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Water Use Determination

Definitions

The following terms used in this guidance are defined in the procedure "Definitions and Acronyms for Contaminated Sites": agricultural land use, aquatic life water use, contamination source, drinking water use, ecologically active zone, groundwater contamination source, industrial land use, irrigation water use, livestock water use, municipality, muskeg, organic soil, qualified professional and Regulation.

Introduction

It is estimated that more than one million British Columbians rely on groundwater for their drinking water. With increasing population, industrial, and agricultural growth and the potential impacts of climate change, now more than ever, we need to be planning and protecting our water resource to ensure it is sustainable for future generations.

The Contaminated Sites Regulation (the Regulation) contains requirements to ensure that groundwater at a site is suitable for current and future uses and is of adequate quality to protect adjacent water uses. This document explains how these provisions are applied by the ministry at contaminated sites throughout British Columbia. The relevant provisions in the Regulation include sections 12 (2) and (5) and section 17 (5).

This guidance replaces our former Technical Guidance 6 "Applying Water Quality Standards to Groundwater and Surface Water" last revised in June 2005.

Groundwater may be used for all defined purposes specified in section 12 (4) of the Regulation (aquatic life, drinking, irrigation and livestock). Further details in this guidance are provided to aid responsible parties and qualified professionals in determining groundwater use at a site.

Drinking water use

Site-specific factors used in the determination of drinking water use are presented in a series of questions below. Depending on the responses to the questions, drinking water use may or may not apply. Current and future water uses are evaluated separately. Questions are summarized in a flowchart provided in Figure 1 to help users navigate the evaluation process.

Current Drinking Water Use

Question 1. Is the water currently used for drinking?

Drinking water use applies at a site where the groundwater or surface water at or near the site is currently used for drinking water. Exemptions provided under the future drinking water use evaluation are not allowed if there is a current drinking water use at or near your site.

For site investigation purposes, nearby drinking water wells or surface water intakes

are those present within a radial distance of 500 metres from the outer extent of the groundwater contamination source. If the groundwater flow direction has been reliably determined using approved methodologies (see Technical Guidance 8, "Groundwater Investigation and Characterization"), nearby current uses may be limited to include drinking water wells or surface water intakes located 100 m upgradient and 500 m downgradient of the outer extent of the contamination source.

The presence of current drinking water wells or surface water intakes near the source may be obtained by using the following methods:

a) A search of the Ministry of Environment's well database).
b) Performing a door to door survey.
c) A search of B.C.'s Water License Database.
d) Contacting local municipalities, water utility owners, Medical Health Officers and local Drinking Water Officers.

All listed methods are not required for every site; however it is up to the qualified professional to ensure that the locations of current drinking water wells and surface water intakes at or near your site are accurate.

The presence of drinking water wells at distances greater than 500 metres may require additional evaluation on a case-by-case basis to ensure that there is no potential for adverse impacts on current drinking water uses. This could include situations where preferential flow pathways are known to exist, where there are high extraction pumping wells or where contamination plumes are large or expanding.

Where applicable and scientifically defensible, well capture zone analysis may be carried out by a qualified professional on drinking water wells located within 500 metres of the contaminated source. Where it can be shown that site groundwater will not enter the capture zone of all nearby wells, current drinking water use does not apply.

If water is currently used for drinking water, then drinking water use applies. If water is not currently used for drinking water, further evaluate future drinking water applicability by answering questions 2 through 4.

Future Drinking Water Use

Question 2. Is there an aquifer below your site with a hydraulic conductivity greater than 1 x 10^{-6} m/s and a yield greater than or equal to 1.3 L/min?

If an aquifer is present below your site and is determined to have a hydraulic conductivity greater than 1 x 10^{-6} m/s then it must be shown that the aquifer yield is less than 1.3 L/min (500 gallons/day) to exclude drinking water use. This yield is considered the minimum rate required to produce enough water to supply a single family dwelling for domestic use (B.C. provincial allocation for domestic surface water licenses). An unconfined aquifer that is present only seasonally or has an average saturated thickness of 1 metre or less is considered incapable of providing sufficient yield to sustain a single family dwelling.

Saturated geological units with hydraulic conductivities less than or equal to 1 x 10^{-6} m/s are considered to have insufficient permeability to allow suitable water extraction for drinking water use.

In situ field investigation is required when estimating formation hydraulic conductivity. The field tests should be conducted in

accordance with ministry Technical Guidance 8, "Groundwater Investigation and Characterization."

An estimate of aquifer yield is best determined by performing a pumping test. However, the ministry recognizes that a pumping test may not be performed at every contaminated site. In lieu of a pumping test, the Cooper-Jacob Approximation [1] is expected to address most circumstances at sites in B.C. and may be used. An example of the calculation is provided in the Appendix 1. Where conditions and assumptions inherent in this method do not apply, alternative methods may be used whose rationale is clearly documented by a qualified professional.

If there is no aquifer below your site with a hydraulic conductivity greater than 1 x 10^{-6} m/s and a yield greater than or equal to 1.3 L/min, then drinking water use does not apply.

Question 3. Is the natural quality of water in the aquifer unsuitable for drinking water?

Groundwater containing a natural total dissolved solids concentration of 4,000 mg/L or greater or is contained within organic soils or muskeg is considered to be unsuitable to be used as drinking water.

If the natural quality of groundwater in the aquifer is unsuitable for drinking water, then drinking water use does not apply.

Question 4. Is there a confining geological unit that protects the aquifer?

Drinking water use may be excluded if a natural confining geological unit exists to protect the aquifer. In this case it must be shown that the natural confining unit:

- is greater than or equal to 5 metres thick;
- has a bulk hydraulic conductivity less than or equal to 1 x 10^{-7} m/s;
- is relatively uniform and free of fractures; and
- is continuous across the extent and predicted migration pathway of the shallow subsurface contamination.

It also must be shown that contamination is contained within overlying geological units and has not penetrated to the deeper aquifer or within the lower 5 metres of the natural confining geological unit that protects this deeper aquifer and that these conditions will persist with time. If it is necessary to drill into the confining unit, drilling need only confirm the presence of at least 5 m of the confining unit below the deepest level of known contamination.

Drinking water use applies to the lower 5 meters of the saturated confining unit that protects the deeper drinking water aquifer. Applicable water use in shallow aquifers overlying deeper confined aquifers must be assessed according to this guidance.

If there exists a confining geological unit that adequately protects the aquifer, drinking water use does not apply.

For all other groundwater conditions, drinking water use applies.

Aquatic life, irrigation and livestock water uses

Aquatic life water use applies to all groundwater located within 500 metres of a surface water body containing aquatic life. Investigations must demonstrate that groundwater containing substances at concentrations greater than the applicable aquatic life water use standards does not have the potential to migrate to within 500 metres of a surface water body used by aquatic life. For

example, aquatic life water use applies at sites where there is potential for contaminants in soil to leach into groundwater for several years and migrate long distances, such as mine tailings impoundments.

Aquatic life water use applies at sites where there is the potential for contaminated groundwater to flow through preferential corridors that discharge directly to a surface water body containing aquatic life. One example involves groundwater from a dewatering system being pumped directly to a stormwater discharge system.

Aquatic life water use does not apply when a site exists within 500 metres of a surface water body containing aquatic life and it is shown, using methods described in Technical Guidance 8, that groundwater at the site flows to another surface water body located greater than 500 metres from the source.

Irrigation and livestock watering water use apply to groundwater located at sites with agricultural land use or within a provincial Agricultural Land Reserve (ALR) unless the geological unit where contamination occurs has a hydraulic conductivity less than 10^{-6} m/s.

Irrigation and livestock watering use applies if irrigation or livestock watering wells or surface water intakes are within a distance of 500 metres from the outer extent of a groundwater contamination source. If the groundwater flow direction has been reliably determined using approved methodologies, nearby current uses may be limited to include irrigation and livestock water wells or surface water intakes located within 100 m upgradient and 500 m downgradient of the outer extent of the contamination source.

Well capture zone analysis as described in the Drinking Water Use, Question 1 section of this guidance can be done to determine if current livestock or irrigation wells within 500 m distance of the contaminant source are pumping at rates that will draw in groundwater from your site.

Applicable water use standards

Whether or not a groundwater source is suitable for direct use can be determined by comparing monitoring results with the applicable generic numerical water use standards in Schedules 6 and 10 of the Regulation. When multiple uses are determined at a particular site, the most stringent of the applicable standards will apply. Consult Technical Guidance 3, "Environmental Quality Standards" for further information.

Water management plans

A qualified professional should consider water uses designated in water management plans approved by the minister under the *Water Act*.

Bedrock aquifers

Determination of water use for a bedrock aquifer is unnecessary if it has been shown that groundwater contamination has not penetrated to the bedrock aquifer. However, field investigations are required to measure aquifer yield if groundwater contamination has migrated to a bedrock aquifer. The advice of a qualified professional should be obtained to plan and conduct a bedrock aquifer investigation.

Requesting a director's determination of water use

Site owners or operators may formally request a Director to make a determination about whether any of the water uses apply to a

particular site. Such a request must be accompanied by a completed Contaminated Sites Services Application form and supporting documentation prepared by a qualified professional.

Grandfathering provisions

This guidance comes into effect February 1, 2011. Applications for contaminated sites services submitted after February 1, 2011 will be reviewed in accordance with this amended guidance. Applications received prior to February 1, 2011 may apply one or the other of (not both) the June 2005 version of Technical Guidance 6 (Applying Water Quality Standards to Groundwater and Surface Water") or this version ("Water Use Determination") for determining water use at a site.

References

1. Cooper H.H. and C.E. Jacob (1946). A generalized graphical method for evaluating formation constants and summarizing well field history. American Geophysical Union Transactions. Vol. 27: 526-534.

2. Theis C.V. (1935). The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. Transactions, American Geophysical Union. Vol. 16: 519-524.

For more information, contact the Environmental Management Branch at site@gov.bc.ca

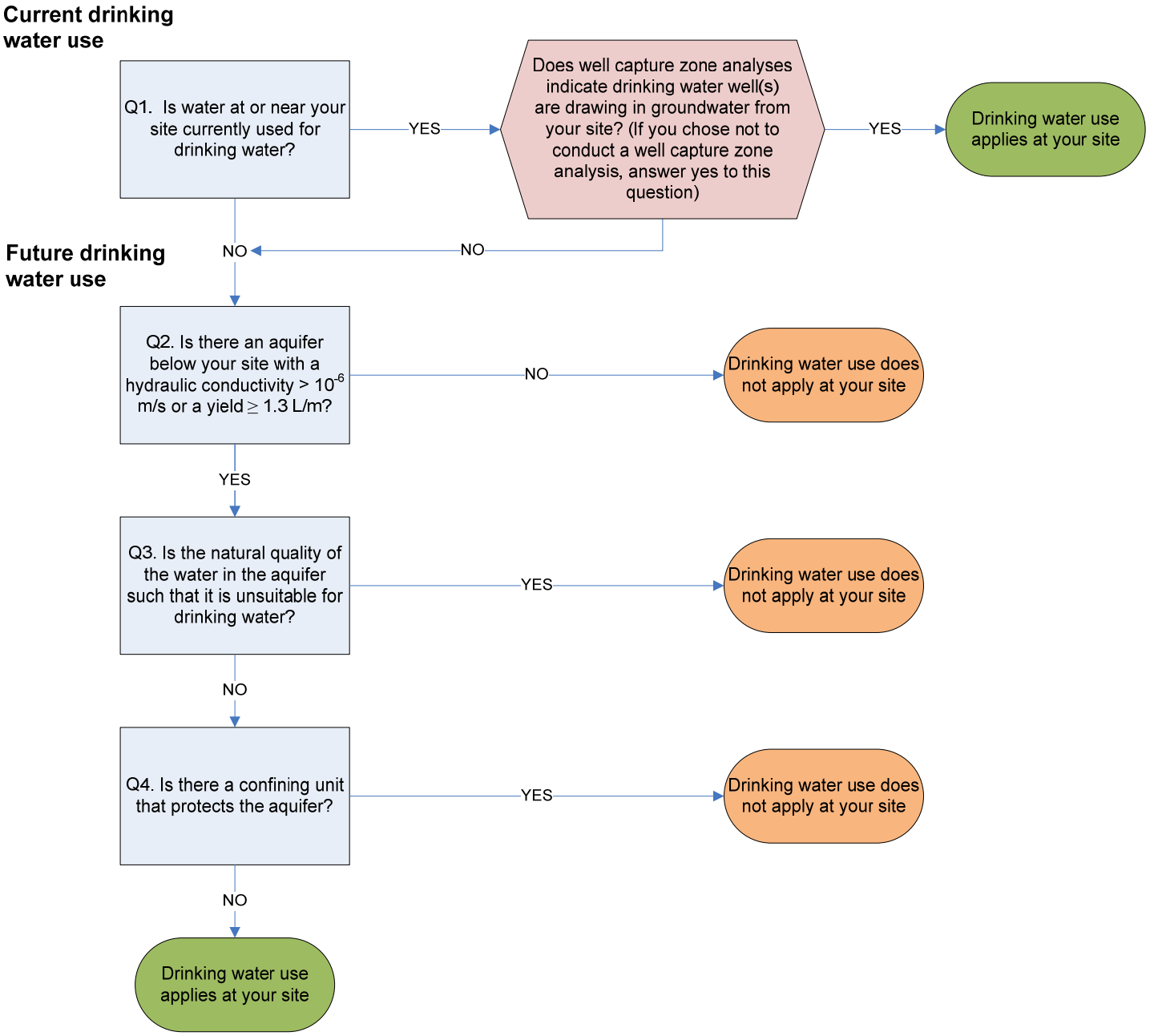

Figure 1. Drinking water use evaluation

Appendix 1

Estimation of Aquifer Yield Using Idealized Well Function Equation

Application of Nonequilibrium Well Function Equation and Estimation of Aquifer Yield based on Hydraulic Parameters.

The Cooper and Jacob [1] approximation to the Theis [2] solution for radial groundwater flow to a pumping well is:

$$s = \frac{2.3Q}{4\pi T}\left[\log\left(\frac{2.25Tt}{r^2 S}\right)\right] \qquad (1)$$

Where:

Q = rate of pumping (m^3/s)
T = transmissivity of water bearing unit (m^2/s)
r = radial distance from well (m)
S = coefficient of storage (dimensionless)
s = water level drawdown (m) at pumping rate (Q) and distance (r)
t = time of pumping (s)

The equation is valid for large values of time (t) and/or small values of radial distance (r), such as will occur at a pumping well. Well yield Q may be expressed in terms of drawdown (s), hydraulic conductivity (K), and saturated thickness (b) and coefficient of storage (S) as follows:

$$Q = \frac{5.46(s)(K)(b)}{\log\left(\frac{2.25Kbt}{r^2 S}\right)} \qquad (2)$$

For use in estimation of aquifer yield, the equation may be simplified by incorporation of typical default values for less sensitive input parameters, as follows:

Where:

r = radius of well in m
S = 1.0×10^{-4} (confined aquifer), 1.0×10^{-1} (unconfined aquifer)
t = 100 days = 8640000 s
K = hydraulic conductivity (m/s)
b = saturated thickness of the aquifer in m.

In unconfined aquifers, a water level drawdown in excess of 70% of the saturated thickness does not significantly increase well yield. Consequently, screening the lower one-half to one-third of the saturated aquifer corresponds to a maximum available drawdown (s_{max}) equal to 70% of the saturated thickness.

In confined aquifers, when the full saturated thickness of the aquifer is screened, this corresponds to a maximum available drawdown equal to 100% of the confining head (h_c).

Based on these design guidelines, maximum available drawdown may be expressed as:

- Confined unit: $s_{max} = (1.0)(h_c)(e)$
- Unconfined unit: $s_{max} = (0.7)(b)(e)$

Where:
h_c = confining head (base of the aquifer to the static water table)
b = saturated thickness (base of the aquifer to the static water table)
e = well efficiency

Substituting these available drawdown terms into the Cooper-Jacob expression (Equation 2), the well yield (Q) associated with utilization of the maximum available drawdown (s_{max}) can be calculated based onsite-specific values of saturated thickness (b), hydraulic conductivity (K), and (for confined units) confining head (h_c), as in the following example:

For a confined aquifer, 6-inch (0.1524m) diameter well screen:

$$Q = \frac{(5.46)(h_c)(K)(b)}{13.52 + \log[(K)(b)]} \qquad (3a)$$

For an unconfined aquifer, 6-inch (0.1524m) diameter well screen:

$$Q = \frac{(3.822)(K)(b^2)}{10.52 + \log[(K)(b)]} \qquad (3b)$$

Where:
b = saturated thickness of water-bearing unit (m)
h_c = confining head (base of aquifer to the static water table) (m)
K = hydraulic conductivity of water-bearing unit (m/s)
Q = well yield (m^3/s)
e = well efficiency (assumed to be 100% for an ideal well)