Appendix 7-5 – Hydraulic Influence Calculations

The landfill expansion area is characterised geologically by peat and underlying sediments which contain varying proportions of clay, sand and gravel. The sediments are of Quaternary age and represent glacial till. Sand and gravel 'lenses' logged in new boreholes are inferred to be of glacio-fluvial origin. There is lithological variability within and between boreholes, and the Quaternary age sediments are best described as 'heterogenous' (i.e., they vary in 3 dimensions).

In this type of geological setting, shallow groundwater flows along complex pathways. These pathways are influenced by the geometry of sand and gravel deposits and elevation differences between groundwater recharge and discharge areas.

Groundwater levels measured in the landfill expansion area indicate that flow is divergent, mainly towards the Cushaling River but also with a flow component in the northern part of the expansion area towards the existing Waste Management Facility (WMF). The latter is likely caused by the existing under-cell drain system at the WMF which lowers groundwater levels beneath cells which are actively being filled.

The planned landfill expansion will also include an under-cell drain system which will be operational in phases. The landfill expansion covers a total area is 593 m × 583 m. Individual cells are 268 m long and 97 m wide. Hence, the under-cell drain system will operate sequentially across 268 m × 97 m areas.

The invert of the underdrain pipe system will control the extent of groundwater lowering when the system becomes operational. When groundwater levels are lowered, the hydraulic effect translates away from the system in all directions. The effect dissipates with distance, and there is a theoretical maximum extent of hydraulic influence where drawdown becomes zero.

Estimated Extent of Hydraulic Influence of Dewatering

This distance of zero drawdown can be estimated using different analytical techniques. A commonly applied method is the 'Sichardt equation' (Preene and Powrie, 2016: PUB C750 Groundwater control - design and practice). The estimated radius of zero drawdown, R_0, is calculated from:

$$R_0 = 3{,}000 \times (H-h) \times K^{0.5}$$

Where,

- R_0 = radius of zero drawdown away from a pumping well (m)
- H = total head of the aquifer prior to pumping (m)
- h = head of the dewatered aquifer at the well location during pumping, assuming steady state conditions (m)
- K = horizontal hydraulic conductivity (sometimes referred to as 'permeability') (m/s)
- 3,000 = empirical constant (conservative)

For the Drehid site, inputs are:

- H = 84 m above ordnance datum (mOD), seasonal high groundwater level based on onsite measurements
- h = 77.745 mOD, which is the invert of the underdrain system
- K = 6.9E-06 m/s, or 5.96 E-01 m/d, which is the 'effective K' of the Quaternary age sediments, as described below.

Site-specific K values were derived from falling and rising head tests in completed monitoring wells in and around the landfill expansion area. The estimated K values for tests conducted in the Quaternary unit range from 3.77E-07 to 2.32E-04 m/s, with a geometric mean of 1.47E-05 m/s. The monitoring wells that were tested are mostly installed with response zones across sand and gravel lenses. Hence, the K values reflect those sediments that will drive groundwater flow through subsoils. In comparison, clays have lower K values, on the order of 10^{-8} to 10^{-10} m/s.

The Quaternary sediments across the landfill expansion area range in thickness between approximately 10 and 24 m, and is roughly 18 m thick on average. The sand and gravel lenses occur in lenses at different depths but are conservatively up to approximately 6 m thick (within the 18 m total thickness). Hence, the effective K of the Quaternary sediments was calculated as follows:

$$\text{Effective K} = [(K_{clay} \text{ x clay thickness}) + (K_{sand/gravel} \text{ x sand/gravel thickness})]/\text{total thickness}$$

Hence,

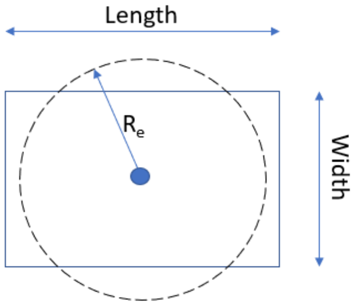
$$\text{Effective K} = [(1.0\text{E-}08 \text{ x } 12)+(1.47\text{E-}05 \text{ x } 6)]/18 = 4.9\text{E-}06 \text{ m/s}$$

Based on these inputs:

$$R_0 = 3{,}000 \times (84-77.745) \times 4.9\text{E-}06^{0.5} = 41.6 \text{ m}$$

The underdrain system is rectangular. To adjust for this, an equivalent radius of influence (R_e) of the rectangular area is calculated, from:

$$R_e = [(\text{width x length})/\pi]^{0.5}$$



Thus, for a 268 m by 97 m underdrain system (covering one phase):

$$R_e = 91 \text{ m}$$

Hence, the estimated distance to zero drawdown is:

$R_0 + R_e$ ~ 132 m from the edge of the rectangular excavation

Estimated Dewatering Rate:

The estimated dewatering rate, Q, is calculated from the Dupuit-Thiem equation (unconfined, steady-state conditions):

$$Q = [\pi \times K \times (H^2-h^2)]/(2.3 \times \log (R_0/R_e))$$

When R_0 (from Sichardt) is less than R_e, then $R_0 = R_0$ (from Sichardt) $+R_e = 132$ m. Hence the term:

$$\text{Log } R_0/R_e = \text{Log } (132/91) = 0.161, \text{ and Q becomes:}$$

$$Q = [3.14 \times 4.9\text{E-}06 \times (84^2- 77.745^2)]/(2.3 \times 0.161) = 0.04 \text{ m}^3\text{/s, or 40 l/s.}$$