WELL PROTECTION TOOLKIT

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INTRODUCTION

It is estimated that over one million British Columbians depend on groundwater for their drinking water supply. British Columbia accounts for nearly one-quarter (23%) of the total groundwater consumption across Canada, almost as much as the three prairie provinces combined or that of Ontario (27%). The demand for potable groundwater in this province is increasing as a result of population growth, increased industrial and commercial demands, and to some degree in response to the occurrence of waterborne diseases caused by micro-organisms, such as cryptosporidium and giardia, in surface water supplies.

Although the quality of groundwater in B.C. is generally excellent, there are local areas where water quality degradation is occurring. A significant percentage of the groundwater aquifers in B.C. are shallow and highly vulnerable to contamination. Experience from elsewhere in Canada, the U.S. and Europe shows that preventing water quality degradation by implementing a well protection plan is the best way to protect a community's well water supply. A well protection plan contains realistic protective measures to manage activities in the capture zone (or recharge area) to reduce the risk of contaminating the well supply.

Well protection planning has many advantages—it provides a mechanism for protecting drinking water sources, human health and the economic investment the water purveyor and community have made in the groundwater supply. While it is recognized that funding, technical expertise, and groundwater protection education are not always available to the degree that is desired, this situation should not keep a water purveyor from working in partnership with the community, its residents, businesses and local government to develop and implement an effective plan. Furthermore, the Drinking Water Protection Act enables the local Drinking Water Officer to require that a water purveyor prepare a well protection plan as part of a water source or system assessment plan.

The Well Protection Toolkit presents the well protection planning process in six steps:

1. Form a community planning team;
2. Define the capture zone (recharge area) of the community well;
3. Map potential sources of pollution in the capture zone;
4. Develop and implement protection measures to prevent pollution;
5. Develop a contingency plan against any accidents; and
6. Monitor, evaluate, and report on the plan annually.

The Toolkit, which contains seven booklets, discusses these six steps in detail and includes an example of how each step is implemented in the fictitious community of Pumphandle, B. C.. The Pumphandle Community Planning Team succeeds in completing its first well protection plan, which is also included with the Toolkit.

The Well Protection Toolkit was prepared by the (former) B. C. Ministry of Environment, Lands and Parks and Ministry of Health in 2000, to assist water purveyors and communities throughout the Province, in their development of well protection plans. This updated edition of the Well Protection Toolkit is intended to reflect legislative and government organizational changes since the original edition only. Recent legislative changes include the Drinking Water Protection Act and Regulation, which came into effect in 2001 and 2003 respectively, and the Ground Water Protection Regulation under the Water Act which came into effect in 2004. The purpose of the Well Protection Toolkit remains unchanged, it continues to act as a guide on how to develop and implement a well protection plan.

At first glance, the Well Protection Toolkit can appear imposing. The Toolkit, however, is written for a broad audience with a varied background; for people with little or no technical knowledge, to individuals with specialized training in hydrogeology. As its name implies, the Toolkit is a tool to guide the reader through a process of groundwater protection.

We sincerely hope this Toolkit will be useful to communities in B.C. and elsewhere in developing and implementing well protection plans to protect this valuable but hidden resource—our groundwater! Any feedback on the Toolkit and its usefulness will be appreciated. You will undoubtedly gain new knowledge and experience about well protection planning during your process, which in turn will be helpful to others. Pass your experiences on!

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Please contact your Regional MoE Office
(see Step 1, Appendix 1.2, for contact information).

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GLOSSARY

AMBIENT GROUNDWATER FLOW: The rate of flow and direction of flow of groundwater under unpumped, natural conditions.

AQUIFER: A geological formation, group of formations, or part of a formation that consists of sufficient saturated permeable materials to yield economical quantities of water to wells and springs.

AQUIFER VULNERABILITY: An intrinsic measure of how easily an aquifer can be contaminated from activities at the land surface, based on the aquifer's geologic and hydrologic characteristics only. Vulnerability for an aquifer does not include the type and intensity of the human activities at the land surface.

AQUITARD: An aquitard is a geological formation that does not transmit a significant amount of water to wells and springs. An aquitard can, however, contribute a significant amount of water over a large area to an aquifer. Aquitards typically consist of till, silt or clay.

BACTERIA: One-celled microorganisms, some of which cause diseases in plants or animals.

BASE FLOW: The part of the streamflow that is derived from inflow of groundwater to the stream. Flows in a stream during the dry season is usually made up entirely of base flow.

BEDROCK: A general term for the solid rock that underlies soil or other unconsolidated materials.

CADASTRAL MAPS: Maps showing the legal property boundaries. Usually large scale maps.

CAPTURE ZONE: The land area around a pumping well which contributes water to the well. Also known as the recharge area for the well.

COMMUNITY WELL: A well supplying water to two or more dwellings or supplying any commercial premise serving the public.

CONCENTRATION: The amount of a chemical constituent in a given weight or volume of water, e.g. milligram per litre (mg/L).

CONFINED AQUIFER: Where an aquitard overlies an aquifer, the low permeability of aquitard can help in protecting the underlying aquifer from impacts of human activities at the land surface. In those cases, an aquifer is said to be "confined."

CONSTANT HEAD BOUNDARY: A hydraulic boundary of an aquifer where the water level is essentially stable and does not change. For example, a river or lake are often considered constant head boundaries for shallow aquifers.

CONTAMINANT INVENTORY: An office and field survey that identifies and locates potential sources of contamination in a specified area such as a capture zone area. Potential sources of contamination can be septic tanks, vegetable fields, contaminated industrial sites, etc.

CONTINGENCY PLANNING: The process of developing advance arrangements and procedures which enable the water purveyor to respond to an event that could happen by chance or unforseen circumstances.

DATABASE: A collection of records and files that are logically organized to assist with the analysis and processing of data.

DISCHARGE AREA: The land area where groundwater flows back towards the land surface. Features that are common to discharge areas are springs, wetlands and shallow water tables.

DRAWDOWN: The difference between the static water level and the pumping water level. Drawdown is expressed in metres (m) or feet (ft).

DRAWDOWN CONE: The difference between the pumping water level and the static water level decreases exponentially with distance in all directions away from a pumping well. The pumping water level forms a cone shape around the pumping well.

DRILLED WELL: A well that is constructed with a drilling rig, such as an air rotary or cabletool drilling rig.

DUG WELL: A well that is dug by hand or excavated by backhoe. Dug wells are usually shallow.

EMERGENCY RESPONSE PLAN: A set of standard operating procedures that addresses a number of emergency situations that are specific to the waterworks systems.

FLOWING ARTESIAN WELL: A well in which water naturally rises above the ground surface or the top of any casing, and is observed to flow naturally, either intermittently or continuously.

FRACTURE: A break or crack in the bedrock.

GIS: Geographic Information System, a computer software and database that stores and analyzes geographic data. ArcInfo™ is an example of a GIS system.

GEOMORPHOLOGY: The study of landforms. Important in identifying aquifers and the occurrence of groundwater.

GLACIOFLUVIAL SEDIMENTS: Sand, gravel, silt and clay deposited by glacial rivers or streams.

GROUNDWATER: Water occurring beneath the ground.

GROUNDWATER DIVIDE: The uppermost groundwater boundary of a groundwater basin.

HOMOGENEOUS: Uniform in structure and composition throughout. For example, a homogeneous aquifer is an aquifer where the hydraulic conductivity of the sediments is uniform.

HYDRAULIC CONDUCTIVITY: A measure of the ease of flow of water through the aquifer. Hydraulic conductivity is usually expressed in metres per day (m/d) or feet per day (ft/d).

HYDRAULIC GRADIENT: The slope of the groundwater level or water table (for an unconfined aquifer), or the slope of hydraulic head level (for a confined aquifer). Hydraulic gradient is usually expressed as a unitless value.

HYDRAULIC HEAD: The level to which water rises in a well with reference to a datum such as sea level. Hydraulic head is usually expressed in metres (m) or feet (ft) above sea level.

HYDROGEOLOGIC MAPPING: Mapping groundwater and groundwater related features. A contour map of the water table, a map outlining the aquifer boundary and thickness, or a map showing the rate and direction of groundwater flow in an aquifer are examples of hydrogeologic maps.

HYDROGEOLOGY: The study of the flow of water and chemicals through the geological formations.

HYDROGRAPH: A continuous graph showing the rate of streamflow or level of groundwater over time.

HYDROLOGIC CYCLE: The continual circulation of water between the ocean, atmosphere, and land.

INFILTRATION RATE: The rate at which water permeates the pores or interstices of the ground.

ISOTROPIC: Exhibiting properties with the same values in all directions. For example, the hydraulic conductivity in a sand and gravel aquifer may be assumed to be equal in all directions, and the aquifer is said to be isotropic.

KARST AQUIFER: Limestone aquifer where groundwater flows through openings formed by water dissolving the rock fractures; these openings are commonly much larger than fracture openings (e.g. caverns, cavities).

LEACHING: Refers to the dissolution of chemicals into the water and movement of chemicals through soil by water.

LEVEL OF GROUNDWATER DEVELOPMENT: The level of groundwater use of an aquifer relative to the aquifer's ability to replenish itself.

LITHOLOGY: All the physical properties, the visible characteristics of mineral composition, structure, grain size, etc. which characterize a rock or sediment. For example, "coarse-grained sand" is a lithological description.

MAXIMUM ACCEPTABLE CONCENTRATION: The concentration established for certain substances that are known or suspected to cause adverse effects on health. These concentrations are derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration.

MEAN: The arithmetic mean or average of a set of numbers is calculated by totalling the items in the set and dividing the total by the number of items in the set.

MEDIAN: The value from a set of measurements that has an equal number of measurements above and below it.

METHOD DETECTION CONCENTRATION (MDC): The lowest amount of a constituent that can be reliably detected/measured based on the variability of either the blank response of a method or that of a low-level standard.

MONITORING WELLS: Wells that are used or intended to be used for the purpose of ongoing monitoring, observing, testing, measuring or assessing the level, quantity or quality of ground water, or subsurface conditions, including geophysical conditions, and are not used or intended to be used for the purpose of exploring for or extracting ground water for use, or injecting water or any other substance into ground water on an ongoing basis.

NON-POINT SOURCE CONTAMINATION: Contamination where the source is diffuse (e.g. urban runoff).

NUMERICAL MODEL: A computer model that is designed to solve a set of mathematical equations that describe the physics of the system that one is modelling (such as an aquifer). Numerical models are usually developed to predict the water table elevation, flow rates, and/or chemical concentrations of a particular contaminant in different parts of the aquifer and over time and is a useful tool to assess implications of different policies or actions being contemplated for an aquifer area.

OBSERVATION WELL: A well used for the purpose of observing parameters such as water levels, pressure changes and water quality in aquifers.

OVERBURDEN: The loose soil, silt, sand, gravel, or other unconsolidated materials overlying bedrock, either transported or formed in place.

PERMEABILITY: The capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow. Permeability is usually expressed in metres squared (m^2) or feet squared (ft^2). It is closely related to the hydraulic conductivity.

PESTICIDE: Under the B.C. *Pesticide Control Act*, any substance or mixture of substances, other than a device, intended for killing, controlling or managing insects, rodents, fungi, weeds and other forms of plant or animal life that are considered to be pests.

pH: A numerical measure of the acidity of water ranging from 0 to 14. Neutral waters have pH near 7. Acidic waters have pH less than 7 and basic (alkaline) waters have pH greater than 7.

POINT SOURCE CONTAMINATION: Contamination where the source is site specific (e.g. landfill).

POROSITY: The percentage of the bulk volume of a rock or soil that is occupied by interstices, relative to the total rock or soil volume. Porosity is usually expressed as a fraction or percentage.

PUMPING INTERFERENCE: The condition occurring when a pumping well lowers the water level in a neighbouring well.

PUMPING TEST: A test that is conducted to determine aquifer or well characteristics. A pumping test is usually conducted to determine the transmissivity and storativity characterstics of an aquifer and the capacity of a well supply.

PURVEYOR: A company, individual or municipality that delivers and sells water to clients, usually the residents in the community.

QUALITY ASSURANCE: The overall verification program which provides producers and users of data the assurance that predefined standards of quality at predetermined levels of confidence are met.

QUALITY CONTROL: The overall system of guidelines, procedures and practices which are designed to regulate and control the quality of products or services with regards to previously established performance criteria and standards.

RECHARGE AREA: Land area where water infiltrates into the ground and replenishes the aquifer.

SALINE GROUNDWATERS: Groundwater consisting of or containing a significant amount of salt.

SANDPOINT: A well pipe with a screen, equipped with a hardened, conical point at the bottom, that is driven into the ground to tap shallow groundwater.

SANITARY SURFACE SEALS: A grouted annular space around the well casing which usually extends from the land surface to several metres deep. The sanitary well seal functions to prevent any contaminated surface and near surface water from seeping down the side of the well to the aquifer.

SEDIMENTARY ROCKS: Rocks formed from consolidation of loose sediments such as clay, silt, sand, and gravel (e.g. sandstone, shale).

SOLE SOURCE AQUIFER: The only source of groundwater supply in an area.

SPECIFIC CAPACITY: The rate of discharge of water from a pumping well per unit of drawdown, commonly expressed in litres per second per metre (L/m/s) of drawdown or gallons per minute per foot (gpm/ft) of drawdown. Specific capacity usually decreases with duration of pumping.

SPECIFIC CONDUCTIVITY: The measure of the ability of water to conduct an electrical current. Specific conductance reflects the concentration of dissolved solids in the water. A rapid determination of total dissolved solids (TDS) of a water sample can be made by measuring the specific conductance. Specific conductance is expressed as microSiemens per centimetre (μS/cm) and is usually 1.5 to 2 times the TDS.

SPILL CONTINGENCY: A plan developed to deal with unexpected spills of contaminants.

STATIC WATER LEVEL: The unpumped level of water in the well or in the aquifer, measured from the ground level.

STEADY-STATE FLOW: State of groundwater flow where rate and direction does not change with time.

STORATIVITY: Volume of water stored or released from a column of aquifer (with unit cross section under unit change in head).

SURFICIAL DEPOSITS: Deposits overlying bedrock and consisting of soil, silt, sand, gravel and other unconsolidated materials.

TILL: Predominantly unsorted and unstratified drift, generally unconsolidated, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogenous mixture of clay, silt, sand, gravel and boulders ranging widely in size and shape.

TIME OF TRAVEL: The time it takes for a particular contaminant to be transported through groundwater flow to a specified location. Time of travel is commonly used to relate the distance of a contaminant source to a drinking water well (e.g. "that gas station is located within a one-year time of travel distance from the community well").

TOPOGRAPHY: The configuration of a surface including its relief and the position of its natural features.

TOTAL DISSOLVED SOLIDS; TDS: A term that expresses the quantity of dissolved minerals in water. TDS is expressed in milligrams per litre (mg/L) or parts per million (ppm).

TRANSMISSIVITY: The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity of an aquifer is the hydraulic conductivity of the aquifer multiplied by the aquifer thickness. Transmissivity is expressed as metres squared per second (m^2/s), feet squared per day (ft^2/d), or gallons per day per foot (gpd/ft).

UNCONFINED AQUIFER: An aquifer where its upper boundary is defined by the water table. Where no aquitards overlie the aquifer, the aquifer is said to be "unconfined." Unconfined aquifers are generally more vulnerable to impacts from human activities at the land surface, particularly if the water table is shallow.

UNCONSOLIDATED DEPOSITS: Deposits overlying bedrock and consisting of soil, silt, sand, gravel, clay and other material which have either been formed in place or have been transported in from elsewhere. Synonymous with Surficial Deposits.

UNIFORM FLOW: Groundwater flow in the same direction and rate.

VOLATILITY: The degree to which a solid or liquid evaporates (evolves a gas).

WATER TABLE: The top of the unconfined aquifer; water level where the pressure is equal to that of the atmosphere; water level in a shallow well.

WELL CAP: Cover for the top of the well.

WELL CAPACITY OR WELL YIELD: The flow of water discharged from a well in gallons per minute (gpm) or litres/second (L/s).

WELL SCREEN: A wire-wound filtering device that allows water but not sediments from entering the well.

WELL PROTECTION: Protection of the recharge (or capture zone) area of a pumping well. Synonymous with the term Wellhead Protection used in the United States.

WINDSHIELD SURVEY: A survey of the capture zone area done by driving through all parts of the area noting the potential sources of contamination. This type of survey works best in areas where most of the sources can be seen from the road.

ACRONYMS

AC	Agriculture Canada
AFR	arbitrary fixed radius
ALR	agricultural land reserve
b	aquifer thickness
B.C.	British Columbia
BCGWA	British Columbia Ground Water Association
BCWWA	B.C. Water and Waste Association
BMP	best management practice
CCME	Canadian Council of Ministers of the Environment
CDBMS	computerized database management system
CFR	calculated fixed radius
CPT	community planning team
d_{TOT}	distance representing the one-, five-, or ten-year time of travel
DFO	Department of Fisheries and Oceans
DWO	Drinking Water Officer
EC	Environment Canada
EHO	Environmental Health Officer
EMS	Environmental Monitoring System
GIS	geographic information system
i	hydraulic gradient
IPM	integrated pest management
K	hydraulic conductivity
MAC	Maximum Acceptable Concentration
MAL	Ministry of Agriculture and Lands
MCS	Ministry of Community Services
MEMPR	Ministry of Energy, Mines and Petroleum Resources
MFR	Ministry of Forests and Range
MHO	Medical Health Officer
MOE	Ministry of Environment
MOH	Ministry of Health
n	porosity
NMP	Nutrient Management Plan
NO_3-N	nitrate-nitrogen
NTS	National Topographic System
PEP	Provincial emergency program
PERC	perchloroethylene
PHE	Public Health Engineer
Q	pumping rate
QA/QC	quality assurance/quality control
r	radius
RCMP	Royal Canadian Mounted Police
S*M*A*R*T	specific, measurable, achievable, realistic and time-bound
t	time
T	aquifer transmissivity
TDS	total dissolved solids
TOT	time of travel
TRIM	Terrain Resource Information Management
U.S.	United States
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WELL	Provincial water well database
X	horizontal distance from the well to the down-gradient edge of a parabolic capture zone
Y	horizontal half width of a parabolic capture zone