Groundwater movement and Dewatering Memo Report

1. Introduction

Changes to groundwater occur when it flows into an excavation or migrates around a cut-off. The lowering of the groundwater level at the excavation site creates a hydraulic gradient towards the excavation or tunnel, so the groundwater moves along that gradient from high pressure to low pressure. The decline in water level is referred to as the 'cone of depression around drawdown zone of an excavation. The extent of groundwater drawdown is influenced by the nature of the aquifer (high or low aquifer transmission capacities), the pumping rate (how quickly water is removed via pump or seepage) and how long the pumping or seepage occurs. Altering the hydraulic gradient may change the groundwater movement from (or to) features such as creeks, rivers and wetlands, thereby causing a reduction in water availability at those features. As a result, drawdown of the water table may impact groundwater dependant ecosystems (GDEs) within the cone of depression, by reducing or removing their water supply for the duration of dewatering (Figure 1). The risks are considered lower if limited or localised drawdown takes place for a short duration and are also considered to decrease in clay soils where hydraulic conductivity is low (Shand et al 2018). GDEs experience seasonal variability in the quantity of use and relative importance of groundwater, so the risks of drawdown are lower in winter when the soil moisture is high the vegetation is not as reliant on groundwater for survival (Eamus and Froend 2002; Zencich et al 2002).

In the case of the TGSI (Hale Rd and Welshpool Rd proposal (hereafter known as the Proposal), the main impact of dewatering on local groundwater will be potential impacts to the GDEs located in the vicinity. In order to determine whether any dewatering for the Proposal will have a significant impact on neighbouring GDEs, an empirical modelling in accordance with DWER online calculator (DER 2015) is presented in this report.

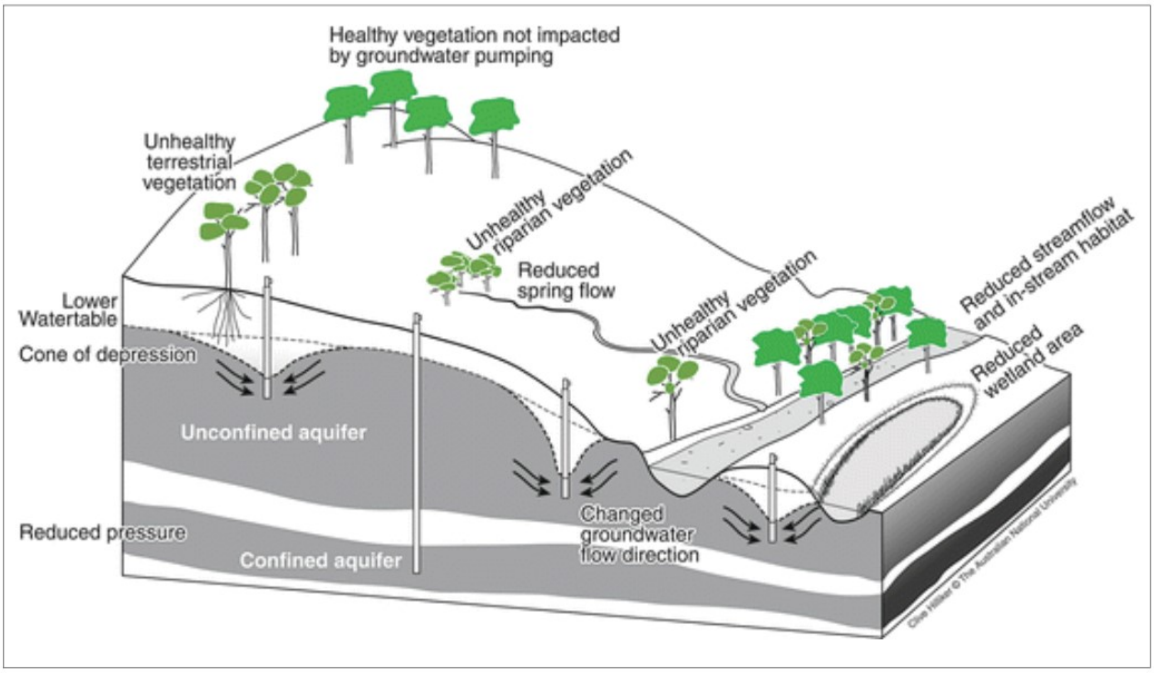

Figure 1. Diagram showing the potential impacts of aquifer dewatering on GDEs (Source: Eamus *et al* 2016). As indicated in the figure 1, impacts of groundwater extraction in an unconfined aquifer is localised and forms a cone of depression that can extend a few metres to several hundreds of metres from the extraction point.

2. Background

Temporary groundwater dewatering is unlikely to be required, but may be required, for the construction of bridge piers, abutment footings. The groundwater table occurs approximately 4-5 m and 5-6 m below the ground surface at Hale Road and Welshpool Road respectively (ARUP 2020). Given the depth of the water table at those locations and the fact that the pile caps are typically installed 1 m below ground, any occurrence of dewatering will be low and will not significantly impact neighbouring vegetation. However, if dewatering, is required, the horizontal extent of groundwater drawdown (cone of depression) is expected to be small.

The Water Register (DWER, 2022) indicates that three groundwater aquifers underlie the Proposal site:

- Perth – Superficial Swan Aquifer
- Perth – Leedervillle Aquifer
- Perth – Yarragadee North Aquifer

The majority of the DE is overlain by Bassendean Sand or granular Guildford formation soils and shallow foundations. Groundwater contours suggest that groundwater is flowing in a westerly direction which is commensurate with the slope of the surface topography. Monitoring boreholes in the area indicates the presence of a granular (highly permeable) layer overlying an interbedded clayey sands / clay (ARUP 2020). Groundwater is typically shallower at the Hale Road section (measured at approximately 4.5 m BGL) and increasing with depth to the south (Welshpool Road approximately 5m to 6.3 m BGL).

3. Methodology

The groundwater modelling has been based on open trench excavation methods and a short period of dewatering at relatively shallow depths.

The empirical modelling approach as per DWER guidelines (DER 2015) is outlined below.

3.1 Empirical Modelling Calculations

The cone of depression, also known as radius of influence (R_0) is estimated utilising the Sichardt's equation:

$$R_o = 3000(H - h)\sqrt{K}$$

$$R_o = 3000 \text{ x } s \text{ x}$$

Where: R_o = radius of influence of an equivalent pumping bore (m)

s = maximum groundwater draw down (m)

K = hydraulic conductivity of aquifer matrix (units of m/s)

Groundwater elevation resulting from dewatering activities are related to the pumping rate, hydraulic conductivity of the aquifer matrix and the radius of influence of pumping by the following equation:

$$H^2 - h^2 = \frac{nq}{\pi k}\left(\ln R_o - \ln r_e\right)$$

Where: H = saturated thickness of the aquifer undisturbed by pumping (m)

h = saturated thickness of the aquifer at maximum drawdown (m)

k = hydraulic conductivity of aquifer matrix (units of m/s)

R_o = radius of influence of an equivalent pumping bore (m)

r_e = effective radius of an equivalent pumping bore (m)

q = pumping rate of individual dewatering well points (m^3/s)

n = number of well points used to dewater the excavation

The pumping time required for the cone of depression to reach the full extent of water table drawdown is calculated utilising the Coopper-Jacob empirical relationship:

$$\mathbf{R_o = ((2.25\ k\ h\ t)/S)^{0.5}}$$

Where: t = pumping time (seconds)

S = specific yield of aquifer sediments

Other parameters as previously defined

3.2 Empirical Modelling Assumptions

The assumptions made for the modelling are:

- Default hydraulic conductivity value (K) for clayey sand reflecting the characteristics of S10 (thin veneer of sand over sandy clay to clayey sand of eolian origin) was applied (DWER 2015).
- Value for saturated thickness of superficial aquifers from the DWER Groundwater Map was used (DWER, 2022).

The empirical modelling for a possible groundwater drawdown has been based on the following scenario:

Length of excavation:	60 m (maximum length of trench dewatering at any one time)
Width of excavation:	5 m
Hydraulic conductivity of the aquifer matrix (k):	0.0000116 m/sec (for clayey sand)
Required groundwater drawdown:	1 m
Saturated thickness of the unconfined aquifer (H):	13 m

A diagrammatic representation of a typical dewatering scenario in shown in Figure 2. This hypothetical example involves a width of excavation of more than 5 m and a drawdown depth of a few metres.

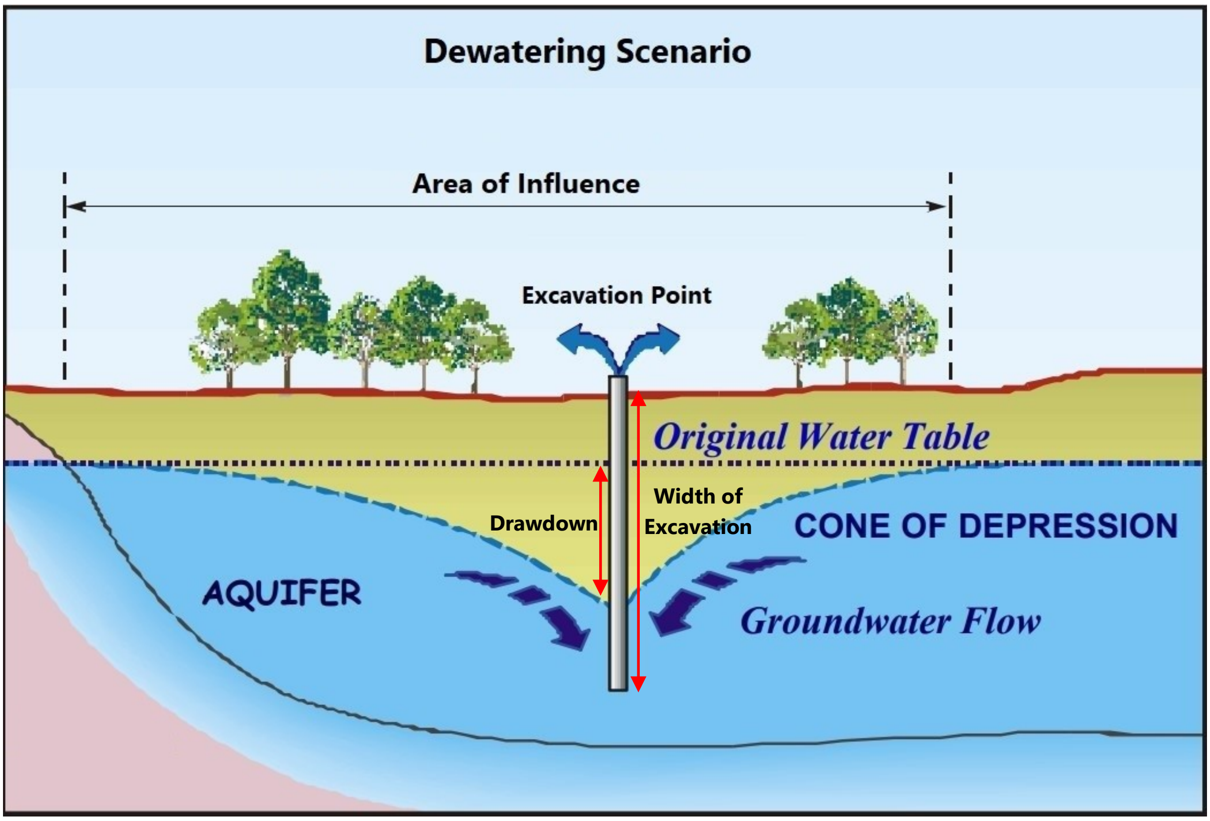

Figure 2. Diagram showing one excavation point and the resulting cone of depression (adapted from ABC's of Groundwater, Centre for Groundwater Studies, 2022).

4. Results and Discussion

The modelling suggests that the cone of depression (or radius of influence) may extend up to 10 m away from the open trench. The outcome of the dewatering modelling is given in Table 1.

Table 1. Summary of Dewatering Modelling

Required Drawdown (m)	Cone of Depression – R_0 (m)	Abstraction Rate (L/s)	Time taken to dewater (hrs)
1	10	21	9

Results from the modelling indicate that the radius of influence (R_0) will cover a distance of 10 m and water abstraction at a rate of 21L/s will be required over a period of 9 hrs.

Based on the above modelling, impacts of construction dewatering on nearby GDEs are considered minor for the following reasons:

- The drawdown extent (1 m) is localised and minor
- The duration of potential dewatering is short (9 hrs)
- Construction activities will be designed to minimise the degree of groundwater and surface water interaction thereby minimising dewatering requirements.

A study conducted on the hydrology of the area indicated that the Greater Brixton St Wetland consists of several irregular-round sumplands that are located within the white clay of the Pinjarra Plain formation and are primarily fed by rainfall (Semeniuk 2001). These waterbodies were found to be seasonal and involved only some interaction with the groundwater (Semeniuk 2001). Given the small cone of depression and the short duration of water abstraction, significant impacts to groundwater dependant vegetation within Brixton St Wetlands and other areas are not anticipated in the event of dewatering. Indeed, impacts due to dewatering across these small stretches for the short period of time, would be difficult to detect and are expected to be within natural flow variations. Consequently, GDEs located in the vicinity of the Proposal are considered unlikely to be impacted unless works are carried out during a drought period (note that a drought period will lower the groundwater level making it less likely that dewatering is required).

5. References

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