ONE WATER STRATEGY - WATER USE PLANNING FOR AQUIFER 560 SUNSHINE COAST, BRITISH COLUMBIA

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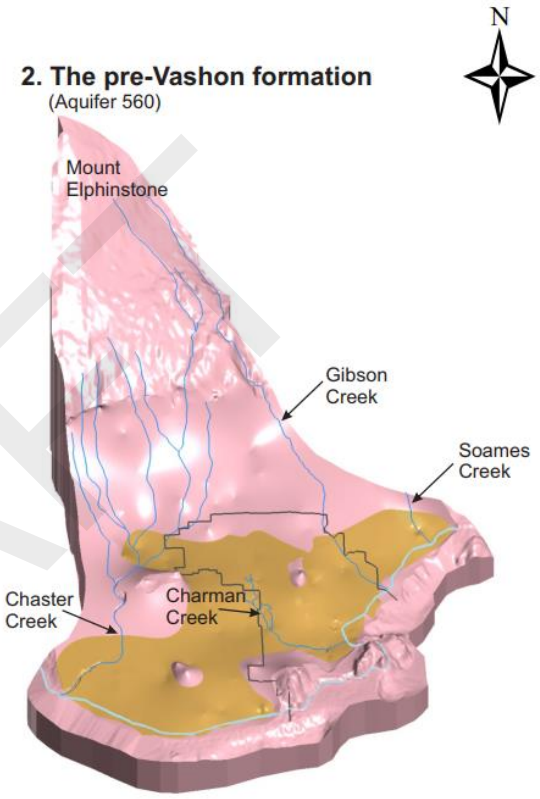

The Town of Gibsons and the Sunshine Coast Regional District

Submitted By:

Urban Systems Ltd. and
Waterline Resources Inc.
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TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS (cont'd)

PAGE

LIST OF TABLES (IN-TEXT)

LIST OF FIGURES (FIGURES SECTION)

1.0 INTRODUCTION

1.1 Background

The Town of Gibsons (the Town) and the Sunshine Coast Regional District (SCRD) obtain potable water from a high-quality artesian aquifer referred to as Aquifer 560 by the Ministry of Environment (ENV, 2024; Figure 1). The aquifer has been mapped as a single aquifer across several watersheds including Soames, Gibson, Charman and Chaster Creek (Figure 2). The headwaters for all four watersheds originate along the south facing slope of Mount Elphinstone at an elevation of greater than 1,100 metres above sea level (masl) and all drain into the Strait of Georgia.

As Aquifer 560 is a valued component of the watershed, the Town has designated the aquifer as a natural asset, which requires careful management and maintenance as with any other valued infrastructure. This approach provides an administrative responsibility to protect the aquifer from potential impacts that could influence the long-term sustainable yield and water supply for both the Town and the SCRD.

The Town and the SCRD access water from Aquifer 560 through a series of water supply wells (WSWs); the WSWs feed into both the Town's water distribution system and SCRD's Chapman Creek Water System; both systems are connected (Figure 3). Water normally flows from the SCRD system to the Town system during extreme events when the Town's WSWs are unable to meet the demand (i.e. fire flows, flushing). The Town also has the ability in emergency situations to supply water back to the SCRD; however, this requires special permission from the BC Ministry of Water, Lands and Resource Stewardship (WLRS), since this means servicing beyond the areas approved by their *Water Sustainability Act* (WSA; BC Government, 2024a) water use licences.

The Town and the SCRD hold WSA conditional use licences for groundwater extraction from Aquifer 560. The total licensed groundwater diversion volume from Aquifer 560 at this time is 2,264,352 cubic metres per year (m^3/year), composed entirely from the Town and the SCRD water licence approved volumes. It should be noted that this water extraction amount does not include volumes from active applications for existing use groundwater licences, nor does it include private domestic groundwater use, which is exempt from WSA licensing.

Building on a history of collaboration between the Town and the SCRD, Urban Systems Ltd. (USL) and Waterline Resources Inc. (Waterline) have established the framework around best management practices for Aquifer 560 and water system infrastructure, referred herein as the "One Water Strategy". Creating this shared direction for water use planning will help align the Town and the SCRD with their water sharing agreement and will help with more effective engagement with the Squamish Nation and WLRS, who govern the groundwater resource.

1.2 Objective and Scope of Work

USL and Waterline have developed the One Water Strategy for consideration by the Town and the SCRD. The One Water Strategy's objective is to help manage Aquifer 560 and the associated water system infrastructure for ongoing and improved water use planning and sharing. To meet this objective, the scope of work included the following tasks:

- Reviewed the water system infrastructure plans and compiled relevant publicly available and third-party hydrogeological data and reports for Aquifer 560;
- Reviewed the applicable regulatory standards and requirements for groundwater source licensing, development and protection in BC;
- Developed groundwater management strategies and identified available natural asset management tools based on a review of the Town and the SCRD water shortage response planning, development permitting, groundwater assessment, monitoring/protection and water licensing ;
- Provided a list of data gaps, their potential impacts and action items to be considered for better groundwater management; and
- Generated a report describing the data compilation and methodology used for developing the One Water Strategy.

2.0 REGULATORY CONSIDERATIONS

2.1 Groundwater Licensing

The WSA and associated regulations came into effect on February 29, 2016, and are intended to protect groundwater resources in BC. The WSA requires licensing of non-domestic groundwater use (e.g., irrigation, water supply, commercial or industrial use) in BC.

Use of a groundwater source for supplying communities must be licensed under the WSA, including use of any volume of groundwater that exceeds previously authorized water use (i.e. existing use groundwater licence). As such, a new use licence application must be submitted and approved by WLRS before the groundwater can be extracted and/or beneficially used. The application for an existing use groundwater licence allows the applicant to continue beneficially using groundwater for the same purpose(s) and volume(s) used prior to the enactment of the WSA in 2016, until WLRS adjudicates the application. Upon receiving an approved licence, licensees must comply with provisions of the WSA and its regulations, the terms and conditions of the licence, and orders under the WSA.

WSA licensing is not generally required for groundwater used for domestic purposes (i.e., the use of water for household purposes by the occupants of one or more private dwellings located on a single parcel of land). As per Section 22(8) of the WSA, each private dwelling on a parcel is authorized to use up to 2.0 cubic metres per day (m^3/day) or the amount of groundwater the engineer is satisfied the occupants have been using for domestic purposes (BC Government, 2024a).

2.2 Groundwater Development

Groundwater development must ensure the water source is protected. Regulatory standards listed in the WSA *Groundwater Protection Regulation* (GWPR; BC Government, 2022) set out several offset distances and conformance requirements for development of new groundwater wells. Guidelines for testing and assessing groundwater, so that existing groundwater users and the receiving environment are protected, are summarized in the *Guidelines for Technical Assessment Requirements in Support of an Application for Groundwater Use in British Columbia* (Todd et al.,

2020). Licensing individual water source wells or well fields with capacities greater than 75 litres per second (L/s) or 6,480 m^3/day requires referral to the Environmental Assessment Office (EAO, 2019), resulting in greater scrutiny of the licence application and potential additional assessment requirements.

Assessment of aquifer vulnerability is also important for groundwater development. The BC aquifer classification system (WLAP, 2002) categorizes aquifers according to the:

1. Level of aquifer development. Aquifer development is assessed based on the balance of water supply vs. water demand. If such assessment has not been completed, aquifer development can also be rated based on the number of registered groundwater wells.
2. Level of aquifer vulnerability to surface contamination. Vulnerability is based on the hydrogeological properties of the aquifer and not the type of surface contamination present.

2.3 Groundwater Quality

2.3.1 Groundwater System Approval

Supplying water to two or more residences is considered a water supply system as defined by the *Drinking Water Protection Act* (DWPA; BC Government, 2024b). The DWPA requires that a Construction Permit and a Permit to Operate be issued by the local health authority (i.e., Vancouver Coastal Health), in accordance with the DWPA *Drinking Water Protection Regulation* (DWPR; Government of BC, 2018), prior to operating any new water source that will be connected to an existing water system.

2.3.2 Groundwater Source Protection

The Ministry of Health, Leisure, and Sport (MHLS) Comprehensive Drinking Water Source-to-Tap Assessment (CS2TA) satisfies the requirements of a water source or system assessment that can be ordered by a drinking water officer when risks to a water system are identified (MHLS, 2010). The CS2TA serves as a tool to develop a more comprehensive understanding of the measures that can be taken to ensure safety and security of a water supply.

For coastal BC, the potential for saltwater intrusion into an aquifer must also be considered and assessed. Under Section 58 or the WSA (BC Government, 2024a), it is prohibited to operate a well in a manner that causes intrusion of saline water into an aquifer. According to the *Best Practice for Prevention of Saltwater Intrusion* published by the former BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD, 2016), wells completed in aquifers adjacent to the coast containing groundwater with chloride concentration greater then 150 milligram per litre (mg/L), electrical conductivity greater then 1,000 microsiemens per centimeter (µS/cm), or a total dissolved solids (TDS) concentration greater than 700 mg/L, are deemed to be affected by saltwater intrusion. These thresholds have been established as operational objectives, and a groundwater well should only be pumped if it can produce a water quality that does not exceed these threshold values (FLNRORD, 2016).

Mitigative measures to protect groundwater resources from impacts related to saltwater intrusion include completing a new groundwater well in a location that is greater than 50 metres (m) from the coastline and limiting drawdown below sea level during operation of the water source well (FLNRORD, 2016).

3.0 PHYSICAL FRAMEWORK

3.1 Site Setting

3.1.1 Surface Water Resources

There are four watershed catchment areas that intersect Aquifer 560 (Figure 2). These include:

- Soames Creek (176 hectares), located within the SCRD, intersecting the northern portion of Aquifer 560,
- Gibson Creek (278.4 hectares), parallel the northeast Town boundary, also intersecting the northern portion of Aquifer 560;
- Charman Creek (125 hectares), located within the Town boundary, intersecting the central portion of Aquifer 560; and
- Chaster Creek (986 hectares), located within the SCRD, comprised of several tributaries, encompassing the entire southern portion of Aquifer 560.

Streamflow, including stage level and discharge rate, is being monitored on the main tributary of each creek (Figure 2). It has been determined that the surface water systems are highly influenced by precipitation and surface water runoff (quick flow component), with lesser influence from groundwater discharge (baseflow component). A flow accretion study for Chaster Creek, indicated there were some reaches of the creek that exhibit “gaining conditions” (Swiftwater, 2024a). Conversely for Gibson Creek, there is more evidence of “losing conditions”, suggesting that groundwater is being recharged by surface water from Gibson Creek (Swiftwater, 2024b). Both studies do not consider surface water withdrawal from registered points of diversion.

All four creeks have ecological significance, as they are all fish bearing (ENV, 2016). Using the Ministry of Environment, Lands and Parks (MELP) watercourse classification (1998), Gibson, Charman and several tributaries of Chaster Creek have been assigned a high to moderate ecological sensitivity rating based on the presence of aquatic life and seasonality of the creek flow (Whitehead, 2005). It should be noted that Soames Creek was not part of the sensitivity analysis.

3.1.2 Land Use

The land use zoning within the lower elevations of the Soames, Gibson, Charman and Chaster creek watershed areas, excluding the Squamish Nation lands (Chekwelp No. 26 and 26a) is dominated by urban development, including residential, commercial, and industrial land use (SCRD, 2024; Figure 4).

At higher elevations and outside of the Aquifer 560 footprint, the land use is typical of a rural setting, with designated forest, residential and agricultural land uses (Figure 4). Within some of the undeveloped land use area, there are Crown Provincial land tenures, designated for protection, recreation and resource development.

As the lands within the Town are predominantly serviced by both a sanitary sewer and storm water collection system, surface water runoff flows and discharges directly into the four creeks, as well as several coastal outfalls (ESSA, 2023; Figure 3). Within the SCRD the developed lands rely on in-ground treatment and disposal systems for sanitary sewage and a roadside ditch system for drainage.

3.1.3 Climate Data

Historical climate data, that is representative of climate conditions near Aquifer 560, is available from the Gibsons Gower Point Climate Station (Climate ID 1043152; Environment Canada, 2024), located 1.5 kilometres (km) west of the Town municipal boundary at an elevation of 34 masl (Figure 2). Average monthly temperature and total precipitation data is available from 1981 to 2010 (climate normals), and yearly total precipitation data is available from 2011 to 2023; this data is summarized in Table 1.

Table 1: Climate Normals and Recent Climate Data from Climate Station ID No. 1043152

Climate Normal Data (1981-2010)													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Avg Yr**
Avg Temp (°C)	4.6	5.2	7.1	9.5	12.7	15.3	17.6	17.9	15.1	10.5	6.5	4.2	10.5
Total Precip (mm)	178	118	118	96	82	67	41	41	58	140	215	170	1324
Precipitation Data (2011-2023)													
Parameter	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Total Precip (mm)	1142	1367	1029	1344	1151	1533	1325	1550	1089	1437	1370	1205	1176

Notes: Avg Temp means average temperature; **Precip** means precipitation; **°C** means degrees Celsius; **mm** means millimetres; **Avg Yr** means average yearly.

There are two distinct seasonal patterns, including a warmer drier period from May to October (late spring to early fall) and a cooler wetter period from November through March (late fall through winter). Recent climate data from 2011 to 2023 suggest the average annual precipitation (1,286 millimetres) has decreased, with the lowest annual recorded precipitation measured in 2013.

The Town has recently commissioned a network of climate monitoring stations at varying elevations within the Gibson, Charman and Chaster Creek watershed areas (Figure 2), to help further quantify stormwater runoff and creek discharge/stage levels. This will have the added benefit of helping better quality groundwater recharge from subsurface infiltration.

3.2 Geological Conditions

The local geology for the Town has been extensively mapped by Waterline (2013). Bedrock is outcropping near surface along the upper reaches of Mount Elphinstone, above 300-400 masl. A thin veneer (<1 m) of surficial sediments and/or colluvium is covering the bedrock surface. A thicker sequence of surficial sediments was deposited below this elevation by glaciation, as the ice sheets expanded/retreated and by interglacial and postglacial processes, which include modern-day fluvial deposition operating during the last 30,000 years.

The following stratigraphically recognized units (Figure 5) from oldest to youngest or deeper to shallower are:

1. The Bedrock (sedimentary and intrusive rocks),
2. The pre-Vashon formation (Aquifer 560),
3. The Vashon till formation (Aquitard 560), and
4. The Capilano formation (Unconfined Aquifer/Aquitard System).

3.3 Hydrogeology

Aquifer 560 has a footprint of 18.3 square kilometers (km^2; ENV, 2024; Figure 1). Although there appears to be a common recharge area to Aquifer 560 at higher elevations, the lower portions of the aquifer appear to be hydraulically disconnected from each other (Waterline, 2022). Bedrock ridges in the subsurface are separating the lower portions of the aquifer, creating “channels” and/or “lobes” of thicker permeable sediments. The three main “lobes” are as follows:

- The Elphinstone Aquifer Lobe/buried channel, which is situated entirely within the lower Chaster Creek Watershed;
- The Gibsons Aquifer Lobe/buried channel, which extends from the upper Chaster Creek Watershed, and incorporates Charman Creek and the west side of Gibson Creek; and
- The Soames Aquifer Lobe/buried channel, which is largely located beneath the Soames Creek Watershed and extends into the upper Gibson Creek Watershed.

Groundwater levels in the Gibsons Aquifer Lobe range from 38.4 masl (118.3 metres below ground level; mbgl) near the base on Mount Elphinstone to 12.3 masl (2.4 metres above ground level; flowing artesian) in the lower Gibsons area (Waterline, 2022). As expected, groundwater flow is gravity driven and generally follows the drainage of the overlying creeks from the highest elevation towards the Strait of Georgia. It should be noted that Aquifer 560 is only partially saturated. As the topography steepens near the shoreline, the aquifer becomes fully saturated and the overlying Vashon till cover (Aquitard 560) causes a rise in groundwater pressure, resulting in flowing artesian wells at lower elevations.

3.3.1 Groundwater Recharge

Based on the age of the groundwater, which ranges from 8-86 years (Doyle, 2013), recharge to Aquifer 560 occurs rapidly. Despite being considered confined by Aquitard 560, infiltration and aquifer recharge likely enters the aquifer(s) within the various drainages/creeks and “recharge

windows" where the aquitard cover is absent or has been eroded by creek flow. The extensive braided network of surface drainage channels in the upper Chaster Creek Watershed suggest that this area could be the main recharge area to the Gibsons and Elphinstone Aquifer Lobes within the larger mapped Aquifer 560. The upper Gibson Creek Watershed drainage likely also contributes some recharge to the Gibsons Aquifer Lobe but is more likely to be the main source of recharge to the Soames Aquifer Lobe.

3.3.2 Groundwater Chemistry

Historical groundwater quality results (2010 to 2024) from active Town water supply wells, used as an analogue for the water quality characteristics of Aquifer 560, indicate the aquifer is supplying high-quality water. Additional observations can be made, including:

  - Aquifer 560 is considered is a fresh water source with low mineralization, as the average TDS concentration is 72 mg/L. For comparison, the average TDS concentration reported for Gibson, Charman and Chaster Creeks is 49 mg/L.
  - Aquifer 560 is not influenced by saltwater, as the average dissolved chloride concentration is 5 mg/L and does not exceed 150 mg/L (FLNRORD, 2016).
- A Piper diagram (Figure 6) plotting the major anion and cation concentrations, expressed as percent milliequivalents per liter, indicates that groundwater from Aquifer 560 is a non-dominant bicarbonate type water, which has remained unchanged since monitoring began.
- Compared with the *Guidelines for Canadian Drinking Water Quality* (GCDWQ; Health Canada, 2024), groundwater from Aquifer 560:
  - Does not exceed the aesthetic objectives (AO) for color (5 True Color Unit) or turbidity (1.0 Nephelometric Turbidity Unit), which is the standard for unfiltered groundwater (Health Canada, 2024).
  - Does not exceed the AO or maximum acceptable concentration (MAC) standards for any total or dissolved metals.
  - *Escherichia coli* (E. coli) has always been below the detection limit, suggesting that Aquifer 560 groundwater is at low risk of containing pathogens.
  - Total Coliform bacteria was detected during two separate sampling events, at different wells and on different years, both exceeding the MAC of 0.0 Coliform Forming Units per 100 milliliters. However, these detections were isolated incidents, not considered representative of aquifer conditions but rather the well conditions at the time of sampling; subsequent sampling for Total Coliform were non-detect.
  - Hydrocarbons and pesticides have been tested as part of enhanced groundwater sampling and do not exceed any MAC standards.

4.0 WATER SUPPLY SYSTEMS

4.1 Water Supply Wells

The Town has four active WSWs and the SCRD has five active WSWs that source water from Aquifer 560. A summary of these WSWs, along with well construction details, are included in Table 2.

Table 2: Water Supply Wells Construction Details

Water Supply Well	Well Plate ID Number	UTM Coordinates (NAD 83)			Well Depth (mbtoc)	Elevation (masl)			Installation Date
		Grid Zone	Easting	Northing		Ground	Screen		
							Top	Bottom	
Town of Gibsons Water Supply Wells									
Town Well 1	50683	10	463057	5472034	23.3	13.6	-6.3	-9.4	1966-04-01
Town Well 3	50676	10	462943	5471715	22.8	18.7	-3.2	-6.2	1984-08-30
Town Well 4	50675	10	463143	5472141	15.4	13.4	1.2	-1.9	2000-09-30
Town Well 6	53547	10	462278	5472228	122.8	107.3	-4	-14.6	2019-08-06
SCRD Water Supply Wells									
Church Road Well 2	53545	10	464107	5473614	60.4	40.2	-9.2	-17.7	2019-07-24
Church Road Well 3	121457	10	464146	5473607	60.4	39.3	-8.9	-18	2020-07-10
Soames Well	53855	10	464293	5473657	35.7	32.1	-0.2	-4.8	1979-10-17
Chaster Well	53866	10	460335	5471278	107.14	92.75	-6.32	-15.55	1970-04-01
901 Sentinel Road Well	-	10	464356	5473801	43.90	52.33	11.18	9.05	1989-07-13

Notes: **NAD 83** means North American Datum 1983; **masl** means metres above sea level; **mbtoc** means metres below top of casing.

4.2 Water Supply Well Licences

A recent search of ENV's Groundwater Wells and Aquifers database (GWELLS) indicated that there are currently 100 wells correlated with Aquifer 560 GWELLS (ENV, 2024). Of these 100 wells:

- 61 are classified as 'Private Domestic' and do not require WSA licences;
- 32 wells are classified as 'Water Works', 'Business or Other Organization', 'Unknown Well Use', or 'Not Applicable', and are currently not licensed under the WSA; and
- Seven are licensed under the WSA, all for non-domestic water use type 'Water Works'.

The Town and the SCRD hold valid WSA conditional water licences for the diversion and use of groundwater from these seven licensed wells completed in Aquifer 560. An overview of the licences, their respective points of well diversion, and licensed annual water volumes are included in Table 3. The total annual licensed diversion volume for the Town and the SCRD is 2.3×10^6 cubic metres (m^3).

Table 3: Conditional Water Licences (Groundwater) Within Aquifer 560

Licence Holder	Licence Number	Point(s) of Well Diversion	Licensed Volume (m^3/year)
Town of Gibsons	503565	Town Well 1 Town Well 3 Town Well 4 Town Well 6	739,530
Town of Gibsons	504580	Town Well 6	274,822
SCRD	502568	Church Road Well 2 Church Road Well 3 Soames Well	1,250,000
		Total (m^3/year)	**2,264,352**

Notes: **m^3/year** means cubic metres per year; **SCRD** means Sunshine Coast Regional District.

It should be noted that the SCRD has two applications in queue with WLRS for groundwater diversion from Aquifer 560. The first application is an Existing Use Groundwater Licence Application (Water File No. 20017348) for 185,760 m^3/year from the Chaster Well. The second application is an Existing Use Groundwater Licence Application (Water File No. 20017428) for an undisclosed volume of groundwater from the 901 Sentinel Road Well. The applications are currently under review by WLRS. As per the authority of the WSA and the existing use groundwater licence applications (BC Government, 2024a), the SCRD is currently diverting and making beneficial use of groundwater from the Chaster Well and the 901 Sentinel Road Well without WSA licence(s).

4.3 Water Supply Infrastructure Components

The SCRD receives their water supply from the Chapman Creek Water System; the primary source is surface water from Chapman Creek located west of Gibsons and east of Sechelt (see Figure 1 inset map). The SCRD also sources groundwater from Aquifer 560 via the Church Road Wells 2 and 3, Soames Well, 901 Sentinel Road Well and Chaster Well (Table 2; Figure 3). The Church Road, Soames and Sentinel Road Wells feed the Church Road booster station, which is controlled by the Reed Road Reservoir (Figure 3). When the booster station is on, it overcomes the existing pressure in the Chapman Creek Water System. The Chaster Well is controlled by distribution system pressure with a high pressure shut-off. Both the Church Road booster station and Chaster Well are normally off in the winter.

The Town receives most of their water supply from Aquifer 560. This is done through four active WSWs (Town Wells 1,3,4 and 6; Table 2). The Town has three pressure zones (Figure 3). Pressure Zone 1 (the lowest elevation zone) is fed primarily by Town Wells 1, 3 and 4, with storage provided by the School Road Reservoir. Pressure Zone 2 is primarily fed by Town Well 6 and the School Road booster pump from Zone 1, with storage provided by the Parkland Reservoir. Pressure Zone 3 (the highest elevation zone) is fed by the Parkland Booster Station from Zone 2. Storage for Zone 3 is provided by the SCRD in the Henry Road Reservoir. There are pressure reducing valves that allow for back-feeding of water from Zone 3 to Zone 2 and Zone 1 under fire flow conditions.

There are two interconnection points between the SCRD and Town water systems (Figure 3). The first is on Reed Road, which connects to the Town's Zone 3 from the Henry Road Reservoir. A check valve opens when the Town's system pressure is below the Chapman system pressure, indicating that the Town's supply cannot match the demand. At this same location there is a manual bypass valve that allows the Town to feed the SCRD if approval is obtained from WLRS due to drought conditions.

The second interconnection point is at the Payne Road pressure reducing valve, which connects to the Town's Zone 2. This valve is normally closed and only opens due to low downstream pressure, which corresponds to low water levels in the Parkland Reservoir (Figure 3). There is currently no monitoring for this interconnection point.

5.0 ONE WATER STRATEGY

5.1 Natural Asset Management Components

Asset Management BC has created a guide titled *Integrating Natural Assets into Asset Management* (2019). In this guide they have defined natural assets as assets that:

"support the delivery of core local government services, while doing so much more. The functions that nature provides to communities beyond core services, such as recreation, climate regulation, clean air, habitat, and biodiversity are invaluable to the overall health and well-being of a community. Including natural assets in asset management processes provides an integrated approach to maintaining or enhancing the natural assets in a community."

In 2008, Living Water Smart: British Columbia's Water Plan (ENV, 2008) provided the context for consideration of natural assets. Furthermore, the plan highlighted the importance of considering the full economic, environmental, and social benefits of green infrastructure on community development. Living Water Smart is being implemented through BC's WSA (BC Government, 2024a).

The focus of the One Water Strategy is around Aquifer 560 as the critical natural asset. However, the health of Aquifer 560 is also dependent on other natural assets, which include forests, wetlands, surface water bodies (lakes, streams, creeks, ditches), and the underlying geological formations above the aquifer.

5.2 Natural Asset Management Risk Assessment Approach

The Town has developed a Natural Asset Management (NAM) Strategy and has been employing the NAM System from the Institute of Public Works Engineering Australasia to consider and integrate natural assets into their asset management planning. As such, we have used this framework to consider risks to Aquifer 560 and other natural assets. This system builds on a traditional risk assessment, which includes risk identification and risk analysis and evaluation.

The technique used for analyzing and evaluating risk was to assign each risk a relative magnitude in comparison to other risks, based on how likely the risk is and the consequences of the risk. The

risks were then ranked from highest to lowest risk to prioritize management actions. Table 4 and Table 5 summarize how each risk has been assessed using the likelihood of occurrence and magnitude of consequence methods, respectively.

Table 4: Likelihood of Occurrence

Level	Description
Almost Certain	Is expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Will probably occur at some time
Unlikely	Could occur at some time
Rare	May only occur in exceptional circumstances

Table 5: Magnitude of Consequence

Level	Description
Insignificant	Insignificant impact, no illness, little disruption to normal operation, little or no increase in normal operating costs
Minor	Minor impact for small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs
Moderate	Minor impact for large population, mild to moderate illness probable, significant modification to normal operation but manageable, operating costs increase, increased monitoring
Major	Major impact for small population, severe illness probable, systems significantly compromised and abnormal operation if at all, high level monitoring required
Catastrophic	Major impact for large population, severe illness probable, complete failure of systems

Once a ranking for both the likelihood and consequence was assigned, the two were multiplied together to determine the risk rating based on the following equation:

$$Likelihood\ x\ Consequence = Risk\ Rating$$

Table 6 shows the range of risk ratings, which identify low, medium, high, and very high risk.

Table 6: Risk Rating Matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	High	Very High	Very High	Very High
Likely	Medium	High	High	Very High	Very High
Possible	Low	Medium	High	Very High	Very High
Unlikely	Low	Low	Medium	High	Very High
Rare	Low	Low	Medium	High	High

5.3 Natural Asset Management Risk Assessment

The two main categories of potential risk to Aquifer 560 include loss of water quantity and degradation of water quality. There are several sub-categories of potential risk, each with varying likelihood of occurrence and magnitude of consequence. Using the risk rating matrix from Table 6, a risk rating was assigned to each natural asset risk sub-category, summarized in Table 7.

Table 7: Natural Asset Risk Assessment Results

Natural Asset Risk Sub-Category	Likelihood	Consequence	Risk Rating
Natural Asset Risk: Loss of Water Quantity			
Inadequate Recharge	Possible	Major	Very High
Over-pumping Aquifer	Unlikely	Major	High
Encountering Uncontrolled Flow from Artesian Conditions	Unlikely	Major	
Natural Asset Risk: Degradation of Water Quality			
Saltwater Intrusion into Aquifer	Possible	Major	Very High
Groundwater Contamination due to Industrial/Commercial Activities	Unlikely	Moderate	Medium
Groundwater Contamination due to Community Development Activities	Unlikely	Minor	Low
Groundwater Contamination due to Natural Resource Activities	Unlikely	Minor	

Included below is an explanation of the risk ratings calculated for the different risk sub-categories that could impact the groundwater quantity and/or quality of Aquifer 560:

- A "**Very High**" risk rating was assigned to risk categories 'Inadequate Recharge of Aquifer 560' and 'Saltwater Intrusion Into The Aquifer'. Despite having evaluated the groundwater source, it is possible for groundwater conditions to change over time.
- A "**High**" risk rating was assigned to risk category 'Over-Pumping Aquifer 560', due to the major impact that improper use of the groundwater resource could have on the aquifer. A "High" risk rating was also assigned to risk category 'Uncontrolled Flow from Artesian Conditions', as inadequate groundwater protection could result in a breach of the aquitard (Aquitard 560), leading to major over-extraction of the groundwater resource.
- "**Medium**" and "**Low**" risk ratings were assigned to risk categories 'Contamination of Aquifer 560 from Varying Land Use Practices'. Despite the minor to moderate consequence ratings, contamination is unlikely, as Aquitard 560, which is regionally extensive, provides a barrier to vertical groundwater flow across the Aquifer 560 footprint and recharge areas.

5.4 Natural Assessment Management Tools

To protect Aquifer 560 from loss of water quantity and degradation of water quality, USL and Waterline have identified seven NAM tools to help mitigate risks to the natural asset. The resources that make up the identified NAM tools are summarized in Table 8.

It should be noted that all resources reviewed by USL and Waterline were commissioned by the Town, the SCRD and by ENV. Additionally, USL and Waterline used their corporate history (i.e., historical and on-going conversations and projects with the Town and SCRD staff) to contribute to the identification of the NAM tools.

Table 8: Natural Asset Risk and Associated NAM Tools

Natural Asset Risk Sub-Category	Natural Asset Risk Rating	NAM Tool No.	NAM Tool	Reference / Data Source	Author	Year(s)
Inadequate Recharge and Saltwater Intrusion	Very High	1	Water Resource Monitoring	ToG Ongoing Monitoring Programs (Monitoring and Town Wells Groundwater Level and Chemistry Data, Water Use Data)	Town of Gibsons	2009-2024
				SCRD Ongoing Monitoring Programs	Sunshine Coast Regional District	2023-2024
				Chaster Creek Flow Accretion Study	Swiftwater Consulting Ltd.	2024
				Gibsons Creek Flow Accretion Study	Swiftwater Consulting Ltd.	2024
				Gibsons Climate Station Data – Various Locations across Upper and Lower Gibsons	Swiftwater Consulting Ltd.	2024
				Hydrometric Station Data – Stage Level Data for Gibsons, Charman and Chaster Creeks	Swiftwater Consulting Ltd.	2024
				Canadian Climate Data – Total Precipitation Data for the Gower Point Climate Station (Climate ID 1043152)	Ministry of Environment	2024
				Provincial Groundwater Observation Well (OW) – Groundwater Level Data for OW 460 and OW 497	Ministry of Environment	2024
Over-pumping the Aquifer and Encountering Uncontrolled Flow from Artesian Conditions	High	2	Groundwater Modelling & Water Resource Planning	Aquifer Mapping Study	Waterline Resources Inc.	2013
				Aquifer Mapping Study Update - Re-evaluation of the Groundwater Use Scenarios	Waterline Resources Inc.	2022
				Gibsons Source to Sea Watershed Modelling	ESSA Technologies Ltd.	2023
		3	Operational Planning	ToG Water Supply Strategy Update	Urban Systems Ltd.	2017
				Gibsons Water System Operation and Control	Urban Systems Ltd.	2023
		4	Emergency Response & Water Shortage Response Planning	ToG Drought Management Plan	Delcan	2005
				ToG Emergency Drought Consequence Plan	Delcan	2005
				Sunshine Coast Emergency Response and Recovery Plan	Sunshine Coast Regional District	2017
				ToG Waterworks Emergency Response Plan	Town of Gibsons	2018
				SCRD Drought Management Plan	Sunshine Coast Regional District	2022
		5	Water Source Licensing	SCRD Conditional Water Licence 502568 (Aquifer 560 Groundwater)	Ministry of Water, Land, and Resource Stewardship	2021
				ToG Conditional Water Licence 503565 (Aquifer 560 Groundwater)	Ministry of Water, Land, and Resource Stewardship	2021
				ToG Conditional Water Licence 504580 (Aquifer 560 Groundwater)	Ministry of Water, Land, and Resource Stewardship	2022
		6	Development Permit Areas (DPA)	SCRD West Howe Sound Official Community Plan - West Howe Sound / Soames Lobe DPA 5	Sunshine Coast Regional District	2011
				ToG Official Community Plan - Gibsons Aquifer DPA 9	Town of Gibsons	2015
				Elphinstone Official Community Plan - Elphinstone DPA	Sunshine Coast Regional District	2018
Groundwater Contamination from Industrial and Commercial Land Use Activities	Medium	7	Wellhead / Aquifer Protection Plan	ToG Preliminary Aquifer Protection Plan	Piteau Associates Engineering Ltd.	2005
Groundwater Contamination from Community or Natural Resource Development Activities	Low			ToG Wellhead Protection Plan	Piteau Associates Engineering Ltd.	2006
				SCRD Well Protection Plan Update - Church Road Well 2 and 3, and Soames Well	Associated Engineering Consultants Inc.	2022

Notes: **NAM** means Natural Asset Management; **SCRD** means Sunshine Coast Regional District; **ToG** means Town of Gibsons.

5.5 Natural Assessment Management Tools Assessment

To ensure the NAM tools are effective in mitigating potential risks to Aquifer 560, USL and Waterline completed a gap analysis of the available resources that each tool is based upon. A summary of the gap analysis, potential impacts posed by the identified gaps and action items to improve the tools are summarized in Table 9.

Through the gap analysis, it was determined that Aquifer 560 is generally being protected from loss of water quantity and/or degradation of water quality, as both the Town and the SCRD are actively promoting and engaging in proper groundwater management. However, data gaps were identified around mitigating 'Over-pumping the Aquifer and Uncontrolled Flow from Artesian Conditions', which have high risk ratings. There is a lack of alignment between governing agencies regarding NAM Tool 4, *Emergency Response & Water Shortage Response Planning* (Table 9). Furthermore, the '*Groundwater Modelling & Water Resource Planning'* tool (NAM Tool 2) is outdated and requires further calibration (Table 9). Lastly, the '*Development Permit Areas'* tool (i.e., policies and bylaws; NAM Tool 6) for protecting groundwater do not cover all of Aquifer 560's identified high risk areas (Table 9).

Conversely, no data gaps were identified for protection of Aquifer 560 from 'Inadequate Recharge and Saltwater Intrusion', considered very high risk, as the Town, the SCRD and ENV have detailed '*Water Resource Monitoring'* tools (NAM Tool 1) that are currently being utilized (Table 9). Despite the medium to low risk of 'Groundwater Contamination from Various Land Use Practices', some attention is required to address the Town's and the SCRD's outdated Wellhead/Aquifer Protection Plans (NAM Tool 7; Table 9).

Priority rankings, with expected timelines and responsible agents, have been assigned to the action items outlined in Table 9. The highest priority was assigned to action items associated with NAM tools that are missing resources or have outdated resources, as both increase the risks to Aquifer 560 (i.e., updating the groundwater flow model and development permit area policies and bylaws). Timelines to complete the action items are all shorter term, within the next 1-2 years. It should be noted that despite the high priority ranking, an update to the groundwater flow model (NAM Tool 2) has a suggested longer timeline than other high priority action items, as additional water resource monitoring is required to complete a meaningful model update.

Table 9: NAM Tool Assessment and Gap Analysis Results

Natural Asset Risk Sub-Category	Natural Asset Risk Rating	NAM Tool No.	NAM Tool	NAM Tool Gap Analysis	Impacts Posed by Identified Gaps	Action Items	Priority Ranking	Timeline	Responsible
Inadequate Recharge and Saltwater Intrusion	Very High	1	Water Resource Monitoring	•The ToG and SCRD groundwater monitoring programs includes data collection across all of Aquifer 560, including collecting groundwater quality sample and groundwater level from water supply and monitoring wells. Water use data from active WSWs is being reviewed annually. •The ToG and SCRD are actively monitoring stage levels and discharge rates from the main tributaries of the Soames, Gibson, Charman and Chaster Creeks. The ToG has completed flow accretion studies on both Gibson and Chaster Creeks. •ENV currently manages two Provincial Groundwater Observation Wells (OWs) that are completed in Aquifer 560. Groundwater level and chemistry data are being collected and shared publicly, adding to overall monitoring of Aquifer 560, specifically the Elphinstone and Gibsons Aquifer Lobes.	None identified. These monitoring programs are capturing the necessary performance monitoring data for proper assessment of Aquifer 560.	•The ToG and SCRD have started sharing groundwater level data for the purpose of understanding regional groundwater levels, to further develop the Aquifer 560 conceptual site model, and to inform groundwater licensing; collaboration should continue. •Ongoing monitoring of groundwater chemistry at monitoring locations near the shoreline is helping act as an early warning sign for saltwater intrusion due to over-pumping and from other climate driven events.	Low	Ongoing	ToG, SCRD and ENV
Over-pumping the Aquifer and Uncontrolled Flow from Artesian Conditions	High	2	Groundwater Modelling & Water Resource Planning	• The numerical groundwater flow model (MODFLOW) only includes the Gibsons Aquifer Lobe. Current modelling predictions do not consider water use by the SCRD; therefore, a complete water budget has not been assessed. Water use scenario predictions do not consider recent climate change predictions. • The stormwater runoff model (PCSWMM) includes the Soames, Gibson, Charman and Chaster Creek Watersheds. During model calibration, only limited surface water monitoring data was available for calibration of creek discharge conditions.	• Over-utilization of the groundwater resource, leading to un-informed land use planning/development. • Uncertainty of surface water runoff (i.e., stormwater) leading to improper characterization of groundwater recharge.	•Use modern climate forecasting tools for climate variability. Available resources include Environment and Climate Change Canada (ECCC) and the Pacific Climate Impacts Consortium (PCIC). •Continue to collect climate data from ToG climate stations at various elevations in the watershed to help assess climate variability (i.e., changes in precipitation at various aquifer recharge zones). •With ongoing water resource monitoring, the numerical groundwater flow model could be updated to provide a better understanding of the Aquifer 560 water budget, which would help with water use planning.	High	2027	ToG and SCRD
		3	Operational Planning	The current operational framework for both the SCRD and the ToG has created several challenges when the SCRD has supply limitations with the Chapman Creek source. There may be potential to adjust the water system operational approach to provide greater operational resiliency.	With both the SCRD and ToG operating under WSA licence limitations, it can be challenging to be proactive in considering what is best for Aquifer 560 and for operational efficiency.	•Add automation/monitoring to the interconnects between the SCRD and the Town, including automating the reverse feed line so that it can be activated remotely as needed (WLRS approval is needed) and adding SCADA monitoring to the Zone 2 interconnection so that when the pressure release valve is opened both the ToG and SCRD are aware of this operational change. •Return to a separated storage for the ToG Zone 3 so that the SCRD interconnect doesn't need to be activated except in emergency situations. This will need a separate feasibility assessment to build another reservoir, booster station capacity/availability and piping. •Consider using Aquifer 560 as the main water supply for the SCRD Areas D, E, and part of Area F, and only use the Chapman Creek source as a backup supply for these areas. This will allow for greater stability in the water supply.	Medium	2026	ToG and SCRD
		4	Emergency Response & Water Shortage Response Planning	•The ToG has a solid approach for documenting and responding to drought/water shortages but the Drought Management Plan is outdated. Despite some of the drought response weaknesses having been improved and several of the water conservation plan programs having been implemented, the drought management team/emergency contacts are still outdated and the Town Well 6 (TW6) infrastructure has not been included. •The SCRD's Drought Management Plan does not provide sufficient detail for water conservation and not all the supporting documents have been provided. •Water audits, including reviewing pumping volumes and household meter are not completed on a regular basis by both the ToG and SCRD. Furthermore, household meter data is not being compared with groundwater diversion rates from the water supply wells to help monitor potential system losses.	•Less effective long-term planning, unnecessary redundancy, lack of ability to adapt/react to drought conditions and less ideal communication with appropriate personnel. •Potential overuse of water, which could lead to regulatory fines, loss of water via leaks and overall less effective management of the Aquifer 560.	•Update the ToG Drought Management Plan and confirm with the SCRD that all available Water Shortage Response Plan(s)/Drought Management Plan(s) have been provided. •More frequent review of household metering data for better water use planning during peak use months. This will provide added value for the assessment of potential system losses when reviewing groundwater diversion from the WSWs. •Establish proactive short-term and long-term summer and winter drought monitoring triggers and thresholds that consider aquifer groundwater levels, as opposed to reactive strategies. •When completing water audits and sharing data with the public, provide common messaging on the thresholds and water conservation practices, helping align neighboring communities. •Assess alternative water supply options (limited) and enhancements (water storage) based on the potential for decreasing trends in groundwater levels. •Update the Waterworks Emergency Response Plans and ensure alignment between the Town and SCRD.	Medium	2026	ToG and SCRD
		5	Water Source Licensing	The ToG holds two conditional use water licences and the SCRD holds one conditional use licence; all three are for groundwater extraction from Aquifer 560. The SCRD also has two existing use licence applications for ongoing groundwater extraction from Aquifer 560 that are still under review and have yet to be approved.	None identified. These applications properly represent the planned groundwater development currently.	The ToG and SCRD are following the WSA groundwater licensing requirements. As such, development of Aquifer 560 can be properly governed and the licensed water use amount can be assessed for beneficial use, helping confirm per capita water demands.	Low	Ongoing	ToG, SCRD, WLRS and Squamish Nation
		6	Development Permit Areas	•The ToG *Official Community Plan* (OCP) *Development Permit Area 9* (DPA 9) guideline helps protect the Gibsons Aquifer from land use development that could cause a breach in the aquitard, which could create uncontrollable flowing artesian conditions. •The SCRD West Howe Sound OCP and the Elphinstone OCP do not include specific measures to protect the Soames or Elphinstone Aquifer Lobes, respectively, from land use changes that could cause a breach in the aquitard, which could create uncontrollable flowing artesian conditions. •There is little to no alignment for the protection of Aquifer 560 on provincial Crown lands designated for resource extraction (e.g., forestry practices) that are typically within the recharge area for Aquifer 560 (upper watershed areas).	• Improper groundwater characterization prior to land use development could cause a breach of Aquitard 560, leading to a loss of pressure in Aquifer 560 and over-extraction of the groundwater resource. • Improper land use protection within the watershed catchment areas could impact recharge to Aquifer 560.	•Although the DPA 9 has been effective at protecting the Gibsons Aquifer Lobe, updates and modifications to the policy and associated bylaws are required as new information on aquifer characteristics become available (i.e., updates from Leapfrog geological model). •Establish aquifer protection guidelines for the West Howe Sound community (Soames Aquifer Lobe) and Elphinstone community (Elphinstone Aquifer Lobe). The new guidelines should require proponents of land development to assess hydrogeological conditions prior to completing any subsurface investigations. •Implement a regional watershed governance and management model on the Sunshine Coast and create a Water Sustainability Plan designation for the Aquifer 560 recharge areas.	High	Ongoing	ToG, SCRD and ENV
Groundwater Contamination from Industrial & Commercial Land Use	Medium	7	Wellhead / Aquifer Protection Plan	•The ToG Preliminary Aquifer Protection Plan and Wellhead Protection Plan are outdated, published in 2005 and 2006, respectively. As such, the TW6 capture zone analysis is not considered. Risk to the aquifer from upgradient land use has not been updated in almost 20 years. •The SCRD has a Wellhead Protection Plan for the Church Road Wells and Soames Well, published in 2022. However, the SCRD has not created a Wellhead Protection Plan for the Chaster or 901 Sentinel Road Wells that are active under WSA existing use licences.	Outdated and/or incomplete protection plans could lead to increased risk of groundwater and drinking water contamination.	•The ToG and SCRD should engage with Vancouver Coastal Health (VCH) to review the requirements of their water system operating permit(s) to ensure all requirements are met, including updating their Aquifer Protection Plans to include up-to-date groundwater hazards, risk rankings, and control measures. •The ToG should include TW6 as a new point of well diversion in their Wellhead Protection Plan, while the SCRD should include the Chaster and 901 Sentinel Road Wells . Both the ToG and SCRD should reflect the most updated water use values for accurate representation of the groundwater capture zones. •Where land use practices pose a risk to Aquifer 560 within the WSW capture zone areas, the ToG and SCRD should update the land use designation or eliminate the risk, if possible.	Medium	2026	ToG and SCRD
Groundwater Contamination from Community or Natural Resource Development	Low								

Notes: **NAM** means Natural Asset Management; **SCRD** means Sunshine Coast Regional District; **ToG** means Town of Gibsons; **WSA** means *Water Sustainability Act*; **WSWs** means water supply wells; **WLRS** means Ministry of Water, Land and Resource Stewardship.

6.0 CONCLUSIONS

The Town and the SCRD are using Aquifer 560, considered a critical natural asset, as a potable water supply. Aquifer 560 is performing well and is supplying high-quality water to Town and SCRD residents and businesses. The groundwater quality is generally unchanged since monitoring began and there has been no evidence of saltwater intrusion based on current use. Both the Town and the SCRD hold WSA conditional water licences for groundwater use from Aquifer 560.

Governance of Aquifer 560 is challenging as the groundwater source crosses municipal boundaries and First Nation lands. Land use types vary across the aquifer footprint and within the aquifer recharge area, consisting of residential, commercial/industrial and resource development lands. Inadequate or outdated groundwater protection policies and bylaws that do not align could allow for degradation of the water quality.

Climate change and altering weather patterns have the potential to change the outlook on groundwater availability through reduced groundwater recharge and as such, Aquifer 560 is vulnerable to loss of water quantity if not properly monitored. If responsible water uses and planned development of the groundwater resource is not considered, overuse of Aquifer 560 is possible. Mismanagement of the groundwater system infrastructure can also lead to reduced groundwater availably, through water wastage from system leaks.

To help reduce the risks to Aquifer 560, seven NAM tools were identified based on existing resources already created and/or in use by the Town and the SCRD. These tools were assessed for completeness via a gap analysis. Assessment results indicated that although the NAM tools have been effective thus far in protecting Aquifer 560, more work is needed to update and/or modify some existing tools to reduce the potential for impacts on water quantity and quality.

Action items with priority ranking, timelines and identified responsible agents have been provided. Implementation of action items to help protect Aquifer 560 should be a collaborative effort between the Town and the SCRD, as both communities are reliant on this critical natural asset for water supply. WLRS and the Squamish Nation also share responsibility in helping govern and develop the groundwater resource and should provide data to help assess groundwater conditions in support of the Town and SCRD initiatives.

7.0 CERTIFICATION

This document was prepared under the direction of a professional geoscientist registered in the Province of British Columbia.

Waterline Resources Inc. and Urban Systems Ltd. trust that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

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9.0 LIMITATIONS AND USE

The information presented in this document was compiled exclusively for the Town of Gibsons and the Sunshine Coast Regional District. (the Client) by Waterline Resources Inc. (Waterline) and Urban Systems Ltd. (USL). This work was completed in accordance with the scope of work for this project that was agreed between Waterline/USL and the Client. Waterline and USL exercised reasonable skill, care, and diligence to assess the information acquired during the preparation of this document but make no guarantees or warranties as to the accuracy or completeness of this information. The information contained in this document is based upon, and limited by, the circumstances and conditions acknowledged herein, and upon information available at the time of the preparation of this document. Any information provided by others is believed to be accurate but cannot be guaranteed. No other warranty, expressed or implied, is made as to the professional services provided to the Client.

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Figures