVED
Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
Initiated: SEP 07, 2004 Approved:

Ministry Contact: HANEMAYER, VINCENT (SURREY) C

Notation Participants	Notation Roles
IMPERIAL OIL LIMITED	SITE PROFILE SUBMITTED BY
IMPERIAL OIL LIMITED	SITE PROFILE SUBMITTED BY

SITE PARTICIPANTS

Participant: GOLDER ASSOCIATES
Role(s): ENVIRONMENTAL CONSULTANT/CONTRACTOR
Start Date: SEP 17, 2010 End Date:

Participant: GOLDER ASSOCIATES LTD.
Role(s): ENVIRONMENTAL CONSULTANT/CONTRACTOR
Start Date: OCT 10, 2014 End Date:

Participant: GOLDER ASSOCIATES LTD.
Role(s): ENVIRONMENTAL CONSULTANT/CONTRACTOR
Start Date: JAN 11, 2007 End Date:

Participant: HANEMAYER, VINCENT (SURREY) C
Role(s): MAIN MINISTRY CONTACT
Start Date: SEP 07, 2004 End Date:

Participant: HAZCO ENVIRONMENTAL
Role(s): ENVIRONMENTAL CONSULTANT/CONTRACTOR
Start Date: SEP 07, 2004 End Date:

Participant: IMPERIAL OIL LIMITED

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      Role(s): SITE PROFILE COMPLETOR
               SITE PROFILE CONTACT
   Start Date: SEP 07, 2004                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
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SITE PARTICIPANTS

  Participant: IMPERIAL OIL LIMITED (NORTH YORK)
      Role(s): PROPERTY OWNER
   Start Date: SEP 07, 2004                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: IMPERIAL OIL LTD
      Role(s): PROPERTY OWNER
   Start Date: NOV 07, 2014                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: KICKHAM, PETER
      Role(s): MINISTRY CONTACT
   Start Date: NOV 07, 2014                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: LOCKHART, DAVE
      Role(s): MINISTRY CONTACT
   Start Date: OCT 01, 2014                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: MORROW ENVIRONMENTAL CONSULTANTS INC (BURNABY (COMMERCE
               COURT))
      Role(s): ENVIRONMENTAL CONSULTANT/CONTRACTOR
   Start Date: MAR 04, 2005                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: O'GRADY, TYLER
      Role(s): ALTERNATE MINISTRY CONTACT
   Start Date: SEP 21, 2010                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: SAMWAYS, JENNIFER
      Role(s): ALTERNATE MINISTRY CONTACT
   Start Date: SEP 17, 2010                    End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Participant: SUNSHINE COAST REGIONAL DISTRICT (BUILDING DEPARTMENT)
      Role(s): MUNICIPAL/REGIONAL CONTACT
   Start Date: SEP 07, 2004                    End Date:
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DOCUMENTS

 Title: ADDENDUM REPORT 1281 MARINE DRIVE, GIBSONS,
           Authored: JUL 22, 2014         Submitted: JUL 22, 2014
 Participants                                   Role
 GOLDER ASSOCIATES LTD.                         AUTHOR
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 Title: STAGE 1 PRELIMINARY SITE INVESTIGATION UPDATE, FORMER HOPKINS LANDING
        BULK PLANT, 1281 MARINE DRIVE, GIBSONS, BC.
           Authored: MAR 18, 2014         Submitted: MAR 18, 2014
 Participants                                   Role
```

GOLDER ASSOCIATES LTD. AUTHOR

- -

Title: PERFORMANCE VERIFICATION PLAN FOR CERTIFICATE OF COMPLIANCE FOR SITE ID 9116
Authored: MAR 18, 2014 Submitted: MAR 18, 2014
Participants Role
GOLDER ASSOCIATES LTD. AUTHOR

DOCUMENTS

- -

Title: DETAILED SITE INVESTIGATION AND CONFIRMATION OF REMEDIATION REPORT, FORMER HOPKINS LANDING BULK PLANT, 1281 MARINE DRIVE, GIBSONS, BC.
Authored: MAR 18, 2014 Submitted: MAR 18, 2014
Participants Role
GOLDER ASSOCIATES LTD. AUTHOR

- -

Title: RELIANCE 1281 MARINE DRIVE, GIBSONS, BC. CORRESPONDENCE
Authored: MAR 17, 2014 Submitted: MAR 17, 2014
Participants Role
GOLDER ASSOCIATES LTD. AUTHOR

- -

Title: SUMMARY OF SITE CONDITION.
Authored: MAR 17, 2014 Submitted: MAR 17, 2014
Participants Role
GOLDER ASSOCIATES LTD. AUTHOR

- -

Title: SITE MONITORING AND SAMPLING REPORT, FORMER HOPKINS LANDING BULK PLANT, 1281 PORT MELLON HIGHWAY, HOPKINS LANDING, BC
Authored: NOV 15, 2005 Submitted: NOV 15, 2005
Participants Role
MORROW ENVIRONMENTAL CONSULTANTS INC (BURNABY (COMMERCE COURT)) AUTHOR

- -

Title: SITE INVESTIGATION, FORMER IMPERIAL OIL BULK PLANT, 1281 PORT MELLON HIGHWAY, HOPKINS LANDING, GIBSONS, BC
Authored: MAR 04, 2005 Submitted: MAR 04, 2005
Participants Role
MORROW ENVIRONMENTAL CONSULTANTS INC (BURNABY (COMMERCE COURT)) AUTHOR

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SUSPECTED LAND USE

Description: PETRO. PROD., WHOLESALE BULK STORAGE OR DISTRIBUTION
Notes: INSERTED FOR SITE PROFILE DATED 2004-08-26(described on Site Profile dated 04-08-26)

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PARCEL DESCRIPTIONS

Date Added: AUG 26, 2004 Crown Land PIN#:
LTO PID#: 010620613 Crown Land File#:

Land Desc: LOT 13 BLOCK 12 DISTRICT LOT 1402 PLAN 7429

Date Added: AUG 26, 2004 Crown Land PIN#:
LTO PID#: 010620737 Crown Land File#:
Land Desc: LOT 14 BLOCK 12 DISTRICT LOT 1402 PLAN 7429

Date Added: AUG 26, 2004 Crown Land PIN#:
LTO PID#: 010620770 Crown Land File#:
Land Desc: LOT 15 BLOCK 12 DISTRICT LOT 1402 PLAN 7429

PARCEL DESCRIPTIONS

Date Added: AUG 26, 2004 Crown Land PIN#:
LTO PID#: 010620800 Crown Land File#:
Land Desc: LOT 16 BLOCK 12 DISTRICT LOT 1402 PLAN 7429

Date Added: AUG 26, 2004 Crown Land PIN#:
LTO PID#: 010620851 Crown Land File#:
Land Desc: LOT 17 BLOCK 12 DISTRICT LOT 1402 PLAN 7429

CURRENT SITE PROFILE INFORMATION (Sec. III to X)
Site Profile Completion Date: AUG 26, 2004

Local Authority Received:

Ministry Regional Manager Received: SEP 07, 2004 Decision: SEP 20, 2004
Decision: INVESTIGATION REQUIRED

Site Registrar Received: Entry Date:

III COMMERCIAL AND INDUSTRIAL PURPOSES OR ACTIVITIES ON SITE
Schedule 2

Reference	Description
F8	PETRO. PROD., WHOLESALE BULK STORAGE OR DISTRIBUTION

AREAS OF POTENTIAL CONCERN

Petroleum, solvent or other polluting substance spills to the environment greater than 100 litres?.....NO
Residue left after removal of piled materials such as chemicals, coal, ore, smelter slag, air quality control system baghouse dust?.....NO
Discarded barrels, drums or tanks?.....NO
Contamination resulting from migration of substances from other properties?.....NO

FILL MATERIALS

Fill dirt, soil, gravel, sand or like materials from a contaminated site or from a source used for any of the activiities listed under Schedule 2?.....NO
Discarded or waste granular materials such as sand blasting grit, asphalt paving or roofing material, spent foundry casting sands, mine ore, waste rock or float?.....NO
Dredged sediments, or sediments and debris materials originating from locations adjacent to foreshore industrial activities, or municipal sanitary or stormwater discharges?.....NO

WASTE DISPOSAL

Materials such as household garbage, mixed municipal refuse, or demolition debris?.....NO
Waste or byproducts such as tank bottoms, residues, sludge, or flocculation precipitates from industrial processes or wastewater treatment?.....NO
Waste products from smelting or mining activities, such as smelter slag, mine tailings, or cull materials from coal processing?.....NO
Waste products from natural gas and oil well drilling activities, such as drilling fluids and muds?.....NO
Waste products from photographic developing or finishing laboratories; asphalt tar manufacturing; boilers, incinerators or other thermal facilities (eg. ash); appliance, small equipment or engine repair or salvage; dry cleaning operations (eg. solvents); or automobile and truck parts cleaning or repair?.....NO

TANKS OR CONTAINERS USED OR STORED

Underground fuel or chemical storage tanks?.....NO
Above ground fuel or chemical storage tanks?.....YES

SPECIAL (HAZARDOUS) WASTES OR SUBSTANCES

PCB-containing electrical transformers or capacitors either at grade, attached above ground to poles, located within buildings, or stored?....NO
Waste asbestos or asbestos containing materials such as pipe wrapping, blown-in insulation or panelling buried?.....NO

Paints, solvents, mineral spirits or waste pest control products or pest control product containers stored in volumes greater than 205 litres?...NO

LEGAL OR REGULATORY ACTIONS OR CONSTRAINTS

Government orders or other notifications pertaining to environmental conditions or quality of soil, water, groundwater or other environmental media?.....NO

Liens to recover costs, restrictive covenants on land use, or other charges or encumbrances, stemming from contaminants or wastes remaining onsite or from other environmental conditions?.....NO

Government notifications relating to past or recurring environmental violations at the site or any facility located on the site?.....NO

X ADDITIONAL COMMENTS AND EXPLANATIONS

SITE DECOMMISSIONING

End of Detail Report

```
As of: OCT 16, 2016        BC Online: Site Registry                    16-11-03
                   For: PK57542  ASSOCIATED ENVIRONMENTAL CONSULTAN 08:42:40
Folio: 2016-8167                                                    Page   1
                                 Detail Report
SITE LOCATION
     Site ID:         9449                          Latitude:  49d 23m 46.4s
 Victoria File: 26250-20/9449                       Longitude: 123d 30m 42.4s
 Regional File:
        Region: SURREY, LOWER MAINLAND

 Site Address: 1170 STEWART ROAD
         City: GIBSONS                          Prov/State: BC
  Postal Code: V0N 1V0

 Registered: JUL 08, 2005  Updated:                 Detail Removed:

 Notations:   4  Participants:  3  Associated Sites:  0
 Documents:   0 Susp. Land Use:  1 Parcel Descriptions:  1

Location Description: SITE CREATED BY SITE PROFILE, ENTERED 2005-07-08

Record Status: INACTIVE - NO FURTHER ACTION
 Fee Category: NOT APPLICABLE

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NOTATIONS

  Notation Type: SITE PROFILE REVIEWED - NO FURTHER INVESTIGATION REQUIRED BY
                 THE MINISTRY
 Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
      Initiated: JUL 08, 2005                       Approved:

 Ministry Contact: WARD, JOHN E H
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Notation Type: SITE PROFILE - NO FURTHER INVESTIGATION REQUIRED BY THE
                 MINISTRY
 Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
      Initiated: JUL 08, 2005                       Approved:

 Ministry Contact: WARD, JOHN E H
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Notation Type: SITE PROFILE RECEIVED
 Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
      Initiated: JUN 14, 2004                       Approved:

 Ministry Contact: WARD, JOHN E H

 Notation Participants                              Notation Roles
 GATEWAY SELF STORAGE                               SITE PROFILE SUBMITTED
                                                    BY
 GATEWAY SELF STORAGE                               SITE PROFILE SUBMITTED
                                                    BY
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Notation Type: SITE PROFILE RECEIVED
 Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
      Initiated: JUN 14, 2004                       Approved:
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 As of: OCT 16, 2016       BC Online: Site Registry                       16-11-03
                      For: PK57542  ASSOCIATED ENVIRONMENTAL CONSULTAN 08:42:40
 Folio: 2016-8167                                                       Page   2
NOTATIONS

 Ministry Contact: WARD, JOHN E H

 Notation Participants                          Notation Roles
 GATEWAY SELF STORAGE                           SITE PROFILE SUBMITTED
                                                BY
 GATEWAY SELF STORAGE                           SITE PROFILE SUBMITTED
                                                BY
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SITE PARTICIPANTS

   Participant: GATEWAY SELF STORAGE
       Role(s): PROPERTY OWNER
                SITE PROFILE COMPLETOR
    Start Date: JUN 14, 2004                          End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
   Participant: MCINTOSH, WILLIAM
       Role(s): SITE PROFILE CONTACT
    Start Date: JUN 14, 2004                          End Date:
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
   Participant: WARD, JOHN E H
       Role(s): MAIN MINISTRY CONTACT
    Start Date: JUN 14, 2004                          End Date:
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SUSPECTED LAND USE

 Description: DRY DOCKS, SHIP BUILDING OR BOAT REPAIR INCL. PAINT REMOVAL
       Notes: INSERTED FOR SITE PROFILE DATED 2004-06-14(described on Site
              Profile dated 04-06-14)
= = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =
PARCEL DESCRIPTIONS

  Date Added: JUN 14, 2004                 Crown Land PIN#:
    LTO PID#: 012448834                   Crown Land File#:
   Land Desc: LOT 5 BLOCK 6 DISTRICT LOT 692 PLAN 3633
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CURRENT SITE PROFILE INFORMATION (Sec. III to X)
                               Site Profile Completion Date: JUN 14, 2004

Local Authority         Received:

Ministry Regional Manager Received:                       Decision: JUL 08, 2005
   Decision: INVESTIGATION NOT REQUIRED

Site Registrar       Received: JUN 14, 2004            Entry Date: JUL 08, 2005

III  COMMERCIAL AND INDUSTRIAL PURPOSES OR ACTIVITIES ON SITE
       Schedule 2
    Reference          Description
        G4       DRY DOCKS, SHIP BUILDING OR BOAT REPAIR INCL. PAINT REMOVAL
```

AREAS OF POTENTIAL CONCERN

Petroleum, solvent or other polluting substance spills to the environment greater than 100 litres?.....NO
Residue left after removal of piled materials such as chemicals, coal, ore, smelter slag, air quality control system baghouse dust?.....NO
Discarded barrels, drums or tanks?.....NO
Contamination resulting from migration of substances from other properties?.....NO

FILL MATERIALS

Fill dirt, soil, gravel, sand or like materials from a contaminated site or from a source used for any of the activiities listed under Schedule 2?.....NO
Discarded or waste granular materials such as sand blasting grit, asphalt paving or roofing material, spent foundry casting sands, mine ore, waste rock or float?.....NO
Dredged sediments, or sediments and debris materials originating from locations adjacent to foreshore industrial activities, or municipal sanitary or stormwater discharges?.....NO

WASTE DISPOSAL

Materials such as household garbage, mixed municipal refuse, or demolition debris?.....NO
Waste or byproducts such as tank bottoms, residues, sludge, or flocculation precipitates from industrial processes or wastewater treatment?.....NO
Waste products from smelting or mining activities, such as smelter slag, mine tailings, or cull materials from coal processing?.....NO
Waste products from natural gas and oil well drilling activities, such as drilling fluids and muds?.....NO
Waste products from photographic developing or finishing laboratories; asphalt tar manufacturing; boilers, incinerators or other thermal facilities (eg. ash); appliance, small equipment or engine repair or salvage; dry cleaning operations (eg. solvents); or automobile and truck parts cleaning or repair?.....NO

TANKS OR CONTAINERS USED OR STORED

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Underground fuel or chemical storage tanks?.....NO
Above ground fuel or chemical storage tanks?.....NO

SPECIAL (HAZARDOUS) WASTES OR SUBSTANCES

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PCB-containing electrical transformers or capacitors either at grade, attached above ground to poles, located within buildings, or stored?....NO
Waste asbestos or asbestos containing materials such as pipe wrapping, blown-in insulation or panelling buried?.....NO
Paints, solvents, mineral spirits or waste pest control products or pest control product containers stored in volumes greater than 205 litres?...NO

LEGAL OR REGULATORY ACTIONS OR CONSTRAINTS

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Government orders or other notifications pertaining to environmental conditions or quality of soil, water, groundwater or other environmental media?.....NO
Liens to recover costs, restrictive covenants on land use, or other charges or encumbrances, stemming from contaminants or wastes remaining onsite or from other environmental conditions?.....NO
Government notifications relating to past or recurring environmental violations at the site or any facility located on the site?.....NO

X ADDITIONAL COMMENTS AND EXPLANATIONS

End of Detail Report

Detail Report

SITE LOCATION
Site ID: 18124 Latitude: 49d 25m 35.0s
Victoria File: 26250-20/18124 Longitude: 123d 30m 10.8s
Regional File:
Region: SURREY, LOWER MAINLAND

Site Address: 1196 STEWART ROAD
City: GIBSONS Prov/State: BC
Postal Code: V0N 1V6

Registered: JUL 10, 2015 Updated: Detail Removed:

Notations: 4 Participants: 3 Associated Sites: 0
Documents: 0 Susp. Land Use: 2 Parcel Descriptions: 1

Location Description: LAT/LONG VERIFIED USING GOOGLE EARTH ON JULY 8, 2015.

Record Status: ACTIVE - UNDER ASSESSMENT
Fee Category: NOT APPLICABLE

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NOTATIONS

Notation Type: SITE PROFILE REVIEWED - FURTHER INVESTIGATION REQUIRED BY THE MINISTRY
Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
Initiated: JUL 08, 2015 Approved:

Ministry Contact: LARSEN, KELLI

Note: RELEASED DEVELOPMENT PERMIT FOR INSTALLATION OF TELUS COMMUNICATIONS TOWER UNDER SCENARIO 2. FUTURE PERMITS WOULD BE REQUIRED TO REDEVELOP THE SITE.

Required Actions: PRELIMINARY SITE INVESTIGATION
- -
Notation Type: SITE PROFILE - FURTHER INVESTIGATION REQUIRED BY THE MINISTRY
Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
Initiated: JUL 08, 2015 Approved:

Ministry Contact: LARSEN, KELLI

Note: RELEASED DEVELOPMENT PERMIT FOR INSTALLATION OF TELUS COMMUNICATIONS TOWER UNDER SCENARIO 2. FUTURE PERMITS WOULD BE REQUIRED TO REDEVELOP THE SITE.

Required Actions: PRELIMINARY SITE INVESTIGATION
- -
Notation Type: SITE PROFILE RECEIVED
Notation Class: ENVIRONMENTAL MANAGEMENT ACT: GENERAL
Initiated: JUN 24, 2015 Approved:

NOTATIONS

Ministry Contact: LARSEN, KELLI

Notation Participants	Notation Roles
VAN HUIZEN CONSULTANTS LTD	SITE PROFILE SUBMITTED BY
VAN HUIZEN CONSULTANTS LTD	SITE PROFILE SUBMITTED BY

Notation Type: SITE PROFILE RECEIVED
Notation Class: WASTE MANAGEMENT ACT: CONTAMINATED SITES NOTATIONS
Initiated: JUN 24, 2015 Approved:

Ministry Contact: LARSEN, KELLI

Notation Participants	Notation Roles
VAN HUIZEN CONSULTANTS LTD	SITE PROFILE SUBMITTED BY
VAN HUIZEN CONSULTANTS LTD	SITE PROFILE SUBMITTED BY

SITE PARTICIPANTS

Participant: ENEVOLDSON, JOHN
Role(s): PROPERTY OWNER
SITE PROFILE CONTACT
Start Date: JUN 24, 2015 End Date:

Participant: LARSEN, KELLI
Role(s): MAIN MINISTRY CONTACT
Start Date: JUN 24, 2015 End Date:

Participant: VAN HUIZEN CONSULTANTS LTD
Role(s): SITE PROFILE COMPLETOR
Start Date: JUN 24, 2015 End Date:

SUSPECTED LAND USE

Description: INDUSTRIAL WOODWASTE (LOG YARD WASTE, HOGFUEL) DISPOSAL
Notes: INSERTED FOR SITE PROFILE DATED 2015-06-05(described on Site Profile dated 15-06-05)

Description: WELDING OR MACHINE SHOPS (REPAIR OR FABRICATION)
Notes: INSERTED FOR SITE PROFILE DATED 2015-06-05(described on Site Profile dated 15-06-05)

PARCEL DESCRIPTIONS

Date Added: JUN 05, 2015 Crown Land PIN#:
LTO PID#: 005742714 Crown Land File#:
Land Desc:

As of: OCT 16, 2016 BC Online: Site Registry 16-11-03
For: PK57542 ASSOCIATED ENVIRONMENTAL CONSULTAN 08:42:51
Folio: 2016-8167 Page 3

CURRENT SITE PROFILE INFORMATION (Sec. III to X)
Site Profile Completion Date: JUN 05, 2015

Local Authority Received: JUN 09, 2015

Ministry Regional Manager Received: JUN 24, 2015 Decision: JUL 08, 2015
Decision: INVESTIGATION REQUIRED

Site Registrar Received: Entry Date:

III COMMERCIAL AND INDUSTRIAL PURPOSES OR ACTIVITIES ON SITE

Schedule 2 Reference	Description
C6	WELDING OR MACHINE SHOPS (REPAIR OR FABRICATION)
H13	INDUSTRIAL WOODWASTE (LOG YARD WASTE, HOGFUEL) DISPOSAL

AREAS OF POTENTIAL CONCERN

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Petroleum, solvent or other polluting substance spills to the environment greater than 100 litres?...NO
Residue left after removal of piled materials such as chemicals, coal, ore, smelter slag, air quality control system baghouse dust?............NO
Discarded barrels, drums or tanks?..NO
Contamination resulting from migration of substances from other properties?...NO

FILL MATERIALS

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Fill dirt, soil, gravel, sand or like materials from a contaminated site or from a source used for any of the activiities listed under Schedule 2?...YES
Discarded or waste granular materials such as sand blasting grit, asphalt paving or roofing material, spent foundry casting sands, mine ore, waste rock or float?..NO
Dredged sediments, or sediments and debris materials originating from locations adjacent to foreshore industrial activities, or municipal sanitary or stormwater discharges?......................................NO

WASTE DISPOSAL (QUESTIONS AS OF JANUARY 1 2009)

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Materials such as household garbage, mixed municipal refuse, or demolition debris?.....NO
Waste or byproducts such as tank bottoms, residues, sludge, or flocculation precipitates from industrial processes or wastewater

treatment?.....NO
Waste products from smelting or mining activities, such as smelter slag, mine tailings, or cull materials from coal processing?.....NO
Waste products from natural gas and oil well drilling activities, such as drilling fluids and muds?.....NO
Waste products from photographic developing or finishing laboratories; asphalt tar manufacturing; boilers, incinerators or other thermal facilities (eg. ash); appliance, small equipment or engine repair or salvage; dry cleaning operations (eg. solvents); for from the cleaning or repair of parts of boats, ships, barges, automobiles or trucks, including sandblasting grit or paint scrapings?.....NO

TANKS OR CONTAINERS USED OR STORED, OTHER THAN TANKS USED FOR RESIDENTIAL HEATING FUEL

Underground fuel or chemical storage tanks other than storage tanks for compressed gases?.....NO
Above ground fuel or chemical storage tanks other than storage tanks for compressed gases?.....YES

HAZARDOUS WASTES OR HAZARDOUS SUBSTANCES

PCB-containing electrical transformers or capacitors either at grade, attached above ground to poles, located within buildings, or stored?....NO
Waste asbestos or asbestos containing materials such as pipe wrapping, blown-in insulation or panelling buried?.....NO
Paints, solvents, mineral spirits or waste pest control products or pest control product containers stored in volumes greater than 205 litres?...NO

LEGAL OR REGULATORY ACTIONS OR CONSTRAINTS

Government orders or other notifications pertaining to environmental conditions or quality of soil, water, groundwater or other environmental media?.....NO
Liens to recover costs, restrictive covenants on land use, or other charges or encumbrances, stemming from contaminants or wastes remaining onsite or from other environmental conditions?.....NO

Government notifications relating to past or recurring environmental violations at the site or any facility located on the site?.....NO

X ADDITIONAL COMMENTS AND EXPLANATIONS

End of Detail Report