MODULE 2
CONDUCT CONTAMINANT SOURCE INVENTORY

COMPREHENSIVE DRINKING WATER SOURCE TO TAP ASSESSMENT PROCESS

MODULE 1:
Delineate and characterize drinking water source(s)

⇩

MODULE 2:
Conduct contaminant source inventory

⇩

MODULE 3:
Assess water supply elements

⇩

MODULE 4:
Evaluate water system management, operation and maintenance practices

⇩

MODULE 5:
Audit water quality and availability

⇩

MODULE 6:
Review financial capacity and governance of water system

⇩

MODULE 7:
Characterize risks from source to tap

⇩

MODULE 8:
Recommend actions to improve drinking water protection

ASSESSMENT COMPONENTS

1. Review information on historical, existing and potential contaminant sources in the water source assessment area.
2. Conduct a contaminant source survey.

DRINKING WATER BARRIER ASSESSED IN MODULE 2

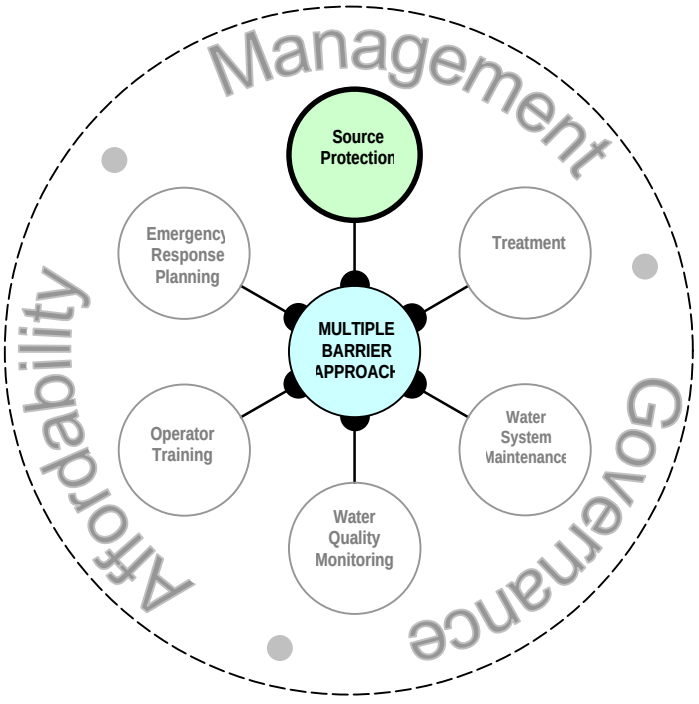

TABLE OF CONTENTS

LIST OF TABLES

LIST OF BOXES

1. INTRODUCTION

Characterization of the drinking water source area in Module 1 involves the description and assessment of intrinsic, natural features of the water source and source area of a water supply. Module 2 of the drinking water source to tap assessment presents a methodology for conducting a contaminant source inventory in the assessment area as defined in Module 1; therefore, Module 1 always precedes Module 2.

A contaminant source inventory identifies and describes land uses, human activities, and other potential contaminant sources[1] that could affect source water quality. First, existing information sources such as aerial photographs, zoning or land use maps, and MWLAP waste management databases (e.g., WASTE, SITE) are consulted to identify possible contaminant sources. This is followed up by a survey or field inspection to verify or reveal other actual or potential sources of contamination. For the purposes of this assessment, contaminant sources are considered drinking water hazards and are to be included in the Module 2 hazard identification table (see Table 2-3) as appropriate.

Contaminant sources include both general land uses, as well as specific activities, or facilities. Information on land uses can provide an indication of the type and extent of non-point source pollution (e.g., application of pesticides, urban run-off). Knowledge of specific activities may identify possible point sources of contaminants (e.g., industrial discharges, landfills, abandoned wells). Line sources such as sewer lines, fuel pipelines, highways, and power lines are other important potential contaminant sources. Knowledge of population density, spatial distribution and settlement trends will assist in determining the anthropogenic magnitude of influence on source water in the present and projected into the future.

A list of potential contaminant sources (Appendix 2C) can be used as a guide for both surface and groundwater sources; however, it should be noted that some contaminant sources are more relevant for one source type than for the other. For example, sediment sources in a watershed present a hazard to surface water, but not generally to groundwater.

The contaminant source inventory provides the information to enable water monitoring and risk management approaches to focus on the contaminants of greatest risk. Module 2 of the source to tap assessment employs a practical approach to the contaminant source inventory where land uses and activities are identified and then potential contaminants of concern inferred. Appendix 2C provides a general cross-reference of land use activities with their commonly associated contaminants. Where the inventory of activities or land uses has identified particular contaminants of concern, more detailed monitoring and source protection planning efforts can be initiated.

Methods used for identifying the existing or potential contaminant sources are essentially the same for both surface water and groundwater source assessment areas. The methodology presented here is a summary of the approach used in the *Well Protection Toolkit*, but adapted for both surface and groundwater sources. See Step Three of the *Well Protection Toolkit*

[1] The term "contaminant source" will be used in this document to mean both actual/existing or potential sources of contamination unless specified otherwise.

(http://wlapwww.gov.bc.ca/wat/gws/well_protection/acrobat.html) (Province of British Columbia, 2000) for more detailed information.

Contaminant source inventories should be conducted in the entire assessment area for each drinking water source. To review, the assessment areas are as follows, by source type:

Table 2-1. Assessment areas for drinking water source types

Source Type	Assessment Area
All watersheds	Contributing watershed + Intake protection zone (min. 100 m radius around intake)
Streams with watersheds >500 km^2	Portion of contributing watershed (e.g, time-of-travel, corridor zones, fixed radius) + Intake protection zone (min. 100 m radius around intake)
Lakes with watersheds >500 km^2	Portion of contributing watershed (e.g, time-of-travel, corridor zones, fixed radius) + Intake protection zone (min. 100 m radius around intake)
Springs	Spring source area + Intake protection zone (min. 100 m radius around spring)
Wells	Capture zone + Well protection zone (min. 100 m radius around well)

1.1 Hazard and Vulnerability Identification

Throughout the process of evaluating water supply elements in the source to tap system, assessors identify and describe hazards that pose a threat to drinking water safety or sustainability, and vulnerabilities in the multiple barrier system or other protective systems (e.g., security).

Hazards are recorded in the Hazard Identification Table (see Table 2-3) used to document hazards in a consistent way throughout the source to tap assessment process. Information on strengths and vulnerabilities in the drinking water supply system identified throughout the assessment is recorded, compiled from each module, and used to inform the multiple barrier system evaluation in Module 7.

1.2 Module 2 Assessment Team

A broad range of issues can exist in a water supply system from source to tap. As a result, comprehensive drinking water assessments require a multi-disciplinary assessment team rather than a single assessor. Each module of the comprehensive drinking water source to tap assessment guideline requires some specialized skills and a unique spectrum of knowledge related to water sources and systems.

Collectively, the assessment team for Module 2 should have knowledge and experience related to:

- hydrology/hydrogeology
- water chemistry, and contaminant fate and transport in surface and groundwater systems
- potential contaminant sources

- spatial analysis and mapping
- public health issues related to drinking water
- legislation relating to drinking water, surface water, groundwater
- microbiology and microbes commonly found in drinking water
- risk assessment and risk management

2. ASSESSMENT COMPONENTS

2.1 Identify potential contaminant sources

A contaminant source inventory involves identifying and describing contaminant sources in the designated assessment area from Module 1. Because the emphasis of the source to tap assessment is on public health, particular attention should be paid to microbiological contaminants or hazards that have immediate acute effects on health. Box 2-1 lists the most common microbial hazards.

BOX 2-1. Common Microbiological Hazards in Drinking Water Sources

Common microbiologic hazards are:
- Grazing animals/feedlots
- Sewage discharges
- Wildlife populations
- Recreational activities
- Unrestricted human access to source
- Land applications of biosolids or manure
- Irrigation with wastewater effluent
- Areas of channel erosion and sediment sources in or adjacent to streams
- Inadequate riparian area
- Failing roads

Identifying contaminant sources is a simplified approach to understanding the risk potential contaminant sources pose. Several factors can significantly influence how susceptible the water source is to contamination (see Box 2-2). Understanding how these factors affect the possibility of contamination will assist the water supplier in selecting appropriate management options.

An analysis of these factors may or may not be part of the Module 2 assessment, depending on the perceived level of risk associated with potential contaminant sources and available resources.

The first step in the contaminant source inventory is to review existing sources of information to identify possible contaminant sources. Common information sources include:

- Interviews with the water supplier and other knowledgeable individuals;
- Recent and historical aerial photographs;
- Waste management databases of all levels of government;
- Zoning and land use maps;
- Regional health authorities for locations of septic systems; and

BOX 2-2. Factors influencing susceptibility to contamination in source area

- Physical integrity of works supplying water
- Physical, geologic, hydrologic, chemical, and biological characteristics that influence water and contaminant flow to supply point
- Type, number and locations of potential contaminant sources and land use within the assessment area of a water supply
- Nature and quantity of contaminants that have been or potentially could be released within a source area; the measures in place to prevent such releases

- Municipal or regional governments for maps, business licenses, construction permits.

In addition to examining present activities and land uses, it may be important to collect information about an area's historical land uses. Contaminants released years ago may still have the potential to affect water quality. Historical land use information can be obtained by reviewing old air photos, through the many resources available at public libraries or archives, or by consulting with knowledgeable residents.

2.2 Conduct a Contaminant Source Survey

Once existing information sources are reviewed, conduct a survey to verify and obtain more specific information on contaminant sources using one or more of the following inventory methods, described in Appendix 2D (BC Ministry of Environment, Lands and Parks & Ministry of Health, 2000):

1. Personal interviews
2. Mail survey
3. Phone survey
4. Windshield survey
5. Door-to-door survey
6. Field inspections

Some inventory methods require more effort and resources than others, and recognizing that capacities of water systems vary, the approach to the contaminant source survey can be scaled accordingly. As a guiding principle, assessments of water systems should include as comprehensive an inventory as resources allow. Having a knowledgeable local resource person involved in the survey can be very helpful.

The contaminant source survey in the intake or well protection zone of a drinking water source (100-metre radius) should be the most intensive, as the risk of contamination is greatest close to the source intake. Pumphouses for wells and infiltration galleries offer protection for the source, but they may also be used as storage areas for contaminants such as gasoline, oil, paint, and pesticides. Ensure pumphouses and areas immediately surrounding a well or intake are investigated for contaminant sources due to their proximity to the water supply.

BOX 2-3. Contaminant transport pathways (Rogers and Johnson, 2002)

- Upgradient direct discharge or injection to water source
- Overland flow
- Subsurface soil diffusion
- Geological strata: fractures, faults, fissures and other forms of secondary porosity in aquifers
- Direct entry to well or intake

For each contaminant source identified, there are several parameters that influence the magnitude of the contamination at the drinking water intake point (Rogers and Johnson, 2002):

- Time of travel from release point to intake
  - Release location,
  - Stream velocity, discharge
- Type and characteristics of contaminant(s)
- Release type: instantaneous or continuous
- Concentration of contaminant at intake point

- Contaminant transport mechanism (see Box 2-3)
- Physical, chemical and biochemical processes that may lower the concentration of a contaminant in water.

It may or may not be possible to examine all the factors influencing the magnitude of a contamination event for every contaminant source identified, but assessors may want to investigate further certain activities or land uses that may pose a serious threat to the water source. These factors should be considered when assigning risk levels to hazards in Module 7.

3. ASSESSMENT DOCUMENTATION AND REPORTING

3.1 Assessment Report

The assessment report should contain, at a minimum, the following components from Module 2 for each water source:

- **Contaminant source inventory table** (see Table 2-2), including a brief description of each land use, activity, or facility; its geographic location using an address, UTM coordinates, or legal property description; its location relative to the water source; possible contaminants of concern; contaminant transport mechanisms; and any additional comments, such as management practices or other observations. Highlight any contaminant sources that may pose a present or imminent threat to source water.
- **Map of potential contaminant sources** depicted on an aerial photograph or a base map (e.g., a TRIM map) showing the source area and assessment area. In addition to mapping the possible contaminant sources, it may be useful to map areas of intrinsic vulnerability (e.g., unconfined aquifer, unstable slopes) to assist in prioritizing the contaminant sources.
- **Discussion of factors influencing susceptibility and magnitude of contamination (see Boxes 2-2 and 2-3) (where applicable).**
- **Completed hazard identification table** for Module 2 (see Table 2-3 for an example).

3.2 Contaminant Source Inventory Table

Information on contaminant sources can be recorded in the Contaminant Source Inventory table (Table 2-2). In this table the contaminant source is described briefly and its location documented as an address, UTM coordinates obtained from a map of appropriate scale or GPS unit, or legal property description. Also recorded in the table are distance and direction of the potential contaminant source to the relevant waterbody, well, or intake; potential contaminants of concern; contaminant transport mechanisms; and where possible, landowner name or jurisdiction accountable for the land use, activity, or facility. Comments can include contamination mitigation or prevention strategies, history of any previous discharges or spills, or any other information relevant to the potential contaminant source.

3.3 Hazard Identification Table

Enter existing or potential contaminant sources identified in Module 2 into the hazard identification table (Table 2-3). Similar to the hazard numbering system explained in Module 1 for multiple drinking water sources, small letters can be used to distinguish between contaminant sources associated with different sources. In the example below, the letter "a" has been assigned to a stream source, and "b" to a well.

Table 2-2. Sample contaminant source inventory table

Hazard No. (Hazard ID Table)	**Contaminant Source Type & Description**	**Owner / Jurisdiction**	**Location** (address / UTM coordinates)	**Distance / direction to the source**	**Possible Contaminants of Concern**	**Contaminant Transport Mechanism**	**Comments**
2-1a	Cattle ranch	John and Kate Sullivan	625 Valley Road	cattle graze as close as 100 metres to the stream, 1.5 km upstream from intake	manure (pathogens)	overland flow	Cattle cannot access stream
2-2b	Gas station	Mike Smith, owner	105 Main Street	300 m NW	gasoline, antifreeze, oils, solvents	overland flow; subsurface soil diffusion	New underground storage tanks 3 years ago
2-3b	Roads	municipal jurisdiction	all throughout capture zone	surrounding	automotive wastes, road salt, herbicides	overland flow; subsurface soil diffusion	No stormwater collection

Table 2-3. Sample Module 2 Hazard Identification Table

Hazard No.	**Drinking Water Hazard**	**Possible Effects**	**Existing Preventative Measures**	**Associated Barrier**
2-1a	Cattle ranch	Pathogens, such as *E.coli*, present in water source.	Chlorine disinfection	Source protection
2-2b	Gas station	Aquifer contamination from gasoline, oil, or other pollutants.	Double-walled underground fuel storage tanks.	Source protection
2-3b	Roads	Aquifer contamination from automotive wastes, road salt, or herbicides.	None identified.	Source protection

APPENDIX 2A
MODULE 2 ASSESSMENT AT-A-GLANCE

Components	Recommended Methods	Scope	Documentation and Reporting
1. Review information on historical, existing and potential contaminant sources in the water source assessment area	• Common information sources include: o Interview with water supplier or other knowledgeable individuals o Recent and historic aerial photographs o Government waste management databases (e.g., WASTE, SITE) o Zoning and land use maps o Regional health authorities (septic systems) o Local government (maps, construction permits, business licences)	• Geographic area: The water source assessment area defined in Module 1 (includes pumphouses). • Contaminant source types: o Historic, existing and potential o Land uses; non-point sources o Individual facilities; point sources; line sources • Contaminant types: o Microbiological o Chemical o Physical	• Draft of Contaminant Source Inventory Table • Draft of map showing contaminant sources in assessment area • Draft of hazard ID Table with contaminant sources shown as hazards (to be verified and completed in Task 2)
2. Conduct a contaminant source survey	• Use one or more of the following survey methods: o Personal interviews o Mail survey o Phone survey o Windshield survey o Door-to-door survey o Field inspections • Evaluate the factors that influence susceptibility and magnitude of contamination (see Boxes 2-2 and 2-3)	• Geographic area: The water source assessment area defined in Module 1. • Contaminant source types: o Historic, existing and potential o Land uses; non-point sources o Individual facilities; point sources; line sources • Contaminant types: o Microbiological o Chemical o Physical	• Completed Contaminant Source Inventory Table • Map showing contaminant sources in assessment area • Discussion of factors influencing susceptibility and magnitude of contamination • Hazard ID Table with contaminant sources included as hazards • Highlight any contaminant sources that may pose a present or imminent threat to source water.

APPENDIX 2B
RECOMMENDED RESOURCES

Source Assessment Guidelines and Information

Canadian Council of Ministers of the Environment (CCME). 2004. *From source to tap: Guidance on the multi-barrier approach to safe drinking water*. Produced jointly by the Federal-Provincial-Territorial Committee on Drinking Water and the CCME Water Quality Task Group. http://www.ccme.ca/sourcetotap/mba.html.

FORREX. Water Management Links. http://www.forrex.org/programs/wmlinks.asp.

US Environmental Protection Agency. 2005. *Source Water Assessment Program*. Office of Groundwater and Drinking Water. http://www.epa.gov/safewater/protect/swap.html

US Environmental Protection Agency. 2005. *Contaminant Source Inventory and Assessment Tools*. Office of Groundwater and Drinking Water http://www.epa.gov/safewater/protect/contamin.html.

Groundwater

Province of British Columbia. 2000. *Well Protection Toolkit*. Victoria: Province of British Columbia. http://wlapwww.gov.bc.ca/wat/gws/well_protection/acrobat.html.

Groundwater Foundation. *Using Technology to Conduct a Contaminant Source Inventory: A Primer for Small Communities*. http://www.groundwater.org/pe/actt/ACTT_Primer052004b.pdf

Water Quality Monitoring

Cavanagh, N., R.N. Nordin, L.W. Pommen and L.G. Swain. 1998. *Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia*. Field Test Edition. Resources Inventory Committee. http://srmwww.gov.bc.ca/risc/pubs/aquatic/design/index.htm.

Cavanagh, N., R.N. Nordin, L.W. Pommen and L.G. Swain. 1998. *Guidelines for Interpreting Water Quality Data*. Field Test Edition. Resources Inventory Committee. http://srmwww.gov.bc.ca/risc/pubs/aquatic/interp/index.htm.

B.C. Source Water Data

Groundwater

Water Well Data Query: http://srmapps.gov.bc.ca/apps/wells/

Interactive Map of Aquifers and Water Wells in British Columbia:
http://srmapps.gov.bc.ca/apps/wlap_aquifer/

Observation Well Network Data: http://wlapwww.gov.bc.ca/wat/gws/obswell/

General information about population served by groundwater in the various communities in BC:
http://atlas.gc.ca/site/english/maps/freshwater/distribution/groundwater

Surface Water

Community Watershed Data Query: http://srmwww.gov.bc.ca/wat/cws/query/cws.htm.

Water License and Water Rights Query: http://www.lwbc.bc.ca/06search/water.html

River Forecast and Snow Survey Bulletin: http://wlapwww.gov.bc.ca/rfc/index.htm

Environment Canada Hydrometric, Climate and Water Quality Station Map Viewer
http://scitech.pyr.ec.gc.ca/climhydro/welcome_e.asp

Water Survey of Canada Real-Time and Historic Hydrometric Data
http://scitech.pyr.ec.gc.ca/waterweb/main.asp.

Floodplain Mapping http://srmwww.gov.bc.ca/aib/fpm/index.html.

APPENDIX 2C
LIST OF POTENTIAL SOURCES OF CONTAMINATION FOR GROUNDWATER AND SURFACE WATER SOURCES

What follows is a list of potential contaminant source activities and the contaminants commonly associated with those activities, modified from Appendix 3.1 of the *Well Protection Toolkit*. It should be noted that this list is not complete and it is not meant to be used as a checklist. There are many other activities that could potentially contaminate a drinking water source and the contaminants listed as associated with a particular activity may not be complete. Any activity or land use in the source area that has the potential to contaminate water should be considered and incorporated into the contaminant source inventory.

Table 2-4: Potential contaminant sources and the contaminants commonly associated with them

NATURALLY OCCURRING SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Rocks and soils	Aesthetic Contaminants: Iron and iron bacteria; manganese; calcium and magnesium (hardness) Health and Environmental Contaminants: Arsenic; asbestos; metals; chlorides; fluorides; sulphates; sulphate-reducing bacteria and other microorganisms
Contaminated Water	Excessive sodium; bacteria; viruses; low pH (acid) water
Sediment Sources	Increases turbidity.
Wildlife	Pathogens including *E-coli*, *Cryptosporidium parvum*, *Giardia lamblia*, *Toxoplasma gondii*
Decaying organic matter	Bacteria, odour, colour, taste
Geological radioactive gas	Uranium deposits, radon gas
100-Year Floodplain	Surface water contamination of well; sediment, bacteria.
Upstream reservoirs (Surface water only)	Sediment during and after a storm
Natural hydrogeological events and formations	Salt-water/brackish water intrusion (or intrusion of other poor quality water); contamination by a variety of substances through sink-hole infiltration in limestone terrains

AGRICULTURAL SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Animal feedlots and burial areas **Manure treatment (composting)** **Manure spreading areas** **Manure storage areas and lagoons** **Animal waste disposal areas**	Viruses, bacteria (coliform and non-coliform) and other pathogens Coliform bacteria can indicate the possible presence of pathogenic (disease-causing) microorganisms that may be transmitted in human or animal feces. Nitrates, phosphates, chloride, colour, taste, odour Chemical sprays and dips for controlling insect, bacterial, viral, and fungal pests on livestock.
Animal grazing areas	Livestock sewage wastes; nitrates; pathogens

Crop areas and irrigation sites	Pesticides[2] including herbicides, insecticides, rodenticides, fungicides, and avicides.; fertilizers[3]; nitrates; gasoline and motor oils from chemical applicators
Chemical storage areas and containers	Pesticides[1]; fertilizers[2]; residues
Farm machinery areas	Automotive wastes: gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic brake fluid; and motor oils[4]. Welding wastes
Agricultural drainage wells	Pesticides[1]; fertilizers[2]; bacteria
Abandoned wells	Contamination of aquifer from surface.
Nurseries	Pesticides[1], fertilizers[2]

FORESTRY-RELATED SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Landslides connected to water source	Suspended sediment, turbidity.
Log sorts	Leachate from decomposing wood waste.
Logging camps	Fecal coliform, motor fuel, oil.
Logging roads	Suspended sediment, turbidity
Cutblocks	Elevated concentrations of nitrate, decrease in pH. (Small watersheds most susceptible)
Channels in logged areas	Turbidity due to increased channel scour and destabilization

MUNICIPAL SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Schools and government offices and grounds	Solvents; pesticides; acids; alkalis; residues from cleaning products that may contain chemicals such as xylene, glycol esters, isopropanol, 1,1,1,-trichloroethane, sulphonates, chlorinated phenols and cresols; Machinery/vehicle servicing wastes; gasoline and heating oil from storage tanks; waste oils; General building wastes[5] Pesticides[1], herbicides, and fertilizers[2].
Park lands, public and residential areas infested with mosquitoes, gypsy moths, ticks, ants, or other pests	Fertilizers[2]; pesticides[1]; herbicides, insecticides
Roads	Runoff; herbicides; accidental spills.
Highways, road maintenance depots, and de-icing operations	Automotive wastes: gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic brake fluid; and motor oils[6]. Herbicides in highway rights-of-way, Road salt (sodium and calcium chloride); road salt anticaking additives (ferric ferrocyanide, sodium ferrocyanide) Anticorrosives (phosphate and chromate)
Municipal sewage treatment plants	Municipal wastewater sludge[7]; treatment chemicals[8]; and sewer lines
Storage, treatment, and disposal of waste from municipal treatment plants	Sewage wastewater; biosolids; nitrates; other liquid wastes; microbiological contaminant ponds, lagoons, and other surface impoundments
Land areas applied with wastewater	Organic matter; nitrate; inorganic salts; heavy metals; coliform and noncoliform or wastewater byproducts, bacteria; viruses; nitrates; sludge; nonhazardous wastes

[2] Pesticides include herbicides, insecticides, rodenticides, fungicides, and avicides. Many pesticides are highly toxic and quite mobile in the subsurface.
[3] The EPA National Pesticides Survey found that the use of fertilizers correlates to nitrate contamination of groundwater supplies.
[4] Automotive wastes can include gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils.
[5] Common wastes from public and commercial buildings include automotive wastes; rock salt; and residues from cleaning products that may contain chemicals such as xylenes, glycol esters, isopropanol, 1,1,1, trichloroethane, sulfonates, chlorinated phenolys, and cresols.
[6] Automotive wastes can include gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils.
[7]Municipal wastewater treatment sludge can contain organic matter; nitrates; inorganic salts; heavy metals; coliform and noncoliform bacteria; and viruses.
[8]Municipal wastewater treatment chemicals include calcium oxide; alum; activated alum, carbon, and lilica; polymers; ion exchange resins; sodium hydroxide; chlorine; ozone; and corrosion inhibitors

Storm water drains and basins	Storm water; urban runoff; gasoline; oil; other petroleum products; road salt; microbiological contaminants
Combined sewer overflows (municipal sewers and storm water drains)	Municipal wastewater sludge and treatment chemicals; urban runoff; gasoline; oil; other petroleum products; road salt; Microbial contaminants
Recycling/reduction/composting facilities	Residential and commercial solid waste residues; nitrates; tannins;
Municipal waste landfills	Leachate; organic and inorganic chemical contaminants; wastes from households and businesses; nitrates; oils; metals Biomedical and related waste.
Open dumping and burning sites, closed dumps	Organic and inorganic chemicals; metals; oils; wastes from households and businesses
Municipal incinerators	Heavy metals; hydrocarbons; formaldehyde; methane; ethane; ethylene; acetylene; sulphur and nitrogen compounds
Fire Stations, fire-training facilities, fire retardant recharge facilities.	Fire retardant; spilled liquids, gasoline, oil.
Water supply wells, monitoring wells, older wells, domestic and livestock wells, unsealed and abandoned wells, and test hole wells	Surface runoff; effluents from barnyards, feedlots, septic tanks or cesspools; gasoline; used motor oil; road salt; fertilizers and pesticides.
Sumps and dry wells	Storm water runoff; spilled liquids; used oil; antifreeze; gasoline; other petroleum products; road salt; pesticides;[vii] and a wide variety of other substances
Drainage wells	Pesticides; [vii] bacteria
Well pumping that causes inter aquifer leakage, induced filtration, landward migration of sea water in coastal area; etc	Saltwater; excessively mineralized water
Artificial groundwater recharge	Storm water runoff; excess irrigation water; stream flow; cooling water; treated sewage effluent; other substances that may contain contaminants, such as nitrates, metals, detergents, synthetic organic compounds, bacteria, and viruses

COMMERCIAL SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Airports, abandoned airfields	Jet fuels; de-icers; diesel fuel; chlorinated solvents; automotive wastes; heating oil; building wastes
Auto repair shops	Waste oils; solvents; acids; paints; automotive wastes;[xi] miscellaneous cutting oils
Barber and beauty shops	Perm solutions; dyes; miscellaneous chemicals contained in hair rinses
Boat yards and marinas	Diesel fuels; oil; septage from boast waste disposal areas; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes
Bowling alleys	Epoxy; urethane-based floor finish
Car dealerships (especially those with service departments)	Automotive wastes; waste oils; solvents; miscellaneous wastes
Car washes	Soaps; detergents; waxes; miscellaneous chemicals
Campgrounds	Septage; gasoline; diesel fuel from boats; pesticides for controlling mosquitoes, ants, ticks, gypsy moths, and other pests; household hazardous wastes from recreational vehicles (RVs)
Carpet stores	Glues and other adhesives; fuel from storage tanks if forklifts are used
Cemeteries	Leachate; lawn and garden maintenance chemicals
Construction trade areas and materials (plumbing, heating and air conditioning, painting, paper hanging, decorating, drywall and plastering, acoustical insulation, carpentry, flooring, roofing and sheet metal, wrecking and demolition, etc.)	Solvents; asbestos; paints; glues and other adhesives; waste tars; insulation; lacquers; sealants; epoxy waste; miscellaneous chemical wastes
Country clubs	Fertilizers; herbicides; pesticides; swimming pool chemicals; automotive wastes
Dry cleaners	Solvents (perchloroethylene, petroleum solvents, Freon); Spotting chemicals (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)
Firing ranges	Lead
Funeral services and crematories	Formaldehyde; wetting agents; fumigants; solvents
Furniture repair and finishing shops	Paints; solvents; degreasing and solvent recovery sludges
Gasoline services stations	Oils; solvents; gasoline; miscellaneous wastes

Golf courses	Fertilizers; herbicides; pesticides for controlling mosquitoes, ticks, ants, gypsy moths, and other pests; shop wastes.
Hardware/lumber/parts stores	Hazardous chemical products in inventories; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote
Heating oil companies	Heating oil; wastes from truck maintenance areas, underground storage tanks
Horticultural practices, garden nurseries, florists	Herbicides, insecticides, fungicides, and other pesticides
Jewellery/metal plating shops	Sodium and hydrogen cyanide; metallic salts
Laundromats	Detergents; bleaches; fabric dyes
Medical institutions	X-ray developers and fixers;[9] infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; miscellaneous chemicals
Office buildings and office complexes	Building wastes; lawn and garden maintenance chemicals; gasoline; motor oil
Paint stores	Paints; paint thinners; lacquers; varnishes; other wood treatments
Pharmacies	Spilled and returned products
Photography shops, photo processing laboratories	Biosludges; silver sludges; cyanides; miscellaneous sludges
Print shops	Solvents; inks; dyes; oils; photographic chemicals
Railroad tracks and yards	Diesel fuel; herbicides for rights-of-way; creosote for preserving wood ties
Research laboratories	X-ray developers and fixers; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; solvents; infectious materials; drugs; disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); miscellaneous chemicals
Scrap, tire, and junk yards	Any wastes from businesses and households; oils
Ski Resorts	Automotive and machinery wastes; salt; heavy metals; wastewater; turbidity.
Sports and hobby shops	Gunpowder and ammunition; rocket engine fuel; model aeroplane glue
Above-ground and underground storage tanks	Heating oil; diesel fuel; gasoline; other petroleum products; other commercially; used chemicals
Transportation services for passenger transit (local and interurban)	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes
Veterinary services	Solvents; infectious materials; vaccines; drugs; disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); x-ray developers and fixers
X-Ray clinics and devices	X-ray developers and fixers may contain reclaimable silver, glutaldehyde, hydroquinone; phenedone, potassium bromide, sodium sulphite, sodium carbonates, thiosulphates and potassium alum.

INDUSTRIAL SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Material stockpiles (coal, metallic ores, phosphates, gypsum)	Acid drainage; other hazardous and nonhazardous wastes
Waste tailing ponds (commonly for the disposal of mining wastes)	Acids; metals; dissolved solids; radioactive ores; other hazardous and nonhazardous wastes
Transport and transfer stations (Trucking terminals and rail yards)	Fuel tanks; repair shop wastes; other hazardous and nonhazardous wastes
Above-ground and underground storage tanks and containers	Heating oil; diesel and gasoline fuel; other petroleum products; hazardous and nonhazardous materials and wastes
Storage, treatment, and disposal ponds, lagoons, and other surface impoundments	Hazardous and nonhazardous liquid wastes; septage; sludge
Chemical landfills	Leachate; hazardous and nonhazardous wastes; nitrates
Radioactive waste disposal materials	Radioactive wastes from medical facilities, Radionuclides (uranium, plutonium)

[9] X-ray developers and fixers may contain reclaimable silver, glutaldehyde, hydroquinone, phenedone, potassium bromide, sodium sulfite, sodium carbonate, thiosulfates, and potassium alum.

Unattended wet and dry excavation sites (unregulated dumps)	A wide range of substances; solid and liquid wastes; oil-field brines; spent acids from steel mill operations; snow removal piles containing large amounts of salt
Operating and abandoned production and exploratory wells (for gas, oil, coal, geothermal, coal bed methane and heat recovery); test hole wells; monitoring and excavation wells	Metals; acids; minerals; sulphides; other hazardous and nonhazardous chemicals
Dry wells	Saline water from wells pumped to keep them dry
Injection wells	Highly toxic wastes; hazardous and nonhazardous industrial wastes; oil-field brines
Well drilling operations	Brines associated with oil and gas operations

INDUSTRIAL PROCESSES (PRESENTLY OPERATED OR TORN-DOWN FACILITIES)	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Asphalt plants	Petroleum derivatives
Communications equipment	Nitric, hydrochloric, and sulphuric acid wastes; heavy metal sludges;
Copper manufacturers	Contaminated etchant (e.g., ammonium persulfate); cutting oil and degreasing solvent (trichloroethane, Freon, or trichloroethylene); waste oils; corrosive soldering flux; paint sludge; waste plating solution
Electric and electronic equipment	Cyanides; metal sludges; caustics (chromic acid); solvents; oils; manufacturers and storage facilities alkalis; acids; paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene; trichloroethane; acetone; methanol; toluene; PCBs
Electroplaters	Boric, hydrochloric, hydrofluoric, and sulphuric acids; sodium and potassium hydroxide; chromic acid; sodium and hydrogen cyanide; metallic salts
Foundries and metal fabricators	Paint wastes; acids; heavy metals; metal sludges; plating wastes; oils; solvents; explosive wastes
Furniture and fixtures manufacturers	Paints; solvents; degreasing sludges; solvent recovery sludges
Machine and metal working shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mould-release agents
Mining operations (surface and underground), underground storage mines	Mine spoils or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulphides
Unsealed abandoned mines used as waste pits	Metals; acids; minerals; sulphides; other hazardous and nonhazardous wastes
Paper mills	Metals; acids; minerals; sulphides; other hazardous and nonhazardous chemicals; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide
Petroleum production and storage companies, secondary recovery of petroleum	Hydrocarbons; oil-field brines (highly mineralized salt solutions)
Industrial pipelines	Corrosive fluids; hydrocarbons; other hazardous and nonhazardous materials and wastes
Photo processing laboratories	Cyanides; biosludges; silver sludges; miscellaneous sludges
Plastic materials and synthetics producers	Solvents; oils; miscellaneous organics and inorganics (phenols, resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfactant; glycols; phenols; formaldehyde; peroxides; etc.
Primary metal industries (blast furnaces, steel works, and rolling mills)	Heavy metal wastewater treatment sludge; pickling liquor; waste oil; ammonia scrubber liquor; acid tar sludge; alkaline cleaners; degreasing solvents; slag; metal dust
Publishers, printers, and allied industries	Solvents; inks; dyes; oils; miscellaneous organics; photographic chemicals
Public utilities (phone, electric power, gas)	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way
Sawmills and planers	Treated wood residue (copper quinolate, mercury, sodium azide); tanner gas; paint sludges; solvents; creosote; coating and gluing wastes
Stone, clay, and glass manufacturers	Solvents; oils and grease; alkalis; acetic wastes; asbestos; heavy metal sludges; phenolic solids or sludges; metal finishing sludge
Welders	Oxygen, acetylene, ozone
Wood preserving facilities	Wood preservatives; creosote

RESIDENTIAL SOURCES	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Abandoned wells	Contamination of aquifer from surface.
Asphalt and roofing tar	Hydrocarbons
Bug and tar removers	Xylene, petroleum distillates
Cesspool cleaners	Tetrachloroethylene, dichlorobenzene, methylene chloride
Cleaners (household, oven)	Xylenes, glycol esters, isopropanol
Disinfectants	Disinfectants (quarternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); cresol, xylenols
Drain cleaners	1,1,1-trichloroethylene, caustic soda
Heating oil, diesel fuel, kerosene	Hydrocarbons
Jewellery cleaners	Sodium cyanide
Junk cars and debris in yards	Gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils .
Laundry soil and stain removers, spot removers	Hydrocarbons; trichloroethylene; 1,1,1-trichloroethane
Lye or caustic soda	Sodium hydroxide
Metal polishes	Petroleum distillates, isopropanol, petroleum naptha
Pesticides (household - all types)	Common household pesticides for controlling pests such as ants termites, bees, wasps, flies, cockroaches, silverfish, mites, ticks, fleas, worms, rats, and mice can contain ingredients including napthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons, arsenic, strychnine, kerosene, nitrosamines, and dioxins.
Pets/Animals	Coliform bacteria and other microbes such as toxoplasmosis in cats.
Photochemicals (photofinishing chemicals)	Phenols, sodium sulphite, cyanide, silver halide, potassium bromide.
Printing Ink	Heavy metals; phenol-formaldehyde
Refrigerants	Trichlorofluoroethane
Rustproofers	Phenols, heavy metals
Septic systems, cesspools, and sewer lines	Septage; coliform and noncoliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides; paints; paint thinner; photographic chemicals; swimming pool chemicals; septic tank/cesspool cleaner chemicals;[10] elevated levels of chloride, sulphate, calcium, magnesium, potassium, and phosphate
Solvents	Acetone, benzene, xylene
Swimming pool disinfection and maintenance chemicals	Free and combined chlorine; bromine, iodine Copper-based and quarternary algicides Cyanuric acid Caclium or sodium hypochlorite Muriatic acid Sodium carbonate
Toilet cleaners	Xylene, sulphonates, chlorinated phenols
Underground storage tanks	Home heating oil

MECHANICAL REPAIR AND OTHER MAINTENANCE PRODUCTS	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Antifreeze (gasoline or coolant systems)	Methanol, ethylene glycol
Automatic transmission fluid	Petroleum distillates, xylene
Battery acid (electrolyte)	Sulphuric acid, bromide
Car wash detergents	Alkyl benzene sulphonates
Car waxes and polishes	Petroleum distillates, hydrocarbons
Degreasers for driveways and garages	Petroleum solvents, alcohols, glycol ether
Degreasers for engines and metal	Chlorinated hydrocarbons, toluene, phenols, dichloroperchoroethylene
Engine and radiator flushes	Petroleum solvents, ketones, butanol, glycol ether
Gasoline and jet fuel	Hydrocarbons
Grease, lubricants	Hydrocarbons

[10] Septic tank/cesspool cleaners include synthetic organic chemicals such as 1,1,1 trichloroethane, tetrachloroethylene, carbon tetrachloride, and methylene chloride

Hydraulic fluid (brake fluid)	Hydrocarbons, fluorocarbons
Motor oils and waste oils	Hydrocarbons, heavy metals

LAWN AND GARDENS	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Fertilizers	Nitrogen
Herbicides and other pesticides	Common pesticides used for lawn and garden maintenance (i.e., weed killers, and mite, grub, and aphid controls) include such chemicals as 2,4,-D; chlorpyrifos; diazinon; benomyl; captan; dicofol; and methoxychlor
Wood preservatives	Pentachlorophenols, creosote, copper, arsenic, metam sodium

WALL, FURNITURE AND FLOOR TREATMENT	
SOURCE	**HEALTH, ENVIRONMENTAL, OR AESTHETIC CONTAMINANT(S)**
Floor and furniture strippers	Xylene
Paint and laquer thinner	Acetone, benzene, butyl acetate, methyl ketones
Paint and varnish removers, de-glossers	Methylene chloride, toluene, acetone, methanol, glycol ethers, methyl ethyl ketones
Paint brush cleaners	Hydrocarbons, toluene, acetone, methanol, glycol ethers, methyl ethyl ketones
Paints, varnishes, stains, dyes	Heavy metals, toluene

APPENDIX 2D
POTENTIAL CONTAMINANT SOURCE INVENTORY METHODS[11]

Personal Interviews

Personal interviews are a valuable way to find out about sources of potential contamination. This can be a 'jumping-off point' for information gathering, as these interviews can bring forward information that will help the planning team set priorities for other information gathering activities.

Local officials can often supply names of appropriate contacts. Contacts may include long-term residents, operators or staff with a wealth of knowledge about present and past operations and practices. Personal interviews with key individuals, such as a facility operator, often provide information that may not be available from other sources.

Results from the survey techniques can direct you to other community members who have valuable information. You may need to conduct a second round of personal interviews.

Mail and Phone Surveys

Mail and phone surveys are a good way to contact a large number of residents and businesses at a relatively low cost. Mailing lists can be obtained from a number of sources such as:

- Property owner names from the tax assessment authority;
- Voter registration lists;
- Chamber of Commerce rosters;
- Utility records; and
- Phone directories.

Once the surveys are completed, they must be collected and the results summarized. The collection effort may be as simple as enclosing a self-addressed stamped envelope with a mailed survey, or as labour-intensive as a door-to-door collection. For telephone surveys, information is collected by filling out survey sheets during the interviews.

Windshield Survey

A windshield survey is used when more information is needed about potential or existing sources of contamination, and maps or aerial photographs do not provide enough information. A windshield survey requires access to a vehicle and one or two people, who drive through the area taking notes. A two-person survey is better, so that one can drive while the other takes down the information. This information is later added to the database.

[11] Contaminant source inventory method descriptions are excerpted from:
Ministry of Environment, Lands and Parks & Ministry of Health. (2000). *Well Protection Toolkit*. Victoria: Province of British Columbia. http://www.elp.gov.bc.ca/wat/gws/well_protection/acrobat.html.

Windshield surveys work well in most communities and may provide a large amount of useful information. They work best in areas where most of the sources can be located from the road, but may be less effective in forested or mountainous areas where many sources are not visible from the road.

Table 2-5. Advantages and Disadvantages of Different Types of Potential Contaminant Source Surveys

SURVEY TYPE	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Personal Interviews	One-on-one interviews with individuals that may have information not available through other sources. Contacts may include long-time residents, water system operators or staff.	• Obtain useful information and insight not available through any other source • Efficient	• Potential for response bias
Mail survey	A survey distributed by mail to a mailing list.	• Low cost to contact a large number of people • Low time requirements • Promotes public awareness and participation	• Usually a low response rate • Variable quality of response • Potential for bias •
Phone survey	Survey conducted verbally over the telephone.	• Low cost to contact a large number of people • Respondents are a "captive" audience – response rates are higher • Can be used selectively to fill in the gaps of a mail survey • Promotes public awareness and participation	• May be a significant labour and time requirement (costs may be reduced by using volunteers) • Potential for response bias
Windshield survey	A windshield survey is conducted by one or two people driving through the well protection area with a vehicle recording where potential sources of contaminants are.	• Requires less time for survey staff • Effective in identifying obvious potential sources covering a large area • Effective in screening sites for future investigation • Access is not a problem • Direct observations	• Not easy to conduct in rough or forested terrain, where sources are not visible from road • No personal contact
Door-to-door survey	Involves canvassing the businesses and residents in the well protection area to identify the potential contaminant sources.	• Increased accuracy and uniformity of the data collected • Increased likelihood of identifying previously unknown sources • More public interaction • Direct observations	• Recruiting and training workers can be costly and labour intensive • Time-consuming
Field Inspections	Consist of an extensive walking survey of an area and may be used to provide a detailed inspection of landuses.	• Good for small areas with easy access • More accurate survey method • More public interaction • Direct observations	• Costly and labour intensive in large areas • Need to get owner approval

Door-to-Door Surveys

Door-to-door surveys involve canvassing the residences and businesses within the well protection area to identify the activities and materials that may pose a hazard to the water supply. This method allows for first-hand observations, which mail and phone surveys do not.

When survey staff are properly trained, the answers to the door-to-door survey will be more concise, complete and uniform than those of mailed surveys. This type of survey can gather a wide range of detailed information and should be tailored for the potential contamination sources expected in the survey area.

Door-to-door surveys should not be conducted during holiday periods. And if survey staff are volunteers, avoid sending them out in bad weather!

Field Inspections

Field inspections consist of an extensive walking survey of an area, and may be used to provide a detailed inspection of specific land uses. Field inspections allow survey staff to look at the area firsthand, without relying on landowners to identify and provide information about sources. It is also an opportunity to see actual management practices.

Select an Appropriate Survey Method

The choice of survey method will depend on:

The nature of human activities in the well protection area
What type of activity are you trying to document? How much detail do you require? For instance, assessing a farm might require an interview with the farmer. For a gas station, a site inspection might be appropriate, while for a trailer park a door-to-door or mail survey might be used.

Availability and skills of labour force
How many people will you need to conduct the surveys? Who will do the work? If you can't afford to hire labour, look at options such as using students or other volunteers. Who will train the survey staff?

Cost
Cost may influence your choice of survey technique. Do you need the level of detail provided by a field inspection, or would a phone survey be sufficient?

Conduct the most complete inventory possible. This may involve conducting more than one type of survey, for example mail, phone surveys or personal interviews in conjunction with historic records, door-to-door surveys or field inspections.