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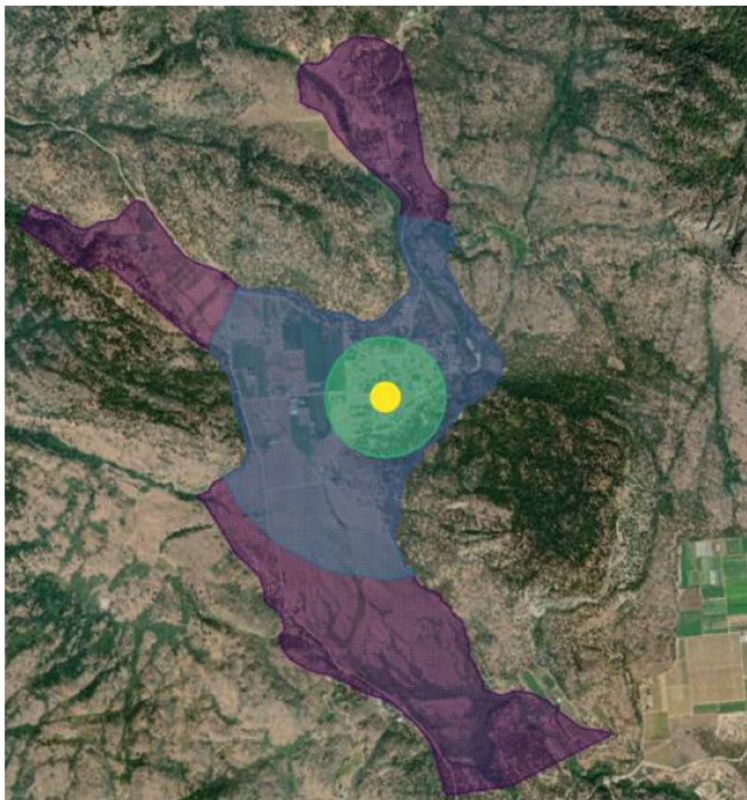


Okanagan Basin
WATER BOARD

REPORT

Regional District of Okanagan-Similkameen

Pilot Study: Delineating Drinking Water Protection Areas at a Regional Scale



MARCH 2023



Platinum
member

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EXECUTIVE SUMMARY

In 2022, the Regional District of Okanagan-Similkameen (RDOS) initiated a pilot project to investigate the feasibility of regional scale-mapping of drinking water protection areas. This work was done in collaboration with Interior Health (IH) and with support from various provincial ministries, and was funded by the Okanagan Basin Water Board Water Conservation and Quality Improvement Grant. The RDOS retained Associated Environmental Consultants Inc. to support the pilot project by providing project management, and scientific expertise.

Almost 5,000 drinking water systems exist in BC, and nearly 2,000 of them are in the Interior Health (IH) region alone. The quality and quantity of drinking water, whether sourced by surface water or by groundwater, depends on the land uses and physical processes that occur within a contributing watershed (for a surface water source) or a capture zone (for a groundwater source).¹ **Understanding the physical boundaries of these contributing watersheds or capture zones, often referred to as drinking water protection areas is an important aspect in source water protection.** However, they are currently delineated on a system-by-system basis (often only for large water systems) and the information is not easily accessible to help inform land use planning and support emergency response decisions (e.g. during wildfire or extreme rain events).

The objective of this **pilot project was to develop and test a method to delineate drinking water protection areas at a regional scale**, and to make recommendations for next phases. To meet this objective, the scope of work for this pilot project included the following general tasks:

- Task 1: Initiate the project and develop a survey to collect information on water systems within the RDOS boundaries.
- Task 2: Review the results of the survey and use this information, along with publicly available data and following provincial guidance, to delineate drinking water protection areas (DWPAs) on a mass-scale.
- Task 3: Discuss lessons learned and develop a work plan for the next phase.

Associated sent the water system survey to 178 water system owners in the RDOS and received responses for 11 groundwater wells and 10 surface water intakes. The intake locations and data provided in these responses were used to delineate DWPAs for each of these 21 systems. The results suggest that a **scaled-up approach could be used to develop DWPAs and upload them as readily accessible layers on the BC Data Catalogue**. Based on the lessons learned from this study, the scaled-up and modified approach could include gathering the necessary information from water system owners via a survey, but supported by workshops (given the limited buy-in on online surveys alone), followed by data synthesis and GIS analysis. Other lessons learned and/or key considerations, such as methods for delineating well capture zones, challenges with lake intakes, and considerations data security and intellectual property, are provided within this report.

A Phase 2 pilot project is recommended to test the workshop component and refine the methods before implementing the program. For planning purposes, we have provided a schedule, high-level overview of the potential scope, and a range of costs. We envision Phase 2 could be completed in 6 months, culminating with a workshop at the Environmental Operators Certification Program (EOCP) conference in September 2023. Approximate costs are also included for discussion and planning purposes.

¹ A contributing watershed is the portion of a watershed that supplies water to a drinking water intake. A capture zone is the land area within which water infiltrates into the ground and contributes groundwater to a well.

In this report, we provide information on the suggested organization framework. We believe the relatively new Ministry of Water, Land, and Resource Stewardship (WLRS) has the mandate and capabilities to lead the program, with support from the health authorities, particularly with the workshops for the water system owners, where information about the water system is needed to be transferred to the project team for the project to be a success. The health authorities (such as IH) have established relationships with the water system owners, and could help encourage participation, and facilitate the data and knowledge transfer. Consultants can support in different areas, such as workshop engagement, scientific support (e.g., GIS analysts, hydrogeologists, or hydrologists, depending on the need), and project management.

ACKNOWLEDGEMENTS

Associated Environmental Consultants Inc. thanks those persons and agencies that provided information for this report and/or provided insight into how water systems operate and are regulated. In particular, we thank the water system owners and operators who took the time to fill in the surveys and to provide their insights.

The project was directed by Shelley Fiorito and Rob Palmer of Regional District of Okanagan Similkameen. The report was prepared by Marta Green, P.Geo., and Christine Indrigo, M.Sc. Members of the leadership team were: Ivor Norlin (Interior Health), Klaus Rathfelder and Emilia Young (Ministry of Water, Land and Resource Stewardship), and Lindsay Johnson (Ministry of Health). GIS analysis was completed by Christine Indrigo with assistance from Klaus Rathfelder, Emilia Young, and Marta Green. Funding was provided by the Okanagan Basin Water Board Water Conservation and Quality Improvement Grant Program, Regional District of Okanagan-Similkameen, and Interior Health.

The project boundaries are within the territory of the Syilx Okanagan People. We are grateful to be able to live, work, and recreate within these beautiful lands. We invite readers to become familiar with the siwłkʷ Water Declaration available [here](#).

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LIST OF ABBREVIATIONS

AFR	Arbitrary fixed radius
BC	British Columbia
BCWWA	BC Water & Waste Association
CFR	Calculated fixed radius
EOCP	Environmental Operators Certification Program
FNHA	First Nations Health Authority
GIS	Geographic information system
IH	Interior Health
IPZ	Intake protection zone
ISC	Indigenous Services Canada
MOE	Ministry of Environment
MOH	Ministry of Health
RDOS	Regional District of Okanagan-Similkameen
SWPP	Source Water Protection Plan
TOT	Time of Travel
TRU	Thompson Rivers University
WLRS	Ministry of Water, Land and Resource Stewardship

1 INTRODUCTION

Associated Environmental Consultants Inc. (Associated) supported the Regional District of Okanagan-Similkameen (RDOS) in completing a pilot mapping project to support source water protection. This pilot project was funded by the Water Conservation and Quality Improvement grant from the Okanagan Basin Water Board (OBWB). RDOS and Associated are working alongside the following partners on this project:

- Interior Health
- Ministry of Health
- Ministry of Water, Land and Resource Stewardship (WLRS) (formerly, the staff on the project were part of the Ministry of Environment and Climate Change).

The scope of work for the pilot project was outlined in the grant application submitted by RDOS to OBWB in 2021, then refined through discussions with RDOS and the project partners during regular progress update meetings in 2021 and 2022.

This document, which was prepared by Associated and reviewed by RDOS, WLRS, and Interior Health, summarizes the methods and results of the pilot project, and provides some suggested next steps for expanding the work completed here more broadly across the province. It is intended to support future phases of the pilot and/or implementation of a permanent program.

1.1 Background

Approximately 5,000 drinking water systems exist in BC, with nearly 2,000 in the Interior Health (IH) region alone. The quality and quantity of drinking water, sourced from either surface water at a water system intake or groundwater in a well, depend in part on the land uses and physical processes that occur within a contributing watershed (for a surface water source) or a capture zone (for a groundwater source).¹ Various types of land use may have an impact on the water quality of the source water. For example, over-applying fertilizers on a farm or golf course could result in contaminated (e.g. with nitrates) water entering a water supply well if applied within the capture zone of that well. In another scenario, designing a road without adequately considering surface drainage may cause erosion during extreme rainfall events, which can result in unacceptable turbidity at a drinking water system intake in the downstream waterbody.

Currently, there are no easy-to-access maps of the boundaries of contributing watersheds or capture zones, often referred to as **drinking water protection areas (DWPAs)**, for most of the drinking water systems in BC, particularly the small systems. Drinking water protection areas are delineated on a system-by-system basis and typically only for large systems. Where capture zones have been delineated, they are typically documented within reports that are in PDF format and only available to the public if requested from the water system owner. Characteristics of an easy-to-assess drinking water protection area dataset would be one that is available on the BC Geographic Warehouse (BC Data Catalogue) in an easy-to-upload KML format or another file type that is GIS-compatible (e.g., Google Earth or ArcGIS).

¹ A contributing watershed is the portion of a watershed that supplies water to a drinking water surface intake. A capture zone is the land area within which water infiltrates into the ground and contributes groundwater to a well.

Mapping DWPA's and making these maps easily accessible would be of assistance to:

- Drinking water providers (who operate and manage public drinking water systems) and the responsible regulator (e.g., IH in the pilot area) to better enable source protection planning and emergency responses;
- Rural residential developers, industries, local governments, and their practitioners who are applying or registering for industrial, municipal, or agricultural waste discharge authorizations better understand where drinking water sources are located relative to their projects²;
- Natural resource industries (forestry, mining, renewable energy, and tourism) and regulators;
- Land use planning agencies, including First Nations, that are developing various watershed-scale and higher level plans; and
- Regulators (e.g., Ministry of Health, Ministry of Environment and Climate Change Strategy, Ministry of Forests, and Ministry of Agriculture) that review discharge and land use applications or respond to complaints.

In 2019, the Auditor General of BC concluded that the province was not doing enough to protect drinking water and the watersheds within which drinking water is sourced (Auditor General of BC 2019). Since then, several initiatives have been launched and are underway. Expanding the current system-by-system approach by developing a procedure to delineate DWPA's on a larger scale is a task that the Ministry of Water, Land and Resource Stewardship and other partners like the regional health authorities could complete, improving drinking water safety. For example, if a method is developed that can reasonably result in 50 areas delineated per year, all 5,000 water systems in BC could be delineated in 10 years. However, before this is done, scaling up will bring additional challenges.

The only other known study that delineated groundwater drinking water protection areas at a regional scale is the "Northeast BC Source Area Delineation for Groundwater Supply Systems" (Ministry of Environment 2012). As part of the project, the authors determine the most appropriate capture zone delineation methodology using Step 2 of the Well Protection Toolkit (MELP 2004). A total of 130 wells were examined, with only the arbitrary fixed radius (AFR) method applied to 113 wells. Calculations for the calculated fixed radius (CFR) method were completed for 81 wells, but due to uncertainty in the input data, only 13 of these were assigned capture zones. The report summarises several challenges and lessons learned, which were discussed and built upon for this pilot project.

For surface water, 466 Community Watersheds have been established across BC under the *Forest & Range Practices Act* (FRPA) to protect drinking water from surface water sources by setting requirements for road-building, harvesting, and other activities within a community watershed area (BC MOE 2022). Community watersheds are defined as "all or part of the drainage area that is upslope of the lowest point from which water is diverted for human consumption by a licensed waterworks" (BC MOE 2022). Most Community Watersheds are on Crown Land, and maps showing their boundaries are available.

1.2 Objective and Scope of Work for Phase 1

The long-term goal of this initiative is to improve drinking water safety by identifying critical DWPA's to inform land use planning and support emergency response decisions, ultimately reducing the risk of drinking water illness and system disruptions.

² Multiple regulations require that a discharge to the environment occur outside of a certain setback from a drinking water source, vulnerable aquifer recharge area, groundwater capture zone, recharge area, well recharge zone, water supply well, watershed or a community watershed. Most would require a site specific investigation to determine the appropriate boundaries, but a simple tool would benefit early-stage discussions and planning.

The objective of Phase 1 is to develop and test a method to delineate DWPAs at a regional or provincial scale, and to make recommendations for subsequent phases leading to implementation.

To meet this objective, the scope of work for Pilot Project Phase 1 included three tasks:

- **Task 1:** Initiate the project and conduct a water system survey. The goal of this task was to gather the data from the water system owners needed to develop the DWPAs.
- **Task 2:** Delineate drinking water protection areas using methods commonly employed in BC and assess the practical feasibility of using one or more of those methods to map DWPAs at a regional scale. The goal of this task was to test the effectiveness of these common methods when working at a regional scale (i.e., developing dozens of DWPAs rather than one at a time).
- **Task 3:** Identify the lessons learned from Tasks 1 and 2, make recommendations for the next pilot phase, and develop a work plan for the next phase (Phases 2 and 3). The goal of this task was to identify ways to improve the applicability of the tested methods to a more regional/provincial level.

1.2.1 Task 1: Initiate the Project and Conduct Water System Survey

This task involved initiating the project, completing a desktop study of available literature and data, and facilitating regular progress meetings with partner organizations to further refine the objectives, scope, and survey questions. In collaboration with IH, Associated developed an online survey and sent it to 178 water system owners within RDOS boundaries. The survey data that was received were reviewed, and a spreadsheet of aquifer and surface water properties was updated based on the data. Appendix A provides the interactive map and survey questions.

1.2.2 Task 2: Delineate Drinking Water Protection Areas

This task involved developing methods for defining DWPAs at a regional scale using GIS, testing those methods, comparing the results, and seeking feedback from the partners. Data on DWPAs were initially stored on the RDOS GIS system. Associated worked closely with WLRS staff to develop GIS spatial layers of DWPAs that could be housed in the Ministry of Environment's BC Geographic Waterhouse (BC Data Catalogue), which is publicly accessible.

Associated worked with water purveyors to collect information required to delineate drinking water protection areas using scientifically defensible methods. This was done by gathering well and surface water intake location data from the survey sent to water purveyors and delineating the drinking water protection areas using the methods described in Section 2 of this report.

1.2.3 Task 3: Lessons Learned and Develop Work Plan for Next Phase

Associated used the results from Tasks 1 and 2, including lessons learned, to develop recommendations for the next steps to expand the RDOS pilot project to a regional or provincial scale. Associated then completed this report, which describes the objectives, methods, and results from each task.

2 METHODS

2.1 Task 1: Survey of Water System Owners

In July 2021, Associated sent a survey to 178 water system owners in the RDOS. These water systems were selected from the Hedgehog Database provided by IH, which lists a total of 191 water systems in the RDOS³. Table 2-1 provides a summary of these water systems by size and intake type. This survey included general questions regarding the water supply system and water use, and specific questions related to groundwater or surface water intakes. The survey also included an interactive map, where participants could locate their well or surface water intake and mark the location to indicate whether it is a surface water or groundwater intake. Marking the well or intake site on the map prompted another set of questions, depending on which intake type was selected. IH staff then telephoned a subset of water users who had not completed the survey to follow up, resulting in additional responses. Appendix A shows the interactive map and survey questions.

Table 2-1 Summary of Water Sources for RDOS Water Users in the IH Hedgehog Database

System Type ⁴	Groundwater	Surface water	Surface & Groundwater	Bulk Delivery	Not Specified
Large	6	7	2	1	
Small	81	12	3		29
Stand alone	8	1			41
Total	95	20	5	1	70

2.2 Task 2: Delineating Drinking Water Protection Areas

2.2.1 Approach and Definitions

The methods used to delineate well capture zones in this study followed Step 2 of the Well Protection Toolkit (MELP 2004). Associated tested the arbitrary fixed radius (AFR), calculated fixed radius (CFR), and analytical methods (Section 2.2.2) on water systems that responded to the survey to assess their suitability for the scale of the pilot. Surface water protection areas were delineated using a combination of methods, including the Comprehensive Drinking Water Source-to-Tap Assessment Guideline: Module 1 (MHL 2010) and reports from various surface water intake DWPA delineation projects from other areas in BC and Ontario. All groundwater and surface water delineations were done using QGIS software (see Appendix B and C for details). Table 2-2 defines the terms used when discussing protection areas for surface water and groundwater.

Building upon previous work completed by WLRS, a spatial database of the protection areas was created, along with areas delineated from previously-completed source water assessments. The purpose of this database is to create a single repository for all publicly available data related to DWPAs and source assessments that can be updated when new water supplies are developed or if new activities are proposed near a drinking water source.

³ The difference between the number of emails sent out compared to the number of water systems on the Hedgehog database is likely due to a combination of lack of email addresses on the Hedgehog database and duplicate systems on one email address (e.g.: BC Parks owns and operates multiple systems with the same email address).

⁴ Small and large systems are based on population and the *Drinking Water Protection Regulation* (BC Reg. 237/2018), which defines small systems as serving >500 individuals in a 24 hour period. Stand alone systems include roadside businesses serving the public, such as gas stations, fruit stands, and restaurants. Technically, stand alone systems would be defined as either a large or small system based on population served and the definition in the DWPR.

Table 2-2 Terms and Definitions for Surface and Groundwater Protection Areas

Spatial Database Level	Term	Definition
Surface Water		
Area A (surface water)	Intake Protection Zone (IPZ) A	100 m radius. Minimum IPZ distance recommended in the Source-to-Tap Assessment Guideline (MHLS 2010).
	Intake Protection Zone (IPZ) B	An additional, more conservative intake protection zone than the 100 m minimum. For example, a 1 km radius for intakes on larger lakes with considerable human activity.
Area B (surface water)	Watershed Area	Watersheds and sub-watersheds. Most suitable for surface intakes on streams or springs. For lake intakes, it may be appropriate to augment the IPZ on the lake with all or part of the contributing watersheds (e.g., where the mouth of a stream is near a lake intake).
Area C (surface water)	Other areas	Any additional delineated areas (rivers/streams, lakes, shorelines, shallow areas, etc.) if judged of value to reduce risk.
Groundwater		
Area A (groundwater)	Well Protection Area A	100 m radius. Area with the highest risk to the well (MHLS 2010).
Area B (groundwater)	Well Protection Area B	200-day time-of-travel (TOT) capture zone. Area used to protect against pathogenic contaminants. The 200-day TOT represents the survival time of pathogens and is consistent with the new version of the BC Ministry of Health's Guideline for Determining Groundwater at Risk of Containing Pathogens (GARP Guideline) (MOH 2017); or,
		300 m radius. If data are not available to estimate a 200-day TOT using the CFR method, a 300 m radius using the AFR method is a suitable alternative. The 300 m distance is a recommendation in the GARP Guideline.
Area C (groundwater)	Well Protection Area C	5-year TOT capture zone. Area used to protect against chemical contaminants (e.g., petroleum contaminants and persistent, mobile contaminants). This is the timeframe typically needed to allow for a remediation program of a hydrocarbon spill or leak to occur (Province of Ontario 2017); or,
		Aquifer area. If data are not available for using the CFR method, then the entire provincially mapped aquifer, with some manual hydrogeological mapping as needed, is a reasonable substitute. The definition is then expanded to be the area used to protect against all chemical contaminants, even the most persistent (equivalent to Well Protection Area D).
Area D (groundwater)	Well Protection Area D	25-year time of travel capture zone. Area used to protect against only the most persistent and mobile contaminants (e.g., chlorinated solvents and nitrates) (Province of Ontario 2017); or,
		Aquifer area. If data are not available to estimate a 25-year time of travel using the CFR method, then the entire provincially mapped aquifer, with some manual hydrogeological mapping as needed, is a reasonable substitute.

AFR – arbitrary fixed radius; CFR – calculated fixed radius; TOT – time of travel

2.2.2 Groundwater Capture Zones Delineation Methods

For groundwater wells, three methods were used to delineate capture zones:

1. Arbitrary Fixed Radius (AFR);
2. Calculated Fixed Radius (CFR); and
3. Analytical method.

These methods are explained in detail in Appendix B. AFR is the simplest as it only requires a location on a map, followed by CFR and the analytical method, which both require information on aquifer properties.

2.2.3 Surface Water Delineation Methods

Detailed methods for delineating surface water protection areas are provided in Appendix C. For each surface water intake where a survey response was received, GIS was used to create two intake protection zones (IPZs A and B, defined as radii 100 m and 1 km as per Table 2-2), the watershed area, a stream buffer area, and a lake buffer area. This was accomplished using three publicly available layers from GeoBC: Freshwater Atlas Watersheds; Freshwater Atlas Lakes (polygons); and Freshwater Atlas Stream Network.

2.2.4 Spatial Data Storage and Access

BC has several online spatial datasets and visualization tools for water resources including GWELLS for well and aquifer data; BC Water Resources Atlas and iMap for web-based mapping tools that include water-related data; GeoBC for geospatial products; and the Ecological Reports Catalogue (EcoCat) for reports, maps, and datasets. The spatial dataset containing the areas delineated as part of this pilot will be hosted and maintained on GeoBC which is the same place a user would access the “community watersheds” layer.

Each regional health authority manages water system information somewhat differently. IH uses a data management database platform called Hedgehog. This platform is currently only accessible by authorized personnel.

3 RESULTS

3.1 Task 1: Survey Responses

As described earlier, the survey was sent to 178 water system owners in the RDOS. Responses were received for 11 groundwater intakes and 10 surface water intakes, a response rate of 12%. One of the surface water responses was located outside of RDOS boundaries and was therefore not delineated or used for analysis. Of the 11 groundwater responses, 10 are small systems and one is a stand alone system. Of the 9 surface water responses, 6 are classified by IH as large systems and 3 are small systems⁵. The survey responses capture a variety of scenarios including various water system sizes (i.e., large, small, stand alone), water sources (i.e., lake, river for surface intakes), and aquifer types (for groundwater wells). Additionally, the distribution of water system sizes in our survey responses is similar to that in the Hedgehog Database of RDOS water systems, where most of the groundwater systems are small.

⁵ "Small system" means a water supply system that serves up to 500 individuals during any 24 hour period, as defined in the *Drinking Water Protection Regulation*, BC Reg. 237/2018.

3.2 Task 2: Delineating Drinking Water Protection Areas

Figure 3-1 provides an example of the DWPA delineated by AFR and CFR for a single well groundwater system. Figure 3-2 is the same well with the capture zone delineated in more detail with aquifer mapping, and Figure 3-3 provides an example of delineated surface water areas for four surface water intakes.

3.2.1 Groundwater - Arbitrary Fixed Radius

The AFR (100 m) was successfully delineated for all 11 groundwater well locations provided in the survey responses. As this method requires only the well locations, it is the simplest method to complete and can easily be done on a large scale for multiple wells.

3.2.2 Groundwater - Calculated Fixed Radius

The CFR was successfully delineated for 10 of the 11 groundwater wells. Capture zones could not be calculated using the CFR for one of the sand and gravel wells, as no data were available for the aquifer thickness. The calculated radial distances for the sand and gravel aquifers using this method ranged from 103 m to 459 m for a 200-day TOT, 311 m to 1,388 m for a 5-year TOT, and 696 m to 3104 m for a 25-year TOT. The radius distances for the bedrock aquifer were 85 m for a 200-day TOT, 257 m for a 5-year TOT, and 574 m for a 25-year TOT.

3.2.3 Groundwater - Analytical Method

Based on the survey and aquifer data that were provided, the analytical method was of negligible practical use for all of the wells. The capture zones produced using this method were unrealistic in the size of their 'X' (distance to the capture zone boundary downgradient of the well) and 'Y' (half-width of the capture zone) values, with X values ranging from 0.0002 m to 31 m and Y values ranging from 0.0001 m to 99 m. The distance representing 1-year TOT ranged from 0.4 m to 56,144 m. These values are unrealistic as they are too small to provide protection and likely reflect the quality of the input data (aquifer properties). Therefore, no maps (shapefiles) for the capture zones were created using this method.

3.2.4 Hydrogeologic Mapping

Associated used the three desktop hydrogeologic mapping methods outlined in Appendix B Section 1.4 for wells in sand and gravel aquifers: 1) aquifer-based extent, 2) Quaternary-based⁶ extent, and 3) manual delineation. Of the 11 wells, only one required manual delineation, as there were no sand and gravel aquifers or Quaternary deposits mapped; one well used the Quaternary area as no sand and gravel aquifers were mapped, and there was only one bedrock well, which maintained the circular well protection areas. The well protection areas for the other eight wells were refined based on the mapped sand and gravel aquifer extents.

⁶ Quaternary deposits are recent (2.58 million years ago to present day) and unconsolidated granular particles, typically comprised of clay, silt, sand and gravel, and till. They are deposited by water, air, gravity or ice. The largest amount of groundwater used in BC comes from unconsolidated sediments (mainly sand and/or gravel) that receive water from precipitation or nearby surface watercourses (MWLAP 2002). Other types of deposits are older types of bedrock, deposited by volcanic, metamorphic or sedimentary (pressure) action.

Figure 3-1 Delineated Capture Zones Without Considering Available Hydrogeology Mapping Information (Well Protection Areas A to D) (Example)

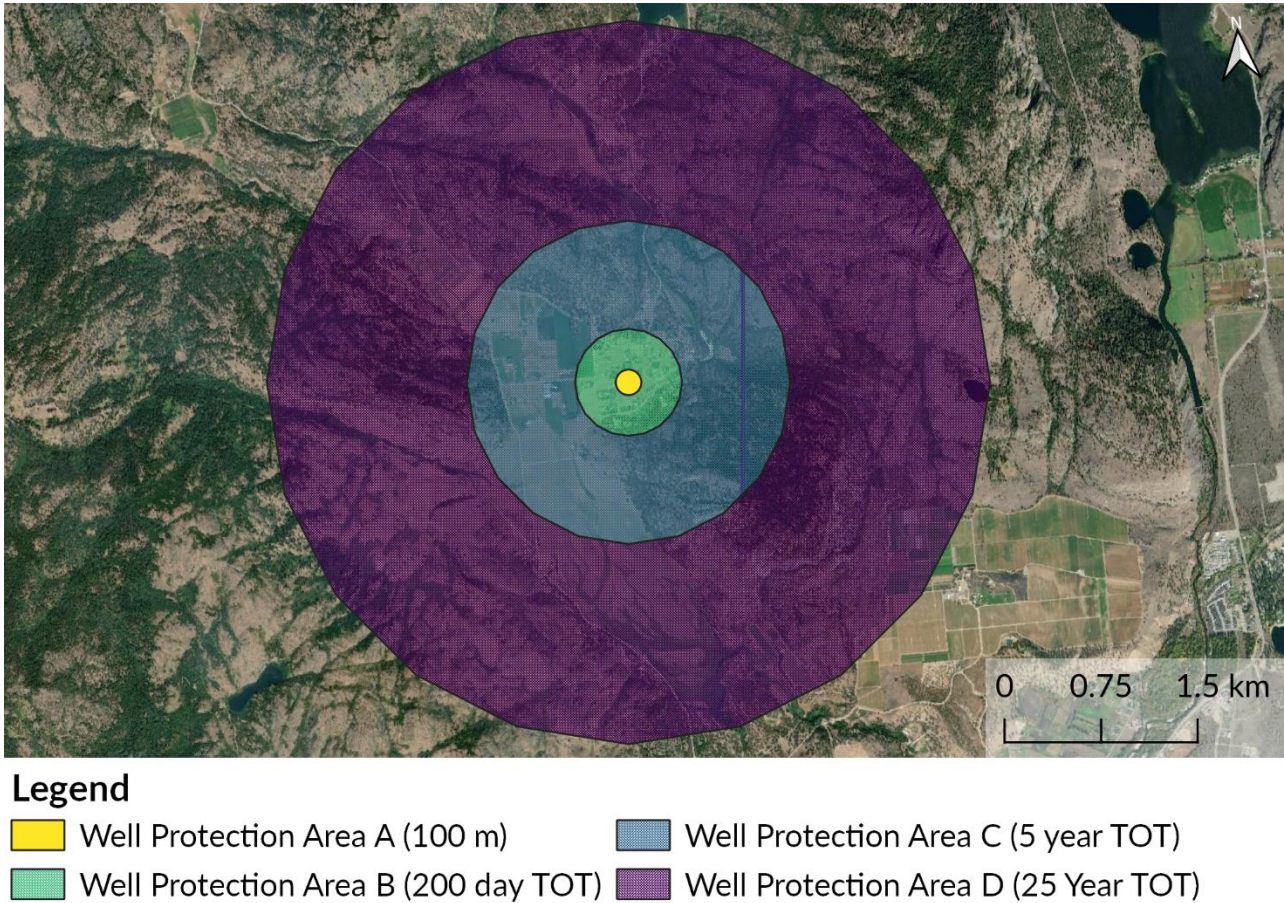
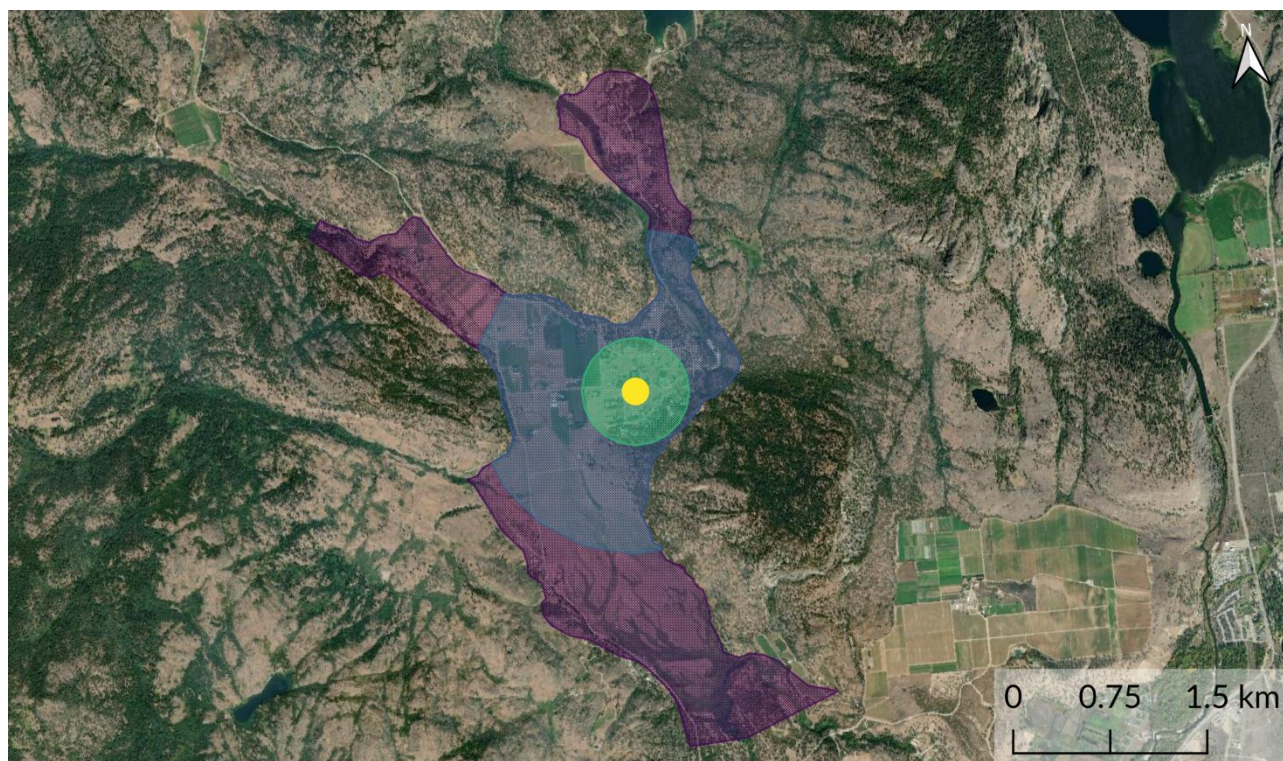


Figure 3-2 Delineated Capture Zones Considering Available Hydrogeology Mapping Information (Well Protection Areas A to D) (Example)



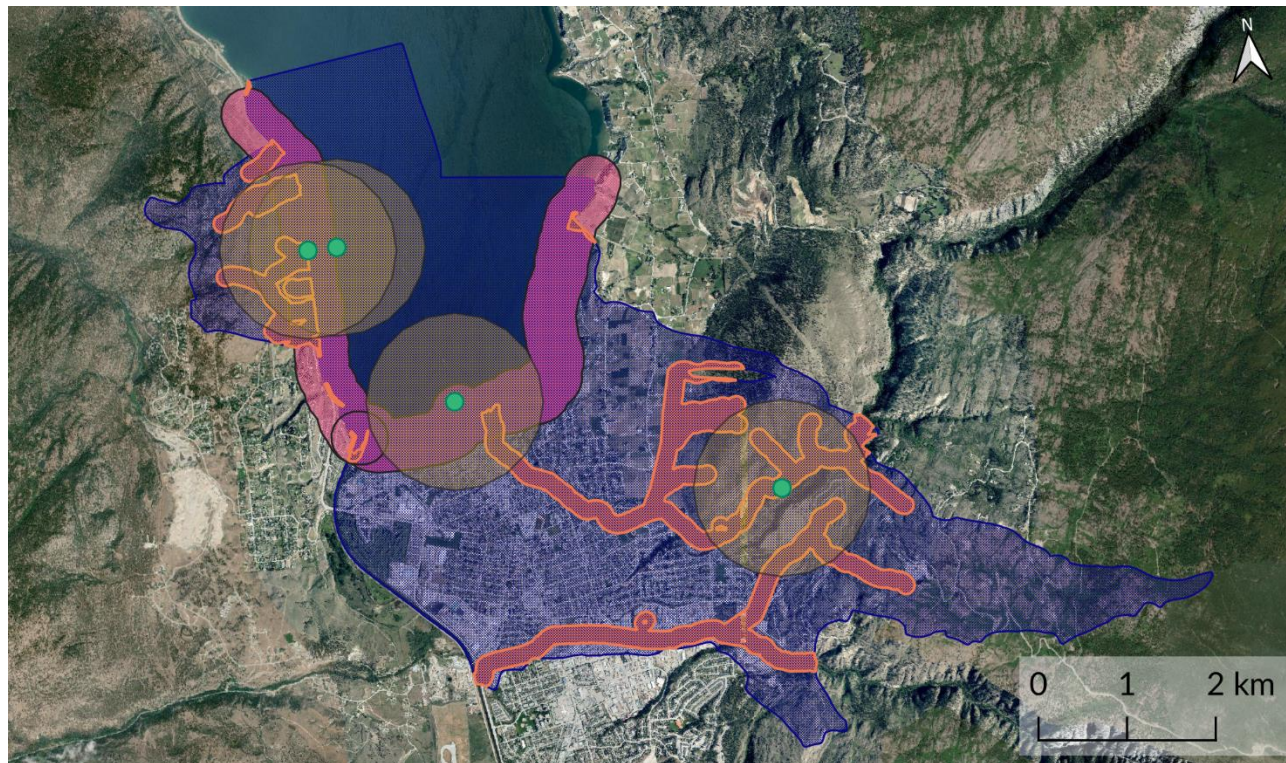
Legend

- | | |
|--|--|
| Well Protection Area A (100 m) | Well Protection Area C (5 year TOT) |
| Well Protection Area B (200 day TOT) | Well Protection Area D (25 year TOT) |

3.2.5 Surface Water

The results for delineating DWPAs for surface water are presented in Appendix C. To summarize, Associated delineated several types of DWPAs for 10 surface water intakes in the RDOS: the IPZ (at 100 m and 1 km radii), watershed area, and lake and stream buffers. Based on discussions with the partners and results from the preliminary review of existing reports across BC and Ontario, a lake buffer area was selected to capture lakeside properties and salt and sediment runoff from nearby roads. Additionally, a stream buffer was selected to capture areas (tributaries) draining into the intake watercourse or waterbody. As noted, 100 m is the minimum recommended radius for the IPZ in the Source-to-Tap Assessment Guideline. In our discussions with the project partners, it was judged that 100 m is too small to provide adequate protection for any of the intakes in the project. As most of the intakes are in Okanagan Lake, we used a 1 km radius. This is generally consistent with other SWPPs. For example, Ontario uses an IPZ of 1 km for intakes in Lake Ontario (CTC 2022). Reports from BC by Larratt Aquatic also noted that 100 m was insufficient and instead recommended radii ranging from 455 m to >500 m (Self and Larratt, 2013; Self and Larratt, 2015a; Self and Larratt, 2015b; Larratt, 2019).

Figure 3-3 Surface Water Areas A to C Delineated for Four Intakes (Example)



Legend

- Area A - IPZ (100 m)
- Area B - Watershed
- Area C - Stream Buffer
- Area A - IPZ (1 km)
- Area C - Lake Buffer

4 DISCUSSION AND LESSONS LEARNED FROM THE PILOT

4.1 Terminology

The terms “water source assessment” and “drinking water protection plan” are legislative tools under BC’s *Drinking Water Protection Act* and therefore were not used to describe the protection areas delineated in this project. Associated had several discussions with the partners regarding naming of the surface water layers and considered the following terms: contributing watershed, source water protection area, and drinking water protection area. Drinking water protection area (DWPA) was chosen to describe the overall dataset, encompassing both groundwater and surface water systems. A protection area is defined in the Source to Tap Guidance Document (BC MHLS 2010) as the “area in which source protection activities are conducted.” Thus, the term “drinking water protection area” is flexible in that different protection areas can be defined for a point of diversion depending the on risk, travel time, or types of source protection activities that may occur in the protection area.

Based on this, the DWPA for this project were categorized as either “well protection area”, “surface water area - intake protection zone”, “surface water protection area – watershed”, or “surface water protection area – other protection area” (where “other” includes any additional types of delineated areas). An example of an “other” area is the mapping of shallow (e.g., less than 7 m) areas of a lake that could be used to inform wake-boats on areas to avoid to

reduce turbidity caused by the wake of the wake boat (see Section 4.2.5 for more information). The exact terms for each layer are described in Table 2-2.

4.2 Lessons Learned from the Pilot Project

4.2.1 Water System Owner Surveys

One of the main challenges encountered during this project was the low response rate to the survey (12%). Of the 178 systems that were contacted by email, 21 completed the survey. Furthermore, several of these survey responses were from Rob Palmer of WLRS, one of the project partners, and thus the number of survey responses voluntarily provided by water system owners unconnected to the survey was lower.

Since the survey response rate was low, IH staff discussed the project with water system owners during regular inspections and forwarded the survey if asked for more information. In the future, more follow-up by phone or in person should take place after surveys are distributed in order to achieve a more representative response rate (e.g., >30%). Water operators are busy people, and targeted follow-up has proven effective during other regional projects like the recent Okanagan Water Supply and Demand Study. Another option is to host one or more regional workshops where water system owners and operators are invited to participate along with their peers.

4.2.2 Technical Challenge – Locating Well Intakes

Accurately defining the locations of the intakes and wells (geocoding) was a technical challenge during the project. Initially, Associated attempted to geocode the locations of water systems based on the Hedgehog Database provided by IH. This database includes names of the water systems and civic addresses. Geocoding was completed using both 1) the QGIS MMQGIS program and 2) Google Earth's built-in geocoding functionality. The QGIS method resulted in 142 out of 196 systems being geocoded. The Google Earth method resulted in 175 of 196 systems geocoded. However, the results from both of these geocoding methods were judged as inaccurate because they represented the civic address, not the location of the wells or drinking water intakes.

Another method that was employed was using QGIS to join the Hedgehog Database with the provincial GWELLS GIS layer, as this layer has the locations of groundwater wells, not just civic addresses. This method proved more successful, with 171 systems successfully mapped. As discussed in Appendix B, Section 1, the locations of the wells used in this project from GWELLS slightly differed from those provided in survey responses by ~0.5 – 15 m, so there are some potential accuracy limitations with this method.

4.2.3 Data Security and Intellectual Property

Concerns over data security and intellectual property were discussed in a meeting with the partners. Groundwater well and surface water intake locations are collected as part of the survey. The intent of this project is to make the locations of the well/intake and the DWPAs created using these well and intake locations publicly available, but not the data needed to create the DWPAs. Consent was obtained from each water system who participated in this project. Future phases of this project and any potential workshops would also benefit from providing a privacy and consent form to participants to fully outline these privacy concerns and to have a record that participants have provided consent to use the data they provide. Because of the nature of the data and the potential concerns, it was suggested that the data be published to the Provincial data systems under an "Access Only" license. This data license allows users to view and download the data but restricts them from reproducing or distributing it.

We also discussed two specific concerns regarding intellectual property: usage of existing Source Water Protection Plan (SWPP) reports and data, and clarification of who owns the data created as a result of this project. Typically, SWPPs are developed by consultants retained by municipalities or water system owners and as such the DWPA outputs can be used by the municipalities or water system owners.

4.2.4 Data Sources

In addition to the survey, Associated relied on data from GWELLS for the groundwater well locations and GIS layers from DataBC for the surface water protection areas. GWELLS often has data gaps in the information needed for delineating capture zones, such as screen length, aquifer types, and pumping rates. This was an issue when estimating aquifer thickness from GWELLS data. The aquifer thickness for confined aquifers is the distance from the bottom of the well (if the bottom of the water-bearing sand layer is unknown) to the top of the water-bearing sand layer. The aquifer thickness for unconfined aquifers is from the bottom of the well (if the bottom of the water-bearing sand layer is unknown) to the water table. Based on our reviews of the well and aquifer data for the wells in this project, sometimes water levels are missing from GWELLS and estimating the top and bottom of aquifers using driller's notes is time consuming. Additionally, driller's notes are not always provided in GWELLS. For these reasons, we used screen length instead of aquifer thickness, as this information was more reliably provided in GWELLS.

The original mapping data (shapefile) sources affect the quality and accuracy of the stream buffer layer. The stream buffer layer was developed using the Freshwater Atlas Stream Network shapefile. This shapefile splits rivers into shorter individual segments. Associated used the Freshwater Atlas Watersheds shapefile, which comprises watersheds for streams rather than the larger lakes. Initially, watersheds overlapping with the 1 km IPZ were selected, but this was found to underestimate the size of watershed areas for lake intakes. Associated then used these resulting watershed areas for lake intakes to select streams that overlapped with these areas. Therefore, the stream buffers only capture streams that intersect with the initial watershed and do not capture the entire length of larger rivers that drain into these lakes. Although the length of the stream buffers might still be underestimated, it appears that this was still a suitable delineation for the purposes of this pilot project because the potential sources of contamination closest to the intakes are generally captured in the watershed and IPZ layers.

4.2.5 Capture Zone Methods

The Well Protection Toolkit states that the CFR method "is suitable for sand and gravel aquifers, where the water table is relatively level and wells supply no more than 100 connections" (MELP et al. 2004). Eight of the 11 survey responses indicated that the wells were in sand and gravel aquifers, with the remainder being unknown. Using data from GWELLS, one of the unknown wells was determined to be in bedrock and another to be in sand and gravel.

The CFR method requires some manual input to determine the value of the aquifer thickness or screen length, depending on the available data. We used the screen length, as aquifer thicknesses could not be determined from the data for our pilot test wells. Using screen length results in a larger radius than using aquifer thickness, resulting in a more conservative capture zone area (MELP 2004).

The analytical method was unsuitable for this project, given the spatial scale of the study and the available data. The capture zones produced using this method were unrealistic in the size of their dimensions. Additionally, the analytical method requires significant manual GIS analysis and calculations and is time-consuming to apply to a large number of wells.

We have determined that the AFR and CFR methods are best suited for delineating groundwater capture zones on a regional or provincial scale, where many systems are small systems. As the AFR only requires well locations, it is the easiest to apply on a large scale. The CFR method can be used for specific TOTs and has fewer requirements than the analytical method, which was more time-consuming to apply and produced inaccurate results with the available data. When the required data are available, the CFR method should also be applied as it is more precise and most of the data can either be determined from well logs, aquifer records, or estimated using standard techniques.

4.2.6 Special Considerations for Lake Intakes

All but one of the surface water responses were from systems with lake intakes, mostly in Okanagan Lake. Simply defining an arbitrary IPZ is relatively straightforward using GIS. In practice, however, water systems customize the IPZ based on the presence of natural features (e.g. a nearby creek mouth) or human-related hazards (e.g. recreational activity or nearby wastewater systems).

A specific hazard for lake intakes that was raised in the meetings with the partners was suspended sediment caused by wake boats and other large watercraft. The group discussed options for using bathymetry data to delineate shallow areas that would be defined as “no wake zones.” Sediment in these shallow areas can become disturbed by boats in the lake, creating turbidity plumes. The goal of delineating these areas is to identify areas where wake-caused turbidity could potentially impact drinking water intakes, so that these areas can be managed for watercraft. The Okanagan Basin Water Board has bathymetry data for Okanagan Lake, Kalamalka Lake, Wood Lake, Skaha Lake, and Osooyos Lake that could be used for this analysis. Older bathymetric maps may be available for other lakes but may require digitization to be used for risk assessment and DWPA mapping.

This example is intended to show how GIS-based methods can be useful for initial planning or where no source water risk assessment has been completed, but site-specific investigation and stakeholder discussions are needed to identify specific hazards and prioritize actions to reduce risk.

4.3 Other Regional Protection Areas in BC

In addition to the areas delineated in this pilot project, Emilia Young (WLRS) has collected 13 existing source assessments, which are available online through the provincial Ecological Reports Catalogue and GeoBC. Among these 13 source water protection plans, three are not yet digitized (indicated by *).

- Beaver Valley Water Service
- Christina Lake Water Utility
- City of Nelson
- City of Merritt
- City of Fernie: James White Park
- City of Fernie: Fairy Creek
- City of Kamloops*
- District of Sicamous Mara Lake
- Columbia-Shuswap Regional District: Cedar Heights
- Columbia-Shuswap Regional District: Sorrento
- Columbia-Shuswap Regional District: Falkland*
- City of Kelowna
- City of West Kelowna*

4.4 Source Protection Leadership and Partners

During the timespan of this project, the Ministry of Environment was reorganized and a new ministry, the WLRS, was formed. The mandate details of WLRS is still being developed, but based on the Premier's mandate letter, source protection is a priority and WLRS is to "lead B.C.'s work on water, watersheds, and our coast, including work to... co-develop, complete, and launch the Watershed Security Strategy and Fund" (Eby 2022).

Before this change, source protection was undertaken by several agencies, including (Office of the Auditor General of BC 2019):

- Ministry of Health;
- Ministry of Forests, Lands, Natural Resource Operations and Rural Development (responsibilities now split into two ministries: Ministry of Forests, and Ministry of Water, Land and Resource Stewardship) ;
- Ministry of Environment and Climate Change Strategy;
- Regional health authorities;
- Ministry of Agriculture;
- Ministry of Transportation and Infrastructure;
- Ministry of Municipal Affairs and Housing; and
- Environmental Operators Certification Program.

Water system owners, operators, and qualified professionals supporting the design, construction, and operation of water systems also play a role. In addition, land use is managed by local government through planning tools such as official community plans and bylaws. Lastly, business and private residents also play a role; for example, agricultural producers decide how much fertilizer to add to their crop lands, and individual residents decide how to clean their cars, store machinery, and apply pesticides to weeds around their home.

Given the complex leadership structure, clear terms of references, with roles and responsibilities, becomes very important. During the project, WLRS staff added value in the areas of understanding watersheds, wells, aquifers, and GIS analysis, which will be the ultimate output to the BC Data Catalogue. IH added value in the areas of understanding the capacity of drinking water system owners and their supporters, how drinking water system owners manage hazards located near the intake or well, human health aspects (including background on outbreaks or number of health advisories/abnormal operations), and industry standards on source protection plans on a system-by-system basis. Consultants offered support in technical areas, including hydrogeology, hydrology, limnology, and project management/coordination. Based on the results of the pilot, a similar team would be successful in a next phase, with the addition of a host for the workshops that is connected to the water system owners and operators.

5 NEXT STEPS – PILOT PHASES 2 AND 3

5.1 Recommended Scope of Phases 2 and 3

Based on the results of the Pilot Phase 1, described in Sections 3 and 4, the following section summarizes our proposed approach for next steps toward delineating drinking water protection areas at the regional or provincial level. We have organized this program into the following components:

- **Pilot Phase 2: Refining methods and testing out workshops (to be completed in 2023):** This phase will close the gaps in the program delivery approach based on some of the lessons learned in Phase 1. It will involve

completing the same steps as in Phase 1, but attendees will fill out the survey in a workshop setting, as the main takeaway from Phase 1 was that participation by email survey was poor. We recommend a workshop host that is already highly integrated with the operators, such as the Environmental Operators Certificate Program (EOCP)¹, BC Water & Waste Association, Online Help Centre for BC Small Water Systems (virtual webinars hosted online by Thomson Rivers University, with potential to be expanded to workshops).

- **Pilot Phase 3: Establishing the first year of full implementation of the program (2024):** The scope of this phase should be adjusted pending the outcome of Phase 2, but generally, would involve completing 14 in-person workshops and three virtual workshops to gather data, and then synthesis and uploading as in Phase 1. We envision that WLRS and the local health authorities could likely complete these tasks fully in-house by this stage. The 14 locations for the workshops could be situated across BC, for example: Kelowna, Cranbrook, Nelson, Kamloops, 100 Mile House, Victoria, Nanaimo, Campbell River, Prince George, Fort St. John, Terrace, Abbotsford, Sechelt, and Squamish. The workshops would also be available to all First Nation water system owners/operators and could be developed and offered in coordination with Indigenous Services Canada and the First Nations Health Authority. The First Nations Health Authority was invited to participate at the beginning of Phase 1, but we did not receive a response. However, now that the project is more developed, they may be interested in participating or co-managing, or they may wish to develop a similar system on their own.

5.2 Work Plan

Table 5-1 presents the work plan for Pilot Phase 2, and Table 5-2 presents the work plan for Pilot Phase 3.

¹ The EOCP is a BC-based non-profit association that has established classification systems for water and wastewater systems and certification programs for operators recognized in the *Drinking Water Protection Regulation*. Under the *Drinking Water Protection Regulation*, certification is not always required for water supply systems and operators serving small water systems (less than 500 people). If this requirement is in place, it is specified as a condition on the system's operating permit.

Table 5-1 Suggested Work Plan for Pilot Phase 2: Refining Methods and Developing Workshops

Task	Objectives	Lead Organization (and Partners)	Other Organizations and Roles
Task 1: Establish workshop team (facilitators).	Establish the team and form roles.	WLRS (IH, consultant)	Discuss workshop venue and advertising with host (e.g., EOCP)
Task 2: Develop workshop materials and content. Includes generating advertisement content (for EOCP to circulate).	Refine methods from Phase 1.	IH and EOCP have established relationships with water suppliers and would play a large part in delivering audience-specific content.	Discuss workshop venue and advertising with host (e.g., EOCP)
Task 3: Deliver workshop.	Connect with water suppliers to gather content. Secondary objectives are to 'Inspire' and 'Recruit': teach about watershed science and drinking water hazards; make connections between drinking water suppliers.	WLRS (IH, consultant)	Host (e.g., EOCP), and water suppliers are the participants
Task 4: Data synthesis and results.	Delineate drinking water protection areas.	WLRS (consultant)	None
Task 5: Confirm information/follow up with attendees. Final uploading to GeoBC. Plan next steps.	Confirm the areas look accurate and usable, and launch to GeoBC. Talk about next steps in source protection plans, grants, resources, etc.	WLRS (IH, consultant)	Check information with water suppliers

EOCP – Environmental Operators Certification Program; IH – Interior Health; WLRS – Ministry of Water, Land and Resource Stewardship

Table 5-2 Suggested Work Plan for Pilot Phase 3: Establishment and First Year of Implementation of the Program

Task	Objectives	Approach
Task 1: Program orientation. Train the trainers. Finalize workshop content.	Get the right team engaged to implement project.	Individual communication, then a project start-up meeting to: 1. Establish leadership team and form roles. 2. Get email lists of water suppliers. 3. Finalize content for first virtual meeting and workshop.
Task 2a: Engage water suppliers. Conduct virtual meeting 1.	Inspire! Recruit! Prepare for main workshop. Teach about watershed science and drinking water hazards. Allow water suppliers to make connections with other water suppliers.	Email/website with agenda and information, then host introduction and meet 'n' greet via virtual meeting. The content could include: 1. Objectives of project (example of a protection area, benefits of a protection area). 2. Review water system information needs (homework). Then operators can do it themselves and not attend workshop 2 (if preferred). 3. Go through one or two real example delineation areas if people are ready. Answer any questions, share contact info. 4. Approval for release form signed.
Task 2b: Engage water suppliers in a series of both in-house (e.g.: 14) and 3 virtual workshops.	Gather data necessary to delineate protection areas. Talk about source protection plans.	Workshops will be held (e.g.: three hours for in-person or 2 hours virtual). Agenda could include: 1. Goals of study and data requirements. 2. Open survey tool. Do a practice one. Follow along. Introduce GWELLS as a tool. Self-paced survey with supports. 3. Wrap-up (next steps, source protection plans, approval for release forms).
Task 3: Data synthesis and results.	Develop draft protection areas in KML format.	Email KML files and list of questions to participants.
Task 4: Confirm information/follow up with attendees. Final uploading to GeoBC. Plan next steps.	Confirm the areas look accurate and usable, and launch to GeoBC. Talk about next steps in source protection plans, grants, resources.	Possible options for this task are a virtual call to distribute results, phone, email with link, PDF handout regarding results and next steps on source protection plan, instruction video for next phase. This could include background/review, example results, common questions, any questions from participants, next steps/resources for a source protection plan.

5.3 Suggested Organizational Framework

5.3.1 Ministry of Water, Land and Resource Stewardship

WLRS staff members include hydrogeologists, hydrologists, and watershed scientists. They understand the interaction between the hazards brought on by different land use activities in the watershed and its potential impact on drinking water. They also have a good understanding of the GIS tools that will be the end-product. These skills and WLRS' mandate indicate that WLRS would be best suited to lead this project, or co-lead with regional health authorities (see next section).

5.3.2 Health Authorities

Approximately 4,825 registered drinking water supply systems exist in the province, across five health authorities. In addition, there are over 300 First Nation water systems. Drinking water officers with the health authorities have a working relationship with drinking water system owners, whose commitment and support must be gained to obtain the information needed to develop DWPAs. As such, the health authorities are well-suited to either co-lead the program or heavily support Steps 1 and 2, which include developing a list of candidates (water system owners) for the workshops, helping develop workshop material relevant to the audience, and facilitating portions of the workshop.

5.3.3 Drinking Water System Owners/Operators

The drinking water system owners and/or operators would attend the workshops to provide the data needed to develop the areas, and check that the data are accurate and a good reflection of reality. They would also make use of the data by continuing with the rest of the source protection plan elements (identifying hazards, ranking risks, and making action items to improve drinking water safety). The EOCP and other drinking water related associations will be engaged to inform the operators of this opportunity and otherwise support their aligned source protection and emergency response initiatives.

5.3.4 Consultants

At this time, depending on resourcing, WLRS and IH have all the working relationships, database access, and skills needed to lead this initiative in-house. However, at any time, experts could be brought in to support as needed. When developing cost estimates for Phase 2, we have assumed involvement from suitably qualified consultants to support the development and implementation of the workshop material, deliver the workshop, synthesize data, and compile lessons learned.

In preparing the cost estimates below, we assume that Phase 3 will be completed in-house by WLRS and IH staff, with no support needed from consultants.

5.4 Cost Estimates

Pilot Phase 2, refining methods and testing workshops (to be completed in 2023), is estimated to cost about \$90,000. This includes \$60,000 for WLRS and IH staff, at \$135/hour (average) as agreed to by the leadership team, and \$30,000 for consultants.

Pilot Phase 3, establishment and first year of implementation (2024), is estimated to take 3,000 hours for WLRS and IH staff. Travel to 14 workshops for the WLRS and IH staff is estimated to be \$30,000.

These approximate cost ranges are provided for planning and discussion purposes only, and would need to be refined depending on the partners that are involved.

5.5 Measures of Success

In Phase 2, as an example, if 30 people attend the workshop in-person and 30 online, and 50% of participants delineated a drinking water protection area, that is 30 more systems mapped. Moreover, we will have a clear understanding of interest and engagement. For Phase 3, 14 in-person workshops and three virtual were conceptualized. If 30 water suppliers were to attend each workshop and we have 50% participation by the end of the project, that amounts to 255 drinking water protection areas delineated, representing 5% of all drinking water systems in BC. If the program is continued for 10 years, we have drinking water protection areas for 50% of all drinking water systems delineated.

6 CONCLUSIONS AND RECOMMENDATIONS

Based on the pilot project results, we conclude that a regional approach is feasible for developing and mapping DWPAs and post them as easily accessible mapping layers on the province of BC Data Catalogue (iMap). These DWPAs will support the ultimate objective of improving drinking water safety by making drinking water protection area maps more easily accessible to the drinking water suppliers, regulators, planning agencies, and other responsible parties to help make informed planning, design, monitoring, and emergency response decisions, and ultimately reduce risks to human health. The specific methodological conclusions from the pilot study are:

1. A survey alone may not be sufficient in gathering inputs from water system owners, even with telephone follow-up. A targeted workshop, where the survey is introduced and completed with support, may result in more participation and better quality results.
2. CFR is the most practical way to delineate groundwater DWPA using GIS and publicly available data. AFR is simpler and requires no hydrogeological data, but it may do a poor job of identifying the highest hazard areas (e.g. it could both underestimate and overestimate the capture zone).
3. Intake protection zones are the simplest surface water DWPA to delineate, as only intake locations are needed. DWPAs for specific areas such as watersheds, lakes, or rivers require more manual analysis and additional GIS data in order to be delineated.
4. For surface water intakes, we determined from research elsewhere that the minimum IPZ of 100 m recommended in the Source-to-Tap Assessment Guideline is too small to adequately protect the source in most cases. Therefore, we recommend delineating two concentric IPZs: the 100 m minimum radius and an outer IPZ covering a larger area (1 km radius for large lakes for example). Typically, management of the 100 m inner IPZ is more restrictive than in outer zone, although this would be customized based on risk assessment.

Based on the lessons learned from this study, the regional approach to develop many drinking water protection areas at one time would include the following steps: gathering the necessary information from water system owners via a survey, supported by workshops, followed by data synthesis and GIS analysis.

WLRS has the mandate and capabilities to lead the program, with support from the health authorities, particularly with the workshops for the water system owners, where information about the water system is needed to be transferred to the project team for the project to be a success. At a minimum, this information should include the location of wells or intakes, but ideally also information about the well or intake construction, and water use and demand). The health authorities have established relationships with the water system owners, and as such, they can help facilitate the data

and knowledge transfer readily. Consultants can support in different areas, such as workshop engagement, technical support (e.g., GIS analysts, hydrogeologists, or hydrologists, depending on the need), and project management.

A Phase 2 pilot project is recommended to test the workshop component and refine the methods before implementing the program. Phase 2 can be completed in 6 months, culminating with a workshop at the EOCP conference in September 2023. The budget for Phase 2 is estimated at \$90,000. This includes budgets for WLRS and IH staff at \$135/hour hourly (average), and \$30,000 for consultants' time and travel expenses. Phase 3 is estimated at 3,000 hours for WLRS and IH staff. Travel to 14 workshops for the WLRS and IH staff is estimated at \$30,000.

In terms of measuring success, in Phase 3, 14 in-person workshops and three virtual were conceptualized. If 30 water suppliers attend each, and we have 50% participation by the end of the project, that amounts to 255 drinking water protection areas delineated, representing 5% of all drinking water systems in BC. If the program is continued for 10 years, we will have drinking water protection areas delineated for 50% of all drinking water systems in BC.

CLOSURE

This report was prepared for the Regional District of Okanagan-Similkameen, Interior Health, Ministry of Health, and the Ministry of Water, Land and Resource Stewardship. The authors and project partners greatly appreciate the financial support from the Okanagan Basin Water Board.

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

Respectfully submitted,

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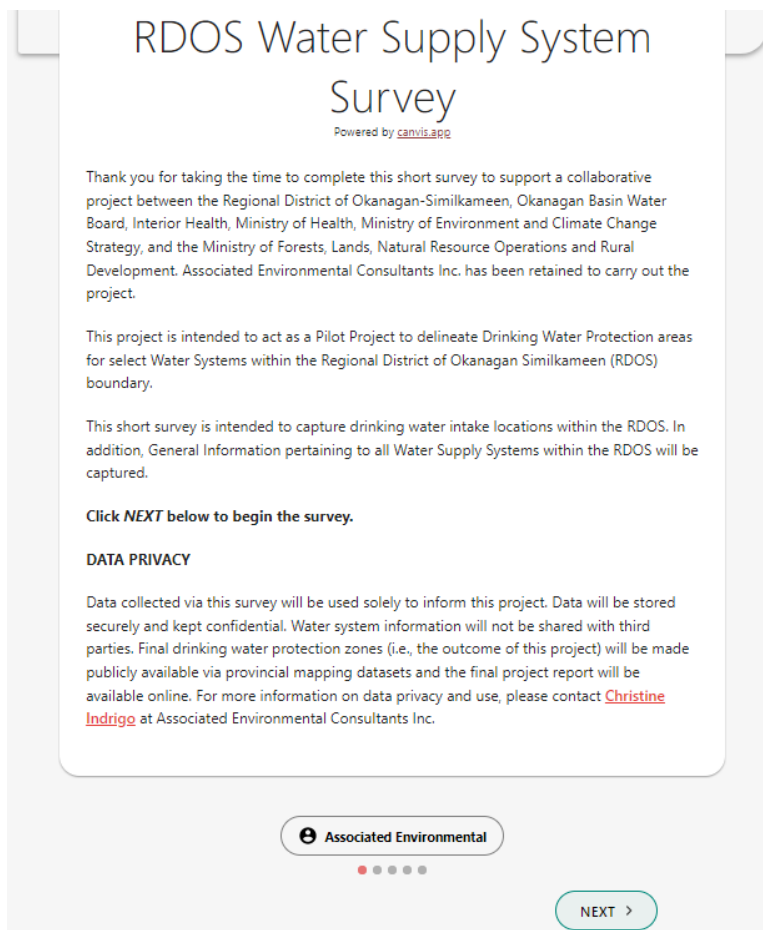
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APPENDIX A – SURVEY QUESTIONS AND INSTRUCTIONS

Date:	January 6, 2022	File:	2021-8866
To:	Keyana Bjornson, Environmental Health Officer, Interior Health	Page:	Page 1 of 8
From:	Marta Green, P.Geo.		
Project:	Regional District of Okanagan Similkameen (RDOS) Pilot Project		
Subject:	RDOS Water Supply System Survey Guide		

1 INTRODUCTION

The purpose of this survey is to collect information on drinking water intakes in the Regional District of Okanagan Similkameen (RDOS). This survey is to support a pilot project with the RDOS to delineate Drinking Water Protection areas. The purpose of this guide is to help the survey participants and the project team helping the survey participants by providing an overview of the steps in the survey in one document, and to provide some tips in parts, where helpful.



**RDOS Water Supply System
Survey**

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Thank you for taking the time to complete this short survey to support a collaborative project between the Regional District of Okanagan-Similkameen, Okanagan Basin Water Board, Interior Health, Ministry of Health, Ministry of Environment and Climate Change Strategy, and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Associated Environmental Consultants Inc. has been retained to carry out the project.

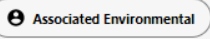
This project is intended to act as a Pilot Project to delineate Drinking Water Protection areas for select Water Systems within the Regional District of Okanagan Similkameen (RDOS) boundary.

This short survey is intended to capture drinking water intake locations within the RDOS. In addition, General Information pertaining to all Water Supply Systems within the RDOS will be captured.

Click *NEXT* below to begin the survey.

DATA PRIVACY

Data collected via this survey will be used solely to inform this project. Data will be stored securely and kept confidential. Water system information will not be shared with third parties. Final drinking water protection zones (i.e., the outcome of this project) will be made publicly available via provincial mapping datasets and the final project report will be available online. For more information on data privacy and use, please contact [Christine Indrigo](#) at Associated Environmental Consultants Inc.



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[NEXT >](#)

Figure 1-1. Survey Page 1

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1.1 General Tips

- Recommended internet browsers are Edge, Chrome, Safari, and Firefox. Internet Explorer is not supported and IS NOT recommended to complete the survey.
- Indicate units for questions related to demand, pumping rates, intake/well depth, and well diameter. Participants can provide information in any unit as long as it is indicated in the response.
- For groundwater wells, the most important and useful information to provide is a Well ID Plate (WIDP) or Well Tag Number (WTN).
- Two known barriers to participation are the inability to go back and change/add to a survey response and the survey length (participants may not have all information on hand)
 - If participants need to change or add more information, they can email Christine Indrigo at indrigoc@ae.ca.

2 PAGE 2: WATER SUPPLY SYSTEM - GENERAL INFORMATION

This page collects general information on the water supply system including:

1. Water Supply System Name (*key information to provide)
2. # of connections
3. Primary types of connections
4. Average annual demand (provide units)
5. Average summer demand (provide units)
6. Average winter demand (provide units)

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Water Supply System - General Information

Questions on this page are intended to capture *General Information* on your Water Supply System.

Please respond to as many of the below questions as possible. Any information is useful! None of the questions are required fields, and all responses can be entered as free text.

Please include the name of your Water Supply System to allow this information to be reconciled with the intake location on the next page.

Once complete, click *NEXT* to proceed to the next page.

Water Supply System Name

Response

How many connections does the Water Supply System Service?

Response

What are the primary types of connections?

☐ Agricultural

☐ Domestic / Residential

☐ Commercial / Industrial

☐ Other

What is the average annual demand (amount of water used annually)? Please include units (e.g., L/s, USgpm, m3/yr, etc.).

Response

What is the average summer (May-September) demand? Please include units (e.g., L/s, USgpm, m3/yr, etc.).

Response

Figure 2. Survey Page 2: General information questions

3 PAGE 3: WATER SUPPLY SYSTEM - INTAKE INFORMATION

This page includes an interactive map. Participants drop a pin on the map by clicking the location of the water intake and selecting one of two options: Surface Water Intake or Groundwater Intake. This will bring up a list of questions.

Water Supply System - Intake Information

Questions on this page are intended to capture information on your Water Supply System's *Intake*.

Please respond to as many of the questions as possible. Any information is useful! None of the questions are required fields, and all responses can be entered as free text.

INSTRUCTIONS

Please read **all** instructions below before moving to the map / survey questions.

- Using the map on the right, please zoom to the location of your Water System's Intake Location / Groundwater Well(s).
- Click the map at the intake location!
- If your Water Supply System uses a Surface Water source, please select the "Surface Water Intake" layer and proceed through the survey questions. Please include the name of your Water Supply System to allow this information to be reconciled with the General Water Supply System information on the previous page.
- If your Water Supply System uses a Groundwater source (Groundwater well), please select the "Groundwater Intake" layer and proceed through the survey questions. Please include the name of your Water Supply System to allow this information to be reconciled with the General Water Supply System information on the previous page.
- Ensure you SAVE survey responses by clicking the SAVE button in the bottom left of the survey question window.**
- If you have multiple intake locations / Groundwater wells, please include each location as a separate point - survey questions should be answered for each intake / Groundwater well. Save and Close the responses for each intake / Groundwater well and click a new location to add an additional intake / Groundwater well.

ADDITIONAL INFORMATION

If you have additional information that may be relevant to this project (e.g., well logs, pumping test data, hydrometric records,

< BACK

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Figure 3. Page 3: Interactive map to indicate intake location(s)

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Water Supply System - Intake Information

Questions on this page are intended to capture information on your Water Supply System's *Intake*.

Please respond to as many of the questions as possible. Any information is useful! None of the questions are required fields, and all responses can be entered as free text.

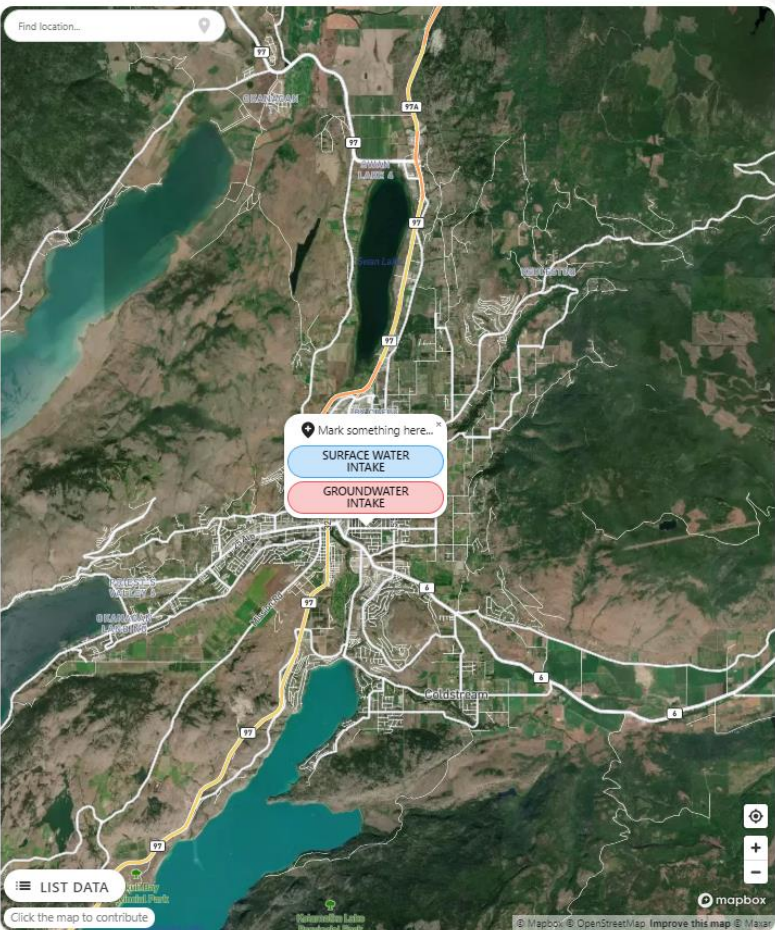
INSTRUCTIONS

Please read **all** instructions below before moving to the map / survey questions.

- Using the map on the right, please zoom to the location of your Water System's Intake Location / Groundwater Well(s).
- Click the map at the intake location!
- If your Water Supply System uses a Surface Water source, please select the "Surface Water Intake" layer and proceed through the survey questions. Please include the name of your Water Supply System to allow this information to be reconciled with the General Water Supply System information on the previous page.
- If your Water Supply System uses a Groundwater source (Groundwater well), please select the "Groundwater Intake" layer and proceed through the survey questions. Please include the name of your Water Supply System to allow this information to be reconciled with the General Water Supply System information on the previous page.
- Ensure you SAVE survey responses by clicking the SAVE button in the bottom left of the survey question window.**
- If you have multiple intake locations / Groundwater wells, please include each location as a separate point - survey questions should be answered for each intake / Groundwater well. Save and Close the responses for each intake / Groundwater well and click a new location to add an additional intake / Groundwater well.

ADDITIONAL INFORMATION

If you have additional information that may be relevant to this project (e.g., well logs, pumping test data, hydrometric records,



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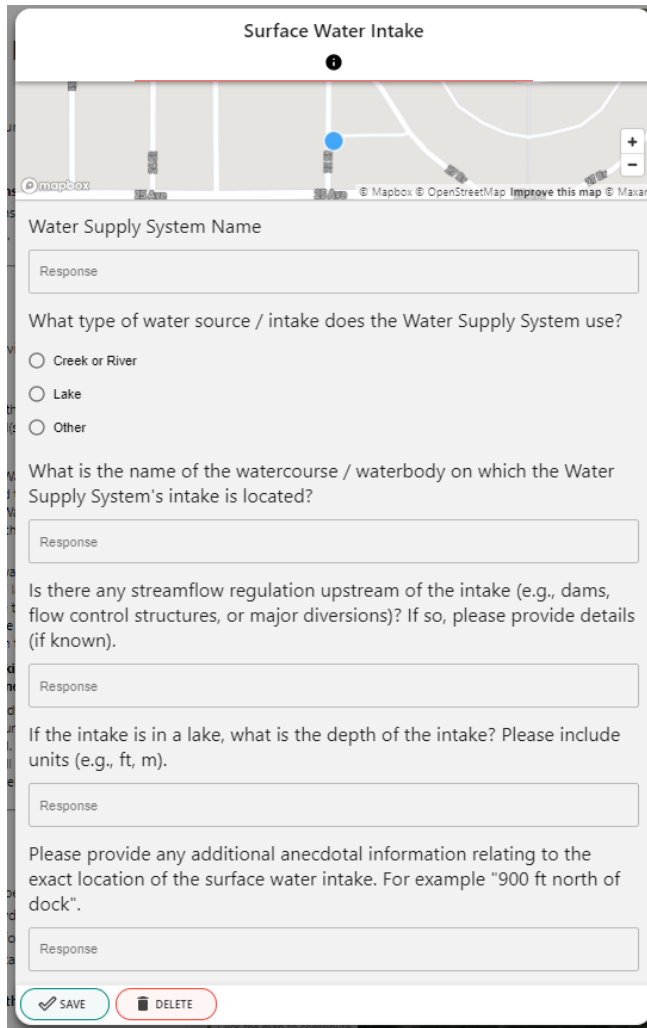
Figure 4. Page 3. Marking a water intake location

3.1 Surface Water Intake questions

- Water Supply System Name
- Type of water source/intake
- Name of water course/waterbody
- Presence of streamflow regulation (dams, diversions, etc.)
- Intake depth (if in a lake) (provide units)
- Additional information on intake location

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Surface Water Intake

Water Supply System Name

Response

What type of water source / intake does the Water Supply System use?

☐ Creek or River

☐ Lake

☐ Other

What is the name of the watercourse / waterbody on which the Water Supply System's intake is located?

Response

Is there any streamflow regulation upstream of the intake (e.g., dams, flow control structures, or major diversions)? If so, please provide details (if known).

Response

If the intake is in a lake, what is the depth of the intake? Please include units (e.g., ft, m).

Response

Please provide any additional anecdotal information relating to the exact location of the surface water intake. For example "900 ft north of dock".

Response

SAVE DELETE

Figure 5. Page 3. Surface water intake questions

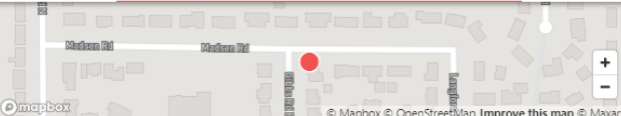
3.2 Groundwater Intake questions

1. Water Supply System Name (**key information to provide*)
2. # of wells in the system (if more than one, add a new point for each well)
3. Well ID Plate (WIDP) or Well Tag Number (WTN) (**key information to provide if available*)
4. Well diameter (*provide units*)
5. Well pumping rate (*provide units*)
6. Pump pumping rate rate (*provide units*)
7. Well depth rate (*provide units*)
8. Aquifer type
9. Do you have a water licence? If so, provide the annual volume
10. Have you applied for a water licence? If so, provide the annual volume
11. Additional information on well location

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Groundwater Intake



Water Supply System Name

Response

How many wells does the system have? (If more than one, please answer these survey questions for each well. Save and close the survey for this well, and add a new point for each well.)

Response

If the well has a Well ID Plate (WIDP) or Well Tag Number (WTN), please include these numbers below. If these numbers are unavailable, please specify the name used to identify it (e.g., North Well).

Response

What is the diameter of the groundwater well? Please include units (e.g., in, cm).

Response

What pumping rate is the groundwater well rated for? Please include units (e.g., USgpm, L/s, m3/s).

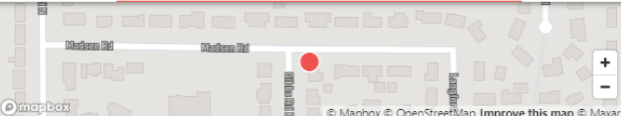
Response

What pumping rate is the pump rated for? Please include units (e.g., USgpm, L/s, m3/s).

Response

✓ SAVE
🗑 DELETE

Groundwater Intake



Response

What pumping rate is the pump rated for? Please include units (e.g., USgpm, L/s, m3/s).

Response

How deep is the groundwater well? Please include units (e.g., ft, m).

Response

What aquifer type is the well installed in?

☐ Unconfined sand and gravel aquifer
☐ Confined sand and gravel aquifer
☐ Bedrock aquifer
☐ Unknown

Do you have a water licence issued from the Province of BC? If so, what is the annual volume?

Response

Have you applied for a water licence from FrontCounterBC? If so, what is the annual volume you've applied for? Please include units (e.g., m3/year).

Response

Please provide any additional anecdotal information relating to the exact location of the groundwater well. For example "900 ft north of barn".

Response

✓ SAVE
🗑 DELETE

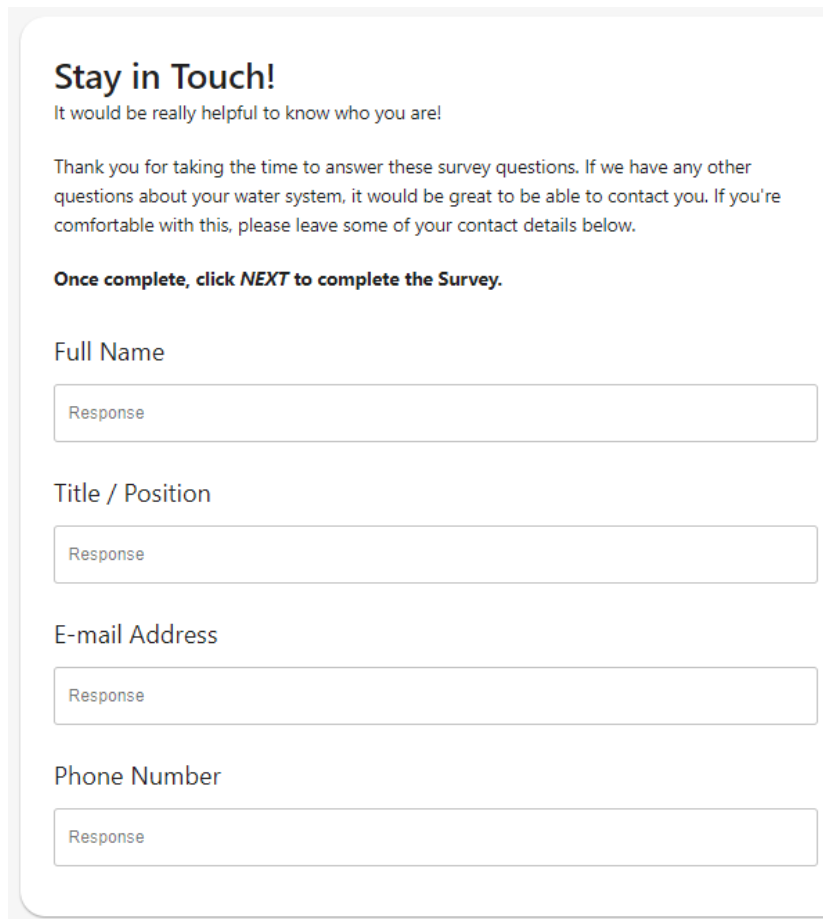
Figure 6. Page 3. Groundwater intake questions

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4 PAGE 4: CONTACT INFORMATION

Participants have the option to provide their contact information for further follow up.



Stay in Touch!
It would be really helpful to know who you are!

Thank you for taking the time to answer these survey questions. If we have any other questions about your water system, it would be great to be able to contact you. If you're comfortable with this, please leave some of your contact details below.

Once complete, click *NEXT* to complete the Survey.

Full Name

Title / Position

E-mail Address

Phone Number

Figure 7. Page 4. Contact information section

5 PAGE 5: CLOSING

For any questions or to provide additional information, participants can contact Christine Indrigo at indrigoc@ae.ca.

APPENDIX B - GROUNDWATER DELINEATION

1 METHODS

For groundwater wells, three methods were used to delineate capture zones:

1. Arbitrary fixed radius;
2. CFR; and
3. Analytical method.

Associated used the well locations provided in the survey responses for the centre point of each capture zone rather than the well locations listed in GWELLS (Groundwater Wells spatial layer; BC MOE 2020a). Based on a review of the surveys, the location of the wells in GWELLS did not exactly match the survey results. The water supply owner or operator is the expert on the location of their infrastructure; therefore, it is reasonable to assume that the survey results are more accurate than the data in GWELLS.

1.1 Method 1: Well Protection Area, Arbitrary Fixed Radius

The arbitrary fixed radius is a method of delineating capture zones using a circle around the wellhead, with a generic fixed radius. Associated used a radius of 100 m around each well head, as land use in the area defined by this radius (approximately 0.314 ha) represents the highest risk to a well and is the minimum distance recommended in the BC Comprehensive Drinking Water Source-to-Tap Assessment Guideline (MELP 2004; Module 1, MHLS 2010).

1.2 Method 2: Well Protection Area, Calculated Fixed Radius

The CFR method uses an equation to determine a fixed radius around each wellhead based on the pumping rate, time of travel (TOT) to the well, aquifer porosity, and the aquifer thickness or screen length.

The CFR equation to calculate the radius (r) in metres is:

$$r = \sqrt{\frac{10038 \times Q \times t}{n \times b}}$$

where Q is the pumping rate in litres per second, t is the TOT to the well in years, n is the estimated aquifer porosity, and b is the aquifer thickness or screen length. Aquifer thickness is estimated from the well records in GWELLS and hydrogeologic cross-sections of the local area. When aquifer thickness cannot be determined, screen length can be used (MELP et al. 2004).

In the CFR calculations, Associated used the well yields provided in the surveys. When no yield information was provided, calculated the pumping rate was calculated as the number of connections (provided in the survey responses) multiplied by 0.02627 L/s (MELP 2004). The TOT was specified as 200 days, 5 years, and 25 years, as described in Table 2-1. An aquifer porosity value of 0.25 is used for sand and gravel or unknown aquifer types. Aquifer thickness values for each of these wells were determined by WLRS based on screen length information in GWELLS. For the single bedrock well, Associated used an aquifer porosity of 5% and used the average well depth minus static water level for other wells in the same aquifer within a 300 m radius, which was 66 m. This bedrock porosity value is the average for fractured crystalline rock, which is between 0-10%, from Table 2.4 in Freeze and Cherry (1979). Using

these inputs, individual shapefiles were created for each TOT value in QGIS by calculating the radius and creating buffers around the wells with the calculated radii. The CFR method requires some manual analysis to determine the aquifer thickness or screen length, as this value is not readily available in the groundwater wells spatial layer.

1.3 Method 3: Well Protection Area, Groundwater Analytical Method

The analytical method is determined from three components: the half-width of the capture zone (Y), the distance to the capture zone boundary downgradient of the well (X), and the distance representing the TOT (d_{TOT}).

The equation for the half-width of the capture zone (Y) in metres is:

$$Y = \frac{Q}{2000 \times T \times i}$$

where Q is the pumping rate in L/s, T is the transmissivity in m^2/s , and i is the slope of the water table, or the hydraulic gradient, under non-pumping conditions (MELP et al. 2004).

The pumping rate, Q , is estimated from well yields provided in the survey responses. When no well yield information was provided, the pumping rate was calculated as the number of connections (provided in the survey responses) multiplied by 0.02627 L/s (MOE 2004). Transmissivity is calculated as $T = Kb$, where K is the hydraulic conductivity (m/y) and b is the aquifer thickness (m). Transmissivity values were calculated from available pumping test information or were estimated on the basis of aquifer type if no pumping test data were available. Slope was estimated by the ground surface topography over a distance of 300 m from the wellhead using the national topographic system 1:50,000 digital elevation model for areas 82e and 92h (GeoBC 2003). Slope values range from 0.003 m to 0.073 m. Hydraulic conductivity values were determined by WLRS staff for each well from the values for transmissivity and aquifer thickness (i.e., $K = T/b$).

The equation for the distance to the capture zone boundary downgradient of the well (X) in metres is:

$$X = \frac{Y}{\pi}$$

The equation for the distance representing TOT is:

$$d_{TOT} = \frac{t \times K \times i}{n}$$

where K is the hydraulic conductivity of the aquifer in m/y, t is the specified TOT in years, i is the slope of the water table or hydraulic gradient, and n is the aquifer porosity (MELP et al. 2004).

Associated used specified times of travel of 200 days, 5 years, and 25 years and assumed an aquifer porosity value of 0.25 for sand and gravel aquifers.

Shapefiles were not created from the analytical method results, as discussed in below Section 3.2.4.

1.4 Hydrogeologic Mapping to Refine Capture Zones

After calculating the capture zone radii, Associated used hydrogeologic mapping to further refine the well protection areas. For wells identified within sand and gravel aquifers, Associated clipped the well protection area extent by the mapped aquifer boundary using the ground water aquifers spatial layer (BC MOE 2020b). Where no aquifer has been mapped, Associated used quaternary mapping boundaries from the Geological Quaternary Alluvium and Cover spatial layer (BC Geological Survey 2018). If a well is located in a sand and gravel aquifer but no mapping of the aquifer extent or quaternary area is available, manual hydrogeologic mapping was done based on topographic contours. Wells identified within bedrock aquifers were not clipped, retaining the full circular well protection areas as predicted by the methods described above.

APPENDIX C – SURFACE WATER DELINEATION

1 INTRODUCTION

1.1 Background and Objectives

Associated Environmental is supporting the Regional District of Okanagan-Similkameen (RDOS) in completing a pilot mapping project to support source water protection. During the pilot project, it became apparent that several methods were being used across Canada for developing surface water drinking water protection areas. The objective of this task was to review these different methods and make a recommendation on a method that could be used across BC for small water systems, and to develop consistent terminology.

To support this objective, Associated completed the following tasks:

- Literature review of currently used methods. Associated reviewed the BC Ministry of Health's Comprehensive Source-to-Tap, Ontario's Source Water Protection documents, and methods completed by consultants whose reports were available on EcoCat or were provided by Interior Health.
- Tested a selected subset of methods and delineation areas.

1.2 Literature Review

1.2.1 Types of Methods

BC's Comprehensive Drinking Water Source-to-Tap Assessment Guideline Module 1 includes the following recommended methods to define the assessment area for surface water intakes such as streams, lakes, and rivers⁹:

- Intake protection zone (min 100 m radius) plus watershed area, or:
- Intake protection zone (min 100 m radius) plus either
 - Corridors (fixed length, time of travel)
 - Arbitrary fixed radius from intake
 - Custom delineation based on risk associated with certain biogeophysical or human features

1.2.2 Existing Source Water Protection Plans

Associated reviewed and considered the methods and results of several SWPP reports including:

- Christina Lake Water Utility Source Water Protection Plan
- Source Assessment of the Cedar Heights Shuswap Lake Drinking Water Intake
- Source Assessment of the District of Sicamous Mara Lake Drinking Water Intake
- Source Assessment of the Sorrento Shuswap Lake Drinking Water Intake

Ontario has 38 local source protection plans developed by 19 source protection committees across the province. Here, we focus on the Approved Source Protection Plan: CTC Source Protection Region covering the Credit Valley, Toronto and Region, and Central Lake Ontario.

⁹ British Columbia Ministry of Healthy Living and Sport (MHLS). 2010. Comprehensive Source-To-Tap Assessment Guideline. Available at: <http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators#source-to-tap-assessment>

In this pilot project, the Christina Lake Water Utility SWPP and Ontario's methods were used as the main guidance documents for delineating the surface water protection areas. The Christina Lake Water Utility SWPP uses an IPZ radius of 1 km to account for boating, water activity hazards, and campgrounds with an additional 120 m setback onto land to capture any septic tank systems near the intake area. The Christina Lake SWPP also delineated two assessment areas. Assessment Area A covers the south half of the lake with a 1 km buffer onto land to capture the highway, with the potential for road salt, sediment, and spill contamination, and lakeside properties. Assessment Area B includes a 500 m buffer around major tributaries on the south half of the lake. Ontario uses multiple IPZ levels and has additional areas to capture additional hazards outside of the IPZ, such as event-based areas and issue contributing areas (see Table B-1).

1.2.3 Terminology

Table B-1 lists terms and definitions used in the existing surface water protection area assessments mentioned in Section 1.2.2.

Table B-1 Terminology and definitions used in existing surface water protection area assessments

Term	Type	Definition	Source
Contributing watershed area	Surface water	The land area from which water drains to the intake.	BC Source-to-Tap ¹
Intake protection zone	Surface water	A circular area surrounding the intake with a radius of at least 100 metres.	BC Source-to-Tap ¹
Assessment area	Surface water	For most surface water sources, the assessment area includes the contributing watershed or portion plus an intake protection zone.	BC Source-to-Tap ¹
Event-Based Area (EBA)	Surface water	An area within a watershed where a spill could pollute the drinking water supply because of sanitary sewers, sewage treatment plants or pipelines that are close to rivers, streams or other water bodies.	Thames-Sydenham and Region Source Protection Plan Glossary of Terms ¹⁰
Issue Contributing Area (ICA)	Surface water	An area where land based activities contribute to the presence of an unwanted substance in the water source. Activities producing the substance may be prohibited or need to be managed more effectively.	Source Protection Plan: CTC Source Protection Region ^{11,12}
Wellhead protection area	Groundwater	Areas on the land around a municipal well, the size of which is determined by how quickly water travels underground to the well, measured in years.	Source Protection Plan: CTC Source Protection Region ⁴

¹⁰ Thames-Sydenham and Region Source Protection Committee. 2015. Thames-Sydenham and Region Source Protection Plan Glossary of Terms. Available at: https://www.sourcewaterprotection.on.ca/wp-content/uploads/sp_plan3/SupDocs/Glossary/SPP%20-%20Glossary%20of%20Terms%20and%20Acronyms.pdf

¹¹ CTC Source Protection Committee. 2018. Source Water Glossary. Accessible at: <https://ctcswp.ca/resources/source-water-glossary/>

¹² CTC Source Protection Committee. 2022. Approved Source Protection Plan: CTC Source Protection Region. Accessible at: https://ctcswp.ca/app/uploads/2022/05/RPT_20220520_Amended_CTCSP v5_clean.pdf

Term	Type	Definition	Source
Intake Protection Zone (IPZ)	Surface water	The area on the water and land surrounding a municipal surface water intake. The size of each zone is determined by how quickly water flows to the intake, in hours.	Source Protection Plan: CTC Source Protection Region ⁴
IPZ-1	Surface water	1-km circle around the intake if it is located in one of the Great Lakes. First zone around an intake, very vulnerable to contamination.	Source Protection Plan: CTC Source Protection Region ⁴
IPZ-2	Surface water	The area where water can reach the intake in a specific time, 2 hours in the CTC. Second zone around an intake where direct impacts are possible – contaminants may reach the intake within 2 hours.	Source Protection Plan: CTC Source Protection Region ⁴
IPZ-3	Surface water	Delineated if modelling demonstrates that spills from a specific activity that is located outside IPZ-1 and IPZ-2 may be transported to an intake and result in a deterioration of the water quality at an intake. Third and largest zone around the intake where activities can impact the source water, but there is time to take action to ensure the intake and municipal water is not impacted.	Source Protection Plan: CTC Source Protection Region ⁴
Highly Vulnerable Aquifer (HVA)	Groundwater	An aquifer that can easily be affected by contamination from human activities and natural processes as a result of its intrinsic susceptibility or by preferential pathways.	Source Protection Plan: CTC Source Protection Region ⁴
Wellhead Protection Area A (WHPA-A)	Groundwater	100 m fixed radius around the well.	Thames-Sydenham and Region Source Protection Plan Glossary of Terms ¹³
Wellhead Protection Area B	Groundwater	2 year time of travel to the well, excluding the area of WHPA-A.	Thames-Sydenham and Region Source Protection Plan Glossary of Terms ⁴
Wellhead Protection Area C	Groundwater	2 to 5 year time of travel to the well.	Thames-Sydenham and Region Source Protection Plan Glossary of Terms ⁶
Wellhead Protection Area D	Groundwater	5 to 25 year time of travel to the well.	Thames-Sydenham and Region Source Protection Plan

¹³ Thames-Sydenham and Region Source Protection Committee. 2015. Thames-Sydenham and Region Source Protection Plan Glossary of Terms. Available at: https://www.sourcewaterprotection.on.ca/wp-content/uploads/sp_plan3/SupDocs/Glossary/SPP%20-%20Glossary%20of%20Terms%20and%20Acronyms.pdf

Term	Type	Definition	Source
			Glossary of Terms ⁶
Wellhead Protection Area E	Groundwater	Delineated if surface water system influence effectively bypasses the aquifer's protection.	Thames-Sydenham and Region Source Protection Plan Glossary of Terms ⁶
Wellhead Protection Area F	Groundwater	Delineated if the well is subject to issues, which originate from outside the other parts of the Wellhead Protection Area	Thames-Sydenham and Region Source Protection Plan Glossary of Terms ⁶

2 PILOT PROJECT CONSIDERATIONS

2.1 Methods

The following are concepts to be considered when developing drinking water protection areas:

- There are over 1,200 water systems within the Interior Health Authority region, and close to 5,000 in BC. Drinking Water Protection Areas would be used by a diverse audience, including: operators, planners and policy makers, emergency responders, consultants, and the general public. As such, the language and communication needs to be able to reach a wide audience.
- There is not a large source of funding to complete these, as such the areas need to be simple for most cases.

2.1.1 Area A – Intake Protection Zone

Two distances are used for the intake protection zones in this pilot. IPZ i. is a 100 m radius, following Module 1 of the Source-to-Tap Guideline. IPZ ii. is a 1km buffer was selected for the IPZ, following methods used in the Christina Lake Water Utility Source Water Protection Plan (Associated Environmental, 2019).

2.1.2 Area B – Watershed

To create the watershed area, Associated used the Freshwater Atlas Watersheds dataset available on GeoBC¹⁴ and selected watersheds intersecting with the 1 km IPZ for each intake.

2.1.3 Area C – Lake and Stream Buffers

Associated produced two additional buffer areas: a 600 m lake buffer (300 m on each side of the coastline) and 200 m stream buffer (100 m on each side of the stream). This area was selected to capture lakeside properties and salt and sediment runoff from nearby roads. A 200 m buffer was selected for streams within the intake sub-watersheds to capture areas draining into the intake watercourse or waterbody.

¹⁴ GeoBC Branch. 2008. Freshwater Atlas Watersheds. Accessible at: <https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-watersheds>

The lake and stream buffer areas were delineated using the output of Area B – Watershed for each intake. The lake buffer uses the Freshwater Atlas Lakes shapefile¹⁵ and the stream buffer uses the Freshwater Atlas Stream Network shapefile¹⁶, both hosted on GeoBC. The lake buffer was created by extracting the FWA Lakes coastlines that fall within the Area B – Watershed boundaries and then applying a 300 m buffer to each side. The stream buffer was created by extracting the FWA Stream Network streams falling within the Area B – Watershed boundaries and applying a 100 m buffer to each side.

2.2 Pilot Test Results and Discussion

Module 1 of the Source-to-Tap Guideline only requires a minimum of 100 m for the IPZ around a surface water intake. We determined 100 m to be too small for most of the intakes provided in the survey responses, as several are located in large lakes spanning several kilometres, such as Okanagan Lake. Similarly, the City of Kelowna Okanagan Lake Intakes Source Protection Report found 100 m to be insufficient for the City of Kelowna's intakes on Okanagan Lake, providing between 21 to 46 minutes of protection¹⁷, considerably shorter than the recommended minimum time of travel of two hours that is used in Ontario for IPZ-2¹⁸.

To provide a more conservative protection area, we also used a radius of 1 km for the IPZ. Table B-2 provides some of the surface water SWPPs Associated reviewed for this pilot project and the IPZ distances for each study. Ontario uses 1 km as the radius for any intakes located in the Great Lakes and the Christina Lake SWPP used a 1 km radius to prioritize hazards associated with boating and water activities.

The minimum IPZ distances in the Cedar Heights Shuswap Lake, Mara Lake, Sorrento Shuswap Lake, and Okanagan Lake source assessments were determined using drogue studies based on the furthest travel distance in two hours. The Okanagan Lake source assessment looked at four intakes at varying depths and reported proposed IPZs in hectares rather than minimum recommended distances. The fastest drogue in the Okanagan Lake study travelled ~600 m in two hours. The Okanagan Lake study produced an additional 5 hour buffer zone for each intake based on the drogue results, to capture high risk areas "where land use can impact the intake but where a contaminant spill would not be an immediate threat to the intake"⁷.

¹⁵ GeoBC Branch, 2008. Freshwater Atlas Lakes. Accessible at: <https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-watersheds>

¹⁶ GeoBC Branch, 2008. Freshwater Atlas Stream Network. Accessible at: <https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-stream-network>

¹⁷ Larratt, H. 2019. City of Kelowna – Okanagan Lakes Source Protection Report

¹⁸ Lake Simcoe Region Conservation Authority. 2015. South Georgian Bay Lake Simcoe Source Protection Plan. Available at: <https://ourwatershed.ca/assets/uploads/2021/10/2021-09-13-AmendedSourceProtectionPlan.pdf>

Table B-2 Source Water Protection Plans and Their Recommended IPZ Areas

Surface Water SWPP	IPZ
Christina Lake Water Utility Source Water Protection Plan ¹⁹	1 km
Source Assessment of the Cedar Heights Shuswap Lake Drinking Water Intake ²⁰	Minimum: >500 m
Source Assessment of the District of Sicamous Mara Lake Drinking Water Intake ²¹	Minimum: 455 m
Source Assessment of the Sorrento Shuswap Lake Drinking Water Intake ²²	Minimum: 470 m
City of Kelowna – Okanagan Lake Intakes Source Protection Report ²³	8.2 to 33.9 ha

2.3 Recommendations

Delineating IPZs for a larger dataset could be achieved using the Water Rights Licences – Water Utilities data available from iMapBC for the active licences layer *Waterworks: Local Provider*.

Watercraft use in shallow waters can increase turbidity by disturbing sediment on the lake bottom. Larratt (2019) recommends that boats in water <5 m deep operate at low power to minimize wake generation and found that wakes can increase turbidity in water as deep as 8 m. We recommend also delineating “no wake zones” as areas with bathymetry less than 8 m deep and including this layer with the overall surface water intake protection areas. In addition to protecting municipal water intakes, implementing no wake zones would help to protect private lake intakes that fall within these shallow areas.

¹⁹ Associated Environmental. 2019. Christina Lake Water Utility Source Protection Plan. Accessible at: <https://jointheconversation.rdkb.com/9514/widgets/37521/documents/28039>

²⁰ Self, J., and H. Larratt, 2013. Source Assessment of the District of Sicamous Mara Lake Drinking Water Intake. Prepared by Larratt Aquatic Consulting Ltd. Prepared for the District of Sicamous.

²¹ Self, J., and Larratt, H., 2015. Source Assessment of the Cedar Heights Drinking Water Intake. Prepared by Larratt Aquatic Consulting Ltd. Prepared for the Columbia-Shuswap Regional District.

²² Self, J., and Larratt, H., 2015. Source Assessment of the Sorrento Shuswap Lake Drinking Water Intake. Prepared by Larratt Aquatic Consulting Ltd. Prepared for the Columbia-Shuswap Regional District.

²³ Larratt, H. 2019. City of Kelowna – Okanagan Lakes Source Protection Report

APPENDIX D – SURVEY RESULTS

Responses in Tables D-1, D-2, and D-3 are fabricated to protect the privacy of survey participants.

Table D-1 General Survey Questions – Example Responses

Question	Response #1	Response #2	Response #3	Response #4	Response #5
Q1: Water Supply System Name	Big City Well	Family Well	Small Town Lake Intake	Winery	RV Community Living
Q2: How many connections does the Water Supply System Service?	20,000	1	500	3	25
Q3: What are the primary types of connections?	Domestic / Residential, Commercial / Industrial	Domestic / Residential	Agricultural, Domestic / Residential	Commercial / Industrial	Domestic / Residential
Q3: other	1 golf course				
Q4: What is the average annual demand (amount of water used annually)? Please include units (e.g., L/s, USgpm, m3/yr, etc.).	18 MLD	Unknown	550,000 m3/year	Unknown	80,000 m3/year
Q5: What is the average summer (May-September) demand? Please include units (e.g., L/s, USgpm, m3/yr, etc.).	30 MLD	Unknown	15,000 m3/day	Unknown	250 m3/day
Q6: What is the average winter (October-April) demand? Please include units (e.g., L/s, USgpm, m3/yr, etc.).	10 MLD	Unknown	1,000 m3/day	Unknown	100 m3/day
Q7: What is the Water Supply System's Maximum Capacity / Design Capacity? Please include units (e.g., L/s, USgpm, m3/yr, etc.).	100 MLD	25 USgpm	Unknown	75 USgpm	400 m3/day
Q8: Full Name	-	-	-	-	-
Q9: Title / Position	Water Operator	-	Utility Manager	Winery Manager	Property Manager
Q10: E-mail Address	-	-	-	-	-
Q11: Phone Number	-	-	-	-	-

Table D-2 Surface Water Intake Questions – Example Responses

Question	Response #3	Response #5
Q1: Water Supply System Name	Small Town Lake Intake	RV Community Living
Q2: What type of water source / intake does the Water Supply System use?	Lake	Lake
Q2: other	-	-
Q3: What is the name of the watercourse / waterbody on which the Water Supply System's intake is located?	Blue Lake	Imaginary Lake
Q4: Is there any streamflow regulation upstream of the intake (e.g., dams, flow control structures, or major diversions)? If so, please provide details (if known).	Dam structure on Cascade Creek ~25 km upstream from the lake	None
Q5: If the intake is in a lake, what is the depth of the intake? Please include units (e.g., ft, m).	15 m	8 m
Q6: Please provide any additional anecdotal information relating to the exact location of the surface water intake. For example, "900 ft north of dock".	75 m from shore	20 m from shore

Table D-3 Groundwater Well Questions – Example Responses

Question	Response #1	Response #1	Response #1	Response #2	Response #4
Q1: Water Supply System Name	Big City Well	Big City Well	Big City Well	Family Well	Winery
"Q2: How many wells does the system have? (If more than one, please answer these survey questions for each well. Save and close the survey for this well and add a new point for each well.)"	3	3	3	1	1
Q3: If the well has a Well ID Plate (WIDP) or Well Tag Number (WTN), please include these numbers below. If these numbers are unavailable, please specify the name used to identify it (e.g., North Well).	WIPN 112233	WIPN 112244	WIPN 112255	WIPN 123456	WTN 98765
Q4: What is the diameter of the groundwater well? Please include units (e.g., in, cm).	8 in	12 in	6 in	6"	200 mm
Q5: What pumping rate is the groundwater well rated for? Please include units (e.g., USgpm, L/s, m3/s).	200 USgpm	100 USgpm	150 USgpm	35 USgpm	75 USgpm
Q6: What pumping rate is the pump rated for? Please include units (e.g., USgpm, L/s, m3/s).	180 USgpm	100 USgpm	125 USgpm	Unknown	50 USgpm
Q7: How deep is the groundwater well? Please include units (e.g., ft, m).	65 ft	90 ft	45 ft	12 m	500 ft
Q8: What aquifer type is the well installed in?	Confined sand and gravel aquifer	Confined sand and gravel aquifer	Unconfined sand and gravel aquifer	Unknown	Bedrock
Q9: Do you have a water licence issued from the Province of BC? If so, what is the annual volume?	Yes	Yes	Yes	Unknown	Unknown
Q10: Have you applied for a water licence from FrontCounterBC? If so, what is the annual volume you've applied for? Please include units (e.g., m3/year).	40,000 m3/year	30,000 m3/year	25,000 m3/year	No	Have not applied yet
Q11: Please provide any additional anecdotal information relating to the exact location of the groundwater well. For example "900 ft north of barn".		Beside city hall	North of 15th St. agricultural field	Behind the house in a small structure	Between two vineyard areas

