BRITISH COLUMBIA | Ministry of Environment

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TECHNICAL GUIDANCE ON CONTAMINATED SITES

Version 3.0 Draft 10 December 2015

Assessment of Hydraulic Properties for Water Use Determinations

This document provides guidance for assessing aquifer properties for use in determinations of water use made under Protocol 21, "Water Use Determination" and the Contaminated Sites Regulation. It supplements general guidance on the investigation of groundwater in Technical Guidance 8, "Groundwater Investigation and Characterization".

1.0 Aquifer yield

In situ field investigations are necessary to assess aquifer yield and aquifer hydraulic properties. Aquifer yield is best determined by performing a pumping test. If it is not practical to perform a pumping test, the Cooper-Jacob Approximation [1] to the Theis solution [2] is expected to address most circumstances at sites in B.C. and may be used. Example calculations are provided in Appendix 1. Where conditions and assumptions inherent in this method do not apply, alternate methods may be used, provided a scientifically defensible rationale is clearly documented by a qualified professional.

1.1 Bedrock

For bedrock units, *in situ* field investigations are necessary at the site under investigation or within 500 metre radial distance of the site boundary where the bedrock can be shown to be of the same geological formation. If it is not practical to determine aquifer yield by performing a pumping test, the *in situ* field investigations need to show whether the aquifer can sustain being pumped at 1.3 L/min. The advice of a qualified professional should be obtained to plan and conduct a bedrock aquifer investigation.

1.2 Unconsolidated Geological Units

In situ field investigations for evaluating hydraulic properties and stratigraphic conditions in unconsolidated geological units are necessary at all sites under investigation. Site specific data may be supplemented with data collected on adjacent properties or affected parcels located within 500 metres radial distance of the site boundary. Supplementary data must be demonstrated to have been obtained from the same unconsolidated geological formation as that at the site. Supporting documentation and appropriate rationale must be provided in site technical reports.

2.0 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.

The current legislation and regulations should be consulted for complete information.

For more information, contact the Environmental Emergencies and Land Remediation Branch at (250) 387-4441.

Revision history

Approved Date	Effective Date	Document Version	Notes
November 30, 2015	February 1, 2016	Ver 3.0	

Appendix 1

Estimation of Aquifer Yield Using Idealized Well Function Equation

Application of the Nonequilibrium Well Function Equation and the 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 (smax) 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 (hc).

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

- Confined unit: smax = (1.0)(hc)(e)
- Unconfined unit: smax = (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 (smax) can be calculated based on site-specific values of saturated thickness (b), hydraulic conductivity (K), and (for confined units) confining head (hc), 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)