# Tsolum River Agricultural Watershed Plan: Phase 1

**Prepared for:**

Comox Valley Regional District

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Comox Valley REGIONAL DISTRICT

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# Contents

# 1 Executive Summary

The Tsolum River, running through the heart of the Comox Valley, is an integral part of the Comox Valley Regional District (CVRD). The Tsolum River watershed lies in the heart of the unceded traditional territory of the K'òmoks First Nation (KFN) and has been a vital part of the KFN community since time immemorial. The Tsolum River watershed and its aquifers provide water that is critical to the health of the Comox agricultural community, as well as the fish, wildlife, and all living things in the watershed. The Tsolum River watershed aquifers provide drinking water for homes, businesses, a school and community centres.

Like many watersheds on the east coast of Vancouver Island, the Tsolum is heavily influenced by seasonal variations in precipitation. In the winter, plentiful rain brings high water levels and occasional flooding. In dry summer months, stream flows become very low when agricultural producers, aquatic life, and residents need water the most.

Access to water has been identified as a major obstacle that faces the agriculture sector in the region. To address historical, current and future concerns about water availability for both agriculture and instream flow needs, the CVRD is developing the Tsolum River Agricultural Watershed Plan. This work is funded in part by the governments of Canada and British Columbia through a grant program administered by the Investment Agriculture Foundation of British Columbia (IAFBC).

IAFBC watershed planning is to be completed in two phases: Phase One involves the collection and interpretation of existing data, community engagement, and recommendations for future phases of work. Phase Two involves activities such as hydrologic modelling, scenario evaluation, and plan development. Once complete, an agricultural watershed plan will identify the significance of agriculture in the watershed, lessen the potential for water use conflicts, and ensure that agricultural needs are considered if a Water Sustainability Plan is developed for the area.

To support the development of this plan, an Agricultural Watershed Planning Advisory Committee (AWPAC) was formed. The AWPAC includes representation from local, provincial, and federal governments, the K'ómoks First Nation, local farming institutes, conservation groups, and Timberwest Forest Corporation.

In October 2017 the CVRD initiated the agricultural watershed planning process. In April 2018 a groundwater licensing workshop was held to assist producers with applying for a groundwater license. In May 2018, Elucidate Consulting was engaged to develop an agricultural watershed plan.

To begin, existing information was gathered and analyzed (Deliverable One: May - July 2018). Next, a multi-faceted community engagement and stakeholder consultation process was conducted (Deliverable Two: September 2018 - February 2019). In this phase, information about the watershed was shared with the community and input obtained from stakeholders. Throughout the process, the AWPAC was consulted for guidance (Deliverable Three). Finally, a draft report summarizing this work and providing recommendations for next steps in Phase Two was presented to the CVRD (Deliverable Four: December 2018 – February 2019). This work will complete with a final presentation to the Board (March 2019).

In Deliverable One, it was found that groundwater plays an important role in the watershed and is a major source for irrigation water and in-stream flows in the summer. It is estimated that irrigation accounts for 85% of all consumptive water use in the watershed. It is also estimated that 77% of anthropogenic water use in the Tsolum River watershed comes from groundwater sources. The availability of groundwater supplies varies throughout the watershed and there is currently no information available on how much water is available in Tsolum River watershed aquifers.

As part of Deliverable One, existing aquifer boundaries were assessed and updated by integrating wells data into a 3-dimensional groundwater model. This work identified a new confined aquifer east of the Tsolum River, called 'Tsolum-2' and proposed updates to the boundary of aquifer 408 which lies between the Tsolum River and the Salish Sea.

Deliverable One also included an assessment of current and future agricultural water needs, using data from the Agricultural Water Demand Model (AWDM), developed by the CVRD and Ministry of Agriculture in 2017. The model estimated that with climate change, water needs for existing farms could increase by approximately 139% in the 2050s. If more farmland was placed in production (40% more farming, using a similar distribution of crops and irrigation systems), water needs could increase by as much as 563% in the worst-case scenario.

Finally, Deliverable One included an assessment of agriculture with respect to economic activities. According to Statistics Canada, in the Tsolum watershed, approximately $18.5 million/year in agri-food products are produced and approximately 800 people are employed on-farm. It is estimated that producers in the Tsolum spend approximately $14 million/year in farm operating costs - with much of this going back into the community.

Consumers are increasingly aware of the benefits of eating locally and it is possible that investment in agriculture will grow. The Comox Valley has one of the most favorable growing climates in the country, and while many areas of the province have exhausted their available agricultural land, there is still a relatively large amount of Agricultural Land Reserve in the Tsolum that could be placed in production – provided there is sufficient access to water.

Between September 2018 and February of 2019, the public and watershed stakeholders were invited to share their water quantity and quality concerns, provide feedback on the information gathered to-date, and discuss future water management solutions (Deliverable Two). This was done through a series of activities including: targeted interviews, a public open house event, public survey, a booth at the Comox Valley Farmer's Market, social media posts, news releases, attendance of the Comox Valley Farmer's Institute and Mid-Island Farmer's Institutes Annual General Meetings, an interview and meetings with K'òmoks First Nation representatives, and Advisory Committee engagement.

The community engagement process confirmed that water supply is a real and increasing concern in the Tsolum River watershed. Many community members stated that they did not have sufficient water available on their property for their farm operations or daily household needs. Throughout the engagement process it was clear that the Tsolum River has an active and engaged agricultural and stewardship community that strongly supports future action to ensure that there is enough water available to meet current and future agricultural, environmental, and community needs.

The following recommendations have been developed to support the CVRD moving forwards in Phase Two of the Agricultural Watershed Planning process:

1) a) Develop a water budget to identify available groundwater and surface water volumes. Given the volume of groundwater use, attention should be paid to the groundwater component, identifying areas of groundwater-surface water interactions and groundwater recharge.

   b) Develop an understanding of Environmental Flow Needs and the Critical Environmental Flow Threshold.

2) Assess water storage options and alternate supplies
3) Community and Advisory Committee engagement
4) Communicate with the Province to identify an interest in the Water Sustainability Planning and ensure that Phase Two work aligns with the guidelines for establishment of an Agricultural Water Reserve and Water Sustainability Plan.
5) Develop a plan for next steps moving forwards.

# 2 Introduction

The Tsolum River, running through the heart of the Comox Valley, is an integral part of the Comox Valley Regional District (CVRD). The Tsolum River watershed and its aquifers provide water that is critical to the health of the Comox agricultural community as well as the fish, wildlife, and all living things in the watershed. The Tsolum River watershed aquifers provide drinking water for homes, businesses, a school and community centres.

Agricultural activity has played a role an important part of the Comox Valley community for thousands of years. The K'òmoks First Nation, who have lived in this watershed since time immemorial, hunted, fished, and cultivated crops in the watershed (K'omoks First Nation, 2013). The food supply in the area was so abundant that they referred to the valley as the "land of plenty". In the 1860's, non-Native settlers came to the Comox Valley to farm. They were attracted by the pre-cleared land, enriched soils, gentle climate, abundant flora and fauna, and plentiful seafood (Courtenay and District Museum and Palaeontology Centre, 2019) (Mackie, The Wilderness Profound: Victorian Life of the Gulf of Georgia, 1995).

Today, agriculture plays an important role in the community and statistics suggest that investment in agriculture is growing (Comox Valley Economic Development, 2018). There is significant potential for expansion (Ministry of Agriculture, 2013), but one of the key limiting factors for current and future agricultural production is access to water (Gulik, Neilsen, Fretwell, & Tam, 2014). To address ongoing and future concerns about water availability for both instream and agricultural needs, the CVRD is developing the Tsolum River Agricultural Watershed Plan.

This Plan is funded in part by the governments of Canada and British Columbia through a grant program administered by the Investment Agriculture Foundation of British Columbia (IAFBC). Agriculture watershed planning funded by IAFBC is to be completed in two phases: Phase One involves collection and analysis of existing data, public engagement, collaboration with the Agricultural Advisory Committee, and the development of recommendations for Phase Two. Phase Two may include activities such as hydrology modelling, scenario evaluation, and management plan development.

Once complete, an Agricultural Watershed Plan will identify the significance of agriculture in the watershed, support the agricultural sector, lessen the potential for water use conflicts, and ensure that agricultural needs are considered if a Water Sustainability Plan is developed for the area. Water Sustainability Plans are a mechanism under BC's Water Sustainability Act (2016) to enable local planning and governance.

In October 2017 the CVRD initiated the agricultural watershed planning process. In April 2018 a groundwater licensing workshop was held to assist producers with applying for a groundwater license. In May 2018, Elucidate Consulting was engaged to develop an agricultural watershed plan.

To begin, existing information was gathered and analyzed (Deliverable 1: May - July 2018). Next, a multi-faceted community engagement and stakeholder consultation process was conducted to share information on the watershed and obtain input from stakeholders (Deliverable 2: September 2018 - February 2019). Throughout this process, the Advisory Committee provided feedback, guidance, and local knowledge (Deliverable 3). Finally, the information gathered through these steps was used to develop a report which included recommendations for future work (Deliverable 4: November 2018 – March 2019).

This report summarizes Phase One of the Tsolum River Agricultural Watershed Plan, and includes a summary of available data on:

- Surface Water Resources
- Groundwater Resources
- Water Uses and Values
- Water Quality
- Environmental Flow Needs
- Significance of Agriculture with Respect to Economic Activities
- Data Gaps

This report also includes an overview of the public communications and engagement activities and recommendations for future work in Phase Two of the Tsolum River Agricultural Watershed Planning process.

# 3 Watershed Overview

The Tsolum River flows from Regan Lake on the northeast side of Mount Washington down to the City of Courtenay. This 248 $km^2$ watershed is relatively low elevation and includes upland forests, low lying rural residential and agricultural land, and suburban areas near the City of Courtenay. Major tributaries include Portuguese Creek, Dove Creek, Headquarters Creek, and Murex Creek.

According to the Canadian Census (2016), there are up to 8,000 people living in the Tsolum River watershed. Agricultural activity has a long history in the Tsolum River watershed. Although it is not one of the largest sectors in the region, agriculture has been a steady contributor to the community and economy. There is significant potential for growth in the agricultural sector, provided there is sufficient access to water.

**What is a watershed?**

A watershed is an area of land that catches rain and snow, and drains or seeps into groundwater, a marsh, river, lake, or ocean.


*Figure 1a: What is a watershed? Source: http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2018/013-1817_DraftGuidance.pdf*

Like many watersheds on the east coast of Vancouver Island, the Tsolum River is heavily influenced by extreme seasonal variations in precipitation. Figure 3 shows the monthly variation in precipitation at the Comox Airport from 1981 – 2010 (approximately 4km outside the watershed). As shown in Figure 3, the Tsolum River watershed receives a great deal of water through precipitation in the fall and winter and little precipitation in the summer.

**What is an aquifer?**

An aquifer is an area of rock that has spaces which allow water to be contained and move. An aquifer can be in consolidated rock like limestone, sandstone, or conglomerate (as shown in the left) or in unconsolidated sand and gravel, or overburden (as shown on the upper right).

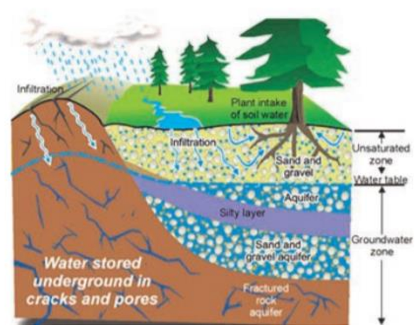


*Figure 2b: What is an aquifer? Source: Department of Natural Resources Canada*

In the winter, plentiful rain brings high water levels and occasional flooding (Northwest Hydraulic Consultants, 2011). In dry summer months, stream flows become very low and stream temperatures become quite warm (Spooner, 2016). The Tsolum is a relatively low elevation river, with about 59% lying below the 300m elevation contour and 91% lying below 800m (Northwest Hydraulic Consultants, 2011). Because of this, less water is stored as snow in the upper watershed to contribute to summer flows.

Underneath the Tsolum watershed lie groundwater aquifers. These aquifers are used as drinking water and irrigation supplies by local residents, producers, and businesses. It takes a great deal of technical work to fully understand how these aquifers connect to the river system. In this project, a 3-dimensional conceptual model was developed to better understand local groundwater systems. If approved, Phase Two of the Tsolum River Agricultural Watershed Plan will further contribute to the understanding of these aquifers.

The Tsolum River's seasonal variations in flow can bring challenges to the water users in the watershed. Although there is substantial water available in winter (Figure 3), precipitation and stream flows are lowest in the summer when water is most needed by irrigators, residents, and aquatic life. It is predicted that these challenges will grow as climate changes and population increases.

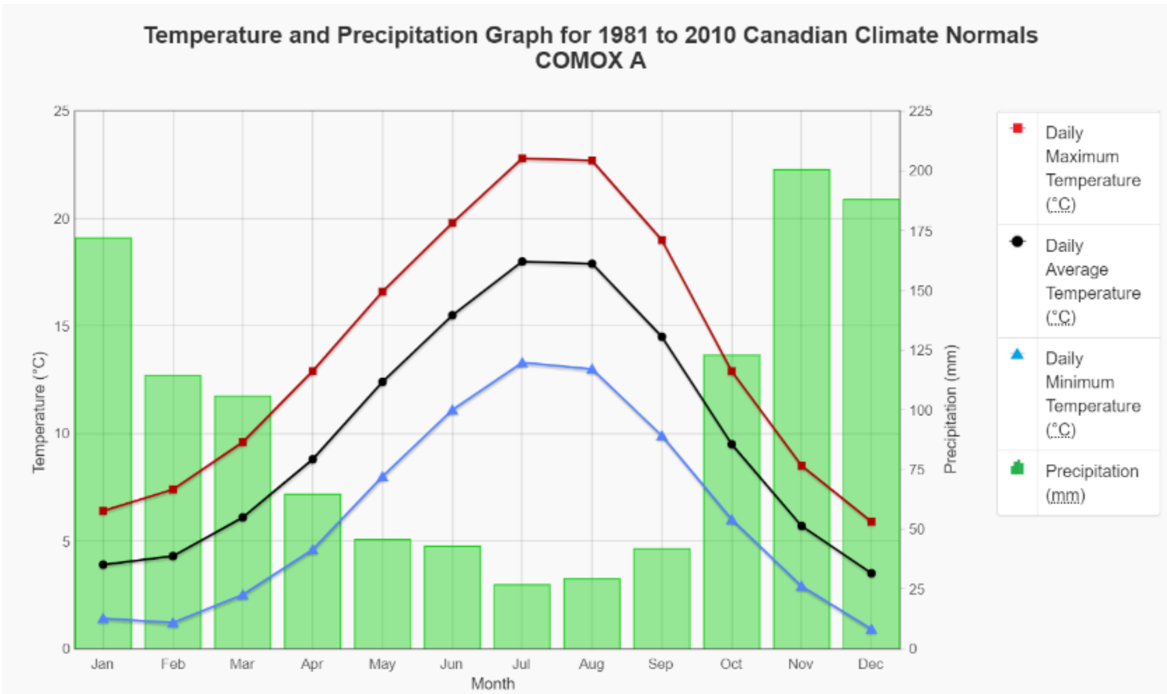


*Figure 3: Climate Normals from Environment Canada. Source: http://climate.weather.gc.ca*

# 4 Stakeholders and Partners

There are many people living in and using the Tsolum River watershed. Today, the watershed contains almost 300 farm properties, many rural residential homes, a school, multiple community centres, and several small businesses. The Tsolum River watershed lies in the unceded traditional territory of the K'ómoks First Nation and flows through the administrative boundaries of IR#2 Puntledge, CVRD Electoral Areas B, C, and the City of Courtenay.

This watershed has been home to the K'ómoks First Nation (KFN) for thousands of years. Prior to colonial settlement, the Tsolum valley was used by the KFN for hunting and fishing, medicine procurement, agriculture, and recreation. Agricultural areas were managed under sophisticated Indigenous agricultural management regimes, including prescribed burning, bulb spacing and re-seeding. Root and berry crops were cultivated and domestic surpluses used in economically beneficial ways (K'omoks First Nation, 2013).

Today, many in the KFN community hunt and fish in the watershed. They also gather berries and medicinal plants. Many recreate and spend time in the watershed with their children and families, especially in the summer. The KFN is also an active participant in watershed stewardship. Through the KFN Guardian Watchmen Program, the community participates in monitoring and restoration activities (C. Frank, personal communication, January 7, 2019).

In the lowlands of the Tsolum River watershed, the primary land uses today are agriculture and rural residential. The local agricultural community is represented by two Farmer's Institutes: the Comox Valley Farmer's Institute and the Mid-Island Farmer's Institute.

In the forested upper portion of the watershed TimberWest Ltd. owns several large portions of land that are actively logged. Residents of the surrounding area and tourists come to the upper and lower watershed to recreate and participate in agritourism activities.

In recent years, the Tsolum River watershed has seen a great deal of community involvement and investment. In the 1960's the Mount Washington Copper Mine became a major source of contamination to the Tsolum River. What was once a rich aquatic habitat and popular fishing destination was declared biologically dead. However, thanks to the efforts of the Tsolum River Partnership (TRP) and a highly dedicated stewardship community, the abandoned mine has been remediated and salmon are returning to the river. The TRP, which is comprised of representatives from government, industry, KFN, and the stewardship community, is now represented by the Tsolum River Restoration Society (TRRS), which actively works to improve channel conditions, enhance riparian areas, and monitor flows and fish populations.

Many private landowners have also taken a role in watershed stewardship. Actions on the land relate directly to water quantity and quality. Producers compromise a large percentage of land ownership in the watershed and several farmers in the area have completed Environmental Farm Plans to help protect water quality and flows. Others have worked with the TRSS to support stewardship actions.

## 4.1 Agricultural Watershed Planning Advisory Committee

The CVRD has identified the Electoral Area Services Committee to act as the Steering Committee for Phase One of the Tsolum River Agricultural Watershed Plan. The CVRD has established an Agricultural Watershed Planning Advisory Committee (AWPAC) to support the Steering Committee by providing input, perspective, guidance, and feedback on Phase One of the Tsolum River Agricultural Watershed Plan.

The AWPAC includes representation from:

- City of Courtenay
- Comox Valley Farmer's Institute
- Comox Valley Conservation Partnership
- Comox Valley Regional District
- K'òmoks First Nation
- Fisheries and Oceans Canada (DFO)
- Mid-Island Farmer's Institute
- Ministry of Agriculture
- Ministry of Forests, Lands and Natural Resource Operations
- TimberWest Forest Corporation
- Tsolum River Restoration Society

The AWPAC met five times to support Phase One work.

## 4.2 Relationship to the Tsolum River Recovery Plan

In 2016, the Tsolum River Restoration Society (TRRS) developed a Recovery Plan for the Tsolum River watershed. The Recovery Plan was developed with multi-stakeholder input and contains guidance on how to manage the water to support ecological health. The TRRS has been implementing this plan since 2016 through annual restoration projects, ongoing community outreach and engagement, fish counts, and flow augmentation work conducted in partnership with the Department of Fisheries and Oceans (DFO).

The Tsolum River Agricultural Watershed Planning process is occurring in parallel with the Recovery Plan work. The goal of the agricultural watershed planning process is to ensure that a sufficient quantity of water is available for agriculture now and in the future, while reducing conflicts between agricultural users and instream flows needs.

Through the Tsolum River Agricultural watershed Planning process, the CVRD will refine the understanding of available water supply and demand in the watershed and assess how to best address growing agricultural water needs, while protecting stream health. This will allow decision-makers to manage water wisely and ensure that the Tsolum River watershed supports both a viable and healthy agricultural community and a productive salmon and trout habitat for the enjoyment of future generations. Given that agricultural water use currently accounts for approximately 85% of water use in the watershed (and has substantial potential to increase), actions to proactively address agricultural water supply and demand, while considering aquatic needs, will be of great benefit to stream health.

It will be important that the TRRS is an active partner in the Tsolum River Agricultural Watershed Planning process to ensure synchronicities between the Recovery Plan and the Agricultural Watershed Plan, where possible.

# 5 Surface Water Resources

The Tsolum River watershed, shown in Figure 4, originates at Regan Lake on the east side of Mount Washington at approximately 530m in elevation. It flows relatively steeply down the mountainside for approximately 7km and then, at a lower gradient, runs parallel to the coastline for 30km south easterly towards Courtenay. Much of the river is a low-gradient channel, flowing along the base of the mountains.

The watershed is a dendritic, or 'tree-like', watershed and has several branches, or sub-watersheds. These branches, or tributaries, include Portuguese Creek, Dove Creek, and Headquarters Creek in the lower watershed. In the upper watershed, Murex Creek, McKay Creek, Pyrrhotite and Hell Diver Creeks drain the abandoned open pit copper mine previously operated by Mt. Washington Copper Co.

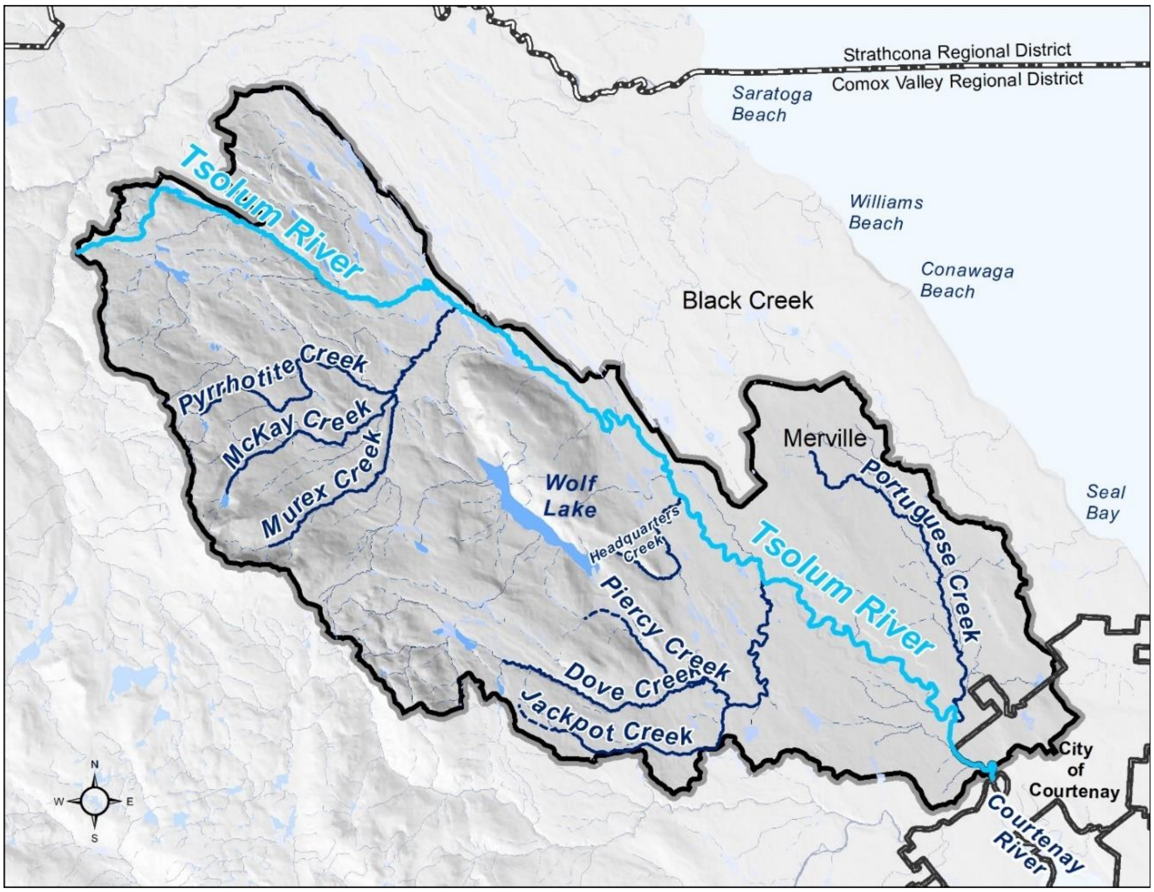


*Figure 4: Study area, Tsolum River Watershed*

Table 1 summarizes the length of the main waterbodies within the Tsolum River Watershed.

| Watercourse name | Length (km) | Watercourse name | Length (km) |
|---|---|---|---|
| **Dove Creek** | 14.8 | Piercy Creek | 4.4 |
| **Headquarters Creek** | 6.3 | Portuguese Creek | 11.6 |
| **Jackpot Creek** | 7.6 | Pyrrhotite Creek | 8.2 |
| **McKay Creek** | 6.6 | Tsolum River | 41.8 |
| **Murex Creek** | 10.5 | | |

*Table 1. Length in kilometers for the main waterbodies*

The watershed is fed by several small lakes, starting with Regan and Blue Grouse Lake in its uplands, Anderson Lake at the headwaters of Dove Creek, and Wolf Lake at the head of Headquarters Creek. Wolf Lake is the largest lake in the watershed and it acts as an important reservoir, storing water to be released in the Lower Tsolum River during times of low flow. This water is stored under a license for conservation purposes held by Fisheries and Oceans Canada. There are also a number of smaller lakes in the watershed including Hell Diver Lake, Little Lost Lake, Lost Lake, and McKay Lake. In addition, several large swamps in the north-east part of the headwaters act as important water storage areas.

## 5.1 Water Flows

On the East Coast of Vancouver Island rivers tend to experience extreme seasonal fluctuations in flow due to seasonal variations in rainfall. The Tsolum River watershed is no exception and the Tsolum experiences very high flows during winter rains (Northwest Hydraulic Consultants, 2011) and very low flows during summer dry periods (Riddell & Bryden, 1996).

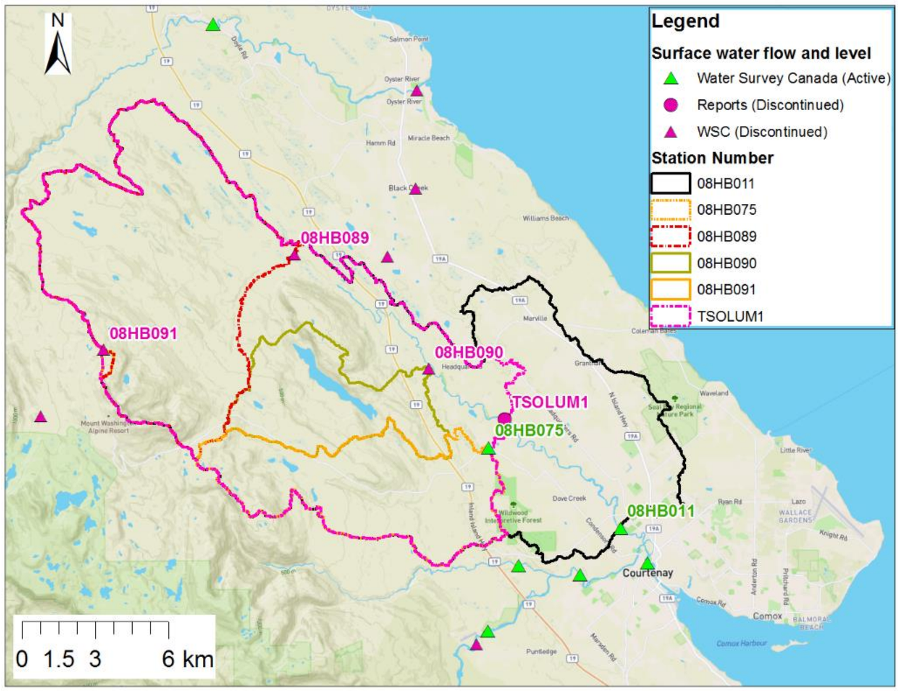


*Figure 5 Location of flow gauged stations and upstream contributing watershed*

In the Tsolum watershed, there are two active and three inactive Water Survey of Canada (WSC) streamflow monitoring stations (Figure 5). The BC Conservation Foundation (BCCF) has also partnered with the Tsolum River Restoration Society (TRRS) to collect hydrometric and water temperature data from the Tsolum River. This station is shown as TSOLUM1 in the Figure 5.

*Table 2: Flow gauging stations within Tsolum Watershed*

| Source | Station Name | Station Number | Data available from | Data available to | Status | Watershed area (km$^2$) | Years of records |
|---|---|---|---|---|---|---|---|
| **WSC** | Tsolum River Courtenay | 08HB011 | 5/1/1914 | 12/31/2016 | active | 254.74 | 102.7 |
| **WSC** | Dove Creek (near mouth) | 08HB075 | 1/1/1985 | 12/31/2016 | active | 41.82 | 32.0 |
| **WSC** | Tsolum River Below Murex Creek | 08HB089 | 4/1/1997 | 3/31/2015 | discontinued | 87.36 | 18.0 |
| **WSC** | Headquarters Creek Above Tsolum R | 08HB090 | 4/1/1997 | 8/31/1999 | discontinued | 28.40 | 2.4 |
| **WSC** | Pyrrhotite Creek At Branch 126 | 08HB091 | 6/1/1997 | 12/31/1999 | discontinued | 0.43 | 2.6 |
| **BCCF/TRRS** | Tsolum River Todd Rd station | TSOLUM1 | 9/13/2012 | 6/18/2015 | active | 195.22 | 2.8 |

The Tsolum River Todd Road semi-permanent hydrometric station was established on the Tsolum River in 2012, 11.7 km upstream of its confluence with the Puntledge River and 0.85 km downstream of the Dove Creek confluence (Figure 5). Table 2 summarizes available data for these stations.

WSC station 08HB011, established 103 years ago, provides the longest flow record. Figure 6 shows the flow analysis report for this station. The upper diagram shows the historical flows from 1914-2016. The middle graph presents the monthly average flows. Finally, the diagram at the bottom summarizes the average daily flow in a normal year. The map shows the location of the gauged station within the study area.

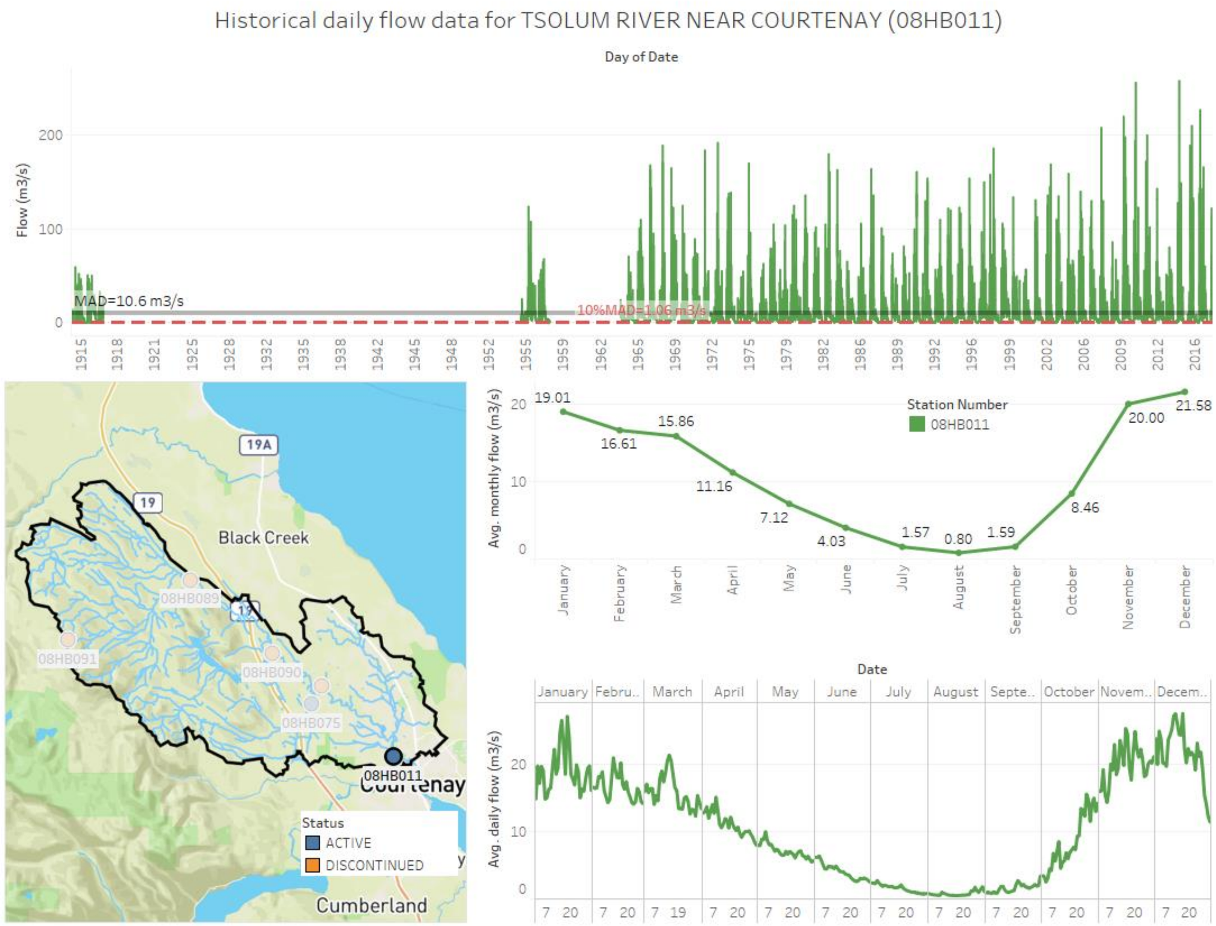


*Figure 6: Flow analysis for station 08HB011 (Tsolum River Near Courtenay)*

As shown in Figure 6, winter flows are substantially greater than summer flows. August flows are often less than five per cent of the mean annual discharge (MAD), which is below the suggested minimum flow guideline for maintaining spawning and rearing habitat for fish. The MAD for the river is 10m$^3$/s, and it is suggested that 5-10% of this flow, or 0.5 m$^3$/s – 1.0 m$^3$/s should be maintained in the river at all times for fish health (J. Szczot, personal communication, June 11, 2018) (more information on this can be found in the Section 9: Environmental Flow Needs).

The greatest river flows occur from direct runoff of rainfall or 'rain on snow events', from November to March. Beginning in March, flows diminish rapidly during the spring and into the summer, resulting in excessively low late summer flows. Because the Tsolum is a relatively low elevation watershed, snow tends to melt earlier than in the higher elevation neighboring catchments (Riddell & Bryden, 1996). Most of the dry season flow is diverted for irrigation and domestic purposes, except for minimum flows maintained for fisheries (Riddell & Bryden, 1996). The lowest flows are recorded from July to September.

Historical information from the other gauging stations (including discontinued stations) is shown in Appendix A.

## 5.2 Review of Available Studies

There have been several prior studies of aquatic habitat, hydrology, and water quality in the Tsolum River watershed. Twenty-two of these historical studies were reviewed and key findings are summarized below.

### 5.2.1 Low Flows

A review of available studies found that the low flows in the Tsolum are particularly problematic because, due to land clearing and historic logging practices, there is a lot of bedload (e.g. sediment, gravel, and boulders) in the channel in the lower Tsolum. This means that a high proportion of flow is travelling sub-surface through the gravel (Gooding, Tsolum River Biophysical Assessment Hydrology and Channel Assessment, 2010). This sub-surface flow does not allow fish to move upstream to spawn. Low flows also allow the river temperatures to rise into the toxic zone for fish ( > 25 degrees Celsius). It is possible that high temperatures may pose an even greater risk to fish than low flows (Neil Goeller, AWPAC meeting, September 26, 2018).

### 5.2.2 High Flows

The streamflow data also shows an increasing trend in winter high flows in recent years. In 2011, the CVRD, City of Courtenay, and Timberwest commissioned a study to investigate the causes of increased flooding in the Tsolum. The study evaluated the relationship between precipitation patterns and streamflow and assessed whether the Tsolum River floods are of a larger magnitude relative to similar nearby watersheds (Northwest Hydraulic Consultants, 2011).

The study found that the Tsolum watershed is experiencing more frequent and larger precipitation events over the last decade, which is resulting in more frequent and larger runoff events. It found that this pattern was consistent with many other streams on the East Coast of Vancouver Island and suggested that the increased flows are most likely the result of more frequent extreme rainfall events, caused by long-term climate variability or climate change. The study did not include an assessment of the relationship between land cover change and stream flow in the Tsolum River watershed. It did include a literature review, which stated that there is no accepted relationship between forest harvesting and stream flow impacts for large rainfall events.

However, the increased flooding does correlate with an obvious increase in land clearing (observed through satellite imagery, with obvious and significant increases in land clearing occurring between 2006-2009). Although there is uncertainty regarding the precise relationship between large rainfall events and forest harvesting, more recent literature reviews state that “The bulk of the literature concludes that peak flows increase after forest harvesting. The direction is agreed upon, but the magnitude of change is both basin-specific and dependent on the chosen statistical method.” (Perry, Lundquist, & Moore, 2016). There is general agreement in the literature that rain-generated peak flows with return period less than 6 years increase after forest harvesting (Perry, Lundquist, & Moore, 2016).

### 5.2.3 Flow Augmentation

Historical streamflow data shows the value of flow augmentation in the watershed. In dry summer months, releases from Wolf Lake at the head of Headquarters Creek play a significant role in regulating flows in the Tsolum. In August and September, almost half (48%) of the flow in the Tsolum River is from the Headquarters Creek subwatershed.

There has been significant research undertaken to identify ways to increase flows in the Tsolum River during dry summer months. One of the main ways to do that would be to capture and store water in the winter for release during the summer. To maintain summer flows, a significant amount of water would need to be stored. A recent study commissioned by the TRRS assessed large-scale storage options in the Tsolum and found that (Gooding, 2007):

- Wolf Lake is the most feasible option for increased large-scale storage (because it would require the least road raising and dam construction)
- The volume of water storage required to increase flows by an additional 10% MAD, or 1 CMS, for 45 days, at gauge 08HB011 near Courtenay, is approximately 390 hectare meters (3,900,000$m^3$)
- Raising the Wolf Lake dam at least 1 meter would provide just under half of the additional 10% MAD flow augmentation needed between the Headquarters-Tsolum confluence and the ocean
- Some water released from Wolf Lake is lost to evaporation from Headquarters Creek and the Tsolum River. Also, water is lost to seepage into the ground in the late summer as water tables get lower. Comparison of the daily gauge readings available from a fisheries service pilot hatchery gauge indicate that up to 0.62$m^3$/s of water passing through the upper gauge did not reach the lower gauge. Although part of this loss would have been diverted to irrigation, the total is well in excess of likely irrigation diversions.

The Gooding study did not evaluate distributed, smaller-scale storage options (e.g. wetlands, dugouts, water storage ponds).

# 6 Groundwater Resources

Underneath the land in the Tsolum River watershed lay several groundwater aquifers. The provincial aquifer mapping shows two unconsolidated aquifers and one bedrock aquifer within/near the Tsolum River watershed.  As part of this project the provincial aquifer mapping was assessed and updated. This section begins with an overview of the existing mapping and is followed by an assessment of these aquifer boundaries and proposed updates. It finishes with a summary of groundwater levels.

## 6.1 Existing Aquifer Boundaries

The provincial aquifer mapping shows the following aquifers in the Tsolum River Watershed: aquifers 408, 952, and 413.

Table *3* summarizes the aquifer material, productivity, vulnerability and demand for these aquifers.

Figure 7 shows the location of aquifers according to the current provincial mapping. As shown in Figure 7, the overburden aquifer, Quadra Sand aquifer 408IIC, present on the eastern side of watershed, is by far the most extensive aquifer within the watershed.  The overburden aquifer 952IIA and the bedrock aquifer 413 IIB only have a limited extent within the lowermost watershed. The extent of the mapped aquifers (bedrock and overburden) within the Tsolum Watershed represents nearly 20% of the area of the watershed.

*Table 3: Summary of BC Ministry of Environment Mapped Aquifers intersecting the Tsolum River watershed*

| Aquifer Number | Lithostratigraphic Unit | Aquifer Materials | Productivity | Vulnerability | Demand |
|---|---|---|---|---|---|
| **408** | Quadra Sediments | Sand and Gravel | Moderate | Low | High |
| **952** | Capilano Sediments, likely sand & gravel lenses within till | Sand and Gravel | Low | High | Low |
| **413** | Nanaimo Group; likely the Comox Formation | Bedrock | Low | Moderate | Low |

### 6.1.1 Aquifer Description

The current aquifer mapping in the lower Tsolum River is dominated by Aquifer 408, which is litho-stratigraphically classified as Quadra Sand. The Quadra Sand is a pre-Fraser glacial deposit consisting mainly of well sorted sand, with minor silt and gravel (Clague, 1975). Gravel content increases with proximity to the Vancouver Island mountain front. It is overlain by till deposited during the Fraser Glaciation and is underlain by fluvial and marine sediments deposited during the preceding non-glacial interval. Aquifer #952 comprises sand and gravel of post-glacial origin, deposited in fluvial outwash areas shedding off Vancouver Island mountain front.

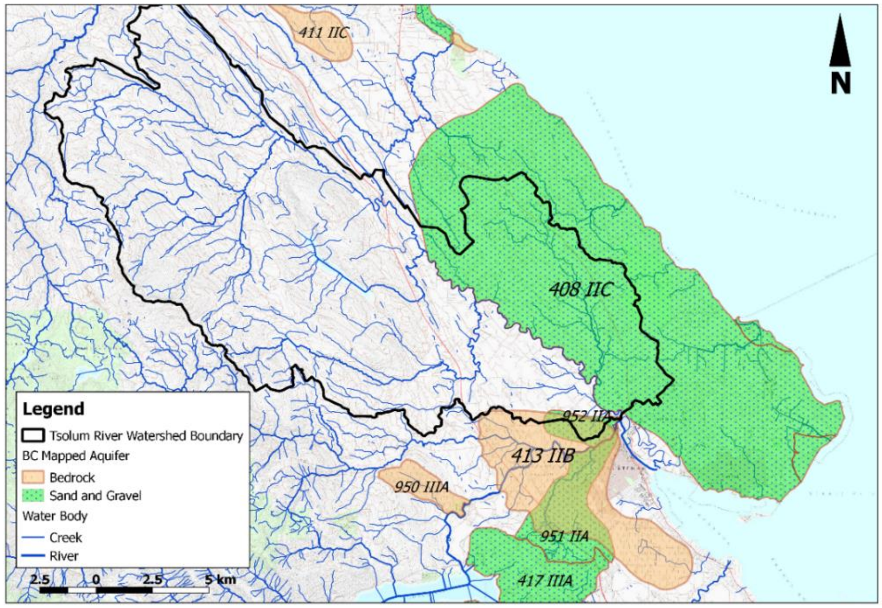


*Figure 7: Mapped aquifer extension according to Imap BC (data catalogue)*

## 6.2 Review and Updating of Aquifer Boundaries

As part of this project, the team was asked to assess and update the provincial aquifer boundaries. To do this, GW Solutions reviewed existing well records and then developed a 3D hydrogeological model based on the most up-to-date well information from the BC Ministry of Environment and Climate Change Strategy (BC MoE) provincial wells database.

GW Solutions developed the 3D hydrogeological model using a geological modelling and visualization software, called Leapfrog 3D (ARANZ Geo Ltd.), in combination with a variety of database and Geographic Information System (GIS) tools. The technical details of this work are included in Appendix A. The Tsolum River model can be updated as new information becomes available; however, preliminary output includes imagery, maps, data tables and 3D model viewer files.

### 6.2.1 Review of Existing Wells

GW Solutions began the assessment of aquifer boundaries by reviewing existing wells from the provincial wells database. There are approximately 500 wells in the database in the Tsolum River watershed. Most of the deeper wells are located on the east side of the Tsolum River and deepen towards the ocean.

Figure 9 shows the location of the water wells within the Tsolum Watershed by completion depth.

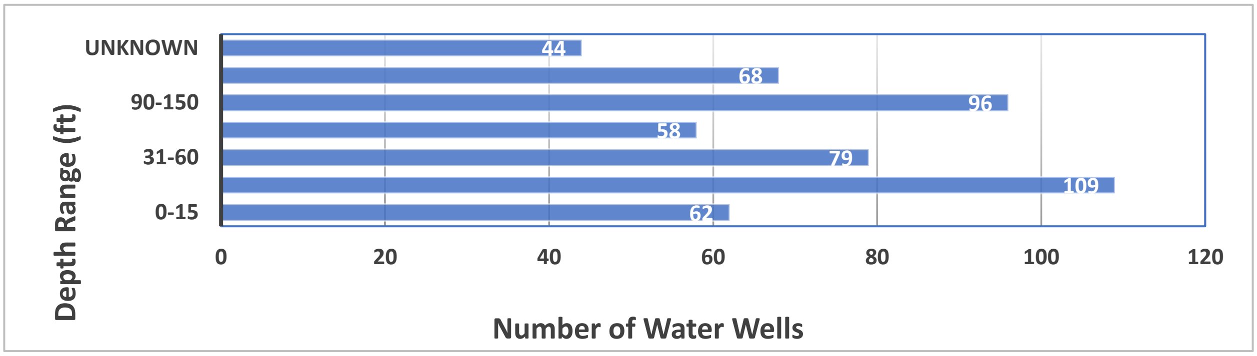


*Figure 8: Number of water wells by depth range*

As summarized in Figure 8 there are approximately 500 water wells within the watershed and approximately 50% are completed at a depth less than 20 m (60 feet). In conducting this work, GW Solutions found that most of the watershed's wells draw from surficial (i.e. non-bedrock) units comprising relatively thin intervals of water-bearing sand and gravel.

High salinity groundwater was noted in nine wells within the Tsolum watershed. The majority of these were drilled into bedrock (sandstone and shale) and occur west of the Tsolum River mainstem. It is notable that saline water was encountered at various elevations in these wells, not necessarily below sea level, and at considerable distances from the ocean (up to 11 km inland).

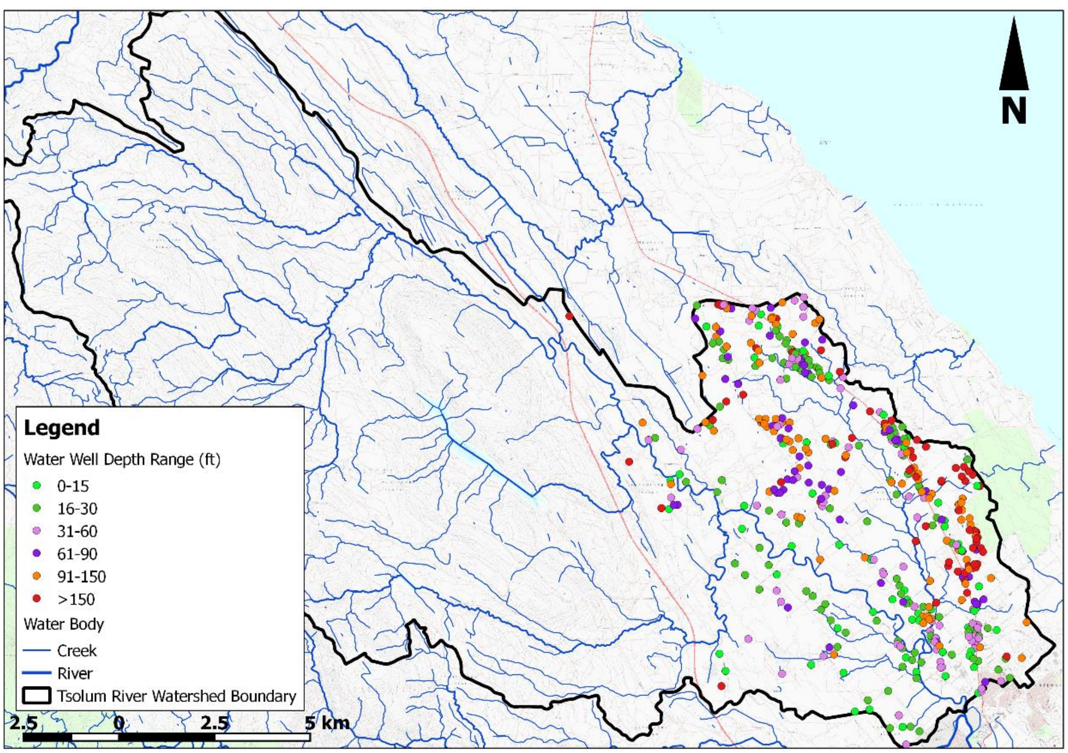


*Figure 9: Water wells within Tsolum River watershed categorized by depth*

Below are examples of this evidence for salty groundwater occurrence, from driller's descriptions:

- Well Tag # 96395: “shale bedrock | salt water encountered @ 111'”
- Well Tag # 41794: “grey shale - occasional coal stringer|saline water @ 340FT|note: 20GPD of saline |water encountered”

### 6.2.2 Hydraulic Gradients

When a well is installed in a confined or pressurized aquifer, the groundwater typically rises up the well casing to a certain height, known as the static water level, or piezometric level. If the groundwater rises to the ground surface, this is known as a flowing, or artesian well. The hydraulic or piezometric level is a surface of liquid pressure of groundwater above a datum, e.g. mean sea level. The difference in piezometric levels divided by the distance where these levels are measured defines the hydraulic gradient.

The following assumptions were made about the available data on groundwater elevations in the Tsolum River watershed;

- Static water levels measured in wells at the time of drilling are a reasonable proxy for aquifer piezometric level, given the “watershed scale” of this study.
- Static water levels were classified according to probable aquifer type: bedrock; shallow or deep, confined aquifers.
- Flowing wells and Licensed springs indicate areas where vertical hydraulic gradients are directed upwards and where there is a greater potential for groundwater to contribute to surface water flows.

### 6.2.3 Results of Aquifer Boundary Assessment

Most of the watershed’s wells draw from surficial (i.e. non-bedrock) units comprising relatively thin intervals of water-bearing sand and gravel. Out of approximately 500 reported wells with lithology information within the watershed:

- 470 are completed in a surficial aquifer, approximately;
- 15 are completed in a bedrock aquifer, approximately.

Integration of standardized WELLS data into a 3-dimensional model resulted in the recognition of two distinct surficial, sand and gravel aquifers present east of the Tsolum River. One is a previously unmapped, confined aquifer that they refer to herein as the Tsolum Aquifer “TS-2”, extending from the Black Creek area south to the lower Tsolum River between the Portuguese Creek and Tsolum River mainstem. GW interprets this as distinct from the mapped Aquifer #408, which extends from Comox Harbour to Black Creek peninsula and is comprised of a Quadra deposit. The Tsolum Aquifer is confined and is characterized by sand and gravel lenses within glacial till. Driller’s note the prevalence of a gravel texture to the aquifer, in contrast to the Quadra deposit and aquifer, which is a more uniform, fine to medium, grey sand. In several areas, this aquifer lays above Aquifer 408.

The wedge of unconsolidated sediment is thickest near the Strait of Georgia, thins considerably west of the Tsolum River and pinches out along the mountain front. Correspondingly, aquifer potential west of the Tsolum River is reduced to localized sand and gravel lenses within till, or within the underlying bedrock.

Figure 10, Figure 11, and Figure 12 present the delineated aquifer of “Tsolum Aquifer TS-2” and the refined boundary of Aquifer #408 with different directions of cross-section, across and along the Tsolum River.

Figure 13 shows a "zoomed in" scene to the groundwater level of available boreholes. The water level within the flowing wells is highlighted by purple.

Observation of flowing wells is important because according to the new Water Sustainability Act, all artesian wells must be under control; "uncontrolled overflow is not permitted".

BC MOE is currently maintaining/managing an aquifer map database. To integrate the new mapped aquifers and modify the extent of Aquifer 408 within the MOE database, certain fields have to be populated/estimated (i.e. vulnerability, productivity).

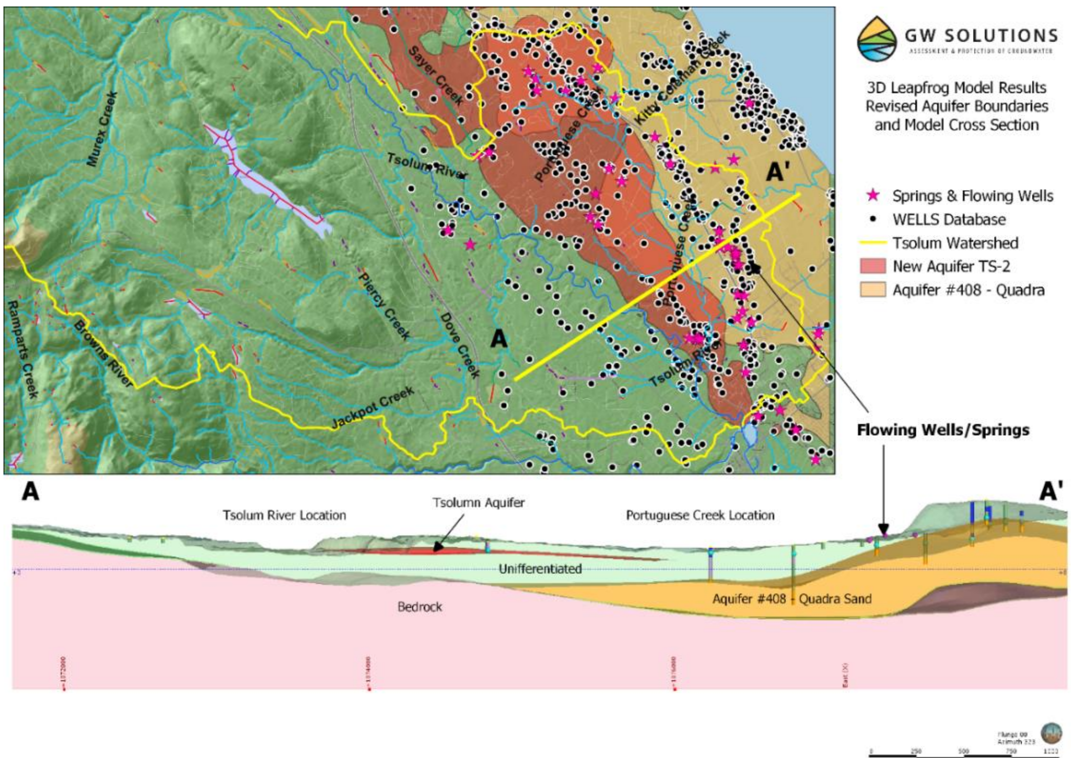


*Figure 10: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek and Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions*

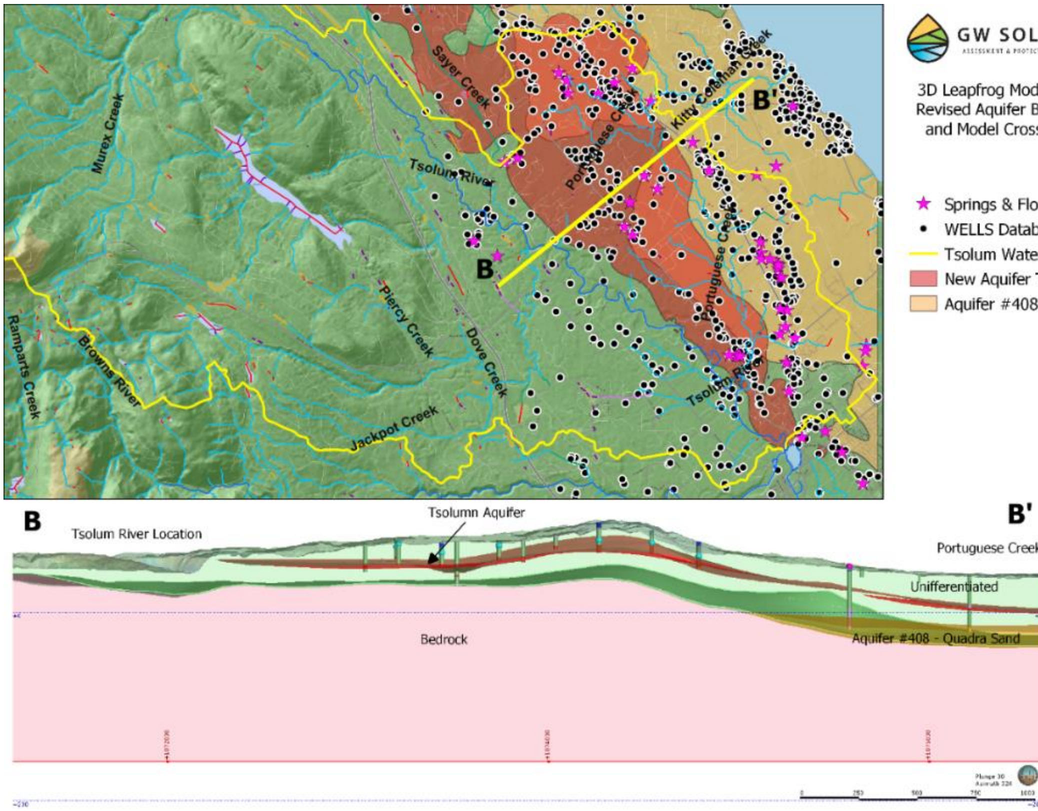


*Figure 11: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek and Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions*

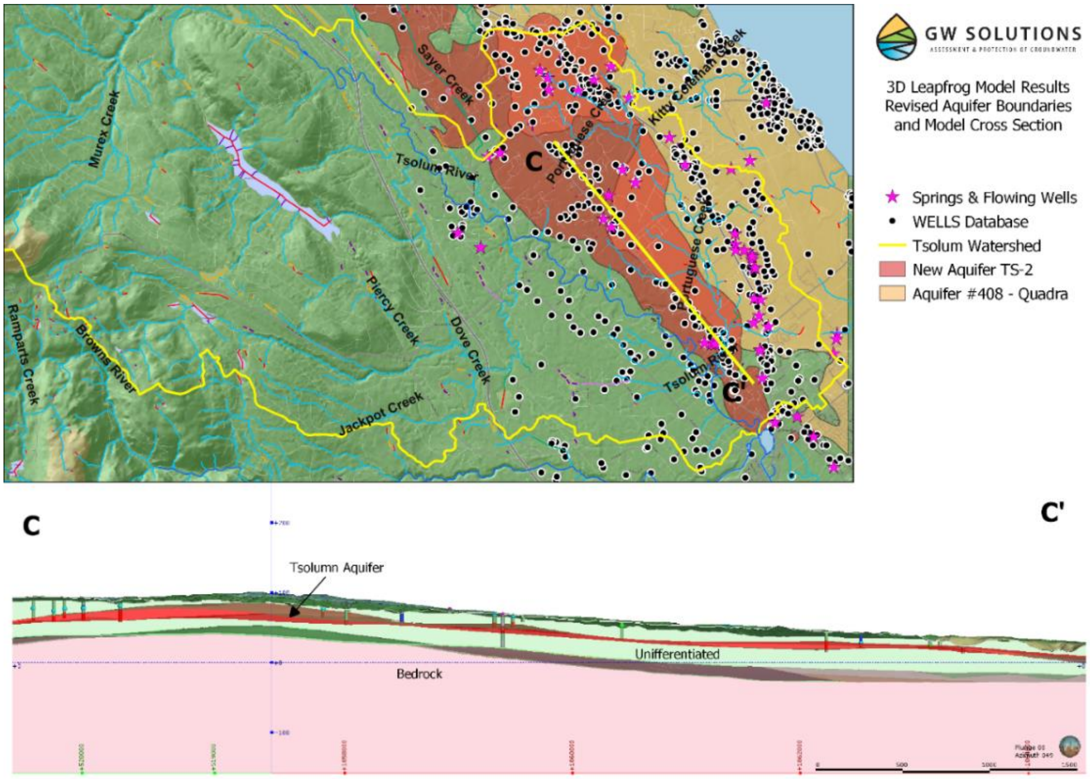


*Figure 12: Map of delineated/refined aquifer boundaries and a cross-section along Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions*

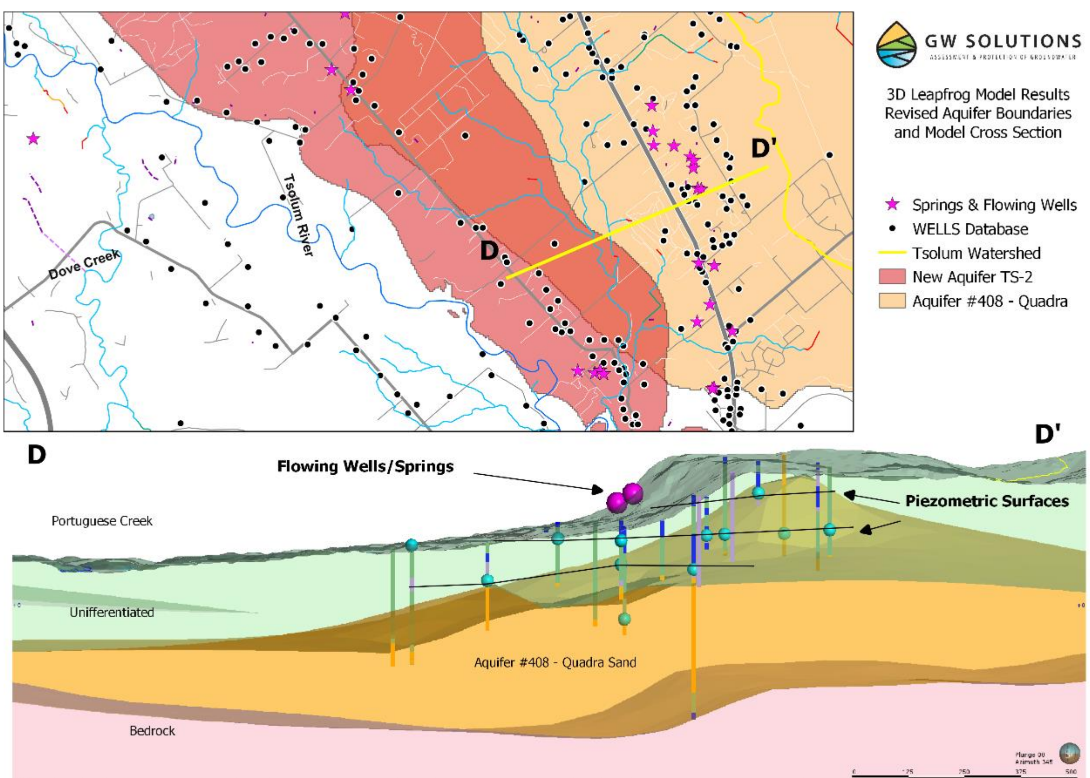


*Figure 13: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek, inferred from developed 3D Leapfrog model by GW Solutions - Zooming in the groundwater level of the water wells and water level in artesian condition*

### 6.2.4 Groundwater Movement

The spatial distribution of flowing wells and springs in the Tsolum River watershed illustrate the interaction between aquifers and topography. Results show that the Portuguese Creek sub-watershed has the highest concentration of springs and flowing wells. These findings suggest that groundwater contribution to Portuguese Creek flows is relatively high. Isolated springs and flowing wells occur within the Tsolum River watershed, near the mountain front and along the east bank.

There is also evidence to suggest that in the lower Tsolum there are areas where groundwater contributes to streamflow in dry summer months. In the drought of 2015, provincial government staff were monitoring stream flows and temperatures along the Tsolum and found particularly cool stream temperatures in the lower Tsolum, indicating a likely groundwater contribution (Szczot, 2018). Groundwater is always at a constant temperature equal to the average air temperature; therefore, groundwater has the benefit to warm up surface water during the winter and to cool it during the summer months.

## 6.3 Groundwater Levels

The provincial government maintains a network of observation wells, used to monitor water levels and quality. Although there is no observation well within the study area, there is one active observation well (OW351) and two abandoned observation wells (OW280 and 285) completed in aquifer 408IIC. The locations of observation wells around the study area is presented in Figure 14.

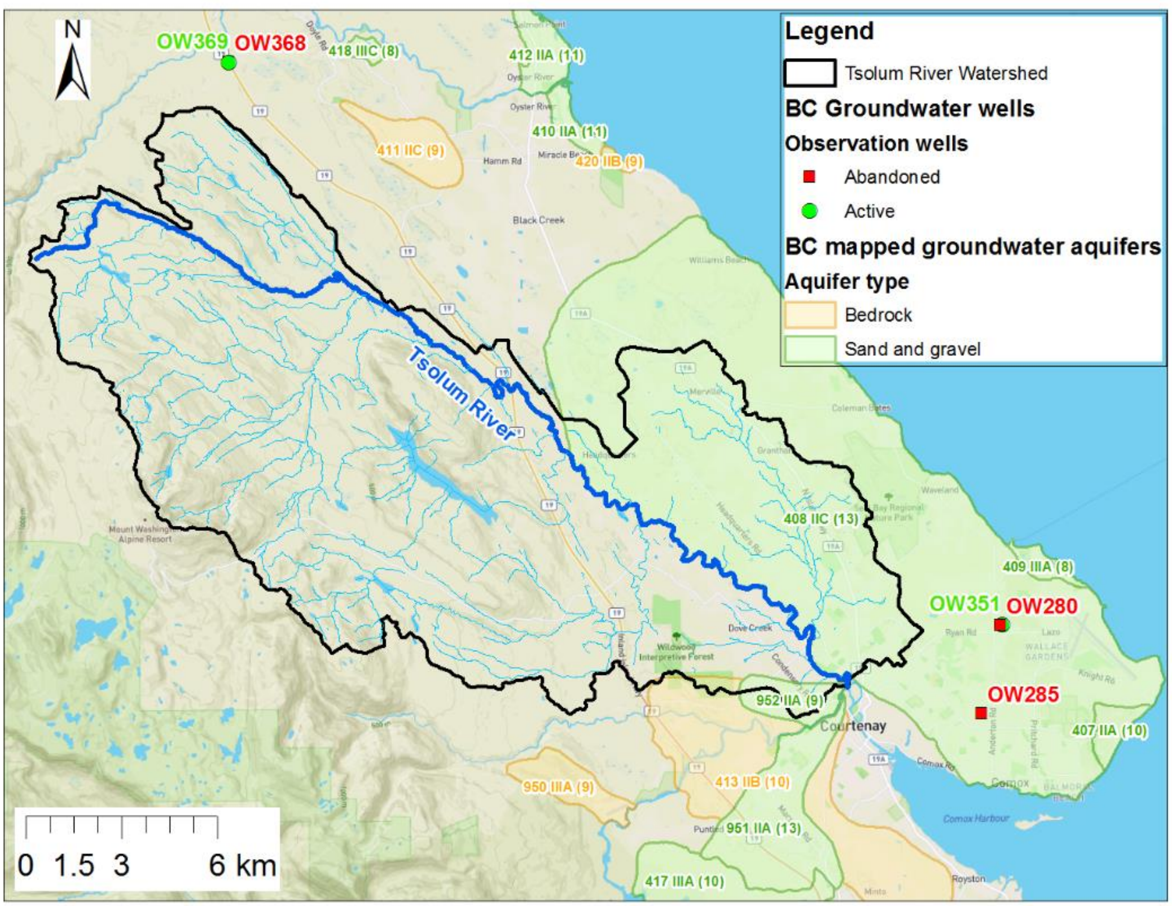


*Figure 14: Location of BC observation wells within/around the Tsolum River watershed*

The water elevation and depth to water for OW351 is shown in Figure 15. Water level data has been collected since 2001 and this well is active. The water level indicates a slightly increasing trend at a rate of 3.0 cm/year.

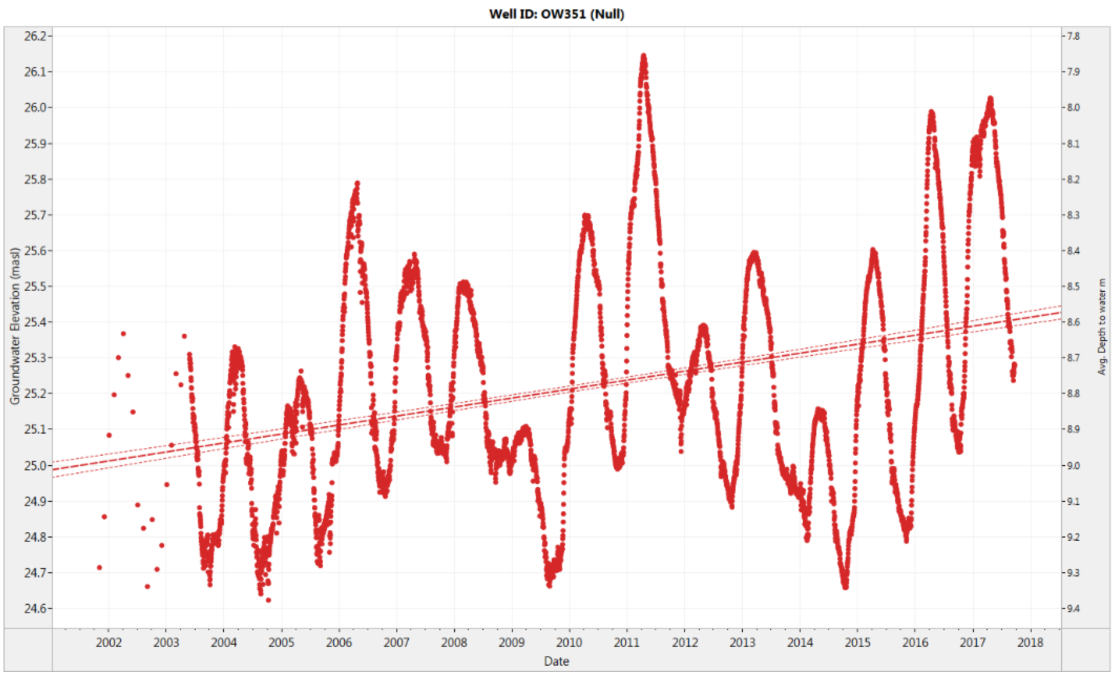


*Figure 15: Water level elevation and depth to water for observation well 351*

Figure 16 shows the monthly historical water level fluctuation. The lowest water table is observed between August and October and the highest level between February and May with an average amplitude of 0.5 m (from low to max water level).

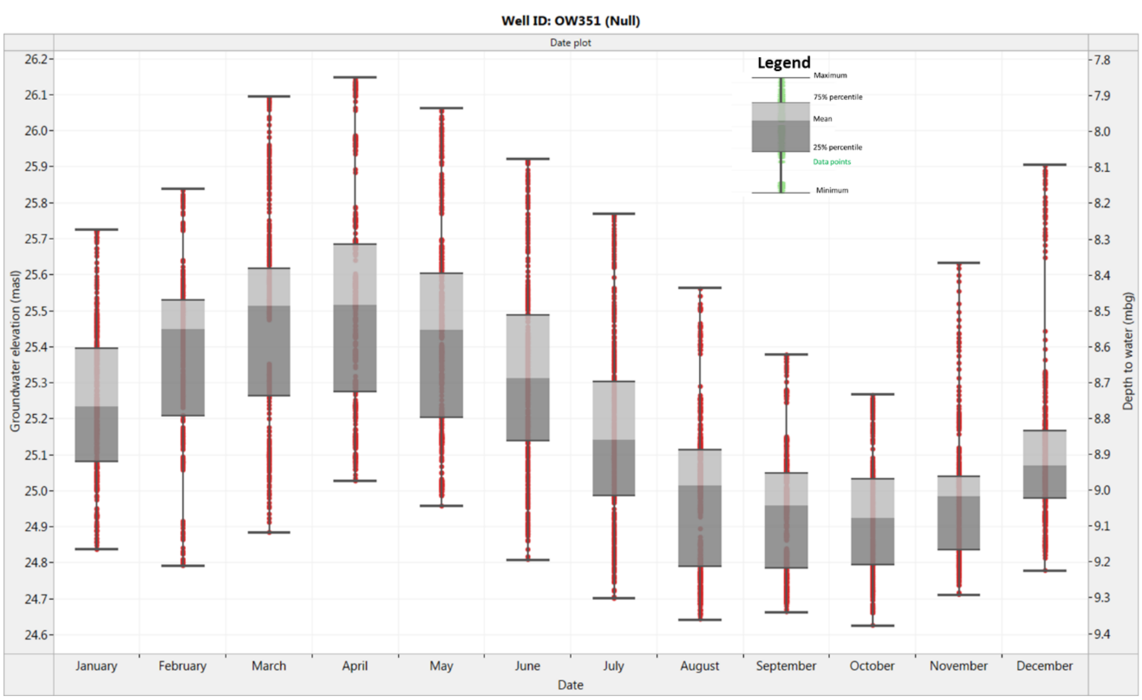


*Figure 16: Water level monthly summary for observation well 351*

# 7 Water Uses and Values

In the Tsolum watershed, residents and businesses use surface water and groundwater for a range of purposes. Below is a description of the ways that humans use surface water and groundwater throughout the watershed. This is followed by an in-depth analysis of current and future agricultural water needs.

## 7.1 Surface Water Use

To use water from surface water and springs in the province of BC, a person is legally required to hold a water license. Figure 17 shows the locations of water licenses for surface water and springs within and near the Tsolum River watershed, classified by source (spring and surface water).

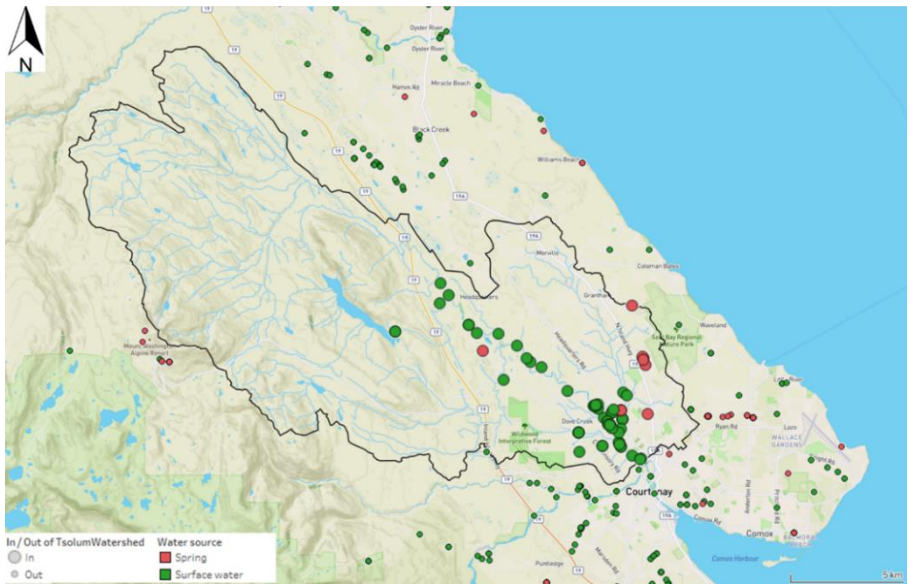


*Figure 17: Points of Diversion (POD) within/near the Tsolum Watershed*

Some of these licenses are no longer in use. Figure 18 shows the location of the surface water 'points of diversion' (PODs) within the study area classified by license status (current, abandoned licenses, abandoned applications and refused applications).

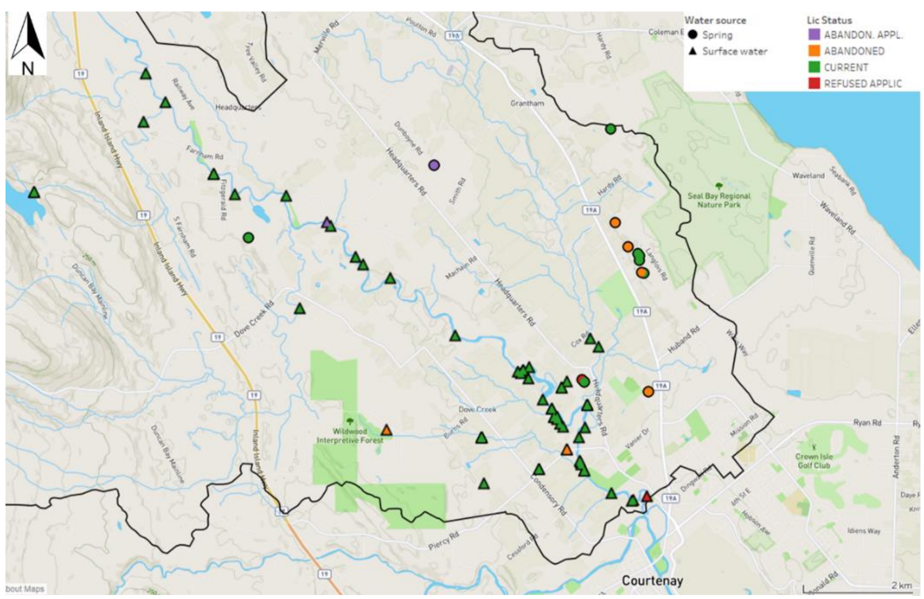


*Figure 18: Points of diversion licenses (POD) within the Tsolum Watershed classified by license status*

It is important to note that not all water licenses that have a 'current' status may actually be used. Some property owners may not even be aware that there is a surface water license on their property. Others may still have a 'license' but have stopped using the river water because it wasn't a consistent source, the river moved, or they had an issue with the piping and are now actually getting their water from a well. As part of the updates to BC's water laws, under the new Water Sustainability Act (2016), water license holders will now be required to prove that they are using the water, called 'beneficial use', in order to maintain their water license. Beneficial use is described as using the water for the purpose and in the quantity described in the license/approval and using the water efficiently.

Figure 19 shows the number of licenses within the watershed classified by purpose, use and sources. There are 67 current licenses within the study area, of which 56 correspond to surface water and 11 to springs. Within the current surface water licenses, most of them correspond to irrigation (30 licenses) followed by domestic use (18 licenses); whereas, for springs, 80% of the licenses are for domestic use.

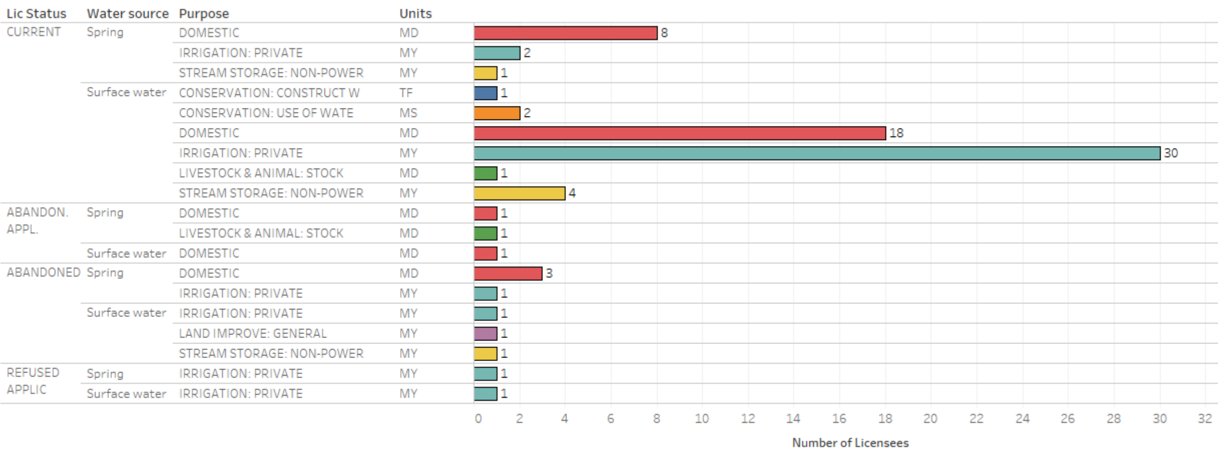


*Figure 19. Number of licenses for water extraction (POD) classified by use within Tsolum River Watershed*

Table 4 shows the total amount of surface water licensed in the Tsolum River watershed based on the type of water use, or ‘licensed purpose’. It identifies whether the water use is consumptive (withdrawn from the river and not entirely returned to the river) or non-consumptive (withdrawn from the river and then returned to the river – much like the water that is stored at the Wolf Lake dam to be released back to the river later in the summer). Overall, 554,521m$^3$/year of surface water is licensed for consumptive purposes and 285,230,977m$^3$/year of water is licensed for non-consumptive purposes (almost all of which is for a water licence, held by the Department of Fisheries and Oceans, for Conservation purposes to maintain flows in the Tsolum River in late summer). It is important to note that this only quantifies the amount of surface water used, and does not include the amount of groundwater use (estimated to be approximately 1,882,506m$^3$/year, as described in 7.2 Groundwater Use). Using these estimates, surface water use accounts for approximately 23% of total water use in the watershed.

*Table 4: Amount of Surface Water Licensed (m$^3$/year) by Purpose/Use*

| Licensed Purpose | Licensed Amount (m3/year) | Consumptive |
|---|---|---|
| **CONSERVATION: CONSTRUCT WORKS** | 0 | NO |
| **CONSERVATION: USE OF WATER** | 281,269,584 | NO |
| **DOMESTIC** | 30,698 | YES |
| **IRRIGATION: PRIVATE** | 520,099 | YES |
| **LIVESTOCK & ANIMAL** | 160 | YES |
| **LIVESTOCK & ANIMAL: STOCKWATERING** | 3,723 | YES |
| **STREAM STORAGE: NON-POWER** | 3,961,393 | NO |
| **Total** | 285,785,659 | |

Figure 20 shows the Tsolum River consumptive surface water usage by purpose; 94% of the water is used for irrigation, 5.5% is used for domestic and the remaining (<1%) for livestock.

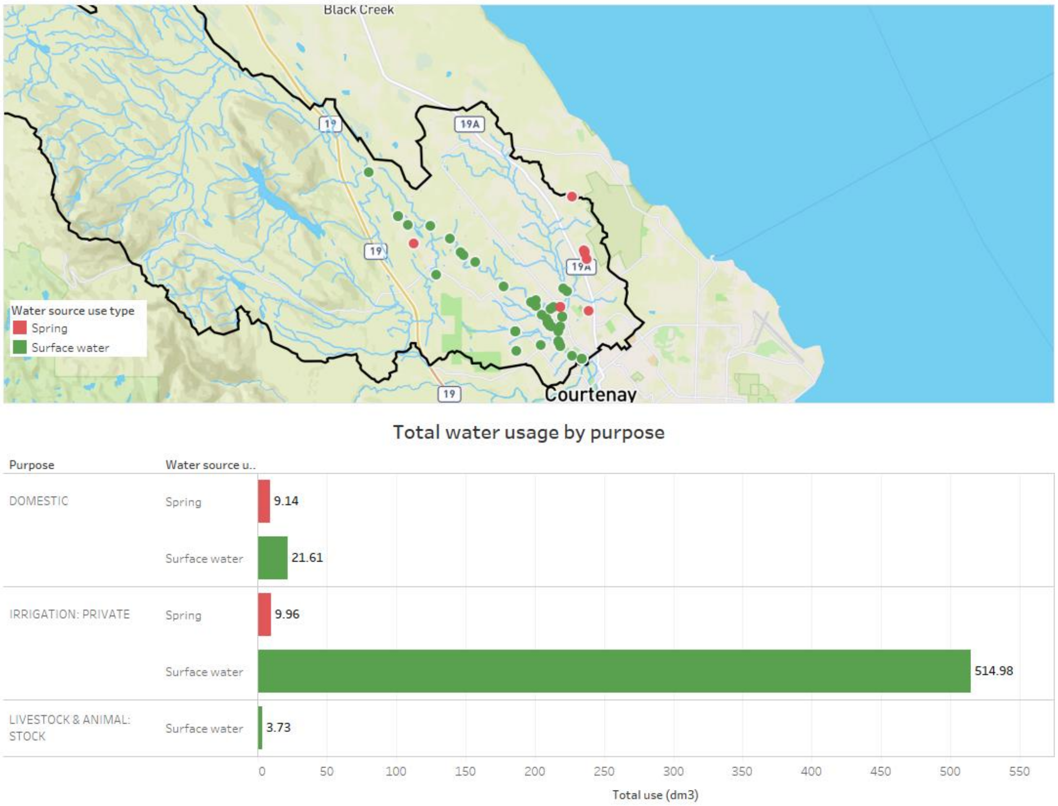


*Figure 20: Total monthly licensed volumes by purpose: domestic, irrigation and livestock (total use in cubic decameter-dm3)*

### 7.1.1 Seasonal Variations in Water Use

Much like it is important to understand seasonal variations in streamflow in the Tsolum River watershed, it is also important to understand seasonal variations in water use in the watershed. In the winter there is a large amount of water available, but in the summer there is much less water and many more people and animals wanting to access it.

Currently, there is no metering or measuring of water use in the Tsolum River watershed, so in order to better understand water management concerns in the Tsolum watershed, the team estimated monthly variations in water use, using licensed water volumes as a proxy for actual water use.

To do this, each month was assigned a monthly water use ‘coefficient’ based on the type of use. For example, an irrigation user would likely use 0% of their yearly water allocation in January, 10% in May, and 30% in August. Table 5 summarizes the monthly coefficients. These coefficients are estimates of monthly variations in water use based on research, consultation with industry experts, and metering data (where available).

*Table 5. Monthly allocation coefficients for estimated water usage from PODs*

| Purpose | Consumptive? | YEAR TOTAL | JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER | NOVEMBER | DECEMBER | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CONSERVATION: CONSTRUCT W** | NO | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| **DOMESTIC (WSA01)** | YES | 12 | 0.85 | 0.85 | 0.85 | 0.85 | 0.95 | 1.00 | 1.50 | 1.50 | 1.10 | 0.85 | 0.85 | 0.85 | Domestic usage - Nanaimo |
| **CONSERVATION: USE OF WATE** | NO | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| **LIVESTOCK & ANIMAL: STOCK** | YES | 12 | 0.85 | 0.85 | 0.85 | 0.85 | 0.95 | 1.00 | 1.50 | 1.50 | 1.10 | 0.85 | 0.85 | 0.85 | Assumed same as domestic |
| **STREAM STORAGE: NON-POWER** | NO | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| **IRRIGATION: PRIVATE** | YES | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20 | 2.40 | 3.60 | 3.60 | 1.20 | 0.00 | 0.00 | 0.00 | AWDM |
| **DOMESTIC** | YES | 12 | 0.85 | 0.85 | 0.85 | 0.85 | 0.95 | 1.00 | 1.50 | 1.50 | 1.10 | 0.85 | 0.85 | 0.85 | Domestic usage - Nanaimo |

The coefficients were then applied to each of the water licenses in the watershed. Figure 21 shows the total monthly licensed volumes in cubic decameters (1dm$^3$ = 1000m$^3$) for all the licenses within the Tsolum

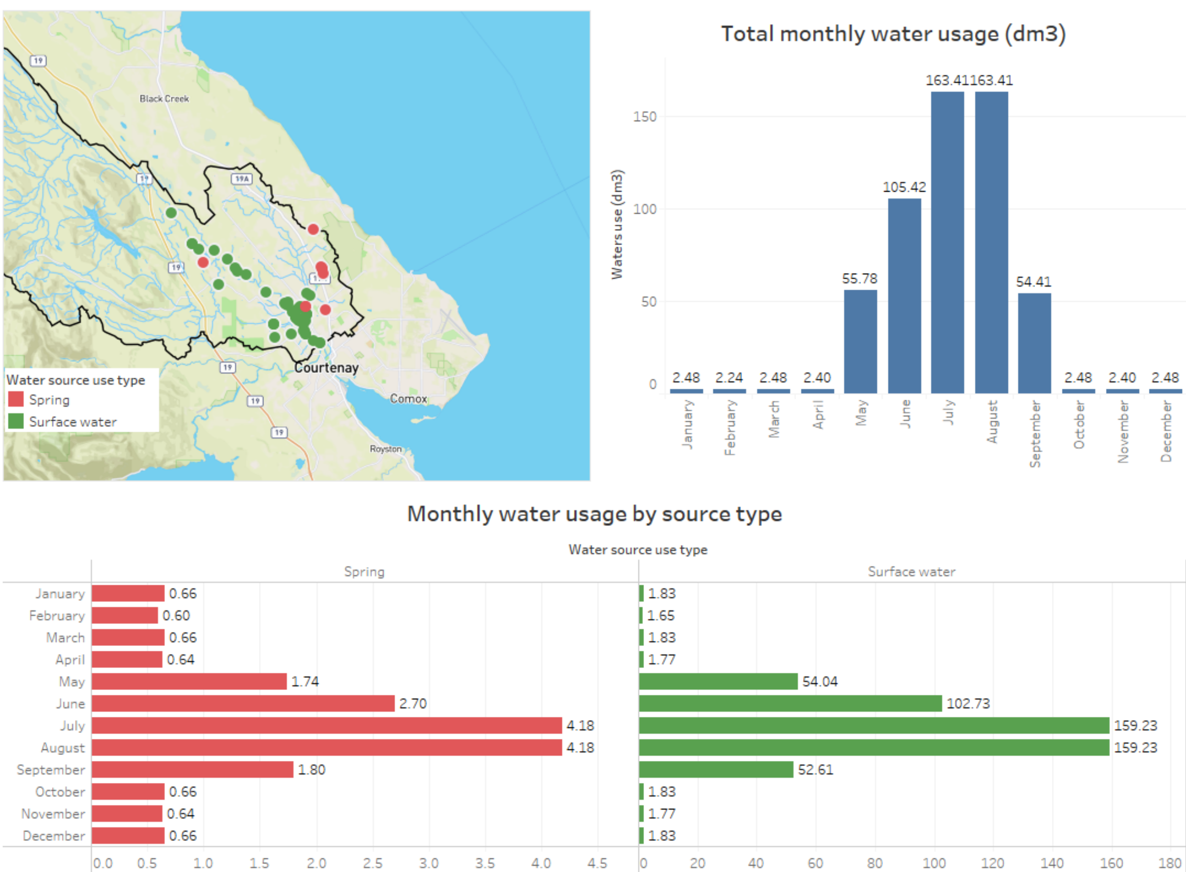


*Figure 21: Total monthly licensed volumes by source: spring and surface water*

River watershed. As shown in Figure 21, July and August are the months with largest water licensed use. 97% of the licensed use corresponds to surface water bodies, mostly from the Tsolum River, while 3% is from springs.

Figure 22 summarizes water usage by waterbody.  Most of the water is extracted from the Tsolum River (92% of the total water usage) followed by Carwithen Swamp (2.8%), Mattoon Spring (1.6%) and Forsyth Creek (1.4%).  The water usage from the other waterbodies is recorded at less than 1% of the total water usage.

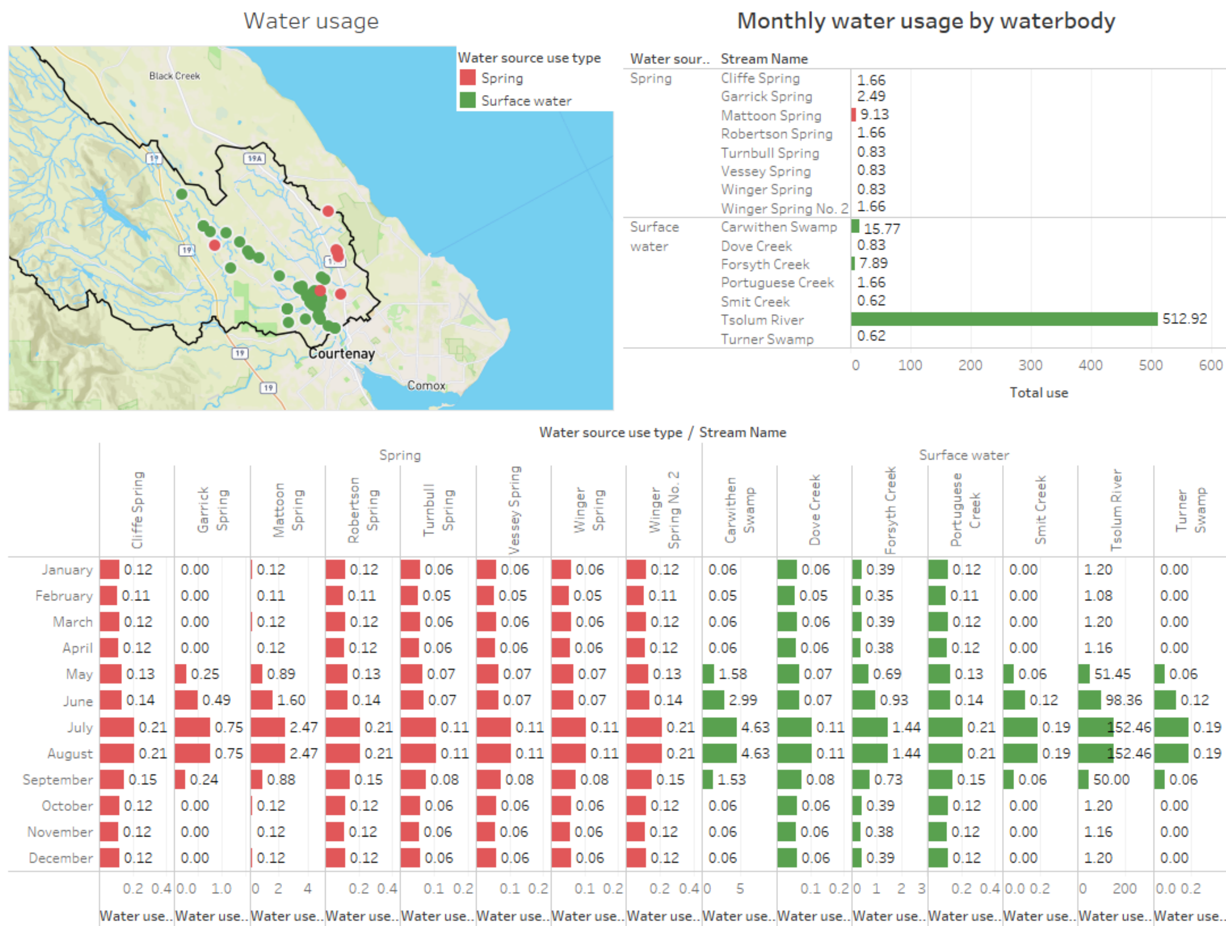


*Figure 22: Total monthly usage by waterbody*

### 7.1.2 Future Surface Water Use

The Provincial government has set restrictions on how much water can be taken out of the Tsolum River. In 1953 a Water Allocation Restriction was placed on the Tsolum River (Ministry of Forests, Lands, and Natural Resource Operations, 2016). A water allocation restriction is a water management tool that Ministry of Forests, Lands and Natural Resource  Operations (FLNRO) staff may use on a stream or an aquifer to alert other staff to current or potential water allocation concerns, ranging from a possible water shortage to fully recorded with limitations on further licensing.

Because flows are so low in the summer, surface water is only available to be taken out of the watershed during the months of October through May when the mean monthly discharge is above 60% MAD (Riddell & Bryden, 1996). The watershed is fully recorded with the exception of domestic users or if a license application is supported by storage.

If someone is interested in obtaining a surface water license in the Tsolum River watershed, they must create storage to capture the water in the winter if they want to use it in the summer. If an existing user is interested in withdrawing more water from the river, they are required to develop storage to store the water during the rainy season.

There is considerable flow available in winter months which is allowed to be stored to support water demands during summer months.

Several local watersheds also have periods of low flow in which water is not allowed to be extracted. Although the Tsolum River has a 4-month low flow period, several local watersheds have longer low flow periods and have even greater restrictions on use.

## 7.2 Groundwater Use

Many water users in the Tsolum River watershed obtain their water from groundwater wells. Although the provincial government has a database containing information on wells, it does not identify how much water is pumped from these wells. The wells database is also limited in that it does not identify all wells in the province, because until 2016, well drillers were not required to submit well records.

To estimate groundwater use for domestic and industrial, institutional, and commercial users, GW Solutions combined information from the Cadastral data-BC Assessment and the wells database. Groundwater usage was estimated based on the location of the well, property use, and size of property. To estimate groundwater use for agricultural users, the Agricultural Water Demand Model results were used (as described in 7.3 Agricultural Water Use).

Groundwater use for water supply system wells was calculated separately because the water usage of these wells depends on the number of connections. To estimate groundwater use for water supply wells, GW used data from groundwater source approvals available in a Vancouver Island Health Authority database.

Figure 23 below shows the location of wells with the study area classified by use and status type. Water wells have been classified by use in seven groups based on cadastral information: Water Supply System, Recreational, Irrigation, Institutional, Industrial, Domestic, and Commercial. This figure also shows the number of water wells considered for each type of use. Most of the active water wells are used for domestic or irrigation purposes (278 and 171 water wells, respectively).

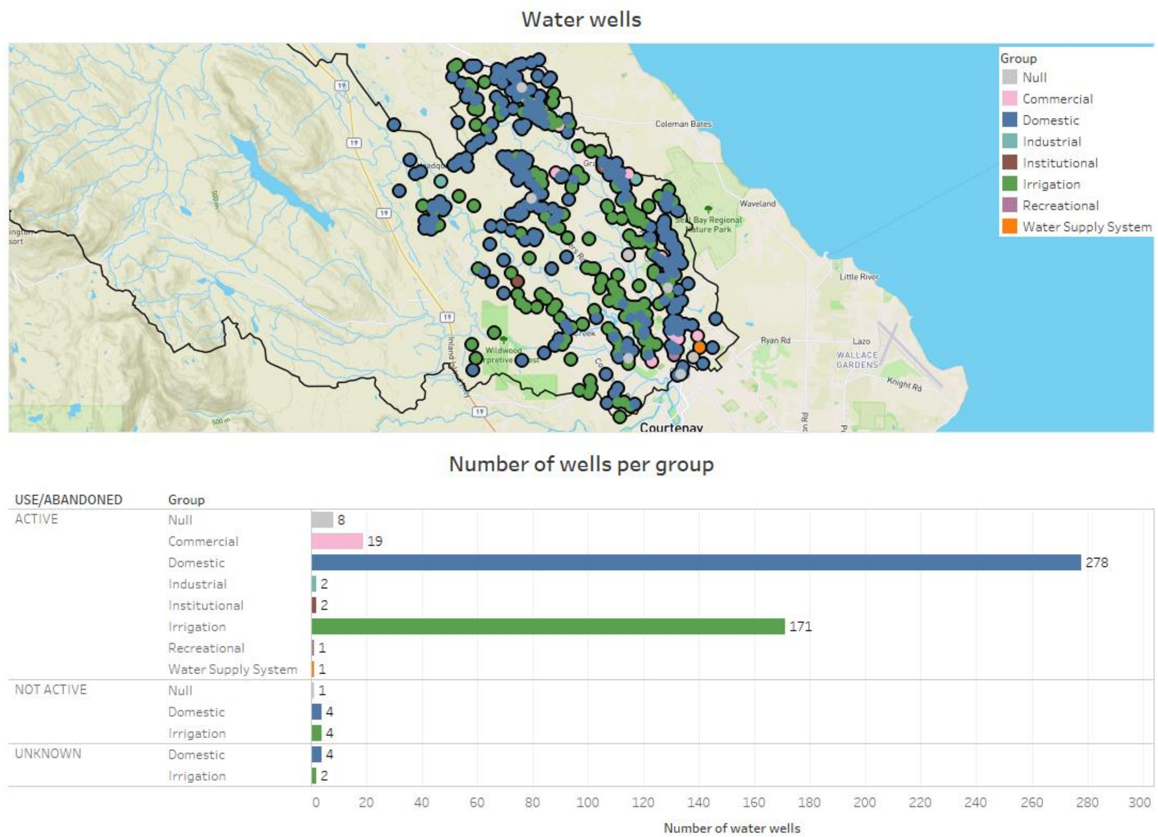


*Figure 23. Number of water wells by status and use*

To estimate water use from non-agricultural wells, only active wells were considered. The full methodology for this work is described in Appendix A.

Figure 24 summarizes the total estimated groundwater use classified by use type. Most of the groundwater wells within the Tsolum River watershed are used for irrigation purposes with 84% of the total groundwater use going to irrigation, followed by domestic and industrial use with 1.6% and 1.8%, respectively.

According to the Vancouver Island Health Authority (VIHA) data, there are seven water supply systems wells within the study area totalling a groundwater usage of 2.7 $dm^3$. These well locations and usage information are also shown Figure 24.

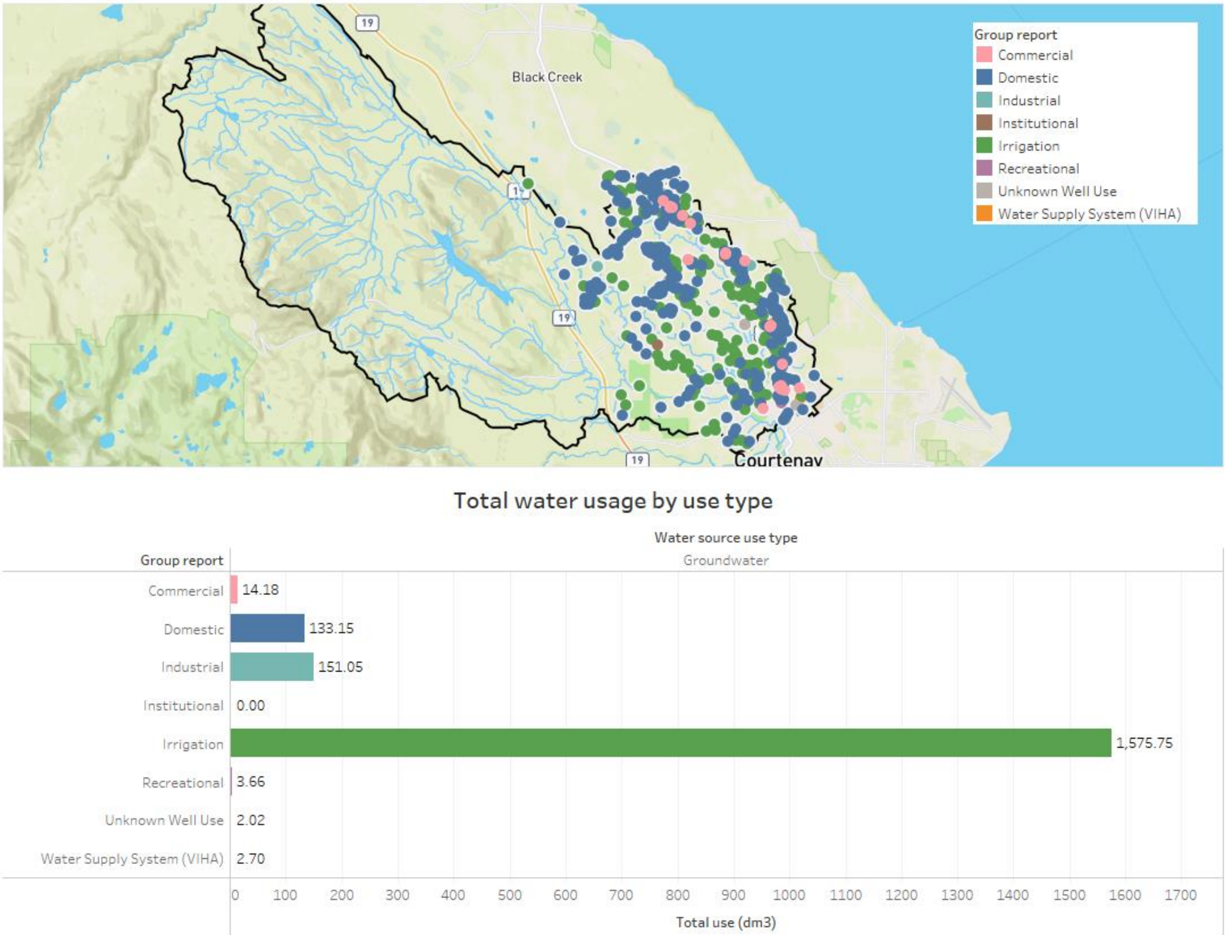


*Figure 24: Total groundwater usage classified by type of use (total use in cubic decameter-dm³)*

### 7.2.1 Future Groundwater Use

The K'omok's First Nation (KFN) is currently in treaty negotiations with the Government of Canada and British Columbia. To date, the KFN has negotiated an agreement for access to surface water on the nearby Puntledge River. Access to freshwater is a very important part of treaty negotiations as access to water impacts the KFN's economic future. A reliable supply of clean, fresh drinking water will allow the KFN to develop their lands and build businesses, housing and infrastructure. The KFN has not yet negotiated an agreement for access to surface water but may be interested in obtaining access to groundwater in the Tsolum River watershed (M. Horton, personal communication, January 9, 2019).

In the future, water license applicants may be required to show that their groundwater license application does not reduce instream flows needed for aquatic life (J. Szczot, personal communication, June 11, 2018).

## 7.3 Agricultural Water Use

As noted earlier, agriculture is a major user of water in the Tsolum River watershed. It is likely that agricultural water needs will increase in the future with climate change and increased agricultural activity. To better understand current and future agricultural water needs, the CVRD partnered with the Ministry of Agriculture in 2014 to conduct a detailed assessment of agricultural water demand in the CVRD (Gulik, Neilsen, Fretwell, & Tam, 2014).

The assessment of agricultural water use was conducted using the Agricultural Water Demand Model (AWDM). This is a tool developed by the Ministry of Agriculture with the Partnership for Water Sustainability of BC. The Model calculates irrigation and livestock watering needs on a property-by-property basis and sums each property to obtain an estimate of the following for the entire basin:

1. Total surface water used for irrigation
2. Total groundwater used for irrigation
3. Total livestock watering needs.

The CVRD and Ministry of Agriculture began this work by conducting an Agricultural Land Use Inventory (ALUI). This inventory, completed in 2013, identified the type of crop grown and type of irrigation system used (if any) on all farmed and ALR parcels in the CVRD (Ministry of Agriculture, 2013).

Next, the Agricultural Water Demand Model was used to estimate current and future water needs. The AWDM combines information from the Agricultural Land Use Inventory with data on soil texture and climate to calculate daily water demand on each parcel. It estimates daily water demand for both a typical hot and dry year (similar to 2003) and a wet and cool year (similar to 1997). The AWDM then sums the water use by watershed, aquifer, and area. A full description of the technical work and detailed calculations can be found in the online report "Agriculture Water Demand Model: Report for the Comox Valley Regional District" (Gulik, Neilsen, Fretwell, & Tam, 2014).

The CVRD and Ministry of Agriculture used the AWDM to identify agricultural water needs under four different scenarios:

- Scenario '0': Current conditions (current climate, current amount of farming)
- Scenario 1: Climate Change
- Scenario 2: Increased Agriculture Activity ('Buildout')
- Scenario 3: Increased Agriculture Activity AND Climate Change

To support the Tsolum River watershed planning process, in 2017 the CVRD requested that these scenarios be run specifically on the Tsolum River watershed. This section provides an overview and analysis of the results for the Tsolum River watershed.

### 7.3.1 Scenario '0': Current Conditions

Currently, relatively little of the agricultural land in the Tsolum River watershed is irrigated. Only 423 ha, or 20% of the 2158 ha of farmed land in the watershed is described as having an irrigation system in place. The predominant crop type in the watershed is forage and the predominant irrigation system used (74%) is travelling guns.

Table 6 below shows that the estimated annual irrigation demand for the watershed using historic climate data for 1997 (a relatively cool, wet year) and 2003 (hot and dry). The AWDM estimates that under current conditions, producers use an average of 2,321,812 $m^3$ of water per year for irrigation and stockwatering. In dry years, the model estimates that producers may use as much as 3,170,941$m^3$ of water.

During a wet year like 1997 irrigation use is only 46% of the amount of water that may be used in a hot dry year like 2003.

*Table 6: Estimate of Current Agricultural Water Demand from AWDM ($m^3$/year)*

| Year | Irrigation Water Use by Sub-watershed (m3/year) | | | Livestock Demand | Average Irrigation demand (surface water) | Average Irrigation demand (groundwater) | Average Total Demand (inc livestock) | Max Demand (inc livestock) |
|---|---|---|---|---|---|---|---|---|
| | Sub-watershed | Surface water | Groundwater | | | | | |
| **1997** | Portuguese Creek | | 772,778 | 51,713 | | | | |
| | Tsolum River Mainstem | 419,423 | 228,769 | | | | | |
| | TOTAL | 419,423 | 1,001,547 | | | | | |
| **2003** | Portuguese Creek | | 1,703,986 | | | | | |
| | Tsolum River Mainstem | 969,283 | 445,959 | | | | | |
| | TOTAL | 969,283 | 2,149,945 | | | | | |
| **Average** | | | | | 694,353 | 1,575,746 | 2,321,812 | 3,170,941 |

It is important to note that these numbers are estimates and the actual water demand supplied by an irrigation system may be less or more than the numbers shown above.

One of the reasons that the actual water use may be slightly lower is that the Model does not have an adjustment for water supplied to crops grown in low lying areas with a high water table. In portions of the Tsolum River watershed, farms located in the lowland regions have high water tables during portions of the growing season. The high water tables will reduce irrigation demand which is not accounted for in the Model outputs. The Model numbers should therefore be considered the higher estimate of demand.

The model also assumes that producers are using average irrigation practices. If farmers are over-watering, than water demands may actually be higher. Similarly, if farmers are using highly efficient irrigation practices, then water use may actually be lower.

### 7.3.2 Scenario 1: Climate Change

In the coming years, climate change will impact the agricultural sector in BC. Although producers are accustomed to adjusting their practices to manage through changing weather and difficult conditions, the scope and scale of climate change is anticipated to exceed anything previously experienced (Crawford & McNair, 2012).

#### *7.3.2.1 Predicted Climate Change Impacts*

Scientists are predicting that we will see the following changes on Vancouver Island in the coming years (Crawford & McNair, 2012):

- Overall, higher temperatures

- Increased winter precipitation and decreased summer precipitation (with a decrease in snowfall and increase in rainfall in the winter)
- Increased extreme conditions:
    - Increased magnitude, frequency, and intensity of extreme events (flooding, drought)
    - Increased risk of wildfires
    - Drier conditions in summer and more hot summer days

As winter snowpack levels in the headwater mountains decrease and winter rains increase, the Tsolum River system is likely to shift to a more rain-driven streamflow pattern. This will make stream flows less predictable, and likely lead to earlier and greater spring flows and potentially higher winter flows (Crawford & McNair, 2012). Increased wet season precipitation may positively impact groundwater recharge in the region, but lower summer precipitation, coupled with warmer temperatures (and increasing evaporation rates for surface water), mean that summer streamflow levels may become lower and flows less reliable (Crawford & McNair, 2012).

Figure 25 summarizes the expected changes to conditions, as described by the Plan2Adapt, a tool developed by the Pacific Climate Impacts Consortium, to help local governments assess climate impacts in their region (Pacific Climate Impacts Consortium, 2018).

**Summary of Climate Change for Comox Valley in the 2050s**

| Climate Variable | Season | Projected Change from 1961-1990 Baseline | |
|---|---|---|---|
| | | Ensemble Median | Range (10th to 90th percentile) |
| Mean Temperature (°C) | Annual | +1.5 °C | +0.9 °C to +2.3 °C |
| Precipitation (%) | Annual | +6% | -2% to +11% |
| | Summer | -17% | -26% to +2% |
| | Winter | +5% | -4% to +14% |
| Snowfall* (%) | Winter | -36% | -55% to -19% |
| | Spring | -52% | -71% to -17% |
| Growing Degree Days* (degree days) | Annual | +342 degree days | +210 to +532 degree days |
| Heating Degree Days* (degree days) | Annual | -516 degree days | -786 to -321 degree days |
| Frost-Free Days* (days) | Annual | +23 days | +13 to +34 days |

*Figure 25: Climate Impacts in the Comox Valley: Source - Pacific Climate Impacts Consortium (http://www.plan2adapt.ca/)*

#### *7.3.2.2 Estimated Changes to Agricultural Water Demand*

With anticipated climate change, drier summer conditions will mean that more water is required. To predict potential increased irrigation needs under climate change, the AWDM was run using future climate scenarios. The model was run using 3 predictive climate model datasets provided by Pacific Climate Impacts Consortium for the years 2053, 2056 and 2059. Three climate models were chosen because it is difficult to know what the future will bring and using these three different models can give a better estimate. The years 2053, 2059, and 2056 were chosen because they are predicted to be the three driest years in the 2050's and should give a good indication of increased water needs. Three climate models were used so that an average could be created to get a more reliable trend. Table 7 shows potential agricultural water demand under changing climate.

*Table 7: Estimate of Agricultural Water Demand with Climate Change from AWDM (m3/year)*

| Year | Irrigation Water Use by Subwatershed (m3/year) | | | Livestock Demand | Average Irrigation Demand (surface water) | Average Irrigation Demand (groundwater) | Average Total Demand (inc livestock) | Max Demand (inc livestock) |
|---|---|---|---|---|---|---|---|---|
| | Subwatershed | Surface water | Groundwater | | | | | |
| **Climate Model #1: access1_rcp85** | | | | | | | | |
| **2053** | Portugese Creek | | 1,914,787 | 51,713 | | | | |
| | Tsolum River Main | 1,203,250 | 637,430 | | | | | |
| | TOTAL | 1,203,250 | 2,552,217 | | | | | |
| **2056** | Portuguese Creek | | 2,338,383 | 51,855 | | | | |
| | Tsolum River Main | 1,234,581 | 687,188 | | | | | |
| | TOTAL | 1,234,581 | 3,025,571 | | | | | |
| **2059** | Portuguese Creek | | 1,698,147 | 51,713 | | | | |
| | Tsolum River Main | 908,542 | 503,233 | | | | | |
| | TOTAL | 908,542 | 2,201,379 | | | | | |
| **Average of Climate Model #1** | | | | | 1,115,458 | 2,593,056 | 3,760,274 | 4,312,007 |
| **Climate Model #2: canesm2_rcp85** | | | | | | | | |
| **2053** | Portugese Creek | | 2,332,604 | 51,713 | | | | |
| | Tsolum River Main | 1,233,674 | 687,495 | | | | | |
| | TOTAL | 1,233,674 | 3,020,098 | | | | | |
| **2056** | Portuguese Creek | | 1,349,536 | 51,855 | | | | |
| | Tsolum River Mai | 724,799 | 405,421 | | | | | |
| | TOTAL | 724,799 | 1,754,957 | | | | | |
| **2059** | Portuguese Creek | | 2,188,766 | 51,713 | | | | |
| | Tsolum River Main | 1,163,364 | 628,365 | | | | | |
| | TOTAL | 1,163,364 | 2,817,131 | | | | | |
| **Average of Climate Model #2** | | | | | 1,040,612 | 2,530,729 | 3,623,101 | 4,305,627 |
| **Climate Model #3: cnrm-cm5_rcp45** | | | | | | | | |
| **2053** | Portugese Creek | | 1,364,916 | 51713 | | | | |
| | Tsolum River Main | 746,502 | 411,699 | | | | | |
| | TOTAL | 746,502 | 1,776,615 | | | | | |
| **2056** | Portuguese Creek | | 965,873 | 51855 | | | | |
| | Tsolum River Main | 525,047 | 295,994 | | | | | |
| | TOTAL | 525,047 | 1,261,868 | | | | | |
| **2059** | Portuguese Creek | | 1,304,912 | 51713 | | | | |
| | Tsolum River Main | 704,006 | 391,723 | | | | | |
| | TOTAL | 704,006 | 1,696,635 | | | | | |
| **Average of Climate Model #3** | | | | | 658,518 | 1,578,373 | 2,288,651 | 2,574,972 |
| **Average of All Scenarios** | | | | | 938,196 | 2,234,052 | 3,224,009 | 3,730,869 |

The AWDM results indicate that without changing crops and irrigation systems, climate change may significantly increase agricultural water demands. The scenarios indicate that future agricultural demand on existing farms with climate change is likely to be an average of 3,224,009$m^3$/year and up to 4,312,007 $m^3$/year.

This means that existing farms will need anywhere from 50-200% more water in the future as the climate changes.

### 7.3.3 Scenario 2: Increased Agricultural Activity ('Buildout')

In the future, it is likely that more land will be placed in agricultural production. There are approximately 72$km^2$ of Agricultural Land Reserve (ALR) in the Tsolum River watershed and only 28% of it is currently used for farming. If this land is developed for agriculture, there would be an increase in agricultural water demand. To understand how much water may be needed, a 'buildout' scenario was created. In this scenario, scientists attempted to be realistic about agricultural activities and only stated that the land would be used if it met the following criteria:

- within 1,000 m of water supply (lake)
- within 1,000 m of water supply (water course)
- within 1,000 m of water supply (wetland)
- within 1,000 m of high productivity aquifer
- within 1,000 m of water purveyor
- with Ag Capability class 1-4 only where available
- must be within the ALR
- below 250 m average elevation

They then estimated the type of crops and irrigation systems that would be used. They predicted that farming would occur in a relatively similar manner to the current situation (e.g. a relatively similar distribution of crops and irrigation systems, with a slight decrease in forage crops and increase in 'grapes' or berry type crops):

- Forage crops: 50% of buildout area with sprinkler irrigation
- Pasture: 10% of buildout area with sprinkler irrigation
- Grapes: 20% of buildout area with drip irrigation
- Vegetables: 20% of buildout area with drip irrigation

Using these criteria, the scientists estimated that it would be possible to farm and irrigate approximately 2,090ha of land, if sufficient water was available. This is approximately five times more land than is currently irrigated (423ha).

Table 8 shows the potential water demands if there was increased agricultural activity in the Tsolum River watershed. This table is not considering climate change impacts. In this scenario, on average it is expected that agricultural water demand would go up to 9,071,118 $m^3$/year on average, and potentially up to 12,414,687$m^3$/year in dry years. That is approximately three times as much water as is currently used.

*Table 8: Agricultural Water Demand with Increased Agricultural Activity (m³/year)*

| Year | Irrigation Water Use by Subwatershed (m3/year) | | | Livestock Demand | Average Irrigation Demand (surface water) | Average Irrigation Demand (groundwater) | Average Total Demand (inc livestock) | Max Demand (inc livestock) |
|---|---|---|---|---|---|---|---|---|
| | Subwatershed | Surface water | Groundwater | | | | | |
| 1997 | Dove Creek | 416,369 | | 51,713 | | | | |
| | Headquarters Creek | 46,950 | | | | | | |
| | Jackpot Creek | 257639 | | | | | | |
| | Piercy Creek | 49,432 | | | | | | |
| | Portuguese Creek | 2,005,834 | 772,778 | | | | | |
| | Tsolum River Main | 1,898,066 | 228,769 | | | | | |
| | TOTAL | 4674289 | 1001547 | | | | | |
| 2003 | Dove Creek | 801,338 | | 51,713 | | | | |
| | Headquarters Creek | 90,833 | | | | | | |
| | Jackpot Creek | 483414 | | | | | | |
| | Piercy Creek | 97,247 | | | | | | |
| | Portuguese Creek | 4,755,713 | 1,703,986 | | | | | |
| | Tsolum River Main | 3,984,484 | 445,959 | | | | | |
| | TOTAL | 10213029 | 2149945 | | | | | |
| **Average** | | | | | 7,443,659 | 1,575,746 | 9,071,118 | 12,414,687 |

It is important to consider that the 'agricultural buildout scenario' considers maximum possible agricultural activity, while it is likely that the actual increase in agricultural activity will be less.

### 7.3.4 Scenario 3: Increased Agricultural Activity AND Climate Change

Finally, the AWDM was used to estimate the impact of both climate change and increased agricultural activity. The results of the scenario are in Table 9. The Scenario results are displayed for the whole Tsolum River rather than by subwatershed, for ease of viewing.

The AWDM results for this scenario show that if the Tsolum River watershed experiences both climate change and increased agricultural activity, it is possible that average water demands could go up as much as 463%.

*Table 9: Estimate of agricultural water demand with increased agricultural activity and climate change from AWDM ($m^3$/year)*

| Year | Surface water | Groundwater | Livestock water demand (m3/year) | Average Irrigation Demand (surface water) | Average Irrigation Demand (groundwater) | Average Total Demand (inc livestock) | Max Demand (inc livestock) |
|---|---|---|---|---|---|---|---|
| **Climate Model #1: access1_rcp85** | | | | | | | |
| **2053** | 12,206,623 | 2,552,217 | 51,713 | | | | |
| **2056** | 14,816,488 | 3,025,571 | 51,855 | | | | |
| **2059** | 10,752,506 | 2,201,379 | 51,713 | | | | |
| **Average of Climate Model #1** | | | | 12,591,872 | 2,593,056 | 15,236,688 | 17,893,914 |
| **Climate Model #2: canesm2_rcp85** | | | | | | | |
| **2053** | 14,904,278 | 3,020,098 | 51,713 | | | | |
| **2056** | 8,536,903 | 1,754,957 | 51,855 | | | | |
| **2059** | 13209047 | 2817131 | 51,713 | | | | |
| **Average of Climate Model #2** | | | | 12,216,743 | 2,530,729 | 14,799,232 | 17,976,231 |
| **Climate Model #3: cnrm-cm5_rcp45** | | | | | | | |
| **2053** | 8,479,118 | 1,776,615 | 51,713 | | | | |
| **2056** | 6,057,357 | 1,261,868 | 51,855 | | | | |
| **2059** | 8,046,401 | 1,696,635 | 51,713 | | | | |
| **Average of Climate Model #3** | | | | 7,527,625 | 1,578,373 | 9,157,758 | 10,307,588 |
| **Average of all Climate Models** | | | | 10,778,747 | 2,234,052 | 13,064,559 | 15,392,578 |

### 7.3.5 Analysis

Table 10 summarizes the results of the AWDM work. The results suggest that it is likely that agricultural water needs will significantly increase in years to come.

Under climate change, with existing levels of farming alone, it is estimated that water needs will increase from an average of 2,321,812$m^3$/year to an average of 3,224,009$m^3$/year. This represents an increase in agricultural water demands of 39%. If all the ALR land that has access to water was developed and used for farming (using similar crops and irrigation systems as currently exist), it is estimated that water consumption would go up to an average of 9,071,118$m^3$/year. This represents an increase in agricultural water demands of 291%. Finally, if both climate change impacts occur and there is an increase in agricultural activity, it is possible that agricultural water demand could go up to an average of 13,064,559$m^3$/year, or even a maximum of 15,392,578$m^3$/year. On average, this would represent an increase water use of 463%.

Although it is difficult to estimate the exact amount of water used and needed by agriculture, this work indicates that it is likely that agricultural water needs will increase substantially in coming years. Given the potential for agriculture in the Tsolum and the fact that water supplies are already limited it will be important to carefully plan for future water needs.

*Table 10: Summary of estimated current and future agricultural water demand according to AWDM ($m^3$/year)*

| Scenario | Average Modelled Irrigation SW Demand ($m^3$/year) | Average Modelled Irrigation GW Demand ($m^3$/year) | Average Modelled SW + GW + Livestock Demand ($m^3$/year) | Max Total Modelled Demand inc. Livestock ($m^3$/year) | Average Percent Increase |
|---|---|---|---|---|---|
| **Scenario '0': Current Use** | 694,353 | 1,575,746 | 2,321,812 | 3,170,941 | |
| **Scenario 1: Climate Change (no Increase in Farming)** | 938,196 | 2,234,052 | 3,224,009 | 3,730,869 | 39% |
| **Scenario 2: Current Climate, More Farming** | 7,443,659 | 1,575,746 | 9,071,118 | 12,414,687 | 291% |
| **Scenario 3: Climate Change, Increased Farming** | 10,778,747 | 2,234,052 | 13,064,559 | 15,392,578 | 463% |

## 7.4 Validation of Water Use

It is difficult to know how much water is used because there are no users in the watershed that are required to report their water use. Farmers generally don't meter their water use and although research was conducted to identify additional sources of information on water use, no additional measurements of water consumption were found.

The earlier description of surface water use is based on water license information and only shows what is legally allowed to be used, which may differ from what is actually used. The information on groundwater use is based on estimates based on size of property, using coefficients developed from metering in other jurisdictions (e.g. the Nanaimo, Gabriola). While this metered data from other areas is useful, it may not be applicable to the Tsolum watershed.

The AWDM, described above, estimates water use based on the type of crops grown, type of irrigation system, weather, soil types, etc. However, the AWDM estimates that more surface water is used in the Tsolum River watershed than is actually licensed. The AWDM estimates that currently an average of 694,353$m^3$/year of surface water is used, which is approximately 25% greater than what is licensed for use (523,982$m^3$/year). It is difficult to assess which water use value is most realistic.

Without measurement it is difficult to know how much water is actually used. Voluntary metering or measurement of water use would be helpful to better quantify water use. Further work is required to better understand surface and groundwater extractions in this watershed. However, there are limits to the quality of information that can be obtained, as described in further detail in the recommendations section. At the moment, the amount of water available is unknown and identifying that also high priority.

# 8 Water Quality

The Tsolum River has received a significant amount of attention with regards to water quality. The provincial Environmental Monitoring System (EMS) contains nearly 5,000 water quality samples for the Tsolum River watershed.

This attention is partially due to water contamination issues caused by the Mount Washington Copper mine. This open pit copper mine, active from 1964 to 1967, was a source of copper contamination for the aquatic life in the waterbodies downstream. Many remediation efforts were attempted over the years to adequately close the mine. In 2006 the Tsolum River Partnership was formed and undertook a 10-year, multi-phased, multi-partnered solution to reverse the environmental damage. The pollution was drastically reduced in 2010 due to effective mine remediation. In 2015, 129,000 salmon returned to the river, indicating water quality is improving.

Of the 5,000 samples in the watershed, approximately 97% of the samples were collected prior to 2012 and the sampling frequency has decreased since 2013 to an average of over 20 samples per year as shown in Figure 26.

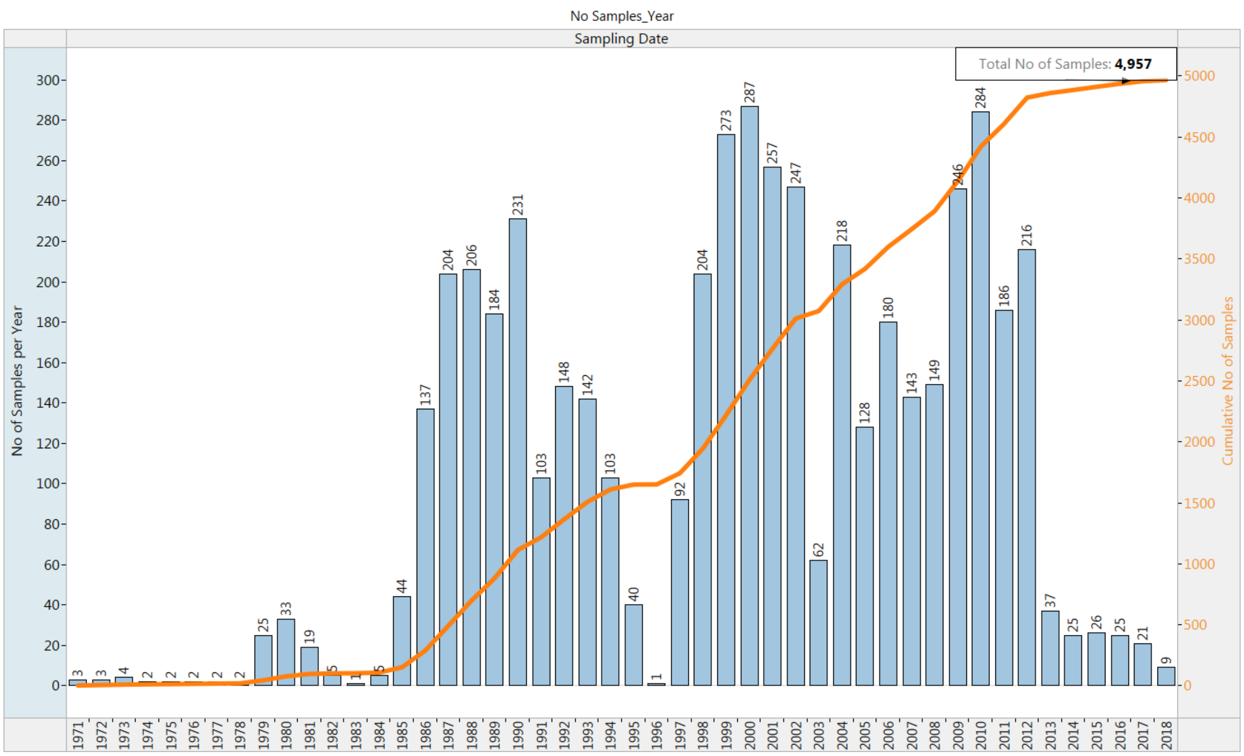


*Figure 26. Number of samples per year compiled for the water quality analysis*

Table 11 summarizes the number of samples and tests including the date range and location type. Approximately 97% of the data corresponds to surface water and the remaining to groundwater and other with percentages of less than 1% and 2.7%, respectively.

*Table 11: Compiled water quality data*

| Location type group | Location type | Date monitoring from | Date monitoring to | No of monitoring stations | Number of tests | No of samples |
|---|---|---|---|---|---|---|
| **Groundwater** | OBSERVATION WELL (GROUNDWATER) | 8/27/1987 | 9/20/2017 | 3 | 547 | 9 |
| **Other** | DITCH OR CULVERT | 10/16/1979 | 9/10/1996 | 3 | 472 | 37 |
| | SEEPAGE OR SEEPAGE POOLS | 10/16/1979 | 11/6/2012 | 5 | 3,508 | 101 |
| **Surface water** | LAKE OR POND | 3/16/1993 | 8/23/2016 | 3 | 57 | 3 |
| | RIVER, STREAM OR CREEK | 5/20/1971 | 5/15/2018 | 25 | 165,201 | 4,816 |
| | | | Total | 39 | 169,785 | 4,966 |

Figure 27 shows the locations of the water quality monitoring stations. The location type group "Other" corresponds to samples taken within the Mount Washington Copper Mine.

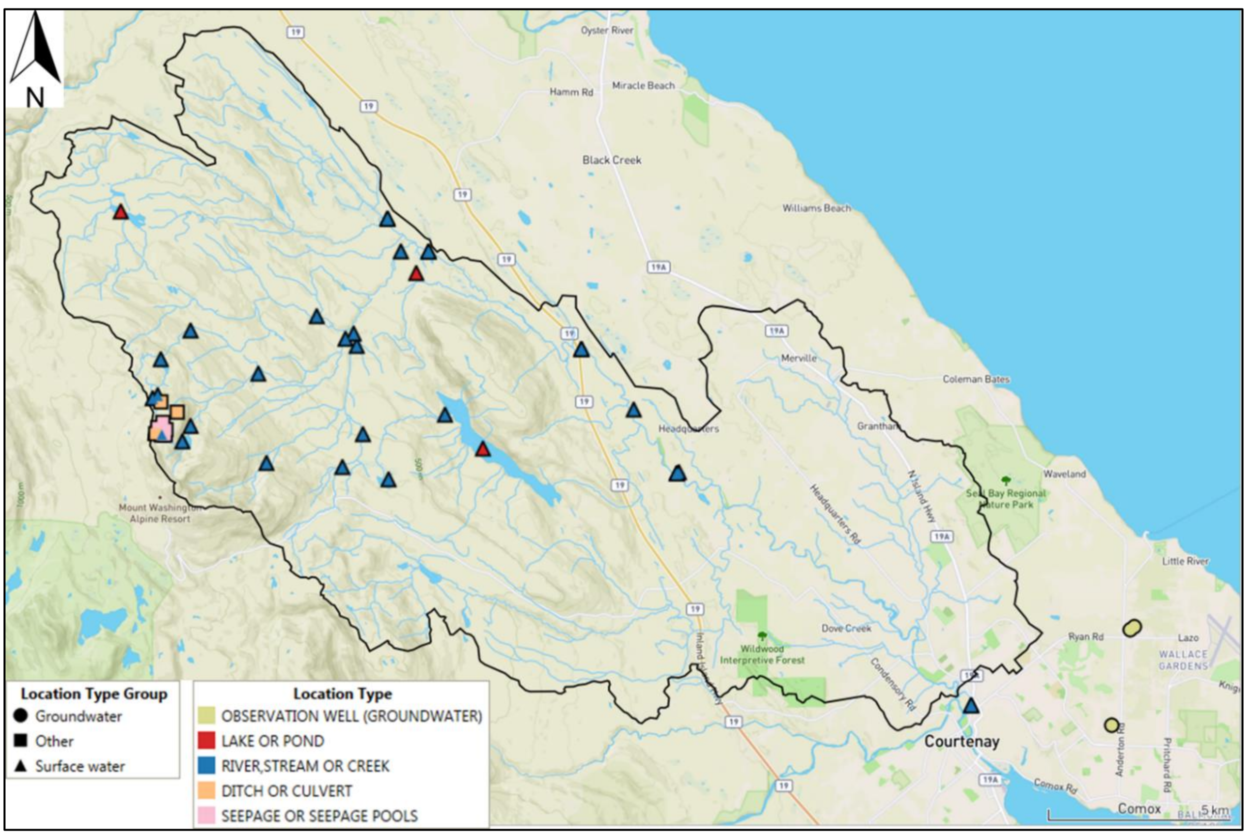


*Figure 27. Location of water quality monitoring stations within/near Tsolum River watershed*

### 8.1.1 Water quality data integration

GW Solutions has developed a management and visualisation tool for data integration, interpretation and display. The water quality data has been updated, cleaned-up, and standardized using this tool. In addition, they have built a series of queries to link data to watersheds, sample type, and sample results.

The federal Drinking Water Quality Guidelines, the provincial Acute Fresh Water Aquatic Life and Agriculture Irrigation and Livestock Guidelines were used to identify the parameters and locations where these guidelines were exceeded.

The water quality interactive analysis platform was used to explore the test results for the monitoring stations. One of the outputs of the platform is a display composed of the following windows:

- Map: It shows the location of the monitoring stations. In addition, it displays information regarding the station such as ID, water body name, location (latitude, longitude) and sample type.
- Water quality summary: It provides the baseline for the selected stations. For instance, it shows the number of tests, minimum, maximum and average results for each parameter group including the sampling year range.
- Water quality data: It shows the scatter plot for water quality results over time for all the tested parameters.

An example of the output is shown in Figure 28 for the station located at the mouth of the Tsolum River prior to discharging to Courtenay River.

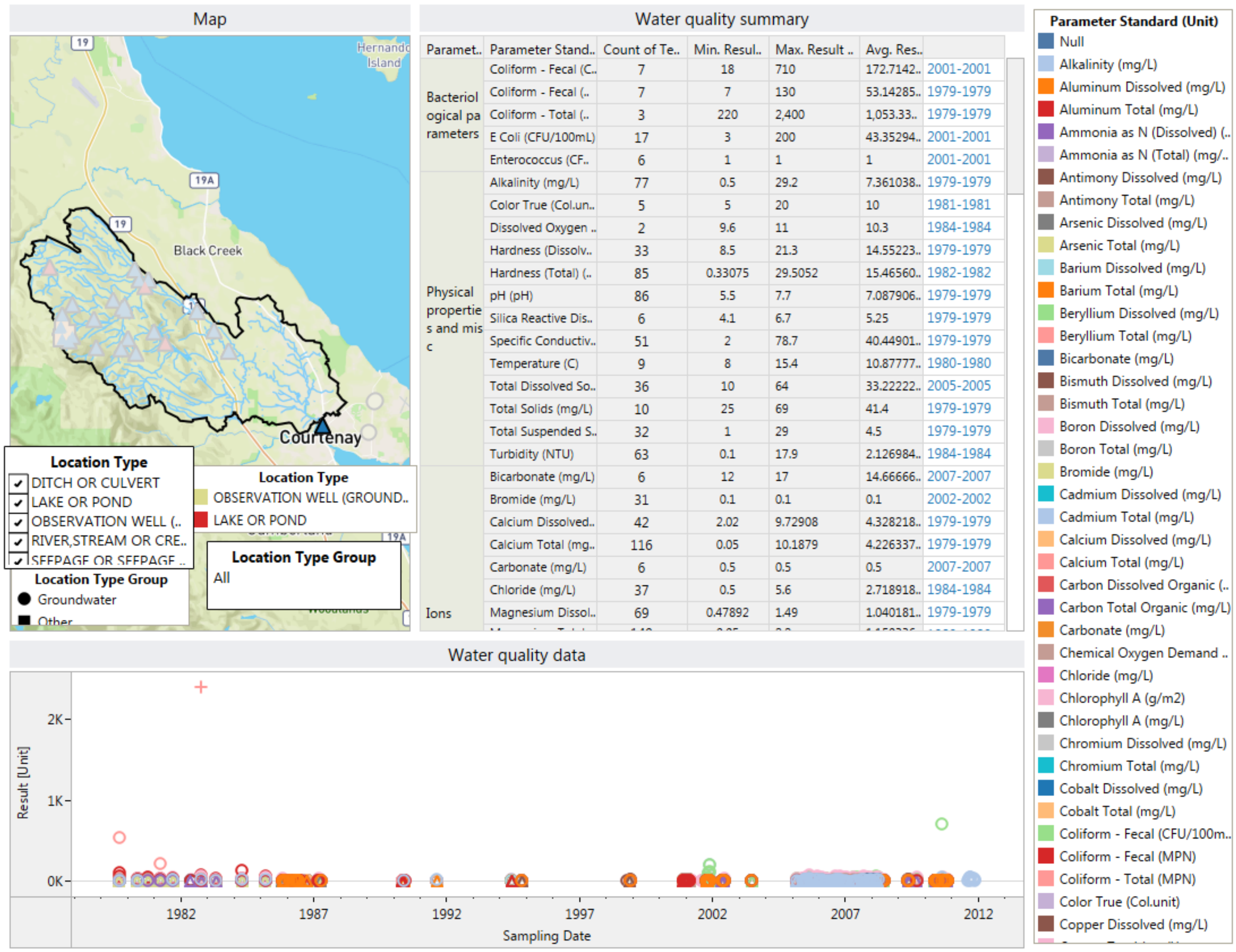


*Figure 28: Water quality results for station: TSOLUM RIVER U/S PUNTLEDGE RIVER (EMS ID: 0127621)*

### 8.1.2 Comparison of water quality data with guidelines

The exceedance analysis presented in this report includes all the water quality results collected after 2010 coinciding with Phase 2 of the rehabilitation of the Mount Washington mine.

Figure 29 shows the locations of the stations for which samples have been taken from 2010 to 2018 and Figure 30 displays the number of samples included per year in the exceedance analysis. The year 2010 is chosen as a starting year because it is more representative of current conditions (years prior to 2010 show extremely high copper contamination levels because the copper mine had not yet been closed).

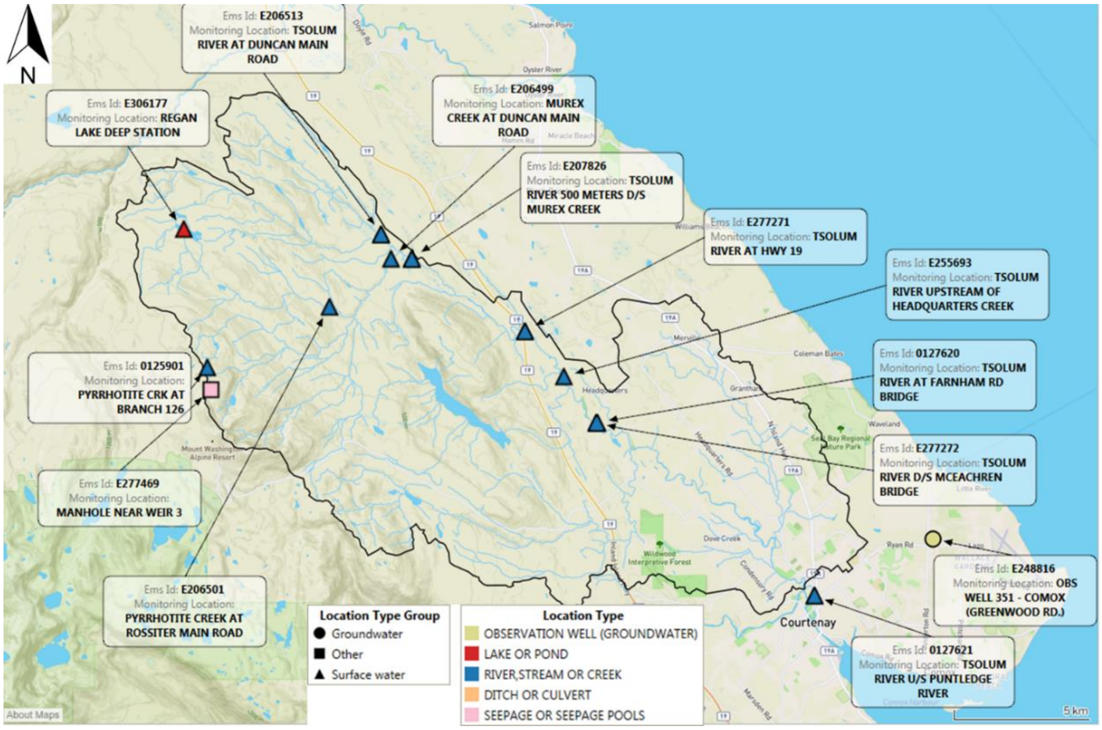


*Figure 29. Location of water quality monitoring stations with data from 2010 to 2018*

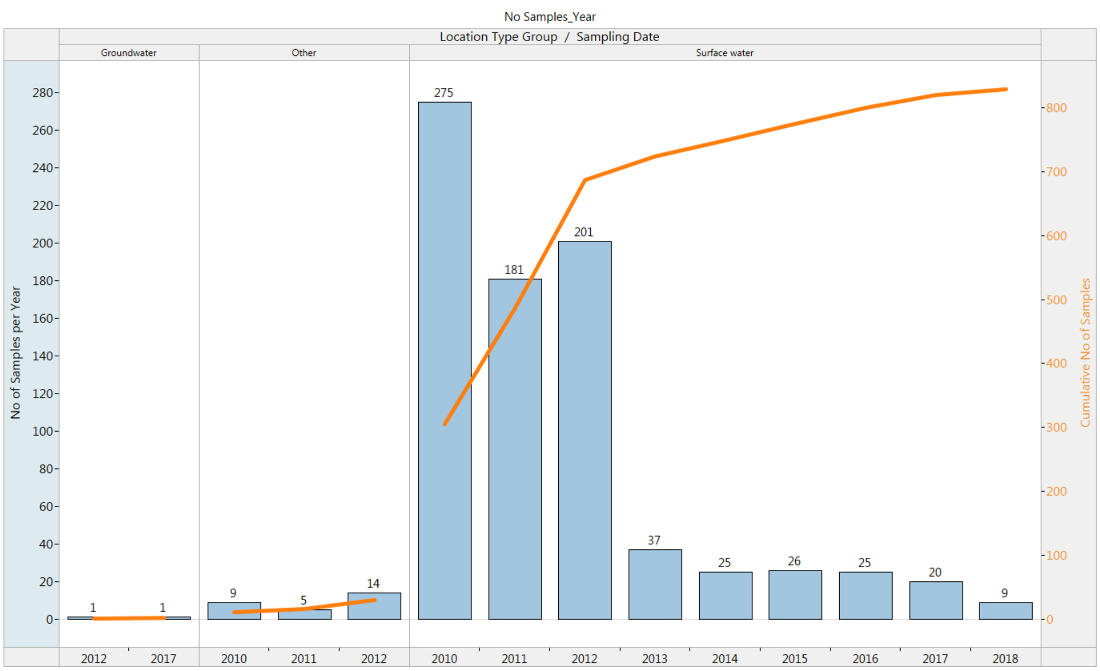


*Figure 30 Number of samples per year included in the exceedance analysis summarized by location type group*

### 8.1.2.1 Concentrations above drinking water quality standards

Figure 31 and Figure 32 show the exceedance analysis results for groundwater and surface water samples, respectively when comparing to the Federal Drinking Water Quality Guideline. The results include water quality comparison for bacteriological, ions, metals, nutrients and physical properties. The diagram shows two summary plots: number of tests and percentage of exceedance. There are no exceedances recorded for groundwater samples; however, surface water samples present some exceedances:

- Bacteriological parameters: 87% of the Fecal coliforms tests exceeded the guideline
- Metals: Three parameters exceed the guideline Aluminum total (20% of the samples exceeded the guideline), Iron total (7%), and Manganese (1%)
- Physical properties: pH, color, and temperature present exceedances of 31%, 36%, and 12%, respectively.

Fecal coliform exceedances in samples tend to increase moving downstream (Phippen, 2012).

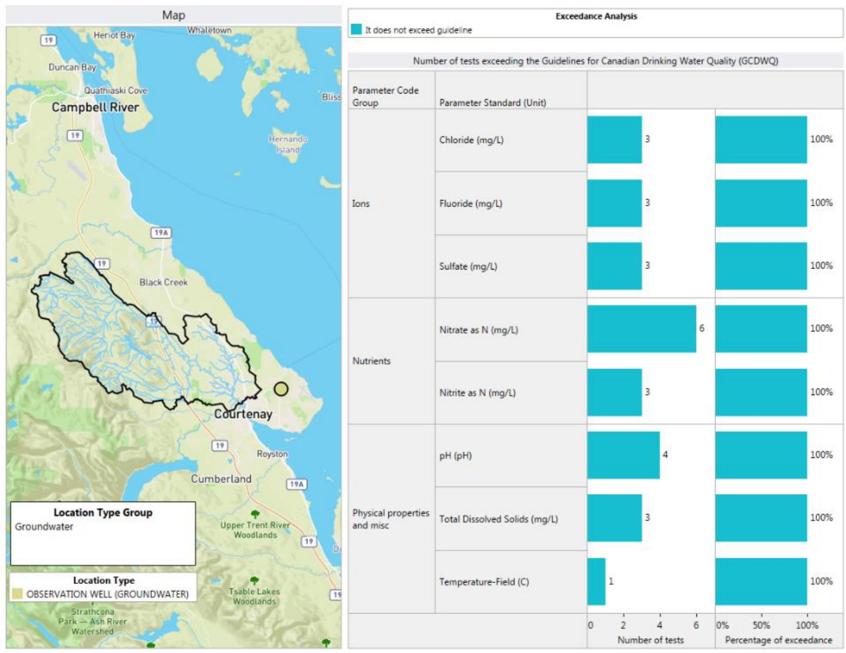


*Figure 31: Exceedance analysis for groundwater samples considering the Federal Drinking Water Quality Guideline*

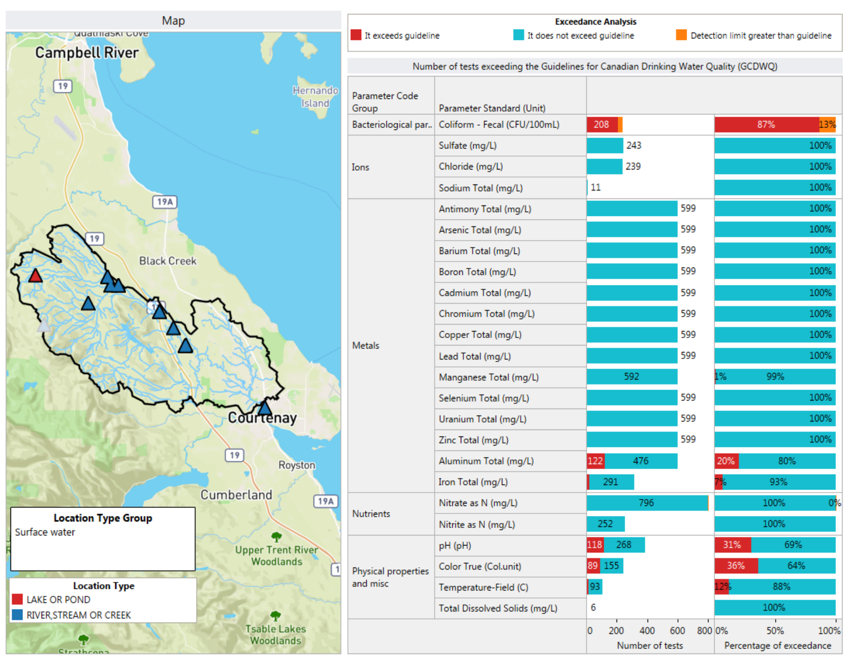


*Figure 32. Exceedance analysis for surface water samples considering the Federal Drinking Water Quality Guideline*

### 8.1.2.2 Concentrations above BC acute aquatic life guidelines

Figure 33 shows the exceedance analysis results for surface water samples when comparing to the BC Aquatic Life Acute Guideline. Total copper exceeded the most the aquatic life guideline with 60% of the samples exceeding the guidelines followed by aluminum dissolved (7%), cadmium dissolved (3%) and zinc and iron (1%). Further research (outside of the scope of this project) is needed to understand the current conditions and their impact on aquatic life.

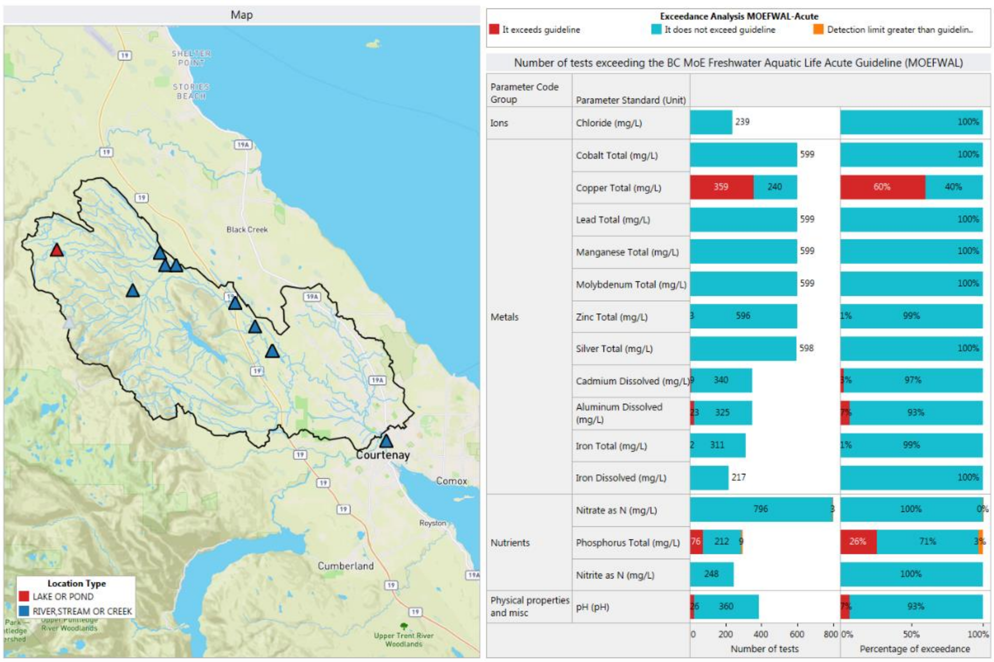


*Figure 33. Exceedance analysis for surface water samples considering the Aquatic Life Acute Guideline*

### 8.1.2.3 Concentrations above BC agriculture-irrigation guidelines

Figure 34 and Figure 35 show the exceedance analysis result for groundwater and surface water samples, respectively, when comparing to the BC guidelines applying to agricultural irrigation. There are no exceedances recorded for groundwater samples; however, surface water samples presented some exceedances of less than 1% for pH and copper.

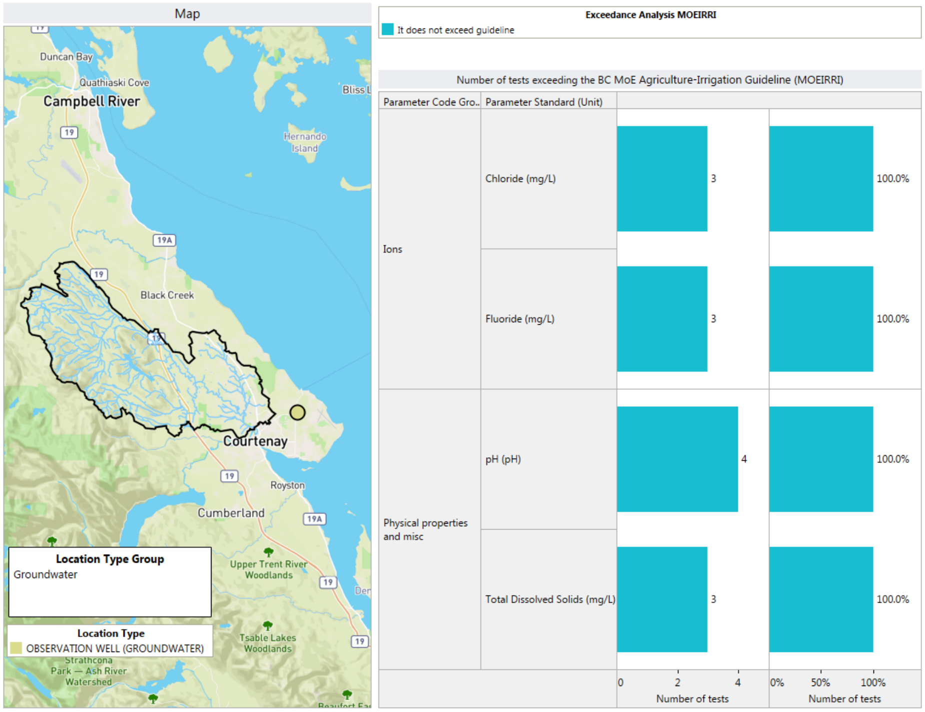


*Figure 34: Exceedance analysis for groundwater samples considering the BC Agriculture-Irrigation Water Quality Guideline*

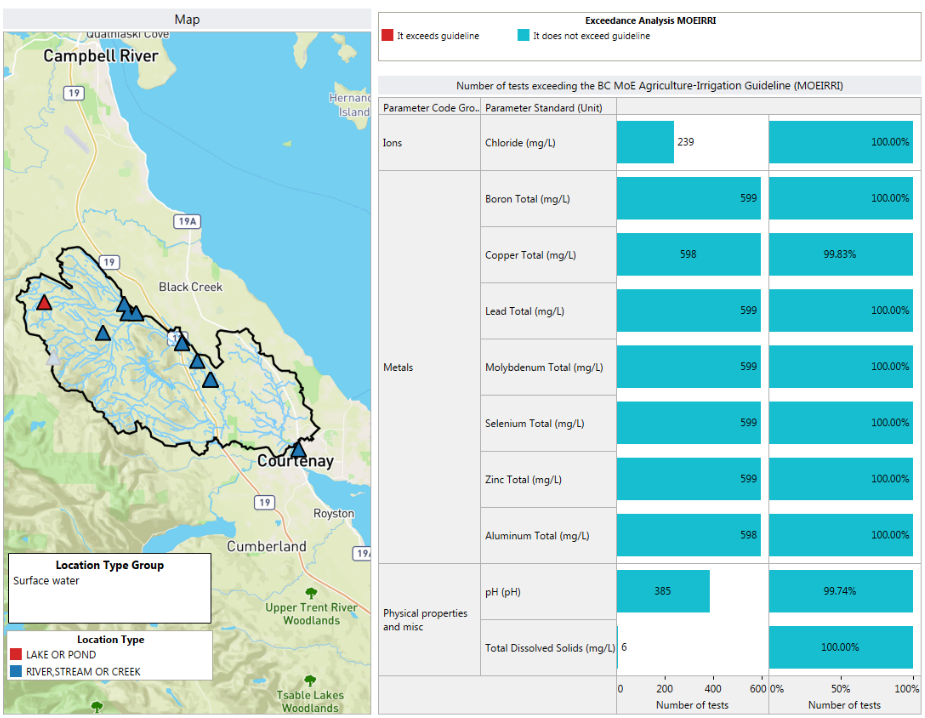


*Figure 35. Exceedance analysis for surface water samples considering the BC Agriculture-Irrigation Water Quality Guideline*

### 8.1.2.4 Concentrations above BC agriculture-livestock guidelines

Figure 36 and Figure 37 show the exceedance analysis result for groundwater and surface water samples, respectively, when comparing to the BC agricultural-livestock guidelines. There are no exceedances recorded for groundwater samples. Nevertheless, surface water samples presented some exceedances of less than 1% for pH, copper and nitrate.

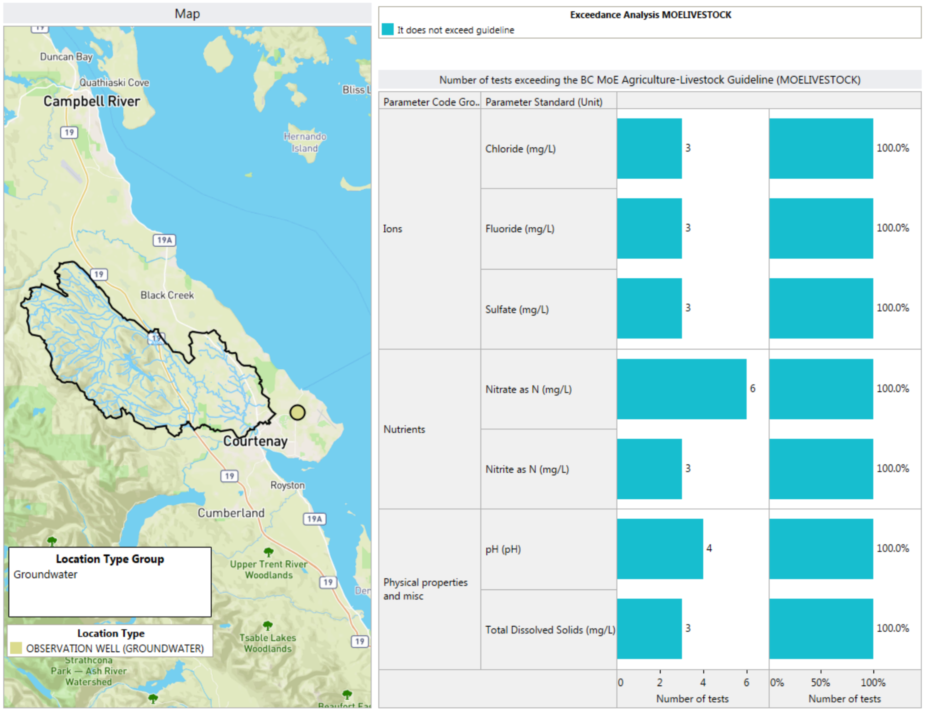


Figure 36. Exceedance analysis for groundwater samples considering the BC Agriculture-Livestock Water Quality Guideline

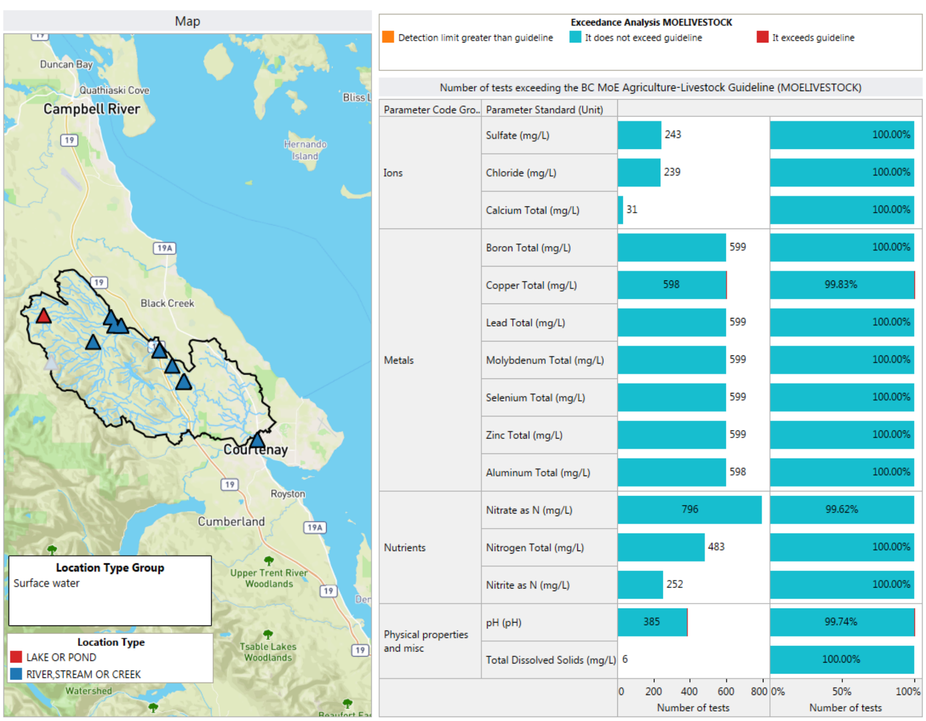


Figure 37. Exceedance analysis for surface water samples considering the BC Agriculture-Livestock Water Quality Guideline

### 8.1.3 Analysis

There have been substantial improvements in water quality in the Tsolum River watershed, due to the efforts of the Tsolum River Partnership. However, there are still some exceedances with surface water samples. There are exceedances of Cadmium, Copper, Aluminum, and Phosphorus, particularly with regards to Acute Aquatic Life Guidelines. Moving forward it would be useful to plot the concentrations of these parameters over time to assess whether there are increasing or decreasing trends. There are also a relatively high number of coliforms in surface water samples.

# 9 Environmental Flow Needs

The Tsolum River watershed is home to many aquatic animals, including, Pink, Coho, Chum, and Chinook Salmon, Cutthroat and Rainbow Trout, and lamprey and freshwater mussels. Although these species were some of the original inhabitants of the stream, fish and aquatic life don't 'hold' official water licenses on the creek.

However, under the new Water Sustainability Act, the provincial government has stated that "Environmental Flow Needs" (EFNs) must be considered in any new decisions about water use on a stream. EFNs are defined as the volume and timing of water flow required for proper functioning of the aquatic ecosystem (*Water Sustainability Act*, Section 1).

As of 2016, EFNs must be considered in decisions about water licences or use approvals on a stream - or an aquifer that is hydraulically connected to a stream.

The amount of water needed in a river for a healthy functioning ecosystem varies from one river to the next. The Provincial government has created an "Environmental Flow Needs Policy" to guide this decision-making (Government of British Columbia, 2018). Based on the Environmental Flow Needs Policy, in the Tsolum River, the flow sensitivity is high in August and moderate in July and September for the river, (considering flow data from 1977 to 2017 at WSC 08HB011) (Government of British Columbia, 2018). However, there is no clear information on how much water needs to remain in the stream to support ecological health in the Tsolum River watershed.

## 9.1 Summary of Available Information on Environmental Flow Needs in the Tsolum

The Courtenay Water Allocation Plan (Figure 38) uses the Modified Tennant (Montana) Method to recommend that an estimated minimum of 10% of MAD is maintained in the Tsolum to support aquatic life (Riddell & Bryden, 1996). In the Tsolum River, MAD is 10m$^3$/s, and August flows are often well below 1m$^3$/s.

However, more recently, Provincial scientists have decided that maintaining flows of 10% MAD in Vancouver Island streams may not be realistic. Many streams on the east coast of Vancouver Island have highly variable flow regimes and may not have had flows above 10% MAD in the summer prior to human disturbance (Szczot, 2018). The regional Senior Aquatic Ecologist stated that a more appropriate target may to be maintain 0.5m$^3$/s in the Tsolum River watershed during low flows (Szczot, 2018).

A prior study (Wolf Lake Study, 1976) stated that at a minimum, in the Tsolum River, 0.42m$^3$/s is required for fish attraction purposes prior to spawning during the period of Aug 15-Sept 15.

| Modified Tennant (Montana) Method Instream Flow Requirements | |
|---|---|
| **Flows** | **Description** |
| 30-60% MAD | Excellent spawning/rearing |
| 20-30% MAD | Good spawning/rearing |
| 10-20% MAD | Fair spawning/rearing |
| 5-10% MAD | Poor spawning/rearing |
| >5% MAD | Severely degraded spawning/rearing |

*Figure 38: Flow needs. Source: Courtenay River Water Allocation Plan*

Except during the irrigation months and occasionally in the winter, the minimum suggested environmental flows are met by the natural flow of the river in the Tsolum watershed. However, in August and early September, flows can become extremely low. A review of flow records shows that flows are often less than 5% MAD, and occasionally under 1% MAD in these critical months. Augmentation from Wolf Lake reservoir attempts to provide flows of 10% MAD in the lower 18 km of the Tsolum River. But in recent drought years, even with augmentation, August flows have dropped well below 5% MAD.

## 9.2 Critical Environmental Flow Thresholds

In addition, to EFNs, the Provincial government has developed criteria called "Critical Environmental Flow Thresholds". A critical environmental flow threshold is a short-term flow threshold, below which significant or irreversible harm to the aquatic ecosystem of the stream is likely to occur (*Water Sustainability Act*, Section 1). On Vancouver Island, the provincial government has identified 2-3% MAD as a 'critical environmental flow threshold' (Szczot, 2018). If flows in the river get this low, the provincial government can step in with a 'Critical Environmental Flow Protection Order' or a 'Fish Population Protection Order'. This can limit water license holders from taking water from the stream. It is better for all users of the river if the conditions don't get to this point, so when flows become very low, provincial staff may begin asking users to modify their use. For instance, they may ask producers to water 24 hours/day at a lower flow rate, rather than 8 hours/day at a higher rate, so that the river flows don't drop suddenly when the 'taps are turned on' (Szczot, 2018).

## 9.3 Determining Environmental Flow Needs for the Tsolum River Watershed

In several watersheds in BC, scientists are conducting research to identify the river's unique Environmental Flow Needs (Okanagan Basin Water Board, 2018). This research has not yet been done on the Tsolum.

Provincial government staff have noted that managing rivers for environmental health may be more complex than simply managing for a certain flow threshold. For example, some research has found that it may be more valuable to manage the stream to keep water temperature below a certain threshold and maintain high value habitat areas (Neil Goeller, AWPAC meeting, September 26, 2018).

Further work is needed to quantify the flows and conditions required to maintain ecosystem health so that everyone can better manage their water use in the Tsolum River watershed. It is recommended that Phase 2 of the Agricultural Watershed Planning work begins with an assessment of Environmental Flow Needs.

# 10 Significance of Agriculture with Respect to Economic Activities

Agriculture plays an important role in the economy of the Comox Valley Regional District and the Tsolum River watershed. In the CVRD, there are 416 farm businesses, managed by 640 farm operators, representing approximately $531 million in farm capital. Although there is a tendency to view farming as merely the growing of food and pastoral landscapes, the reality is that farms play an important role in a much larger supply chain in which the farmer is both a consumer and producer of goods and services (Fraser Valley Regional District, 2017). In BC, it is estimated that agriculture and the agri-food system account for over 13% of BC's employment. Nationwide, producers spend approximately $50 billion in operating expenses which flows back in the broader economy (Fraser Valley Regional District, 2017).

In the Tsolum River watershed, agriculture plays a role in the four main areas of economic activity: production of commodities, consumption of goods, employment, and the provision of services. In this section, we use Statistics Canada Census of Agriculture data to identify the current significance of agriculture in the watershed with respect to economic activities. Then, we use information on trends in agriculture in the Comox Valley to demonstrate the potential economic significance of agriculture in the watershed.

## 10.1 Background

Every five years, Statistics Canada gathers data on the Canadian agricultural industry and farm operators as part of the Census of Agriculture. This data is then summarized and reported for each electoral area and Regional District across the country. Although information on agriculture is not summarized for the Tsolum River watershed specifically, it is possible to roughly estimate the contribution of agriculture to the economy in the watershed using existing data. Approximately half of the agriculture in the CVRD occurs in the Tsolum River watershed[1] so it could be very roughly estimated that approximately 50% of the economic activities related to agriculture in the CVRD are in the Tsolum River watershed.

## 10.2 Production

In the last Census of Agriculture (Statistics Canada, 2016), farmers in the CVRD reported that they received approximately $34 million ($33,662,551) in funds for off-farm sales, according to total gross farm receipts. In addition, many farmers produce their own inputs (e.g. dairy farmers produce hay to feed cattle), so the actual value of goods produced on farm is likely higher. In general, local production consumed or used by the producer is estimated at 10% of the value of agri-food products, so the value of goods produced by farmers in the CVRD is likely closer to $37 million.

If agriculture in the Tsolum River watershed accounts for approximately 50% of agricultural activities in the CVRD (British Columbia Assessment data) it is possible to estimate that the value of goods produced by agriculture in the Tsolum River watershed is approximately $18.5 million.

## 10.3 Consumption

As a primary industry, agriculture not only provides inputs to the economy, it is also a consumer of goods and services from other local businesses. In the CVRD, farm businesses spent $29 million ($29,490,823) in operating costs in 2016 and much of this was input into the local economy. At a rate of approximately

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[1] 54% of the CVRD's farm properties[1] are in the Tsolum watershed and 42% of the farmed land cover in the CVRD is in the Tsolum River watershed.

50%, one could estimate that farm business operating expenses were approximately $14 million for producers in the Tsolum River watershed and that agriculture in the Tsolum River contributed approximately $14 million to the local economy through consumption.

## 10.4 Employment

Within the CVRD, 1,975 people are reported to be employed in agriculture in 2016. This means that 6.3% of all employment in the CVRD for those over the age of 15 is on farm or related to agri-food processing. In 2011[2], approximately $7 million dollars was paid to employees on farms in the CVRD. If it is estimated that half of the farm activities in the CVRD are in the Tsolum River watershed, one would estimate that there are approximately 800 people employed on-farm in the Tsolum River watershed, and that agricultural employment accounts for approximately $3.5 million worth of wages earned in the watershed.

Those employed by the agricultural industry (farm operators and employees) also contribute to the broader economy by spending the wages earned from farming consuming good and services in the community (food, entertainment, household items, personal services, etc.).

## 10.5 Good and Services

Farms also play a role in providing services in the watershed through agritourism, direct sales, and food processing. These services contribute to the overall quality of life, economy and tourism industry in the greater CVRD.

Agritourism is a growing way in which farms contribute to the economy. Agritourism promotes visits to the farm (and surrounding area) for the purposes of recreation and includes services such as corn mazes, petting zoos, bed and breakfasts, campsites, winery and orchard tours, horse rentals for trail riding, pumpkin patches, etc. Increasingly, tourists are coming to the Comox Valley to experience local cuisine, attend farmer's markets, stay at on-farm bed and breakfasts, and participate in the growing agritourism industry. These visitors will have far-reaching contributions to the Comox Valley economy.

In addition, many farms sell directly to the public through permanent or temporary stores such as fruit-stands, u-pick, or restaurant/take out services (Statistics Canada Census of Agriculture, 2016). Small farms and direct marketing play a large role in BC, and this is particularly a trend in the Comox Valley. Almost half of farms in the CVRD sell directly to consumers, with the primary venue being through sales of unprocessed products, and secondarily through farm gate, stands, kiosks, and u-pick (Statistics Canada Census of Agriculture, 2016).

Finally, farms provide extended services to the community through food and agri-food product processing. This includes fruit canning, wine and cider making, meat processing, etc.

## 10.6 Future Significance

It is likely that the economic significance of agriculture in the Tsolum River watershed will increase. The demand for locally grown agricultural products is anticipated to grow as the population grows and there are a number of consumer trends that suggest that there will be increasing demand for local foods: the 100-mile diet, slow food, real food, organic food, etc. Increasingly, consumers are becoming aware of the

[2] This data was not gathered in 2016

benefits of eating locally and are making choices at supermarkets and markets to eat more locally produced food. Increasing fuel costs have already pushed the price of food up and climate change will likely make importing food from other areas (e.g. California) less reliable. It is likely that local food production will become more profitable and local foods more in demand.

The Comox Valley has significant potential to expand for its agricultural base, related employment and businesses. The Tsolum River watershed has the potential to generate a much higher level of agricultural production, if there is sufficient water available. The valley's favorable climate, available land, and access to local markets make it well-poised for future growth. The Comox Valley has one of the most favorable growing climates in the country (a very high number of frost-free days and growing degree days) and while many areas of the province have exhausted their available agricultural land, there is still a large reservoir of land available to build a strong and viable agriculture sector into the future. In the Tsolum River watershed, only 28% of the ALR land is currently used for farming and with drainage and irrigation improvements, the productivity of some of that land could be greatly increased. However, much of the unused ALR is currently uncleared and the quality of the soils may be low.

The Comox has an active local farming community and local support. The Comox Valley Farmers' Market operates twice a week from April to December with 50 to 60 vendors and several grocery stores in the Valley sell local products. The fact that the Farmer's market has grown from 6 to 60 vendors in just 10 years as a sign of the increasing popularity of agriculture (Penfold, Rolston, & Guiton, 2002).

Looking forwards, agricultural development is a viable and desirable economic development option for the Comox Valley. Expanding the agriculture base in the Comox Valley would be a wise choice for investment in the future health of the CVRD in terms of economic potential, food security, and community development (Penfold, Rolston, & Guiton, 2002). Agriculture growth would also be an asset to the local economy because agriculture is a relatively stable industry. Although farm operators definitely experience their share of 'ups and downs', the industry has generally maintained itself. The agriculture sector in the CVRD has remained relatively stable when sectors such as fisheries, mining, forestry, construction, and manufacturing sectors have faltered.

# 11 Data Gaps

As part of this report, the consultants were asked to identify key data gaps in the Tsolum River watershed. The following is a list of data gaps in the watershed. Although it would be helpful to address many of these in the future, much of this work would be outside the scope of the agricultural watershed planning process.

## 11.1 Water Quantity

- **Water usage data for groundwater and surface water:** There is currently no actual information on water use. All water use values in this report are estimates. It would be helpful to have information on water use, monthly, particularly in low flow months (July to September) so flows in the river can be compared with water usage. Ideally it would be better to work with the seven-day low flows, however, daily or weekly water usage scales are not feasible at this point because of too many assumption and unknowns. With the available information, only monthly water usage could be estimated.
- **Environmental flow needs:** Information on environmental flow needs should be developed.
- **Groundwater and surface water data:** There are no observation wells within the aquifers in the watershed. Designing a groundwater and surface water monitoring program for water quantity analysis is recommended: To study whether dropping groundwater levels is a concern in the study area, implementing observation wells and a monitoring program is essential. In addition, there are only two active hydrometric stations for the whole watershed. It would be helpful to have information on flows (gauges) above the confluences of Pyrrhotite Creek, McKay Creek, Murex-Creek, Headquarters Creek, Piercy Creek, Jackpot Creek and Portuguese Creek. More stations along Tsolum River will provide a better insight to surface water-groundwater interconnection as well as water availability along the river.
- **Surface water and groundwater interaction along Tsolum River and Portuguese Creek:** The current hydrogeological study shows that there are artesian conditions within the Portuguese Creek sub watershed suggesting upward groundwater flow (discharge to the River). Information on hydraulic connectivity is required for Portuguese Creek and the Tsolum River.
- **Aquifer mapping and characterization:** Information on potential mapped and characterized aquifers should be continuously refined as new data is collected. Drilling of observation/test wells may be necessary to validate the existence and characteristics of the aquifers.
- **Assessment of landscape-scale flow augmentation opportunities:** Although there have been studies looking at the potential for flow augmentation, using large-scale regional storage such as Wolf Lake, there has been no work done to investigate the potential of smaller-scale distributed storage in the watershed (e.g. by adding water storage ponds, dugouts, wetlands, etc.). There has also been no assessment of opportunities to augment flow by retaining water in landscape (e.g. through different land use management strategies that increase vegetation and forest retention).

## 11.2 Water Quality

- **Groundwater quality data:** There is no groundwater quality data available for the Tsolum River watershed. Voluntary sharing of private well test data (as is done in the Regional District of Nanaimo) would be useful. A groundwater monitoring program should be designed and implemented. It would be helpful for VIHA data and private sampling analysis to be available in the water quality database. Currently, the water quality database only includes EMS sources.

- **Water quality data for tributaries:** There is currently no water quality data for Portuguese Creek and Dove Creek.
- **Chronic guideline analysis:** Characterize waterbodies for chronic guideline analysis as there is a lack of chronic data for the whole watershed. In BC there are two sets of aquatic life guidelines: chronic and acute. Acute guidelines refer to concentration at any time; however, the 30-day average or (chronic) concentration is based on five weekly samples collected within a 30-day period. Thresholds for chronic exposure are stricter (lower) than for acute exposure; however, concentrations describing the chronic conditions are more representative of the long-term exposure of fish and fish habitat to water. Therefore, the chronic concentration is a better representation of the conditions of the water quality of a water body.
- **Water Quality Objective attainment monitoring:** The Province has established water quality objectives for the Tsolum River watershed and suggests monitoring for compliance every 5 years (Five sites on the mainstem Tsolum).

# 12 Public and Stakeholder Consultation and Engagement

Informed and inclusive public consultation is a critical part of watershed plan development and helps ensure that the final agricultural watershed plan reflects the aspirations and ideas of agricultural producers and the wider community within the watershed. Community engagement is also important as an engaged community can help support the implementation of Phase Two.

There are several organizations and agencies involved in the Tsolum River watershed. These include:

- Stewardship Groups: Tsolum River Restoration Society, Comox Valley Land Trust, Project Watershed, Comox Valley Naturalists Society
- Agricultural Organizations: Mid Island Farmer’s Institute, Comox Valley Farmer’s Institute
- First Nations: K'ómoks First Nation, Kwakiutl Territorial Fisheries Commission
- Provincial Government: Ministry of Agriculture, Ministry of Environment, Ministry of Forests, Lands, Natural Resource Operations, & Rural Development, Ministry of Energy & Mines
- Federal: Department of Fisheries and Oceans, Environment Canada
- Commercial/Industrial/Institutional: Businesses, schools, meeting venues, exhibition grounds
- Large industry: Timberwest (also, large landowner), Canadian Pacific Railway
- Recreational User Groups: Courtenay Fish and Game Club, Golf Courses, Mt. Washington Ski Resort, etc.
- Local Government: CVRD, City of Courtenay

Between September 2018 and February of 2019, the public and watershed stakeholders were invited to share their water quantity and quality concerns, provide feedback on the information gathered to-date, and discuss future water management solutions. This was done through a series of activities including: targeted interviews, a public open house event, public survey, a booth at the Comox Valley Farmer’s Market, social media posts, news releases, engagement with the Comox Valley Farmer’s Institute and Mid-Island Farmer’s Institutes at their Annual General Meetings, and interview and meetings with the K’òmoks First Nation, and Advisory Committee engagement.

The goal of these activities was to:

- Share information about the Tsolum River Agricultural Watershed Planning process
- Share information on the Tsolum River watershed (results of Deliverable #1)
- Obtain feedback on the information gathered to date and next steps
- Obtain local information to be included and considered in plan development
- Develop an increased understanding of water supply and demand challenges in the watershed
- Identify levels of community support for different water management solutions
- Increase support for a planning process to reduce current and future water use conflicts.

The community engagement and consultation work resulted in the following:

- 170 survey responses (exact number to be confirmed)
- 60+ people reached at October 13th Farmer’s Market
- 37+ people reached at October 29th Public Open House event
- 35+ reached via the Comox Valley Farmer’s Institute and Mid-Island Farmer’s Institutes Annual General Meetings, September 18th and 19th

- 15 local or subject matter experts reached through targeted stakeholder interviews
- Numerous people reached via posters and brochures distributed at 14 busy locations in the community
- Numerous people reached through two media releases
- Up to 5,500 'followers' reached via social media (CVRD site, Comox Valley Farmer's Institute sites, Mid-Island Farmer's Institute site)

## 12.1 Potential Solutions

During the engagement process, participants were asked to provide feedback on several proposed solutions for addressing agricultural water supply issues in the Tsolum River watershed. The following provides an overview of the proposed solutions.

Overall, participants showed significant support for the development of water storage infrastructure, with a preference for on-farm storage. Several participants recommended supporting producers in developing storage on-farm by providing financial support in the form of incentives and/or interest-free loans. Participants were also supportive of demand management and pursuing legal approaches to water management, with the caveat that these are considered in partnership with steps to address the obvious water supply concerns. The following provides a brief description of several of the proposed solutions.

### 12.1.1 On-farm storage

On-farm water storage, in the form of dugouts, ponds, or cisterns, can be used to hold rainwater, groundwater, or surface water from a river/stream/creek or overland flow. On-farm storage can be used to store water from rainy months to be used in dry summer months. It can also be used to modulate flow from marginal groundwater wells.

On-farm storage has been used in agriculture for hundreds of years and is already in place in many parts of the watershed. Distributed on-farm storage is beneficial from an environmental perspective because it increases retention of water throughout the watershed and provides wildlife habitat. There is potential for on-farm storage to help modulate high flows and possibly increase low flows in the river. It may also be useful for firefighting.

*Figure 39: Irrigation Pond at Cherry Point Vineyards (Cowichan)*

Although, on-farm storage can have benefits for both producers, the broader community, and the environment, it comes at a significant cost that is borne exclusively by the producers.

Dugouts cost a substantial amount of money. A dugout may cost a producer $60,000-$150,000, and as most producers would be taking out a loan to finance this infrastructure, the ultimate cost of the dugout may be even 30% greater after paying accumulated interest. If a producer is able to obtain a loan of this size and invest in on-farm storage, they do so at the expense of other on-farm (and household/family) investments. However, it is likely that on a regional level, dugouts would be less costly than large-scale storage such as a dam.

On-farm storage also requires a substantial area of land and can take a great deal of farmland out of production. For example, to store enough water to irrigate a 153-acre forage field in the Comox Valley, a producer would be required to construct a dugout approximately 10 feet deep and covering approximately 20 acres, or 13% of their field. (The amount of water required to irrigate in the Comox Valley is higher than in other areas of Vancouver Island or in the Fraser Valley (Agriculture, 2005)). The dugout area would no longer be available for crop production. The remaining 87% of the land would need to be 15% more productive to account for the land lost to the dugout area, or else the producer would lose income. Because of this, on-farm storage is more suitable for operations with high efficiency water use like fruit and vegetable operations and greenhouses. For example, in the Comox Valley, a local intensive vegetable farm experienced a doubling of productivity using only 2% of the farm's productive area for their dugout and buffer area (Mid Island Farmers Institute Board, 2018). But it is important to note that not every farm has the space or landscape for water storage infrastructure.

Once a dugout is constructed, the dugout requires maintenance and has a lifespan. Depending on how a dugout is constructed, it may be considered a dam, which requires additional engineering and construction costs, as well as permitting, inspection, and maintenance. Dams also increase farm liability.

On-farm storage can be beneficial for producers because it provides a water supply source that can be managed independently and may add value to their farm. A dugout can have additional indirect farm and watershed benefits, because it may provide an incentive for investment in water conservation practices. On-farm storage can take advantage of the plentiful winter rains without drawing down the aquifers. It is also likely that water retention in dugouts may contribute to local groundwater recharge.

However, the costs to producers and potential barriers to implementation need to be addressed when considering dugouts as a water supply solution.

### 12.1.2 Regional storage

Large-scale, regional water storage could also be created to enhance local agricultural water supplies. Water would be collected during the rainy season and stored for release in dry summer months. In 2007 a study was conducted to identify the best options for large-scale storage and found that Wolf Lake was the most suitable location (Gooding, Flow Augmentation in the Tsolum Watershed, 2007). The study found that if the Wolf Lake dam height was increased by one meter, the additional flows in the Tsolum would only be half of what was needed for fish. Hover, the study raised concerns about impacts of a dam on wetland habitat. There were also issues related to land ownership in the area. In 1976 a study was conducted to estimate the cost of increasing storage in Wolf Lake (Associated Engineering Services Ltd, 1976), however those cost estimates are now out-of-date.

Developing storage at Wolf Lake would require a significant amount of money. In order to ensure that this large investment benefited multiple members of the community, a distribution system would be required to share the water supplies with producers throughout the watershed. Currently, it is unclear whether it is feasible to develop such a large-scale water storage reservoir and distribution network and who might own, manage, and take responsibility for such a system.

Although some producers are attracted to the idea of large-scale storage because it requires less producer investment, initially (ideally the producer would be charged a monthly bill) and leaves land available for farming, it is likely that if additional water was added to the Tsolum River, this water would not be available for additional irrigation. Several stakeholders including stewardship groups, the K'òmoks First Nation, and the Mid-Island Farmers Institute were opposed to the idea of using Wolf Lake as an agricultural water supply, because they think that the storage in the lake should be used in support of Environmental Flow Needs.

In the public engagement process, two producers suggested investigating aquifer storage and recovery, however there are currently no local examples of successful use of this technology.

### 12.1.3 Collective dugouts

It may be possible for producers to share water storage areas, by developing storage at the corners of fields, where machinery may not easily reach. This would require substantial long-term collaboration by multiple property owners and received limited interest from producers and other stakeholders.

### 12.1.4 On-farm integration of drainage and storage

Currently, in the Tsolum watershed and other areas of BC, some producers integrate drainage and irrigation through sub-irrigation (see Figure 41) and/or by storing drainage water for later use in irrigation. This is beneficial because it meets drainage and irrigation objectives, increases water retention in the watershed, reduces environmental impacts of drainage, reduces flood impacts, provides wildlife habitat, 'shortens' the water cycle, and helps retain soil and nutrients. However, this sort of solution is very costly, management intensive, reduces available farmland, and will not be possible on all properties.

*Figure 40: Pendray Farms (Saanich, BC): Using tile drainage to supply irrigation ponds (also replenished with wells)*

### 12.1.5 Demand management

There are several ways in which the amount of water required by agriculture can be reduced. Irrigation system improvements such as inspecting and fixing irrigation system components, upgrading the type of irrigation system, and/or using improved irrigation practices (e.g. soil moisture sensors, irrigation scheduling tools) to only water as much as needed can help reduce water needs.

One producer noted that it is common in the Tsolum watershed to irrigate forage fields using an inch of water per week, rather than as prescribed by the B.C. Irrigation Management Guide (Agriculture, 2005). With this approach, producers may be over-watering at certain times of the year and there is likely room to reduce water needs.

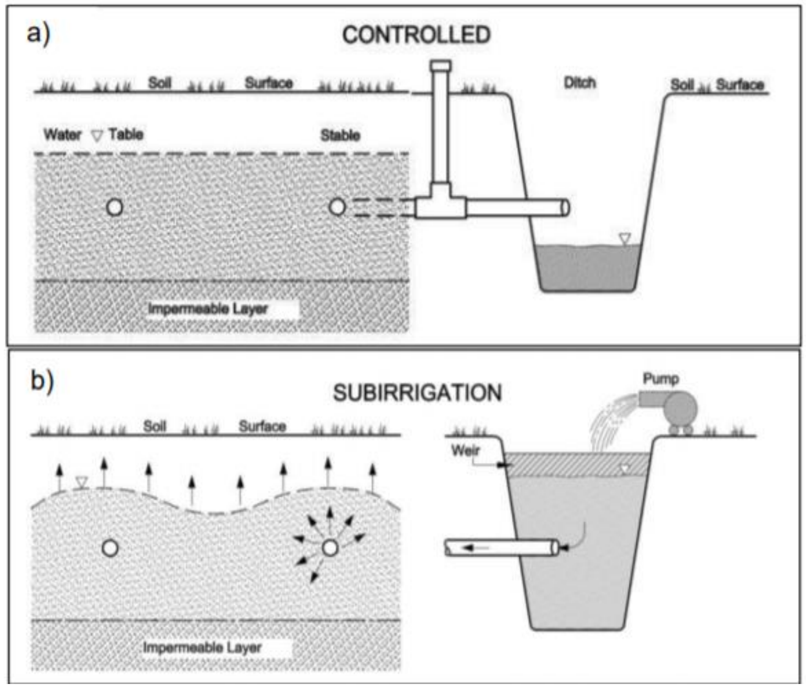


*Figure 41: Combining drainage and sub-surface irrigation (Delta, BC)*

There may also be ways in which other farm practices can be adjusted to reduce water demand such as through the use of more drought crop tolerant varieties, weed control, limited/no tillage, soil amendments to increase soil moisture, and varied cropping strategies. Demand management is an important consideration for the future but should not be viewed as the primary solution to water management in the Tsolum, as many producers who have water supply concerns are already using the most efficient form of irrigation possible. Demand management approaches should be paired with suitable water supply solutions.

### 12.1.6 Legal options

There are a variety of legal options that may be used to support agricultural water management.

#### *12.1.6.1 Agricultural Water Reserve*

The CVRD could apply for an Agricultural Water Reserve (AWR), which is a new mechanism available under the Water Sustainability Act (2016). Much like the ALR, which reserves land for future agricultural use, an AWR reserves water for future use on ALR and agricultural-zoned lands. An AWR would include existing allocations to agricultural properties as well as reserves for lands in the ALR that do not now have water rights. Unlike a water license, where a producer must use the water or lose rights to it (to prevent speculative water licensing), an AWR reserves water for the future. This is useful because it provides an incentive for conservation (if water demand is reduced through water conservation, the water saved will be available for agriculture in the future).

#### *12.1.6.2 Water Sustainability Plan*

The Water Sustainability Act (WSA) enables the creation of Water Sustainability Plans, which are powerful tools which may allow for the development of regulations which can restrict or limit users of land and water and delegate or share watershed decision-making. The province has not yet created guidelines for Water Sustainability Planning, so it is unclear what the criteria and process is for this work.

## 12.2 Consultation and Engagement: Group Highlights

In the consultation and engagement process, there were a few notable differences between participant groups.

- Participants at the Farmer's Institute AGMs were concerned about water quantity and many emphasized that water supplies were becoming an increasingly limiting factor on farms. Several producers at these meetings had already carefully evaluated various water supply and storage options and proposed potential solutions.
- The K'òmoks First Nation representatives stated that fish are a big priority. Fish are a main life source for the community and KFN community members have observed that fish are being cumulatively impacted by the many activities in the watershed, including historical mine contamination, irrigation extractions in summer months, and forestry. KFN Guardian Watchmen, Cory Frank, stated that after a lifetime spent fishing, hunting, gathering plants, and recreating in the watershed, he found that increased forestry activities in recent years has decreased water retention in watershed, causing greater and more frequent floods, more gravel and sediment transport, more channel alteration, increased bedload (filling in salmon habitat, covering eggs, making low flows effectively lower and causing river temperatures to rise to dangerous levels for fish). He also noticed that forestry reduced connectivity in the forest, which reduced wildlife health and populations. Cory observed reduced soil moisture and groundwater levels and found that increases flood flows were impacting historical sites in the estuary. With the river flowing much higher than historical averages, and significantly increased gravel transport, there has been a lot of erosion in the estuary, which is filling in old channels and creating new paths for water. These changes have far surpassed historical conditions and ancient fish traps are being carried away. KFN representatives also noted that while land use is already "wreaking havoc" on watershed, climate change will make everything worse. They recommended more tree planting in the watershed, increased vegetation retention, and no more extractions without storage.

> ***"The Tsolum is where I go to get my mint every year and I didn't get half of it this year. Even at the lower end of the river, the salmon berries aren't as prevalent as they used to be*"** Cory Frank, K'òmoks First Nation Guardian Watchmen Manager

- Public survey respondents had concerns about both water quality and quantity. Survey respondents who had concerns about water quantity were often already taking steps on their property to manage water efficiently (drip-irrigation systems, soil moisture sensors, irrigation scheduling). Many noted wanting to invest in water storage but not being able to cover the up-front costs. Some producers in the Tsolum who responded to the survey did not have quantity concerns, which demonstrates the variability of groundwater in the area.
- Participants at the public open house event focused on water supply issues on farm, stream health, and water governance. This event was well-attended by the stewardship community (approximately 37 participants in total) and there were approximately 6 producers in attendance. Many expressed concerns about impacts of forest practices on hydrology. There was a strong interest in solutions that focused on shared governance, demand management, and funding mechanisms (interest-free loans, funding assistance), to support development of on-farm storage.
- Several key stakeholders stated that they did not support the use of Wolf Lake as an irrigation water supply source (KFN, MIFI) due to its potential to be used for flow augmentation for EFNs. They stated that until EFNs are understood, this option should not be considered. Several also

thought it shouldn't be considered due to the substantial costs of construction of a dam and distribution system and challenges of establishing a new water service authority.

- Several people suggested that it may be possible to use reclaimed water from the wastewater treatment plant for watering in some cases (e.g. sub-surface irrigation, forage)
- Many stakeholder groups and individuals and the K'òmoks First Nation were interested in the development of a Water Sustainability Plan.

## 12.3 Key Themes

A few core ideas emerged from all the feedback received:

- **Water supply is variable and is a real limiting factor on many farms and residential properties:** While some producers in the Tsolum watershed have sufficient water supply, there are many that don't. In the community engagement process, over 81 comments were provided from producers and residents in the Tsolum River watershed, stating that they did not have enough water to run their farming operations and/or homes. Many producers mentioned not having enough water to utilize large portions of their property, even when using advanced water efficient technology and irrigation systems. Several residents described not having enough water for basic household needs and described ordering water deliveries by truck, storing water in bathtubs, using outhouses to save water, showering at friend's houses, and doing laundry in town.
- **Water supply is becoming an increasing concern:** Many producers described declining water availability and noted that they were able to grow less and less food on their property in recent years due to decreased water supplies. These comments were provided by both dryland farmers and irrigators. Many were concerned that water supply issues will become even greater with climate change and increased population.

  Most water quantity issues in the feedback were related to groundwater supplies, as groundwater is the primary source of water in this watershed.
- **Groundwater quality is variable:** Several residents and producers described groundwater quality concern, primarily related to naturally occurring iron, manganese, turbidity, and salinity.

> ***"Water supply is definitely an issue. There isn't enough water to go around by a long shot. Most people with water licenses aren't drawing their full allotments. I'm not sure what would happen to the river if everyone drew what they're licensed for."*** *Tsolum producer, 20 years*

- **We don't know how much water is available:** Many noted that it is difficult to plan for the future without knowing how much water is available. Given that there are already significant water supply limitations in the watershed, and a strong likelihood that water demands will grow, many suggested limiting future use approvals until we better understand how much water is available in local aquifers. Several noted that although we do not know exactly how much water is available, we *DO* know that there is a lot of water available in the winter, which supports the idea of using water storage in future plans.
- **Need to better understand groundwater/surface water interaction and aquifer recharge:** It is also important to understand how these aquifers are recharged and how much water can be used from them sustainability. It will also be important tto understand how much water that is being stored in Wolf Lake and released during low flow periods is going from the river into the local

aquifers. Understanding groundwater/surface water interaction also has a role in pollution control.

- **Prioritize water for agriculture, aquatic health, and existing domestic users:** There is a strong desire to see future water allocations prioritized for agriculture, aquatic health, and domestic purposes.
- **There is an interest in exploring water storage options but more information is needed to understand which option is best:** Over 50 participants suggested developing water storage to capture the plentiful water in rainy winter months for use in dry summer months. Participants were interested in both on-farm and regional-scale storage, with a preference for on-farm storage. It is important to note that the overall preference for on-farm storage reflects feedback from both producers and the broader public. Among producers, alone, there was a slightly greater interest in regional storage, due to the loss of land and financial barriers to on-farm storage. There are still many questions to be answered to assess the feasibility of each. For example, for regional storage, how much would it cost, how would it be distributed, who could benefit? For on-farm storage, are there ways to help producers make this large infrastructure investment?

> ***"Better water management is the cornerstone of food security, the protection of the environment, and our local economy. We are all concerned about a water deficit and the need to plan for the future. Our community needs to ensure that farmers are supported in creating food security."*** *Mid-Island Farmer's Institute Board*

- **Concerns about the impact of land clearing:** Many participants noted concerns about land clearing throughout the watershed and the impacts on flows. These comments were provided from stewardship groups, producers, and the K'òmoks First Nation. Several stated that over the past 25-30 years they had noticed flows become 'flashier' and a reduced holding capacity in the watershed. Most of these concerns were related to forest harvesting, and some were related to agriculture. Several were also concerned about the increased potential for groundwater contamination due to land clearing.
- **Local water governance:** Many, including stewardship groups, the K'òmoks First Nation, and some producers, were interested in watershed planning and/or developing a watershed roundtable, where various interests in the watershed were represented and could help make decisions about water management, particularly related to licenses and water use in times of scarcity.

- **Demand management is important but cannot be considered alone:** As water is a scarce resource in the summer, it will be important for producers to reduce demand, where possible. This can be done by assessing irrigation systems, improving irrigation systems were possible through maintenance and/or technology upgrades. However, this cannot be considered alone, as many of the producers who noted water supply issues in the survey were already using water efficient drip irrigation systems with soil moisture sensors and irrigation scheduling. In addition, many dryland farmers who are currently not irrigating will need to install irrigation systems in coming years, as climate change results in less summer precipitation.
- **Climate change brings uncertainty. A precautionary approach is wise.** Given that historical climate and flow data may not be an accurate predictor of future flows and climate patterns, it will be important to take a precautionary approach to ensure that the ecological health of the watershed is protected until we better understand climate impacts and both current and future water availability.

> ***"We are living in an era where 1-in-100 year climatic events are happening somewhere on this continent, even this province, every 2 to 5 years. This means that reliance on historical measurements may not be enough…. I would like to see reserves for fish double, not to 5% MAD but 20%. If we are (happily) wrong we can go back and allocate more water elsewhere later, but we need to safeguard the ecological basis of the coast before it is too late."*** *Conservation Partnership*

## 12.4 Summary of Public Engagement

The following is a summary of what was heard from participants:

- Prioritize access to water for agriculture, stream health, and residential needs
- Support water storage to increase agricultural water supply and reduce demand on local watercourses and aquifers in dry summer months.
- Quantify how much water is available in watershed aquifers and characterize these aquifers to understand aquifer recharge so they can be sustainably managed
- Support water conservation
- Take a watershed-scale approach, that considers the impacts of various land uses and users on water supply

Overall, one thing is clear from the many people who participated in Phase One; Tsolum River producers, residents, and the stewardship community care greatly about the watershed and are genuinely concerned about agricultural water needs and watershed health. A summary of public engagement activities can be found in Appendix C.

# 13 Recommendations and Next Steps

In order to develop recommendations for the next phase of Tsolum River agricultural watershed planning, the following actions were taken:

- Review of relevant policy and legislation and consultation with provincial staff
- Review of IAFBC Phase Two goals and objectives, including consultation with IAFBC
- Review of data gaps and assessment of their relationship to Phase Two work
- Review of all recommendations provided in the public engagement process
- Research into costs of recommended actions to assess their feasibility within the Phase Two budget
- Review of other local government watershed management programs and best practices

The following provides:

- An overview of the provincial water management context
- Recommendations for next steps in Phase Two of the Agricultural Watershed Planning process
- Recommendations for long term water management in the Tsolum watershed (if a suitable funding source or partnerships were established).

It is important to note that watershed management is both a multi-phase and multi-year process. Recommendations in this report are for Phase Two only. Partial funding for Phase Two is available from the IAFBC, and the recommendations for this work follow the IAFBC guidelines. Additional work is suggested at the end of Phase Two to identify next steps and potential funding sources. For the long-term recommendations, the CVRD would need to establish an appropriate funding source, water management service area, or complete work in partnership with other agencies.

## 13.1 Provincial Context

Provincial government staff were consulted to obtain information on the next steps required to initiate a Water Sustainability Plan (under the Water Sustainability Act) or alternative planning process, and the steps to prepare an Agricultural Water Reserve.

They shared that the Provincial government is in a place of transition as it begins implementing the Water Sustainability Act (2016). The Province is taking a phased approach to implementation, and at this point, has not yet developed clear guidance on the process for developing Water Sustainability Plans (WSPs) and/or Agricultural Water Reserves (AWRs). In addition, it has not clearly identified how it will be prioritizing watersheds or regions for plan development (Vigano, 2018).

The Province has stated that the only way to dedicate water to agriculture in the future is to establish an Agricultural Water Reserve, and to do that, a community must enter a Water Sustainability Planning process. This planning process is required because there are serious implications to establishing an Agricultural Water Reserve. It is essential that there is a rigorous process involved to ensure there is community support and a suitable scientific basis for a reserve (Vigano, 2018).

At this point, the Province has limited financial resources and capacity available for Water Sustainability Planning and there are many communities interested in this watershed planning process. Because of this, the Province is focusing water sustainability planning in a few select watersheds where there are high priority needs, existing impacts, and available information.

The Province is maintaining an informal list of communities and watersheds in which Water Sustainability Plans are of interest. Although the Province does not have clear criteria on how it will assess applications to establish Water Sustainability Plans, there is an interest in knowing which communities are interested in the planning process and where background data is being collected (P. Lapcevic, personal communication, November 13, 2018), (J. Vigano, personal communication, November 13, 2018).

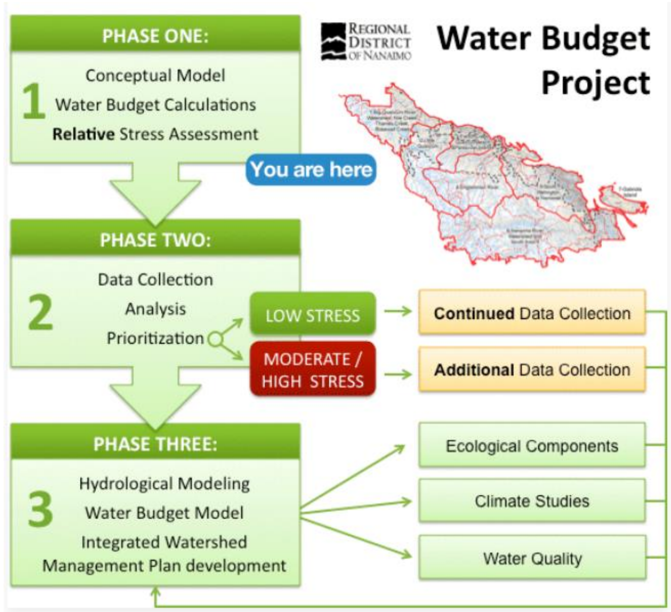

*Figure 42: Regional District of Nanaimo Water Budget Project Model*

## 13.2 Phase Two Recommendations

Phase Two of the watershed planning process is intended to include: hydrology modeling, scenario evaluations, and plan development.

Based on the feedback received from the community, guidance from IAFBC advisors (S. Tam, personal communication, December 14, 2018), and the existing information gaps, it is suggested that Phase 2 efforts focus on understanding:

- How much water is moving through the system (and how water moves through the system)
- How much of that needs to stay in the system (e.g. Environmental Flow Needs)
- And, how much water could be made available for producers (including where this water could be obtained from and how it could be stored).

If approved, up to $70,000 may be available for Phase Two work.

### 13.2.1 Hydrology Modelling

**Recommendation #1a): Develop a water budget, identifying the volume of surface water and groundwater available in the watershed.**

To support management of the watershed and the potential establishment of an Agricultural Water Reserve, the CVRD should develop a water budget, estimating the amount of water available in local aquifers and surface water and comparing this to the amount of water used. The assessment of water used should include the identification of how much water is needed by the natural environment, or Environmental Flow Needs, as described in Recommendation #2.

Given that groundwater use accounts for approximately 77% of water use in the region, particular care should be taken to quantifying how much water is available in local aquifers, groundwater/surface water interactions, and groundwater recharge.

Water budgets should be completed on a sub-watershed basis.

***Approach***

Before this project is initiated, the CVRD should meet with the KFN to identify opportunities for collaboration. The KFN may also be completing a groundwater budget in the Tsolum River watershed as part of their research and it would be beneficial to collaborate where possible to reduce duplication of efforts and combine resources to create a greater understanding of local aquifers.

Given the volume of groundwater use, attention should be paid to the groundwater component of the water budget, identifying areas of groundwater-surface water interactions and groundwater recharge. It will be important to assess the hydraulic connectivity of groundwater and surface water, to the greatest extent possible within the given budget. When developing an Agricultural Water Reserve it is essential to understand how much of the water in the stream (which is needed for aquatic life), comes from aquifers. The Provincial Water Science Series Report - "Determining the Likelihood of Hydraulic Connection" should be used when assessing hydraulic connectivity of the watershed (Lapcevic, 2018).

In order to ensure that the information that is gathered is of a suitable nature and quality, the CVRD and their consultant should meet with Regional staff (e.g. Section Head, Water Protection and Section Head, Water Authorizations) to obtain guidance (J. Vigano, personal communication, November 13, 2018). The MFLNRORD is developing an approach to estimating groundwater availability and conducting water budgets for the purpose of establishing water reserves. This will be described in a provincial 'Water Science Series" report in early 2019 (Lapcevic, 2018). The CVRD should ensure that the estimates of groundwater availability and water budget assessments meet the minimum standards outlined in this document. A more sophisticated and robust approach would be preferable if budget permits.

Provincial staff have advised that the information on water use developed through the AWDM and used in Phase One is of a suitable quality for estimating agricultural water demand for this initial water budget (Lapcevic, 2018).

Given that there is currently limited information available on several components of the water budget, the work conducted in Phase Two will be a preliminary water budget. As more information on different components of the water budget becomes available, the water budget can be refined. Figure 42 shows how a preliminary water budget can fit into the broader picture of long-term watershed management.

**Recommendation #1b): Develop an understanding of Environmental Flow Needs and the Critical Environmental Flow Threshold.**

Legally, the environment is the highest priority user of water, so Environmental Flow Needs and the Critical Environmental Flow Threshold must first be determined in order to identify how much water is available for agriculture and other users.

Environmental Flow Needs of the Tsolum Watershed should be developed on a sub-watershed basis and include consideration of stream temperature, instream habitats, proper functioning condition of riparian areas, and climate change. The KFN and TRRS (at a minimum) should be involved in this process.

**Approach:**

The following approach is suggested:

1. Project initiation meeting with representatives from organizations that understand local aquatic ecosystems including the EFN consultants, CVRD, DFO, a Provincial Aquatic Ecosystems Specialist, K'òmoks First Nation, the Tsolum River Restoration Society, and the consultant engaged to complete the Phase Two Agricultural Watershed Planning work.
2. Desktop screening assessment: Apply Provincial EFN Risk Management Framework to determine the risk management level in the Tsolum River under the current and potential future allocations, in consideration of the natural sensitivity of the stream. This screening assessment will identify potential measures to assess or mitigate effects of water use (e.g., field studies).
3. Background review to identify previous studies that may be useful and gather key information about the ecology of the Tsolum River. Includes review of AWP Phase 1 report and relevant studies that have been conducted to date (e.g., 2010 Biophysical Assessment, 2014 Fish Habitat Assessment Procedure Report (FHAP), 2007 Flow Augmentation Feasibility Study)
4. Instream Flow Study (IFS) field study and habitat modelling to develop relationships between habitat and flow
5. Additional Fish Habitat Assessment Studies (if required, depends on the outcome of 3. above)
6. Preparation of a report describing impact on flow-sensitive environmental values should all future allocations be applied, including potential mitigation options.

Items 1-3, a portion of 6, and a portion of 5, should be included in the Phase Two work (dependent upon whether additional FHAP field work is required to support the IFS work). Actions 4 and much of 5 may need to be completed outside of Phase Two funding.

Where possible, it is suggested that the approach used in the Okanagan Basin is followed (recognizing that the OBWB has significantly greater resources to conduct the work).

EFNs have recently been developed for the Puntledge River. Some of the information used in the development of these may be of use and this report should be shared with the consultant working on EFNs for the Tsolum.

### 13.2.2 Scenario Evaluations

**Recommendation #2: Assess water storage options and alternate supplies**

Phase One of the Tsolum River Agricultural Watershed Planning process has identified that water storage capacity will need to be increased in the Tsolum River watershed to meet the joint challenges of agricultural production growth, environmental protection, and climate change. In Phase Two, the CVRD should evaluate options to improve access to irrigation water through increased water storage and alternate supplies.

This work should be carefully coordinated with the water budget work so that there is a sufficient understanding of available water volumes from the different water supply sources. Any numerical values that are identified in the scenario development should be reported on a sub-watershed basis, where possible.

***Approach***

It is suggested that the following water management scenarios are evaluated:

1) On-farm water storage: identify using GIS tools approximately how much land could be used for water storage on farm properties and how much water could be made available through storage. This should include a consideration of available land for on-farm storage (based on lot sizes, cleared land, etc.), as well as feasibility of (e.g. would it be possible to store and distribute the amount of water required?). The storage volumes should be compared to the estimated future water needs under AWDM scenarios. Where appropriate, integrated drainage and water supply systems should be considered, as these will have multiple benefits for producers and aquatic life.
2) Alternate water supply sources and distribution options: assess the potential to use alternate water supply sources (e.g. reclaimed water) for irrigation. Reclaimed water is not appropriate in many agricultural contexts but may be appropriate for watering forage or in some cases for sub-surface irrigation. Currently there is no water supply service area or irrigation district to take on the responsibility for large-scale regional storage, so this would need to be considered.
3) Demand management: estimate approximately how much water could be saved through the use of demand management (e.g. irrigation system upgrades, beneficial management practices). Much of this information should be available from the AWDM study.

The water management scenario work should include:

- An assessment of the long-term and short-term costs of the different scenarios
- Potential funding mechanisms;
- A preliminary assessment of the potential impact of each option on other users and aquatic health.

This work should be done on a sub-watershed basis and integrated with the water budget work to the greatest extent possible.

**Recommendation #3: Community and Advisory Committee engagement.**

Once the CVRD has gathered information on the amount of water available and has completed an assessment of water storage and distribution options, they should consult with producers to obtain feedback on the various possible water management scenarios. The CVRD should also consult with the broader community including stewardship groups and other watershed stakeholders to ensure diverse interests are considered. Throughout the work, the CVRD should consult with the local representatives through the Advisory Committee.

***Approach***

According to feedback from survey the best way to reach producers is through local Farmer's Institutes, Internet/Social media, and the Country Life in BC publication.

### 13.2.3 Plan Development

**Recommendation #4: Communicate with the Province to identify an interest in Water Sustainability Planning.**

The final deliverable for Phase Two will be a plan for the watershed that is intended to be endorsed and/or adopted by the CVRD. The following provides an overview of Phase Two.

It is recommended that the CVRD communicate with the Provincial government regional staff at the onset of Phase Two work to ensure that the work, where possible, aligns with the guidelines required by the Province for the establishment of an Agricultural Water Reserve.

Given the historic, current, and future concerns regarding water supplies, and the substantial amount of agricultural land available, regardless of how current and future agricultural water needs are met, it would be valuable to support a portion of the water in the watershed being reserved for agriculture now and in the future. Although the CVRD has not committed to developing a Water Sustainability Plan, or an Agricultural Watershed Reserve, understanding the potential planning process and its information requirements will be a proactive measure.

***Approach***

When communicating with the Province, it is advised that the CVRD develop a "Problem Statement", identifying historical, current, and anticipated water supply issues, projected climate impacts and future water needs. It should note that an AWR could help ensure there is enough water available for agricultural users, the environment, and domestic needs now and in the future. This "Problem Statement" should be provided to Regional Staff so that they are aware of the watersheds in the province that are potential future candidates.

In engagement for this work, the KFN may also have a desire to provide a letter of support to the Province for this process and should be reached out to early on in the process.

**Recommendation #6: Develop plan for next steps**

Once the community and Advisory Committee has provided input on the preferred approaches for water management scenarios in the watershed, a plan should be developed, identifying next steps and actors. This plan will not be a watershed plan but provide the information to support the CVRD in taking next steps with the development of a Water Sustainability Plan, if desired. This plan should also summarize the work completed in Recommendations #1-4.

### 13.2.4 Cost and Implications of Phase Two Recommendations

The following is a summary of the estimated costs associated with Phase Two recommendations.

| Phase 2 Component | Recommendation | Estimated Cost |
|---|---|---|
| **Hydrology modelling** | #1a: Develop water budget | $25,000[3] |
| **Hydrology modelling** | #1b: Identify Environmental Flow Needs | $21,000 |
| **Scenario evaluations** | #2: Assess water storage options | $12,000 |
| **Scenario evaluations** | #3: Community engagement: assess scenarios with producers, broader community, and Advisory Committee | $7,000 |
| **Watershed plan** | #4: Communications with Province | - |
| **Watershed plan** | #5: Development of report and plan for next steps | $4,000 |
| **Total Cost** | | **$70,000** |

These actions will  support the CVRD in meeting the goals identified in the Regional Growth Strategy, including:

- 2C-8 Support increased water availability for agriculture while ensuring natural systems remain healthy and functioning.
- 3C1 - Work with the Ministry of Agriculture and Lands and the Agricultural Land Commission to develop strategies and actions to increase the amount of actively farmed agricultural lands and reduce barriers to agricultural viability in Agricultural Areas.
- 3C-2 - Encourage the development of infrastructure to help increase agricultural production such as irrigation water and regional drainage improvements.
- 6-A: Protect land for existing and future agriculture and associated activities and allow for the growth and expansion of such activities.
- 6C-1 Local governments and farmers should work together to increase irrigation water supply to support agricultural activities
- 6C-2 Local governments, agricultural stakeholder groups and farmers should work together to increase non-potable irrigation water to farmland.

## 13.3 Long Term Recommendations

Based on the completed data gathering and public engagement process we have identified several recommendations for the Tsolum River watershed that are beyond the scope of Phase Two of the Agricultural Watershed Planning process. These general recommendations for watershed management are not eligible for IAFBC funding under Phase Two and would require an additional funding source such as grant funding, partnership with other organizations, or establishment of a watershed management service area, similar to the Drinking Water and Watershed Protection Program at the Regional District of Nanaimo.

If a watershed protection service area was established, further work should be done to develop long-term recommendations for management that incorporate all watershed interests and objectives.

These additional recommendations are described in further detail below.

**Additional Recommendation #1: Pilot on-farm water storage and/or demand management actions**

While the best way to address long-term agricultural water supply needs may require significant planning and study, it would be ideal to balance long-term planning efforts with actions 'on the ground' for on-farm water management actions. This will help maintain the engagement and support of the agricultural community and demonstrate a commitment to action.

There are many 'low' or 'no-regrets' actions that could be taken immediately which would have immediate value and multiple benefits, such as demonstration or piloting of beneficial practices in the area of demand management or on-farm water storage.

During the engagement process, several participants described several potential 'early actions' that could provide concrete, immediate benefits.  Examples included incentives for producers to develop on-farm storage (highest ranked) and a forage trial testing the effectiveness of various watering practices (e.g. comparing forage yields when watering an inch/week compared to watering using the provincial irrigation guidelines). The MIFI and other participants suggested support sharing information on other methods of farming that focus on water conservation. Many of these methods involve storing water in the soil and vegetation, as well as capturing seasonal rains, with the added benefit of potentially recharging aquifers. Such an initiative could likely be delivered for a low administrative cost through one of the local farmer's institutes.

If possible, it would be ideal to work with a local Farmer's Institute to apply for top-up funding from other initiatives (e.g. Growing Forward, Group Environmental Farm Plan, or Farm Adaptation Innovator funding).

This approach (providing funding for 'early actions', while developing a long-term plan) was used with great success among agricultural and rural residential communities in the development of the Ontario Source Water Protection program and is an excellent way to maintain community relationships and forward momentum during long-term plan development.

Potential Partners: Local farmer's institutes, Environmental Farm Planning program, funding sources listed above.

**Additional Recommendation #2: Increase understanding of groundwater and surface water resources and aquatic needs**

If funds were available and/or partnerships could be established, there are many ways in which an improved understanding of the groundwater and surface water sources in the watershed could help support watershed management.

Table 12 provides information on steps that could be taken to address data gaps in the Tsolum River watershed, if funding sources were available. This table identifies potential next steps to fill data gaps, as well as potential partners, funding sources, and costs (where possible).

*Table 12: Recommendations to address data gaps (beyond Phase Two)*

| Data Gap | Discussion/Approach | Term | Leadership | Potential partners | Phase 2? | Approximate Cost |
|---|---|---|---|---|---|---|
| **WATER QUANTITY** | | | | | | |
| **1) Environmental Flow Needs** | If the Phase Two EFN work discovers that a instream flow study is required, to quantify EFNs, this work should be completed, to help provide a clearer picture of how much water should remain in the watershed and how much water is available for agriculture and other users. | Short Term | CVRD | TRRS, KFN | Partially | \$65,000-\$70,000 |
| **1) Water usage data for groundwater and surface water** | It would be very helpful to better understand water use in the watershed, but it is difficult to know how to best address this data gap. Generally, metering water use causes a user to conserve water, so metered data is not the best representation of use for unmetered users. Also, given that 85% of the water use in the watershed is for irrigation, and irrigation demand is very dependent on individual producer's practices, land, irrigation systems, crop type, etc. a large amount of data would be required to refine irrigation use estimates. Although the Provincial government staff have stated that AWDM values are sufficiently accurate at this time to be used in provincial decision making, it may be helpful at a later date to monitor a few farms to test the AWDM estimations. | Longer Term | CVRD | MIFI, CVFI | No | Unknown |
| **2) Groundwater data** | Currently there is no monitoring of groundwater levels in the Tsolum River watershed. It is recommended that the CVRD work with private well owners (similar work is done at the RDN) to monitor groundwater levels by installing water level loggers in one or more volunteer unused/private domestic wells. The information collected would be of value in the longer term (after 10-15 years). This would likely be led by the CVRD as other organizations have limited authority/funding for this sort of work. The Provincial Government ( MFLNRORD) has developed a tool to store and share water data, called the Real-time Water Data Tool. This should be used if possible. (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools/real-time-water-data-reporting). | Medium Term | CVRD, MFLNRORD | Private well owners, expertise from MFLNRORD with regards to equipment and monitoring plan | No | \$10,000-\$15,000/year (higher costs in first year to establish program) |
| **3) Surface Water Data** | Flow monitoring would provide information that is useful in the medium term for calculating water budget values and in the long term for identifying trends. This data could be stored in the Real-time Water Data Tool (above). The MFLNRORD is also working to develop its own hydrometric network, and should be conducted to identify partnership potential. It would be ideal to store and share surface water data via the Real-time Water Data Tool (link above). | Medium and Long Term | MFLNRORD, Water Survey of Canada | TRRS, BCCF | No | Unknown |

| | | | | | | |
|---|---|---|---|---|---|---|
| **4) Surface water/ groundwater interaction along Tsolum River and Portuguese Creek** | Suggested: use guidance documents from MFLNRORD on assessing hydraulic connectivity. This work would likely be partially considered in the development of a water budget. | Short Term | CVRD | TRRS, grant funding? | Partially: with water budget | Unknown |
| **5) Aquifer mapping and characterization** | Requires technical work and potentially drilling of observation/test wells to validate the characteristics of the aquifers. Some of this work may be addressed with the development of the water budget. The aquifer mapping and characterization should continue to be refined as new information is gathered. | Medium Term | | | Potentially: with groundwater budget. | Unknown |
| **6) Land Use Management** | Residential and (non-agricultural) Industrial/Commercial development on agricultural lands in the watershed should be limited. If this development is allowed to occur, strict water conservation practices should be required. | Short-term | CVRD | | No | None |
| **WATER QUALITY** | | | | | | |
| **7) Groundwater quality data** | Voluntary sharing of private well test data (as is done in the Regional District of Nanaimo in partnership with North Island Labs/Maxxam Analytics) would likely require little staff investment and little to no funding from the CVRD. | Short Term | CVRD | Maxxam Analytics | No | Limited ($3,000 to launch program with rebates for completing water analysis) |
| **8) Water quality data for tributaries** | Currently, there is no water quality information from tributaries. TRRS is willing to assist with sample collection provided there is funding available for analysis | Medium Term | MOE | CVRD, TRRS | No | Depends on parameters and partnership with stream keepers groups |
| **9) Chronic guideline analysis** | This would help provide a better understanding of water quality impacts on aquatic life. | Long term | MOE | CVRD, TRRS | NO | Unknown |
| **10) Water Quality Objective attainment monitoring** | The MOE has established water quality objectives (1995, 2012) for the watershed and suggests monitoring for compliance every 5 years. Therefore it is timely to revisit whether objectives are met and/or adequate and whether they should be updated to the present understanding of watershed. | Medium Term | MOE | CVRD, TRRS | NO | Unknown |

# 14 Conclusions

Access to water is a current and increasing concern for producers and residents in the Tsolum River watershed. In coming years, it is likely that water supply challenges will increase as climate changes, agricultural land is developed, and population increases. The Tsolum River Agricultural Watershed Planning process can help reduce conflicts for water users, reduce the environmental impact of the extreme high and low flows, and support local agricultural producers in securing access to reliable water supplies. The information gathered in this report and the proposed recommendations will help ensure that there is a sufficient amount of water available in the Tsolum River watershed for agriculture, fisheries, and watershed residents, now and in the future.

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# Tsolum River Agricultural Watershed Plan: Phase 1

## Data compilation and preliminary analysis of existing data
## Hydrogeology Study

**Prepared for:**

Elucidate Consulting

**Prepared by:**

GW Solutions Inc.

July 2018

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# 1 BACKGROUND AND TASKS

GW Solutions has been retained by Elucidate Consulting to assist with the following tasks:

- Water quantity
    - Review, compilation and analysis of surface water licenses
    - Estimation of domestic groundwater withdrawals within the project area
    - Review of mapped aquifers and water wells
    - Delineate aquifers based on well information
    - Review, compilation and analysis of surface water flows
- Water quality
    - Review and compilation of water quality data
    - Water quality data integration
    - Comparison of water quality data with guidelines (aquatic life, drinking water, irrigation, and livestock)
- Provide comments on data gaps for both water quality and quantity

# 2 INFORMATION SOURCES

To complete the above tasks, GW Solutions has accessed the following sources of data:

- Water quantity
    - Water Survey Canada
    - BC Conservation Foundation (BCCF) and Tsolum River Restoration Society (TRRS) Station

  - BC data catalogue (BC MoE): Mapped aquifers, water wells database
  - BC Cadastre and land use
  - Licensees of Points of Diversion (PODs) for surface water and springs
  - Vancouver Island Health Authority (VIHA)
  - Ecological Reports Catalogue (EcoCat)
  - Freshwater Watersheds Atlas (FWA)
- Water quality
  - Ecological Reports Catalogue (EcoCat)
  - Environmental Monitoring System (EMS), Ministry of Environment
  - Vancouver Island Health Authority (VIHA)

# 3 STUDY AREA

The study area, shown in Figure 1, is composed of the Tsolum River watershed located within the Comox Valley Regional District (CVRD). The Tsolum River is the longest River (42km) within the study area. Table 1 summarizes the length of the main waterbodies within the Tsolum River Watershed.

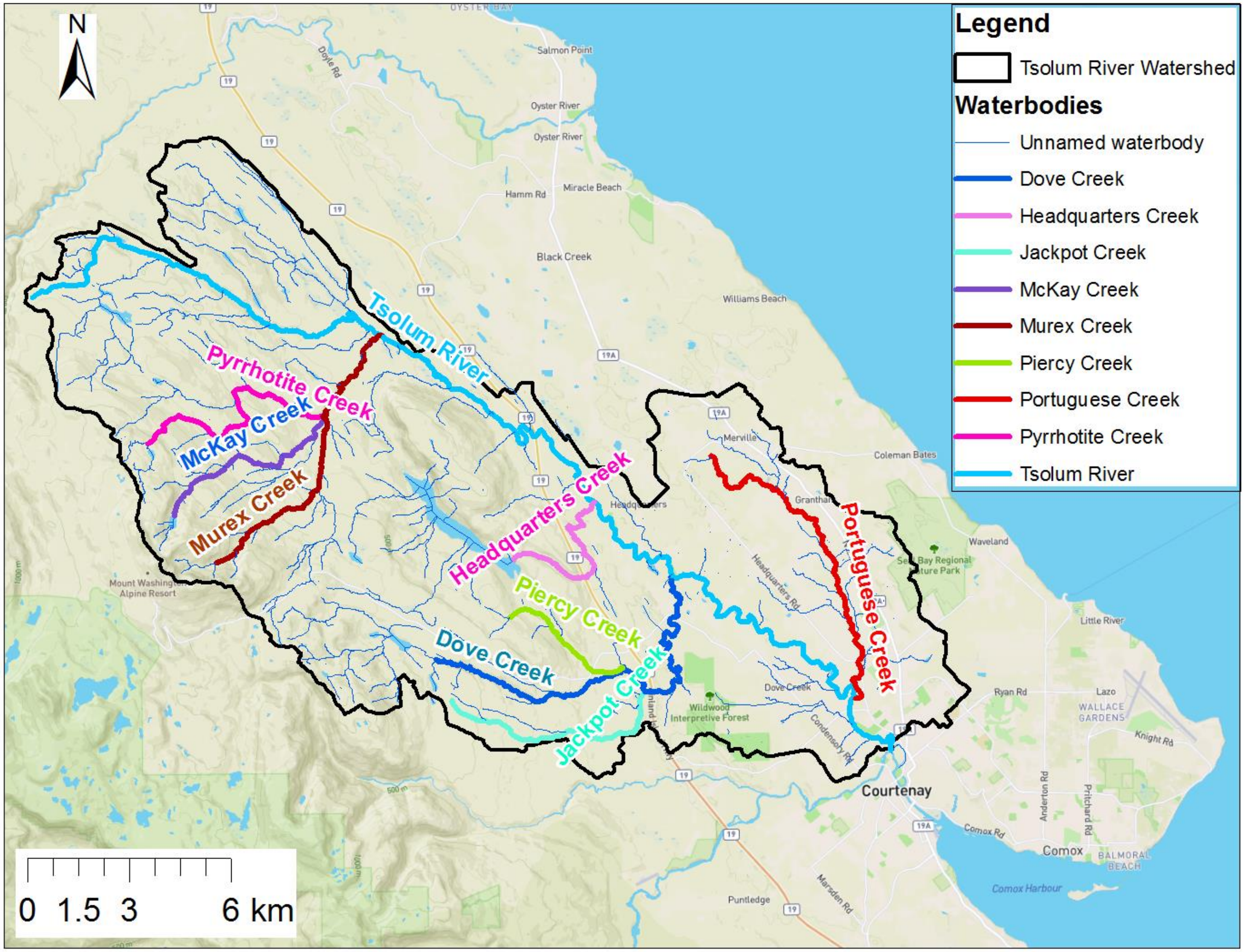



**Figure 1. Study area, Tsolum River Watershed**

**Table 1. Length in kilometers for the main waterbodies**

| Waterbody name | Length (km) |
|---|---|
| Dove Creek | 14.8 |
| Headquarters Creek | 6.3 |
| Jackpot Creek | 7.6 |
| McKay Creek | 6.6 |
| Murex Creek | 10.5 |
| Piercy Creek | 4.4 |
| Portuguese Creek | 11.6 |
| Pyrrhotite Creek | 8.2 |
| Tsolum River | 41.8 |

# 4 WATER QUANTITY

## 4.1 Review, Compilation and Analysis of Surface Water Licenses

### 4.1.1 Licenses of Points of Diversion – POD

The BC Points of Diversion (POD) includes Water License information for surface water and springs. This database contains a record for each water license on each Point of Diversion that exists in the province (each Point of Diversion can have multiple licenses). For each record, some basic information about the water license is included such as license status (refused applications, pending, expired, current, cancelled, active applications, abandoned, and abandoned applications), expiry date, granted volume and its corresponding unit and purpose (there are 60 classes for current licenses on Vancouver Island).

Figure 2 shows the location of the POD licenses for surface water and springs within and near the Tsolum River watershed classified by source (spring and surface water). Figure 3 shows the location of POD licenses within the study area classified by license status (current, abandoned licenses, abandoned applications and refused applications). Figure 4 shows the number of licenses within the watershed classified by purpose, use and sources. There are 67 PODs current licenses within the study area from which 56 correspond to surface water and 11 to springs. Within the current surface water licenses, most of them correspond to irrigation (30 licenses) followed by domestic use (18 licenses); whereas, for springs, 80% of the licenses are for domestic use.

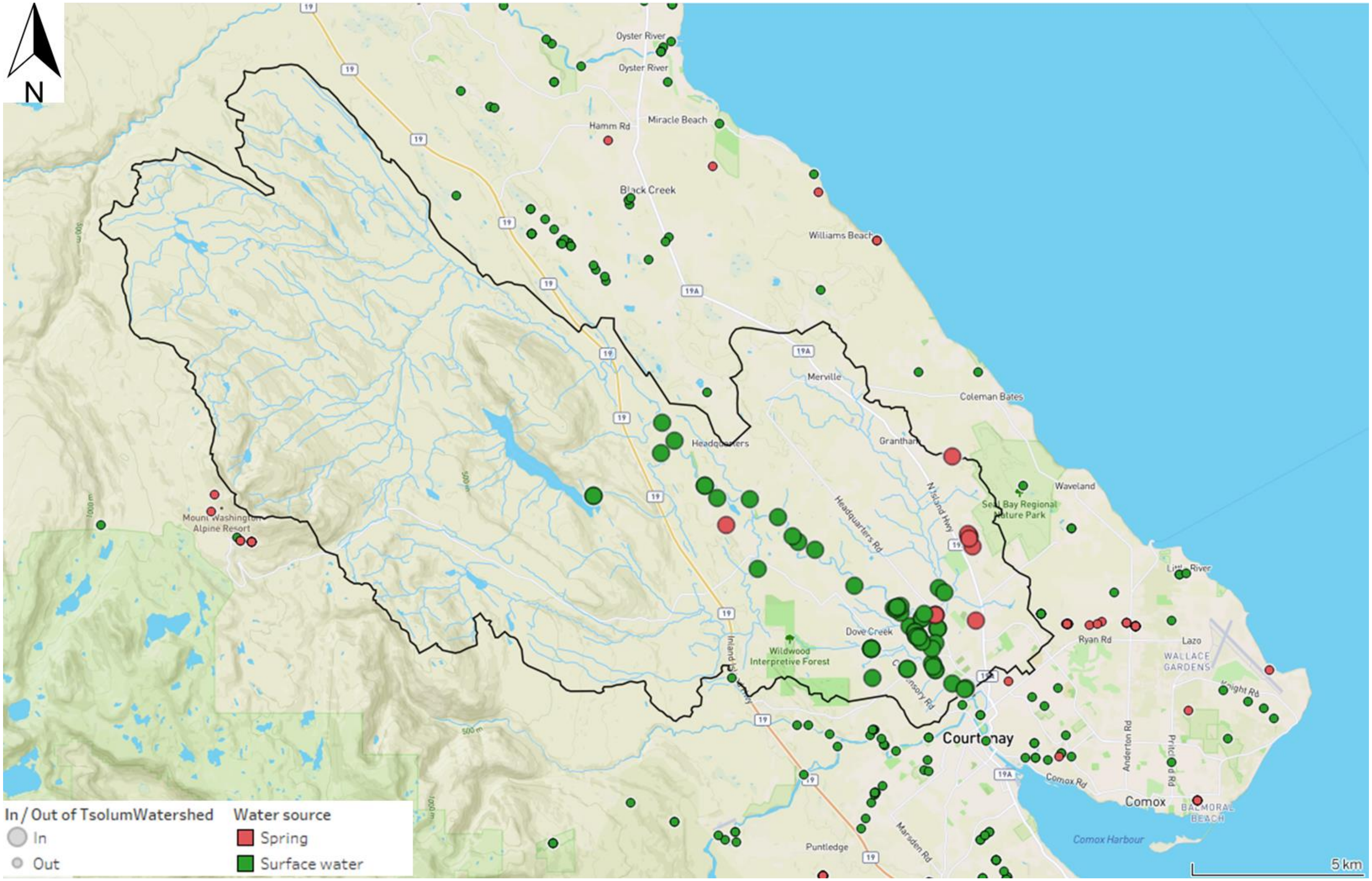



**Figure 2. Points of Diversion licenses (POD) within/near the Tsolum Watershed**

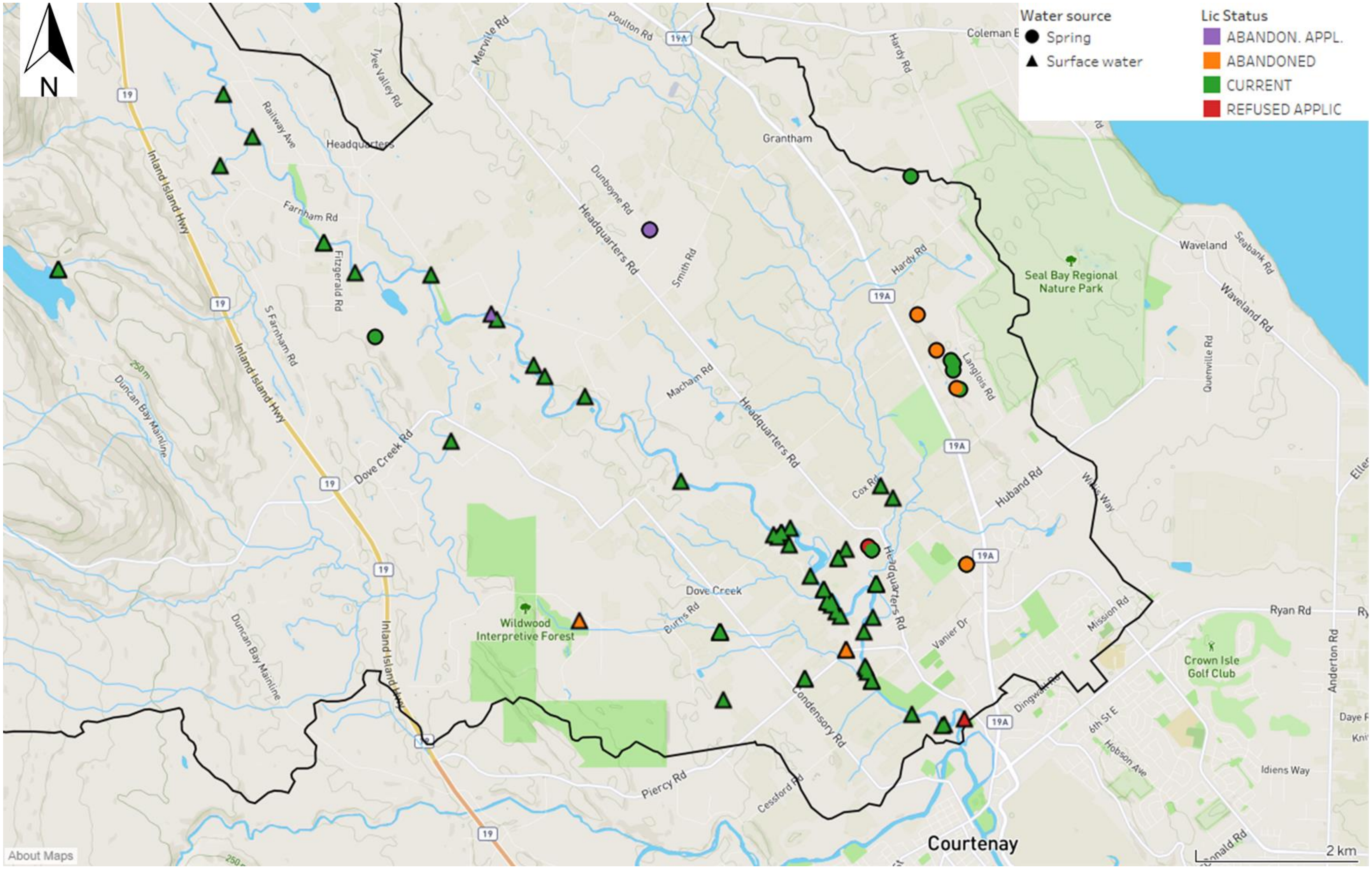



Figure 3. Points of diversion licenses (POD) within the Tsolum Watershed classified by license status

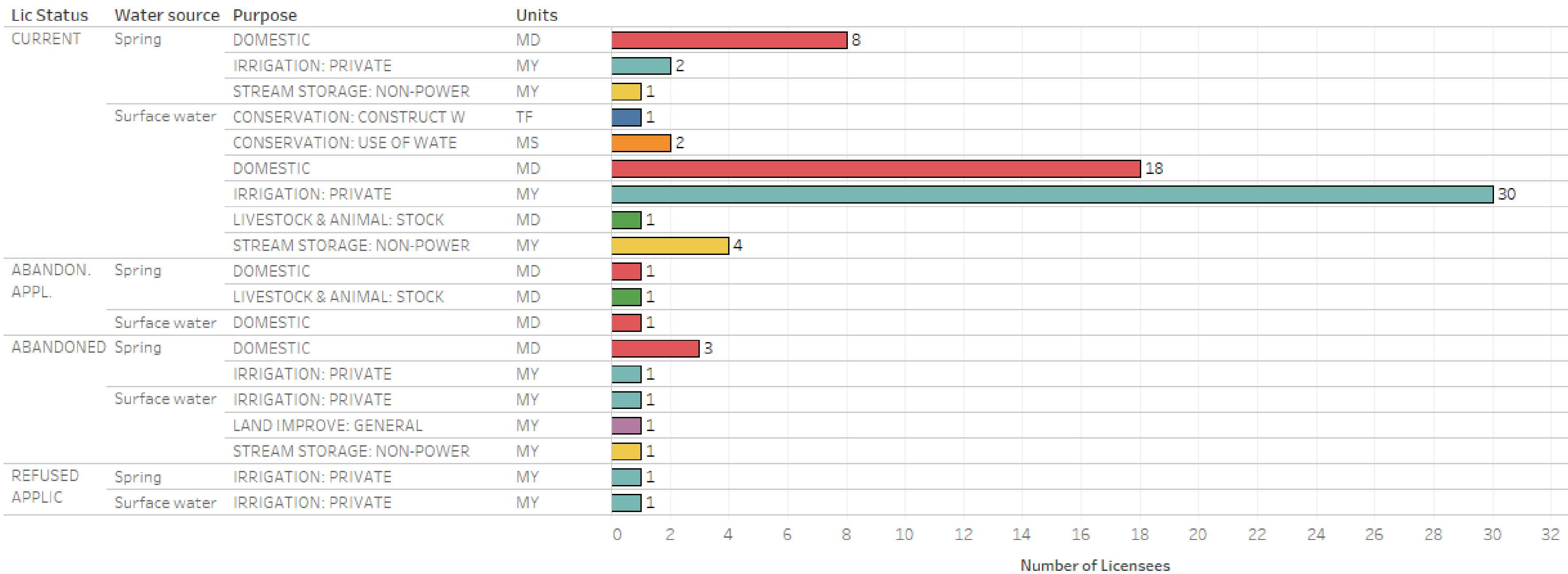



**Figure 4. Number of licenses for water extraction (POD) classified by use within Tsolum River Watershed**

### 4.1.2 Estimation of water volumes for current PODs

GW Solutions has estimated the water usage considering current licenses for both springs and surface water. Table 2 summarizes the monthly coefficients used for the estimation of monthly water usage from PODs.

Figure 5 shows the total monthly usage in cubic decameters (1dm$^3$ = 1000m$^3$) for all the licenses within the Tsolum River watershed. July and August are the months with largest water usage. In addition, 97% of the water usage corresponds to surface water.

Figure 6 shows the resulting water usage by purpose; 94% of the water is used for irrigation purposes, 5.5% is used for domestic and the remaining (<1%) for livestock.

Finally, Figure 7 summarizes water usage by waterbody. Most of the water is extracted from the Tsolum River (92% of the total water usage) followed by Carwithen Swamp (2.8%), Mattoon Spring (1.6%) and Forsyth Creek (1.4%). The water usage from the other waterbodies is recorded at less than 1% of the total water usage.

**Table 2. Monthly allocation coefficients for estimated water usage from PODs**

| Purpose | Usage | YEAR TOTAL | JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER | NOVEMBER | DECEMBER | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONSERVATION: CONSTRUCT W | **NO** | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| DOMESTIC (WSA01) | **YES** | 12 | 0.85 | 0.85 | 0.85 | 0.85 | 0.95 | 1.00 | 1.50 | 1.50 | 1.10 | 0.85 | 0.85 | 0.85 | Domestic usage -Nanaimo |
| CONSERVATION: USE OF WATE | **NO** | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| LIVESTOCK & ANIMAL: STOCK | **YES** | 12 | 0.85 | 0.85 | 0.85 | 0.85 | 0.95 | 1.00 | 1.50 | 1.50 | 1.10 | 0.85 | 0.85 | 0.85 | Assumed same as domestic |
| STREAM STORAGE: NON-POWER | **NO** | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| IRRIGATION: PRIVATE | **YES** | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20 | 2.40 | 3.60 | 3.60 | 1.20 | 0.00 | 0.00 | 0.00 | AWDM |
| DOMESTIC | **YES** | 12 | 0.85 | 0.85 | 0.85 | 0.85 | 0.95 | 1.00 | 1.50 | 1.50 | 1.10 | 0.85 | 0.85 | 0.85 | Domestic usage -Nanaimo |

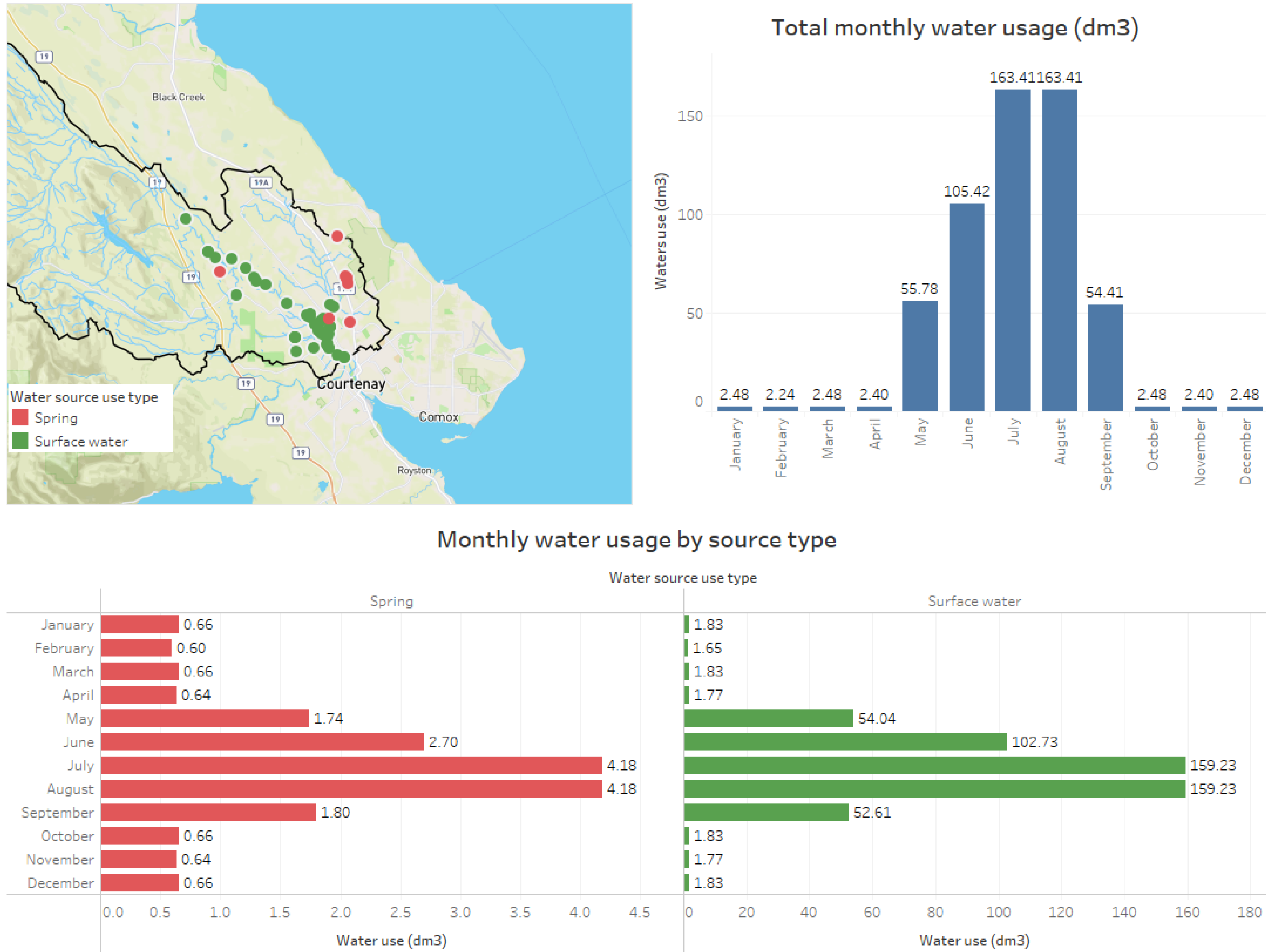



**Figure 5. Total monthly usage by source: spring and surface water**

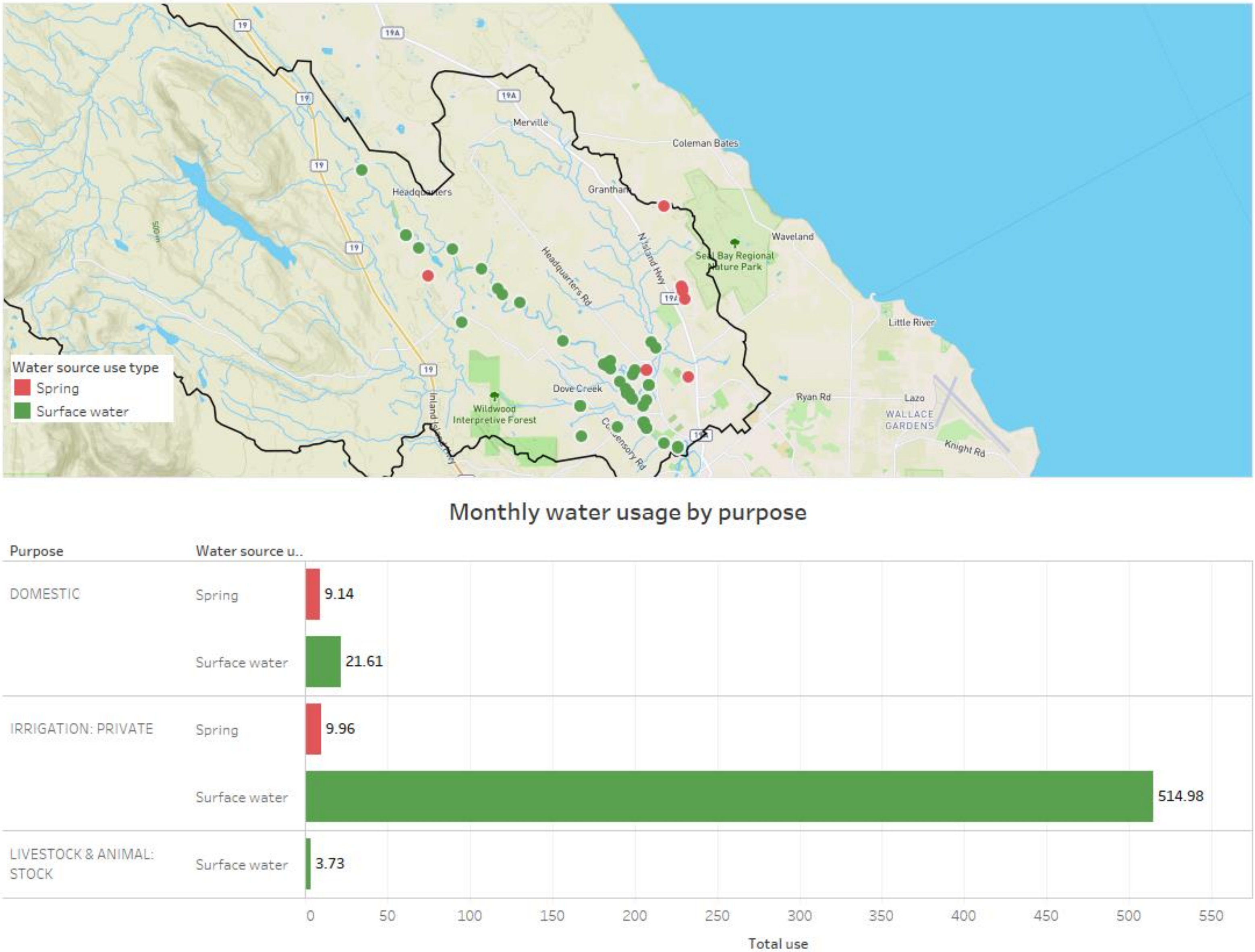



**Figure 6. Total monthly usage by purpose: domestic, irrigation and livestock (total use in cubic decameter-dm$^3$)**

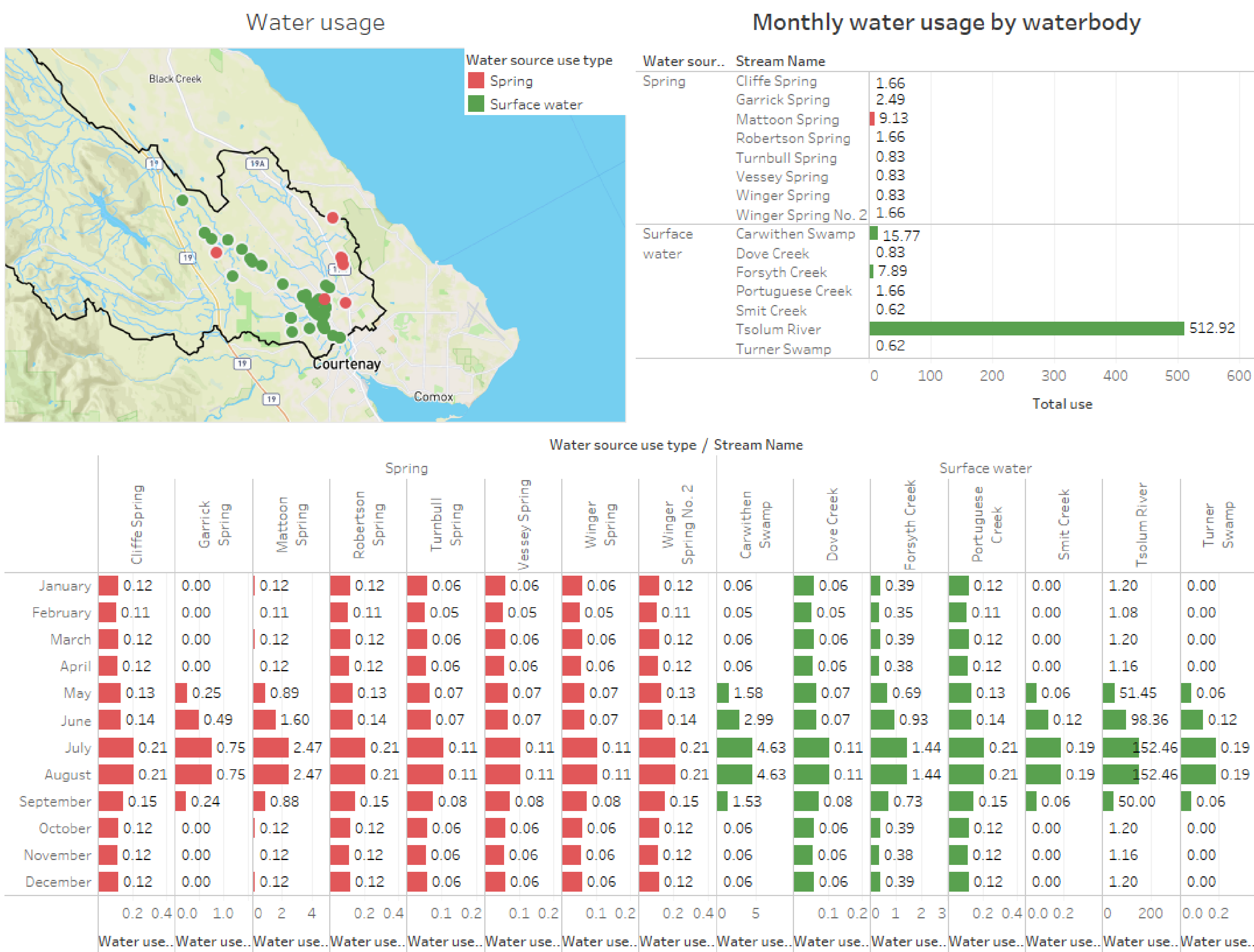



**Figure 7. Total monthly usage by waterbody**

## 4.2 Estimation of Domestic Groundwater Withdrawals within the Project Area

### 4.2.1 Data sources

#### 4.2.1.1 *Population from the Canadian census 2016*

According to the Canadian Census (2016), there are approximately over 8,000 people in approximately 3,500 private dwellings.

#### 4.2.1.2 *Water wells database and cadastral information-BC Assessment*

The groundwater wells database is maintained and operated by the Province. It includes information on construction, completion, alteration, or decommissioning of a well, encountered lithology, and the water bearing characteristics of the aquifer.

The wells are classified by use: Water Supply System, Unknown Well Use, Test, Private Domestic, Observation Well, Irrigation, Commercial and Industrial, and Other. Not all the wells in the database are active. For instance, abandoned wells, closed wells, dry wells, and test/observation wells are listed.

The wells database does not provide pumped volumes. GW Solutions has combined information from the Cadastral data-BC Assessment and the wells database. Groundwater usage was estimated based on the location of the well and the property type.

Water supply system wells were not included in the analysis because the water usage of these wells cannot be estimated based on the land but rather on the number of connections. Therefore, we relied on groundwater source approvals from the Vancouver Island Health Authority data which are more adequate to estimate water use.

#### 4.2.1.3 *Vancouver Island Health Authority – VIHA*

According to VIHA's website, 889 water supply systems are recorded; however, they do not include First Nations water supply systems. A source is considered a water supply system if it serves two or more connections.

The VIHA data was used only for groundwater source (water wells) since surface water and springs are already included in the BC POD database.

The available VIHA data describes the range of number of connections being used by each source. GW Solutions assumed an average number of connections per source and applied an average usage per person of 250 litres per day.

### 4.2.2 Methodology

The water wells have been classified by use in seven groups based on cadastral information: Water Supply System, Recreational, Irrigation, Institutional, Industrial, Domestic, and Commercial.

Figure 8 shows the location of wells with the study area classified by use and status type. Additionally, this figure shows the number of water wells considered for each type of use. Most of the active water wells corresponds to domestic and irrigation use, with 278 and 171 water wells, respectively.

For the water use estimation from water wells, only active wells were considered. In addition, usage coefficients, summarized in Table 3, were applied to estimate monthly pumped volumes. Table 3 takes into account seasonality usage and land size. For instance, for irrigation two seasonality labels are used:

- “h”: estimated volume depends on the size of the land
- “5 mh”: estimated volume depends on the size of the land and frequency of use where “5 m” refers to number of months of usage (May to September) and “h” means it depends on the size of the land.

Monthly seasonal variation was also applied to water usage with percentages summarized in Table 4. The percentages are very similar to the coefficients used for the POD water usage estimation.

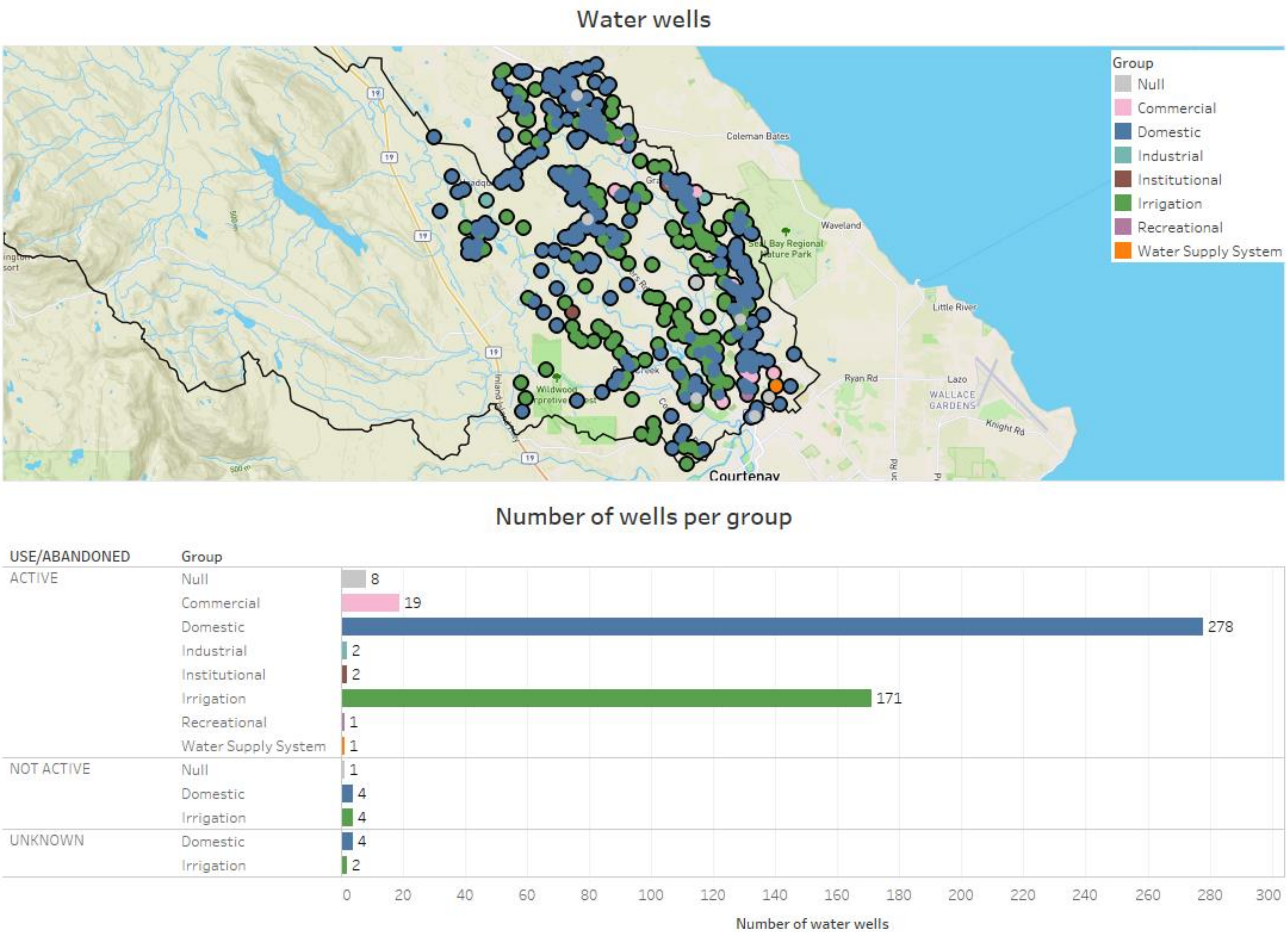



**Figure 8. Number of water wells by status and use**

**Table 3. Usage coefficients based on parcel information**

| Group | Name only | L/day/parcel | Seasonality | Number per ha |
|---|---|---|---|---|
| Commercial | Automobile Dealership | 5997 | | |
| Commercial | Automobile Paint Shop, Garages, Etc. | 1409 | | |
| Commercial | Convenience Store/Service Station | 5549 | | |
| Commercial | Gas Distribution Systems | 34067 | | |
| Commercial | Hall (Community, Lodge, Club, Etc.) | 3919 | | |
| Commercial | Self Storage | 100 | | |
| Commercial | Storage & Warehousing (Closed) | 1974 | | |
| Commercial | Store(S) And Living Quarters | 1068 | | |
| Commercial | Store(S) And Service Commercial | 1129 | | |
| Commercial | Telephone | 2429 | | |
| Commercial | Vacant IC&I | 0 | | |
| Domestic | 2 Acres Or More (Manufactured Home) | 1500 | | |
| Domestic | 2 Acres Or More (Outbuilding) | 0 | | |
| Domestic | 2 Acres Or More (Single Family Dwelling, Duplex) | 1500 | | |
| Domestic | 2 Acres Or More (Vacant) | 0 | | |
| Domestic | Manufactured Home (Not In Manufactured Home Park) | 750 | | |
| Domestic | Residential Dwelling with Suite | 1500 | | |
| Domestic | Single Family Dwelling | 750 | | |
| Domestic | Vacant Residential Less Than 2 Acres | 0 | | |
| Industrial | Industrial (Vacant) | 0 | | |
| Industrial | Winery | 393067 | | |
| Institutional | Civic, Institutional & Recreational (Vacant) | 0 | | |
| Institutional | Schools & Universities, College Or Technical Schools | 10944 | | |
| Irrigation | Beef | 50 | h | 1 |
| Irrigation | Beef (Vacant) | 0 | h | |
| Irrigation | Dairy | 250 | h | 3 |
| Irrigation | Dairy (Vacant) | 0 | h | |
| Irrigation | Golf Courses (Includes Public & Private) | 40887 | 5 mh | |

| Group | Name only | L/day/parcel | Seasonality | Number per ha |
|---|---|---|---|---|
| Irrigation | Grain & Forage | 36708 | 5 mh | |
| Irrigation | Grain & Forage (Vacant) | 0 | 5 mh | |
| Irrigation | Mixed | 33333 | 5 mh | |
| Irrigation | Other | 33333 | 5 mh | |
| Irrigation | Parks & Playing Fields | 2000 | 5 mh | |
| Irrigation | Small Fruits | 27784 | 5 mh | |
| Irrigation | Tree Fruits | 48500 | 5 mh | |
| Irrigation | Vegetable & Truck | 23395 | 5 mh | |
| Recreational | Recreational & Cultural Buildings (Includes Curling | 9521 | | |
| Water Supply System | Water Distribution Systems | 0 | | |

## Table 4. Monthly seasonal variation for estimation of monthly pumped volumes

| Month | No of days | Irrigation | Water Supply System | Domestic and others |
|---|---|---|---|---|
| | | Distributed (%) | Increase by (%) | Increase by (%) |
| January | 31 | | | |
| February | 28 | | | |
| March | 31 | | | |
| April | 30 | | | |
| May | 31 | 10% | 15% | 10% |
| June | 30 | 20% | 25% | 12% |
| July | 31 | 30% | 80% | 14% |
| August | 31 | 30% | 80% | 14% |
| September | 30 | 20% | 20% | 13% |
| October | 31 | | | |
| November | 30 | | | |
| December | 31 | | | |

### 4.2.3 Groundwater usage

Figure 9 summarizes the total groundwater use classified by use type. Most of the groundwater within the Tsolum River watershed is used for irrigation purposes with 96% of the total groundwater followed by domestic and industrial use with 1.6% and 1.8%, respectively.

According to the VIHA data, there are seven water supply systems wells within the study area totaling a groundwater usage of 2.7 $dm^3$.

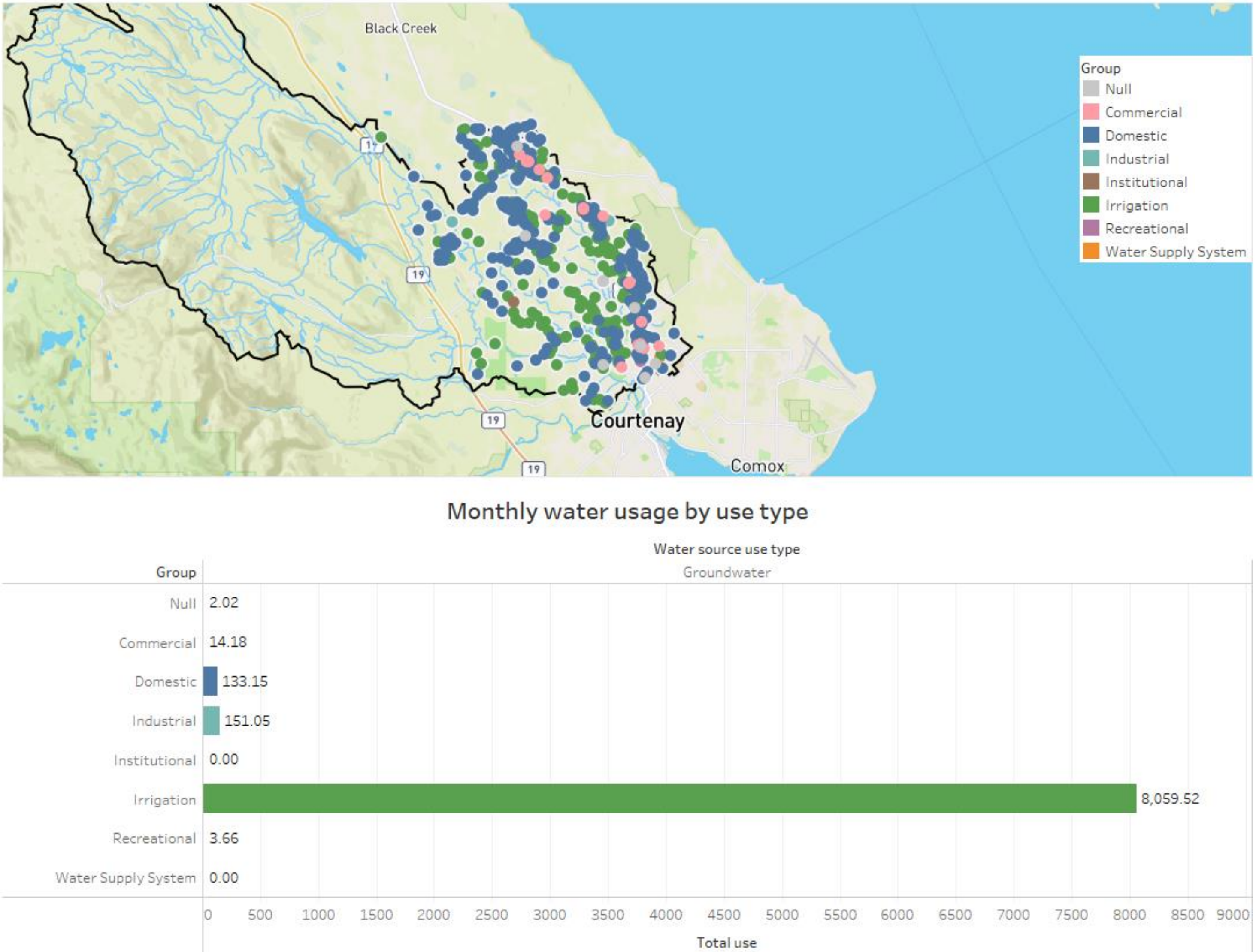
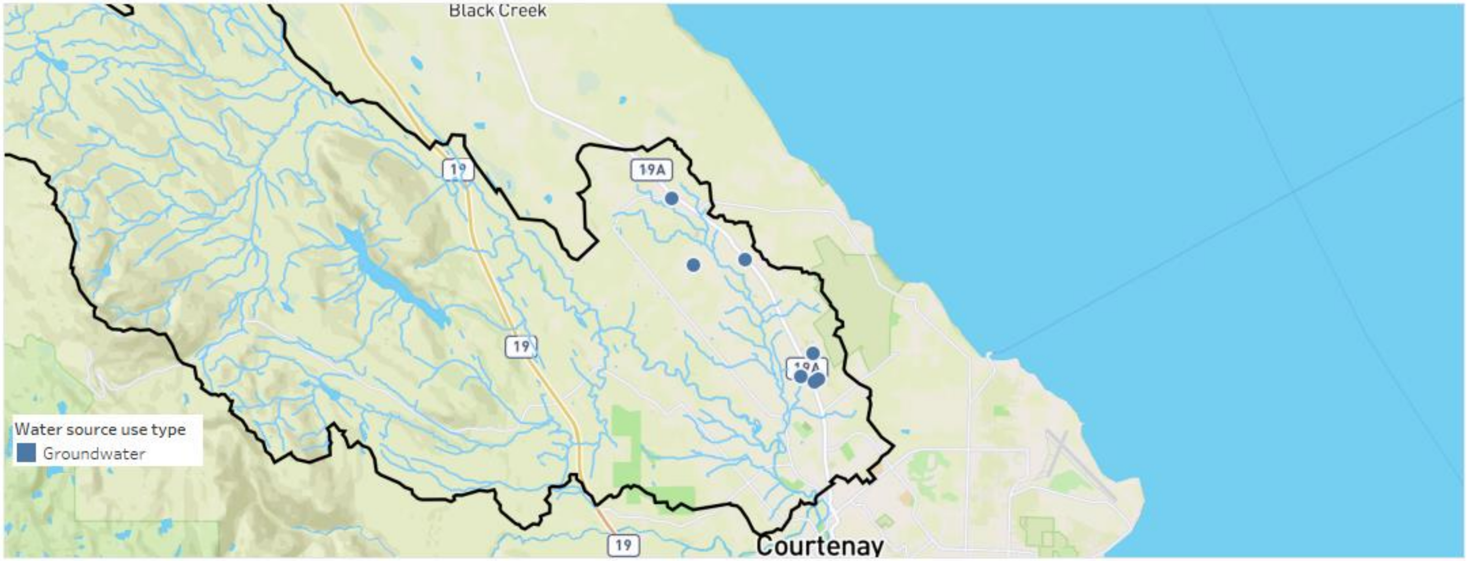



**Figure 9. Total groundwater usage classified by type of use (total use in cubic decameter-dm$^3$)**



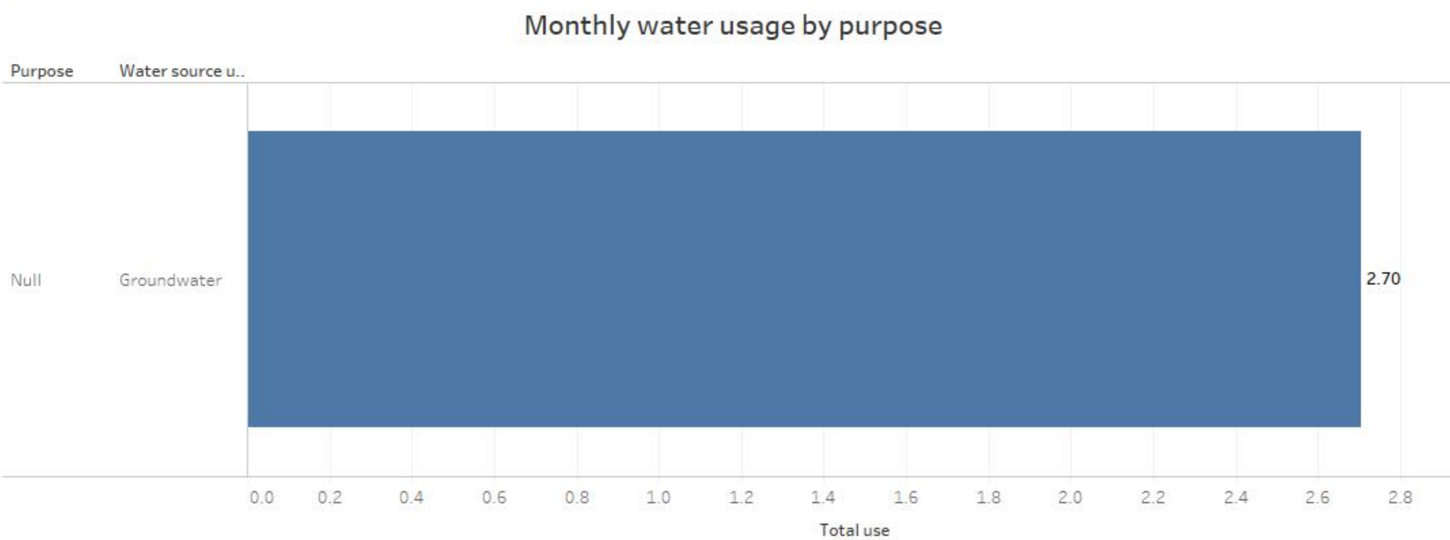




**Figure 10. Groundwater usage based on VIHA data (total use in cubic decameter-dm$^3$)**

## 4.3 Review of Mapped Aquifers and Water Wells

### 4.3.1 Mapped aquifers

BC MoE has mapped aquifers in the province using the Aquifer Classification System developed in 1994. The final product of this aquifer mapping is a set of spatial polygons outlining the extent of the aquifers. A total of 1,160 aquifers (370 bedrock and 790 overburden) have been mapped and classified for the whole province (until June 2018).

Two unconsolidated aquifers and one bedrock aquifer have been mapped within/near the Tsolum River watershed. Table 5 summarizes the aquifer material, productivity, vulnerability and demand for the mapped aquifers.

As Figure 11 shows, the overburden aquifer, the Quadra Sand aquifer 408IIC, present on the eastern side of watershed, is by far the most extensive aquifer within the watershed. The overburden aquifer 952IIA and the bedrock aquifer 413 IIB only have a limited extent within the lowermost watershed.

The extent of the mapped aquifers (bedrock and overburden) within the Tsolum Watershed represents nearly 20% of the area of the watershed.

**Table 5. Summary of BC Ministry of Environment Mapped Aquifers intersecting the Tsolum River watershed.**

| Aquifer Number | Aquifer Code | Lithostratigraphic Unit | Aquifer Materials | Descriptive Location | Productivity | Vulnerability | Demand |
|---|---|---|---|---|---|---|---|
| 408 | 408 IIC (13) | Quadra Sediments | Sand and Gravel | Comox Harbour to 10 km north of Merville, west to Tsolum River and Portuguese Creek | Moderate | Low | High |
| 952 | 952 IIA (9) | Capilano Sediments, likely sand & gravel lenses within till | Sand and Gravel | North of Puntledge River | Low | High | Low |
| 413 | 413 IIB (10) | Nanaimo Group; likely the Comox Formation | Bedrock | West of Royston, north to Puntledge River | Low | Moderate | Low |

The current aquifer mapping in the lower Tsolum River is dominated by Aquifer 408, which is litho-stratigraphically classified as Quadra Sand. The Quadra Sand is a pre-Fraser glacial deposit consisting mainly of well sorted sand, with minor silt and gravel[1]. Gravel content increases with proximity to the Vancouver Island mountain front. It is overlain by till deposited during the Fraser Glaciation and is underlain by fluvial and marine sediments deposited during the preceding non-glacial interval. Aquifer #952 comprises sand and gravel of post-glacial origin, deposited in fluvial outwash areas shedding off Vancouver Island mountain front.

1 Clague, J.J. 1975. Quadra Sand and its relation to the late Wisconsin glaciation of southwest British Columbia. Canadian Journal of Earth Sciences. Vol.13, pg.803-815

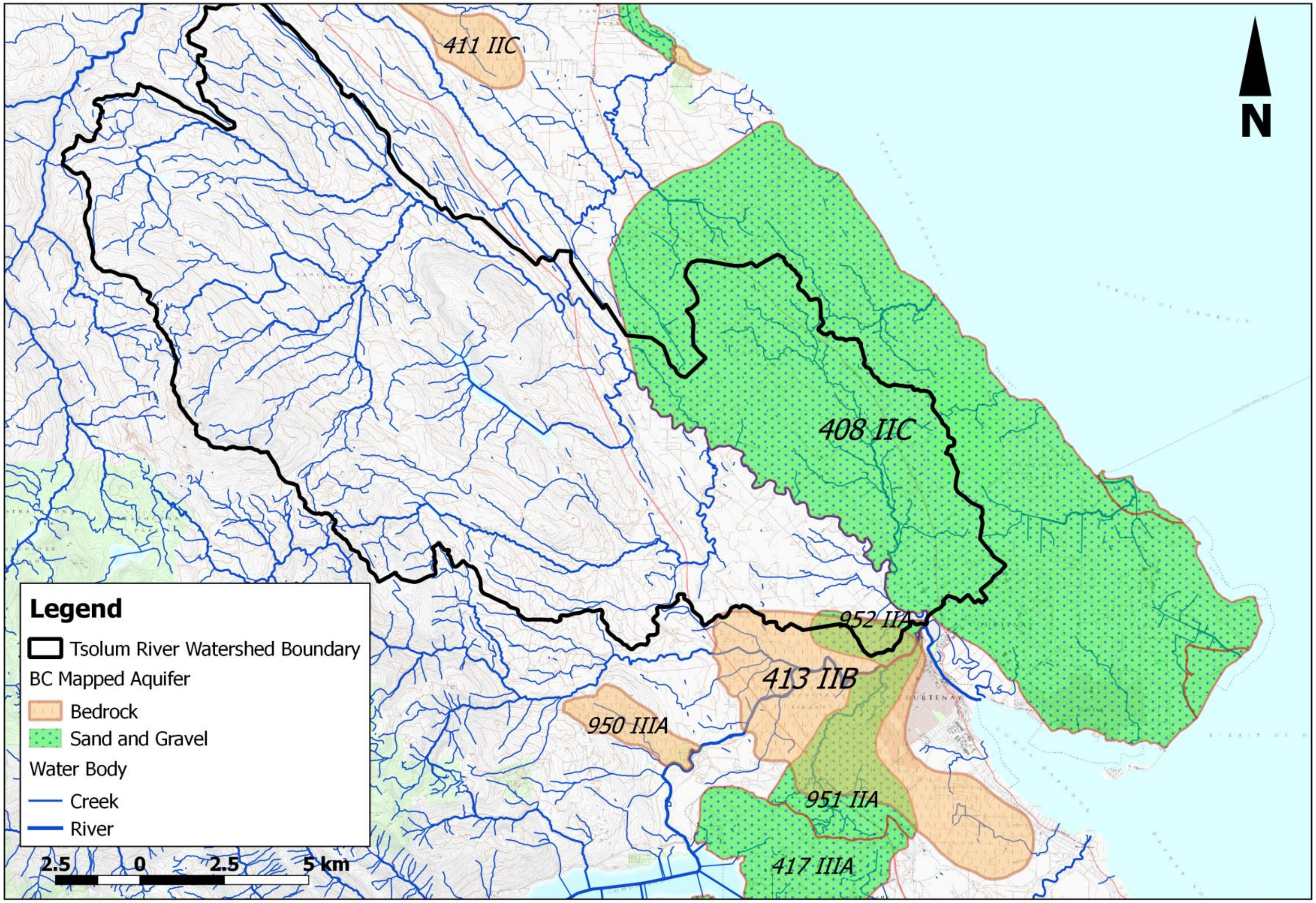



**Figure 11: Mapped aquifer extension according to Imap BC (data catalogue)**

### 4.3.2 Water wells

A water wells database is maintained and operated by the BC Ministry of Environment and Climate Change Strategy (BC MoE). The database is composed of four data tables: general, screen, casing and lithological information as shown in Figure 12.

The database includes information on construction/completion, alteration, or decommissioning of a well, encountered lithology, and the water bearing characteristics of the aquifers. The wells are classified by their use (e.g. water supply system, unknown well use, test, private domestic, observation well, irrigation, commercial and industrial, and other).

GW Solutions has cleaned and standardized the wells database and extracted relevant information for data analysis including aquifer delineation and groundwater usage. More explanation about cleaning up and standardization is presented in section 4.4.

Figure 13 shows the location of the water wells within the Tsolum Watershed by completion depth. As summarized in Figure 14, there are approximately 519 water wells within the watershed from which approximately 50% are completed at a depth less than 20 m (60 feet). Most of the deeper wells are located on the east side of the Tsolum River and deepen towards the ocean.

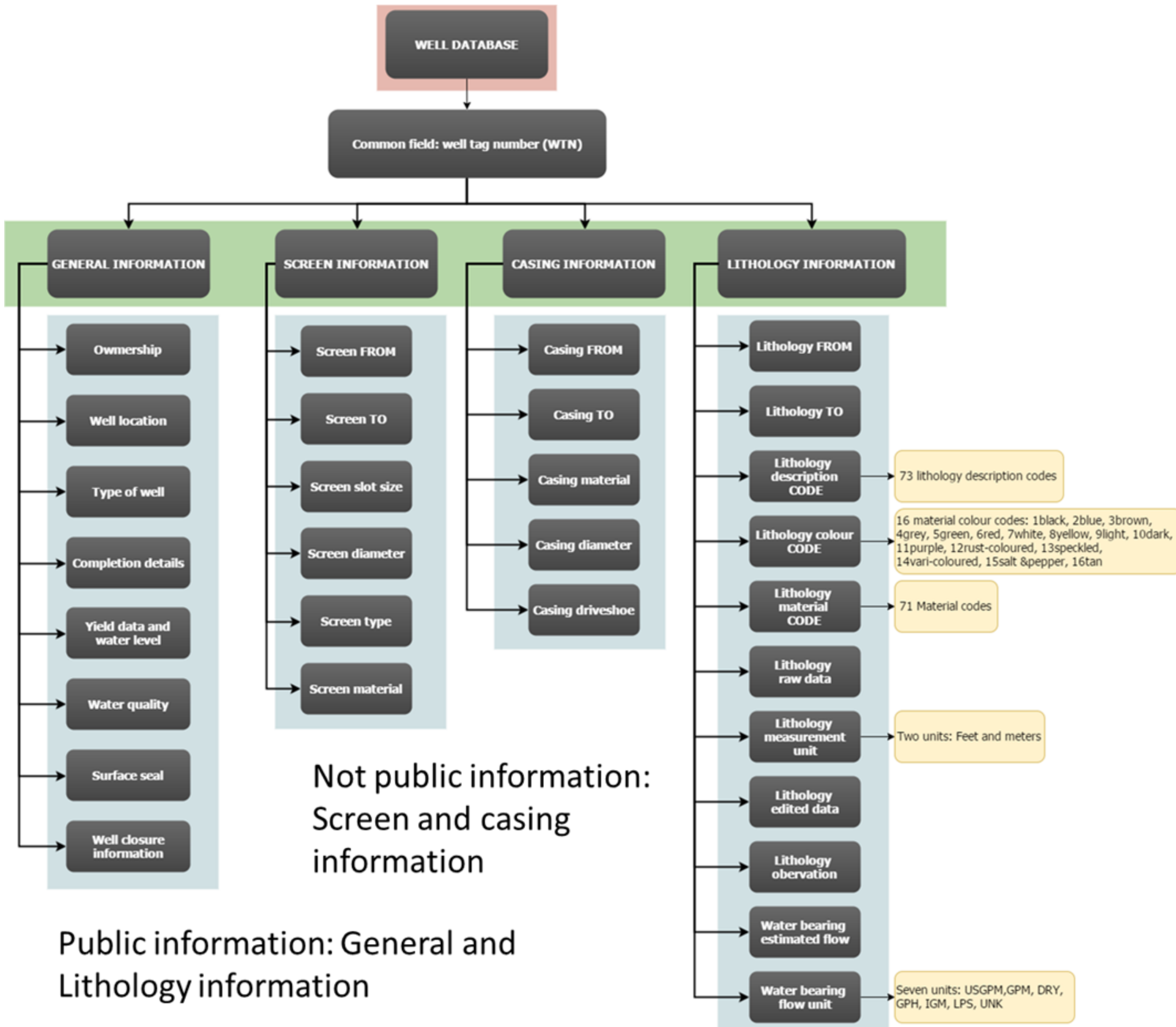



**Figure 12. Provincial water well database organization**

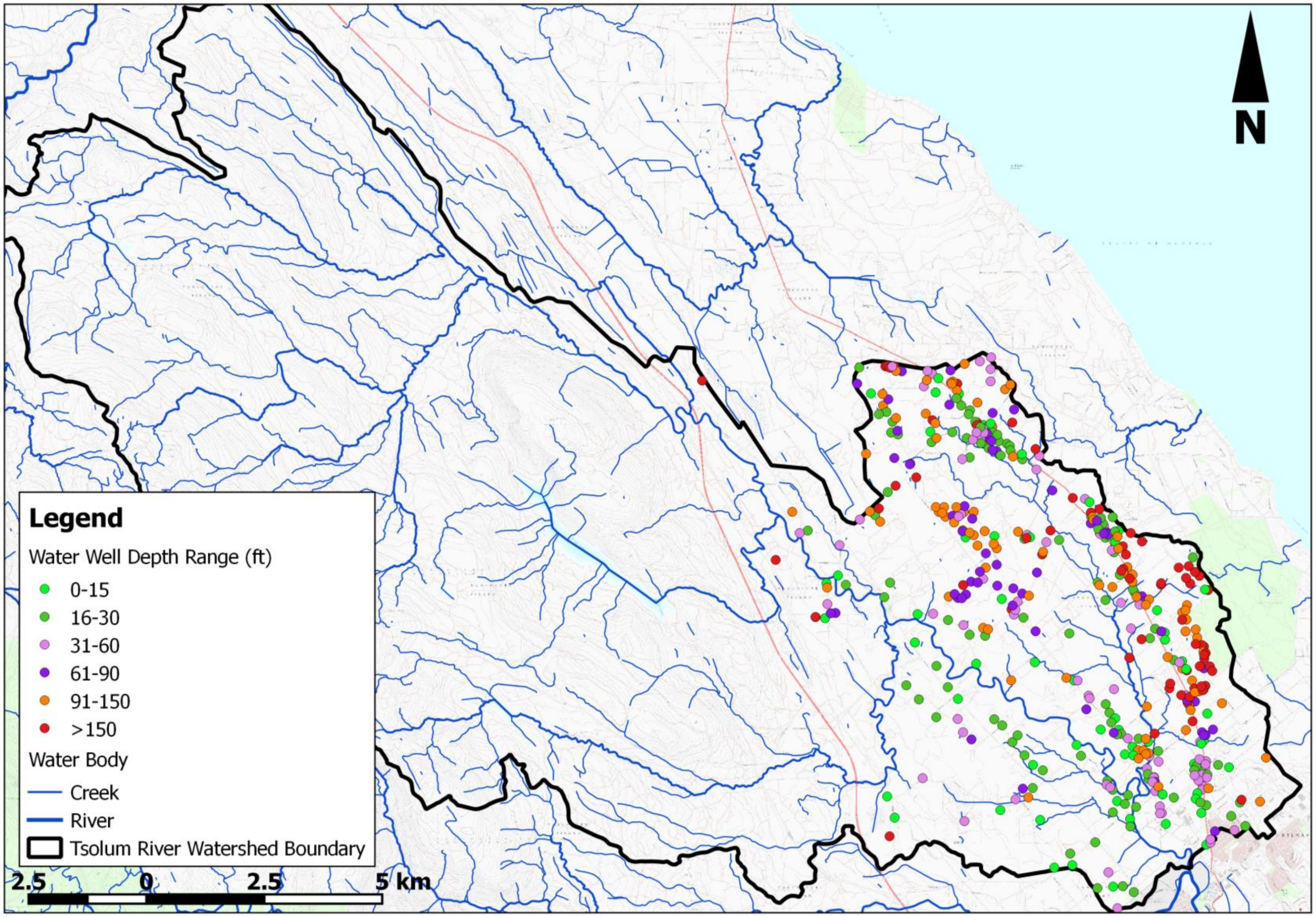



**Figure 13. Water wells within Tsolum River watershed categorized by depth**

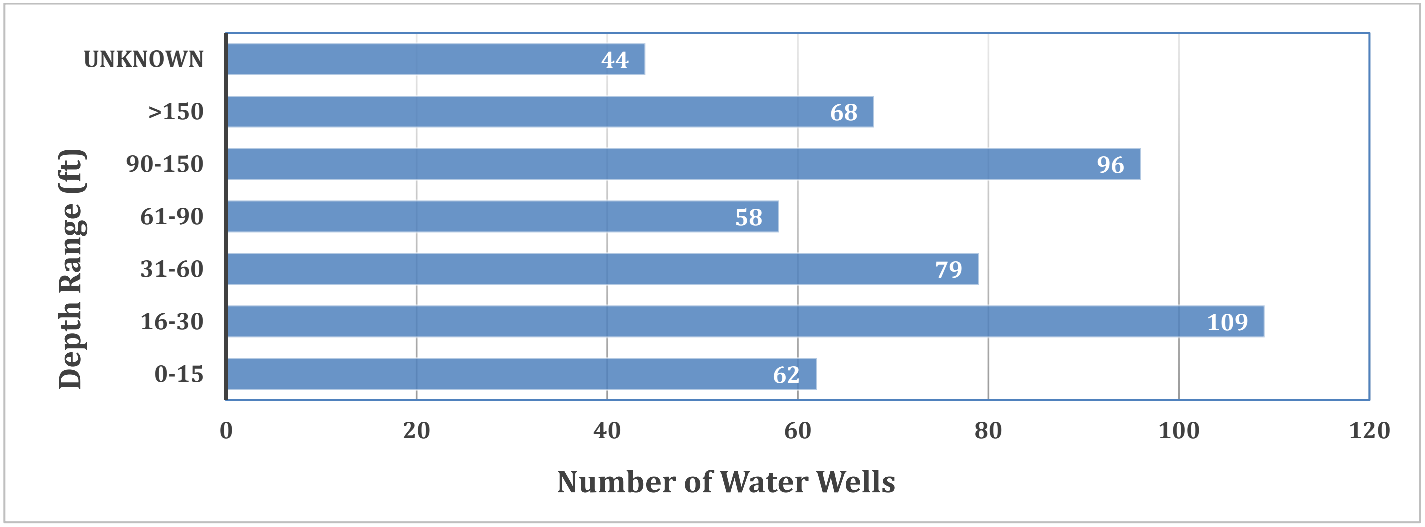



**Figure 14. Number of water wells by depth range**

Additionally, the Province operates and maintains a network of water wells used for water level and water chemistry monitoring. As of the end of May 2017, there are 193 active and 258 inactive observation wells in BC. There is no observation well within the study area; however, there is one active observation well (OW351) and two abandoned observation wells (OW280 and 285) completed in aquifer 408IIC. The locations of observation wells around the study area is presented in Figure 15.

Table 6 summarizes the available data for the observation wells regarding water levels and water quality. There is only water quality data for OW285.

Figure 16 shows the water elevation and depth to water for OW351. Water level data has been collected since 2001 and this well is active. The water level indicates a slightly increasing trend at a rate of 3.0 cm/year. Figure 6 shows the monthly historical water level fluctuation. The lowest water table is observed between August and October and the highest level between February and May with an average amplitude of 0.5 m (from low to max water level).

Appendix 2 shows the water elevation and monthly historical water level fluctuation for OW280.

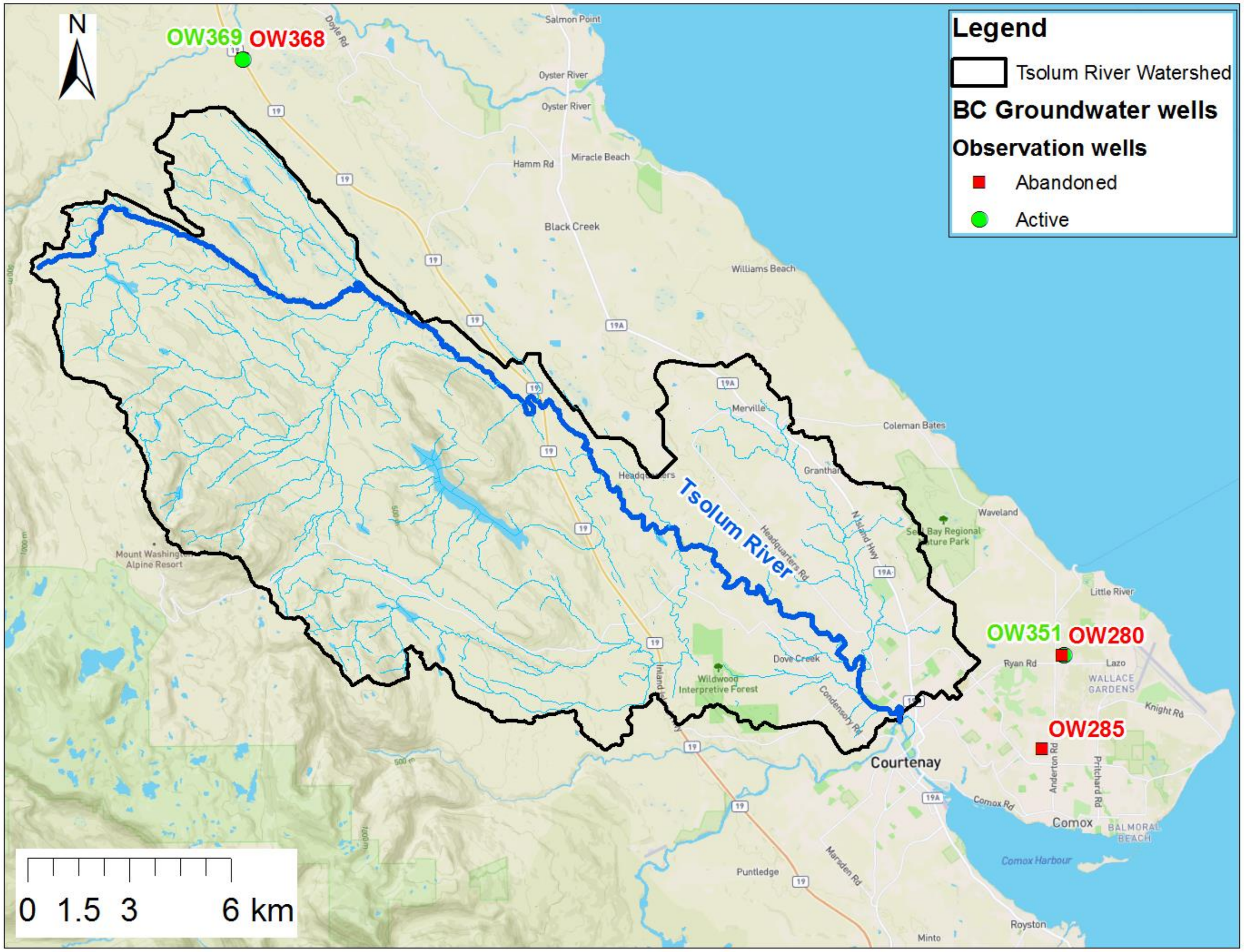



**Figure 15. Location of BC observation wells within/around the Tsolum River watershed**

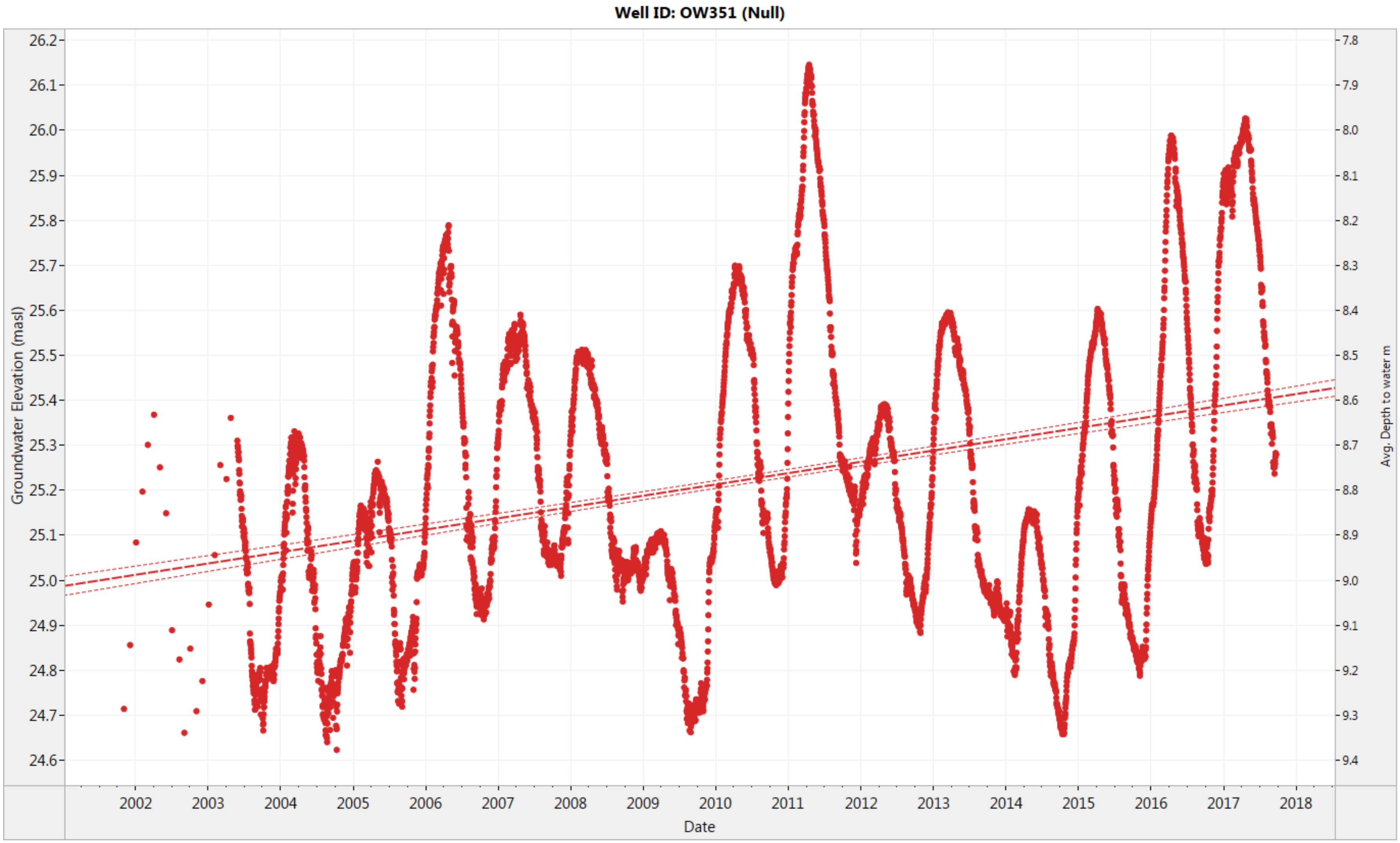



**Figure 16. Water level elevation and depth to water for observation well 351**

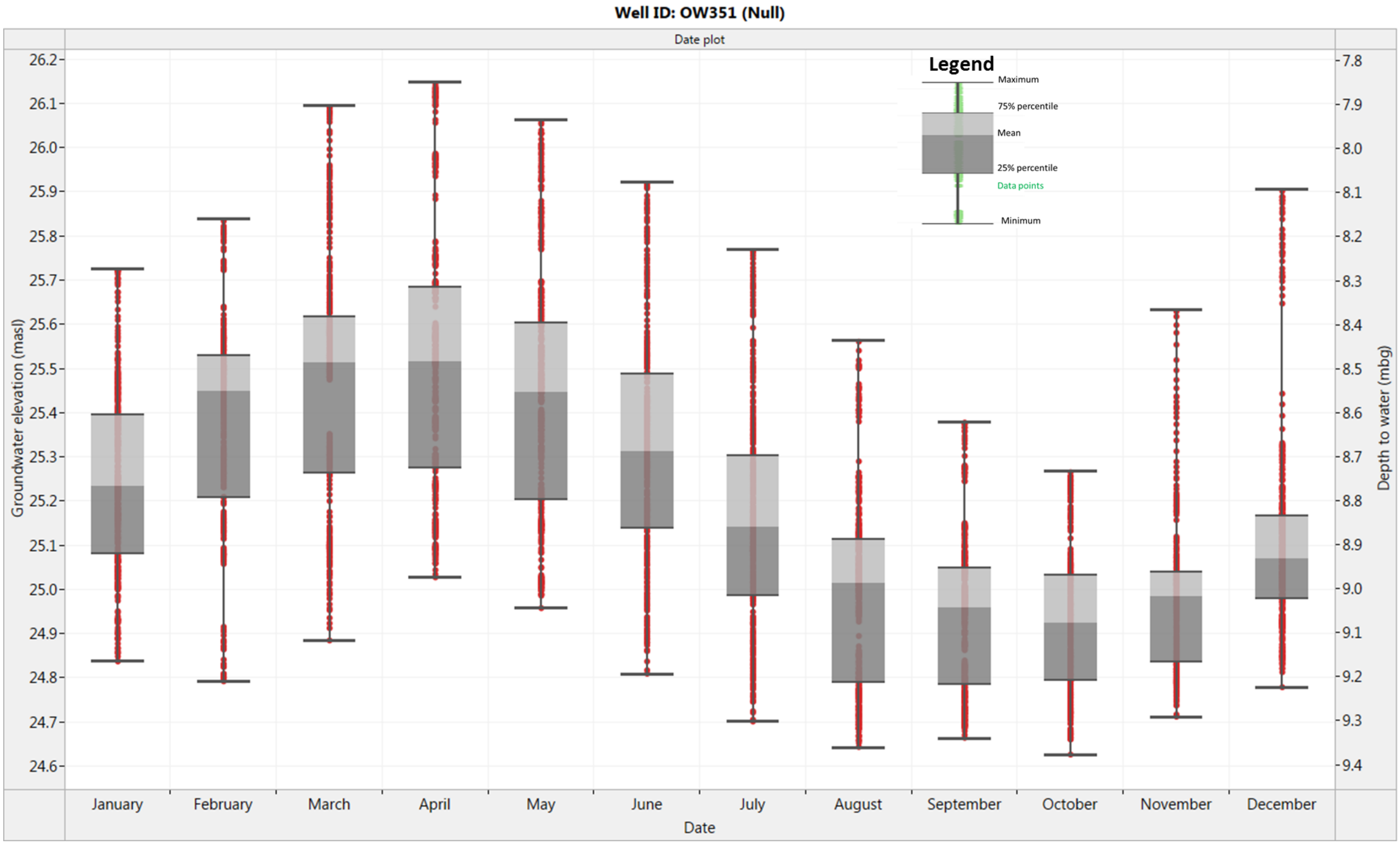



**Figure 17. Water level monthly summary for observation well 351**

**Table 6. Observation wells available data summary**

| Observation well ID | Status | Water level from | Water level to | Water quality from | Water quality to | EMS ID | No of samples | Number of tests | Parameters tested |
|---|---|---|---|---|---|---|---|---|---|
| OW351 | Active | November 2001 | July 2018 | 8/7/2002 | 9/20/2017 | E248816 | 4 | 325 | 98 |
| OW280 | Abandoned | December 1992 | November 2001 | 8/27/1987 | 6/24/1998 | 1401945 | 4 | 176 | 76 |
| OW285 | Abandoned | | | 8/4/1988 | 8/4/1988 | 1401950 | 1 | 46 | 45 |

## 4.4 Delineation of Aquifers Based on Well Information

GW Solutions has developed a 3D hydrogeological model to update the Tsolum River watershed aquifer boundaries based on the most up-to-date well information. Building a 3D model of an aquifer requires integrating available well log information in context with topography, groundwater levels, and relevant geology mapping.

### 4.4.1 Methodology

#### 4.4.1.1 *Tools*

The goal of the model is to derive the fundamental hydrogeological building blocks of aquifers, aquitards, bedrock topography and hydraulic gradients. To achieve this, we use Leapfrog 3D (ARANZ Geo Ltd.), a geological modelling and visualization software, in combination with a variety of database and Geographic Information System (GIS) tools. The Tsolum River model can be updated as new information becomes available; however, preliminary output includes imagery, maps, data tables and 3D model viewer files.

The primary database system used in this project is Excel, with full spatial (GIS) integration. Desktop GIS software - used to display and analyze data stored in the database, includes both proprietary (ESRI's ArcMap) and open source (QGIS) software.

#### 4.4.1.2 *Information sources*

Information sources that supported the modeling effort include:

- Standardized Groundwater Wells Database based on BC Ministry of Environment "WELLS Database";
- Groundwater level data from WELLS database
- Digital Terrain Model (DTM) generated from a 16m-resolution digital elevation model (DEM) from NRCAN (Vancouver Island)
- Geology mapping for terrain[2] and soils[3] available from DataBC; and
- Streams mapping from the Provincial Freshwater Atlas.

The Leapfrog model focused on the lower Tsolum River since this is where wells are more abundant, and therefore where more information about the subsurface could be gained.

#### 4.4.1.3 *Data Standardization*

The BC WELLS database is the primary source of information on the subsurface and groundwater in BC. However, the well logs in the database must undergo an intensive data refining and standardization process before they can be interpreted geologically or used in a 3D model. The aim of standardizing well logs is to classify well driller's descriptions into terms relevant to geology and groundwater. Lithology records were processed using a series of algorithms intended to extract standard geological terms from well driller's logs. Additional manual interpretation was in some cases required. The original interval descriptions were retained in the database for cross-referencing to the standardized lithologies.

The standardized data greatly facilitates grouping subsurface units into litho-stratigraphic or hydrogeologic units (HGU's). Ultimately, this allows us to link wells in the database to the aquifers they draw groundwater from (See Figure 18).

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[2] Government of British Columbia, 2011. Terrain Mapping (TER) Polygon Attributes. Vector polygon data downloaded via: https://catalogue.data.gov.bc.ca/dataset/terrain-mapping-ter-polygon-attributes

[3] Government of British Columbia, 2017. Soils Survey Spatial View. Vector polygon data downloaded via: https://catalogue.data.gov.bc.ca/dataset/soil-survey-spatial-view

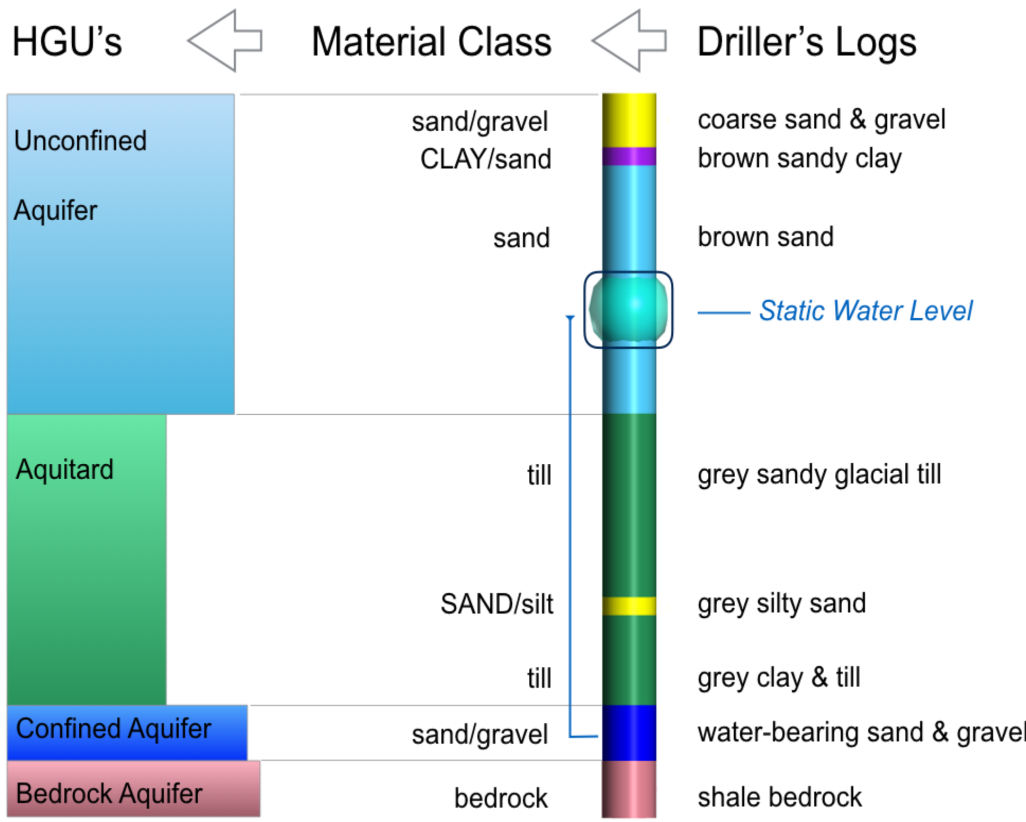



**Figure 18: HGU's area assigned to the boreholes in Leapfrog**

The following assumptions and potential sources of error are inherent in the data:

- Due to the lack of legal requirement to submit drilling logs in the past, the number of wells in the database is thought to underrepresent the actual number of wells drilled in the province;
- Horizontal (x-y) positional accuracy of wells is highly variable and not all wells are accurately located within a land parcel;
- Vertical (z) accuracy is dependent on x-y positional accuracy, since well elevations are obtained from the available digital elevation model (DEM) at a particular location. The level of accuracy of the DEM, in turn, will affect the vertical accuracy of wells points; and
- Well lithologies can only be as complete or accurate as the original driller's descriptions.

#### 4.4.1.4 *3D Modelling Process*

The starting point in the modelling process consisted of a systematic review of the standardized BC WELLS database, including well attributes and lithology records. The standardized well lithologies in this study were refined from the thousands of unique lithological descriptions, generated by well drillers, and stored in the BC WELLS database.

All unconsolidated materials in well logs are grouped in terms of their relative permeability with respect to water: 1) high permeability; 2) low-permeability; and 3) "ambiguous" – i.e. units that could be permeable or of low permeability. The ambiguous units are lithologies that may be subsequently re-interpreted as either having an affinity with aquifers or aquitards, based on their relation to other information, e.g. details in the driller's notes, screened interval, or the hydraulic head in wells.

All rock types (e.g. shale, sandstone etc.) are grouped into one bedrock category.

Next, the relative permeability of the subsurface units was assessed in relation to the following information (where available):

- depth to water at time of drilling;
- well completion/screened intervals;
- local hydraulic gradients;

- depth to producing fractures;
- driller's notes;
- surficial geology; and
- bedrock topographic trends.

This step involves the interplay of various datasets in an iterative process of grouping lithologies according to hydrogeologic affinities (i.e. unconfined versus confined aquifers or aquitards). The grouping of hydrogeologic units in borehole data is informed by the interpretation of the surficial geology of the area. Layers of permeable material such as sand and gravel are potential aquifers; whereas glacial tills and glaciomarine silts and clays are typically lower permeability and are therefore assigned to aquitard layers. Hydrogeological units are assigned directly to borehole intervals, and are given color codes to allow for fast, visual identification and correlation between units.

### 4.4.2 **Hydraulic Gradients**

When a well is installed in a confined or pressurized aquifer, the groundwater typically rises up the well casing to a certain height, known as the static water level, or piezometric level. If the groundwater rises to the ground surface, this is known as a flowing, or artesian well. The hydraulic or piezometric level is a surface of liquid pressure of groundwater above a datum, e.g. mean sea level. The vertical distance between two or more piezometric levels determines the hydraulic gradient.

The following assumptions were made about the available data on groundwater elevations in the Tsolum River watershed;

- Static water levels measured in wells at the time of drilling are a reasonable proxy for aquifer piezometric level, given the "watershed scale" of this study.
- Static water levels were classified according to probable aquifer type: bedrock; shallow or deep, confined aquifers.
- Flowing wells and Licensed springs indicate areas where vertical hydraulic gradients are directed upwards and where there is a greater potential for groundwater to contribute to surface water flows.

### 4.4.3 Aquifer delineation result

Most of the watershed's wells draw from surficial (i.e. non-bedrock) units comprising relatively thin intervals of water-bearing sand and gravel. Out of approximately 500 reported wells with lithology information within the watershed:

- 470 are completed in a surficial aquifer, approximately;
- 15 are completed in a bedrock aquifer, approximately.

Integration of standardized WELLS data into Leapfrog resulted in the recognition of two distinct surficial, sand and gravel aquifers present east of the Tsolum River. A previously unmapped, confined aquifer that we refer to herein as the Tsolum Aquifer "TS-2", extends from the Black Creek area south to the lower Tsolum River and between the Portuguese Creek and Tsolum River mainstem. We interpret this as distinct from the mapped Aquifer #408, which extends from Comox Harbour to Black Creek peninsula and is comprised of a Quadra deposit. The Tsolum Aquifer is confined and is characterized by sand and gravel lenses within glacial till. Driller's note the prevalence of a gravel texture to the aquifer, in contrast to the Quadra deposit and aquifer, which is a more uniform, fine to medium, grey sand.

The wedge of unconsolidated sediment is thickest near the Strait of Georgia, thins considerably west of the Tsolum River and pinches out along the mountain front. Correspondingly, aquifer potential west of the Tsolum River is reduced to localized sand and gravel lenses within till, or within the underlying bedrock.

Static water levels reported in the WELLS database were assigned to a probable aquifer:

- bedrock;
- shallow (i.e. dug) wells;
- Aquifer #408 (Quadra); and
- Tsolum Aquifer "TS-2".

The spatial distribution of flowing wells and springs in the Tsolum River watershed illustrate the interaction between aquifers and topography. Results show that the Portuguese Creek sub-watershed has the highest concentration of springs and flowing wells. These findings suggest that groundwater contribution to Portuguese Creek flows is relatively high. Isolated springs and flowing wells occur within the Tsolum River watershed, near the mountain front and along the east bank.

Figure 19, Figure 20 and Figure 21 present the delineated aquifer of “Tsolum Aquifer TS-2” and the refined boundary of Aquifer #408 with different directions of cross-section, across and along the Tsolum River and Figure 22 shows the “zoom in” scene of leapfrog to the groundwater level of available boreholes. The water level within the flowing wells is highlighted by purple.

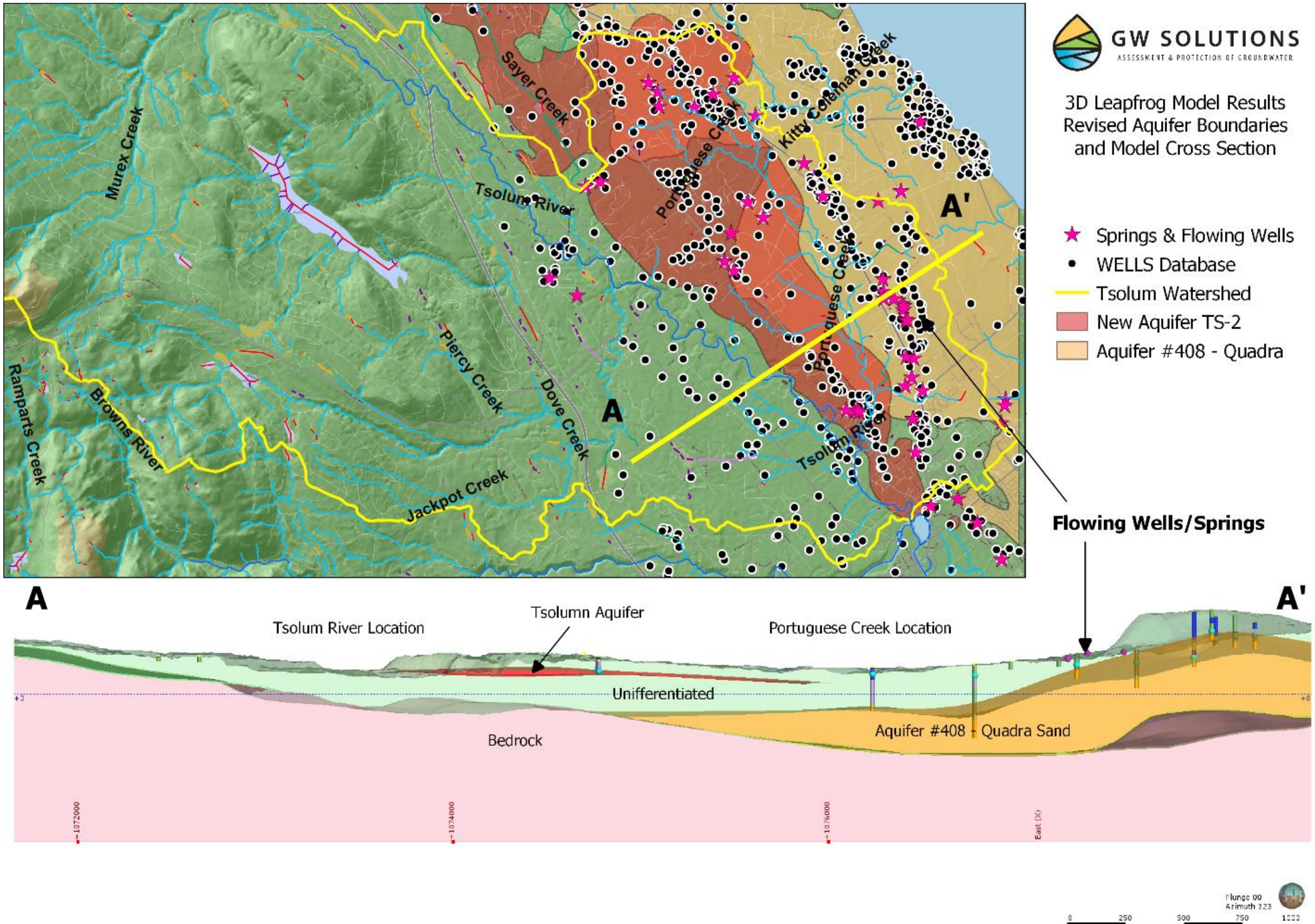



**Figure 19: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek and Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions**

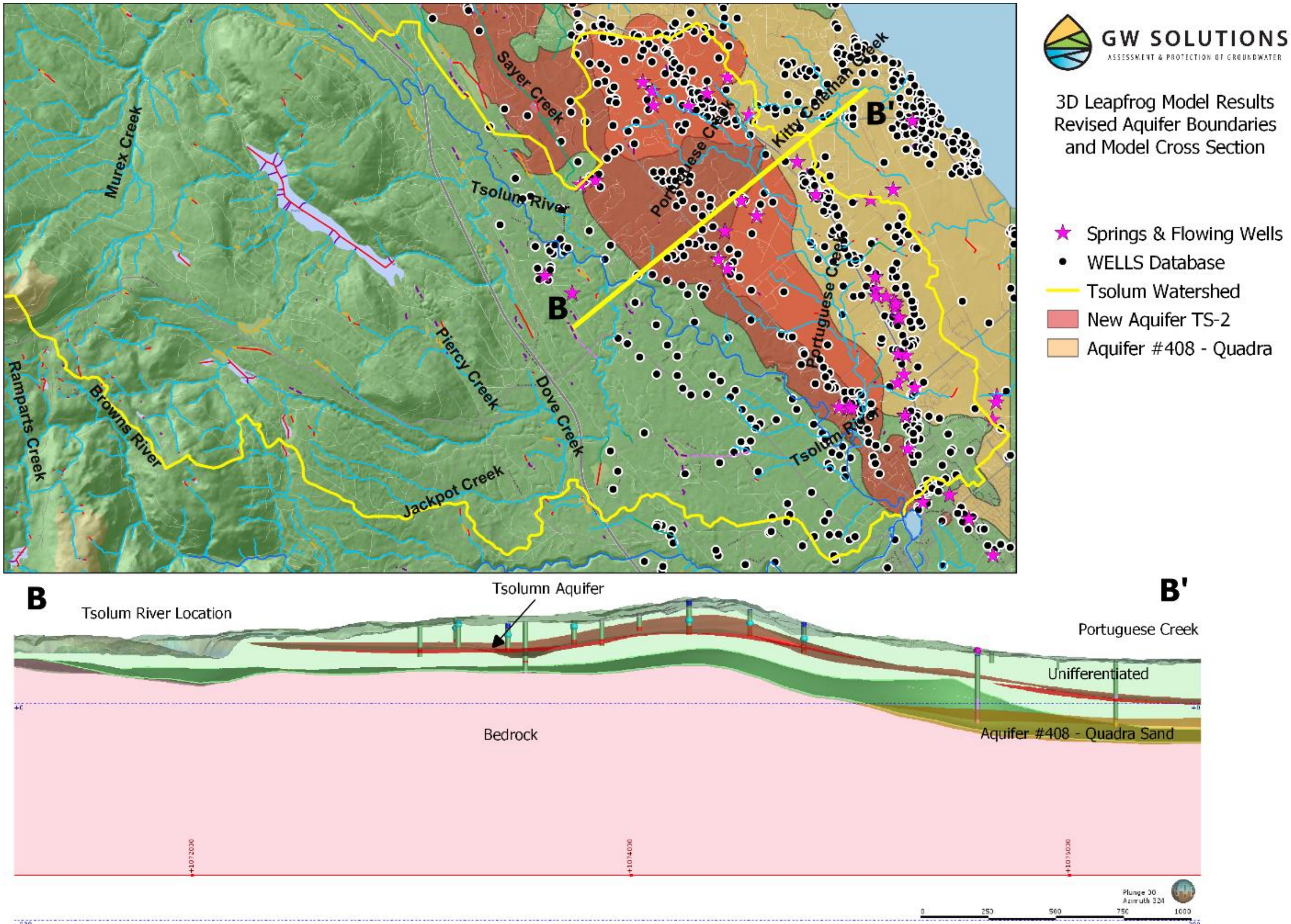



**Figure 20: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek and Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions**

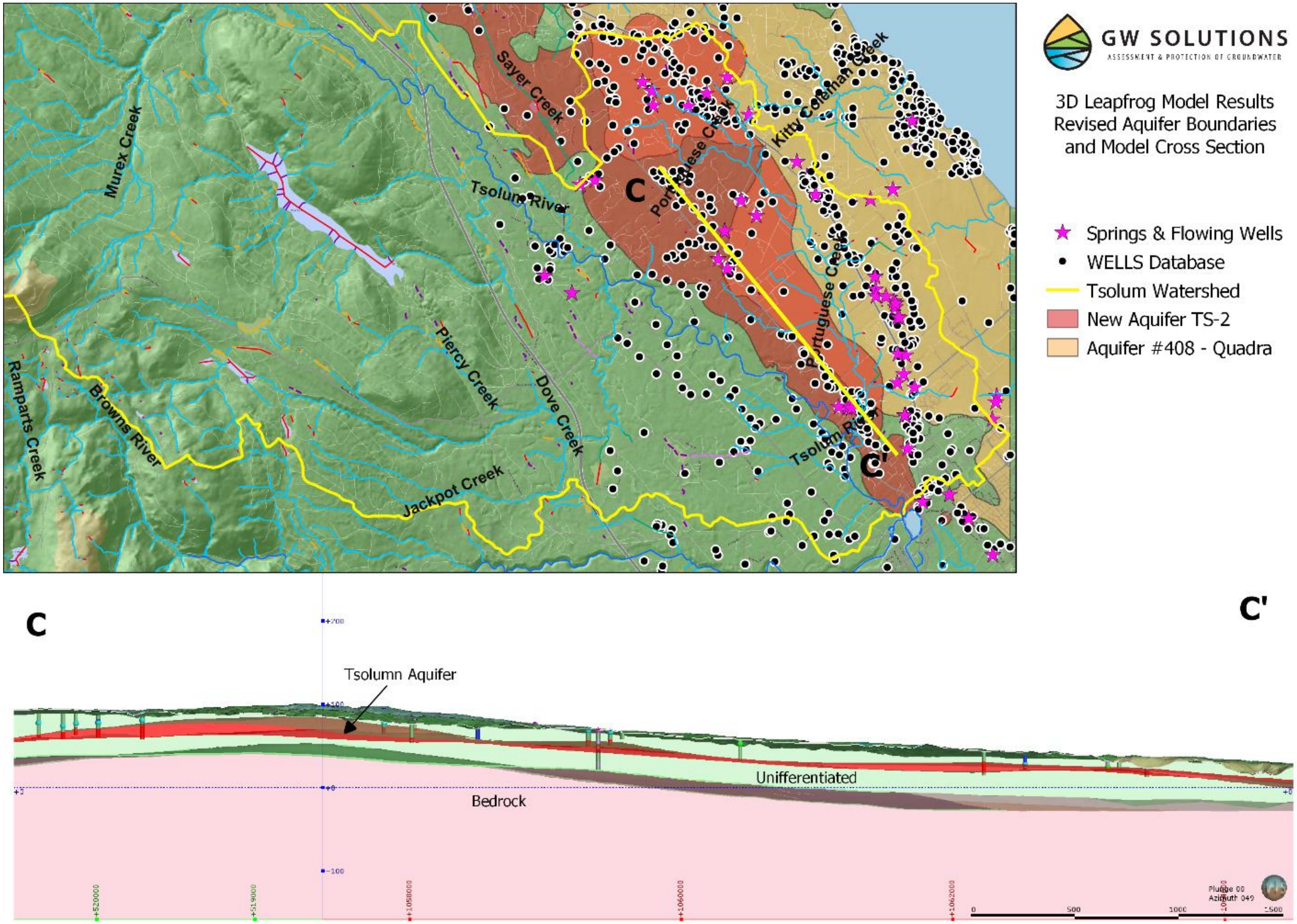



**Figure 21: Map of delineated/refined aquifer boundaries and a cross-section along Tsolum River, inferred from developed 3D Leapfrog model by GW Solutions**

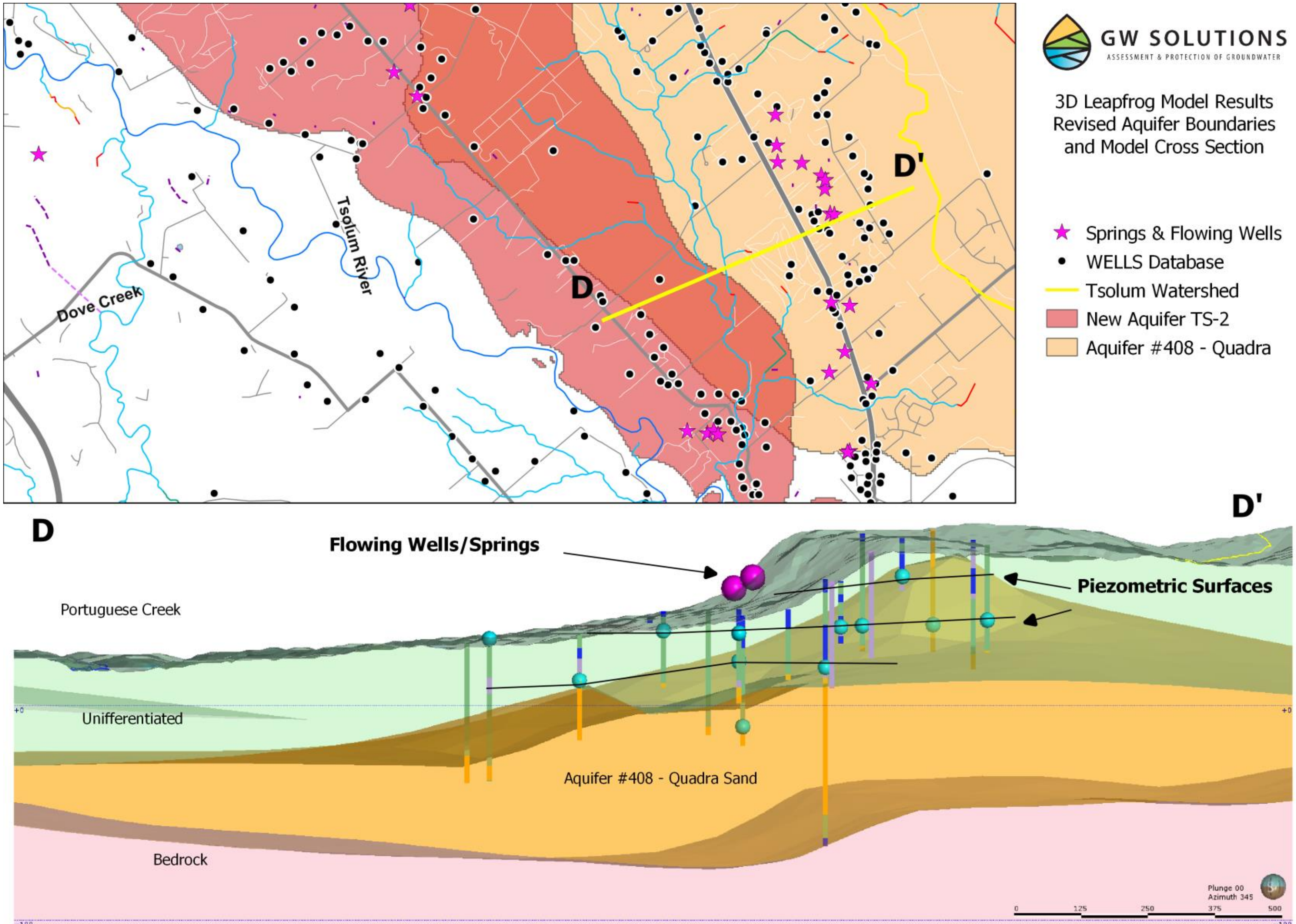



**Figure 22: Map of delineated/refined aquifer boundaries and a cross-section across the Portuguese Creek, inferred from developed 3D Leapfrog model by GW Solutions - Zooming in the groundwater level of the water wells and water level in artesian condition**

High salinity groundwater was noted in nine wells within the Tsolum watershed. The majority of these were drilled into bedrock (sandstone and shale) and occur west of the Tsolum River mainstem (Figure 23). It is notable that saline water was encountered at various elevations in these wells, not necessarily below sea level, and at considerable distances from the ocean (up to 11 km inland).

Below are examples of this evidence for salty groundwater occurrence, from driller's descriptions:

- Well Tag # 96395: "shale bedrock | salt water encountered @ 111'"
- Well Tag # 41794: "grey shale - occasional coal stringer|saline water @ 340FT|note: 20GPD of saline |water encountered"

## 4.5 Review, Compilation and Analysis of Surface Water Flows

### 4.5.1 **Data review and compilation**

For surface water flows, two sources of information have been investigated and integrated for the data analysis.

#### 4.5.1.1 *Water Survey Canada Station*

The Water Survey of Canada (WSC) is the national authority responsible for the collection, interpretation and dissemination of standardized water resource data and information in Canada. In partnership with the provinces, territories and other agencies, WSC operates over 2800 active hydrometric gauges across the country. The data is stored within the HYDAT database. This database includes: daily and monthly means of flow, water levels and sediment concentrations (for sediment sites).

Within the Tsolum River Watershed, there are two active and three inactive WSC stations as shown in Figure 23. The station located at the mouth of Tsolum River (station number: 08HB011) provides the longest flow records (nearly 103 years of data).

#### 4.5.1.2 *BCCF and TRRS Station*

BC Conservation Foundation (BCCF) partnered with the Tsolum River Restoration Society (TRRS) to collect hydrometric and water temperature data from the Tsolum River. The Tsolum River Todd Road semi-permanent hydrometric station was established on the Tsolum River 11.7 km upstream of its confluence with the Puntledge River and 0.85 km downstream of the Dove Creek confluence as shown in Figure 23.

The station was installed in September 2012 and consisted of a level logger housed in a vented steel tube bolted to a massive boulder located mid-channel. A baro logger was kept nearby. Discharge was collected using methods outlined in the Manual of British Columbia Hydrometric Standards *(Province of BC, 2009).*

Table 1 summarizes the available data for these stations.

### 4.5.2 Data integration and analysis

A data integration and visualisation platform created by GW Solutions has been used to integrate and analyze the flow information. Appendix 3 shows the flow analysis results for both active and discontinued gauged stations. Figure 24 shows the flow analysis report for station 08HB011. The upper diagram shows the historical flow data, the middle graph presents the monthly average flow in a normal year considering the historical data, the diagram at the bottom summarizes the average daily flow in a normal year considering the historical data, and the last diagram shows the location of the gauged station within the study area. Most of the flow occurs from November to March and the lowest flows are recorded from July to September.

**Table 7. Flow gauged stations within Tsolum Watershed**

| Source of information | Station Name | Station Number | Latitude | Longitude | Data available from | Data available to | Status | Watershed area ($km^2$) | Years of records |
|---|---|---|---|---|---|---|---|---|---|
| WSC | Tsolum River Courtenay | 08HB011 | 49.70586 | -125.0115 | 5/1/1914 | 12/31/2016 | active | 254.74 | 102.7 |
| WSC | Dove Creek (near mouth) | 08HB075 | 49.73658 | -125.0857 | 1/1/1985 | 12/31/2016 | active | 41.82 | 32.0 |
| WSC | Tsolum River Below Murex Creek | 08HB089 | 49.80881 | -125.1950 | 4/1/1997 | 3/31/2015 | discontinued | 87.36 | 18.0 |
| WSC | Headquarters Creek Above Tsolum River | 08HB090 | 49.76611 | -125.1208 | 4/1/1997 | 8/31/1999 | discontinued | 28.40 | 2.4 |
| WSC | Pyrrhotite Creek At Branch 126 | 08HB091 | 49.77389 | -125.3047 | 6/1/1997 | 12/31/1999 | discontinued | 0.43 | 2.6 |
| BCCF and TRRS | Tsolum River Todd Road station | TSOLUM1 | 49.74694 | -125.0761 | 9/13/2012 | 6/18/2015 | discontinued | 195.22 | 2.8 |

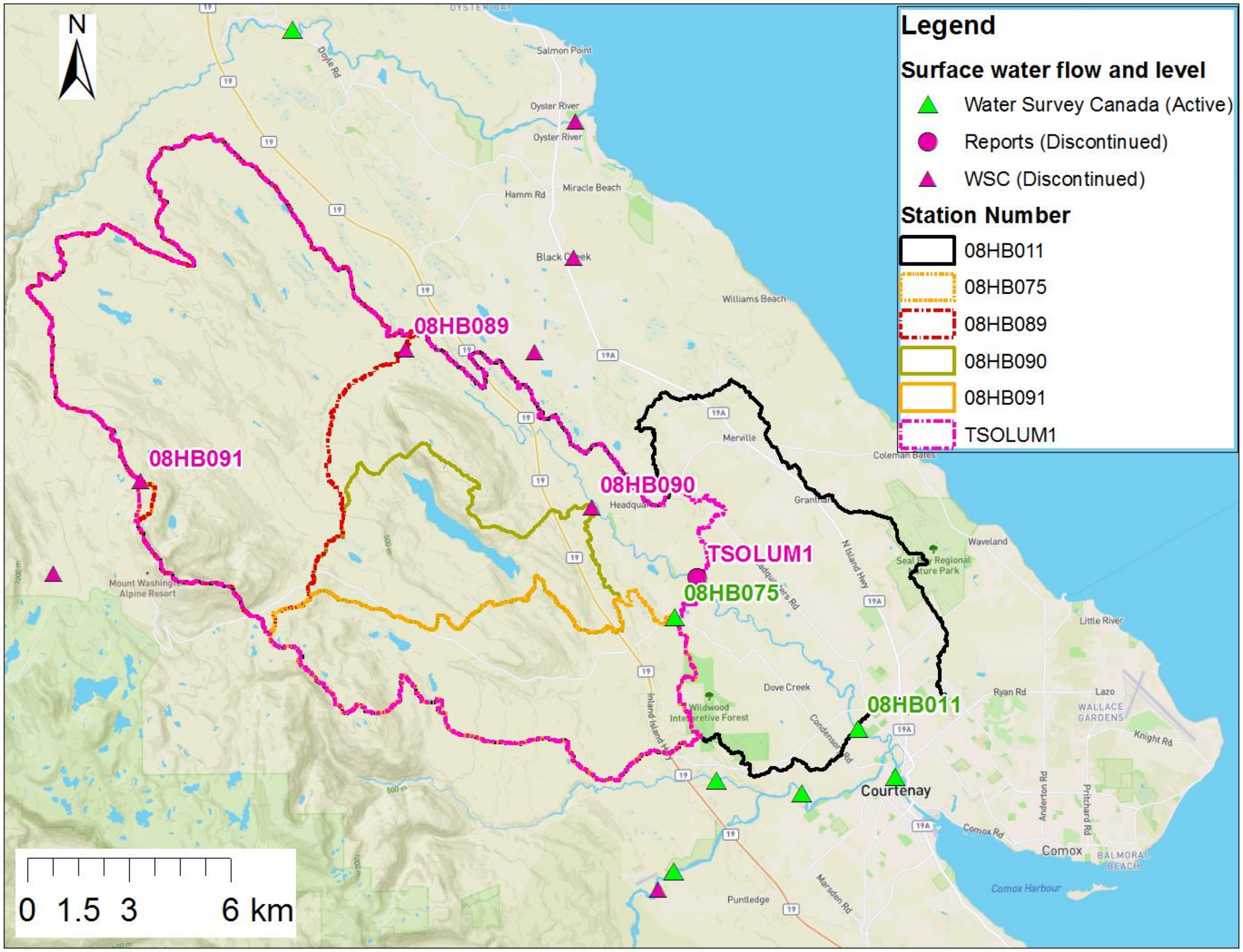



Figure 23. Location of flow gauged stations and upstream contributing watershed

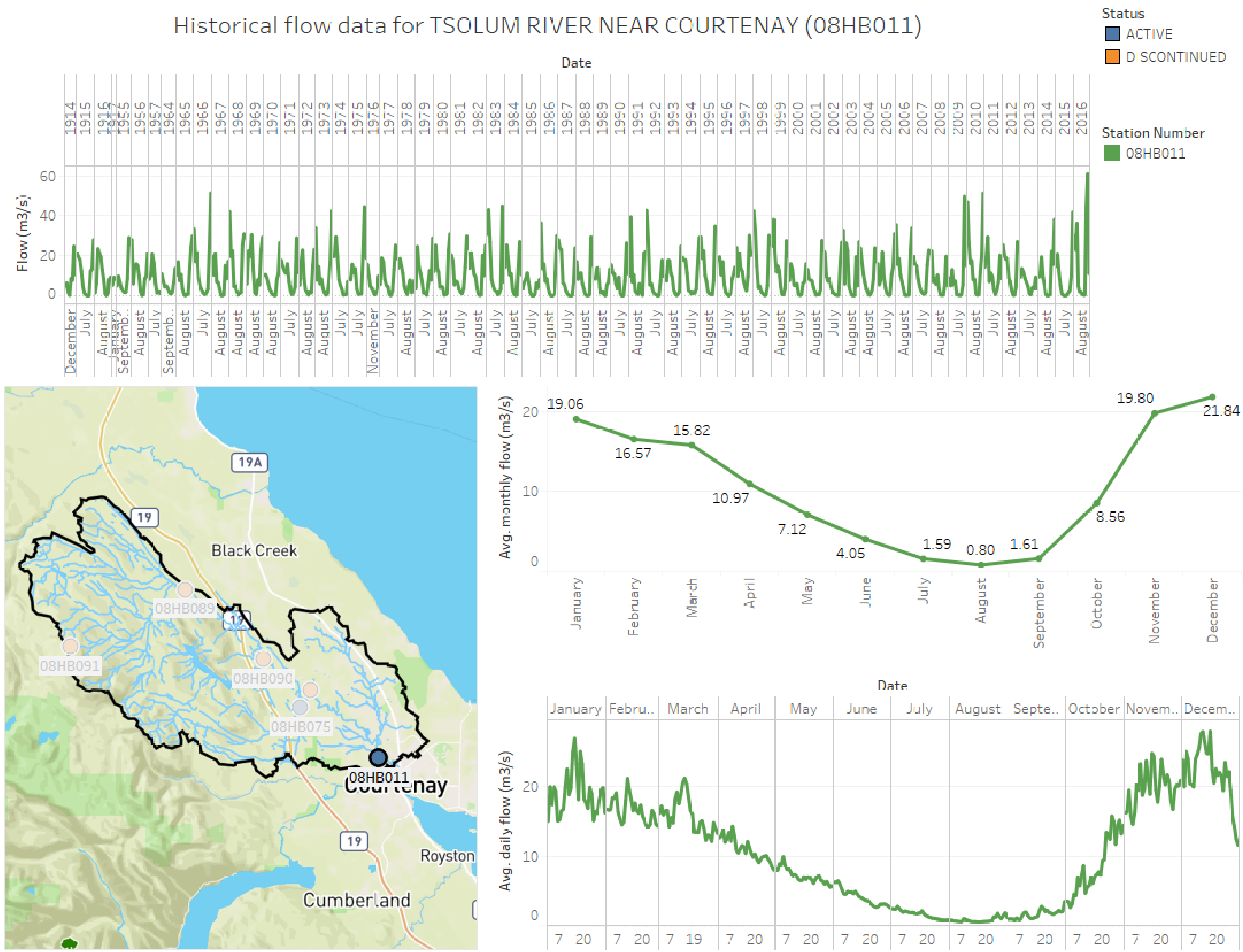



**Figure 24. Flow analysis for station 08HB011 (Tsolum River Near Courtenay)**

# 5 WATER QUALITY

### 5.1.1 Review and compilation of water quality data

On Vancouver Island, four main sources of information are available:

- The provincial Environmental Monitoring System (EMS);
- Vancouver Island Health Authority (VIHA);
- First Nations Health Authority (FNHA); and
- Technical Reports.

The EMS is a water quality repository system created and maintained by the government of British Columbia. It includes chemical analyses results on air, water, and soil for samples collected by ministry staff and industry. The database presently stores over 13 million publicly available water and sediments quality results. The data can be filtered by sampling location, sample type-class-state, sampling details, watershed, and other variables. Data from the EMS is publicly available through the EMS Web Reporting (EMS WR) with no login required[4]. In addition, monitoring locations can be accessed through the Surface Water Monitoring Sites Interactive Map[5]. Our review indicates that there are no groundwater sampling points in the EMS database for our study area and the sampling locations are limited to surface water.

The VIHA publicly available data corresponds only to bacteriological parameters (Coliforms and E. Coli). Although VIHA has a complete set of water quality results for water systems, they are not available to the public.

The First Nations Health Authority (FNHA) data set is limited for any region and available upon request.

For the current study, only EMS data has been considered for data compilation and analysis.

[4] https://a100.gov.bc.ca/pub/ems/mainmenu.do?userAction=mainmenu

[5] https://governmentofbc.maps.arcgis.com/apps/webappviewer/index.html?id=0ecd608e27ec45cd923bdcfeefba00a7

Table 8 summarizes the number of samples and tests including the date range and location type compiled by GW Solutions. The compiled water quality data contains nearly 5,000 samples collected since 1971. Approximately 97% of the data corresponds to surface water and the remaining to groundwater and other with percentages of less than 1% and 2.7%, respectively.

Figure 25 shows the locations of the water quality monitoring stations. The location type group "Other" corresponds to samples taken within the Mount Washington Copper open pit copper mine active from 1964 to 1967. The mine was a source of copper contamination for the aquatic life in the waterbodies downstream. Many remediation efforts were attempted over the years to adequately close the mine. In 2006 the Tsolum River Partnership was formed and undertook a 10-year, multi-phased, multi-partnered solution to reverse the environmental damage.

Approximately 97% of the samples were collected prior to 2012 and the sampling frequency has decreased since 2013 to an average of over 20 samples per year as shown in Figure 26.

**Table 8. Compiled water quality data**

| Location type group | Location type | Date monitoring from | Date monitoring to | No of monitoring stations | Number of tests | No of samples |
|---|---|---|---|---|---|---|
| Groundwater | OBSERVATION WELL (GROUNDWATER) | 8/27/1987 | 9/20/2017 | 3 | 547 | 9 |
| Other | DITCH OR CULVERT | 10/16/1979 | 9/10/1996 | 3 | 472 | 37 |
| | SEEPAGE OR SEEPAGE POOLS | 10/16/1979 | 11/6/2012 | 5 | 3,508 | 101 |
| Surface water | LAKE OR POND | 3/16/1993 | 8/23/2016 | 3 | 57 | 3 |
| | RIVER, STREAM OR CREEK | 5/20/1971 | 5/15/2018 | 25 | 165,201 | 4,816 |
| | | | **Total** | **39** | **169,785** | **4,966** |

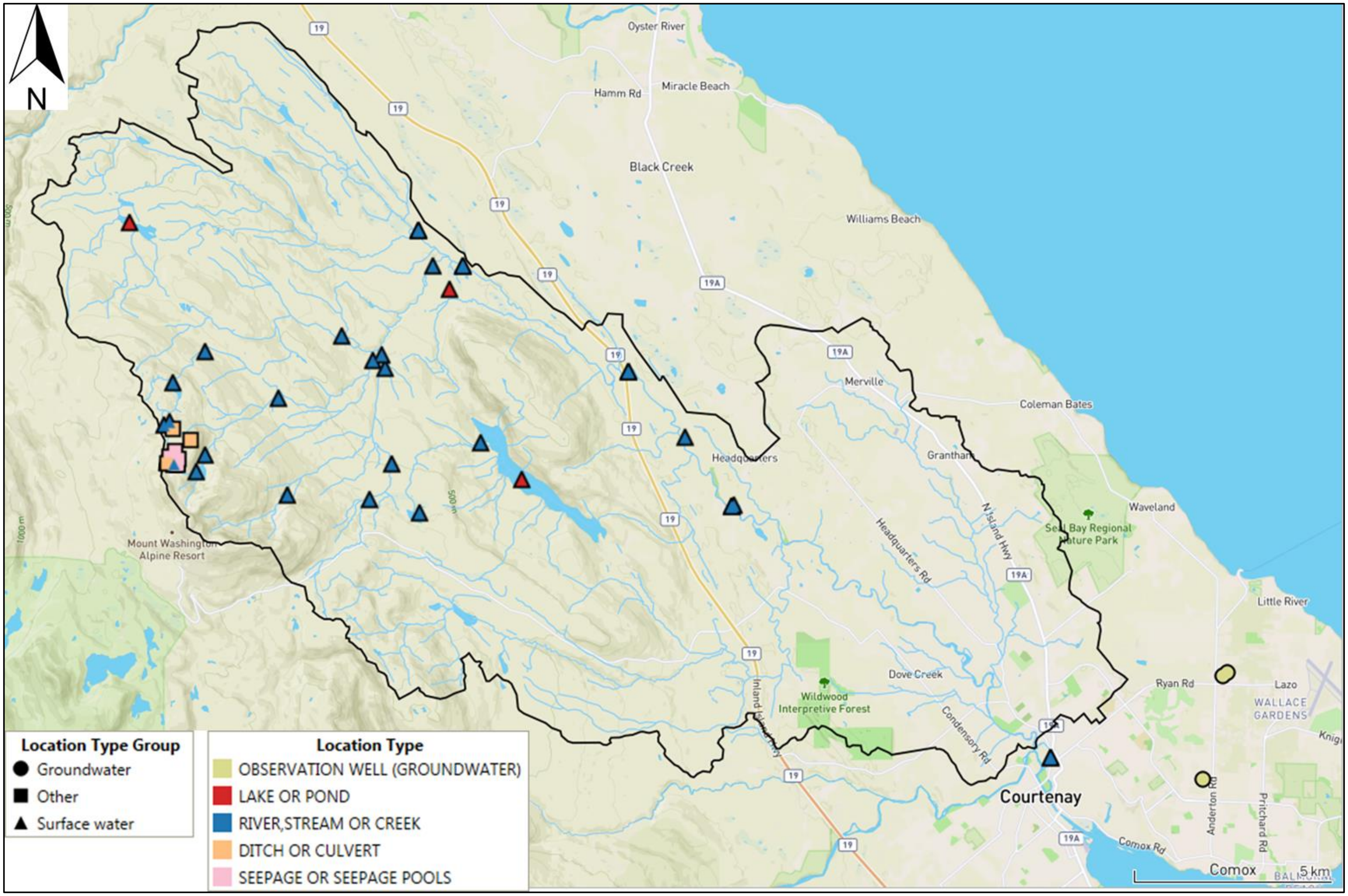



**Figure 25. Location of water quality monitoring stations within/near Tsolum River watershed**

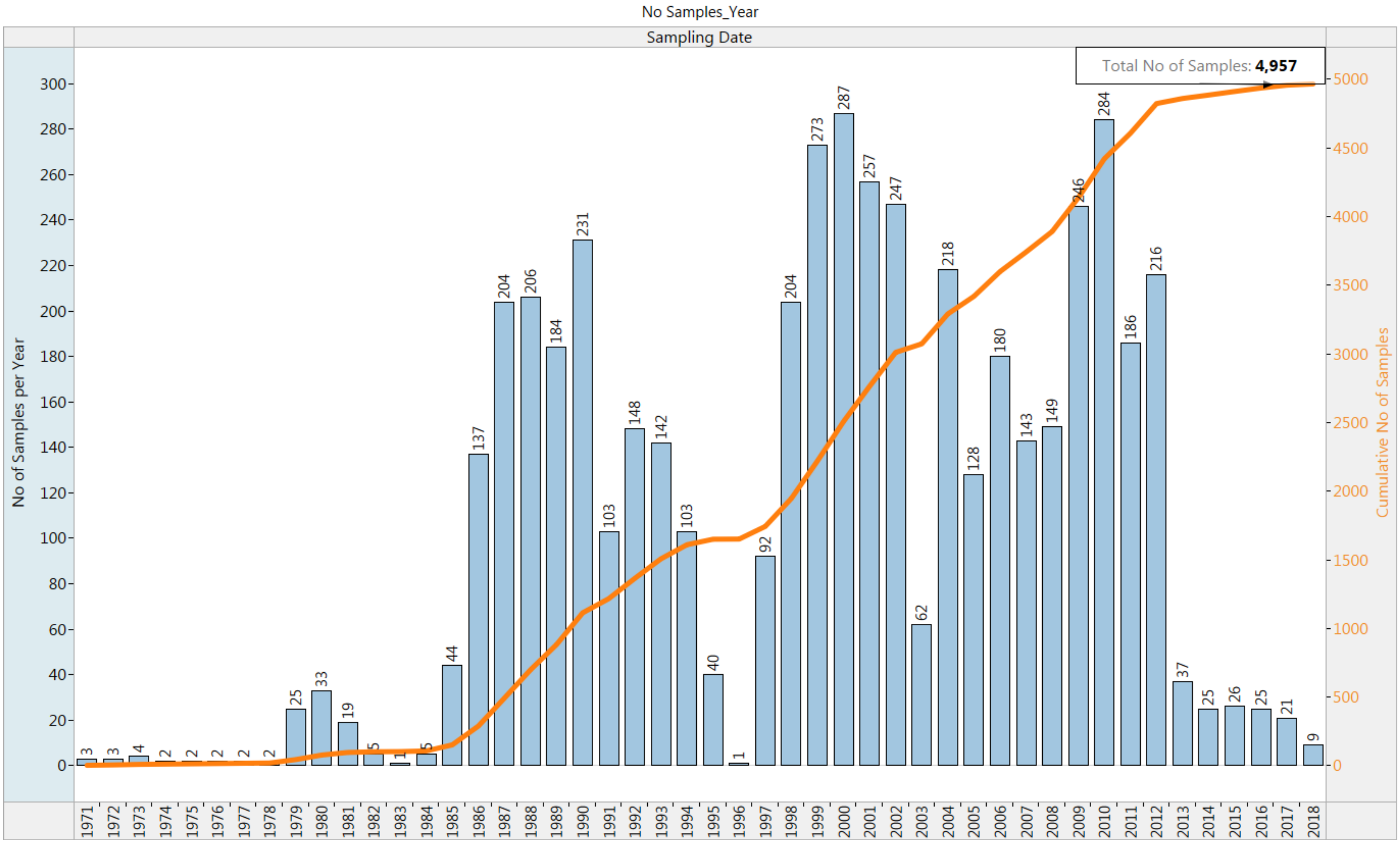



**Figure 26. Number of samples per year compiled for the water quality analysis**

### 5.1.2 Water quality data integration

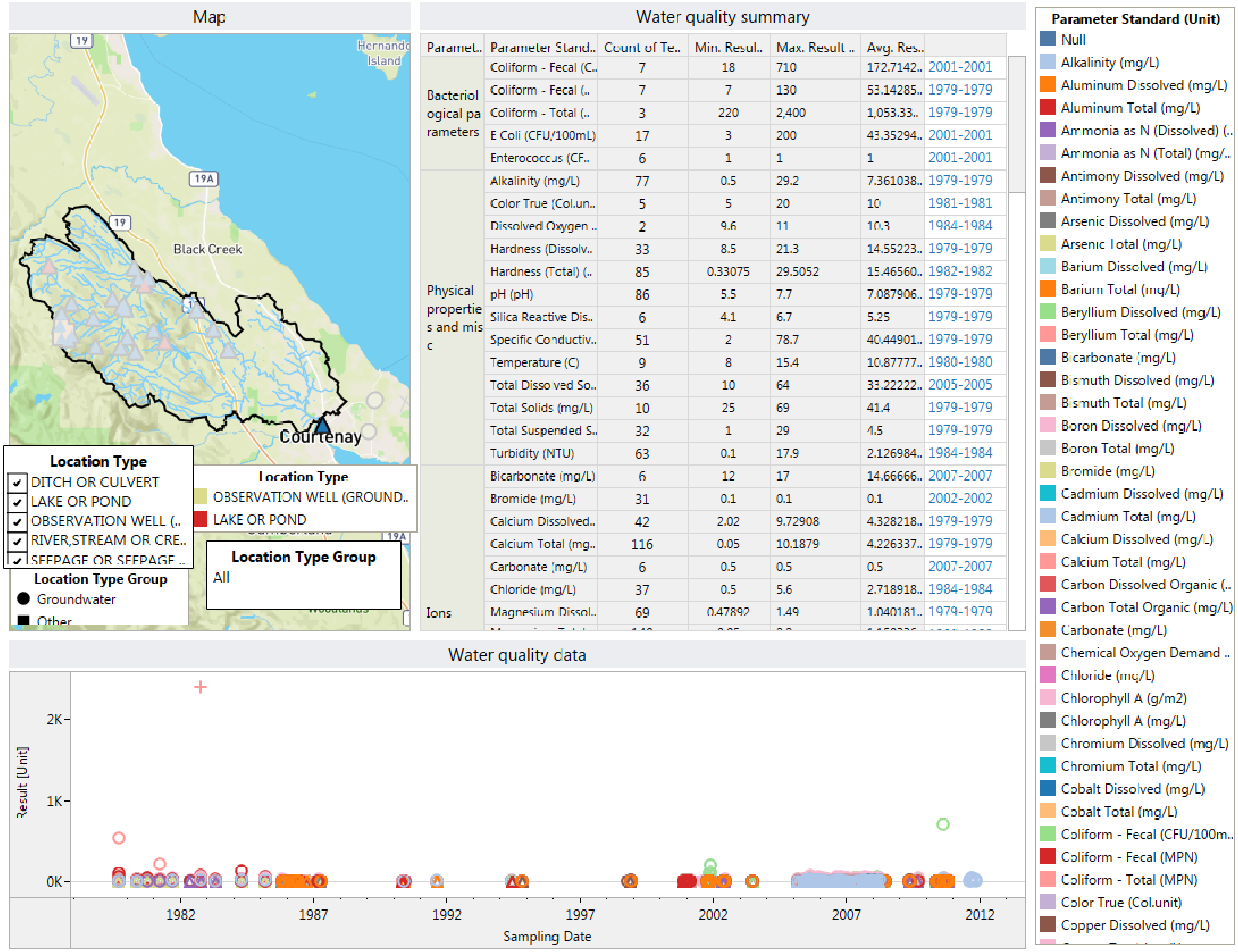
GW Solutions has developed a management and visualisation tool for data integration, interpretation and display. The water quality data has been updated, cleaned-up, and standardized using this tool. In addition, we have built a series of queries to link data to watersheds, sample type, and sample results.

The federal Drinking Water Quality Guidelines, the provincial Acute Fresh Water Aquatic Life and Agriculture Irrigation and Livestock Guidelines were used to identify the parameters and locations where these guidelines were exceeded. The results are available in Tableau workbooks.

The water quality interactive analysis platform was used to explore the test results for the monitoring stations. One of the outputs of the platform is a display composed of the following windows:

- Map: It shows the location of the monitoring stations. In addition, it displays information regarding the station such as ID, water body name, location (latitude, longitude) and sample type.
- Water quality summary: It provides the baseline for the selected stations. For instance, is shows the number of tests, minimum, maximum and average results for each parameter group including the sampling year range.
- Water quality data: It shows the scatter plot for water quality results over time for all the tested parameters.

An example of the output is shown in Figure 27 for the station located at the mouth of the Tsolum River prior to discharging to Courtenay River.



| Paramet.. | Parameter Stand.. | Count of Te.. | Min. Resul.. | Max. Result .. | Avg. Res.. | |
|---|---|---|---|---|---|---|
| Bacteriological parameters | Coliform - Fecal (C.. | 7 | 18 | 710 | 172.7142.. | 2001-2001 |
| | Coliform - Fecal (.. | 7 | 7 | 130 | 53.14285.. | 1979-1979 |
| | Coliform - Total (.. | 3 | 220 | 2,400 | 1,053.33.. | 1979-1979 |
| | E Coli (CFU/100mL) | 17 | 3 | 200 | 43.35294.. | 2001-2001 |
| | Enterococcus (CF.. | 6 | 1 | 1 | 1 | 2001-2001 |
| Physical properties and misc | Alkalinity (mg/L) | 77 | 0.5 | 29.2 | 7.361038.. | 1979-1979 |
| | Color True (Col.un.. | 5 | 5 | 20 | 10 | 1981-1981 |
| | Dissolved Oxygen .. | 2 | 9.6 | 11 | 10.3 | 1984-1984 |
| | Hardness (Dissolv.. | 33 | 8.5 | 21.3 | 14.55223.. | 1979-1979 |
| | Hardness (Total) (.. | 85 | 0.33075 | 29.5052 | 15.46560.. | 1982-1982 |
| | pH (pH) | 86 | 5.5 | 7.7 | 7.087906.. | 1979-1979 |
| | Silica Reactive Dis.. | 6 | 4.1 | 6.7 | 5.25 | 1979-1979 |
| | Specific Conductiv.. | 51 | 2 | 78.7 | 40.44901.. | 1979-1979 |
| | Temperature (C) | 9 | 8 | 15.4 | 10.87777.. | 1980-1980 |
| | Total Dissolved So.. | 36 | 10 | 64 | 33.22222.. | 2005-2005 |
| | Total Solids (mg/L) | 10 | 25 | 69 | 41.4 | 1979-1979 |
| | Total Suspended S.. | 32 | 1 | 29 | 4.5 | 1979-1979 |
| | Turbidity (NTU) | 63 | 0.1 | 17.9 | 2.126984.. | 1984-1984 |
| Ions | Bicarbonate (mg/L) | 6 | 12 | 17 | 14.66666.. | 2007-2007 |
| | Bromide (mg/L) | 31 | 0.1 | 0.1 | 0.1 | 2002-2002 |
| | Calcium Dissolved.. | 42 | 2.02 | 9.72908 | 4.328218.. | 1979-1979 |
| | Calcium Total (mg.. | 116 | 0.05 | 10.1879 | 4.226337.. | 1979-1979 |
| | Carbonate (mg/L) | 6 | 0.5 | 0.5 | 0.5 | 2007-2007 |
| | Chloride (mg/L) | 37 | 0.5 | 5.6 | 2.718918.. | 1984-1984 |
| | Magnesium Dissol.. | 69 | 0.47892 | 1.49 | 1.040181.. | 1979-1979 |



**Figure 27. Water quality results for station: TSOLUM RIVER U/S PUNTLEDGE RIVER (EMS ID: 0127621)**

### 5.1.3 Comparison of water quality data with guidelines

#### 5.1.3.1 *Methodology*

The exceedance analysis presented in this report includes all the water quality results collected after 2010 coinciding with Phase 2 of the rehabilitation of the Mount Washington mine.

Figure 28 shows the locations of the stations for which samples have been taken from 2010 to 2018 and Figure 29 displays the number of samples included per year in the exceedance analysis.

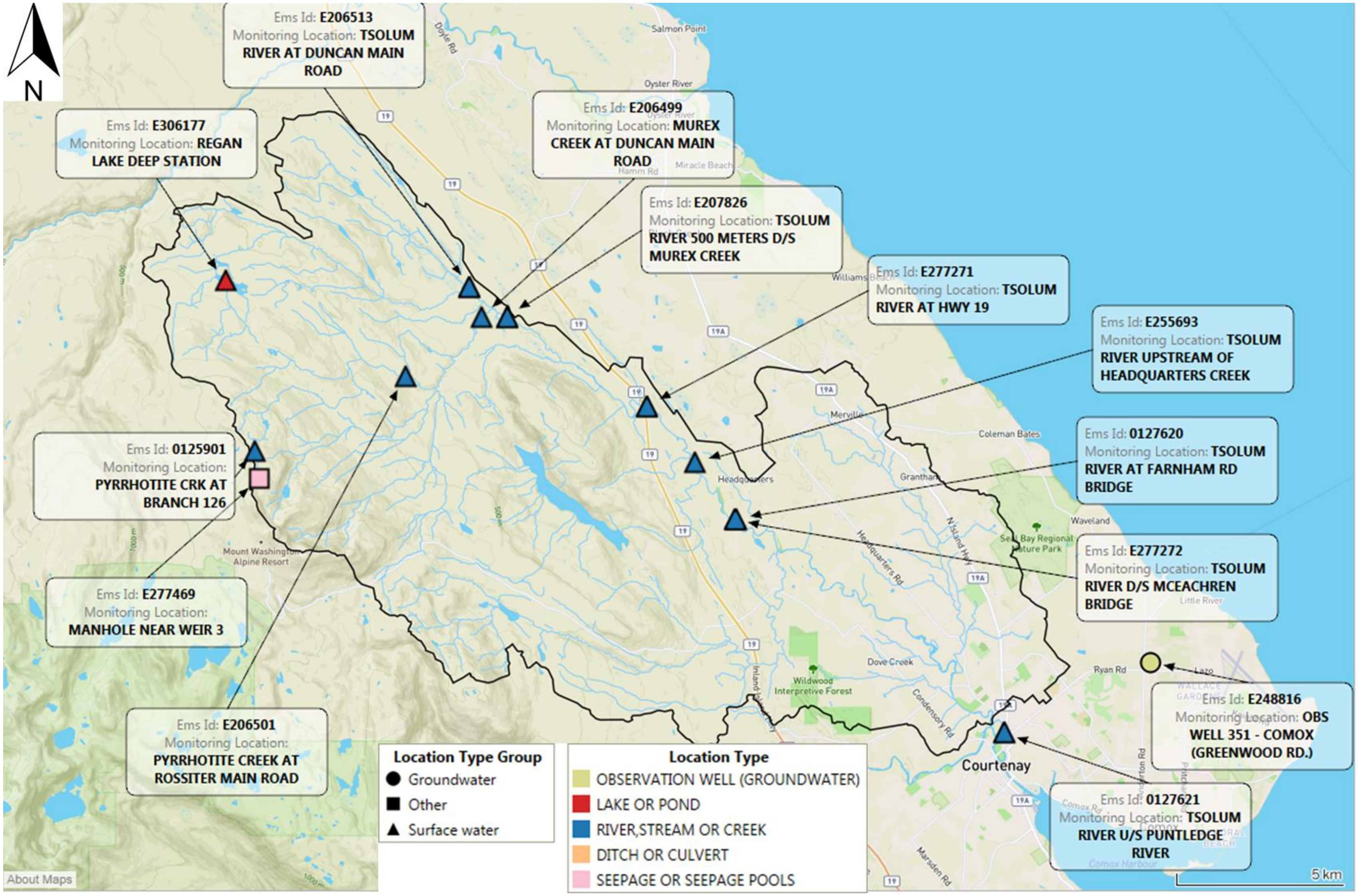



**Figure 28. Location of water quality monitoring stations with data from 2010 to 2018**

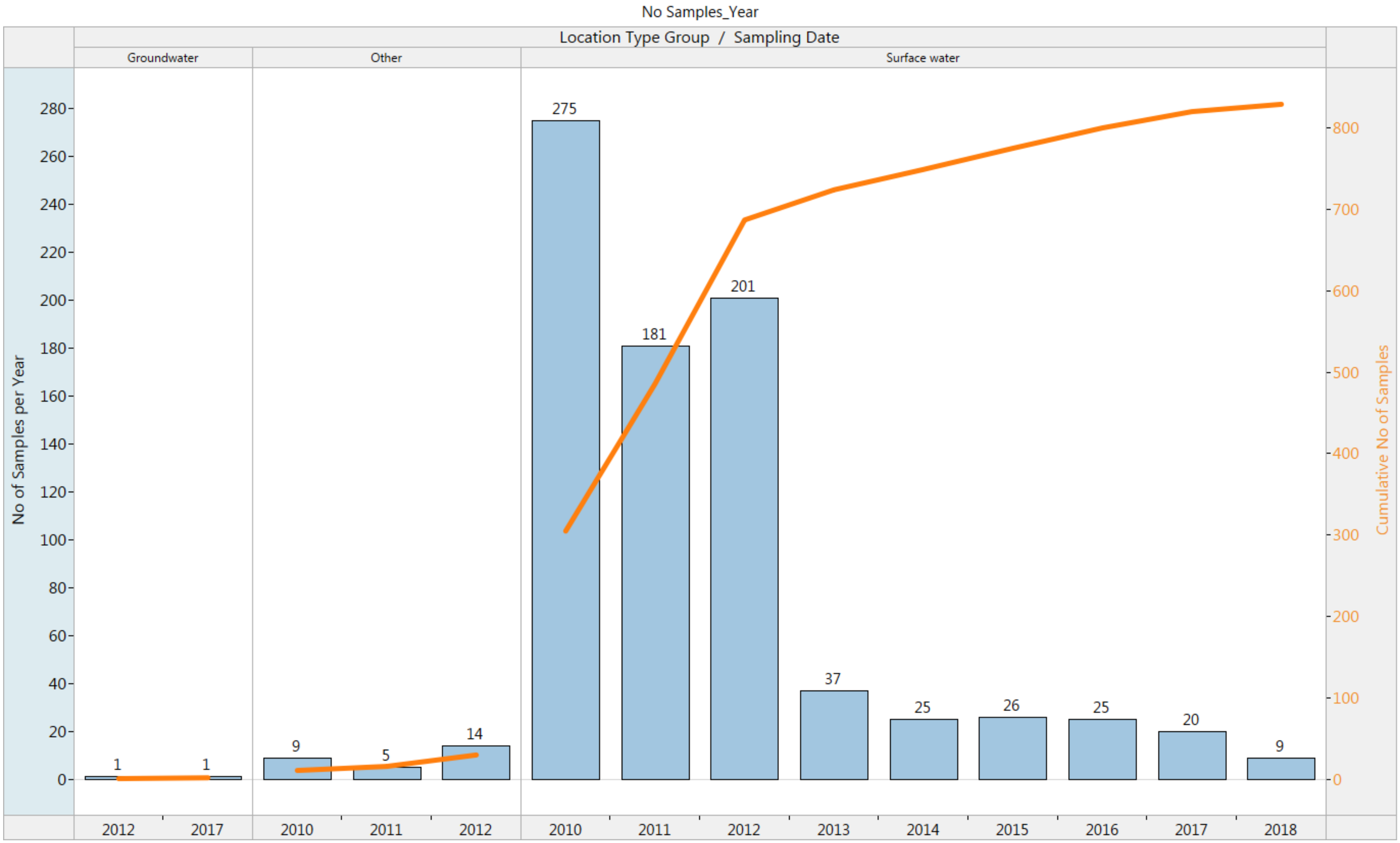



**Figure 29. Number of samples per year included in the exceedance analysis summarized by location type group**

#### 5.1.3.2 *Concentrations above drinking water quality standards*

Figure 30 and Figure 31 show the exceedance analysis results for groundwater and surface water samples, respectively. The results include water quality comparison for bacteriological, ions, metals, nutrients and physical properties. The diagram shows two summary plots: number of tests and percentage of exceedance. There are no exceedances recorded for groundwater samples; however, surface water samples present some exceedances:

- Bacteriological parameters: 87% of the Fecal coliforms tests exceeded the guideline
- Metals: Three parameters exceed the guideline Aluminum total (20% of the samples exceeded the guideline), Iron total (7%), and Manganese (1%)
- Physical properties: pH, color, and temperature present exceedances of 31%, 36%, and 12%, respectively.

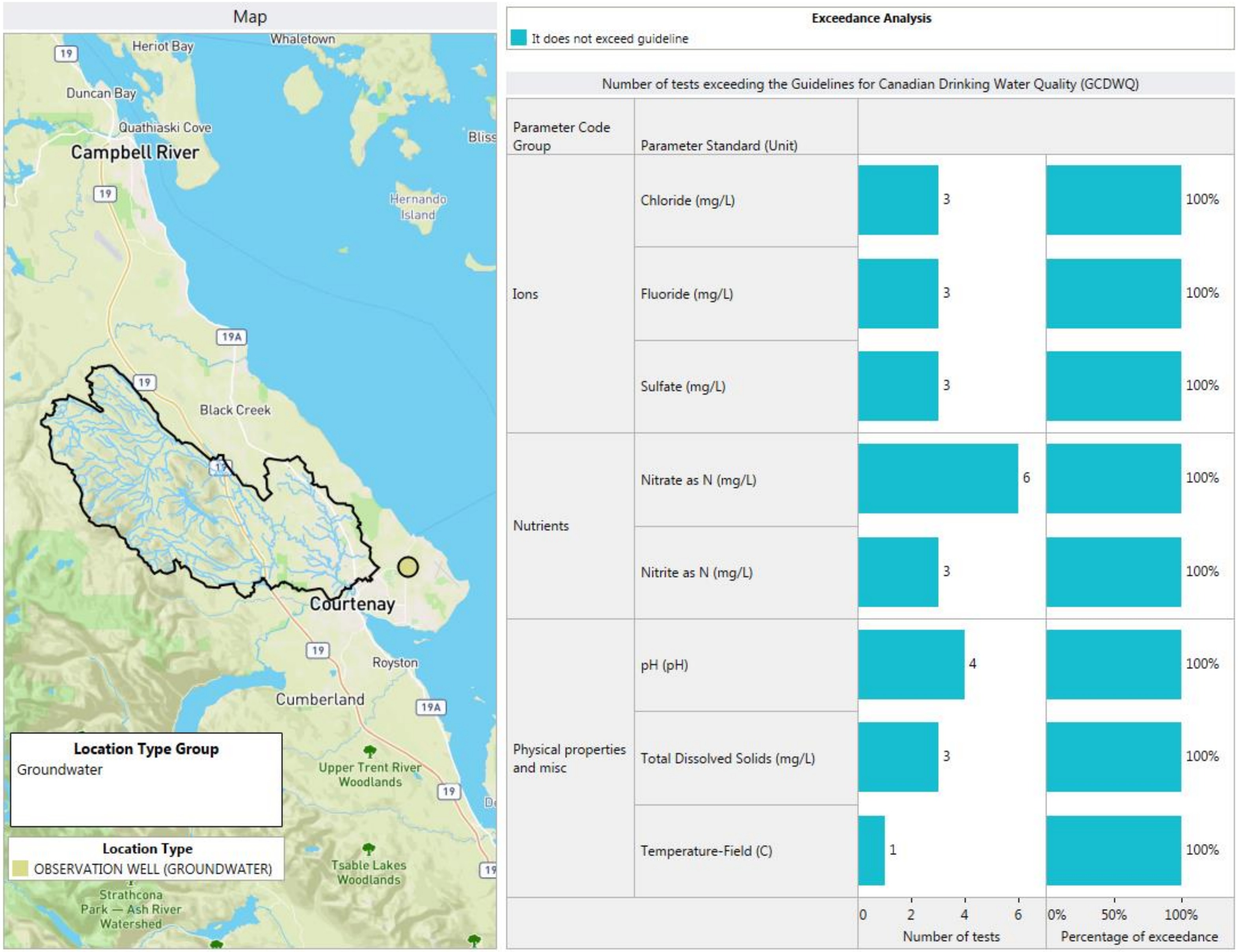



**Figure 30. Exceedance analysis for groundwater samples considering the Federal Drinking Water Quality Guideline**

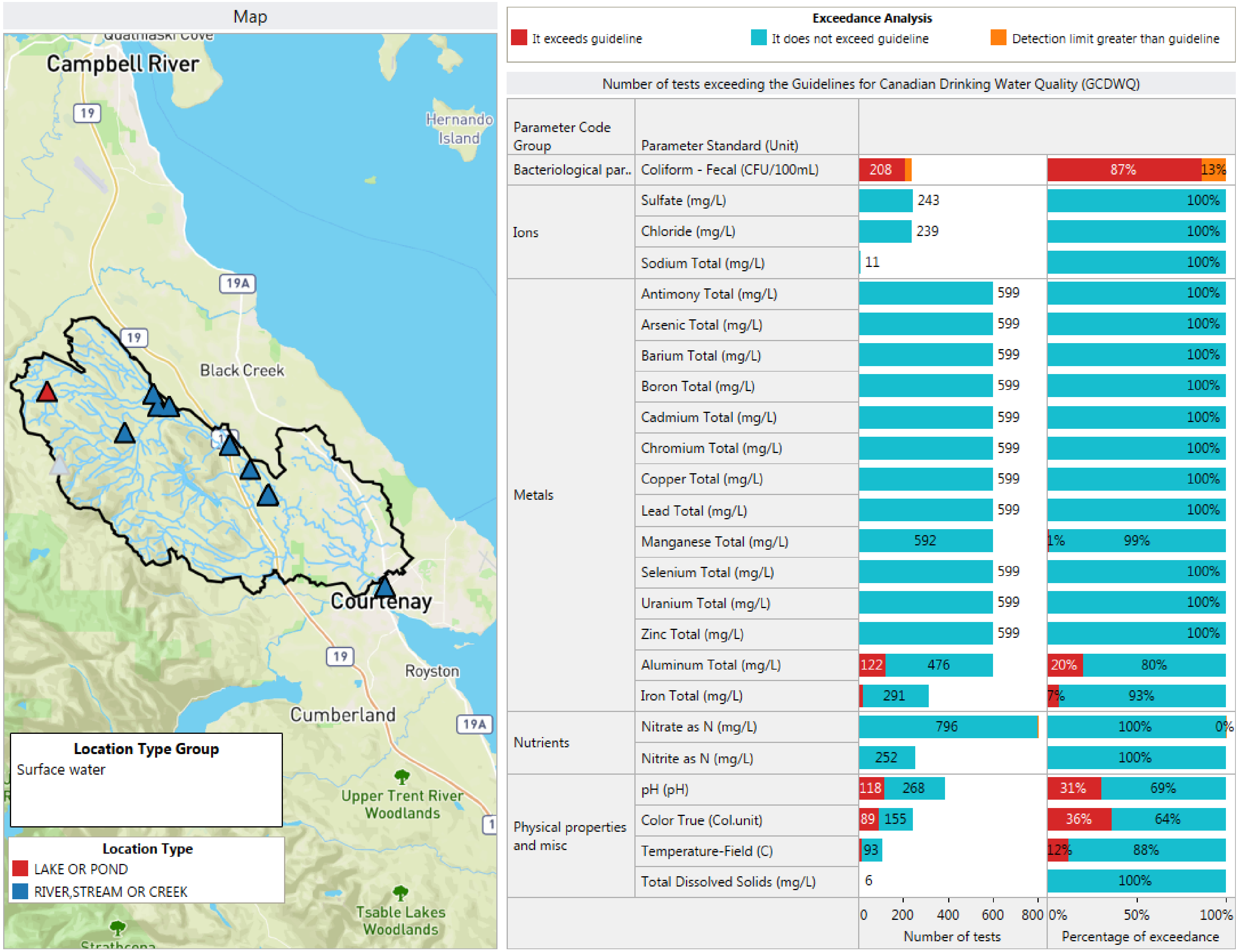



**Figure 31. Exceedance analysis for surface water samples considering the Federal Drinking Water Quality Guideline**

#### 5.1.3.3 *Concentrations above BC acute aquatic life guidelines*

Figure 32 shows the exceedance analysis results for surface water samples. Total copper exceeded the most the aquatic life guideline with 60% of the samples exceeding the guidelines followed by aluminum dissolved (7%), cadmium dissolved (3%) and zinc and iron (1%).

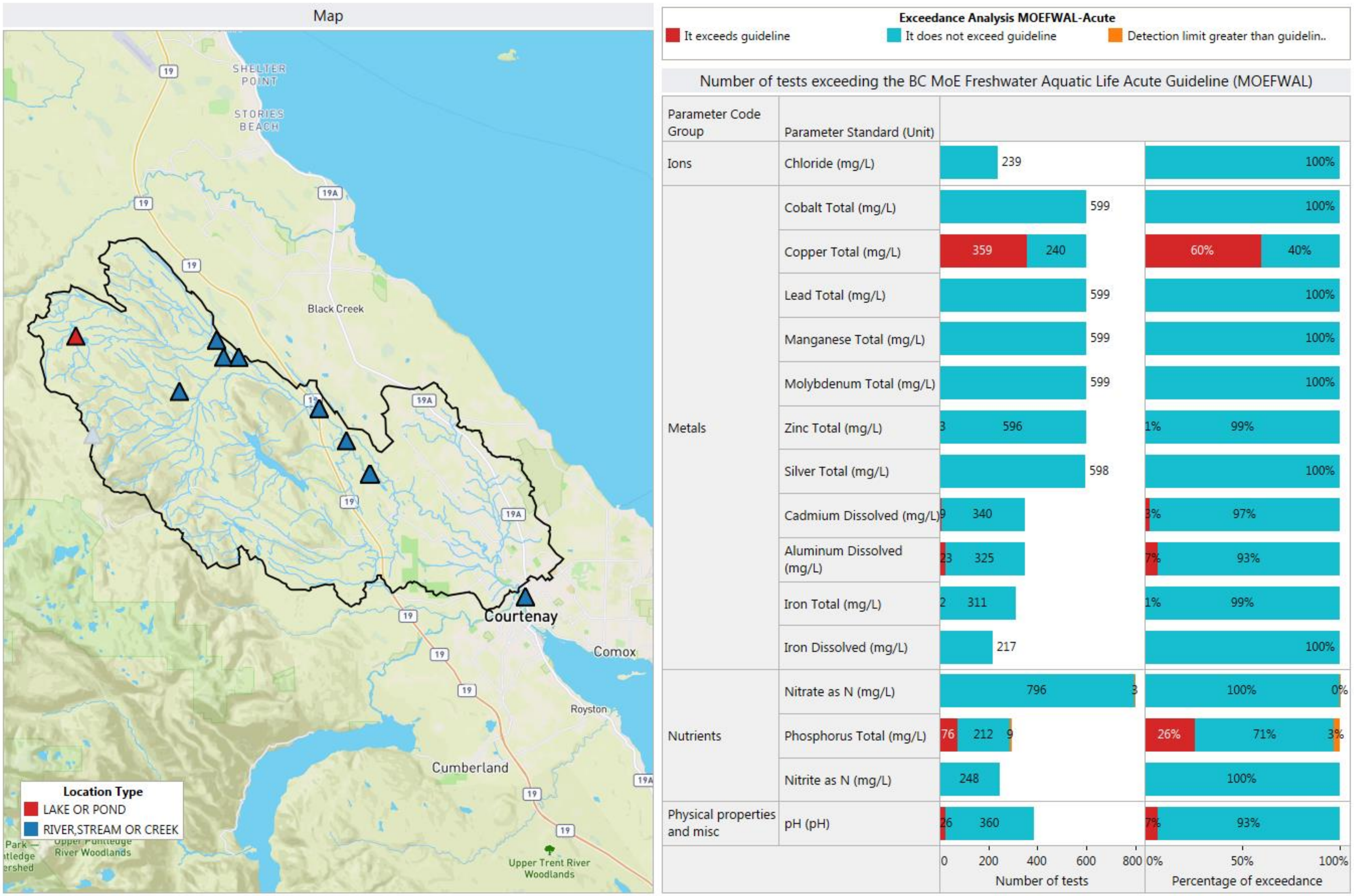



**Figure 32. Exceedance analysis for surface water samples considering the Aquatic Life Acute Guideline**

#### 5.1.3.4 *Concentrations above BC agriculture-irrigation guidelines*

Figure 33 and Figure 34 show the exceedance analysis result for groundwater and surface water samples, respectively. There are no exceedances recorded for groundwater samples; however, surface water samples presented some exceedances of less than 1% for pH and copper.

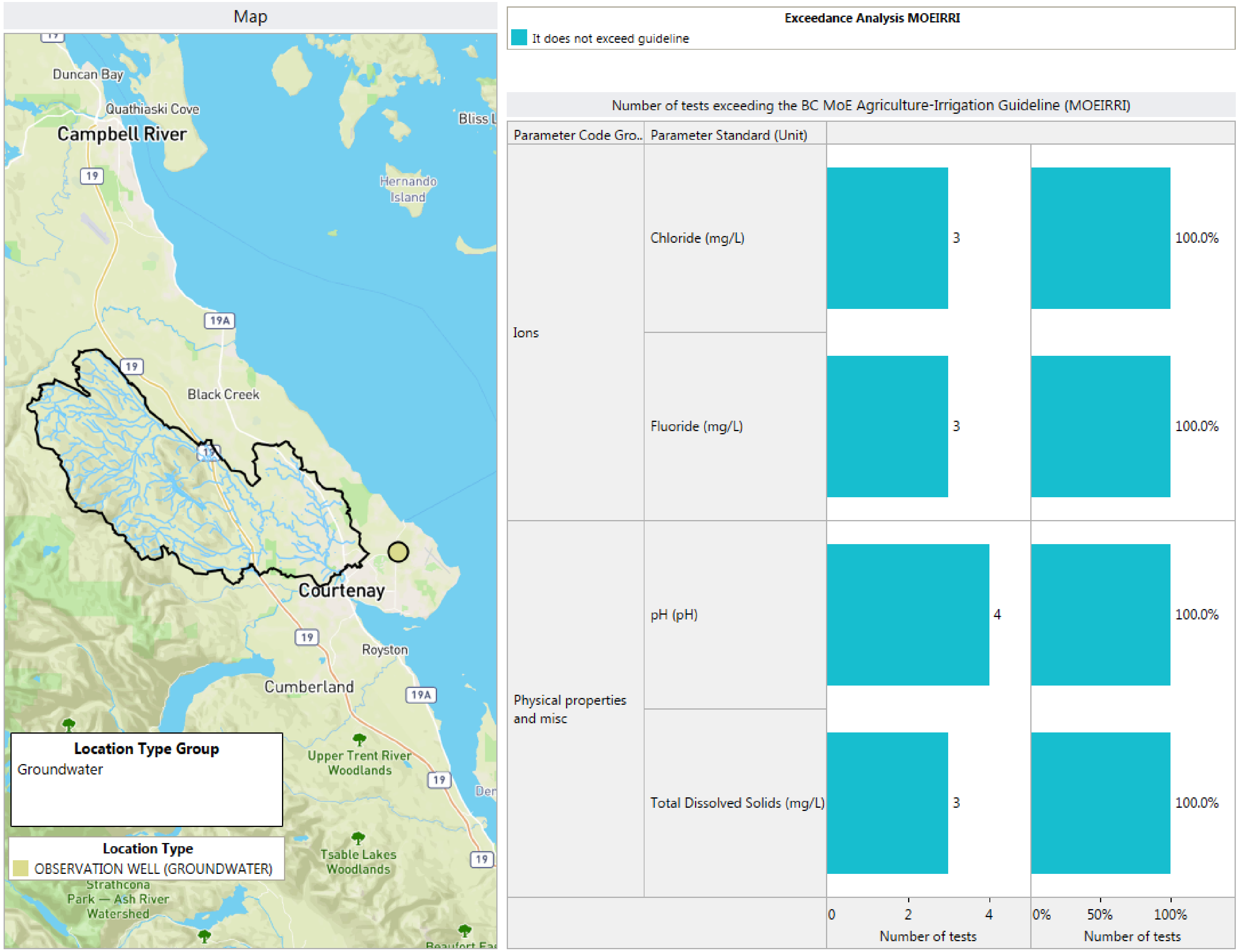
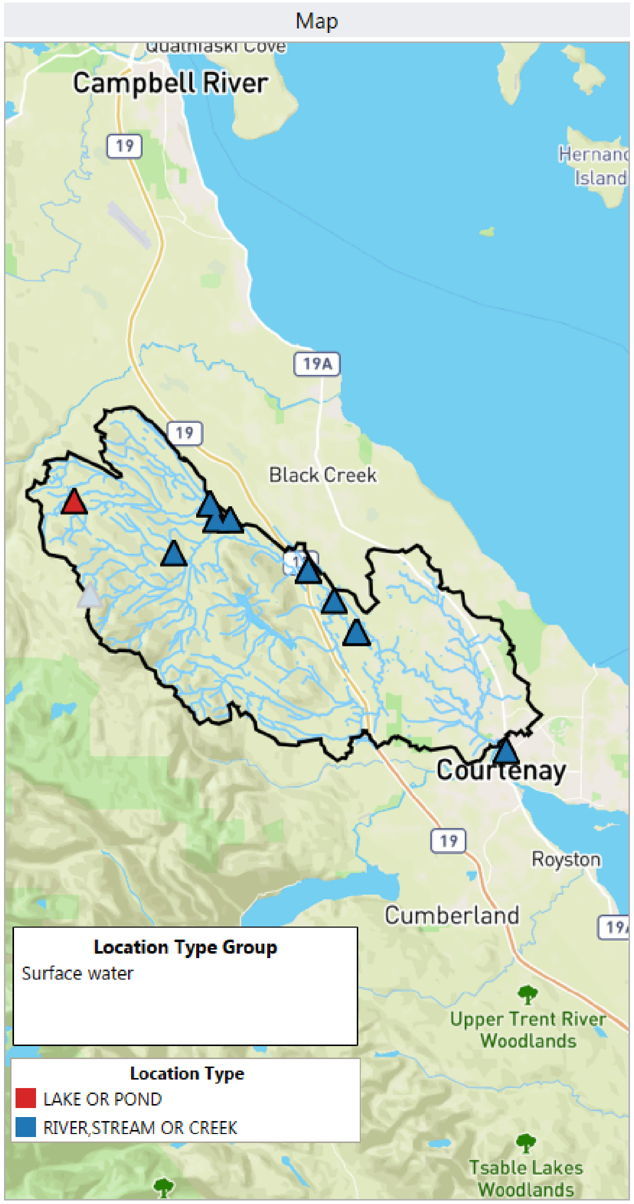



**Figure 33. Exceedance analysis for groundwater samples considering the BC Agriculture-Irrigation Water Quality Guideline**



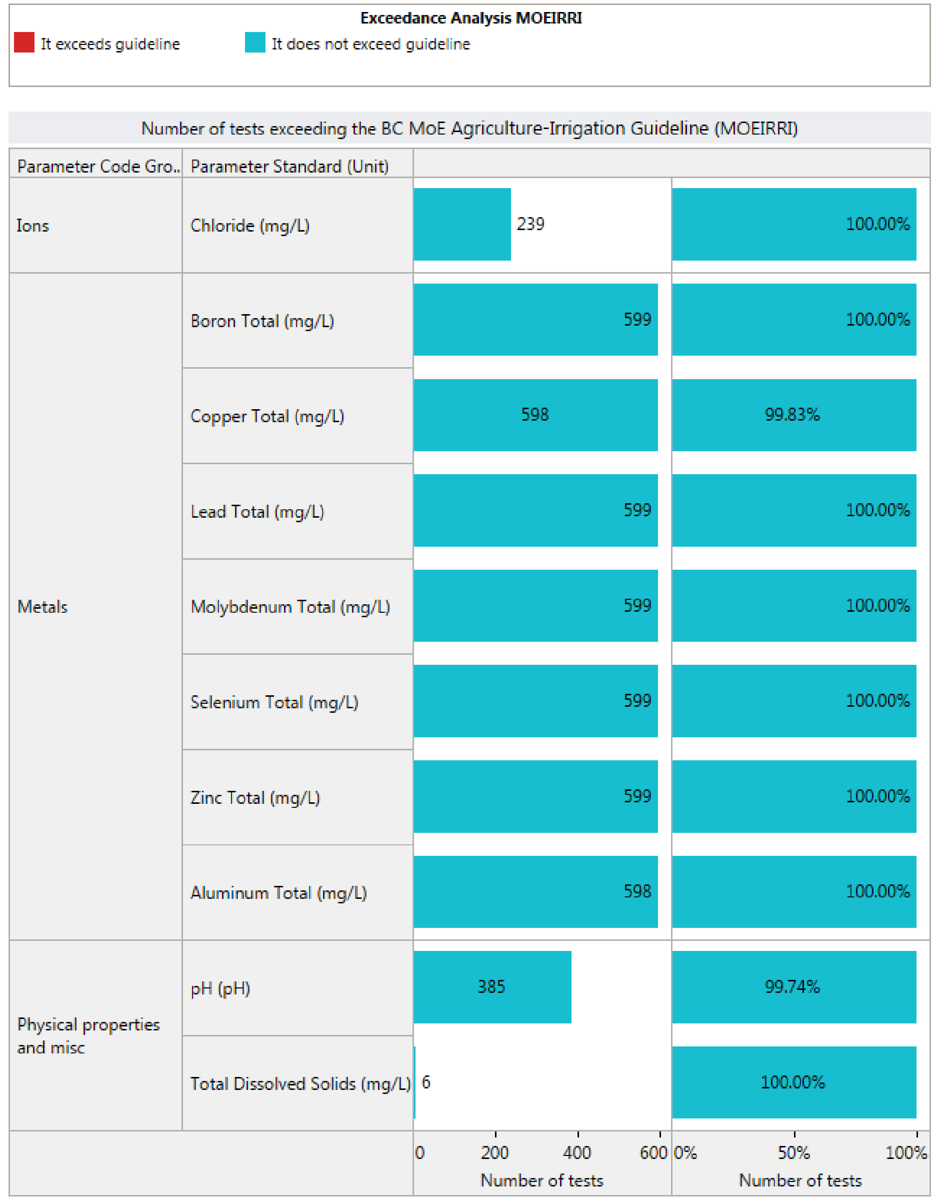




**Figure 34. Exceedance analysis for surface water samples considering the BC Agriculture-Irrigation Water Quality Guideline**

#### 5.1.3.5 *Concentrations above BC agriculture-livestock guidelines*

Figure 35 and Figure 36 show the exceedance analysis result for groundwater and surface water samples, respectively, comparing BC agricultural-livestock guidelines. There are no exceedances recorded for groundwater samples. Nevertheless, surface water samples presented some exceedances of less than 1% for pH, copper and nitrate.

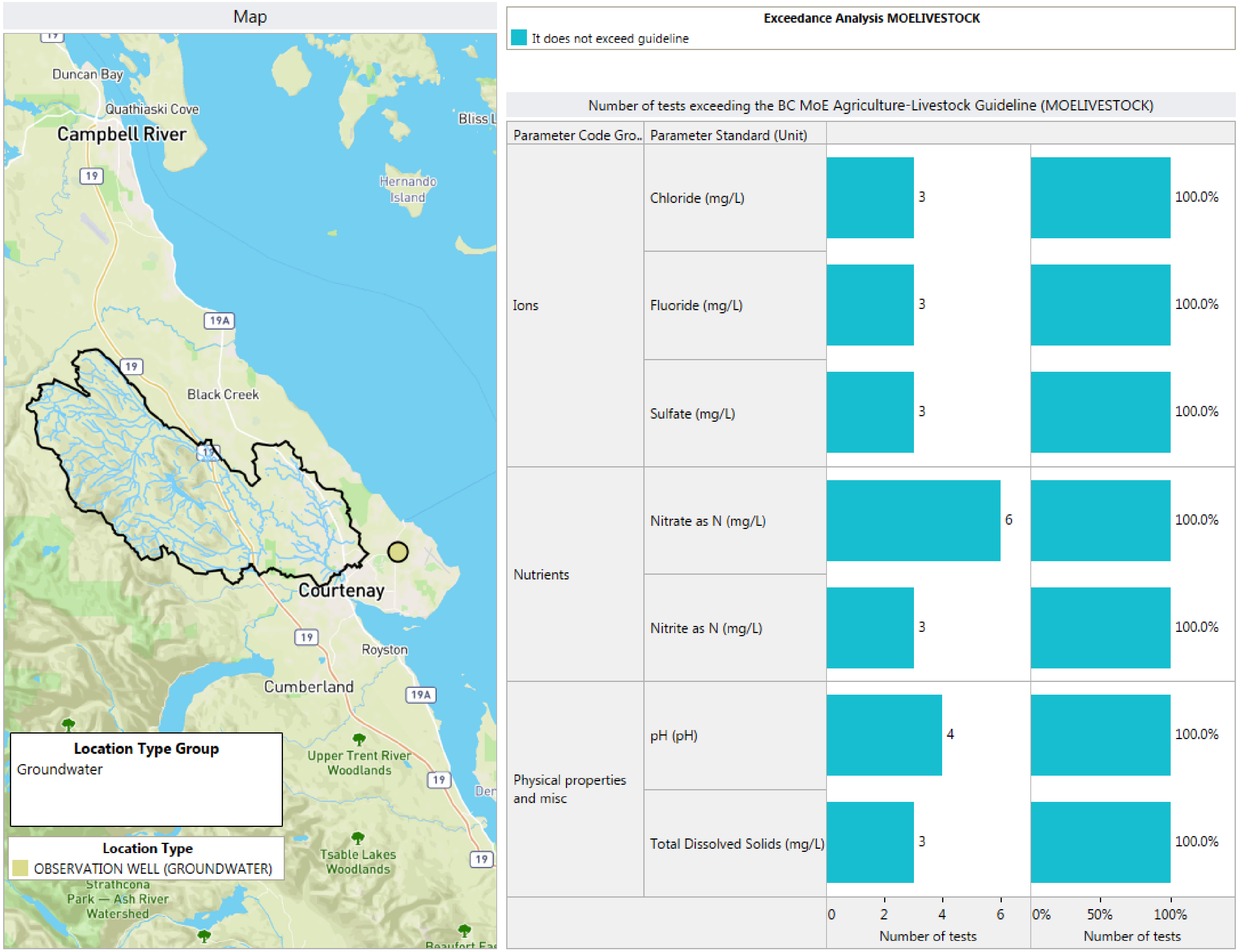



**Figure 35. Exceedance analysis for groundwater samples considering the BC Agriculture-Livestock Water Quality Guideline**

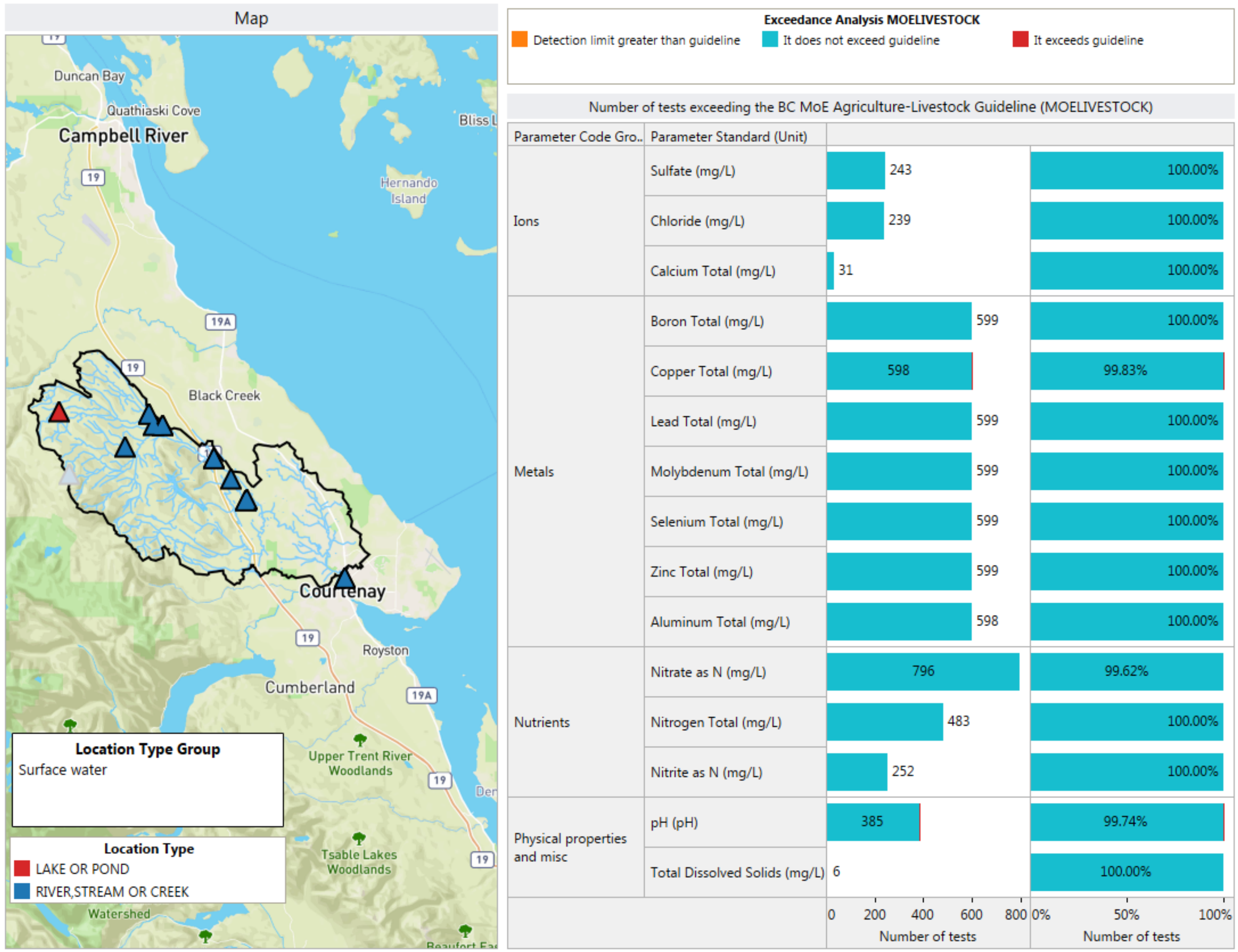



**Figure 36. Exceedance analysis for surface water samples considering the BC Agriculture-Livestock Water Quality Guideline**

# 6 COMMENTS ON DATA GAPS

## 6.1 Water Quantity

Section in a draft form – To be refined with Elucidate Consulting.

Monthly water usage is necessary: The lowest flows occur from July to September coinciding with the largest use of water. Flows in the river must be compared with monthly water usage.

Environmental flow need analysis should be included.

Designing a groundwater and surface water monitoring program for water quantity analysis is recommended: There are no observation wells within the aquifers in the watershed. To study whether dropping groundwater levels is a concern in the study area, implementing observation wells and a monitoring program is essential. In addition, there are only two active hydrometric stations for the whole watershed. We recommend installing gauges above the confluences of Pyrrhotite Creek, McKay Creek, Murex-Creek, Headquarters Creek, Piercy Creek, Jackpot Creek and Portuguese Creek.

Refining groundwater usage using groundwater point of diversion (not available) and field data (i.e. well survey) is suggested: For groundwater, BC has started the process of issuing groundwater licenses. This process will take several years before information becomes available.

Carrying out a groundwater wells survey is recommended: Data collected includes well type and completion details, pumping rate, months of use, type of use (domestic, irrigation), and available water testing.

Characterizing surface water and groundwater interaction along Tsolum River as well as Portuguese Creek is necessary: For instance, the current hydrogeological study shows that there are artesian conditions within the Portuguese Creek sub watershed suggesting upward groundwater flow (discharge to the River).

Potential mapped and characterized aquifers should be continuously refined as new data is collected. In addition, drilling of observation/test wells may be necessary to validate the existence and characteristics of the aquifer.

Estimating flows in sub watersheds should be considered.

## 6.2 Water Quality

Section in a draft form – To be refined with Elucidate Consulting.

It is recommended to:

Design a groundwater monitoring program for groundwater quality characterization, as there are no groundwater quality data available for the Tsolum River watershed.

Extend water quality monitoring to water bodies that don't have water quality information (i.e. Portuguese Creek and Dove Creek).

Characterize waterbodies for chronic guideline analysis as there is a lack of chronic data for the whole watershed.

Include VIHA data and private sampling analysis if available in the water quality database. Currently, the water quality database only includes EMS sources.

Identify possible and existing sources of contamination within the watershed (i.e. nitrates and phosphorous from fertilizers).

## Study Limitations

This document was prepared for the exclusive use of Elucidate Consulting. The inferences concerning the data, site and receiving environment conditions contained in this document are based on information obtained during investigations conducted at the site by GW Solutions and others, and are based solely on the condition of the site at the time of the site studies. Soil, surface water and groundwater conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors.

In evaluating the subject study area and water quality data, GW Solutions has relied in good faith on information provided. The factual data, interpretations and recommendations pertain to a specific project as described in this document, based on the information obtained during the assessment by GW Solutions on the dates cited in the document, and are not applicable to any other project or site location. GW Solutions accepts no responsibility for any deficiency or inaccuracy contained in this document as a result of reliance on the aforementioned information.

The findings and conclusions documented in this document have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care normally exercised by hydrogeologists currently practicing under similar conditions in the jurisdiction.

GW Solutions makes no other warranty, expressed or implied and assumes no liability with respect to the use of the information contained in this document at the subject site, or any other site, for other than its intended purpose. Any use which a third party makes of this document, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. GW Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or action based on this document. All third parties relying on this document do so at their own risk. Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore no party can rely upon the electronic media versions of GW Solutions' document or other work product. GW Solutions is not responsible for any unauthorized use or modifications of this document.

GW Solutions makes no other representation whatsoever, including those concerning the legal significance of its findings, or as to other legal matters touched on in this document, including, but not limited to, ownership of any property, or the application of any law to the facts set forth herein.

If new information is discovered during future work, including excavations, sampling, soil boring, predictive geochemistry or other investigations, GW Solutions should be requested to re-evaluate the conclusions of this document and to provide amendments, as required, prior to any reliance upon the information presented herein. The validity of this document is affected by any change of site conditions, purpose, development plans or significant delay from the date of this document in initiating or completing the project.

The produced graphs, images, and maps, have been generated to visualize results and assist in presenting information in a spatial and temporal context. The conclusions and recommendations presented in this document are based on the review of information available at the time the work was completed, and within the time and budget limitations of the scope of work.

Elucidate Consulting may rely on the information contained in this memorandum subject to the above limitations.

# 7 CLOSURE

Conclusions and recommendations presented herein are based on available information at the time of the study. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgement has been applied in producing this letter-report.

This letter report was prepared by personnel with professional experience in the fields covered. Reference should be made to the General Conditions and Limitations attached in Appendix 1.

GW Solutions was pleased to produce this document. If you have any questions, please contact me.

Yours truly,

**GW Solutions Inc.**

DRAFT

Gilles Wendling, Ph.D., P.Eng.

President

# APPENDIX 1

GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS

This report incorporates and is subject to these "General Conditions and Limitations".

**1.0 USE OF REPORT**

This report pertains to a specific area, a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment. This report and the assessments and recommendations contained in it are intended for the sole use of GW SOLUTIONS's client. GW SOLUTIONS does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than GW SOLUTIONS's client unless otherwise authorized in writing by GW SOLUTIONS. Any unauthorized use of the report is at the sole risk of the user. This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of GW SOLUTIONS. Additional copies of the report, if required, may be obtained upon request.

**2.0 LIMITATIONS OF REPORT**

This report is based solely on the conditions which existed within the study area or on site at the time of GW SOLUTIONS's investigation. The client, and any other parties using this report with the express written consent of the client and GW SOLUTIONS, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive. The client, and any other party using this report with the express written consent of the client and GW SOLUTIONS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the area or subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made. The client acknowledges that GW SOLUTIONS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

**2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS**

During the performance of the work and the preparation of this report, GW SOLUTIONS may have relied on information provided by persons other than the client. While GW SOLUTIONS endeavours to verify the accuracy of such information when instructed to do so by the client, GW SOLUTIONS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

**3.0 LIMITATION OF LIABILITY**

The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of GW SOLUTIONS providing the services requested, the client agrees that GW SOLUTIONS's liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

(1) With respect to any claims brought against GW SOLUTIONS by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to GW SOLUTIONS under this Agreement, whether the action is based on breach of contract or tort;

(2) With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless GW SOLUTIONS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by GW SOLUTIONS, whether the claim be brought against GW SOLUTIONS for breach of contract or tort.

**4.0 JOB SITE SAFETY**

GW SOLUTIONS is only responsible for the activities of its employees on the job site and is not responsible for the supervision

of any other persons whatsoever. The presence of GW SOLUTIONS personnel on site shall not be construed in any way to relieve the client or any other persons on site from their responsibility for job site safety.

**5.0 DISCLOSURE OF INFORMATION BY CLIENT**
The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

**6.0 STANDARD OF CARE**
Services performed by GW SOLUTIONS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

**7.0 EMERGENCY PROCEDURES**
The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

**8.0 NOTIFICATION OF AUTHORITIES**
The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by GW SOLUTIONS in its reasonably exercised discretion.

**9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE**
The client acknowledges that all reports, plans, and data generated by GW SOLUTIONS during the performance of the work and other documents prepared by GW SOLUTIONS are considered its professional work product and shall remain the copyright property of GW SOLUTIONS.

**10.0 ALTERNATE REPORT FORMAT**
Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by GW SOLUTIONS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by GW SOLUTIONS shall be deemed to be the overall original for the Project. The Client agrees that both electronic file and hard copy versions of GW SOLUTIONS's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except GW SOLUTIONS. The Client warrants that GW SOLUTIONS's instruments of professional service will be used only and exactly as submitted by GW SOLUTIONS. The Client recognizes and agrees that electronic files submitted by GW SOLUTIONS have been prepared and submitted using specific software and hardware systems. GW SOLUTIONS makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

# Appendix B: Public Engagement Materials

The following engagement materials were created for this project:

1. Public engagement plan
2. Project brochure
3. Project survey
4. Mapping materials
5. Website content
6. Media releases
7. Social media content
8. Public open house event plan
9. Posters for open house

Samples of these materials are included in this appendix. (Only one of the three version of the survey developed is included in this document and two of the public open house posters are included).

The following materials were developed and are not included in this appendix.

1. Presentations (3 to Advisory Committee, 1 for public open house, 2 for Farmer's Institute meetings)
2. Email content
3. Speaking points to support media inquiries

# Public engagement plan

On May 29, 2018 the Tsolum River Agriculture Watershed Planning Advisory Committee (AWPAC) met to initiate the Tsolum River Agricultural Watershed Plan. At this meeting the AWPAC was provided with an overview of the proposed approach and asked to provide input on the public engagement portion of the project. The AWPAC provided valuable feedback which helped the consultant identify and prioritize communications activities that align with the needs, opportunities and resources of the project and watershed stakeholders.

The following summarizes the recommendations provided by the AWPAC:

***1) To reach a broad range of stakeholders, use a variety of communications approaches, with a focus on online engagement through existing networks***

To reach the watershed's diverse stakeholders, the AWPAC suggested using a range of communications methods, including web-based, face-to-face, and print media. AWPAC members stated that many watershed residents and producers are too busy to attend public events/open houses, but that online communications and survey have worked well in the region. Several local organizations represented on the AWPAC have well-utilised email distribution lists and social media networks and offered to distribute project information through these networks. AWPAC members also provided feedback on the best community hubs for distributing printed materials.

***2) Conduct face-to-face outreach at existing community events***

The AWPAC also recommended conducting face-to-face outreach at several existing community events. Existing events can reach a more diverse audience, while project-specific events may attract limited (and already-engaged) stakeholders. Utilizing existing events would also focus public engagement resources on communications activities, rather than event coordination/logistics/promotions. The AWPAC reviewed a list of potential community events and advised on which would be best for reaching the target audience. Recommended events included the Farmers Market on Headquarters Road, Comox Valley Farmer's Institute AGM, and the Tsolum River Restoration Society River's Day event.

One public-open house event will be delivered in late October (following election season) to present the results of the project to-date and obtain community input.

## Details of Proposed Public Engagement and Communications Activities

Table 1 summarizes the proposed public communications and engagement activities, based on recommendations provided by the AWPAC and CVRD staff.

Table 1 also includes details on key project milestones and deliverable components.

*Table 1: Public Communications and Engagement Activities – Timelines and Details*

| COMMUNICATIONS ACTIVITIES | DATE/ DUE DATE | TIME | COMPONENTS | DETAILS |
|---|---|---|---|---|
| **Face-To-Face Communications at Events and Meetings** | | | | |
| **Comox Valley Farmer's Institute meeting @ Dove Creek Hall** | Sept. 18 | 7 - 9pm | Presentation and survey | |
| **Mid-Island Farmer's Institute meeting** | Sept. 19 | 7 - 9pm | Presentation and survey | |
| **Agricultural Advisory Committee Meeting** | Sept. 26 | 1-3pm | Presentation and survey | |
| **Farmer's Market @ Comox Exhibition Grounds** | Oct. 13 | 9am - 1pm | Brochures, maps, watershed model, iPad for survey | Tsolum River Restoration Society will be present with a display which has watershed games and activities to attract and engage participants |
| **Public Open House @ TBD** | Oct. 29 | 6 – 7:30 pm | Presentation, brochures, maps, watershed model, information/input stations | |
| **Agricultural Advisory Committee Meeting** | Nov. 28 | | Presentation | |
| **Final presentation to the Board** | Jan (TBD) | | Presentation | |
| **Communications Materials** | | | | |
| **Project brochure** | Oct. 1 | | | Developed in partnership with a graphic designer. |
| **Online questionnaire: requesting stakeholder input on concerns, priorities, and solutions regarding water management in the Tsolum** | Oct. 3 | | | Questionnaire will be directed at Tsolum River stakeholders (e.g. producers, residents, businesses). Respondents will be asked to self-identify if they live/work in the watershed by viewing a map and responding: yes/no/partially. Results will be summarized in the final report and used to develop recommendations for next steps. |
| **Maps** | Sept. 30 | | | |
| **Project Webpage - Web Content** | Oct. 3 | | Include brochure | Draft to Tanis by Sept. 3. The CVRD will create a dedicated webpage space for this project. CM will provide web content for this page including a project description, project brochure, questionnaire link, and event information. |
| **Media release/news article** | Oct. 4, Oct. 22 | | Link to webpage | Two media releases proposed: one, released early October, providing information on the project and inviting community members to provide |

| COMMUNICATIONS ACTIVITIES | DATE/ DUE DATE | TIME | COMPONENTS | DETAILS |
|---|---|---|---|---|
| | | | | input via the survey. A second, released Oct. 22 (following election), announcing the open house. The first media release will be approx. 600 words and include a photo (draft sent to Tanis by Sept. 11, released Oct. 4). The second media release will be approx. 250 words and include a photo (draft to Tanis Oct. 14, release Oct. 22) |
| **Social media content** | Oct. 11, Oct. 29 | | Image, text, link to webpage | Oct. 11: post to announce survey and open house event; Oct. 29: post to remind people of open house. Christina to provide content to Tanis 3 business days prior to each post |
| **Emails** | Oct. 8 | | Link to webpage | Share information on project, request input via survey, invitation to public open house. Email include a link to the project webpage. Draft email to Tanis Oct. 4. Emails released Oct. 8. |
| **Communications Avenues** | | | | |
| **Comox Valley Farmer's Institute email distribution list** | Oct. 8 | | Text, link to webpage | Share information on project, request input via survey, invite to public open house |
| **Comox Valley Farmer's Institute Social Media** | Oct. 11 | | Image, text, link to webpage | Post before Oct. 13 Farmer's Market event and day before public open house. Request input via survey |
| **Mid Island Farmer's Institute email distribution list** | Oct. 8 | | Text, link to webpage | Share information on project, request input via survey, invite to public open house |
| **Mid-Island Farmer's Institute Social Media** | Oct. 11 | | Image, text, link to webpage | Post before Oct. 13 Farmer's Market event and day of public open house. Request input via survey |
| **Direct emails to stakeholder groups (over 20 groups identified)** | Oct. 8 | | Text, link to webpage | Share information on project, request input via survey, invitation to public open house |
| **CVRD Facebook page** | Oct. 11, Oct. 29 | | Image, text, link to webpage | Ideally posting before Oct. 13 Farmer's Market day of public open house |
| **CVRD webpage** | Oct. 3 | | Image, text, brochure | Share information on project, request input via survey, invitation to open house |
| **Distribution of project brochure at community hubs** | Oct. 12 | | | Distribute to Creek Farm and Feed, Top Shelf, Merville Hall, Merville store, CVRD office, Iritex, Corix, North Island Tractor, Shar-Kare, Andrew Sheret |
| **Direct communications with K'ómoks First Nation** | TBD | | | Details TBD. Christianne, Darry, Tanis, Christina to discuss |

# Project Brochure

## How Much Water Will We Need in the Future?

While producers are accustomed to adapting to changing weather and difficult conditions, climate change will bring conditions that are very different than anything experienced so far, including:

- Higher average temperatures
- Increased winter precipitation and decreased summer precipitation
- More frequent and intense extreme conditions (flooding, drought, wildfires, very hot days)

Warmer winter temperatures and more winter rainfall means less snowpack will accumulate, making winter flows more unpredictable and summer flows lower and less reliable.

## Agricultural Water Demand Model

In 2017, the CVRD and the Ministry of Agriculture used an Agricultural Water Demand Model to estimate current and future agricultural water needs in the Tsolum River watershed under four possible scenarios:

*Estimate of agricultural water use (m3/year) (approx. 40% from surface water, and 60% from groundwater wells)*

| Scenario | Average Use ($m^3$/year) | Percent Increase |
|---|---|---|
| Current climate + current amount of farming | 2,321,812 | 0% |
| Climate change (2050s) + current amount of farming | 3,224,009 | 139% |
| Current climate + increased amount of farming* | 9,071,118 | 291% |
| Climate change (2050s) + increased amount of farming* | 13,064,559 | 463% |

*Assuming 40% of available farmland (ALR not in production) is cultivated using a relatively similar distribution of crops and irrigation systems.

The model showed that agricultural water needs could increase as much as 463% on average, and up to 500% in a dry year (worst case scenario).

These projections make it clear we need to plan ahead to manage water in this watershed.

## Planning Ahead

The CVRD has partnered with the Investment Agriculture Foundation of British Columbia to develop a plan to address ongoing and future concerns about water availability in the Tsolum River watershed.

To date, information on water and agriculture in the Tsolum watershed has been gathered and analyzed. Now, we are looking at ways to prepare for the future.

### We Want to Hear from You!

**Is access to water affecting your home, farm, business, or your future planning?**

**What are your concerns regarding water management in the Tsolum watershed?**

**What solutions might work for you?**

**Tell us more...**

**Online:**
**www.comoxvalleyrd.ca/tsolumwatershed**

## Public Meeting

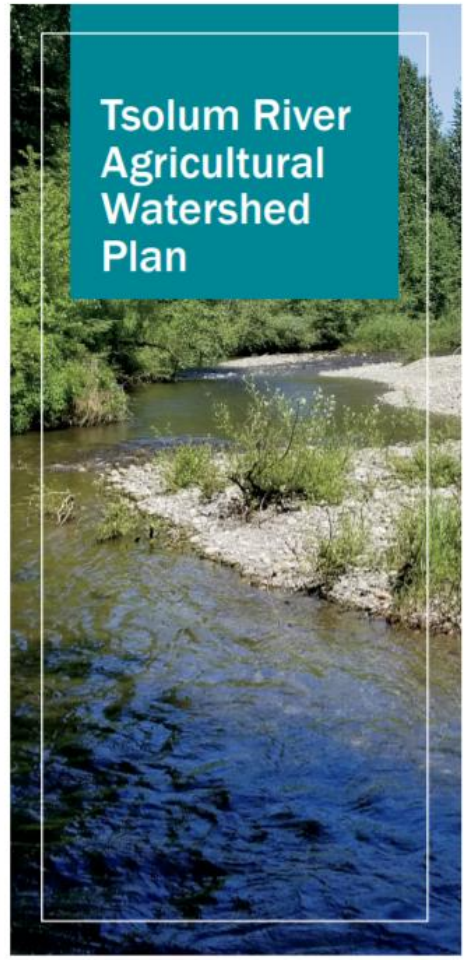
**Monday October 29, 2018 I 6:00 - 7:30 pm**

**Rotary Hall, Florence Filberg Centre, Courtenay**

Learn about water in the Tsolum watershed: get information on local aquifers, climate impacts, and join the discussion on our water future.

Engineering Services
Comox Valley Regional District
250-334-6000 | www.comoxvalleyrd.ca

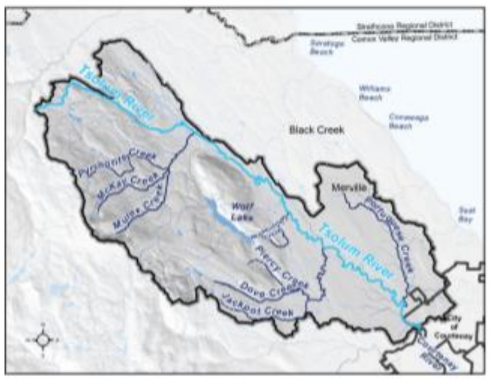
DELIVERED BY FUNDING PROVIDED BY
British Columbia Canada




Comox Valley Regional District
comoxvalleyrd.ca

## Where is the Tsolum River Watershed?

This 258 km² watershed is relatively flat and includes upland forests, low lying rural residential and agricultural land, and suburban areas near Courtenay.




## Who Uses the Watershed?

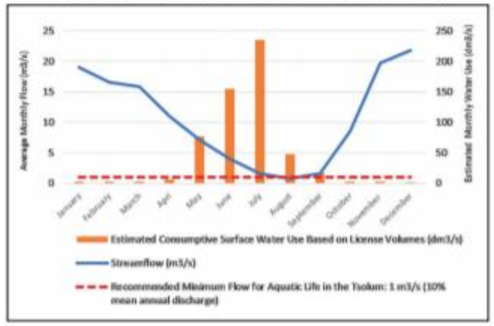
Up to 8,000 people live in the Tsolum River watershed. The watershed and its aquifers provide water that is critical to the health of the local agricultural community and the health of the river. Drinking water for homes, businesses, a school and community centres is provided by the Tsolum River and its aquifers.

## What Do We Know About the Watershed?

Like many watersheds on the east coast of Vancouver Island, the Tsolum experiences extreme seasonal variations in precipitation.

In the winter, plentiful rain brings high water levels and flooding. In dry summer months, stream flows become very low and water temperatures rise.

*Tsolum River monthly flows (average 1914-2016) compared to licensed consumptive surface water use*




These seasonal variations in flow bring challenges for producers, fish, and residents. As shown in the figure above, river flows are lowest in August, when the water is most needed by agricultural producers and aquatic life. Groundwater is an important source of irrigation water and instream flows in the summer.

**Did you know that pink salmon move up the river in late August, if water levels are high enough?**

**It is estimated that irrigation accounts for at least 84 per cent of consumptive water use in the Tsolum watershed.[1]**

## Agriculture in the Tsolum

Agricultural activity has a long history in the Tsolum River watershed and plays an important role in the economy. It is estimated that agricultural land in the Tsolum watershed supports[2]:

- Production of $18.5 million/year in agri-food products
- Expenditure of $14 million/year in farm operating costs - with much of this going back into the community
- Employment of 800 people on-farm, and $3.5 million in farm wages
- Community services and agritourism opportunities including direct sales, bed and breakfasts, wineries, u-picks, horse riding, and pumpkin patches

Consumers are increasingly aware of the benefits of eating locally and it is expected that investment in agriculture will grow.

The Comox Valley has one of the most favorable growing climates in the country and while many areas of the province have exhausted their available agricultural land, in the Tsolum watershed, there is still a relatively large amount of farmland available.

[1] Based on surface water licenses and estimates of groundwater use from the Tsolum River Agricultural Water Demand Model, 2017

[2] Based on estimations from the Statistics Canada Census Data

# Project Survey

### Tsolum River Agricultural Watershed Plan: Survey #1: For Producers in the Tsolum River Watershed

***This survey is intended to be completed by agricultural producers who live and/or work in the Tsolum River watershed. There are three versions of this printed survey:***

*Survey #1: For agricultural producers in the Tsolum Watershed*

*Survey #2: For non-agricultural watershed stakeholders (residents, business owners, community group members), and*

*Survey #3: For CVRD residents who live outside the watershed (general survey)*

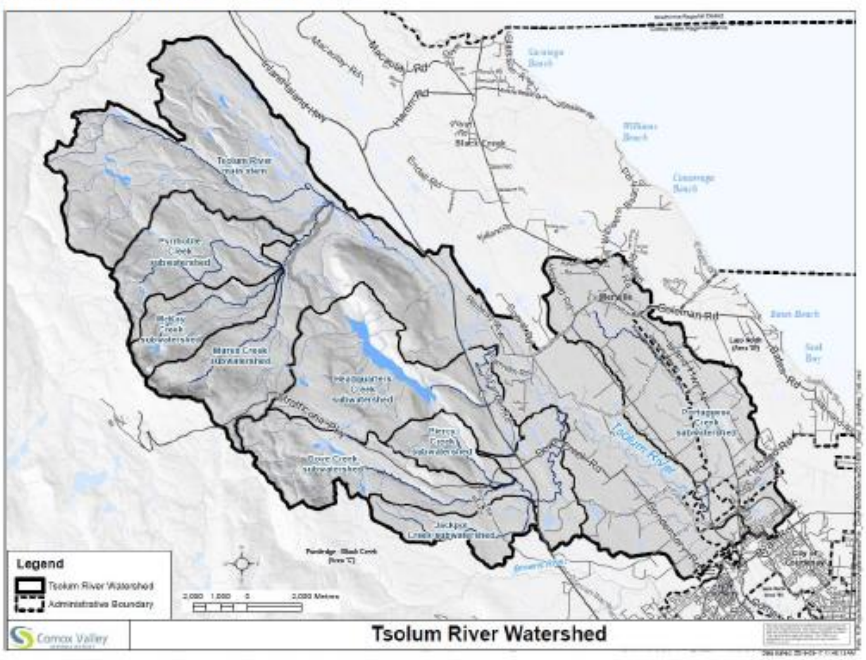
**Background**

The Comox Valley Regional District (CVRD) is developing a Tsolum River Agricultural Watershed Plan to address ongoing and future concerns about water availability for both instream and agricultural needs.

The information collected on this form is gathered under the authority of Section 26 (c) of the Freedom of Information and Protection of Privacy Act and will be used solely for the development of Phase 1 of the Tsolum River Agricultural Watershed Plan. The information will be available to the public upon request in a summarized format. The summary will be shared in the final report for the Tsolum River Agricultural Watershed Plan.

Should you have any questions about the collection and use of this information, please contact the CVRD at 250 334-6000 or engineeringservices@comoxvalleyrd.ca.

Completed surveys can be returned to the CVRD main office at 600 Comox Road, Courtenay, BC V9N 3P6. The deadline for input is October 31, 2018.



# Tsolum River Agricultural Watershed Plan: Survey #1: For Producers in the Tsolum River Watershed

Please note, all questions are optional.

1. Do you know which sub-watershed you live (or work) in? (See map on first page)

   ❍ Portuguese Creek

   ❍ Dove Creek (including Jackpot Creek, Piercy Creek)

   ❍ Headquarters Creek

   ❍ Tsolum main stem

2. Which of the following categories describes you (check all that apply)?

   ☐ a) Producer/farmer in the Tsolum watershed

   ☐ b) Interested in becoming a producer in the Tsolum watershed

   ☐ c) Rural resident of the Tsolum watershed

   ☐ d) Business owner (other than farm)

   ☐ e) Manager or operator of an institution/organization in the watershed (e.g. school, community centre, etc.)

   ☐ f) Member of a community or stewardship group. If so, which one? ______________________

   ☐ g) Resident of the CVRD, living OUTSIDE of the Tsolum River watershed

   ☐ h) Other, describe ___________________________

3. What do you produce on farm?

4. What type of water supply source do you use for your operation (check all that apply)?

   ☐ Well

   ☐ Surface water intake

   ☐ Spring

   ☐ Groundwater fed dugout/pond

   ☐ Surface water fed dugout/pond

   ☐ Rainwater harvesting and storage

   ☐ Other, describe ____________________________

Delivered by Funding provided by British Columbia Canada Comox Valley Regional District

5. If you use more than one water source, please indicate which water source is your primary water source and which is your secondary water source.

   Primary: ______________________________

   Secondary: ______________________________

   More details (if required): ____________________________________

6. Do you have a sufficient **amount** of water to meet your production needs?

   ❍ Yes
   ❍ No

7. If not, please tell us more about your water quantity concerns: what time of year, and for how long do you experience reduced water supplies? How do reduced water supplies affect the way you manage your farm?

8. Do you have sufficient **quality** of water to meet your production needs?

   ❍ Yes
   ❍ No

9. If not, can you describe your water quality concerns (e.g. coliform bacteria? iron/manganese)? What time of year and for how long do you notice a decline in water **quality**?

10. Does the quantity or quality of water on your farm limit your future planning for your operation?

   ❍ Yes
   ❍ No

11. If yes, how does the quality or quantity of water on your farm limit your future planning?

12. Do you use an irrigation system?
    - ❍ Yes
    - ❍ No

13. If yes, please tell us a little more about your irrigation system:

    What kind of irrigation system do you use?

    How efficient do you think your water use is?

    Not Efficient at all 1 2 3 4 5 6 7 8 9 10 Very Efficient

    Have you ever used an irrigation scheduling calculator or other method (e.g. soil moisture sensors) to fine-tune your irrigation?

    - ❍ Yes
    - ❍ No

14. Have you installed (or do you have existing) water storage infrastructure on your farm (e.g. dams, reservoirs, holding ponds, cisterns, 'expanded' wells, rainwater harvesting, etc.)?

    - ❍ Yes
    - ❍ No

15. If yes, what kind of water storage infrastructure do you have on-farm?

16. Have you ever considered installing water storage infrastructure? If you have considered it, but decided against it, why did you decide against it?

17. Are you concerned about drainage/flooding on your property?

    - ❍ Yes
    - ❍ No

18. Are your fields tile drained?

    - ❍ Yes
    - ❍ No

19. What are some of the other practices you are using to manage water on your farm?

20. Is there anything you'd ***like to do*** to help manage water on your farm that you ***haven't done yet***? If so, what have you considered and what has stood in the way?

## Priorities and Values

21. How important is *agricultural activity* to you on a scale of 1-10?

| Not Important | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Very Important |
|---|---|---|---|---|---|---|---|---|---|---|---|

22. How important is *stream health* to you on a scale of 1-10?

| Not Important | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Very Important |
|---|---|---|---|---|---|---|---|---|---|---|---|

23. How important is *eating locally produced* food to you?

| Not Important | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Very Important |
|---|---|---|---|---|---|---|---|---|---|---|---|

24. How important is *economic development* (job creation, diversification, retention and expansion) in the CVRD to you?

| Not Important | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Very Important |
|---|---|---|---|---|---|---|---|---|---|---|---|

25. How important is it to you to *keep costs* (expenses related to the cost of living and cost of farming) *low*?

| Not Important | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Very Important |
|---|---|---|---|---|---|---|---|---|---|---|---|

26. How concerned are you about *climate change impacts* in the Tsolum River watershed?

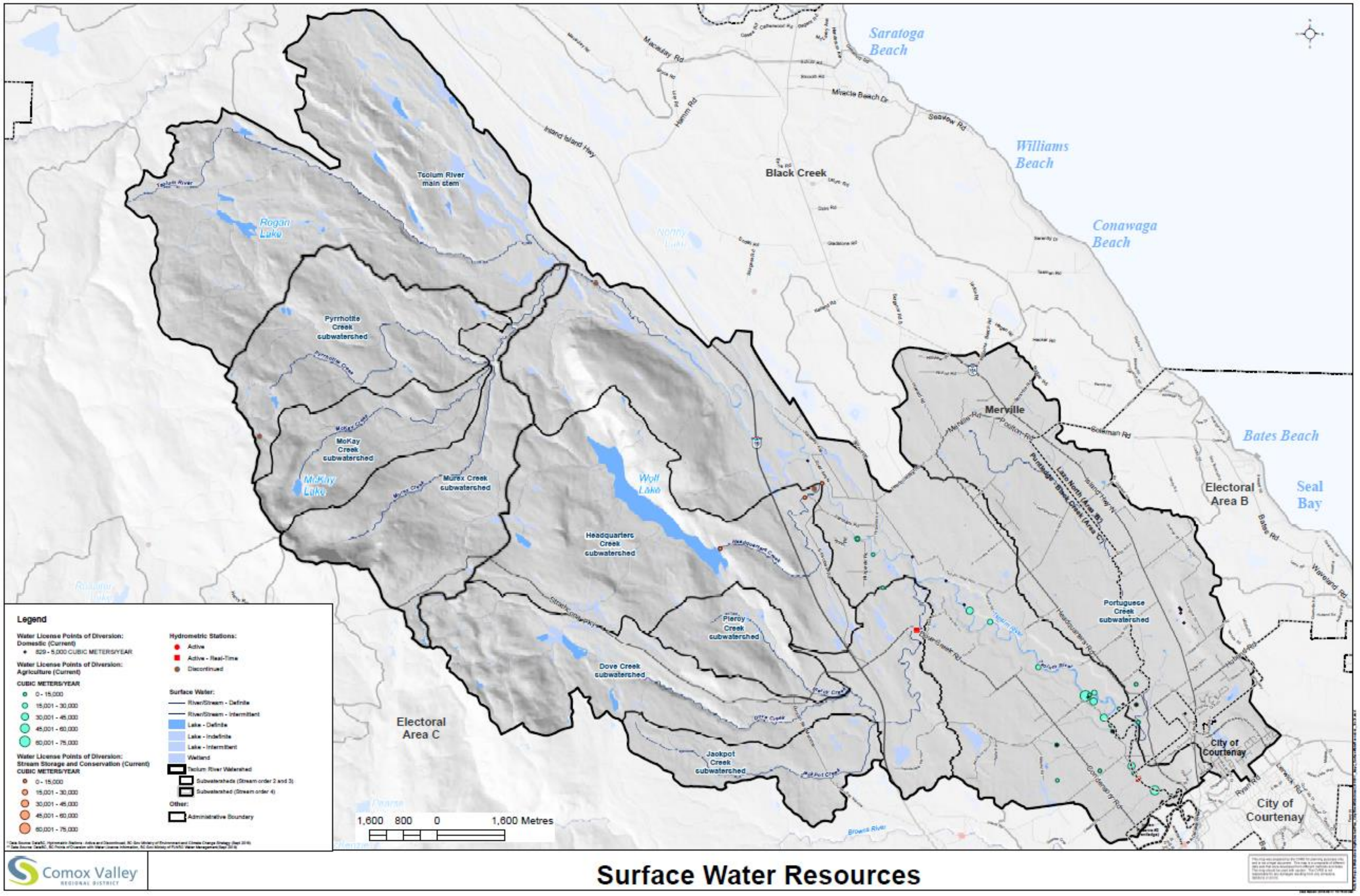
| Not Important | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Very Important |
|---|---|---|---|---|---|---|---|---|---|---|---|

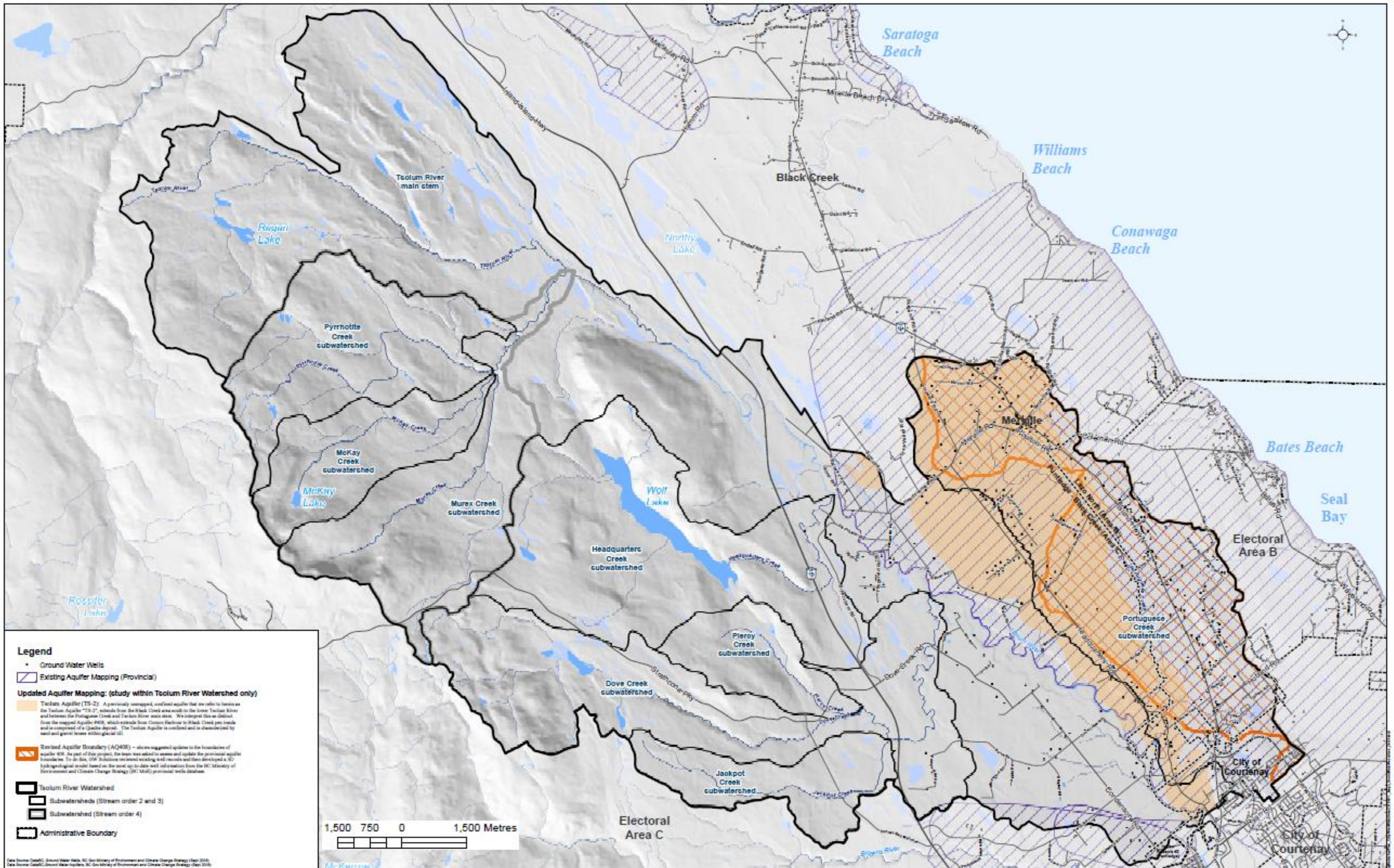
## Tell Us More!

27. Do you have any other issues, concerns, comments, questions, or potential solutions that you'd like to share?

28. What is your main source for local and farm-related news?

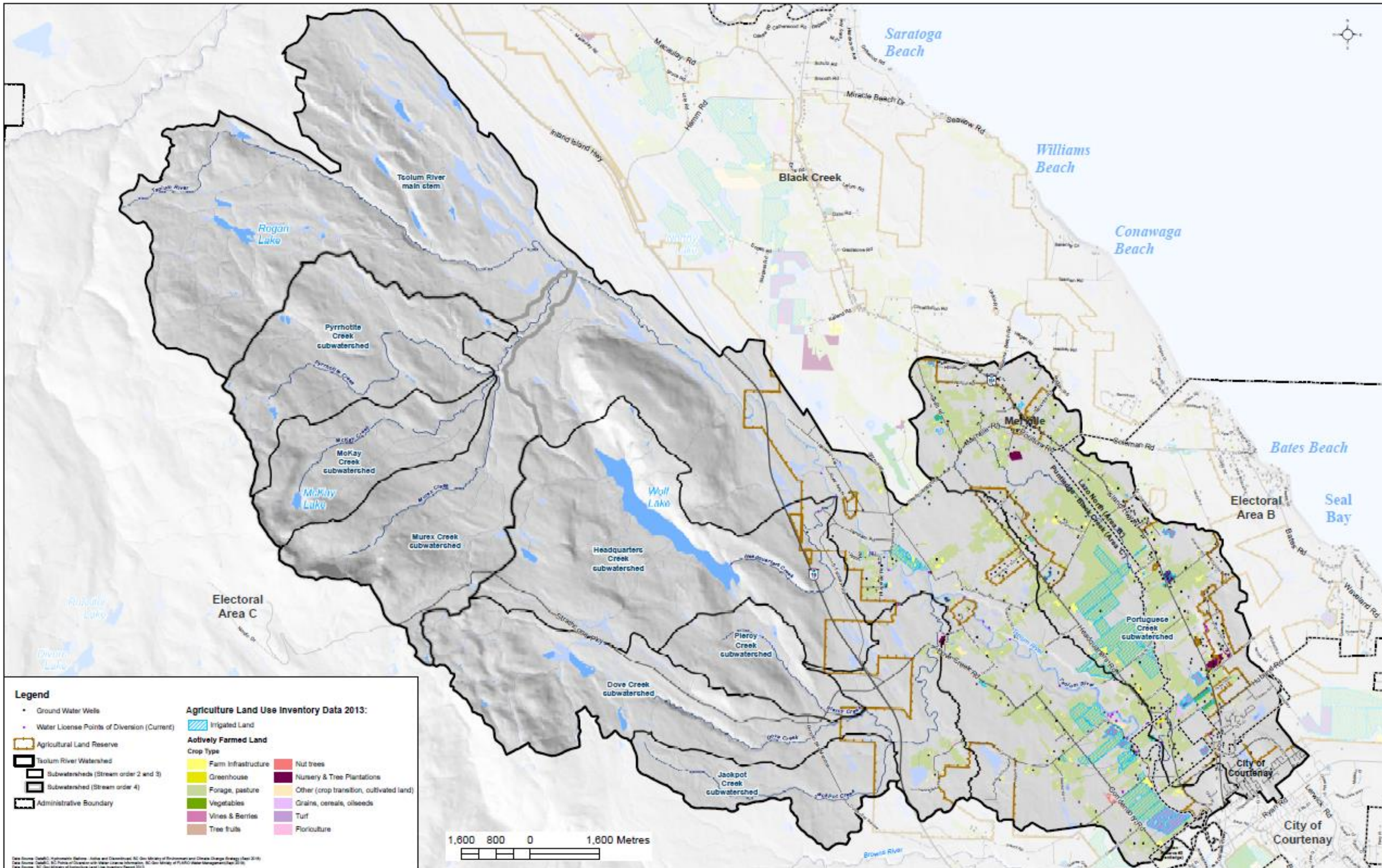
## Mapping materials






Comox Valley REGIONAL DISTRICT

# Ground Water Resources

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# Land Use

# Website content

## Tsolum River Website

Give your input! Take a survey about your water needs or concerns in the Tsolum watershed:

- Tsolum River Agricultural Watershed Planning survey, the deadline for input is October 31

A project open house to solicit public and agricultural producer feedback will be held:

**October 29 from 6:00 – 7:30 pm at the Florence Filberg Centre, Rotary Room**

- *The meeting will begin with a 30-minute presentation and be followed by an informal opportunity for community members to browse informative displays, provide input, and ask questions of project representatives.*

The Tsolum River watershed and its aquifers provide water that is critical to the health of the local agricultural community and the health of the environment. The Tsolum River and its aquifers also provide drinking water for homes, businesses, a school, and community centres.

The Tsolum watershed is heavily influenced by seasonal variations in precipitation. In the winter, plentiful rain brings high water levels and occasional flooding. In dry summer months, stream flows become very low at the same time that agricultural producers, fish, and residents need water the most. Groundwater is an important source for irrigation water and in-stream flows in the summer, however, its availability varies.

*Salmon in the river during the month of August.*

The CVRD is developing Phase One of a Tsolum River Agricultural Watershed Plan to address current and future concerns about water availability for agriculture, instream and community needs. This work is funded in part through a grant program administered by the Investment Agriculture Foundation of British Columbia, which is supported by both the provincial and federal governments.

Information on water and agriculture is being gathered and analyzed as part of Phase One. This work will be complete in December 2018. Phase One will produce recommendations for further plan development.

For more information see the project brochure: **Tsolum River Agricultural Watershed Plan**

# Media releases

## Media release #1: CVRD seeking input on the development of the Tsolum River Agricultural Watershed Plan

This fall, the Comox Valley Regional District (CVRD) is inviting the community to learn more about the Tsolum River watershed and participate in the development of the Tsolum River Agricultural Watershed Plan.

The CVRD is developing the Tsolum River Agricultural Watershed Plan to address current and future concerns about water availability for both agriculture and instream needs. This work is funded in part through a grant program administered by the Investment Agriculture Foundation of British Columbia, which is supported by both the provincial and federal governments.

The Tsolum River watershed, running through the heart of the Comox Valley, provides water that is critical to the health of the local agricultural community and the environment. The Tsolum River and its aquifers also provide drinking water for homes, businesses, a school, and community centres.

Like many watersheds on the east coast of Vancouver Island, the Tsolum is heavily influenced by seasonal variations in precipitation. In the winter, plentiful rain brings high water levels and occasional flooding. In dry summer months, stream flows become very low at the same time that agricultural producers, aquatic life, and residents need water the most. Groundwater is an important source for irrigation water and in-stream flows in the summer. However, availability of groundwater supplies varies.

Agriculture has a long history in the Tsolum watershed and plays an important role in the local community. According to Statistics Canada, in the Tsolum watershed, approximately $18.5 million/year in agri-food products are produced and approximately 800 people are employed on-farm. It is estimated that producers in the Tsolum spend approximately $14 million/year in farm operating costs - with much of this going back into the community.

Consumers are increasingly aware of the benefits of eating locally and it is possible that investment in agriculture will grow. The Comox Valley has one of the most favorable growing climates in the country, and while many areas of the province have exhausted their available agricultural land, there is still a relatively large amount of Agricultural Land Reserve in the Tsolum that could be placed in production – provided there is sufficient access to water.

In 2017, the CVRD and the Ministry of Agriculture used an Agricultural Water Demand Model to estimate current and future agricultural water needs in the Tsolum River watershed. The model estimated that with climate change, water needs for existing farms could increase by approximately 139% in the 2050s. If all possible farmland was placed in production (assuming a similar distribution of crops and irrigation systems), water needs could increase by as much as 500% (worst case scenario). These estimates make it clear that we need to plan ahead to manage water in this watershed.

In May of 2018, the CVRD initiated Phase One of the Tsolum River Agricultural Watershed Plan. So far, information and data on the Tsolum has been gathered and analyzed. Now, the CVRD is reaching out to watershed stakeholders for input: Is access to water affecting your home, farm, business, or future planning? What solutions might work for you?

Community members are invited to learn more about the Tsolum River watershed and provide input on the plan through an online survey available at: www.comoxvalleyrd.ca/tsolumwatershed.

The CVRD will  be hosting a public meeting on the project on Monday, October 29 from 6-7:30 pm. The meeting will begin with a 30-minute presentation and be followed by an informal opportunity for community members to browse informative displays and ask questions of project representatives. The CVRD will also be reaching out to several stakeholder groups for feedback over the coming month.

## Media release #2: Residents invited to Oct 29th Open House on Tsolum River Agricultural Watershed Plan

The Comox Valley Regional District is hosting an Open House on October 29 for the community to learn more about the Tsolum River watershed and participate in the development of the Tsolum River Agricultural Watershed Plan.

The CVRD is developing the Tsolum River Agricultural Watershed Plan to address current and future concerns about water availability for both agriculture and instream needs.

"In May of 2018, the CVRD initiated Phase One of the Tsolum River Agricultural Watershed Plan. Over the summer, information and data on the Tsolum was gathered and analyzed. Now, the CVRD is reaching out to watershed stakeholders for input" explains Manager of Liquid Waste Planning Darry Monteith. "Is access to water affecting your home, farm, business, or future planning? What solutions might work for you?"

The event will begin with a 30-minute presentation at 6 pm. This will be followed by an informal opportunity for community members to browse informative displays, provide input, and ask questions of project representatives.

Date: October, 29, 2018

Time: Doors open at 5:45 pm, presentation starts at 6 pm with Q&A and open house to follow

Location: Rotary Hall, Florence Filberg Centre, 411 Anderton Ave, Courtenay, BC

Community members are invited to learn more about the Tsolum River watershed and provide input on the plan through an online survey available at: www.comoxvalleyrd.ca/tsolumwatershed.

## Social media content

### Post #1 - Oct 11: Announce survey

*CVRD Facebook & Twitter* (Figure 1 with text below)

**Text option 1:** *attention-seeking and will likely result in increased exposure (it is interesting enough that users may 'share' on their profile or with others)*

Did you know that water needs in the Tsolum River watershed could increase by up to 500% in the 2050's with climate change and increased agricultural production?

Learn more about the watershed and participate in the development of the Tsolum River Agricultural Watershed Plan at www.comoxvalleyrd.ca/tsolumwatershed.

*Figure 1: Tsolum Through Branches*

**Text option 2:** *simple and targeted to those with water supply concerns in the Tsolum. Does not directly target those outside the watershed or those with sufficient water.*

Is access to water affecting your home, farm, business, or future planning? What solutions might work for you?

Learn more about the watershed and participate in the development of the Tsolum River Agricultural Watershed Plan at www.comoxvalleyrd.ca/tsolumwatershed.

### Post #2 – Oct 24: Share Public Event

*CVRD Facebook & Twitter* (Figure 2 with text below)

Water - its essential for our food, our bodies, our environment, our community.

Join us at the Tsolum River Agricultural Watershed Plan Open House on October 29th from 6 - 7:30 pm to learn more about the watershed and participate in the development of the agricultural plan.

October 29, 2018 | 6:00 - 7:30 pm Rotary Hall, Florence Filberg Centre, Courtenay

*(on Facebook – share event page in Oct 24 post)*

*Figure 2: Salmon Splash*

*CVRD Facebook Event Page* (use Figure 3 with text below)

**Event Title:** Tsolum River Agricultural Watershed Plan Open House

**Date and Time:** Monday, October 29 from 6:00 - 7:30 pm

**Location:** Rotary Hall, Florence Filberg Centre, Courtenay

**Event Details:** The Comox Valley Regional District (CVRD) is inviting the community to learn more about the Tsolum River watershed and participate in the development of the Tsolum River Agricultural Watershed Plan.

This event will begin with a 30-minute presentation and be followed by an informal opportunity for community members to browse informative displays, provide input, and ask questions of project representatives.

*Figure 3: Tsolum through Branches 2 Event Photo*

## Post #3 – Oct 29: Public Event Reminder

*CVRD Facebook & Twitter* (use Figure 4)

Join us tonight for the Tsolum River Agricultural Watershed Plan Open House!

6:00-7:30 pm, Rotary Hall, Florence Filberg Centre, Courtenay

Join the main presentation at 6 pm and/or join for the drop-in session between 6:30 and 7:30 pm.

(share Facebook event)

*Figure 4: Tsolum and Gravel Bar*

# Public open house event plan

**EVENT: Public Open House for the Tsolum River Agricultural Watershed Plan**

**DATE: Monday, October 29, 2018 | 6:00 - 7:30 pm**

**LOCATION: Rotary Hall, Florence Filberg Centre, Courtenay**

---

**Event overview**

"Learn about water in the Tsolum watershed: Get information on the river system, local aquifers, water use, climate impacts, and join the discussion on our water future."

**Event objectives**

- Share information about the Tsolum River Agricultural Watershed Planning process
- Share information on the Tsolum River watershed (results of project deliverable #1)
- Obtain feedback on the information gathered to date and next steps
- Develop an increased understanding of water supply and demand challenges in the watershed
- Identify levels of community support for different water management solutions
- Increase support for a planning process to reduce current and future water use conflicts.

**Format + set up**

Event begins with a 30-minute presentation, followed with a 20-minute Q&A and discussion. This will be followed with a 40-minute open house style 'drop-in' public engagement process.

**Presentation and Q&A/Discussion (50 minutes):** the following equipment is required: laptop (from CVRD), projector, screen, cable to connect from projector to laptop, extension cord, table for projector and laptop, laser pointer.

**'Open House' Engagement Session (40 minutes):**

Participants will visit six stations. At each station, they will be provided with information and/or asked to provide input. After visiting each station, they will receive a stamp. If they visit all stations, they can be entered into a prize draw. Participants are requested, but not required to participate in the passport component.

At each stations, the staff person/attendant, has a clipboard and can note any concerns that a participant would like to share informally.

***Station #1 (input) – Where am I on the map?***

**Purpose:** Participants identify which area of the watershed (or District) they represent and develop a better understanding of the watershed area.

**Display Components:** Map of the Tsolum watershed (with aerial photo in background) taped to wall. Stickers provided to participants, so they can identify their home/business location. If people are from outside of the CVRD, they can place their sticker on the frame of the map (white background, as labelled). The watershed model will be at this station to help participants understand how a watershed works and the scope of the project area. As this is the first station, participants can pick up their 'passport' here.

**Attendant:** Lindsay Eason

***Station #2 (information) – Water science in the Tsolum***

**Purpose:** Participants learn about groundwater and surface water resources in the Tsolum watershed. They can view the proposed changes to the aquifer boundaries and new aquifer. They can also see the distribution of groundwater wells and licenses and the relative size and type of surface water licenses.

**Display Components:** Two maps displayed: "Surface Water Resources" and "Groundwater Resources". The gauging data from the station at the mouth of the Tsolum will be printed and displayed next to the surface water map. Four aquifer cross sections will be printed and displayed next to the groundwater map. A copy of the report will be available for reference (not to be distributed).

**Attendant:** Tanis Gower.

***Station #3 (information) – Agriculture in the Tsolum***

**Purpose:** Participants can see the extent and nature of agriculture in the Tsolum. They can also see the potential for growth. Participants have an opportunity to ask questions of a local producer.

**Display components:** Land Use Map, mounted to wall. ALR with Potential, displayed on table.

**Attendant:** Brian Geiger (confirmed) and Arzeena Hamir (potential)

***Station #4 (input + information) – Water stresses and concerns***

**Purpose:** Participants can view and share information on known or anticipated water quality and quantity concerns.

**Display Components:** Map of Tsolum watershed on wall (with air photo in background). Participants are provided with post-it notes and asked to identify any known issues. Water quality test results displayed on table.

**Attendant:** Darry Monteith

***Station #5 (information) – Aquatic life in the Tsolum***

**Purpose:** Participants can learn about aquatic life in the watershed

**Display Components:** provided by TRRS

**Attendant:** Caroline Heim

***Station #6 (information and input) – Planning for the future***

***Purpose:*** Participants can share recommendations on water management solutions and general comments.

**Display Components:** Poster showing potential water management options (large-scale storage, small scale storage, agricultural water reserve, watershed management planning, demand management, increased retention, etc.). Participants are asked to leave a sticker or post-it note identifying their preferred solutions and note other suggestions. The station includes a 'scrawl wall' for people to share general thoughts and solutions and provide feedback

**Attendant:** Marc Rutten

***Station #7 (survey) – Providing input***

***Purpose:*** Participants can provide input through the online survey.

**Display Components:** Participants can complete the survey on an iPad or in paper format.

**Attendant:** Vince Van Tongeren

**Equipment and Supplies:**

- Sign-in Sheets
- Refreshments: suggested light snacks are provided as timing overlaps with many people's dinner (coffee and tea, cookies, cheese and crackers, veggies)
- 6 different-colored stamps
- 2 rolls of green painters tape
- Box of 45 clear 'thumb' style tacks
- 6 clipboards and paper
- Post it notes
- Small coloured stickers for the 'where are you' map
- Pens and coloured markers
- Tripod stands

**Is this a controversial issue? If yes, how will you handle confrontational participants?**

The topic has the potential to be controversial. In all cases, confrontational participants will be shown empathy and understanding. In cases where confrontation participants are expressing anger/frustration at a situation and are unlikely a threat to the safety or comfort of other participants, then they will be addressed as follows:

- Where concerns are related to mis-information, the facilitator(s) will share accurate information with tact and thank them for bringing up the concern so we can clarify an important point.
- Where concerns can be potentially addressed by the project, the facilitator(s) will thank the participant for sharing their concerns, acknowledge that they will be documented, and identify how the project may help address their concerns.
- If facilitators are identifying concerns that are not able to be addressed by the project (e.g. water bottling plant), the facilitator will identify the jurisdictional differences and, if possible, identify the process by which the participant can share their concerns with suitable authorities.
- If the participant's concerns are related to a 'lack of action', the facilitator will express empathy, optimism for future action, and thank participant for their passionate engagement.
- If the participant needs to speak in detail, then they will be requested to participate a one-on-one conversation following the group discussion.

If there is a threat to public safety, law enforcement can be contacted.

**Promotion**

News releases (2), direct emails to stakeholder groups, CVRD social media (including an event page), stakeholder groups social media, CVRD website via Tsolum River Watershed web page.

**Roles/Responsibilities**

| Roles | Person | Responsible for… |
|---|---|---|
| Event Coordination and Presentation | Christina Metherall | Event coordination: including providing direction (schedule, task requests), responding to inquiries from participants, 'float' during the open house session.<br><br>Presenter and discussion/Q&A facilitator. |

| | | |
|---|---|---|
| Event Support, notetaking, Station #1 | Lindsay Eason | Event setup, sign-in (until 6:45), taking notes during Q&A and discussion<br><br>Representative at station: “Where am I on the map?” |
| Station #2 | Tanis Glower | Assist with event setup<br><br>Station: “Water Science in the Tsolum” |
| Station #3 | Brian Geiger | Station: “Agriculture in the Tsolum” |
| Event welcome, closing<br><br>Station #4 | Darry Monteith | Event host: providing opening remarks, introducing presenter, time-keeping during Q&A.<br><br>Station: “Water stresses and concerns” |
| Station #5 | Caroline Heim | Station: “Aquatic Life in the Tsolum” |
| Station #6 | Marc Ruttan | Station: “Planning for the Future” |
| Station #7 | Vince Van Tongeren | Station: “Providing Input” |

**Agenda**

| Time | Planned Activity |
|---|---|
| **6:00 – 6:30 pm** | **Presentation** |
| **6:30 – 6:50 pm** | **Question and answer period and discussion** |
| **6:50 – 7:30 pm** | **Open house style public engagement session** |

**Materials**

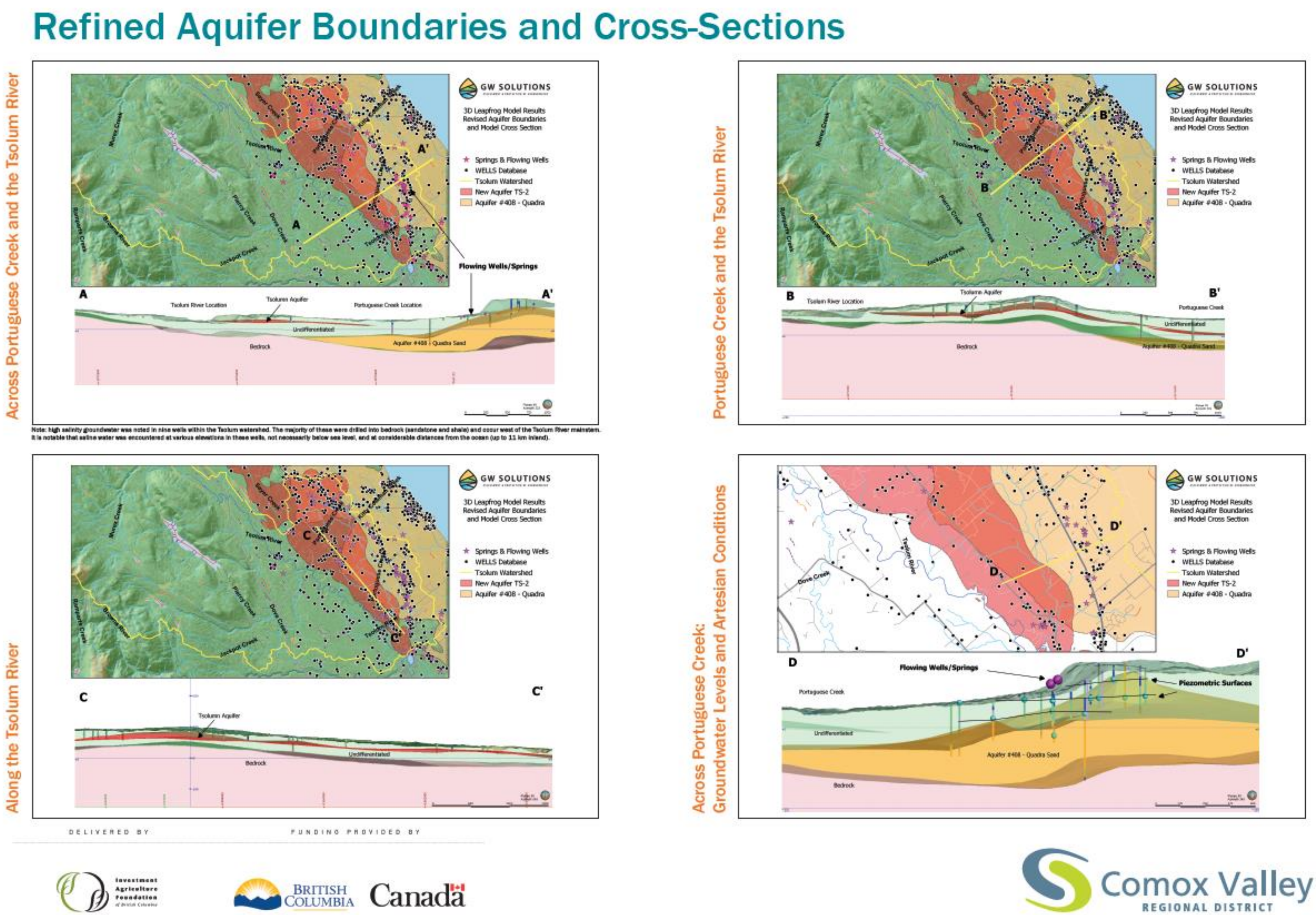
| Item | Details of Content |
|---|---|
| 1. Presentation | Christina to develop |
| 2. Guided discussion questions | Christina to develop thematic discussion questions |
| 3. Map of the Tsolum with air photo background | Complete, CVRD to print |
| 4. Surface water resources map | Complete, CVRD to print |
| 5. Groundwater resource map | Almost complete (need to remove air photo in background), CVRD to print |
| 6. Printouts of water quality data | Christina to develop and print |
| 7. TRRS booth | TRRS to prepare |
| 8. Watershed model | Lindsay to request |
| 9. Land use map | Complete, CVRD to print |
| 10. Available ALR | Complete, CVRD to print |
| 11. Solutions poster | Christina to develop, CVRD to print |

| | |
|---|---|
| 12. Scrawl wall | Christina to develop, CVRD to print |
| 13. Station labels | Christina to develop and print |
| 14. Printed copy of report | Christina to print |
| 15. Aquifer cross-sections | Christina to develop and print |
| 16. Gauging data | Christina to develop and print |
| 17. 'Passport' | Christina to develop and print |
| 18. Project brochure | CVRD to print, 100 copies |
| 19. Project survey | CVRD to print, 3 versions 20 copies each |

### Event Budget

| Item | Details | Cost |
|---|---|---|
| **Event supplies** | CVRD provides post-it notes, small stickers, pens, markers | N/A |
| **Refreshments** | CVRD to arrange snacks and coffee service for 100 people (will purchase milk/cream) | $250 (approx.) |
| **Room rental** | | $213.15 |
| | **Total Budget** | **$463.15 (approx.)** |

Posters for Public Open House



# Planning for the Future: Which Options Most Appeal to You?

## Legal Approaches

**Water Sustainability Plan**
Develop long term plan and potential land and water management regulations

**Agricultural Water Reserve**
Set aside water in a stream or aquifer for agriculture

**Collaborative water governance**
Shared, local decision-making about water

## Other

Please share your ideas!

Which scenarios would you like to see investigated?

?

Select all that apply!

## Demand Management

**Improve/upgrade existing irrigation systems**
Irrigate according to plant water demands using scheduling and technology (e.g. soil moisture sensors), fix and repair existing systems, upgrade irrigation technology

**Reduce crop water requirements**
Use drought tolerant varieties, weed control, varied cropping strategies, etc.

**Integrate drainage, storage, and irrigation**
E.g. Tile drainage to dugout, combine drainage and sub-irrigation

**Increase soil moisture holding capacity**
Cover crops, soil amendments, conservation tillage or no-tillage seeding, etc.

## Increased Storage

**Large-scale, regional storage**
E.g. Wolf Lake (plus distribution)

**On-farm storage**
Ponds, dugouts, and cisterns to increase or regulate water supply

**Collective dugouts**
Water storage shared between several farms

DELIVERED BY
Investment Agriculture Foundation of British Columbia
FUNDING PROVIDED BY
British Columbia
Canada

Comox Valley
REGIONAL DISTRICT

# Appendix C: Public Engagement Activities

In September and October of 2018, the CVRD invited watershed stakeholders to get involved in Phase One of the Tsolum River Agricultural Watershed Planning process. The goal was to identify, identify, share and discuss their water quantity challenges, water quality concerns, and suggestions and feedback on future water management.

Key events are outlined below, along with a description of activities and input collected from each event.

### 1.1.1 Stakeholder and Expert Interviews

One-on-one Interviews were held with 14 targeted stakeholders and subject matter experts early on in the process to understand local context, discover available information sources, identify issues for the plan to address, and help raise awareness about the project. Participants included:

*Table 1: Stakeholder and expert interviews*

| Interviewee | Role | Organization |
|---|---|---|
| **Brian Geiger** | Representative, Secretary | Comox Valley Farmer's Institute |
| **Arzeena Hamir** | President | Mid-Island Farmer's Institute |
| **Jill Hatfield** | Regional Agrologist | Ministry of Agriculture |
| **Jaroslaw Szczot** | Senior Aquatic Ecologist | Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD) |
| **Brian Epps** | Senior Regional Specialist, Water and Dike Safety | MFLNRORD |
| **Jill Hatfield** | Regional Agrologist | Ministry of Agriculture |
| **Jack Minard** | Former Executive Director | Tsolum River Restoration Society |
| **Stephanie Tam** | Water Resources Engineer | Ministry of Agriculture |
| **Wayne White** | President | Tsolum River Restoration Society |
| **Caroline Heim** | Education and Outreach Coordinator | Tsolum River Restoration Society |
| **Cali Melnechenko** | Water Authorizations Specialist | MFLNRORD |
| **Ted VanderGulik** | President, Developer | Water Sustainability Partnership of BC, Agricultural Water Demand Model |
| **Geoff Crawford** | Business Development Manager | Comox Valley Economic Development Society |
| **Gerry McClintock** | Former President | Comox Valley Farmer's Institute |
| **Cory Frank** | Guardian Watchmen Manager | K'òmoks First Nation |

#### 1.1.1.1 Input Received

Input from these interviews was used to raise awareness about the project, understand historical and organizational context, identify information and data sources to support the technical portion of the project, develop communications and engagement partnerships to support the public engagement portion of the work, and better understand key issues and priorities.

### 1.1.2 Survey

A public survey was available from October 10th to October 31st. The questionnaire collected input on:

1. Do you have concerns with water quality or quantity on your farm?
2. Is it affecting current operations or future planning?
3. Identified current water management practices
4. Identified values and priorities moving forward

The survey was available online through the project webpage and paper copies available at the Farmer's Market, Farmer's Institute AGMs and the Public Open House. Information on the survey was shared via the following:

- Email to Advisory Committee members for distribution to their members (including membership of both Farmer's Institutes)
- Two media releases
- Email to CVRD departments
- Social media: five posts on the Comox Valley Farmer's Institute and the Mid-Island Farmer's Institute Facebook pages and three posts on the CVRD Facebook pages
- Included in brochure at 14 community locations

A copy of the survey is included in Appendix B.

#### 1.1.2.1 Input received

A total of 370 survey responses were received (including 329 online and 41 paper submissions).

### 1.1.3 Farmer's Market

A project ambassador also attended the Comox Valley Farmer's Market on October 13th to raise awareness of the project and collect feedback through digital surveys on tablets. The project ambassador set up a display next to the Tsolum River Restoration Society, who had a table and the watershed model

Input received: 40 surveys completed, 50 brochures distributed for future reading

### 1.1.4 Public Open House Event

A public open house event was held on October 29th at the Rotary Room in the Filberg Centre from 6:00-7:30 pm. The event began with a 30-minute presentation from the lead consultant, which was followed with a 20-minute Q&A and discussion. The final 40-minutes of the event included an open house style 'drop-in' public engagement process. This interactive session included a range of activities to share information about the project and gather community input. Approximately 37 people attended this event. A full description of the event is included in the event plan in Appendix B.

#### *1.1.4.1 Activities and Input Received*

The public event used a 'passport' to guide participants through the various interactive stations; some stations provided information and others collected input. Full information on the event is included in Appendix B.

### 1.1.5 Targeted Engagement with Producers at Farmer's Institute AGMs

On September 18 and 19th project and CVRD representatives attend the Farmer's Institute AGMs. Close to 40 local producers attended the Farmer's Institutes meetings. At these events, project consultant presented information on the project and asked local producers to share their concerns about water in the Tsolum and their ideas for future management solutions. Darry Monteith of the CVRD also attended to respond to question on behalf of the CVRD.

#### *1.1.5.1 Input Received*

Producers provided comments at the end of the meeting

### 1.1.6 Staff Communications

An email was circulated by Christianne to Wile  to provide the Electoral Area Services Committee and CVRD staff from a variety of departments the opportunity.

#### *1.1.6.1 Input Received*

Staff forwarded concerns to the project consultant.

### 1.1.7 Engagement with K'òmoks First Nation

The K'òmoks First Nation were engaged through the following activities:

- Interview with Guardian Watchmen Manager (Cory Frank)
- 2 meetings with CVRD, KFN, and consultant. Those in attendance included
    - Tina McLean, KFN Band Administrator
    - Monty Horton, KFN Lands Manager
    - Tim Ennis (consultant to KFN)
    - Darry Monteith, CVRD
    - Marc Ruttan, CVRD
    - Christina Metherall, Elucidate Consulting
- Review of Phase One report by KFN consultant, Tim Ennis
- Review of Phase One report Ron Frank

#### *1.1.7.1 Input Received*

The Tsolum River watershed is in the heart of the traditional territory of the KFN. The KFN have been using the watershed to hunt, fish, farm, gather food and medicine, and recreate, for thousands of years. Fish are a huge priority for the community and determination of Environmental Flow Needs are key. There may be potential to collaborate in the development of a groundwater budget.

A full summary of the interview with Cory Frank can be found in Section 1.8 of this Appendix.

## 1.2 Promotion and Outreach to Drive Participation

The launch of the project and Phase 1 activities were promoted extensively and in advance through the following channels:

- Project webpage including a link to the project survey and more detailed background on project in project brochure
- Press release announcing the release of survey and describing the project in detail, October 13, 2018. A second press release announcing public open house October 21, 2018. One press release developed in partnership with the Mid-Island Farmer's Institute announcing participation in AGM and describing project
- Social Media: 3 dedicated website posts from CVRD, a Facebook event with a total of __ interested in attending, promoted through community networks – 3 dedicated invitations to participate in survey by the Comox Valley Farmer's Institute, 2 posts by the Mid-Island Farmer's Institute
- Distribution through Farmer's Institute email lists
- Poster and brochures distributed at key locations throughout the community including:

- Black Creek Store
- Black Creek Farm and Feed
- Top Shelf Farm and Feed
- Black Creek Community Hall
- Black Creek Church
- Merville Store
- Meville Hall
- Courtenay Country Market
- Shar Kare
- Tsolum School
- Andrew Sheret
- CVRD office
- Lewis Centre
- Comox Valley Sports Centre

- Advisory Committee members promoted the project and engagement activities through their networks

## 1.3 Who Participated

Participants were asked to identify where they live. While area of origin was not captured in all public engagement situations (e.g. farmer's market), on average (considering other metrics sch as survey response and Farmer's Institute attendance), approximately half of all respondents were from the Tsolum River watershed and about half were from outside the watershed. Of respondents within the watershed, approximately half all feedback came from agricultural producers and half came from non-agricultural residents.

## 1.4 What We Heard

Engagement activities used a variety of qualitative and quantitative questions to collect feedback, the majority of feedback being qualitative. Qualitative questions included a range of open-ended questions.

Each of the engagement activities included a range of activities although most included similar questions.

## 1.5 Critical Issues

Participants identified their most critical issues or topics for the Tsolum River Agricultural Watershed to address. The following provides a summary and count of major themes.

**Decreased water supplies on farm and residential properties (81 comments)**

**Land cover change (13 comments)**

**Climate change (5 comments)**

**Increased flooding (2 comments)**

**Impact of low flows on fisheries (2 comments)**

### 1.5.1 Feedback on Storage

A total of 50 comments were received on storage, including on-farm storage, regional storage, and collective storage.

**On-farm storage (33 comments)**

- Support use of on-farm storage (17 comments)
- Provide financial incentives/funding (10 comments)
- Support provision of interest-free loans (5 comments)
- There is often part of a farm that is not arable

**Regional storage/distribution system (11 comments)**

- Interested in paying for water on farm if there is a reliable supply and distribution system
- It will be challenging to understand who would manage a regional storage and distribution system and to ensure that everyone benefits

- Regional storage is better because on-farm storage reduces amount of farmable land (3 comments)
- Alternate intake sources proposed: lower Tsolum/Courtenay River (3 comments – suggested pipeline up railway line), Puntledge (3 comments – however, not suitable, due to low flow concerns in that system)

**Collective dugouts (6 comments)**

## 1.6 Legal Options

Participants provided 29 comments about potential legal options.

**Collaborative water governance (12 comments)**

**Agricultural Water Reserve (10 comments)**

- An agricultural water reserve 'makes sense'
- You can't have an ALR without water

**Water Sustainability Plan (7 comments)**

## 1.7 Demand management

Participants provided 31 comments in support of farm practices to reduce water needs, including: Increase soil moisture holding capacity (12 comments)

- Integrate drainage and irrigation (7 comments)
- Where possible, reduce crop water requirements through varied cropping practices(7 comments)
- Improve Irrigation systems (5 comments)

Other suggestions

- Understand aquifer recharge and the amount of water available before allocating further water (6 comments)
- Increase retention of forested areas in watershed to increase water retention and reduce flooding (6 comments)
- Promote maintenance and restoration of wetlands (2 comments)
- Monitor private wells (2 comments)
- Update ALUI – there are now many more vegetable producers
- Pursue water reserve for environmental protection purposes
- Groundwater monitoring from satellite data (only possible with additional monitoring data)
- Develop multiple dams on the Tsolum River to hold back water for agriculture and fisheries

**Other suggestions**

Participants provided input on preferences for future management

## 1.8 Summary of Conversation with Cory Frank, K'omoks First Nation Guardian Watchmen Manager (January 7, 2019)

- Cory has spent a lot of time in the watershed, growing up in the community, hunting, fishing, collecting berries and medicinal plants in the watershed, as Guardian Watchmen Manager, and working with the TRRS, etc. He has seen changes due to forestry and other activities on watershed.
    - Fish are a big priority for the K'omoks First Nation. Fish are a main life source for the community and fish are being cumulatively impacted by the many activities in the watershed including historical mine contamination, extractions for irrigation mean less water is left in river in summer months
    - Forestry: increased forestry means that there is less water retention in watershed causing greater and more frequent floods, more gravel and sediment transport, more channel alteration, increased bedload (filling in salmon habitat, covering eggs, making low flows effectively lower), landslides, and impacts on the estuary
    - Cumulative impact of agriculture and forestry: together, high extractions and increased bedload mean that the water depth in the river is lower and river temperatures rise, creating dangerous environment for fish
    - Climate change: land use is already "wreaking havoc" on watershed and climate change is making everything worse
- Community relationship to watershed: Community hunts and fishes in the watershed. They also gather berries and medicinal plants. Many recreate and spend time in the watershed with their children and families, especially in the summer.
- Concerns:
    - Fisheries are a real priority and impacts on fisheries are impacting community.
    - Water extraction. River can't sustain having more water taken out of it unless we find a way to retain it in the winter months. There is currently not enough storage in the forests in the watershed to hold water back.
    - Impact of forestry on wildlife: there is less connectivity for animals in the forest, which reduces animal health and populations
    - Reduced soil moisture and groundwater levels: "The Tsolum I where I go to get my mint every year and I didn't get half of it this year. Even at the lower end of the river, the salmon berries aren't as prevalent as they used to be"
    - Impacts of flooding on estuary. They are losing historical areas in the estuary due to erosion. With the river flows higher than historically normal right now, and all the gravel coming out of the Tsolum due to logging, this is creating a lot of erosion in the estuary. This is filling in old channels and creating new paths for water and ancient fish traps are being carried away.
    - Increased forestry activity in recent years has reduced retention of water in watershed
- Recommendations for the future?
    - Needs to be more tree planting in the watersheds.
    - No more extractions (unless there is more storage).
    - Others?