

BRITISH COLUMBIA SMALL WATER SYSTEMS SOURCE PROTECTION PLAN TOOLKIT

Prepared for:

Interior Health Authority

519 Columbia Street
Kamloops, B.C.
V2C 2T8

Prepared by:

Urban Matters CCC

550–1090 Homer St.
Vancouver, British Columbia
V6B 2W9

Project 1900.0006.01

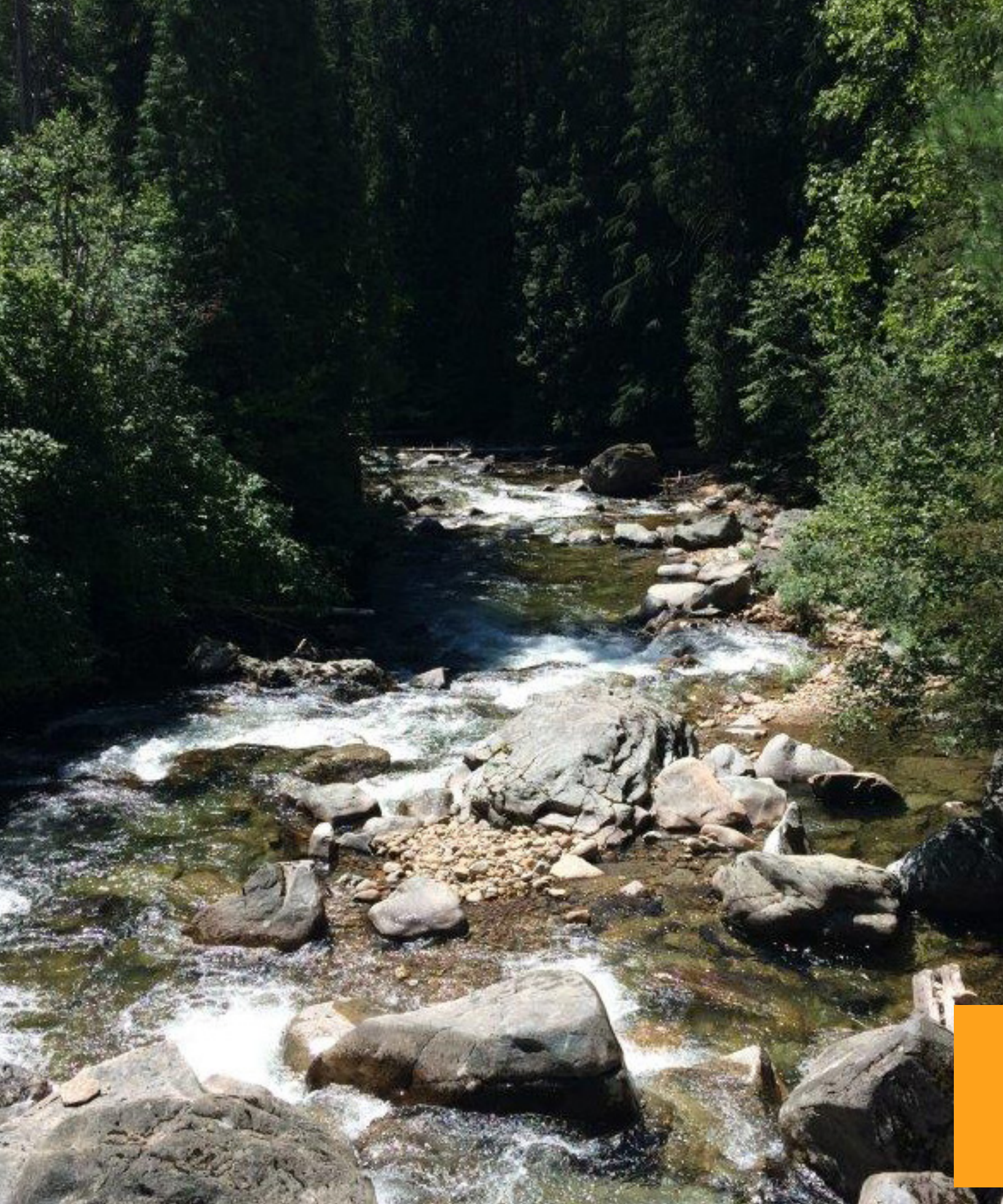
March 2017

urban
matters



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INTRODUCTION



Source water is the surface water and groundwater that is available for use by a water system provider. A **surface water** source is open and flowing at the point of withdrawal and includes streams, lakes, rivers, reservoirs and springs. A **groundwater** source is the water that is present below the surface of the ground in an **aquifer** which can supply water to a well. Therefore, **source water protection** is the prevention of contamination or depletion of the source through a variety of management steps. Source protection is important to small water systems because:

- BC has the highest incidence of enteric illness; like E. coli or Giardia
- BC is a natural resource dependent province
- Increasing population growth continues to increase pressure on those natural resources, which means we need to start planning for the future
- Source protection is a key component to the Multi-barrier approach for safe drinking water.
- Source protection is a key element in a sustainable water system strategy.

A **watershed** is defined as the geographical area that encompasses the source water. It is the topographical slope contributing water to a certain surface water source like a river or a stream.

Sources water assessments in British Columbia are normally based on guidance documents like the Comprehensive Drinking Water Source-to-Tap Assessment Guidelines. The Comprehensive approach to completing a source assessment provides water suppliers with details on the real and potential hazards observed in the watershed, a risk ranking of the hazards and a strategy how to improve or protect water quality before it enters the water system. However, for small water systems a comprehensive source assessment maybe complicated and require a large commitment of a small water systems limited resources. For small water suppliers a source assessment can be completed by water system owners, operators or interested water users. The assessment should provide a report that:

- Provides a clear map of the assessment area
- Identifies and evaluates existing and potential drinking water hazards
- Ranks the watershed hazards using a risk matrix
- Proposes management strategies for improving water quality and quality before it enters the water system.

Who is this Toolkit for?

This toolkit is intended for all small water systems as a resource to complete a source assessment and protection plan. A more extensive guide can be found in the Comprehensive Drinking Water Source-to-Tap Assessment Guideline provided by the provincial Ministry of Health (the guideline can be found at the link under the Useful Resources section).

This toolkit is intended for use by:

- Small water systems providers (< 500 population)
- Technical Advisory Committee established by the Drinking Water Officer
- Interested community members
- Qualified Professionals working on behalf of a small water system



Source Water Assessment vs. Source Water Protection Plan

A source water protection plan (SWPP) is a document that outlines how to protect the quality and quantity of source water. The SWPP includes a source water assessment (SWA), which identifies and prioritizes potential contamination sources and the second part of the SWPP is the action plan, which outlines how the potential contamination sources will be mitigated.

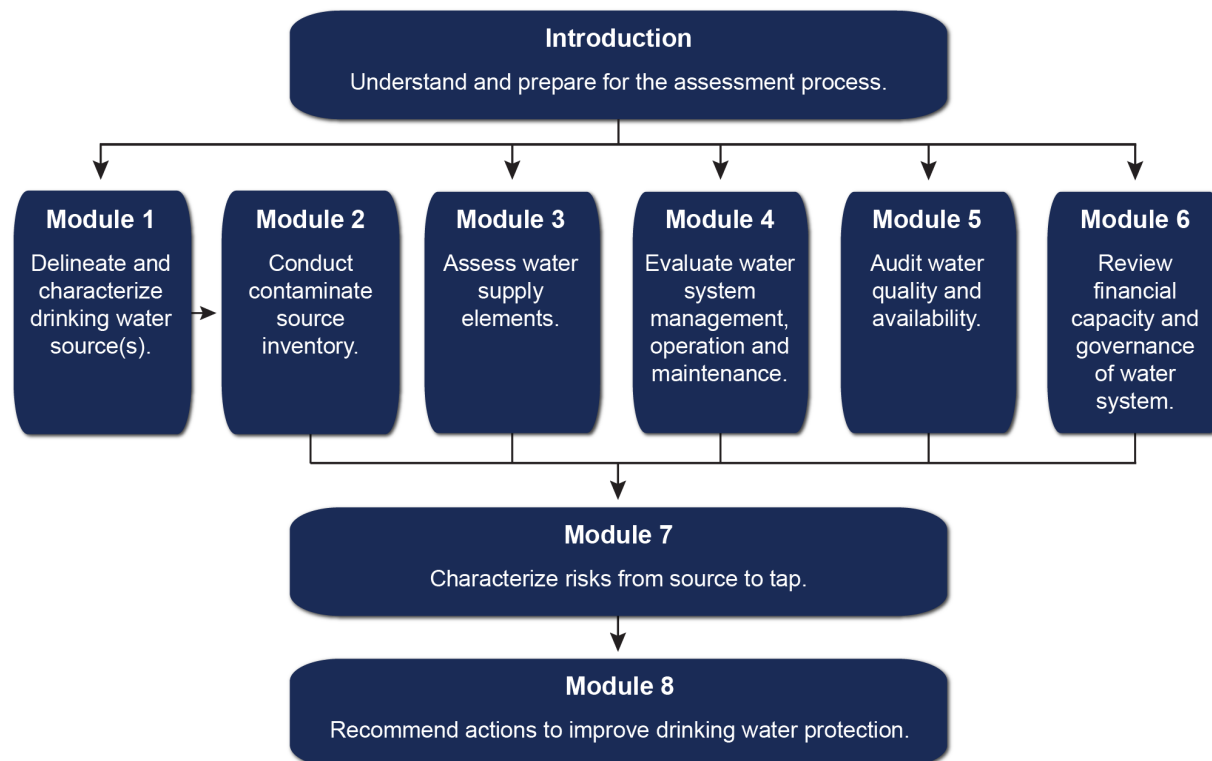
Multi-barrier Approach

The availability of clean, safe drinking water is an expectation of every Canadian. To provide this service the multi-barrier approach is used to ensure that safe drinking water is available now and into the future. The multi-barrier approach is a combination of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source-to-tap in order to reduce risks to public health (CCME, 2004). This is the foundation for the Source-to-Tap Assessment, there are six barriers included in the approach:

- Source Protection
- Treatment
- Water System Maintenance
- Water Quality Monitoring
- Operator Training
- Emergency Response Planning

This guide focuses on source assessment and source protection for small water. The guide has been simplified to make source assessments and protection planning manageable for small water suppliers. However, the source BC Source to Tap Guide ([link](#)) is useful for water suppliers who want a more in-depth review of their water sources. There are eight modules that guide the source-to-tap assessment. This workbook only focuses on Modules 1, 2, 7 and 8. See Figure on page 3.

The widely quoted “multiple barrier approach” is only as good as your ability to keep all the barriers functioning at their individual peak efficiency. Even though multiple elements usually must fail for a complete system failure to occur, if individual barriers are not adequately maintained, you may eventually find yourself with no functional barriers to prevent contamination from reaching your consumers.



When to Hire a Qualified Professional and Which One



While reviewing this toolkit and completing the workbook you may identify questions that are not easily answered and require a Qualified Professional to provide knowledge and expertise. A Qualified Professional is an applied scientist or technologist who is registered and in good standing with an appropriate B.C. professional organization constituted under the Act. A Qualified Professional must be acting under that association's code of ethics, and subject to the organization's disciplinary action. They must have an area of expertise that is recognized in the assessment methods as one that is acceptable for the purpose of providing all or part of an assessment report for the particular project being assessed.

Ideally, Qualified Professionals have knowledge and technical experience in (either individually or as a collective):

- Collection, treatment and conveyance of water
- Public health issues related to drinking water
- Legislation related to surface water, groundwater and drinking water
- Risk assessment and management
- Water chemistry
- Water microbiology

Hiring a QP can be quite expensive so it is important to make sure you engage the person with the proper technical expertise. It is also important to make sure everyone is clear about the scope of work to be undertaken and the associated budget. Qualified Professionals capable of conducting source water protection plans within their Field of Expertise/Specialty include: Biologists, Agrologists, Foresters, Engineers and Geoscientists.

Not all Professionals are qualified to perform source water protection plans. Qualified Professionals are required to list their Field(s) of Expertise/Specialties and Practising Status. Information on the Associations and Members can be found at the following links:

Association	Designation	Website Links
Association of Professional Engineers and Geoscientists of BC (APEGBC) https://www.apeg.bc.ca/Home	Professional Engineer (P.Eng) or Professional Geoscientist (P.Geo)	Member Profile: https://www.apeg.bc.ca/Member-Directories/APEGBC-Membership-Directory
College of Applied Biology https://www.cab-bc.org/	Registered Professional Biologist (RPBio)	Member Listings: https://www.cab-bc.org/members-list/partial
Association of BC Forest Professionals https://abcfp.ca/web	Registered Professional Forester (RPF)	Member Directly: https://abcfp.ca/web/ABCFFP/About_Us/Directory_Public.aspx
British Columbia Institute of Agrologists https://www.bcia.com/	Professional Agrologist (P.Ag.)	Areas of Agrology: https://www.bcia.com/about-bcia/areas-practice

If you are dealing with a surface water source (i.e. creek or spring) then the QP Field of Expertise should include one of the following:

- Hydrologist / Hydrology
- Hydrologic Assessment
- Water Resource

If you are dealing with a groundwater source then the QP Field of Expertise should include one of the following:

- Hydrogeologist / Hydrogeology
- Groundwater

Additional expertise may be required to assess water quality concerns, forest activity, terrain stability, etc.

Below is a simple check list to help select a Qualified Professional:

- Confirm what portion of the project requires a Professional.
- Ask others for referrals.
- Ask to see proof of current registration as a Profession and Field of Expertise/Specialty.
- Ask for a list of previous projects related to Source Water Protection Planning.
- Confirm scope of work and budget.
- Talk with your Drinking Water Officer to confirm the QP is suitable.

Additional information and questions to consider before hiring any Qualified Professional can be found in the Hiring a Professional Engineering or Professional Geoscientist document <https://www.apeg.bc.ca/getmedia/8ae03dd0-f68d-47f9-a73d-a2252f19ec3b/APEGBC-Advice-on-Hiring-Eng-Geo-in-BC.aspx>.



Who Should Conduct and Participate in Assessments?

Source assessments for small water suppliers can be completed by the water supplier. However, inviting stakeholders to be part of a technical advisory committee can improve the quality of the assessment. Technical Advisory Committee is made up of people who can provide valuable input into the assessment or help to protect the water source. Often Technical Advisory Committees include both Government representatives who regulate activities in your watershed and stakeholder representatives who recreate, extract resources or occupy land in your watershed to guide the process to include, but not limited to:

- Water Supplier
- Environmental Health Officer / Drinking Water Officer
- BC Government representative (invite representatives that regulate activities in your watershed)
- Local Government – Planners and area directors
- Stakeholders with activities potentially affecting source water (e.g. – Fish and Game Groups, Recreational Groups, etc.)



Interior Health and Your Permit

Each of the five Health Authorities within BC employs Drinking Water Officers and Environmental Health Officers who are responsible for the implementation of most sections of the Drinking Water Act (DWPA). Drinking Water Officers and Environmental Health Officers are delegated powers under the DWPA and use the legislation and associated policies, guidelines and tools to make discretionary decisions. The purpose of the legislation and policies is to reduce public health threats.

Under the Drinking Water Protection Act the DWO may attach terms and condition that are more stringent than the DWPA. These conditions may include monitoring of source water(s), source assessments and protection plans.

Large water suppliers within Interior Health have condition attached to their permit that specifies that a source assessment and protection plan is a requirement. These assessments are posted on EcoCat (<http://a100.gov.bc.ca/pub/acat/public/welcome.do>).



Report Guide and Template

To assist a small water system in completing a source protection plan this template report has been compiled to facilitate the reporting process. This toolkit and the template report provides a small water system provider step-by-step guidance and tools to complete a source assessment. The method is a five-stage process identifies all hazards and assigns a risk rating to the water source, identified management actions for the risks and an implementation strategy for those actions. The sequential stages are summarized below:

Stage 1 – Form a Technical Advisory Committee

A technical advisory committee provides valuable input into source assessment. The technical advisory committee should be formed early in the assessment so their comment and expertise are reflected in the assessment. The committee should consist of the water supplier, public health engineer, drinking water officer, ministry of environment representative, local government representative and any group or agency that potentially affects the water source. The committee will provide guidance on the preparation, form, content, area of coverage, hazards identified and associated risk rating, and review the draft assessment report. The committee members may also participate in regular meetings, field inspection, review reports and inform community members.



Stage 2 – Complete your source water assessment

This stage uses Module 1, 2 and 7 from the Comprehensive Drinking Water Source-to-Tap Assessment Guideline as a reference. This is where the water source features and hazards are identified, described, assessed and prioritized based on risk associated with any potential contamination sources. These three modules are completed sequentially.

- Module 1 – Delineate and characterize drinking water source
 - In module 1 the main goal is to determine the watershed area that contributes the source water to the water system, determine what the assessment area will be for the report, and describe the water source and describe the intake.
- Module 2 – Conduct contaminant source inventory
 - In module 2 all hazards that could have potential to contaminate the water source are identified. These contaminant sources are inventoried and identified on a map (AKA Hazard Inventory).
- Module 7 – Characterize risks from source to tap
 - After completing module 1 and 2 the hazards are prioritized using a risk analysis matrix. First the likelihood of a hazard is determined, then the consequence of a hazard occurring is determined and using that information the risk analysis matrix gives each hazards a risk ranking (AKA Risk Matrix).

Stage 3 – Identify management actions to address potential risks

This stage will address management actions for each identified risk from stage 2, and follows Module 8 as reference the Comprehensive Drinking Water Source-to-Tap Assessment Guideline. The end result is a “Road Map” for the water system provider and the DWO to consider when proceeding with risk management planning. The final decisions and implementation of any management actions will be the responsibility of the water system provider in consultation of the DWO.

Stage 4 – Develop an implementation strategy

An implementation strategy is necessary to ensure the management activities identified in Stage 3 are executed. This stage is where roles and responsibilities are assigned, an implementation schedule is developed, resources are allocated, and a monitoring program is developed to measure progress.



Stage 5 – Undertake a full plan review

The source assessment report is a living document, which should be reviewed and updated regularly. As changes occur with the water system and the environment the source assessment report will require updating every 5 years. The review will be guided by a new/updated technical advisory committee, who will undertake stages 2 through 4 and update the assessment report as needed.



Water Monitoring Program

Currently small water systems are typically required to complete microbiological testing by an accredited lab for Total Coliforms and Escherichia coli (E.coli) four times a month on treated water. Coliform bacteria are considered an “indicator bacteria”, which usually do not cause any health problems but when present indicate contamination containing bacteria, viruses or parasites. Total coliforms are found in water, soils and the digestive tract of warm-blooded animals. However E.coli are found almost exclusively in the digestive tracts of animals. The presence of either can indicate that fecal material has contaminated the water system.

Aside from microbiological testing a DWO can also require a water supplier to also test for further parameters like heavy metals (arsenic, lead, mercury), nutrients (phosphorous, nitrate/nitrite, ammonia) or oil/gas.

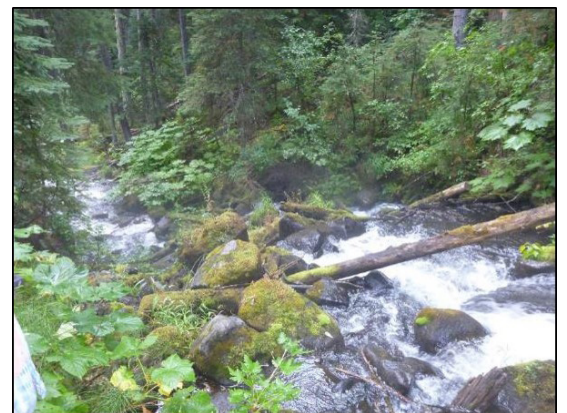
There are a few additional parameters that can be tested by an operator/supplier inline or manually which can help indicate change in a water source or contamination. These parameters include; colour, smell, water clarity, turbidity, pH and temperature. Colour and smell are an aesthetic parameter that can be important to customers but can also indicate bigger issues.

A **Secchi Disk** can be used to measure water clarity by lowering the disk into the water until it just disappears from view; this depth is called the Secchi depth and is related to turbidity. Lower the depth the higher the turbidity, and higher the depth the lower the turbidity.

Turbidity is a measure of how clear or murky a solution is, it is the suspended particles within a sample that is measured by how much or little light is scattered when light is shone through the sample. The suspended particles can be made up of clay, silt, and organic and inorganic matter. Turbid water can clog filters, shield bacteria from disinfection and reduce the effectiveness of ultra-violet disinfection.

pH is a measure of how acidic or basic a solution is; surface water is typically between 6.5 and 8.5. If the pH is found to be outside this range further investigation upstream is required, there is a possibility of contamination.

Temperature affects a variety of aquatic characteristics, including dissolved oxygen concentration, chemical reaction rates, biological processes, species composition, and water density. All of these characteristics can have a direct correlation of the water source health, therefore if a major change in temperature is noted this can indicate changing conditions in the water source.



Useful Links

Name	Description
Safe Water Supply: Vital to your Health	Provides information on risks, operations and basic components of small water systems, as well as how to maintain existing systems. http://www2.gov.bc.ca/assets/gov/environment/air-land-water/safe-water-supply-vital-health.pdf
Drinking Water Source-to-Tap Screening Tool	A question and answer document that is meant to assess risks to a drinking water system. This document helps a supplier and DWO determine if a Comprehensive Source-to-Tap Assessment. http://www.smallwaterusers.com/docs/Source-to-tap%20screening%20tool.pdf
Comprehensive Drinking Water Source-to-Tap Assessment Guideline	An in-depth assessment guideline that identifies, prioritize and plan management actions for risks to a drinking water system. http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators#safe-water-supply
Emergency Response Planning for Small Water Systems	A guideline that helps operators and suppliers to develop their own emergency response plan. http://www.health.gov.bc.ca/library/publications/year/2000/PHI061.PDF
Small Water System Guidebook	Facts, instructions and tips for water suppliers serving up to 500 people. http://www2.gov.bc.ca/assets/gov/environment/air-land-water/small-water-system-guidebook.pdf
Water System Assessment User's Guide	A tool that is used to help operators/suppliers assess their water system's safety and security. http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water-system-assessment-user-guide.pdf
Water Licenses Query	To look up your water licenses and see any applicable information attached to the license. http://a100.gov.bc.ca/pub/wtrwhse/water_licences.input
Small Water Users Association of BC	Non-profit society serving the interests of small water systems in BC. http://www.smallwaterusers.com

A Few Applicable Legislation Documents

Name	Link
Drinking Water Protection Act	http://www.bclaws.ca/civix/document/id/complete/statreg/01009_01
Drinking Water Protection Regulation	http://www.bclaws.ca/civix/document/id/complete/statreg/200_2003
Water Sustainability Act	http://www.bclaws.ca/civix/document/id/complete/statreg/14015
Water Sustainability Regulation	http://www.bclaws.ca/civix/document/id/complete/statreg/36_2016
Forest and Range Practices Act	http://www.bclaws.ca/Recon/document/ID/freeside/00_02069_01



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References

Ministry of Healthy Living and Sport. 2010. Comprehensive Drinking Water Source-to-Tap Assessment Guideline. Victoria: province of British Columbia.

Interior Health – EHO contact and other reference material (<https://www.interiorhealth.ca/YourEnvironment/DrinkingWater/Pages/default.aspx>)

ECoCat – reference for previously completed studies in watersheds and in the environment. (<http://www.env.gov.bc.ca/ecocat/>)

IMap – BC Government Website mapping tool (<http://www2.gov.bc.ca/gov/content/governments/about-the-bc-government/databc/geographic-data-and-services/imapbc>)

Water Resource Atlas – water data and tools for BC (<http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-data-tools>)

You need to have full and complete understanding of new equipment and technology; so full and effective commissioning, including comprehensive training of operational staff with the new facilities, must be part of any contracts to supply equipment or technology.

SOURCE ASSESSMENT REPORT



Introduction

the goal of the assessment is to help small water suppliers identify hazards and vulnerabilities to the water system, and then provide recommendations on risk management action steps.

To conduct the assessment, the Comprehensive Drinking Water Source-To-Tap Assessment Guideline is used to provide guidance during the assessment process. From the guideline four modules were completed: Module 1, 2, 7 and 8. Module 1 delineates and characterizes the drinking water source, module 2 provides an inventory of any containment sources within water system, module 7 characterizes the risks identified during module 1 and 2, and module 8 will recommend action steps that can protect/improve the water system.

Module 1 – Characterization of Water Source

Name of your water supplier: _____

Name of the water source: _____

Water license number: _____

The following pages are a summary of the important information related to the water source and system. This information will help give a clearer understanding and characterization to the water source, which can then be used to identify any applicable hazards. The location of hazards as well as the intake location are to be recorded on the map(s) provided in Appendix A, using a numerical identifier associated with the numbering system from Table 2.

Water demand has been allowed to grow for centuries because the benefits of using water are so great. The greatest advances in human longevity arrived when we figured out how to bring clean water to our homes and take dirty water away. We found many other ways to enjoy water's blessing and encouraged people to enjoy those blessings by giving water away, for free.

Administrative Info

Name of Watershed:

Health Authority /Name of DWO :

Water license number:

Community Watershed Code:

Delineation of Water Source Area Info

Source water body name:

Latitude & longitude or UTM coordinates of intake:

Intake Elevation:

Mapped location of intake:

Intake Location and Integrity Info

Describe intake location and depth: _____

Describe the accessibility for inspection and cleaning of intake: _____

Sediment Build-up? Yes / No

Comments: _____

How often do you clean out the build-up? _____

Do you have protection from animals and vandalism?

• Is the intake fenced? _____

• Is there signage? _____

Does ice form at the intake? Yes / No

Comments: _____

Describe intake integrity and sanitary features: _____

• Do you have a fish-bearing stream? Yes / No

• Do you have a screen on the intake? Yes / No

• What material is your piping? (PVC, ABS , Copper, Concrete) Yes / No

• Do you use a diversion ? (Include a photo) Yes / No

• Is your intake on private or crown land? Yes / No

Intrinsic Vulnerabilities of Source Area Info

Watershed area

Terrain stability:

- Have there been landslides? Years? Frequency? _____
- Have there been mudslides? Years? Frequency? _____
- Have there been avalanches? Years? Frequency? _____

Runoff direction (map?)

Vegetation type and cover: Circle any applicable types of forests found in watershed

Interior cedar-hemlock / Englemann spruce-subalpine fir / Montaine Spruce / Interior Douglas fir

Wildlife:

Are there any beaver dams or log jams present in your stream/river? Yes / No

If yes, where are they located? (Mark on map)

% crown land _____ % privately owned land _____

Source Water Quality and Volume Info

Water Quality (physical, biological and chemical)

- Do you test your water? Yes / No
- What do you test for? _____

- How is your sampling preformed? Inline / manual
- Frequency of testing? weekly / monthly / annually

License quantity and type of use: Residential / Commercial / Agriculture / Other

Do you track your water use? i.e –metered used at intake or individual users: Yes / No

Source Water Quality and Volume Info

Climate data (from environment Canada)

- Precipitation _____
- Mean monthly and annual temperature _____
- Annual monthly and annual humidity _____
- Average date of spring freshet for water source _____
- Has this system suffered from low flows due to drought in the past? Specific years? _____

- Has flash flooding occurred in the past? Specific years? _____
- Likelihood and susceptibility of extreme weather (drought, flood, etc) _____



Module 2 – Inventorying Contaminant Sources

Circle any applicable hazards in your watershed and mark on the map in the appendix with an associated number:

Natural Hazards

1. Landslides
2. Wildfires
3. Low Flows/Drought
4. Wildlife
5. Algae Blooms
6. Avalanches
7. Sediment / Coarse material
8. Floods

Human Caused Hazards

9. Mines
10. Major Roads (highways)
11. Logging/Forestry
12. Culverts/bridges
13. Agriculture (herbicides/pesticides)
14. Forest Service Roads
15. Recreation (hiking, ATV, camping, horseback, mountain biking, etc.)

16. Septic Fields
17. Gasoline/Diesel Storage
18. Range Animals (cattle/horses)

Note: Please refer to Appendix B for information on the above hazards and the potential contaminants associated with them. Keep in mind that this is not a complete list, just a starting point for some typical hazards.

All source waters are vulnerable to contamination. Microbial pathogens are the most pervasive (widespread) contaminants and definitely the most certain to cause human illness if they are allowed to breach your water treatment processes.

Table 1 – Hazard Identification Table

	Drinking Water Hazard	Possible Effects	Distance from source	Description of existing barrier *	Owner	Map Number
	e.g. Coarse material	e.g. Plug intake	e.g. Directly upstream	e.g. Screen on intake	e.g. water supplier	#??
Physical						
Chemical						
Biological						

*Preventative measures



Examples of Existing Preventative Measures:

- Source Protection Plan
- Treatment/disinfection I.e. - chlorination, UV, filtering, settling pond
- Fence and locks around intake
- Signage (e.g. drinking water source, community watershed)
- E.g. - Gas station as a hazard a double walled storage tank would be an existing preventative measure



Module 7 – Characterize Risks From Source-to-Tap

After completing Modules 1 and 2 the hazards are assigned and prioritized using a risk analysis matrix. First the likelihood of a hazard is determined (Table 2), then the consequence if that hazard occurred is determined (Table 2). Based on this information each hazard is assigned a risk ranking (Table 3).

Table 2: Likelihood Table

Likelihood is an estimate of the probability the event, condition, action or inaction will occur and that negative impacts would result.

Level	Descriptor	Description	Probability in Next 10 Years
A	Almost Certain	Is expected to occur in most circumstances	>90%
B	Likely	Will probably occur in most circumstances	71-90%
C	Possible	Will probably occur at some time	31-70%
D	Unlikely	Could occur at some time	10-30%
E	Rare	May only occur in exceptional circumstances	<10%

Table 3: Consequence Table.

Consequence is the nature and degree of impacts if a hazard does occur.

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

Table 4. Risk Analysis Matrix = Likelihood x Consequence

Likelihood	Consequence				
	1 Significant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (Almost Certain)	Moderate	High	Very High	Very High	Very High
B (Likely)	Moderate	High	High	Very High	Very High
C (Possible)	Low	Moderate	High	Very High	Very High
D (Unlikely)	Low	Low	Moderate	High	Very High
E (Rare)	Low	Low	Moderate	High	High

For each Hazard identified in Table 2 assign a likelihood of occurrence, consequence rating and overall risk level. Provide any assumptions about why you chose that level of likelihood or consequence or if measures have been put in place to reduce the impact of the hazard on water quality or quantity.

Table 5 – Risk Characterization Table

Drinking Water Hazard	Likelihood Level	Consequence Level	Risk Level	Assumption/ Comments



Module 8 – Management Plan and Implementation Strategy

The foundation for delivering safe drinking water is the use of multiple barriers to limit the exposure of drinking water to a particular hazard. This starts with barriers in the source water and source protection is the first barrier in the multi-barrier approach to protecting drinking water quality and quantity.

The intent of the Source Water Assessment is to recommend a process to address the hazards that are a threat to drinking water safety and sustainability of a drinking water supply. Based on the risks to drinking water quality and quantity presented in Table 5, there may or may not be a need for protection of the source water quality through the implementation of strengthened and additional barriers in the watershed area. In Table 6 list the hazards based on their risk ranking, the associated risk ranking, existing barriers in place to mitigate the hazard, if there are management actions that can be taken to address the risk and whom would carry out the action.

Table 6 – Recommended Risk Management Actions

Risk Ranking (highest to lowest)	Drinking Water Hazard	Existing Management Actions or barriers	Proposed Management Actions	By whom?

We built cities in floodplains with the assumption that walls and levees could defend them. We built reservoirs with the assumption that precipitation would fill them. Some of these assumptions were wrong, and we lost lives, property and money. Climate change will increase the rate of assumption failure and the suffering of people depending on infrastructure that is too weak to resist nature’s might. Since 2012, “Superstorm” Sandy has hit America’s east coast, floods have submerged Brisbane, Calgary and central Europe, and Typhoon Haiyan has devastated the Philippines. These events will become more common and their damage more painful. We need to reduce our exposure to risk.

WELL CHARACTERIZATION REPORT



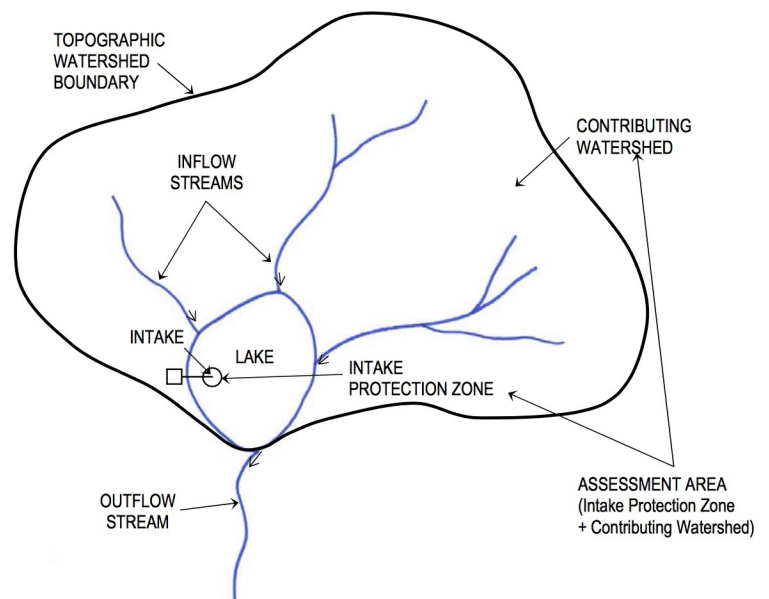
Introduction

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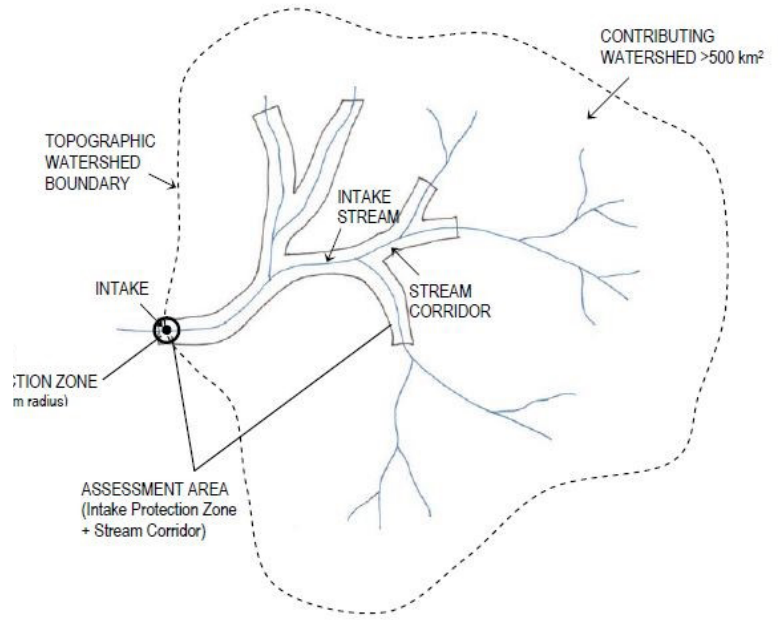
Lakes & Reservoir

To delineate the source area of lakes and reservoirs a zone approach is applied. The **intake protection zone (IPZ)** is an area set out to protect drinking water intake. This zone can be separated into three different zones depending on the distance from the intake, which is directly related to the time it would take for a contaminant to reach the intake. It is this amount of time that determines the distance for each zone. The first zone is the red zone and is a 100 meter radius around the intake; this is an area where no dilution is possible for a potential contaminant therefore the highest risk. The second zone is the yellow zone, which has a 1 Km radius in water and a 120 meter distance inland from the shore. The third zone is the green zone and has no set distance but includes any additional hazards within the watershed that may pose a threat to the drinking water supply.



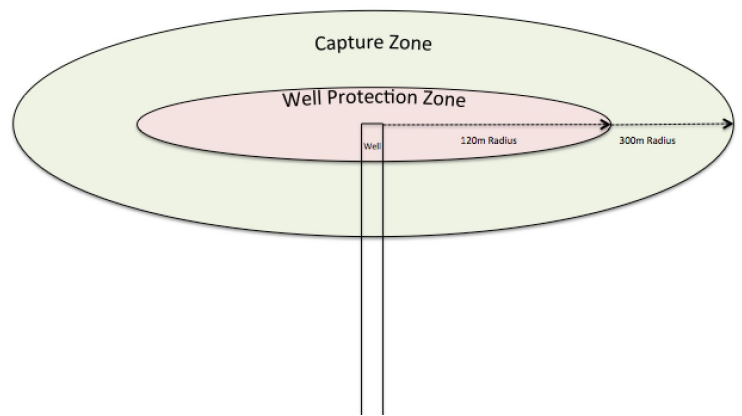
Streams & Rivers

When delineating stream and river source areas, the intake protection zone (IPZ) also applies. Therefore, the 100 meter radius around the water supply intake is the most critical area and requires the most caution for potential hazards. Outside the IPZ, the area upstream of the intake must be assessed for hazards as well. For small water systems the distance upstream to include in the assessment is 1 Km from the intake and a width of 100 meter from each side of the stream or river shoreline. If there is another stream or river that contributes (i.e. tributary) to the system, the distance and width should include that waterbody as well.



Wells & Springs

To delineate the source area of a well or spring the **capture zone** must be determined, much like an IPZ. A capture zone is the area of land that is beside the well. The highest risk section of the capture zone is called the **well protection zone**, which is the area within 120 meters of the well. For small water systems a fixed radius of 300 meters can be used as the capture zone when describing hazards and risks.



Module 1 – Characterization of Water Source

Name of your water supplier: _____

Address of Wellhead: _____

Legal Description (on property tax assessment notice):

Lot:	Block:	Range:
Plan:	Section:	Land District:
District Lot:	Township:	PID:

*Note: The majority of the information below can come directly off your well log found on the WELLS database ([insert website link](#)) provided by the province.

Administrative Info

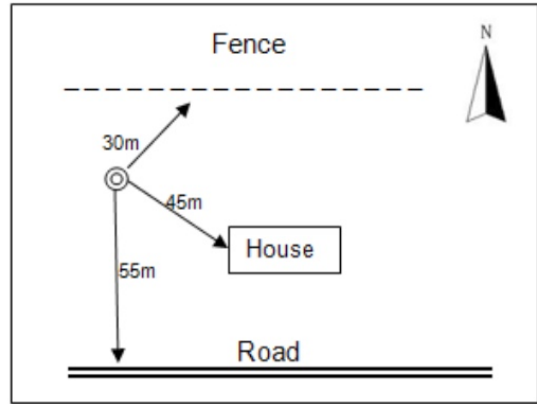
Owner of Property where Well is Located:

of population served:

Healthy Authority / Name of DWO:

Well ID Plate or Well Tag #:

Example Sketch



Delineation of Water Source Area Info

Latitude & longitude or UTM coordinates of intake:

Sketch Well Location to the right:

Intake Location and Integrity Info

Describe well location: _____

Total Well Depth (to bottom): _____

Depth to screen: _____

Depth of casing: _____

Do you have protection from animals and vandalism? Yes / No

- Is the wellhead enclosed in a wellhouse? Yes / No
- Does the wellhead have a well cap? Yes / No
- Is the wellhead fenced? Yes / No
- Is there signage? Yes / No

Does surface water pool around the wellhead? Yes / No

Does the wall casing extend at least 0.3m (12 in) above ground surface? Yes / No

Is there a wellhead seal? Yes / No

- If yes, what is the condition of the seal? _____

What hazard are observed in the area?

Watershed area

Terrain stability:

- Have there been landslides? Years? Frequency? _____
- Have there been mudslides? Years? Frequency? _____
- Have there been avalanches? Years? Frequency? _____

Vegetation type and cover: Circle any applicable types of forests found in the vicinity of the well:

Interior cedar-hemlock / Englemann spruce-subalpine fir / Montaine Spruce / Interior Douglas fir

Wildlife or Range Animals

Are there ant grazing animals in and around your wellhead Yes / No

Source Water Quality and Volume Info

Water Quality (physical, biological and chemical)

- Do you test your water? Yes / No
- What do you test for? _____

- How is your sampling preformed? Inline / manual
- Frequency of testing? weekly / monthly / annually

Do you track your water use? (i.e metered used at intake or individual users): Yes / No

Are there any surface water sources within the capture zone? Yes / No

- If yes, please name them:

Has your well ever run dry? Yes / No

- If yes, what time of year was it?

Did you investigate the cause? Yes / No

- If yes, did you find a cause? Yes / No

Is your well at risk of pathogens? Yes / No

Source Water Quality and Volume Info

Climate data (from environment Canada)

- Precipitation _____
- Mean monthly and annual temperature _____
- Annual monthly and annual humidity _____



Module 2 – Inventorying Contaminant Sources

Circle any applicable hazards in your capture zone and mark on the map in the appendix with an associated number:

Natural Hazards

1. Landslides
2. Wildfires
3. Low Flows/Drought
4. Wildlife
5. Avalanches
6. Floods

Human Caused Hazards

7. Mines
10. Major Roads (highways)
11. Logging/Forestry
12. Culverts/bridges
13. Agriculture (herbicides/pesticides)
14. Forest Service Roads
16. Septic Fields
17. Fuel Storage
18. Range Animals (cattle etc.)
19. Recreation Activities

Note: Please refer to Appendix B for information on the above hazards and the potential contaminants associated with them. Keep in mind that this is not a complete list, just a starting point for some typical hazards.

All source waters are vulnerable to contamination. Microbial pathogens are the most pervasive (widespread) contaminants and definitely the most certain to cause human illness if they are allowed to breach your water treatment processes.

Table 1 – Hazard Identification Table

	Drinking Water Hazard	Possible Effects	Distance from source	Description of existing barrier *	Owner	Map Number
	e.g. Coarse material	e.g. Plug intake	e.g. Directly upstream	e.g. Screen on intake	e.g. water supplier	#??
Physical						
Chemical						
Biological						

*Preventative measures



Examples of Existing Preventative Measures:

- Source Protection Plan
- Treatment/disinfection I.e. - chlorination, UV, filtering, settling pond
- Fence and locks around intake
- Signage (e.g. drinking water source, community watershed)
- E.g. - Gas station as a hazard a double walled storage tank would be an existing preventative measure



Module 7 – Characterize Risks From Source-to-Tap

After completing Modules 1 and 2 the hazards are assigned and prioritized using a risk analysis matrix. First the likelihood of a hazard is determined (Table 2), then the consequence if that hazard occurred is determined (Table 2). Based on this information each hazard is assigned a risk ranking (Table 3).

Table 2: Likelihood Table

Likelihood is an estimate of the probability the event, condition, action or inaction will occur and that negative impacts would result.

Level	Descriptor	Description	Probability in Next 10 Years
A	Almost Certain	Is expected to occur in most circumstances	>90%
B	Likely	Will probably occur in most circumstances	71-90%
C	Possible	Will probably occur at some time	31-70%
D	Unlikely	Could occur at some time	10-30%
E	Rare	May only occur in exceptional circumstances	<10%

Table 3: Consequence Table.

Consequence is the nature and degree of impacts if a hazard does occur.

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

Table 4. Risk Analysis Matrix = Likelihood x Consequence

Likelihood	Consequence				
	1 Significant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (Almost Certain)	Moderate	High	Very High	Very High	Very High
B (Likely)	Moderate	High	High	Very High	Very High
C (Possible)	Low	Moderate	High	Very High	Very High
D (Unlikely)	Low	Low	Moderate	High	Very High
E (Rare)	Low	Low	Moderate	High	High

For each Hazard identified in Table 2 assign a likelihood of occurrence, consequence rating and overall risk level. Provide any assumptions about why you chose that level of likelihood or consequence or if measures have been put in place to reduce the impact of the hazard on water quality or quantity.

Table 5 – Risk Characterization Table

Drinking Water Hazard	Likelihood Level	Consequence Level	Risk Level	Assumption/ Comments



Module 8 – Management Plan and Implementation Strategy

The foundation for delivering safe drinking water is the use of multiple barriers to limit the exposure of drinking water to a particular hazard. This starts with barriers in the source water and source protection is the first barrier in the multi-barrier approach to protecting drinking water quality and quantity.

The intent of the Source Water Assessment is to recommend a process to address the hazards that are a threat to drinking water safety and sustainability of a drinking water supply. Based on the risks to drinking water quality and quantity presented in Table 5, there may or may not be a need for protection of the source water quality through the implementation of strengthened and additional barriers in the watershed area. In Table 6 list the hazards based on their risk ranking, the associated risk ranking, existing barriers in place to mitigate the hazard, if there are management actions that can be taken to address the risk and whom would carry out the action.

Table 6 – Recommended Risk Management Actions

Risk Ranking (highest to lowest)	Drinking Water Hazard	Existing Management Actions or barriers	Proposed Management Actions	By whom?

We built cities in floodplains with the assumption that walls and levees could defend them. We built reservoirs with the assumption that precipitation would fill them. Some of these assumptions were wrong, and we lost lives, property and money. Climate change will increase the rate of assumption failure and the suffering of people depending on infrastructure that is too weak to resist nature’s might. Since 2012, “Superstorm” Sandy has hit America’s east coast, floods have submerged Brisbane, Calgary and central Europe, and Typhoon Haiyan has devastated the Philippines. These events will become more common and their damage more painful. We need to reduce our exposure to risk.



APPENDIX A

DEFINITIONS

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Aquifer – a water formation below the surface that can provide an economical quantity of water to a well or spring.

Assessment Area – the area in which assessment activities are analyzed.

Capture Zone – the zone around the well contributing water to the well.

Coliform Bacteria – a group of bacteria that inhabits the intestines of humans or animals and is an indicator bacterium of the possible presence of pathogenic organisms.

Consequence – nature and degree of impacts if a hazard does occur.

Contaminant – a substance not normally present or in higher concentrations not normally present in the water soils or environment.

Contaminant Source Inventory – a list that identifies and locates potential sources of contamination.

Contributing Watershed – the portion of the watershed supplying water to an intake.

Groundwater – water occurring beneath the surface of the ground.

Groundwater Source – a groundwater source is the aquifer that supplies a well including the capture zone that supplies the well.

Hazard – agents of harm, which can be events, conditions, actions or inactions that impact safety or availability of the water supply.

Intake – the point of entry of water into a drinking water system.

Likelihood – a time related estimate of the probability that a hazard will occur.

Multiple Barrier Approach – Six-barrier system to ensure safe drinking water:

1. Protection of source water quality
2. Ensuring there is adequate treatment
3. Providing safe storage and distribution of water
4. Monitoring drinking water quality and enforcing standards
5. Ensuring operators of drinking water systems are adequately trained.
6. Emergency response planning

Non-Point Source – is where the source of a contaminant cannot be pinpointed (e.g. – agricultural runoff).

Pathogen – disease producing agent usually applied to living organisms.

Point Source Contamination – is where the source of a contaminant is site specific (e.g. – landfill).

Protection Area – the area in which source protection activities are conducted.

Reservoir – a pond, lake, basin or artificially created lake, either natural or artificial, used for storage.

Risk – is the combination of the likelihood that a hazard will occur and cause harm, and the extent and degree of harm.

Risk Characterization – is the process of assigning a risk level to each of the hazards.

Source Area – is the land area supplying water to a drinking water supply, is the same as watershed or capture zone.

Source Water – the surface water and groundwater that is available for use by a water system provider.

Surface Water – is open and flowing at the point of withdrawal and includes streams, lakes, rivers, reservoirs and springs.

Vulnerabilities – the processes, conditions, and characteristics of a water supply system and its operation that increase or fail to prevent harm related to a hazard.

Watershed – a geographical area that encompasses the source water.

Well Casing – the pipe that protects and supports the wall of the well.

Well Protection Zone – area within 100 meters of a well.

Well Screen – is the filtering device that allows water but not sediment to enter a well.



APPENDIX B

WATERSHED MAP

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APPENDIX C

HAZARDS & ASSOCIATED CONTAMINANTS

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Hazard	Potential Contaminants
Landslide	<ul style="list-style-type: none"> • Suspended sediment • Turbidity • Organic material which contains bacteria and causes odor, color and taste concerns
Wildfire	<ul style="list-style-type: none"> • Sediment from terrain instability • Hydrophobic soil
Low Flows/ Drought	<ul style="list-style-type: none"> • Concentrates any contaminants present • Quantity concerns
Wildlife	<ul style="list-style-type: none"> • Pathogens like E.coli or giardia • Sediment introduction
Algae Blooms	<ul style="list-style-type: none"> • Decreased oxygen levels • Increased turbidity
Mines	<ul style="list-style-type: none"> • Tailing ponds can contain acids, metals, dissolved solids, radioactive ores • Machine shop waste • Sediment
Major Roads	<ul style="list-style-type: none"> • Automotive wastes (metals, oil, gas etc) • Road Salt • Herbicides • Accidental spills (i.e. – crashes) • Storm water runoff
Logging/Forestry	<ul style="list-style-type: none"> • Leachates from decomposing wood • Fecal coliforms from camps • Motor fuel/oil • Sediment • Storm water runoff
Culverts/Gravel Roads	<ul style="list-style-type: none"> • Sediment
Agriculture	<ul style="list-style-type: none"> • Viruses, bacteria, parasites • Nitrates, phosphates which can cause algal blooms • Pesticides and fertilizers
Recreation	<ul style="list-style-type: none"> • Sediment • Pathogens
Septic Fields	<ul style="list-style-type: none"> • Sewage from leakage • High nutrient concentrations • Viruses, bacteria, parasites
Gasoline/Diesel Storage	<ul style="list-style-type: none"> • Gas/oil • Solvents • Automotive wastes
Range Animals	<ul style="list-style-type: none"> • Viruses, bacteria, parasites • Algae blooms • Nutrients (phosphorous, nitrates, ammonia)
Water Crossings	<ul style="list-style-type: none"> • Sediment • Automotive wastes



APPENDIX D

SECCHI DIP & MONITORING DATA
(TURBIDITY INFORMATION)

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Secchi Dip and Monitoring Data

General Information

Date: _____

Utility Name: _____ Telephone # _____
 Date of Last Monitoring: _____
 Intake Name: _____ Stream/River Name: _____
 Region of Waterbody: _____
 Nearest Town: _____ Postal Code of Nearest Town: _____

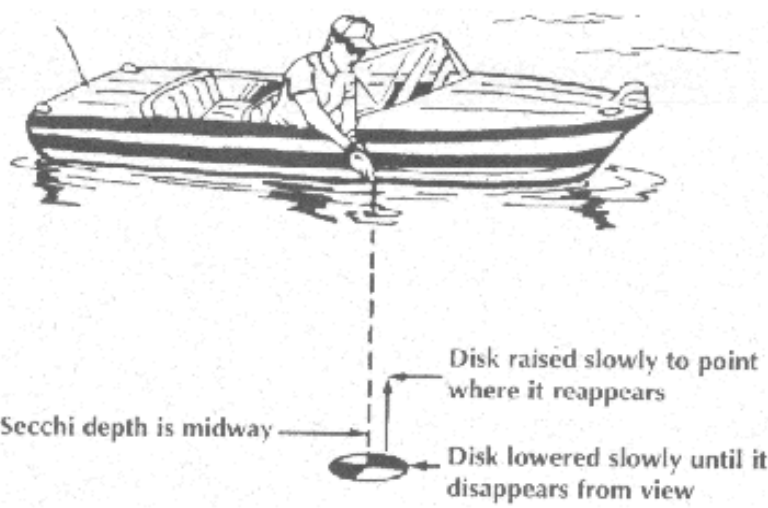
Waterbody Coordinates

Longitude: _____ Degrees _____ Minutes _____ Seconds
 Latitude: _____ Degrees _____ Minutes _____ Seconds

Site Information for Secchi Depth

Depth at Sampling Location (if known): _____ m
 Time of Observation: _____ am / pm
 Weather During Sampling (circle): sunny cloudy overcast rain other _____
 Weather Yesterday (circle): sunny cloudy overcast rain other _____
 Where Did You Sample From (circle): boat dock/pier bridge shore/wade in other _____
 Secchi Reading: Distance A _____ m
 Distance B _____ m $(\text{Distance A} + \text{Distance B}) = \text{Secchi Depth}$
 Secchi Depth _____ m 2
 Can the disc be seen on the bottom? (circle) Yes No
 Size of disc (circle): 8in/20cm 16in/40cm
 Did you use a viewscope? (circle) Yes No
 If yes, is it: open tube closed tube w/glass or plastic plate on btm

If using an instrument other than a Secchi disc, please indicate here and give measurement: (i.e. Turbidity Column, Turbidity Tube, Turbidity meter, etc.):



- Secchi Depth Tips:**
- Best done on a clear day
 - Measure in the shade or shady side of stream
 - Don't wear sunglasses
 - Estimate to the nearest cm
 - High Secchi Depth = Clear Water
 - Low Secchi Depth = Turbid/Coloured Water

Water Quality

Record water quality data, if collected :

Temperature: _____ °C / °F

Fixed Depth Reading: _____ m

pH: _____ pH paper/ meter

Width: 1 _____ m

Depth: 1 _____ m

Velocity: 1 _____ m/s

2 _____ m

2 _____ m

2 _____ m/s

3 _____ m

3 _____ m

3 _____ m/s

Average _____ m

Average _____ m

Average _____ m/s

Cross Sectional Area (W x D): _____ m²

Flow (Area x Velocity): _____ m³/s

Please indicate your preception of the following:

General Water Quality (check one)

- Beautiful, no problems
- Minor problems
- Slight use impairment
- Use totally impaired

Has the water quality changed in the past year?

- Better
- Worse
- No Change
- Don't Know

Has the transparency changed in the last year?

- Clearer
- More Turbid
- No Change
- Don't Know

Has the quantity of water changed (i.e.-flow)?

- Increased
- Decreased
- Hasn't Changed
- Don't Know

What factros (if any) negatively affect the general water quality at your site?

Problem	I don't Know	Beautiful, causes no problems	Causes minor problems	Causes slight use impairment	Causes a lot of use impairment	Use totally impaired
Algal scum						
Aquatic weeds (milfoil)						
Turbidity						
Boats/Boating						
Poor Fishing						
Bacteria						
Dense Housing in area						
Bank Stability						
Trash and litter						
"Pests" wildlife (ducks, beavers, etc.)						
Recreation (snow mobiling, biking, etc)						
Drought or extreme weather patterns						
Freshet, flooding or high water levels						
Other: _____						



APPENDIX E

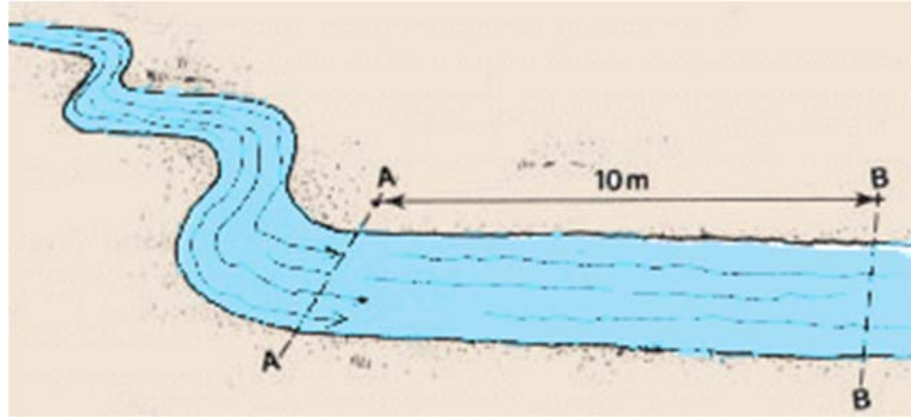
MEASURING WATER QUANTITY

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Measuring Stream Width, Depth and Velocity

Preparation:

- Find a relatively straight section of stream, upstream from your intake.
- Mark off a point A and a point B that's at least 10m apart on the stream bank.
 - If possible, make these points a permanent fixture at the high water level for future measurements which will help with consistency.



Stream Width:

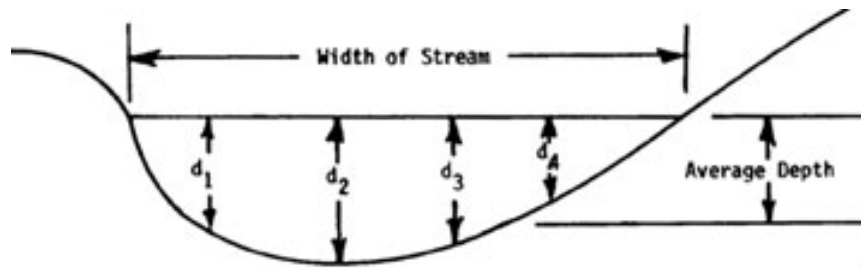
- Between points A and B measure the stream width (in meters) at least 3 times and take the average of these measurements as the Average Stream Width (m).
- $W_1+W_2+W_3/3 = \text{Avg. Width}$
 - Note if more/less measurements are taken then the '3' in the equation above then the equation needs to reflect that change.



Stream Depth:

- Pick a location between points A and B and measure at least 3 depths along the width of the stream (in meters), using a rigid meter stick.

- Then take the average of these measurements for the Average Stream Depth (m).
- $D_1 + D_2 + D_3 / 3 = \text{Avg. Width}$
 - Note if more/less measurements are taken then the '3' in the equation above then the equation needs to reflect that change.



Stream Depth Alternative/Additionally:

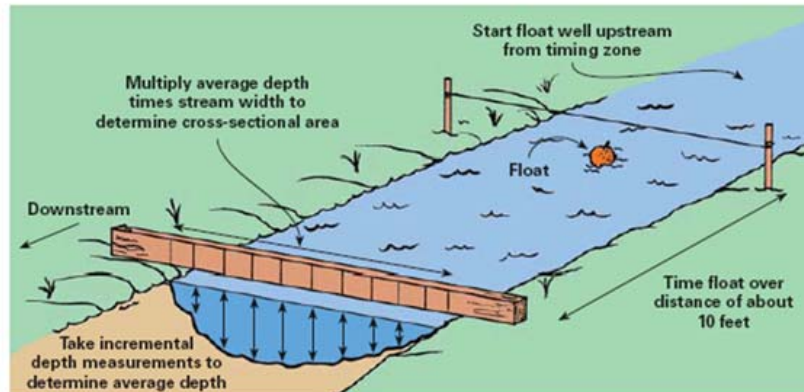
- The depth can also be taken at one specific location where a permanent/semi-permanent fixture has been installed
- A rigid meter stick can be affixed and installed in an accessible location which can be quickly read each time the site is visited



Stream Velocity:

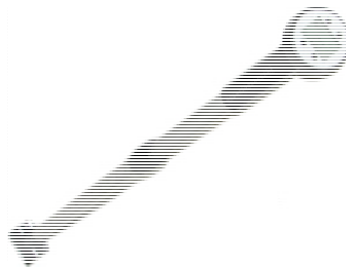
- Two velocity methods are described here (1) The Float Method and (2) The Flow Meter Method
 1. Float Method
 - Using the predetermined points, A and B, release a floatable object (i.e.- a leaf, a small ruler sized branch or ball) in the middle of the stream
 - Using a timer measure the amount of time (seconds) it takes to get from point A to point B
 - Then divide the distance between point A and point B by the amount of time it took to float from point A to point B.
 - $\text{Distance (m) / Time (s) = Velocity (m/s)}$
 - Repeat this test 2 more times and calculate the average velocity.

The Float Method of Estimating Flow



2. Flow Meter Method

- The best time to perform this test is at the same time as the stream depth measurements are taken
- At each depth take a velocity reading from the meter, ensuring you have the meter pointing the right direction (there should be an arrow) and stand to the side of the meter so your body does not interrupt the flow.
- Make sure that the meter is reading in metric i.e.- m/s



Stream Flow/Discharge:

- This measurement is a calculation using the data collected in the above sections.
 - The cross sectional area needs to be calculated using the average depth and width found above:
 - $\text{Area (m}^2\text{)} = \text{Depth (m)} \times \text{Width (m)}$
 - The Flow can then be determined by multiplying the cross sectional area by the average velocity found above:
 - $\text{Flow (m}^3\text{/s)} = \text{Area (m}^2\text{)} \times \text{Velocity (m/s)}$
 - To convert the flow from $\text{m}^3\text{/s}$ to L/s multiply the value by 1000 ($1\text{m}^3\text{/s} = 1000\text{L/s}$)



APPENDIX F

WELL MONITORING DATA

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Well Monitoring Data

General Information

Date: _____

Utility Name: _____

Telephone # _____

Date of Last Monitoring: _____

Well Name: _____

Well Tag/Well Plate ID# _____

Nearest Town: _____

Postal Code of Nearest Town: _____

Well Coordinates

Longitude: _____ Degrees _____ Minutes _____ Seconds

Latitude: _____ Degrees _____ Minutes _____ Seconds

Well & Well Site Information

Well Condition: _____

Time of Observation: _____ am / pm

Weather During Sampling (circle): sunny cloudy overcast rain other _____

Weather Yesterday (circle): sunny cloudy overcast rain other _____

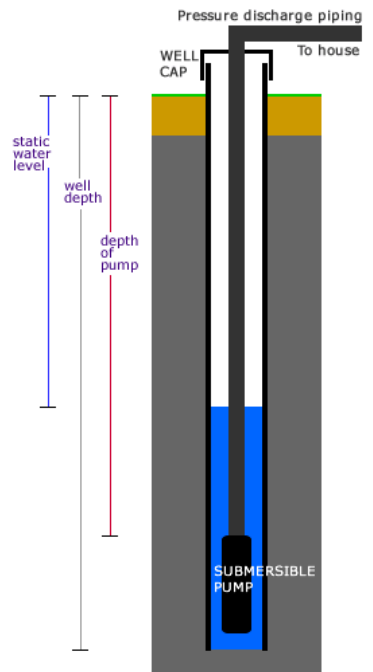
Type of Well (circle): Drilled Dug Other _____

Well Depth: _____ m Diameter: _____ m

Static Water Level (non-pumping): _____ m

Sampling:

Before collecting a sample, 3x times the volume that is static in the well needs to be purged. Also preferably pH, temperature and conductivity should be monitored and samples shouldn't be taken until all three parameters have stable readings.



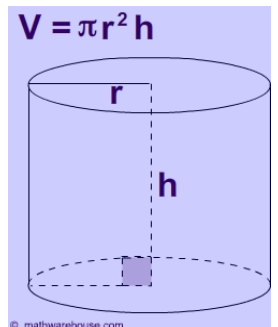
Height of Static Water (h): _____ m
(Well Depth - Static Water Level)

Radius of Well (r): _____ m
(1/2 the diameter of well)

Volume of Static Water: _____ m³
(pi=3.14, Vol = πr²h)

Note: 1m³=1000L

Purge Volume Required: _____ L
(3xVolume)



Water Quality

Record water quality data, if collected :

Temperature: _____ °C / °F
 pH: _____ pH paper/ meter

Conductivity: _____ μS/cm
 Hardness: _____ mg/L (ppm) strips/meter

Please indicate your preception of the following:

General Water Quality (check one)

- Beautiful, no problems
- Minor problems
- Slight use impairment
- Use totally impaired

Has the water quality changed in the past year?

- Better
- Worse
- No Change
- Don't Know

Has the transparency changed in the last year?

- Clearer
- More Turbid
- No Change
- Don't Know

Has the quantity of water changed (i.e.-flow)?

- Increased
- Decreased
- Hasn't Changed
- Don't Know

What factros (if any) negatively affect the general water quality at your site?

Problem	I don't Know	Beautiful, causes no problems	Causes minor problems	Causes slight use impairment	Causes a lot of use impairment	Use totally impaired
Turbidity						
Bacteria						
Dense Housing in area						
Bank Stability						
Range Animals (cows, horses, etc.)						
Agricultural Practices						
Trash and litter						
"Pests" wildlife (ducks, beavers, etc.)						
Recreation (snow mobiling, biking, etc)						
Drought or extreme weather patterns						
Freshet, flooding or high water levels						
Other: _____						



APPENDIX G

SECCHI DIP & MONITORING DATA

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