REPORT

Tonkin+Taylor

Huia Water Water Treatment Plant Replacement Project

Groundwater and Settlement Effects

Prepared for

Watecare Services Limited

Prepared by

Tonkin & Taylor Ltd

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Exceptional thinking together

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Executive Summary

Watercare Services Limited (Watercare) is proposing to construct a new water treatment plant (WTP) near Titirangi to replace the aging Huia WTP. Watercare is also proposing to construct two 25 ML treated water reservoirs as part of the overall scheme. The replacement WTP is to be constructed on the southern side of Woodlands Park Road, between Manuka Road and Scenic Drive.

A single 25 ML reservoir (Reservoir 1) is to be constructed on the northern side of the Woodlands Park Road, directly opposite the proposed replacement WTP. Associated with Reservoir 1 is a tunnel shaft and valve chamber required for the North Harbour No. 2 (NH2) pipeline. A second 25 ML reservoir (Reservoir 2) will be constructed within the existing Huia WTP once the latter is decommissioned.

Both the replacement WTP and Reservoir 1 will require substantial excavations to be undertaken in order to create the building platforms as well as to form the in-ground structures. No excavations below the groundawater level will be required for Reservoir 2 as this will be a largely above-ground structure. Reservoir 2 is therefore not addressed further in this report.

A groundwater drawdown and settlement assessment has been undertaken to assess the potential physical effects of undertaking the proposed excavations. The assessment has been based on established simplified methods coupled with conservative design parameters and assumed unconstrained groundwater flows into the excavations. Existing geotechnical information has been used to develop a ground and groundwater model for both the replacement WTP and Reservoir 1/tunnel shaft sites. This encompasses the best available geological, geotechnical and hydrogeological knowledge of the area. No investigations specific to the proposed development had been undertaken at the time of the preparation of this report due to access restrictions.

The two sites have essentially the same geological and groundwater conditions, with the upper 10 to 15 m of the profile being colluvial soils underlain by variably weathered sandstones. The colluvial soils are not typical of those usually encountered in Auckland in terms of their origin, however their overall characteristics are not considered to be unusual or particularly problematic. The ground conditions are essentially the same as that encountered at the existing WTP site.

The relatively deep nature of the groundwater in the project area means that the earthworks at the replacement WTP will not encounter groundwater and will therefore not induce drawdown and drawdown-related settlement. The construction of Reservoir 1 and the tunnel shaft will however result in groundwater drawdowns of up to 10 m and drawdown-induced settlements of up to 90 mm immediately adjacent to the excavations.

The drawdown effects at the combined Reservoir 1-tunnel shaft site are estimated to extend between 50 m and 70 m from the excavations but remain entirely within Watercare-owned property. The only non-Watercare property located within the potentially affected area is Woodlands Park Road where up to 30 mm of settlement is estimated. The broad nature of this settlement is expected to result in differential settlement less than those considered damaging for those existing services located within the road corridor. All existing buried services within Woodlands Park Road are owned by Watercare.

The closest dwellings are located at the top of the Exhibition Drive rock escarpment, some 60 m to the north from the nearest excavation. Not only are these properties located beyond the estimated extent of groundwater drawdown, their position on a rock escarpment means that they will not be affected by settlement regardless of the extent of groundwater drawdown. Armstrong Gully Stream is located close to the proposed tunnel shaft/valve chamber location, however, it is not expected to be affected by groundwater drawdown on account of the depth of the perched groundwater system and the proposed method of shaft construction.

This assessment is based on interpretations developed from the historic investigations that cover the general project area rather than the footprint of specific structures. The data that is currently available is considered to adequately represent the geological and hydrogeological conditions for a resource consent level of assessment. A programme of structure-specific geotechnical investigations will be required prior to the undertaking of further design. This will allow the ground model (geotechnical and hydrogeological) to be modified as necessary and detailed seepage/drawdown analyses to be undertaken. Additional piezometers installed at that time will be able to be used for groundwater monitoring during construction. A programme of groundwater and ground surface monitoring should be undertaken during construction in order to ensure that the effects are within the predicted range. The requirements would be contained within a project Groundwater and Settlement Monitoring and Contingency Plan.

1 Introduction

Watercare Services Limited (Watercare) is responsible for the treatment and supply of potable water, and for the collection, treatment and disposal of wastewater to around 1.5 million people in Auckland. Watercare is a Council Controlled Organisation (CCO), wholly owned by the Auckland Council.

Watercare operates five dams within the Waitākere Ranges, including the Upper and Lower Huia Dams and the Upper and Lower Nihotupu Dams. Water from these western water supply dams is treated at the Huia and Waitākere Water Treatment Plants before being distributed via the water transmission network, primarily to west and north Auckland. The Huia Water Treatment Plant (Huia WTP) is the third largest water treatment plant in Auckland, and is a crucial component of Auckland's water supply network, treating approximately 20% of Auckland's water.

The Huia WTP was constructed in 1929 and is now nearing the end of its operational life (90 years old). Watercare therefore proposes to construct a new WTP to replace the aging Huia WTP. As part of this project Watercare is also proposing to construct two treated water reservoirs (50 ML total capacity) to increase treated water storage within the western supply zone.

This report has been prepared to assess the groundwater drawdown and settlement effects of the proposed works, and to accompany the regional resource consent application and/or outline plan of works in relation to the proposed construction and operation of the WTP and reservoirs.

2 Project description

The replacement WTP will be constructed on the corner of Manuka Road and Woodlands Park Road directly across from the existing Huia WTP site. The replacement WTP will have a treatment capacity of 140 mega-litres per day (MLD).

A new 25 ML treated water reservoir will be located on the northern side of Woodlands Park Road (Reservoir 1), with another 25 ML reservoir (Reservoir 2) subsequently constructed on the existing Huia WTP site once the existing plant has been decommissioned.

The proposed works also includes construction of the North Harbour 2 watermain (NH2) valve chamber and tunnelling reception shaft within the Reservoir 1 site.

This report addresses all of the elements of the project with the exception of Reservoir 2 which will not require subsurface excavation to an extent that groundwater will be encountered.

Full details of the project are provided in the "Huia Replacement WTP Assessment of Environmental Effects Report, prepared by Tonkin + Taylor Ltd (May 2019)".

A general layout plan showing the major elements referred to in this report is presented as Figure A1 in Appendix A.

3 Site Description

3.1 General

The project is located on land owned by Watercare and is designated in the Auckland Unitary Plan (AUP) for 'Water supply purposes – water treatment plants and associated structures' (designation reference 9324 – Huia and Nihotupu Water Treatment Plants). The project spans three sites owned by Watercare, which have a total site area of approximately 145,700 m^2. The site on which the proposed replacement Huia WTP is located has an area of approximately 42,000 m^2 and the proposed Reservoir 1 site has an area of approximately 63,600 m^2.

The replacement Huia WTP is proposed to be located adjacent to the existing Huia WTP site on the corner of Woodlands Park Road and Manuka Road. Reservoir 1 will be located on the northern side of Woodlands Park Road below Exhibition Drive and across from the existing Huia WTP. The sites are both accessed from Woodlands Park Road. These two sites along with the existing WTP site are collectively referred to as "the project site".

The project site is located approximately 1 km from Titirangi Village and approximately 1.5 km north of the closest reach of the Manukau Harbour. It is located on a natural bench formed within a south-facing ridge of the Waitakere Ranges (Figure 3.1). The bench slopes gently to the south, although its profile is interrupted by a number of distinct elongate mounds or topographic highs located either side of Woodlands Park Road. The bench terminates to the north against a steep escarpment. The site is largely vegetated in native bush with a previously cleared area located near the centre of the site.

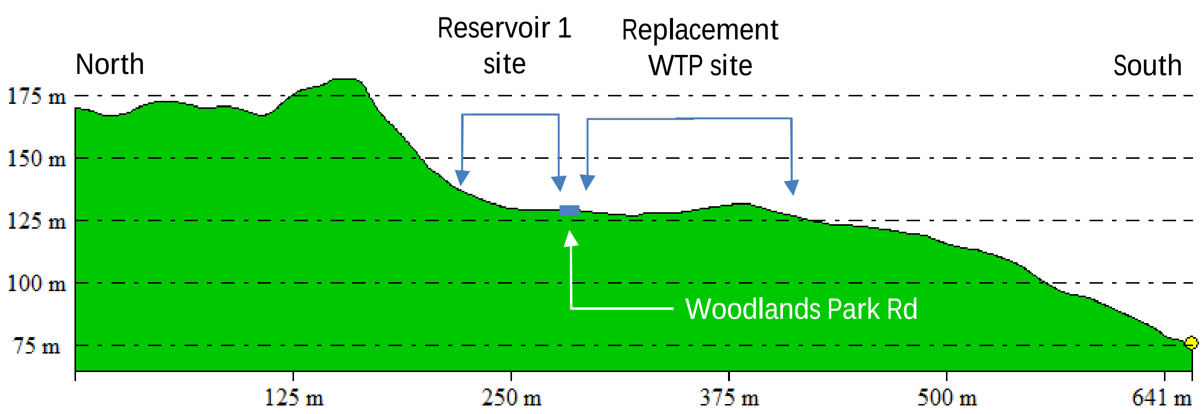

Figure 3.1: North-south topographic section through the Reservoir 1 and replacement WTP sites.

3.2 Replacement WTP Site

The replacement WTP site slopes gently from the Woodlands Park Road to the south with gullies located at the southern boundary running north to south. The eastern extent of this site features steep slopes which rise up towards Scenic Drive.

A section of the Yorke Gully Stream traverses the south eastern part of the replacement WTP site and a small tributary of the Armstrong Gully Stream is located in the north-western corner of the site.

The replacement WTP contains a number of major structures that require subsurface excavations. These include:

- Dissolved Air Flotation (DAF) unit;

- Biological Activated Carbon (BAC) unit
- Chlorine contact tanks; and
- Washwater and sludge thickener tanks.

The layout of the replacement WTP is shown on Dwg No. 51-3357505-C001 presented in Appendix B.

3.3 Reservoir 1 site

The Reservoir 1 site is relatively hummocky with a knoll located in the middle of the site near the southern boundary. The Reservoir 1 site is largely vegetated in native bush and a small gully feature (Armstrong Gully) runs through the site. An escarpment with extremely steep slopes is present along the northern boundary beneath Exhibition Drive. A permanent section of Armstrong Gully stream is located to the west of Reservoir 1.

The site will contain a single large in-ground approximately rectangular tank as shown on Dwg No. 3255336.K110 in Appendix B.

3.4 Tunnel Shaft

A tunnel boring machine reception shaft is required for the construction of a tunnel for the North Harbour No. 2 (NH2) waterman. It is currently proposed that this shaft will be located approximately 85 m to the west of Reservoir 1. The shaft is estimated to be 16 m in diameter and founded approximately 13 m below existing ground level. After completion of tunnel construction the reception shaft shall become a permanent valve chamber.

The shaft location is shown on Figure A1 and Dwg No. 3255336.K110. In the discussions below, the tunnel shaft/valve chamber structure will be considered to be part of the Reservoir 1 site.

4 Previous work and available data

4.1 Historic investigations

The existing Huia WTP site has been the subject of a number of geotechnical investigations since the plant was first constructed in 1926, although the earliest available geotechnical information dates from the 1970's. Tower Foundations Ltd collated all known geotechnical data available for the existing site up to and including 2008 (Tower Foundations, 2008).

A plan showing the location of these historic investigations is presented as Dwg No. 2005523.017 in Appendix C. This drawing shows that up until 2008, three boreholes (MH-1 to MH-3) had been undertaken on the replacement WTP site but no investigations had been undertaken on the Reservoir 1 site.

4.2 T+T 2010

T+T undertook a geotechnical investigation in 2010 as part of a proposed WTP upgrade (T+T, 2010). Although the majority of these investigations were located within the site of the existing WTP, three boreholes (BH 5, BH 7 and BH 8) were drilled north of Woodlands Park Road, immediately to the west of the proposed Reservoir 1 site.

The locations of the T+T investigations are shown on Dwg. No. 27064.001-01 presented in Appendix C.

4.3 Opus 2013

Opus International Consultants Limited (Opus) undertook an extensive programme of geotechnical investigations north of Woodlands Park Road, including the western end of the proposed Reservoir 1 site (Opus, 2013). A limited number of borehole and cone penetration tests (CPT) were undertaken along the western edge of the replacement WTP site.

The locations of the Opus investigations is shown in “Opus Borehole Plan (2013)” in Appendix C.

4.4 Project-Specific Investigations

No investigations specific to the currently proposed development had been undertaken at the time of the preparation of this report due to access limitations for drilling rigs. The assessment presented herein has therefore been based on interpretations developed from the historic investigations, which cover the general project area rather than the footprint of specific structures.

The data that is currently available is considered to adequately represent the geological and hydrogeological conditions requiredfor a resource consent level of assessment. A programme of additional geotechnical investigations and analysis will be required for preliminary and detailed design.

5 Geology and hydrogeology

5.1 Published geology

The published geology map for the Auckland urban area (Kermode, 1992) shows the project site to be located at the junction of three major geological units: the Cornwallis Formation, the East Coast Bays Formation (ECBF), both part of the Waitemata Group and the Nihotupu Formation, which is part of the Waitakere Group (Figure 5.1). All three formations are predominantly sandstone-dominated marine sediments with a significant but variable volcanic component.

Kermode (1992) shows the bench containing Woodlands Park Road and Manuka Road to be underlain by Cornwallis Formation, whereas the steep escarpment to the north is underlain by Nihotupu Formation. The slopes that descend down to the Manukau Harbour are formed from ECBF.

In basic stratigraphic terms the Cornwallis Formation conformably overlies the ECBF and conformably underlies the Nihotupu Formation. However, because there is an overlap in the time when these deposits were forming, the Cornwallis Formation interdigitates (i.e. merges) with both the ECBF and Nihotupu Formation.

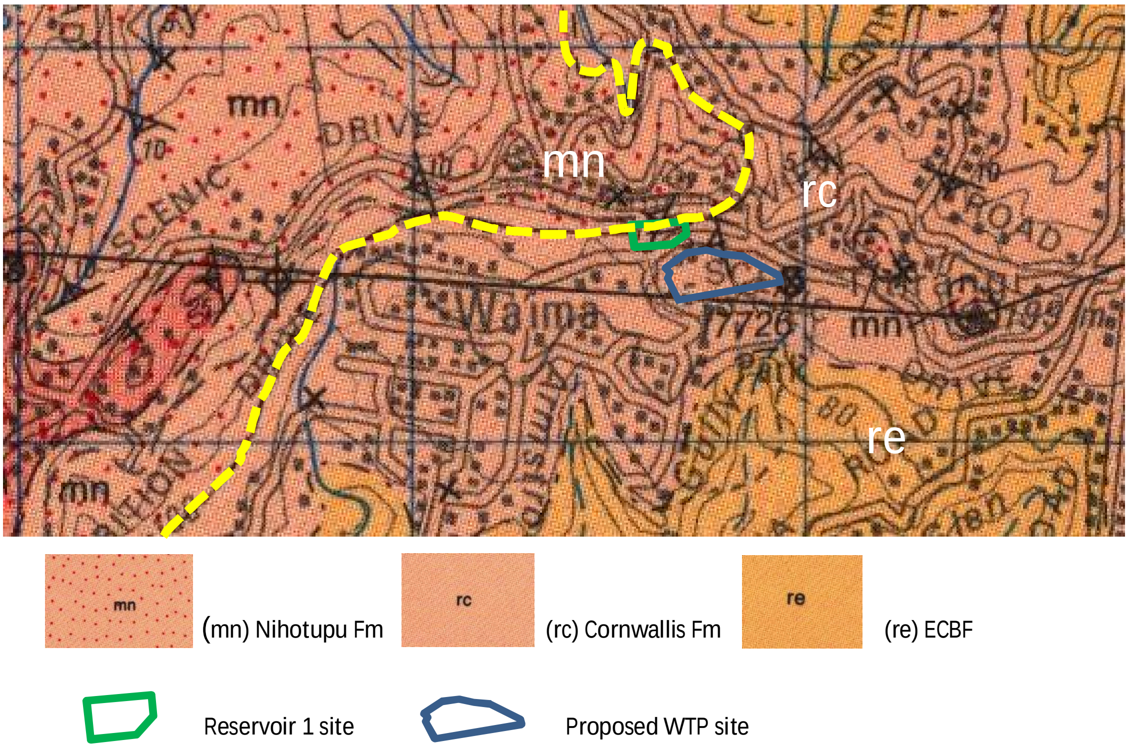

Figure 5.1: Published geology (source: Kermode, 1992). The yellow line has been added to distinguish the Nihotupu Formation (left) from the Cornwallis Formation (right)

5.2 Site geology

All three of the geotechnical investigations that have targeted the replacement WTP and/or Reservoir 1 sites (Ormiston Associates, 2008[1]; T+T, 2010; Opus, 2013) identified a thick upper layer of primarily sandy silt to clayey silt, with a variable component of angular gravels and occasional cobbles or boulders. This has been described by all three investigations as colluvium. Being a surficial soil-like material, the colluvium is not mapped as a geological unit by Kermode (1992).

[1] In Tower Foundations (2008)

The colluvium is underlain by residual soils and variably weathered rock. Opus logged the primary rock unit on the bench as Nihotupu Formation, whereas both Ormiston Associates (2008) and T+T (2010) logged it as Cornwallis Formation in line with Kermode (1992). The difference is essentially one of terminology and does not affect the outcome of this assessment.

5.2.1 Colluvium

The previous investigations have shown the colluvium to be alternatively silt or sand-dominated with angular gravels and occasional cobbles and boulders of sandstone and mudstone. Clay tends to be a secondary material, although it dominates the soils within the upper 1 m or so of the ground surface.

Standard Penetration Test (SPT) blow count (N) data shows that the colluvium increases in strength/density with depth, although there is significant scatter in the results (Figure 5.2).

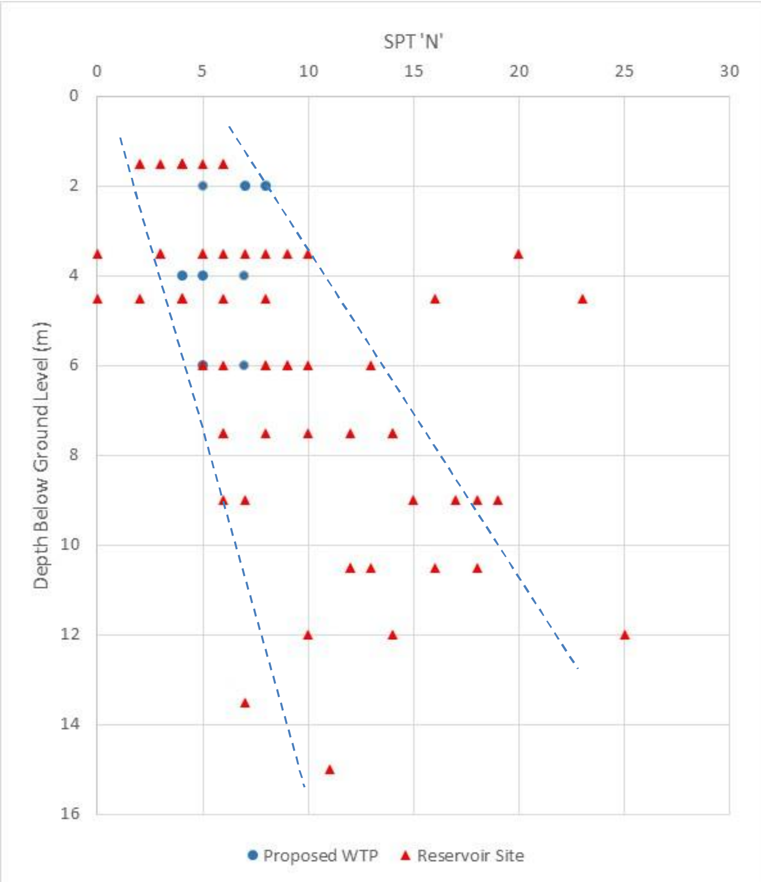

Figure 5.2: SPT N vs depth for colluvium in the replacement WTP and Reservoir 1 sites

5.2.2 Cornwallis Formation

Kermode (1992) describes the Cornwallis Formation as a volcanogenic proximal flysh consisting of alternating beds of grey-brown, graded sandstone containing angular to well-rounded gravel to cobble sized clasts of primarily basaltic andesite. The Cornwallis Formation weathers to a soft pale yellow grey to reddish grey silty clay to depths of 20m.

The description provided by Kermode (1992) of the Nihotupu Formation is broadly similar to the Cornwallis Formation although the former tends to be more massive (i.e. less bedded) and finer grained. There is insufficient evidence from the available information to determine whether the site is underlain, at least in part, by the Nihotupu Formation rather than the Cornwallis Formation. The difference is not of significance to this assessment, therefore the mapped unit (Cornwallis Formation) is adopted.

Boreholes undertaken within the general project site indicate that different grades of rock weathering are difficult to differentiate with reliability. There were differences in interpretation by T+T (2010) and Opus (2013) for the same materials. All of the geotechnical data was re-examined by an experienced senior engineering geologist from T+T, which allowed a more consistent and reliable interpretation of the entire data set to be obtained.

Two main geotechnical materials have been identified within the Cornwallis Formation:

- Completely weathered to highly weathered rock that has been reduced to an engineering soil. These materials are recovered primarily as silts and sands; and
- Moderately to slightly weathered sandstones that are typically extremely weak to very weak rock.

A number of gravel-conglomerate layers were encountered within the Cornwallis Formation by T+T (2010) north of Woodlands Park Road.

5.3 Groundwater

Piezometers were installed in selected boreholes completed on the northern side of Woodlands Park Road by T+T (2010) and Opus (2013), however no groundwater data is known to have been obtained from the Ormiston (2008) or Opus (2013) investigations for the replacement WTP site. A limited number of groundwater measurements are contained within the historic data (Tower Foundations, 2008), although it is unclear whether these were recorded within properly constructed piezometers or just with the open boreholes. Nor is it known whether the reported water depths were recorded during drilling of the boreholes or at a time when water levels would have recovered to their normal levels.

Pore pressure data from CPT's undertaken by Opus (2013) were considered unreliable with respect to determining groundwater levels as there was no consistent correlation between the CPT and piezometer data when immediately adjacent investigations were available. The borehole data available for the northern side of Woodland Park Road (Table 5.1) indicates that there is perched water within the colluvium and a deeper water level within the rock. Some very low water levels (e.g. BH 5, BH 7, BH 8) indicate that the Cornwallis Formation is actively being drained, presumably to the Manukau Harbour. The overlying colluvium is subject to recharge by rainfall and together with the presence of clay-rich aquitard layers, it is able to support perched groundwater. T+T (2010) reported that significant water loss was recorded in boreholes BH5, BH7 and BH8 whilst drilling through a 1.5 to 2.0 m thick bed of conglomerate which was typically located at depth of approximately 11 m below ground level. This illustrated the potentially high permeability of some materials present and the drainage that results.

The available data indicates that two groundwater levels are present within the Reservoir 1 site: a groundwater level of approximately 6.5 m below ground level (mbgl) for shallow-screened piezometers and approximately 10 mbgl for the deeper screened piezometers. Similar groundwater levels were recorded in the existing WTP site area, where available data (Table 5.2) indicate a mean groundwater level of 5.5 mbgl for shallow or single piezometers and 8.5 mbgl for deeper screened piezometers.

Figure 5.3 presents a plot of head (height of water column) versus screen depth. Hydrostatic conditions would be indicated by a consistent increase in head with depth. As this is not apparent in the data, the highest possible elevation for hydrostatic conditions is 19 m below ground level (i.e. at the deepest data point), although it could be deeper. Hydrostatic conditions can be considered to be representative of the regional groundwater system, whereas water above this level would represent various perched systems undergoing drainage from below and recharge from above.

It has been inferred from this that there are two groundwater systems present within the project site: one in the colluvium or residual soils at approximately 6 mbgl and a deeper groundwater system in the rock of approximately 9 mbgl. The true regional groundwater system could be deeper still. For the purposes of this assessment it has been conservatively assumed that saturated hydrostatic conditions generally exist from 5 m bgl.

Table 5.1: Groundwater levels, north of Woodlands Park Road

Borehole No.	Piezometer	Screen Depth (m)	Material	Groundwater depth from ground level	Groundwater Elevation (m RL)
BH 5	1 2	4.0 – 7.0 15.5 – 18.5	MW Cornwallis Fm SW Cornwallis Fm	6.60 m 11.10 m	114.4 109.9
BH 7	1 2	8.0 – 10.0 13.0 – 15.0	CW-HW Cornwallis Fm SW Cornwallis Fm	9.55 m 9.55 m	110.9 110.9
BH 8	1 2	4.5 – 6.5 17.5 – 19.5	Colluvium CW-HW Cornwallis Fm	Dry 15.10 m	Dry 108.9
BH 13/02	1	1.5 – 6.0	Colluvium	3.9	123.2
BH 13/04	1	10.7 – 15.0	Colluvium	9.3	113.1
BH 13/07	1 2	2.5 – 6.0 10.5 – 15.0	Colluvium Colluvium	4.5 4.5	114.7 114.7
BH 13/08	1	1.5 – 8.0	Colluvium	5.1	117.5
BH 13/09	1	4.6 – 15.0	Colluvium	6.2	117.4

Table 5.2: Groundwater Levels, existing WTP

Borehole No.	Piezometer	Groundwater depth from ground level	Head (m above piezo tip)
BH 1	P1 P2	7.6 8.6	3.44 16.36
BH 2	P1 P2	5.9 11.1	3.65 9.9
BH 3	P1 P2	4.4 5.1	3.63 19.73
BH 4	P1	4.3	6.7
BH 6	P1 P2	8.3 9.1	4.72 13.32
BH4796	P1	5.5	
BH4798	P1	3.7	
AH4	P1	3.9	
BH5	P1	6.0	
BBH2	P1	8.2	
BBH4	P1	1.4	
MB01	P1	5.0	
MB02	P1	5.5	
MB03	P1	7.4	

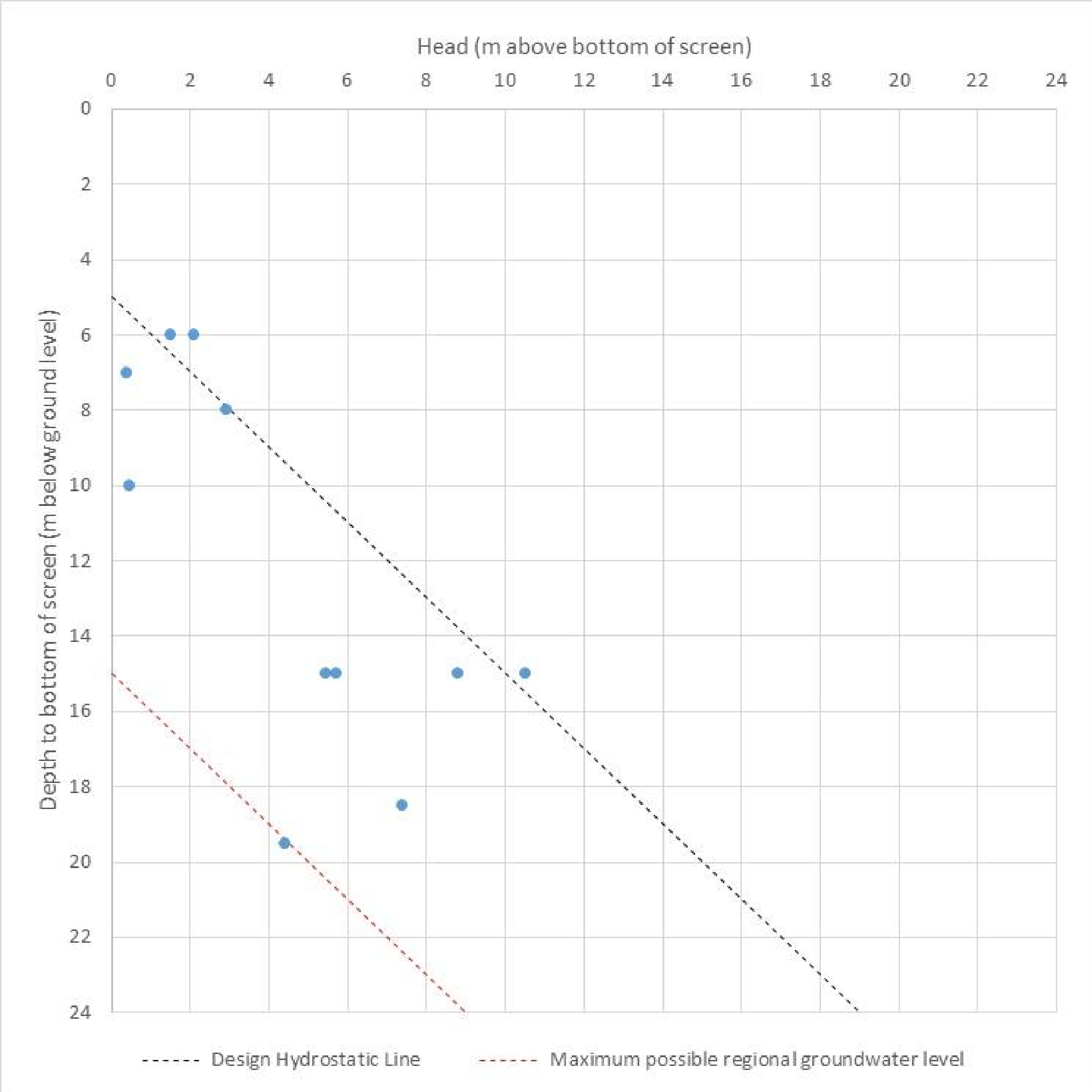

Figure 5.3: Head of groundwater vs depth of screen

5.4 Formation of the slope bench and mounds

The topographic bench on which the replacement WTP and Reservoir 1 sites are located is a distinct topographic feature that has previously been the subject of some conjecture.

Opus (2013) interpreted the escarpment behind the existing WTP as the headscarp of a very large ancient landslide, some 1.7 km long and 1.4 km wide. Certainly the profile seen in Figure 3.1 is indicative of a large translational landslide. Opus (2013) inferred that the landslide was many thousands of years old on the basis that significant valleys had been eroded into the inferred landslide mass. Opus (2013) concluded that there was a very low risk of landslide reactivation affecting the WTP.

Tower Foundations (2008) described unnamed historical reports that had also interpreted the escarpment above the WTP site as a relic of an ancient and deep-seated landslide. They also describe recent work by themselves and Ormiston Associates that *"provided compelling evidence that confirms the earlier work by the DSIR that there is no large-scale landslide encompassing the Little Muddy Creek catchment (and the subject site)."* This evidence was not presented or discussed.

Regardless of the nature and magnitude of previous large-scale landsliding on the site, the bench containing the replacement WTP and Reservoir 1 sites has a significant thickness (typically in the order of 10 m but up to 20 m beneath the mounds) of mass movement debris (landslip, colluvium or talus) that has been deposited on the bench from higher up on the escarpment. Debris that comes off escarpments typically forms an apron of material at the toe (talus slope) that thins out with distance. The presence of the mounds on the bench is unusual and reminiscent of the mounds that sometimes form as a result of large slope failure or collapse. It is our interpretation that these mounds represent the eroded remnants of debris piles from large scale landslip failures from higher up the escarpment.

6 Ground model

6.1 A unified ground model

The data and geological interpretations contained within the three previous investigations that include or are adjacent to the replacement WTP and Reservoir 1 sites (i.e. Ormiston, 2008; T+T, 2010 & Opus, 2013) were assessed with the objective of developing a single comprehensive ground model.

Some of the T+T (2010) and Opus (2013) investigations were undertaken within the same area west of the Reservoir 1 site, in and around the tunnel shaft/valve chamber. It was found that the borehole logs and geological long sections developed from them differed significantly in places, particularly with respect to the interpreted thickness of the colluvium. T+T (2010) typically interpreted a thinner layer of colluvium than Opus (2013). Furthermore, T+T interpreted the surface mound located to the west of the existing tank as representing a high point in the underlying Cornwallis Formation whereas Opus (2013) included this same mound within the colluvium.

T+T has recently reviewed all of the available factual data and reinterpreted the stratigraphy of the site in order to develop a more consistent and reliable ground model. The reinterpretation typically resulted in:

- A generally greater thickness of colluvium than inferred by T+T (2010);
- A generally reduced thickness of colluvium than inferred by Opus (2013); and
- The mounds were interpreted to be colluvium or landslip debris and not representative of the underlying rock.

As described above, the rock underlying the large bench has been interpreted as being Cornwallis Formation. This has been divided into two geotechnical units: an engineering soil formed from residual soils to highly weathered material (primarily silty sand), and an extremely weak to weak rock that is moderately to slightly weathered. Typically moderately weathered and slightly weathered rock would be separated within a ground model, however, this distinction was not readily apparent from the available data.

6.2 Hydrogeology

The groundwater regime is considered to consist of a perched water table located either at the contact between the colluvium and the Cornwallis Formation (where the colluvium is thin), or within 5m of the ground surface where the colluvium where is thicker. The assumed groundwater level beneath debris mounds reflects the levels either side of the mound rather than a specific depth below the mound itself i.e. it is not assumed that groundwater rises in elevation beneath the mounds. As described above, the regional groundwater levels are considerably deeper and beyond the zone of influence of this project.

6.3 Geological sections

A series of five geological sections have been developed on the basis of the existing geotechnical investigations and topography (Sections A, B, D to F). A sixth geological section through the Reservoir 1 site (Section C) was developed on the basis of the stratigraphy shown on the other geological sections as no investigation data is currently available for this specific location.

The location of the geological sections and historic geotechnical investigation points are shown in Figure A1 in Appendix A.

Geological cross-sections D to F (Figures A3 and A4) present the ground model for that part of the site located west of Reservoir 1. These, together with limited investigations undertaken at the replacement WTP site, served as the basis for developing the ground model used in the groundwater drawdown and settlement assessments presented below.

From the geological sections it is apparent that the replacement WTP and Reservoir 1 sites have the same general geological and groundwater conditions, with the upper 10 to 15 m of the profile being colluvial and landslide soils underlain by variably weathered sandstones.

For the purpose of simplicity, the underlying rock shown on the geological sections in Appendix A is assumed to be entirely Cornwallis Formation, although in reality it likely transitions into the Nihotupu Formation somewhere beneath the escarpment.

7 Assessment of groundwater drawdown effects

7.1 General

We have reviewed the Auckland Unitary Plan Operative in Part (AUP) rules[2] regarding the take, use, damming and diversion of groundwater that are relevant to the proposed excavations. A Groundwater Take and Diversion Consent will be required, specifically with respect to:

- The take and use of groundwater associated with dewatering during construction;
- The potential for settlement effects on surrounding land as a result of diversion (i.e. lowering) of groundwater levels; and
- The construction of structures that physically impede the flow of groundwater.

The following is an assessment of the magnitude and extent of groundwater drawdown that can be reasonably expected to occur, both from the temporary earthworks required to construct the WTP and reservoir structures, as well as permanent diversions that result from them.

It is based on the existing borehole data located within and adjacent to the replacement WTP and Reservoir 1 sites. Although the actual footprints of the replacement WTP and Reservoir 1 structures have had limited geotechnical investigations to date, based on extensive investigations undertaken in close proximity, it is expected that the hydrogeological model presented provides a relevant assessment of the effects of construction.

7.2 Methodology of assessment

Groundwater drawdown estimates have been made using established simplified methods commensurate with the assumed nature of the ground model and stage of design.

The lateral extent of groundwater drawdown away from an open excavation has been estimated using the following equation published in CIRIA (2016):

$$R_o = C.(H-h_w)k^{0.5}$$

where:

R_o is the radius of influence;

C is an empirical calibration factor (usually taken as 3000);

$(H - h_w)$ is the depth of water drawdown at the excavation; and

k is the permeability (hydraulic conductivity) of the soil.

7.3 Design permeability

The CIRIA method assumed a single uniform permeability within the drawdown zone. As the majority of the groundwater drawdown will occur within the colluvium, and that this sandy and gravelly material can be expected to have an overall higher permeability than the underlying completely weathered to highly weathered Cornwallis Formation, the analysis has been undertaken assuming the presence of colluvium only.

No measurements of k are available for the colluvium at the project site. Upper bound and "expected" permeability values have been derived from a consideration of previous project

[2] AUP Rule E7.4.1 (A20) - Dewatering associated with a groundwater diversion as a restricted discretionary activity and Rule E7.4.1 (A28) – Diversion of groundwater caused by an excavation as a restricted discretionary activity.

experience with Tauranga Group Silt and sandy Silt soils in Auckland (Table 7.1). The design values as follows:

Upper bound: $k = 5 \times 10^{-6}$ m/s

Expected value: $k = 2 \times 10^{-7}$ m/s

The upper bound permeability is 25 times the “expected” value. Lower bound values were not used in the assessment as these will necessarily result in an underestimation of the potential effects.

Table 7.1: Comparison of estimated permeability (m/s) for comparible soils from other Auckland projects

Project	Material	Higher estimates	Typical or mean values
Waterview Tunnel	Alluvium	2.3×10^{-7}	2×10^{-7}
Victoria Park Tunnel	Tauranga Group	2×10^{-7}	
New Lynn Rail	Tauranga Group	3×10^{-7}	
Rosedale Tunnel	Tauranga Group	2×10^{-7}	
Central Interceptor	Tauranga Group	2×10^{-6}	2×10^{-7}
Northern Interceptor	Tauranga Group		2×10^{-7}
Britomart	Tauranga Group		2.5×10^{-7}
This project	*Colluvium*	*5×10^{-6}*	*2×10^{-7}*

7.4 Replacement WTP site

7.4.1 Extent of excavations

A plan showing the layout of the replacement WTP is shown on Dwg No. 51-3357505-C001 in Appendix B. A north-south section through the site (SK011 in Appendix B) shows the proposed building platform slope gently to the south, with the majority of the excavation being required to remove the mound located in the middle of the site.

Significant additional excavation will however be required to form the major DAF, BAC and chlorine contact tank structures. Excavation below the building platform level is also required for the washwater and sludge thickener tanks. The extent of these excavations is indicated on Dwg No. 51-3357505-SK002 in Appendix B.

The deepest excavation is approximately 11 m below existing ground level, although it is typically less than 4 m. Approximately half of the site will need filling in order to achieve final grade.

7.4.2 Extent of groundwater drawdown

The ground model for the replacement WTP is shown as Section A on Figure A2 in Appendix A. This shows that all earthworks will be undertaken at or above the groundwater table, which is inferred to be located 5 mbgl, just above the colluvium-Cornwallis Formation contact. As such, the proposed excavations will not extent below the groundwater level except potentially a very small drawdown at the northern end of the BAC structures. Given the location of this structure within the middle of the WTP site and the perched nature of this upper groundwater system, it is concluded that there will be no effect on the groundwater regime and no drawdown-related settlement for the replacement WTP site.

7.5 Reservoir 1 site

7.5.1 Extent of excavation

A plan showing the layout of Reservoir 1 is shown on Dwg No. 3255336.K110 in Appendix B. A series of design profiles have been constructed through Reservoir 1. The locations of these sections are indicated by chainages on Dwg No. 35255336.K118 in Appendix B. The section at Ch 70m on Dwg No. 35255336.K133 (Appendix B) lies at the same approximate position as geological section C (Figure A3). It shows that the structure will be located almost entirely below existing ground level. Groundwater drawdown and settlement can therefore be expected to occur. Dwg No. 35255336.K119 presents contours of cuts within the Reservoir 1 site.

The geological model for the Reservoir 1 site is presented as Section B (Figure A2) and Section C (Figure A3) in Appendix A. These shows that:

- Reservoir 1 will extend a maximum of 15 m below existing ground level. This depth varies due to the presence of a hummock of colluvium over part of the site;
- The groundwater level decreases in elevation across the reservoir excavation in a north-south direction and is located entirely within the colluvium;
- The groundwater is interpreted to rise up beneath the rock escarpment;
- Excavation will be undertaken mostly within colluvium, with only the reservoir floor and the lower section of the north wall likely to be formed in weathered Cornwallis Formation.

The following sections present assessments of the extent of groundwater drawdown and settlement that is expected to result from these deep excavations.

7.5.2 Extent of groundwater drawdown

Groundwater data from the Opus (2013) boreholes BH13/02, BH13/04 and BH13/07 show groundwater levels to be 4 m, 9.0 m and 5.0 m below ground level respectively. As described in Section 5.3, this is considered to reflect the presence of a complex perched and under-drained groundwater system. A single design groundwater level of 5 m below ground level (bgl) has been adopted for the drawdown analysis.

The assumed pre-excavation groundwater level is shown on Section B (Figure A2) and Section C (Figure A3).

The groundwater drawdown effects are expected to be strongly 3-dimensional and asymmetric. Groundwater drawdown has therefore been assessed separately for the four sides of the excavation. Supporting calculations are presented in Appendix D.

7.5.2.1 North face

The north wall of Reservoir 1 will be constructed in a mixture of colluvium (0-10 m) and CW-HW Cornwallis Formation (10 – 15m). The basis of the assessment is as follows (Section C, Figure A6):

- The excavation is 15 m deep;
- The existing groundwater depth is 5 m;
- The excavation is free draining and the groundwater will drop to the base of the excavation;
- Groundwater drawdown at the excavation face will be 10 m.

Based on the CIRIA methodology, drawdown would extend a distance of 67 m from the excavation if the upper bound permeability is adopted, but only 13 m is the expected value is used.

7.5.2.2 South face

The south wall of the reservoir is effectively the reverse of the north wall, with the excavation being located at the top of a south-facing slope. It will be constructed entirely within colluvium and will be founded at or near the colluvium-CW-HW Cornwallis Formation contact.

The basis of the assessment is as follows (Section C, Figure A6):

- The excavation will be 15 m deep;
- Depth to groundwater: 7 m. (This is deeper than the assumed standard of 5 m as there is a hummock);
- Groundwater drawdown at the excavation face will be 8 m.

Based on the CIRIA methodology the maximum extent of drawdown is 54 m. Given that the ground slopes to the south, the lateral extent of drawdown maybe somewhat greater than this, although geometric considerations (Figure A3) would suggest not by much. Any extension will be limited to WSL land. The drawdown will however encapsulate Woodlands Park Road, the only non-Watercare asset in this area.

7.5.2.3 West face

The west end of the reservoir excavation will be excavated mostly in colluvium with the lower 2m being Cornwallis Formation.

The basis of the assessment is as follows (Section B, Figure A5):

- The excavation will be 12 m deep;
- Depth to groundwater: 5 m;
- Groundwater drawdown at the excavation face will be 7 m.

Based on CIRIA, the maximum extent of drawdown is 47 m. This will however be affected by drawdown from the tunnel shaft.

7.5.2.4 East face

The east wall of Reservoir 1 is similar to the west wall in that it is formed mostly in colluvium with only the lower 2 m in Cornwallis Formation

The basis of the assessment is as follows (Section B, Figure A5):

- The excavation will be 15 m deep;
- Depth to groundwater: 5 m;
- Groundwater drawdown will be 10 m.

Based on CIRIA the maximum extent of drawdown is 67 m.

7.5.2.5 Cutting between Reservor 1 and Tunnel Shaft/Valve Chamber

A west-east cutting will extend from the tunnel shaft/valve chamber to Reservoir 1 (Dwg No. 35255336.K119). This will be located almost entirely at or above the groundwater level. Drawdown of any signficiance has therefore not been assumed.

7.5.2.6 Composite drawdown

The upper bound and “expected” lateral extent of the groundwater drawdown associated with the construction of Reservoir 1 is Figure A7 (Appendix A). This indicates that:

- Upper bound groundwater drawdown is almost entirely limited to Watercare property, with the possible exception of three properties located on the southern edge of the escarpment, where the limit of drawdown is estimated to approach but not enter the property boundaries;
- Up to 300 m of Woodlands Park Road will be located within the potential drawdown zone;
- If the “expected” permeability values are adopted then the entire zone of drawdown will be limited to Watercare property, with neither private land nor Woodlands Park Road expected to be affected.

Given that the expected construction method (i.e. secant pile walls or similar) will greatly reduce the inflows of groundwater to well below those assumed for the CIRIA method, the extent of groundwater drawdown indicated on Figure A7 is considered conservative, and probably worst-case.

7.5.3 Drawdown-induced settlements

Settlement induced by the lowering of the groundwater occurs as a direct response to increases in effective stress acting on the underlying soils. Settlement is therefore directly related to the extent of drawdown. As such settlement will be at a maximum immediately adjacent to the excavation and will reduce with radial distance.

The material parameters adopted for the analyses are presented in Table 7.2. The moderately weathered to unweathered Cornwallis Formation was assumed to be incompressible.

Table 7.2: Design parameters for settlement estimates

Material	SPT N	E (MPa)
Colluvium/Landslide Debris	7	7[b]
Completely weathered to highly weathered Cornwallis Fm	17	30

Notes: a) average of four tests b) the estimate from the SPT tests (which include the less compressible rock fragments in the colluvium is 10 MPa whereas the average from the consolidation tests was 5 MPa.

The settlement analyses for Reservoir 1 are presented in Appendix D and summarised in Table 7.3. Groundwater-induced settlement varies significantly around the edge of the reservoir in response to differences in initial groundwater level and stratigraphy. The maximum settlement of 83 mm is estimated for the south wall (i.e. facing Woodlands Park Road) primarily because of the very thick colluvium in this area. The minimum estimated settlement is 44 mm at the west wall, due to the thinner colluvium and smaller groundwater drawdown.

The decrease in settlement with distance will depend on the shape of the drawdown cone. More detailed groundwater modelling will be required in later stages of the project to enable these estimates to be made, however it is apparent from the extent of drawdown that apart from Woodlands Park Road, the only property that could potentially be negatively affected is that owned by Watercare.

Table 7.3: Maximum settlement at edge of excavation – Reservoir 1

Parameter	North Wall	South Wall	West Wall	East Wall
Drawdown (m)	10	8	7	10
Settlement (mm)	54	83	44	66

Notes: 1) Assumed limit of compressibility; 2) Groundwater Level, metres below ground level

Additional settlement will occur at the edge of the excavation as a result of mechanical movement associated with the retaining walls. The magnitude of these vertical displacements will depend upon the construction methodology, however, they can be expected to be small (<10 mm) and limited in extent to the immediate vicinity of the structure.

7.6 Tunnel shaft

7.6.1 Extent of excavation

Details of the tunnel shaft have yet to be finalised. For the purposes of this assessment it has been conservatively assumed that the tunnel excavation with be 13 m deep (it is likely to be 10 m). The analysed excavation is shown on Section B (Figure A5) and Section D (Figure A6).

7.6.2 Extent of groundwater drawdown

A single geological and groundwater profile has been adopted for analysis of the shaft although some variability around the perimeter is expected. The largest anticipated depth of excavation and groundwater drawdown has been adopted in the interest of conservatism.

The basis of the assessment is as follows:

- The excavation will be 13 m deep;
- Depth to groundwater: 5 m
- Groundwater drawdown will be 8 m.

Based on the CIRIA methodology, the maximum lateral extent of drawdown away from the tunnel shaft is 54 m. The drawdown of groundwater to the east will overlap with drawdown originating from the west face of Reservoir 1, significantly deepening the potential drawdown cone in the area between the two structures. The slope of the ground and groundwater system towards the south means that the 54 m drawdown distance is likely to be much greater than the actual values, however at this stage it serves as a conservative estimate.

7.6.3 Drawdown-induced settlements

The groundwater drawdown is estimate to result in settlement immediately adjacent to the shaft of 91 mm. However, as the shaft is likely to be constructed using secant pile walls (or similar) that extend into the underlying rock, actual drawdown and settlement is expected to be a fraction of what is presented here. This can be modelled in more detailed using SEEP/W once additional geotechnical investigations have been completed.

7.7 Post-construction effects

Once the reservoir and tunnel shaft excavations become fully water proof with the pouring of their concrete floors, the groundwater will begin to recover. In a perfectly static groundwater regime the groundwater would be expected to return to pre-construction levels simply on the basis of rainfall recharge. In reality however, the groundwater is likely to be flowing north to south i.e. from the escarpment towards the Manukau Harbour.

The perched groundwater system can be expected to flow around the permanent structures. As such the groundwater may rise above the initial level on the northern wall of the structures as the flows will be impeded. Conversely the flows on the downstream side of the structure may be permanently lower than prior to construction.

Detailed numerical modelling would be required in order for the magnitude of these flow effects to be estimated. Regardless of what permeant groundwater effects may result, the full extent of settlement will occur during construction and not afterwards.

7.8 Potential effects on neighbouring properties and services

The groundwater drawdown and surface settlement assessment presented above has assessed that:

- No groundwater drawdown or surface settlement will occur in either Watercare's property or neighbouring property as a consequence of the replacement WTP being constructed downslope of Woodlands Park Road;
- Groundwater drawdown and surface settlement will occur as a result of the Reservoir 1 being constructed upslope of Woodlands Park Road. The effects vary depending on topography and geology;
- The greatest effects from construction of Reservoir 1 or the tunnel shaft will be located within and immediately adjacent to these excavations i.e. within Watercare property;
- Dewatering effects may extend towards the properties located at the southern edge of the escarpment, however as this is formed from rock, no settlement of the escarpment or the properties located on it could reasonably be expected;
- The only non-Watercare's property that could be potentially impacted by settlement is Woodlands Park Road; and
- The only buried services within the Woodlands Park Road corridor belong to Watercare.

The extent of groundwater drawdown beneath Woodlands Park Road has been estimated from the drawdown curve shown on Section C (Figure A6) and the profile summarised in Table 7.4. The estimated settlement for Woodlands Park Road is 30 mm. With settlement potentially extending over a 300 m length of the road, potentially damaging differential settlement can be expected to remain less than the allowable limits of these services.

Table 7.4: Maximum groundwater drawdown and settlement – Woodlands Park Road

Material	Groundwater drawdown (m)	Material stiffness (MPa)	Estimated settlement (mm)
Colluvium	4	7	14
Weathered Cornwallis Fm	0	30	16
Total	4	-	30

7.9 Potential effects on Armstrong Gully Stream

The portion of the Project Site to the north of Woodlands Park Road encompasses the headwaters of the Armstrong Gully (Boffa Miskell, 2018). The Armstrong Gully watercourses consist of both permanent and ephemeral channels located west of the tunnel shaft (Figure 7.1). The main channel is narrow at approximately 0.5 m average width, with slow water flows (Boffa Miskell, 2018).

The close proximity of the stream to the tunnel shaft excavation means there is some potential for groundwater drawdown associated with the shaft construction to affect flows in the creek. Geotechnical investigations undertaken in this area have shown however that the upper-most groundwater table is located some 6 m below ground level. It is apparent that the Armstrong Gully Stream is fed directly from overland flows as well as water entering the channel via the soils that form its banks. The stream sits at an elevation above that of the groundwater table and is probably independent of it. The stream will potentially provide water to the underlying groundwater system but not the reverse. As such, drawdown of the static groundwater table is not expected to negatively affect the flows with the stream.

Figure 7.2 presents a view of a small creek located immediately adjacent to a tunnel shaft currently under construction for Watercare in Glendowie. The tunnel shaft is the same approximate diameter and depth as that proposed for the Huia WTP. Despite the extremely close proximity of the shaft to the creek, there has been no observable impact on water flows nor flows into the shaft.

Figure 7.1: Armstrong Gully watercourses (source: Auckland Council GIS). The proposed tunnel shaft is indicated in orange

Figure 7.2: Small creek located immediately adjacent to a tunnel shaft in Glendowie

7.10 Potential effects on trees

Lowering of the perched groundwater table does not remove water from the soils as such (i.e. the soils do not become dry), it merely extends the depth of the unsaturated zone. The soils above the saturated zone still contain abundant water. With ongoing recharge from rainfall and surface water flows off the escarpment, we would expect there to be abundant soil moisture available for the vegetation on the project site.

8 Conclusions

Construction of the proposed replacement Huia WTP and the 25 ML Reservoir 1 will require significant earthworks to be undertaken. Existing geotechnical information has been used to develop a ground model for both sites. This encompasses the best available geological, geotechnical and hydrogeological knowledge of the area. The proposed earthwork plans have been used to estimate the nature and extent of effect that the required excavations will have on the groundwater regime.

The ground conditions at the replacement WTP, Reservoir 1 and tunnel shaft/valve chamber sites are essentially the samel as those encountered at the existing WTP site. This comprises an upper layer of colluvial soils approximately 10 to 15 m thick, underlain by variably weathered sandstone. The colluvial/landslide debris soils are not particularly unusual in their composition or material characteristics. Both the replacement WTP and Reservoir 1 sites are considered suitable from a geotechnical perspective in terms of settlement and groundwater effects.

The relatively deep nature of the groundwater in the project area means that the earthworks at the replacement WTP will not encounter any substantial groundwater and will therefore not induce drawdown-related settlement.

The construction of Reservoir 1 and the tunnel shaft will result in groundwater drawdowns of up to 10 m. The lateral extent of the drawdown effects vary from approximately 50 m to 70 m depending on direction relative to the sloping topography. This estimate is considered to be conservative as it is based on an upper bound soil permeability and a fully drained excavation. The expected use of secant pile walls during construction of Reservoir 1 and the tunnel shaft would probably reduce groundwater drawdown considerably. The upper bound groundwater drawdown cone (and therefore potential for settlement) is contained entirely within Watercare property, with the exception of Woodlands Park Road.

Drawdown-induced settlements of approximately 40 mm to 90 mm are predicted immediately adjacent to Reservoir 1 and the tunnel shaft. While this is in in excess of what would be considered to be the upper limit for existing structures, in this case only the open excavation of Reservoir 1 and its retention structure will be affected. Settlements in the order of 30 mm has been estimated for Woodlands Park Road. Extending over an estimated 300 m length of the road, the differential settlements are expected to be less than those that could potentially affect buried services in the road, all of which are owned by Watercare.

The Armstrong Gully Stream lies within the zone of potential impact of the dewatering, however as the surface flows within the creek are not directly connected to the deeper perched groundwater system and substantial recharge will continue from both direct rainfall as well as surface flows off the adjacent escarpment, neither the stream not existing vegetation is expected to be negatively affected by construction.

Additional geotechnical investigations will be required prior to the undertaking of preliminary and detailed design. This will be required to verify the current ground model as well as provide additional data on the groundwater regime at the two sites. Additional piezometers installed at that time will be able to be used for groundwater monitoring during construction.

It is proposed that detailed seepage modelling be undertaken during design which will allow both the magnitude and lateral extent of groundwater drawdown effects be more accurately assessed. As this modelling will be able to account for the low permeability of the secant pile walls (or similar) that will support the deep excavations, the extent of drawdown (and resulting surface settlement) are likely to be signficiantly smaller than has been assumed in the assessment presented here.

Once the results of detailed modelling are available, it will then be possible to set appropriate alert and alarm trigger levels for inclusion in the draft Groundwater and Settlement Monitoring

Contingency Plan (GSMCP) and consent conditions. Trigger levels will be set for both groundwater levels and ground surface settlement which will be monitored using a network of piezometers and surface monitoring pins respectively.

Monitoring of adjacent private properties will not be required as they are located on a rock escarpment immune to the effects of dewatering and settlement near Woodlands Park Road.

9 References

Boffa Miskell. 2018. Huia WTP Upgrade. Assessment of ecological effects. Report prepared for Watercare Services Limited dated 24 August 2018.

CIRIA (2016). Groundwater control: design and practice, 2nd Ed.

Kermode, L.O. 1992.Geology of the Auckland urban area. Scale 1:50,000. Institute of Geological and Nuclear Sciences.

Opus International Consultants. 2013. Woodlands Park Road Reservoirs, Geotechnical Factual Report. Report GS13/424.

Tonkin & Taylor. 2010. Huia Water Treatment Plant Rebuild – Geotechnical Investigation and Assessment.

Tower Foundations. 2008. Huia Water Treatment Plant – Review of Historical Geotechnical Information. Report 5330.

10 Applicability

This report has been prepared for the exclusive use of our client Watercare Services Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:

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Authorised for Tonkin & Taylor Ltd by:

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Peter Roan

Project Director

kjh
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Appendix A: Figures

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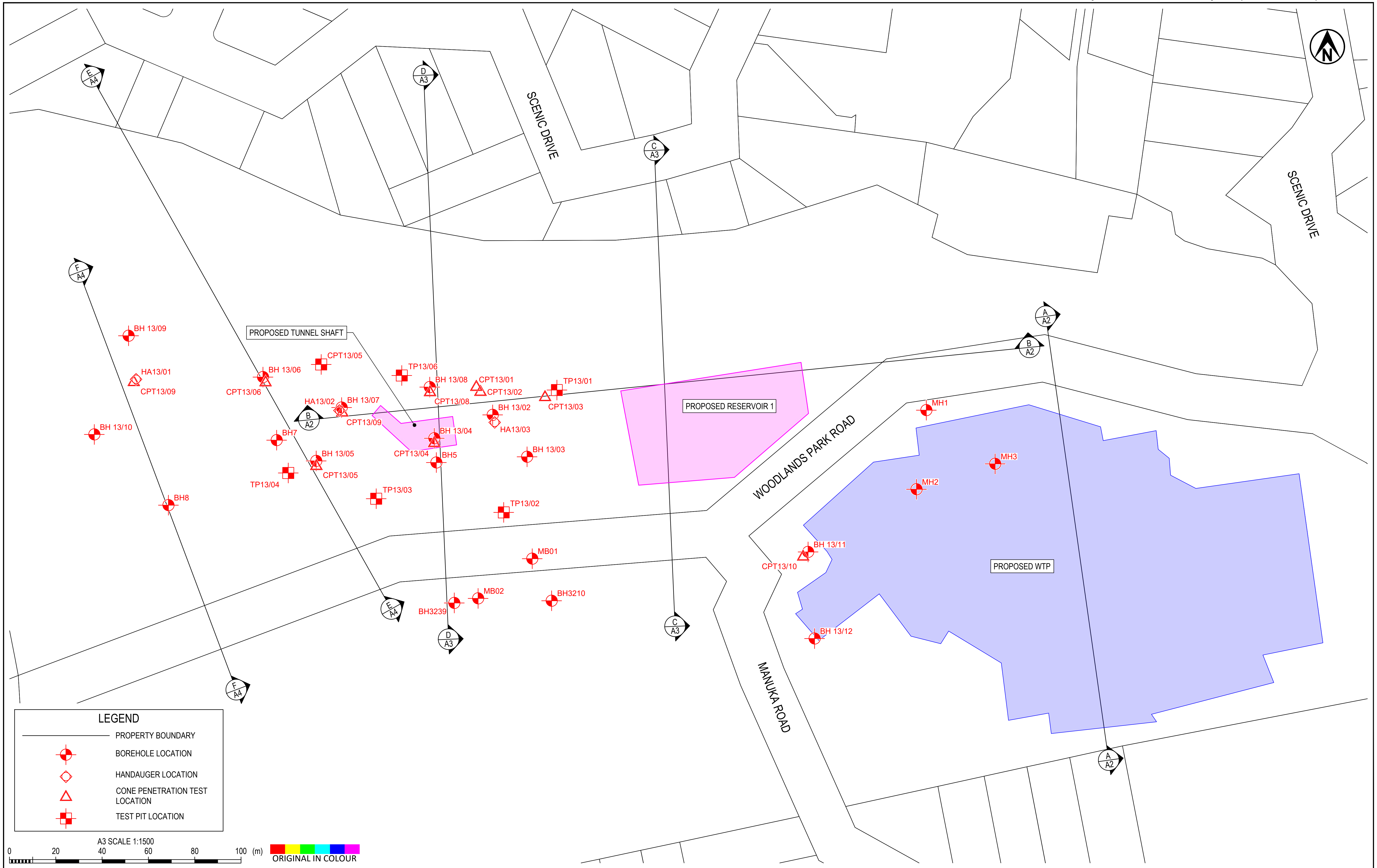

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DESIGNED	KJH	May.19
DRAWN	JC	May.19
CHECKED	KJH	May.19
APPROVED	KJH	22 May.19

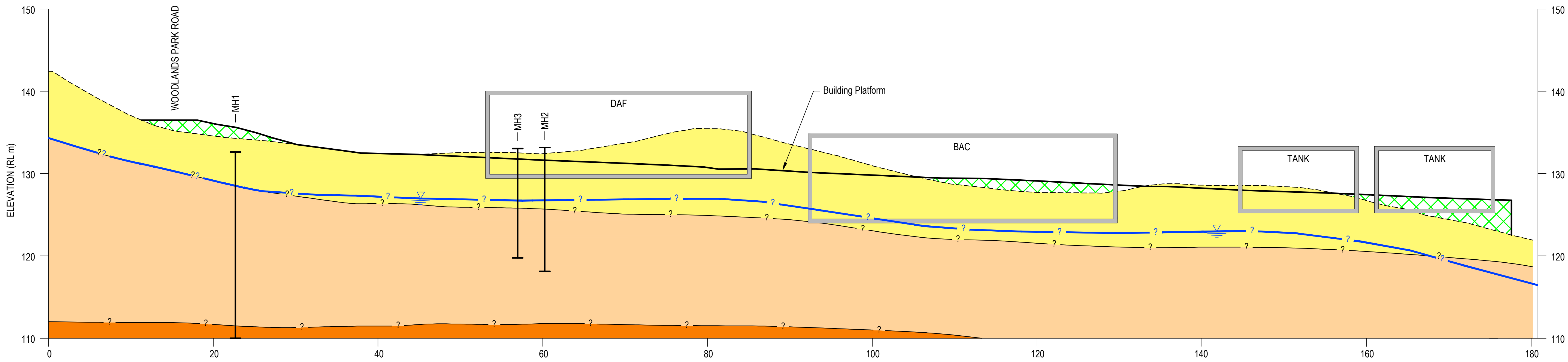
DATE

CLIENT **WATERCARE SERVICES LIMITED**

PROJECT **HUIA WTP REPLACEMENT PROJECT**

TITLE WOODLANDS PARK ROAD, TITIRANGI
SITE PLAN

SCALE (A3) AS SHOWN FIG No. FIGURE A1 REV 1



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SECTION A PROPOSED WTP
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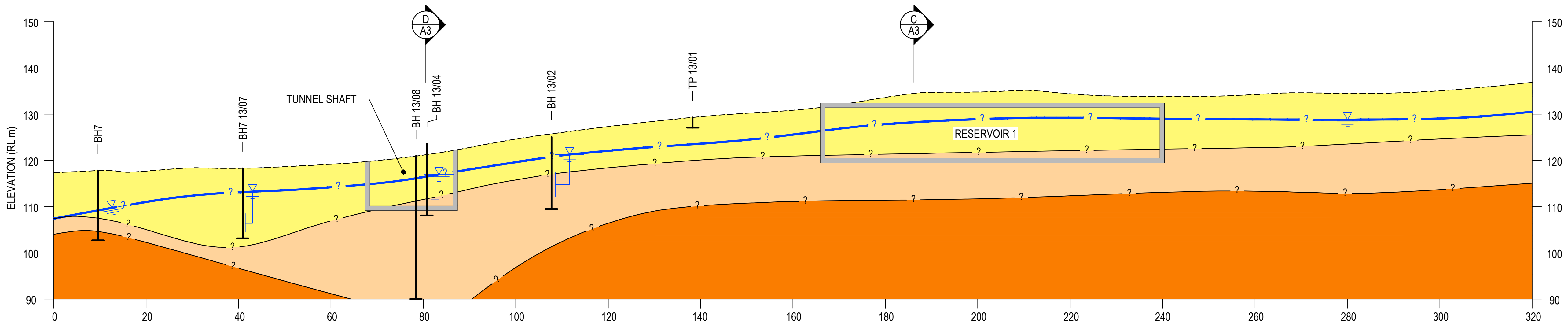

A3 SCALE 1:1000
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SECTION B RESEVOIR 1
SCALE 1: 1000 A1

LEGEND

EXISTING GROUND PROFILE		FILL	
INFERRED GEOLOGICAL BOUNDARY		COLLUVIUM / LANDSLIDE DEBRIS	
ASSUMED PERCHED GROUNDWATER LEVEL		COMPLETELY WEATHERED TO HIGHLY WEATHERED CORNWALLIS FORMATION	
GROUNDWATER LEVEL IN PIEZOMETER		MODERATELY WEATHERED TO SLIGHTLY WEATHERED CORNWALLIS FORMATION	

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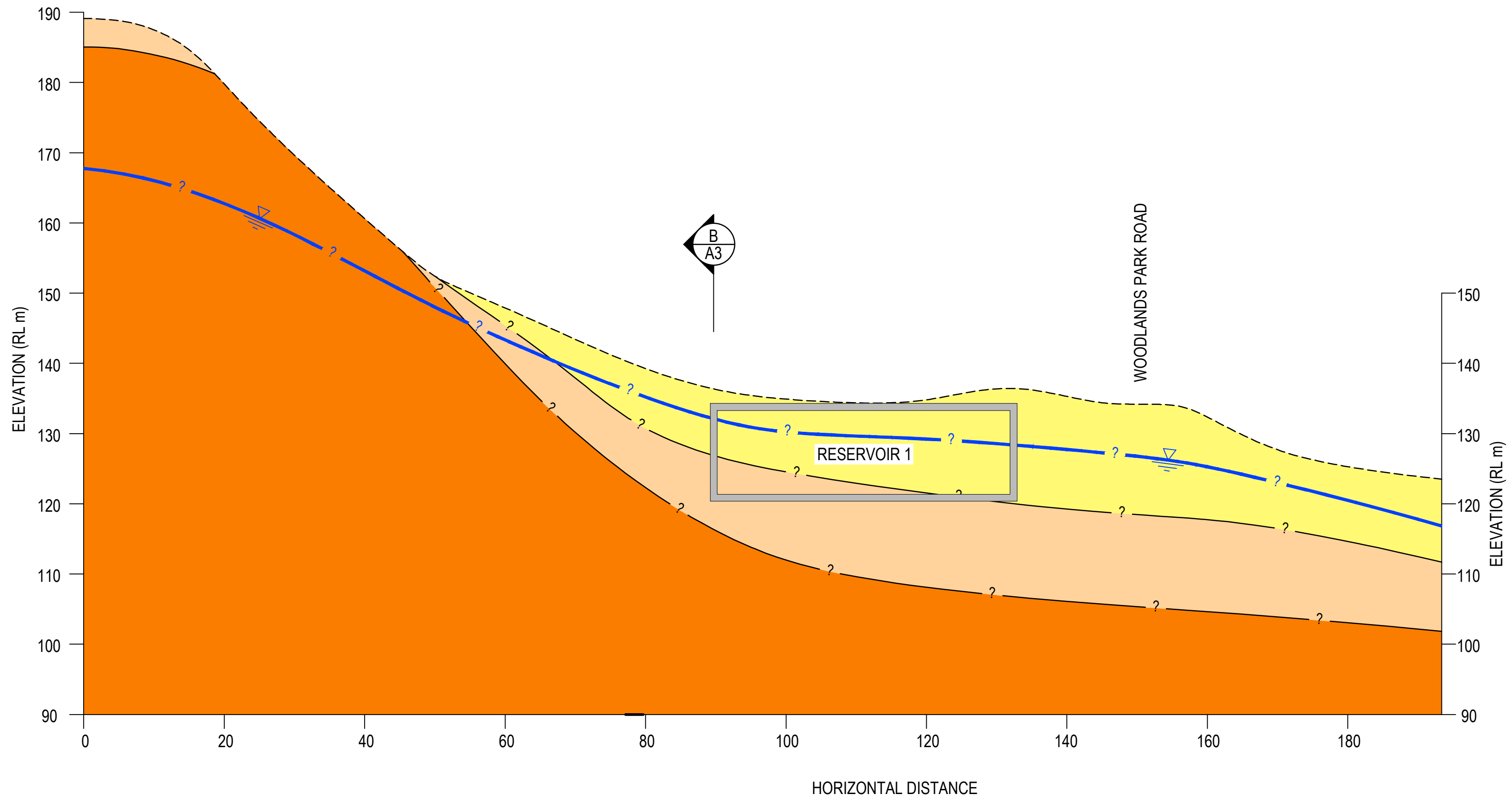
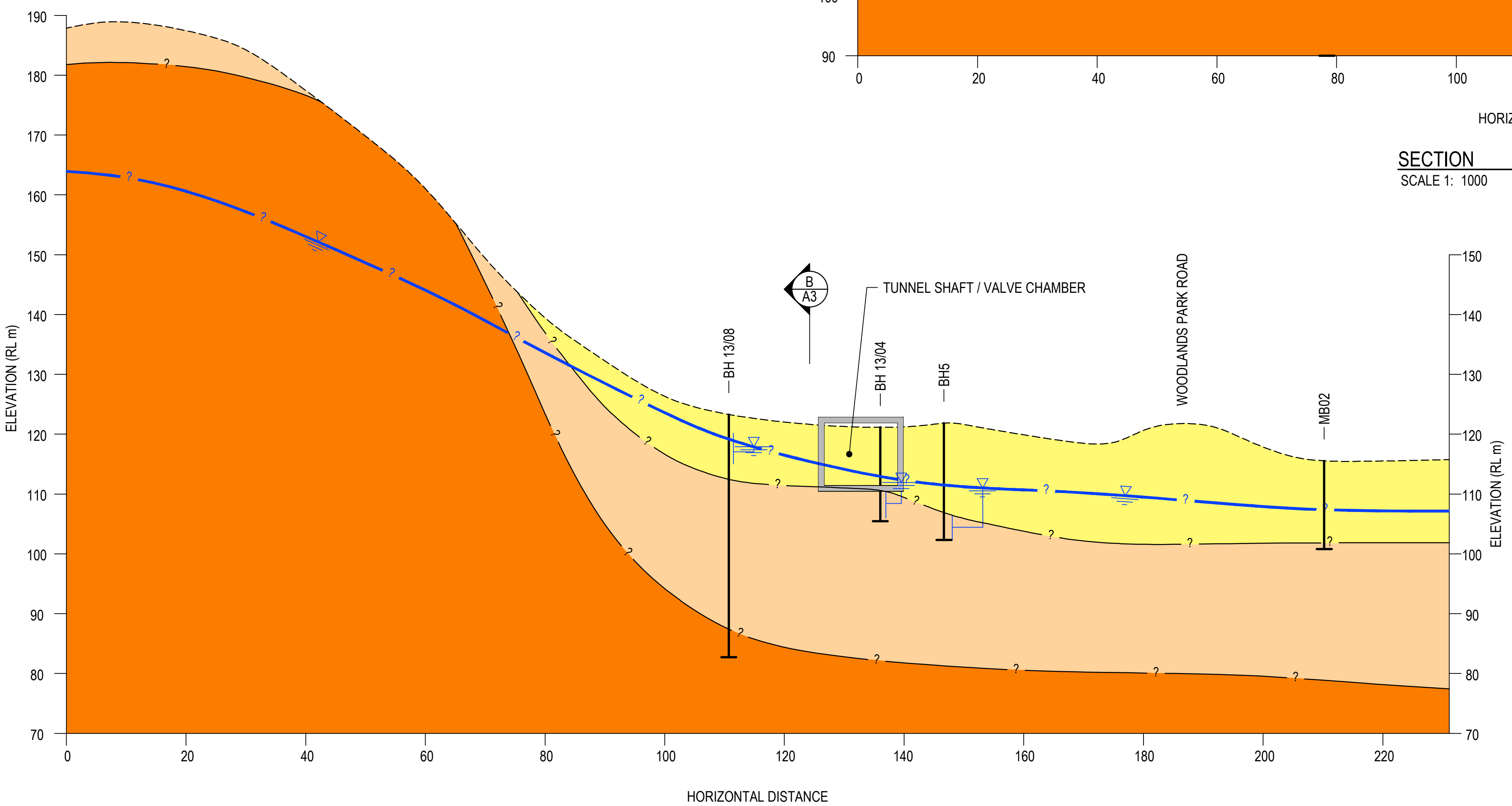
CLIENT WATERCARE SERVICES LIMITED
PROJECT HUIA WTP REPLACEMENT PROJECT
TITLE WOODLANDS PARK ROAD, TITIRANGI
GEOLOGICAL CROSS SECTIONS A & B

SCALE (A3) AS SHOWN FIG No. FIGURE A2 REV 1



SECTION C/A1 RESERVOIR 1
SCALE 1: 1000



SECTION D/A1 WEST OF RESERVOIR 1
SCALE 1: 1000

LEGEND

- EXISTING GROUND PROFILE
- INFERRED GEOLOGICAL BOUNDARY
- ASSUMED PERCHED GROUNDWATER LEVEL
- GROUNDWATER LEVEL IN PIEZOMETER
- FILL
- COLLUVIUM / LANDSLIDE DEBRIS
- COMPLETELY WEATHERED TO HIGHLY WEATHERED CORNWALLIS FORMATION
- MODERATELY WEATHERED TO SLIGHTLY WEATHERED CORNWALLIS FORMATION

A3 SCALE 1:1000
0 5 10 15 20 30 40 50 (m)

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CLIENT WATERCARE SERVICES LIMITED
PROJECT HUIA WTP REPLACEMENT PROJECT
TITLE WOODLANDS PARK ROAD, TITIRANGI GEOLOGICAL CROSS SECTIONS C & D
SCALE (A3) 1:1000 FIG No. FIGURE A3 REV 1

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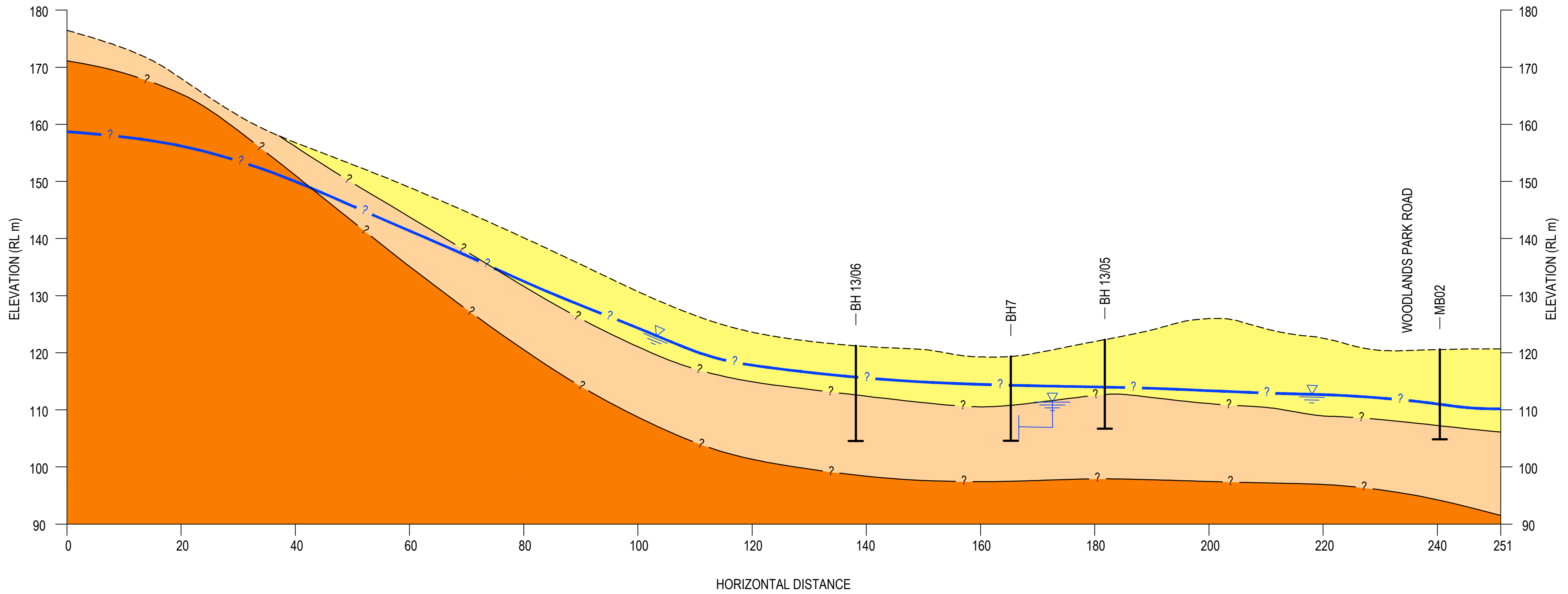

SECTION E WEST OF RESEVOIR 1
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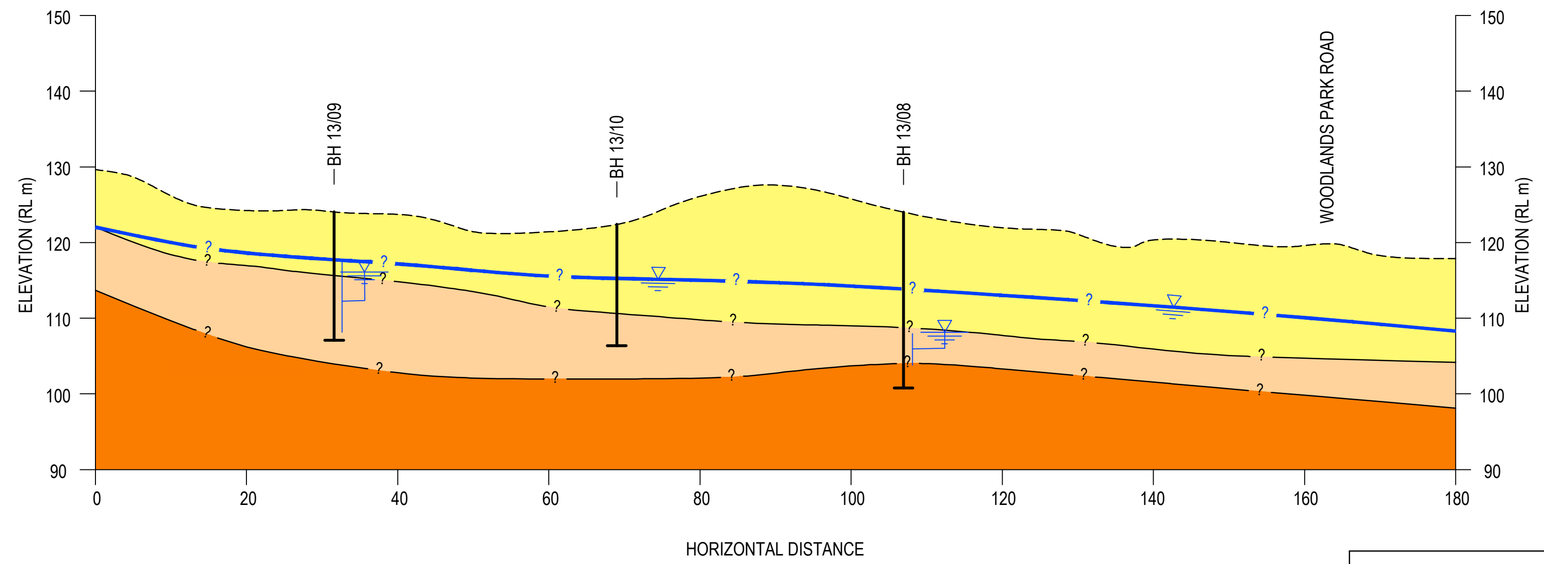

SECTION F WEST OF RESEVOIR 1
SCALE 1: 1000 A1

LEGEND

EXISTING GROUND PROFILE	FILL
INFERRED GEOLOGICAL BOUNDARY	COLLUVIUM / LANDSLIDE DEBRIS
ASSUMED PERCHED GROUNDWATER LEVEL	COMPLETELY WEATHERED TO HIGHLY WEATHERED CORNWALLIS FORMATION
GROUNDWATER LEVEL IN PIEZOMETER	MODERATELY WEATHERED TO SLIGHTLY WEATHERED CORNWALLIS FORMATION

A3 SCALE 1:1000
0 5 10 15 20 30 40 50 (m)

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APPROVED	KJH	22 May.19

CLIENT WATERCARE SERVICES LIMITED
PROJECT HUIA WTP REPLACEMENT PROJECT
TITLE WOODLANDS PARK ROAD, TITIRANGI
GEOLOGICAL CROSS SECTIONS E & F
SCALE (A3) AS SHOWN FIG No. FIGURE A4 REV 1

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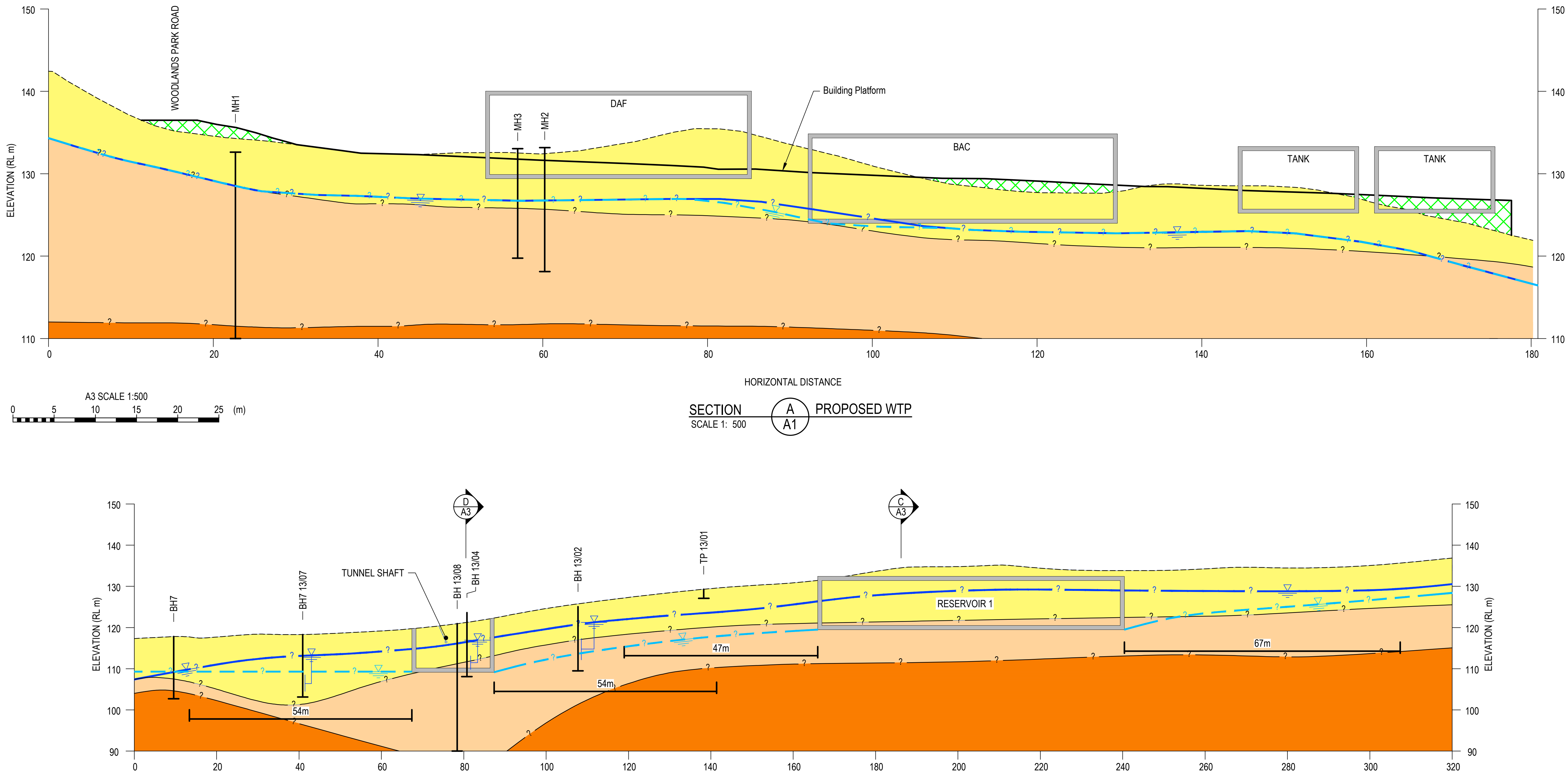

LEGEND

EXISTING GROUND PROFILE		FILL	
INFERRED GEOLOGICAL BOUNDARY		COLLUVIUM / LANDSLIDE DEBRIS	
ASSUMED PERCHED GROUNDWATER LEVEL		COMPLETELY WEATHERED TO HIGHLY WEATHERED CORNWALLIS FORMATION	
GROUNDWATER LEVEL DUE TO CONSTRUCTION		MODERATELY WEATHERED TO SLIGHTLY WEATHERED CORNWALLIS FORMATION	
47m CIRIA ESTIMATE OF LATERAL EXTENT			
GROUNDWATER LEVEL IN PIEZOMETER			

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APPROVED	KJH	22 May.19 (DATE)

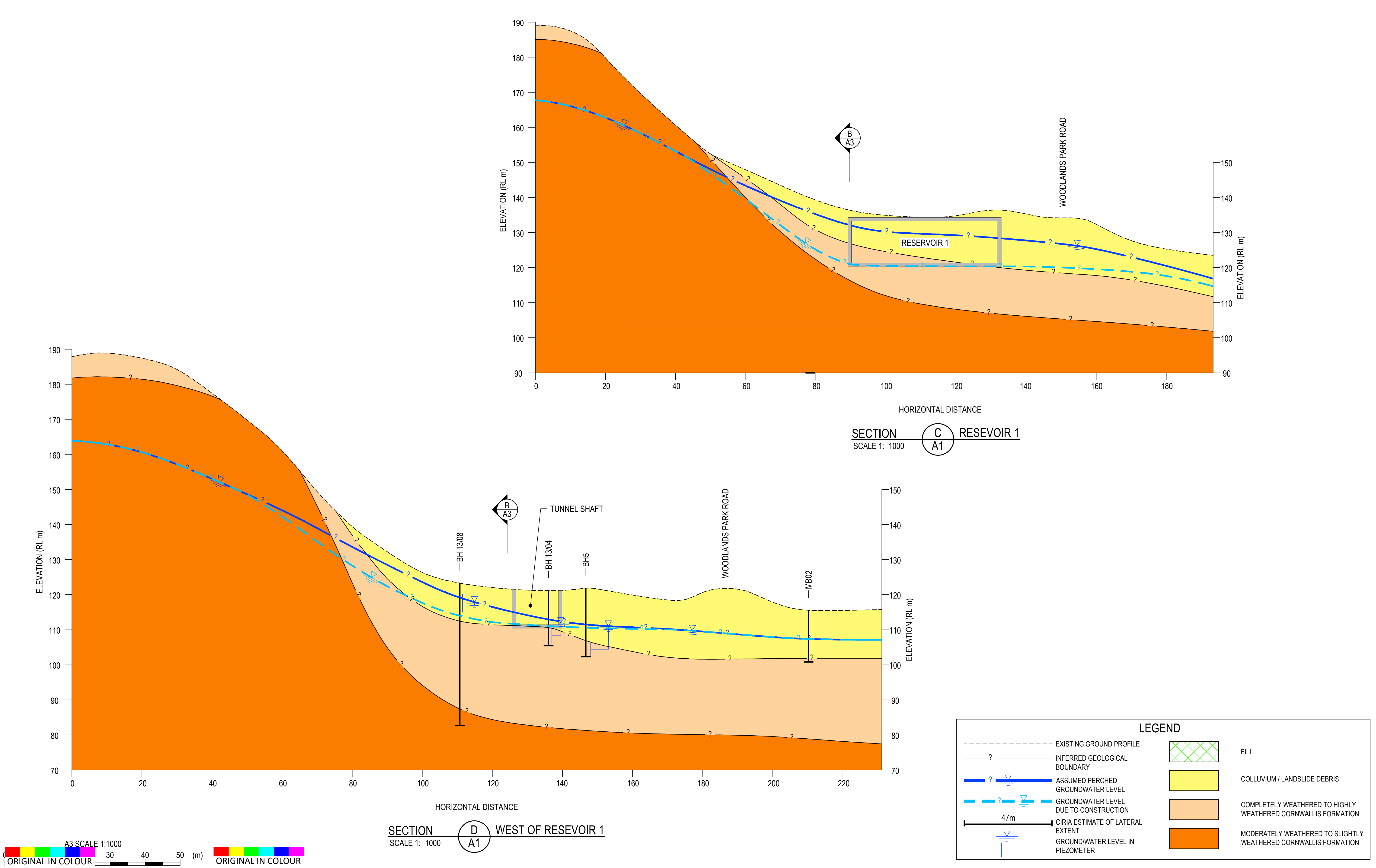
CLIENT WATERCARE SERVICES LIMITED

PROJECT HUIA WTP REPLACEMENT PROJECT

TITLE WOODLANDS PARK ROAD, TITIRANGI GROUNDWATER DRAWDOWN

SCALE (A3) AS SHOWN FIG No. FIGURE A5 REV 1

\\ttgroup.local\infrastructure\CAD\30848\30848.2000\WorkingMaterial\CAD\FIG\30848.2000-GEO-A2_A6.dwg 2019-May-14 8:54:27 PM Plotted By: JONALD CASTRO



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CHECKED	KJH	May.19
APPROVED	KJH	22 May.19 (DATE)

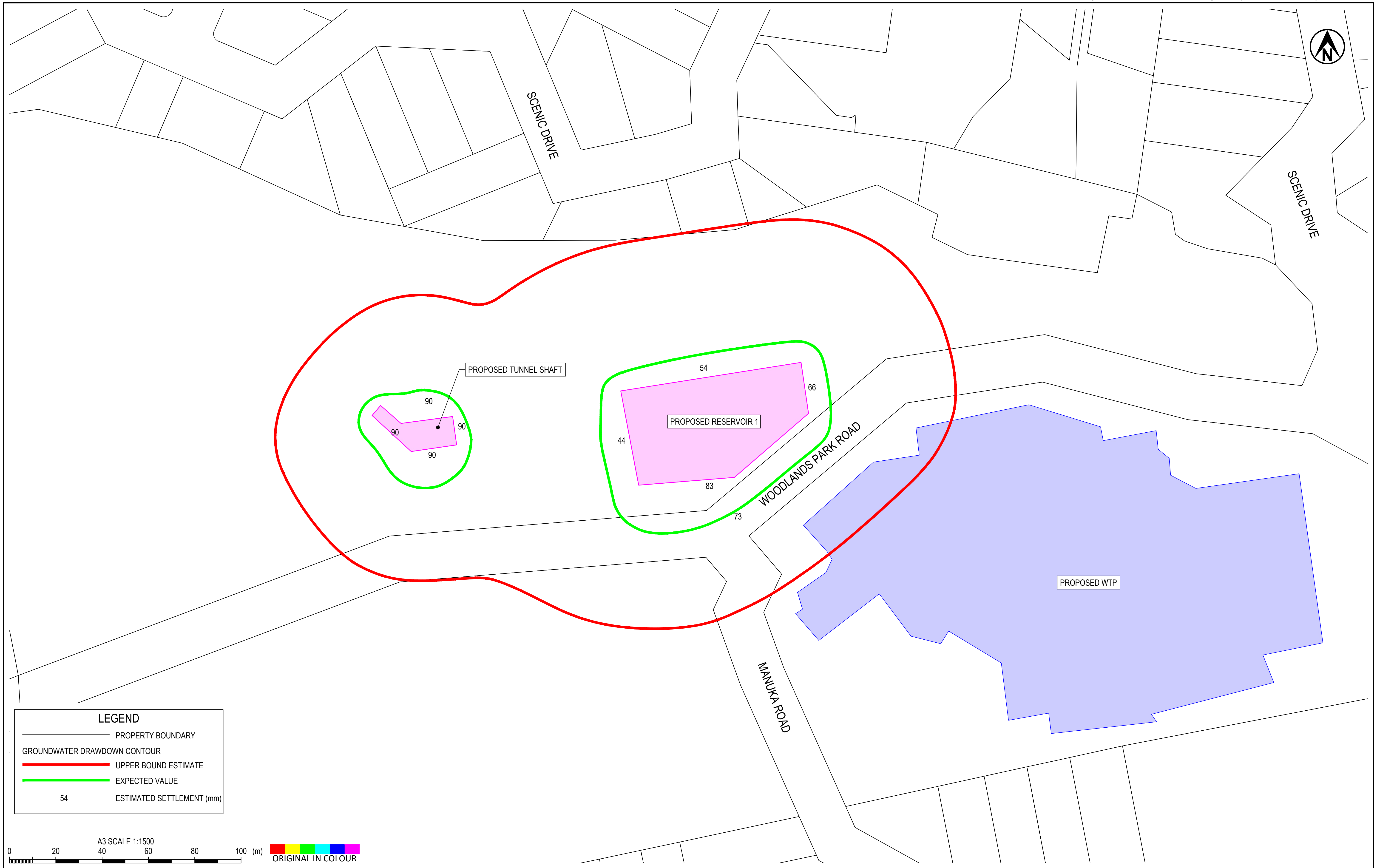
CLIENT **WATERCARE SERVICES LIMITED**

PROJECT **HUIA WTP REPLACEMENT PROJECT**

TITLE WOODLANDS PARK ROAD, TITIRANGI GROUNDWATER DRAWDOWN

SCALE (A3) AS SHOWN FIG No. FIGURE A6 REV 1

L:\30848\30848.2000\WorkingMaterial\CAD\FIG\30848.2000-GEO-A7.dwg 2019-May-21 4:03:16 PM Plotted By: JONALD CASTRO



NOTES:

1. PROPERTY BOUNDARIES SOURCED FROM LAND INFORMATION NEW ZEALAND DATA (CROWN COPYRIGHT RESERVED).

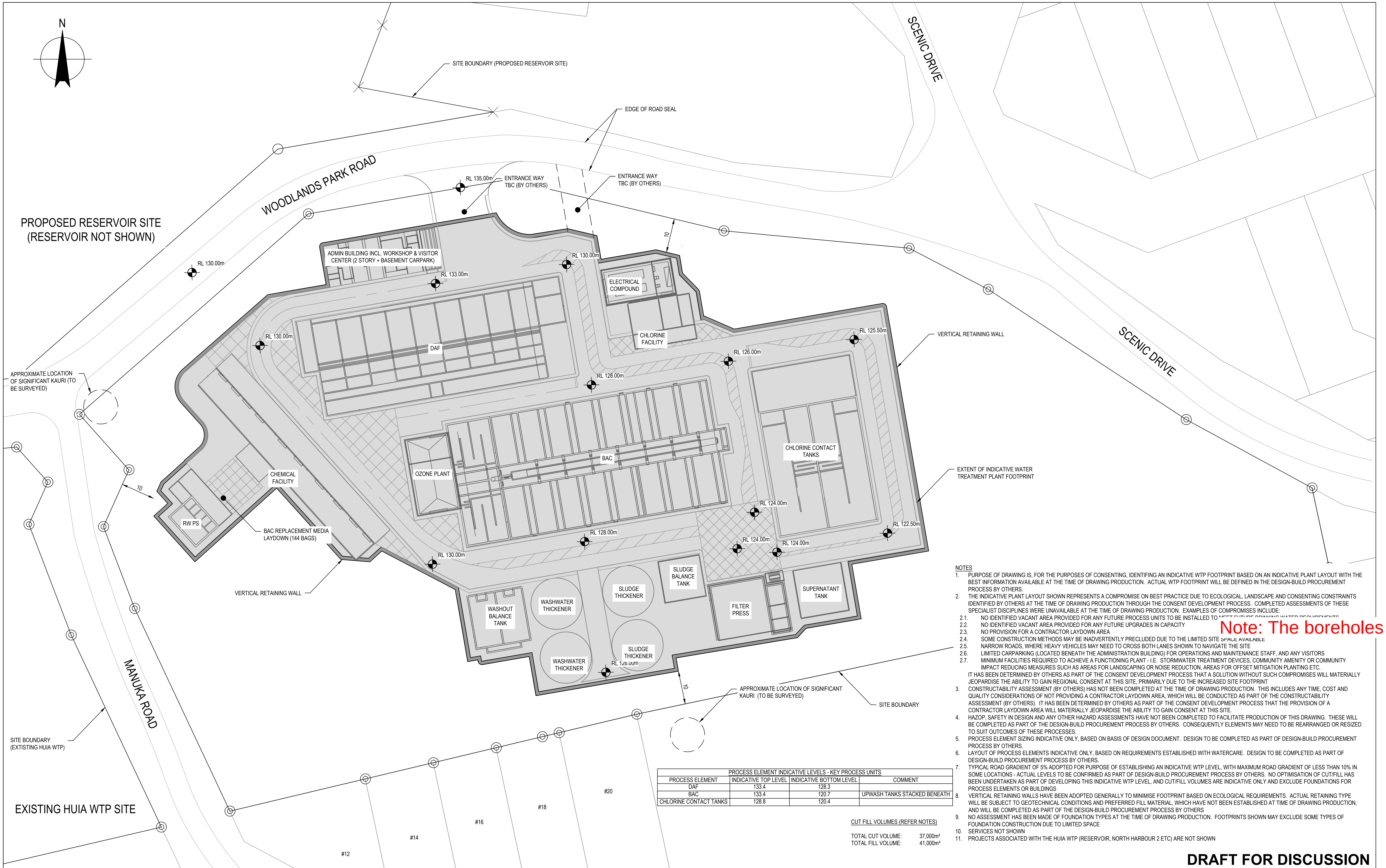
Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

PROJECT No.	30848.2000	
DESIGNED	KJH	May.19
DRAWN	JC	May.19
CHECKED	KJH	May.19
APPROVED	KJH	22 May.19 (DATE)

CLIENT	**WATERCARE SERVICES LIMITED**
PROJECT	**HUIA WTP REPLACEMENT PROJECT**
TITLE	WOODLANDS PARK ROAD, TITIRANGI GROUNDWATER DRAWDOWN AND SETTLEMENT
SCALE (A3)	AS SHOWN
FIG No.	FIGURE A7
REV	1

Appendix B: Design Drawings



Note: The boreholes inc

NOTES

1. PURPOSE OF DRAWING IS, FOR THE PURPOSES OF CONSENTING, IDENTIFING AN INDICATIVE WTP FOOTPRINT BASED ON AN INDICATIVE PLANT LAYOUT WITH THE BEST INFORMATION AVAILABLE AT THE TIME OF DRAWING PRODUCTION. ACTUAL WTP FOOTPRINT WILL BE DEFINED IN THE DESIGN-BUILD PROCUREMENT PROCESS BY OTHERS.
2. THE INDICATIVE PLANT LAYOUT SHOWN REPRESENTS A COMPROMISE ON BEST PRACTICE DUE TO ECOLOGICAL, LANDSCAPE AND CONSENTING CONSTRAINTS IDENTIFIED BY OTHERS AT THE TIME OF DRAWING PRODUCTION THROUGH THE CONSENT DEVELOPMENT PROCESS. COMPLETED ASSESSMENTS OF THESE SPECIALIST DISCIPLINES WERE UNAVAILABLE AT THE TIME OF DRAWING PRODUCTION. EXAMPLES OF COMPROMISES INCLUDE:
   - 2.1. NO IDENTIFIED VACANT AREA PROVIDED FOR ANY FUTURE PROCESS UNITS TO BE INSTALLED TO MEET FUTURE DRINKING WATER REQUIREMENTS
   - 2.2. NO IDENTIFIED VACANT AREA PROVIDED FOR ANY FUTURE UPGRADES IN CAPACITY
   - 2.3. NO PROVISION FOR A CONTRACTOR LAYDOWN AREA
   - 2.4. SOME CONSTRUCTION METHODS MAY BE INADVERTENTLY PRECLUDED DUE TO THE LIMITED SITE SPACE AVAILABLE
   - 2.5. NARROW ROADS, WHERE HEAVY VEHICLES MAY NEED TO CROSS BOTH LANES SHOWN TO NAVIGATE THE SITE
   - 2.6. LIMITED CARPARKING (LOCATED BENEATH THE ADMINISTRATION BUILDING) FOR OPERATIONS AND MAINTENANCE STAFF, AND ANY VISITORS
   - 2.7. MINIMUM FACILITIES REQUIRED TO ACHIEVE A FUNCTIONING PLANT - I.E. STORMWATER TREATMENT DEVICES, COMMUNITY AMENITY OR COMMUNITY IMPACT REDUCING MEASURES SUCH AS AREAS FOR LANDSCAPING OR NOISE REDUCTION, AREAS FOR OFFSET MITIGATION PLANTING ETC.

   IT HAS BEEN DETERMINED BY OTHERS AS PART OF THE CONSENT DEVELOPMENT PROCESS THAT A SOLUTION WITHOUT SUCH COMPROMISES WILL MATERIALLY JEOPARDISE THE ABILITY TO GAIN REGIONAL CONSENT AT THIS SITE, PRIMARILY DUE TO THE INCREASED SITE FOOTPRINT
3. CONSTRUCTABILITY ASSESSMENT (BY OTHERS) HAS NOT BEEN COMPLETED AT THE TIME OF DRAWING PRODUCTION. THIS INCLUDES ANY TIME, COST AND QUALITY CONSIDERATIONS OF NOT PROVIDING A CONTRACTOR LAYDOWN AREA, WHICH WILL BE CONDUCTED AS PART OF THE CONSTRUCTABILITY ASSESSMENT (BY OTHERS). IT HAS BEEN DETERMINED BY OTHERS AS PART OF THE CONSENT DEVELOPMENT PROCESS THAT THE PROVISION OF A CONTRACTOR LAYDOWN AREA WILL MATERIALLY JEOPARDISE THE ABILITY TO GAIN CONSENT AT THIS SITE.
4. HAZOP, SAFETY IN DESIGN AND ANY OTHER HAZARD ASSESSMENTS HAVE NOT BEEN COMPLETED TO FACILITATE PRODUCTION OF THIS DRAWING. THESE WILL BE COMPLETED AS PART OF THE DESIGN-BUILD PROCUREMENT PROCESS BY OTHERS. CONSEQUENTLY ELEMENTS MAY NEED TO BE REARRANGED OR RESIZED TO SUIT OUTCOMES OF THESE PROCESSES.
5. PROCESS ELEMENT SIZING INDICATIVE ONLY, BASED ON BASIS OF DESIGN DOCUMENT. DESIGN TO BE COMPLETED AS PART OF DESIGN-BUILD PROCUREMENT PROCESS BY OTHERS.
6. LAYOUT OF PROCESS ELEMENTS INDICATIVE ONLY, BASED ON REQUIREMENTS ESTABLISHED WITH WATERCARE. DESIGN TO BE COMPLETED AS PART OF DESIGN-BUILD PROCUREMENT PROCESS BY OTHERS.
7. TYPICAL ROAD GRADIENT OF 5% ADOPTED FOR PURPOSE OF ESTABLISHING AN INDICATIVE WTP LEVEL, WITH MAXIMUM ROAD GRADIENT OF LESS THAN 10% IN SOME LOCATIONS - ACTUAL LEVELS TO BE CONFIRMED AS PART OF DESIGN-BUILD PROCUREMENT PROCESS BY OTHERS. NO OPTIMISATION OF CUT/FILL HAS BEEN UNDERTAKEN AS PART OF DEVELOPING THIS INDICATIVE WTP LEVEL, AND CUT/FILL VOLUMES ARE INDICATIVE ONLY AND EXCLUDE FOUNDATIONS FOR PROCESS ELEMENTS OR BUILDINGS
8. VERTICAL RETAINING WALLS HAVE BEEN ADOPTED GENERALLY TO MINIMISE FOOTPRINT BASED ON ECOLOGICAL REQUIREMENTS. ACTUAL RETAINING TYPE WILL BE SUBJECT TO GEOTECHNICAL CONDITIONS AND PREFERRED FILL MATERIAL, WHICH HAVE NOT BEEN ESTABLISHED AT TIME OF DRAWING PRODUCTION, AND WILL BE COMPLETED AS PART OF THE DESIGN-BUILD PROCUREMENT PROCESS BY OTHERS
9. NO ASSESSMENT HAS BEEN MADE OF FOUNDATION TYPES AT THE TIME OF DRAWING PRODUCTION. FOOTPRINTS SHOWN MAY EXCLUDE SOME TYPES OF FOUNDATION CONSTRUCTION DUE TO LIMITED SPACE
10. SERVICES NOT SHOWN
11. PROJECTS ASSOCIATED WITH THE HUIA WTP (RESERVOIR, NORTH HARBOUR 2 ETC) ARE NOT SHOWN

PROCESS ELEMENT INDICATIVE LEVELS - KEY PROCESS UNITS

PROCESS ELEMENT	INDICATIVE TOP LEVEL	INDICATIVE BOTTOM LEVEL	COMMENT
DAF	133.4	128.3	
BAC	133.4	120.7	UPWASH TANKS STACKED BENEATH
CHLORINE CONTACT TANKS	128.8	120.4	

CUT FILL VOLUMES (REFER NOTES)

TOTAL CUT VOLUME: 37,000m³
TOTAL FILL VOLUME: 41,000m³

DRAFT FOR DISCUSSION

No	Revision	Drawn	Job Manager	Project Director	Date
F	BATTER SLOPES DELETED AND MODIFIED LAYOUT	AB			11/06/18
E	MINOR DRAFTING CHANGES	AB			06/06/18
D	UPDATED WITH RW PS, OPS LAYDOWN AND VERT RETAINING	AB	AB	RW	23/05/18
C	DRAFT UPDATE WITH LOCATION OF KAURI; FOR PUBLIC CONSUL	AB	AB		21/05/18
B	LAYOUT REVISED BASED ON WATERCARE REQUIREMENTS	JA	AB	RW	09/05/18

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

Watercare

Level 3, GHD Centre
27 Napier Street, Freemans Bay, Auckland 1011 New Zealand
T 64 9 370 8000 **F** 64 9 370 8001
E auckland@ghd.com **W** www.ghd.com

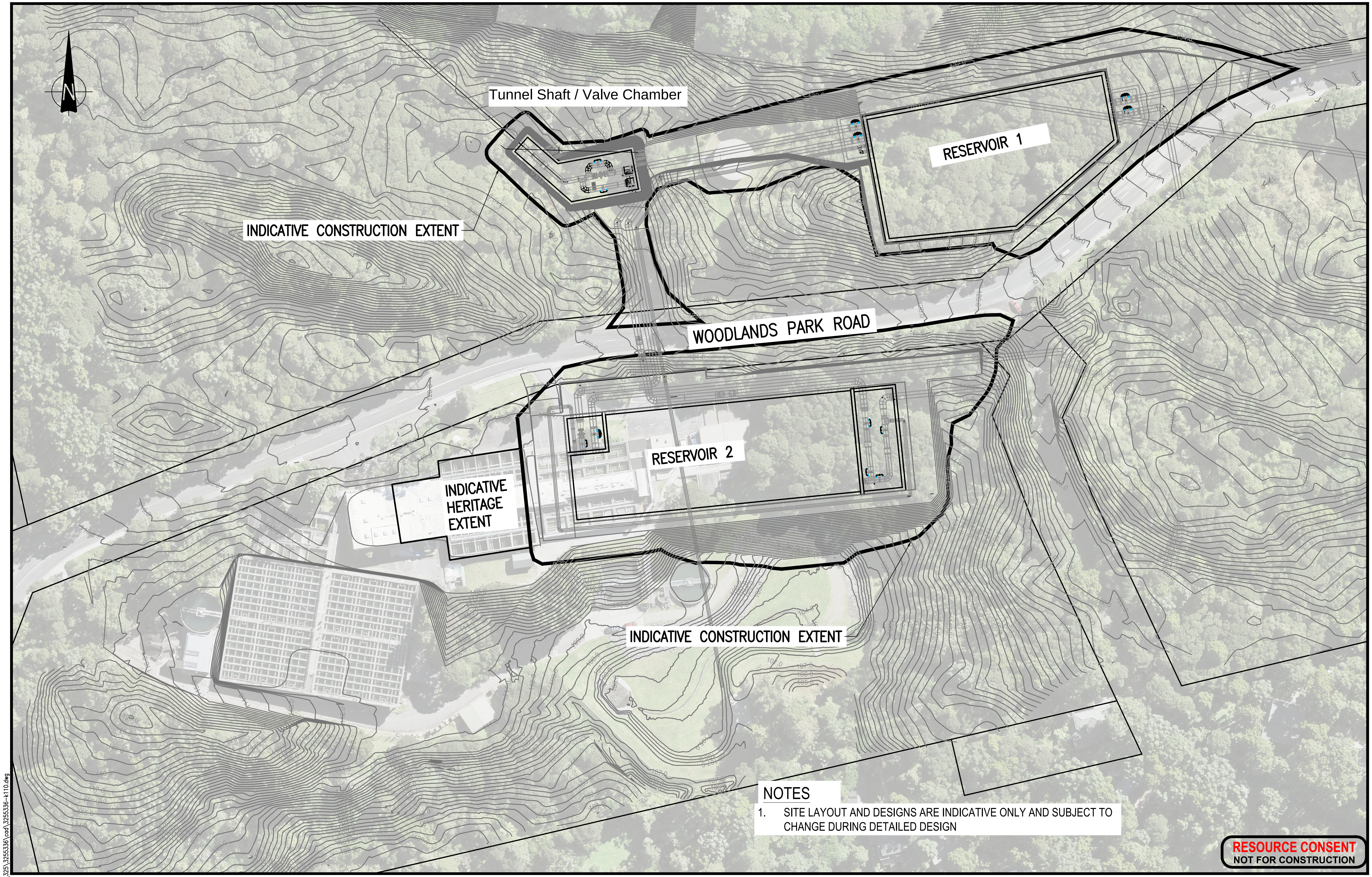
DO NOT SCALE

Drawn J. ALCASID | Designer C. GAMST
Drafting Check J. ROSS | Design Check A. BLOW
Approved (Project Director)
Date
Scale 1:500
This Drawing must not be used for Construction unless signed as Approved

Client **WATERCARE SERVICES LTD**
Project **HUIA WATER TREATMENT PLANT**
Title **SITE LAYOUT AND EARTHWORKS PLAN**

Original Size **A1** Drawing No: **51-3357505-C001** Rev: **F**

Plot Date: 11 June 2018 - 11:44 AM Plotted by: Andrew Blow Cad File No: G:\51\3357505\CADD\Drawings\51-3357505-C001.dwg



NOTES

1. SITE LAYOUT AND DESIGNS ARE INDICATIVE ONLY AND SUBJECT TO CHANGE DURING DETAILED DESIGN

RESOURCE CONSENT
NOT FOR CONSTRUCTION

ISSUE	DATE	AMENDMENT	BY	APPD.
0B	17.05.19	ISSUED FOR CONSENT	GT	

		BY	DATE
DESIGNED		SP	05.19
DES. APPROVED			
DRAWN		SMB	05.19
DWG. APPROVED			
WSL DESIGN MGMT.			
WSL PROJ. LEAD			

Watercare

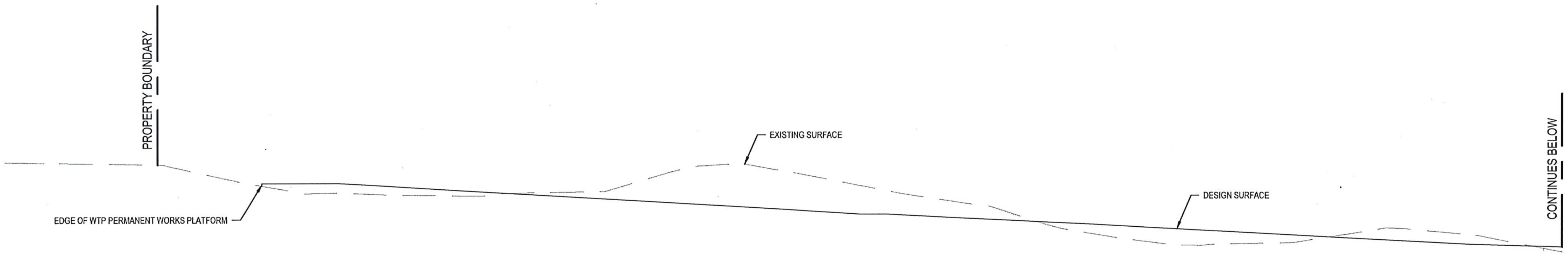
HUIA REPLACEMENT WATER TREATMENT PLANT
TREATED WATER STORAGE RESERVOIR

RESERVOIR CONCEPT – PLAN

DRAFT

CAD FILE 3255336–K110	DATE 17.05.19
ORIGINAL SCALE A3 1:1000	CONTRACT No. –
REF No.	
DWG No. 3255336 –K110	ISSUE 0B

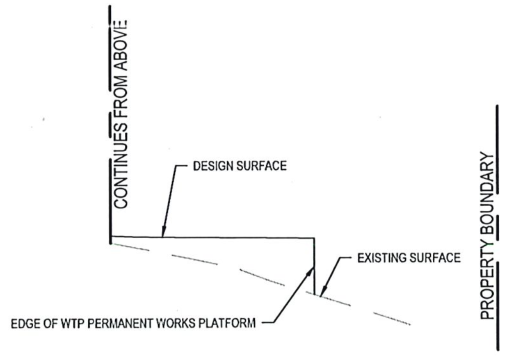
Document: \\beca.net\projects\325\3255336\cad\3255336-k110.dwg



DATUM RL. 122.00

DESIGN SURFACE LEVEL				133.000	132.532	131.946	131.359	130.772	130.148	129.736	129.232	128.689	128.145	127.606	127.067	126.737
LEVEL DIFFERENCE CUT - / FILL +				0.95	0.68	-0.14	-1.49	-4.06	-3.07	-1.69	0.17	1.39	1.03	-0.52	-0.96	0.48
EXISTING SURFACE LEVEL	135.06	134.90	133.74	132.05	131.85	132.09	132.85	134.84	133.22	131.43	129.07	127.30	127.11	128.13	128.03	126.26
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00

E SECTION
SK006 SCALE 1 : 250



DATUM RL. 116.00

DESIGN SURFACE LEVEL	126.737	126.611		
LEVEL DIFFERENCE CUT - / FILL +	0.48	2.61		
EXISTING SURFACE LEVEL	126.26	124.00	120.82	
CHAINAGE	150.00	160.00	170.00	180.00

E SECTION
SK006 SCALE 1 : 250

0 2.5 5 7.5 10 12.5m
SCALE 1:250 AT ORIGINAL SIZE

A			
rev	description	app'd	date

WATERCARE SERVICES LTD
HUIA WATER TREATMENT PLANT
WATER TREATMENT PLANT SECTIONS

11/F Alphaland Southgate Tower 2258 Chino Roces Ave corner EDSA
Makati City 1232 Philippines
T 63 2 479 5600 F 63 2 479 5601
E mnlmail@ghd.com W www.ghd.com

scale 1:250 for A1 job no. 51-3357505
date 2018.06.15 rev no. A
approved (PD) SK011

Plot Date: 25 July 2018 - 4:29 PM Plotted by: Ralph Kenneth Guevarra Cad File No: G:\51\33575\CADD\Drawings\SKETCH\51-3357505-SK011.dwg

CUT FILL VOLUMES

TOTAL CUT VOLUME: 41,460m^3
TOTAL FILL VOLUME: 30,400m^3

EARTH WORKS CUT / FILL DEPTH	
CUT / FILL DEPTH	DEPTH COLOUR
-13 to -12	
-12 to -11	
-11 to -10	
-10 to -9	
-9 to -8	
-8 to -7	
-7 to -6	
-6 to -5	
-5 to -4	
-4 to -3	
-3 to -2	
-2 to -1	
-1 to 0	
0 to 1	
1 to 2	
2 to 3	
3 to 4	
4 to 5	
5 to 6	
6 to 7	
7 to 8	
8 to 9	
9 to 10	

PLAN
SCALE 1:500

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director	Date
A			EP			

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

Watercare

GHD
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Makati City 1232 Philippines
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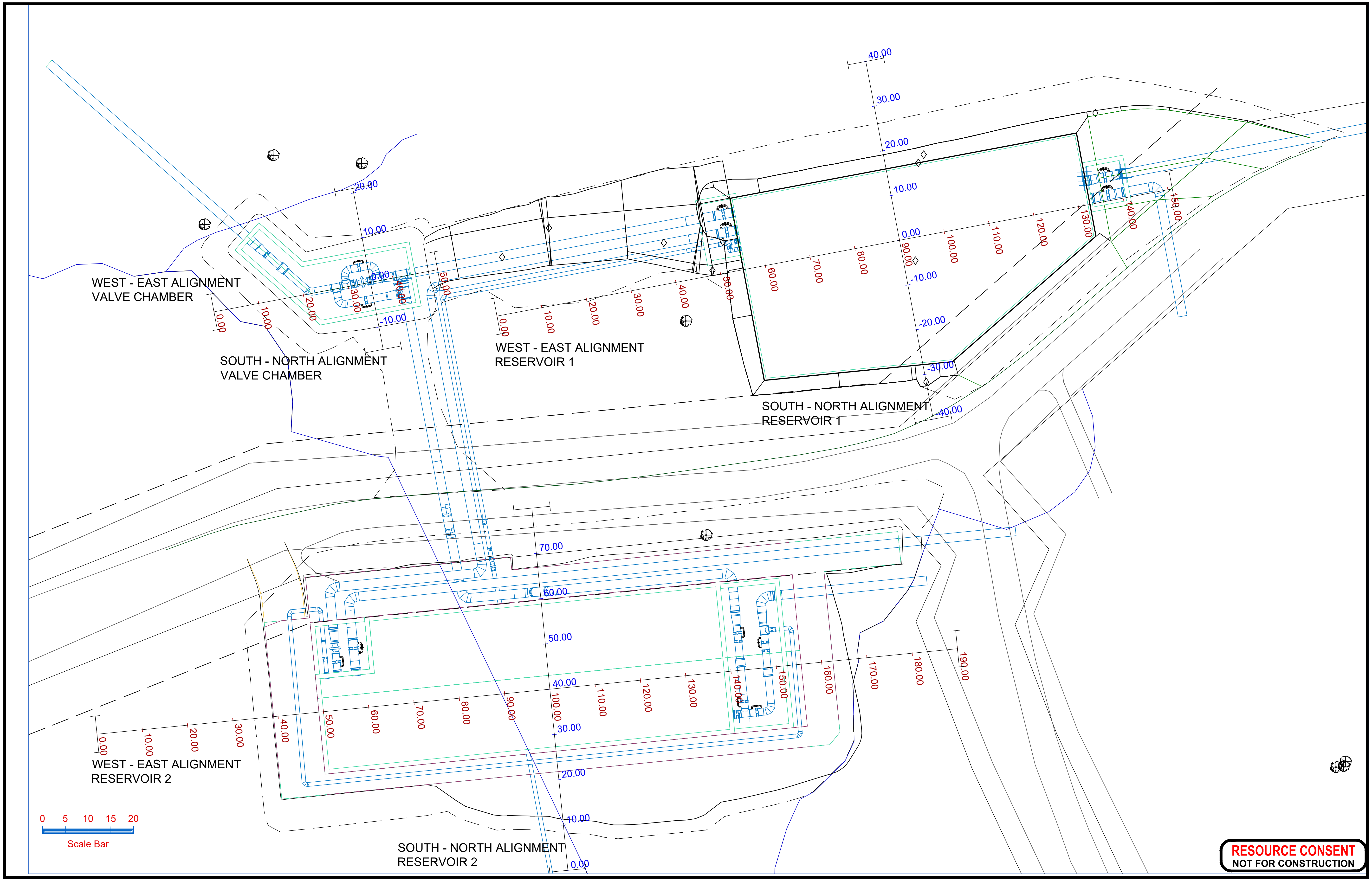
Drawn E. PARCIA	Designer
Drafting Check	Design Check
Approved (Project Director) Date	
Scale 1:500	This Drawing must not be used for Construction unless signed as Approved

Client WATERCARE SERVICES LTD
Project HUIA WATER TREATMENT PLANT
Title CUT AND FILL THEMATIC MAP
PLATFORM WITH BURIED STRUCTURES

Original Size A1 Drawing No: 51-3357505-SK002 Rev: A

Plot Date: 3 August 2018 - 10:45 AM Plotted by: Ella Genn Parcia Cad File No: G:\51\33575\CADD\Drawings\SKETCH\51-3357505-SK002.dwg



ISSUE	DATE	AMENDMENT	BY	APPD.
OB	17.05.19	ISSUED FOR CONSENT	GT	

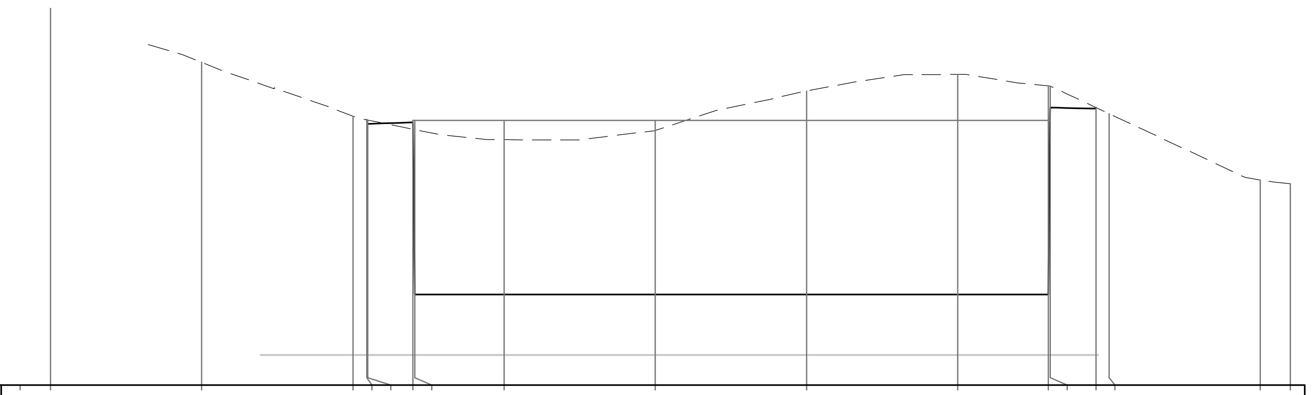
DESIGNED	SB	05-19
DES. APPROVED	Design Approved	mm-yy
DRAWN	Drawn	mm-yy
DWG. APPROVED	Drawing Approved	mm-yy
WSL DESIGN MGMT.	WSL Design Mgmt.	mm-yy
WSL PROJ. LEAD	WSL Proj. Lead	mm-yy
	BY	DATE

Watercare

HUIA WATER TREATMENT PLANT REPLACEMENT
TREATED WATER STORAGE RESERVOIR
RESERVOIR 1 & 2 AND VALVE CHAMBER LAYOUT – CHAINAGE INFORMATION

DRAFT

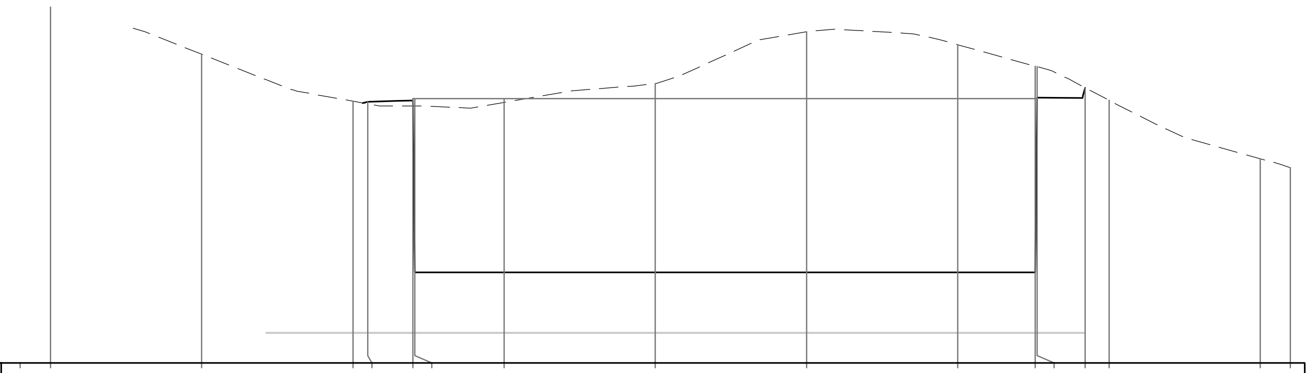
CAD FILE 3255336-K118
DATE 17-05-19
ORIGINAL SCALE A3 1:500
CONTRACT No. –
REF No.
DWG No. 35255336.K118
ISSUE OB



Datum 112.00

Proposed top of structure							129.50	129.50	129.50	129.50	129.50	129.50	129.50	129.50				
Proposed ground/ structure floor level					129.55	129.29	129.38	118.00	118.00	118.00	118.00	118.00	118.00	130.36	130.36			
Existing ground			133.36	129.78	129.55	129.53	128.93	128.91	128.23	128.84	131.45	132.55	131.81	131.77	130.36	129.96	125.58	125.33
Offset	-32.00	-30.00	-20.00	-10.00	-9.09	-9.02	-6.02	-5.91	0.00	10.00	20.00	30.00	35.99	36.11	39.14	40.00	50.00	52.00

CHAINAGE 70



Datum 112.00

Proposed top of structure						129.50	129.50	129.50	129.50	129.50	129.50	129.50	129.50				
Proposed ground/ structure floor level					129.29	129.37	118.00	118.00	118.00	118.00	118.00	118.00	129.56	130.22			
Existing ground			132.43	129.32	129.15	129.00	129.00	129.25	130.49	133.91	133.06	131.64	131.61	130.22	129.38	125.52	124.92
Offset	-32.00	-30.00	-20.00	-10.00	-9.02	-6.02	-5.91	0.00	10.00	20.00	30.00	35.12	35.24	38.42	40.00	50.00	52.00

CHAINAGE 60

RESOURCE CONSENT
NOT FOR CONSTRUCTION

ISSUE	DATE	AMENDMENT	BY	APPD.
0B	17.05.19	ISSUED FOR CONSENT	GT	

	BY	DATE
DESIGNED	SB	05–19
DES. APPROVED	Design Approved	mm–yy
DRAWN	Drawn	mm–yy
DWG. APPROVED	Drawing Approved	mm–yy
WSL DESIGN MGMT.	WSL Design Mgmt.	mm–yy
WSL PROJ. LEAD	WSL Proj. Lead	mm–yy

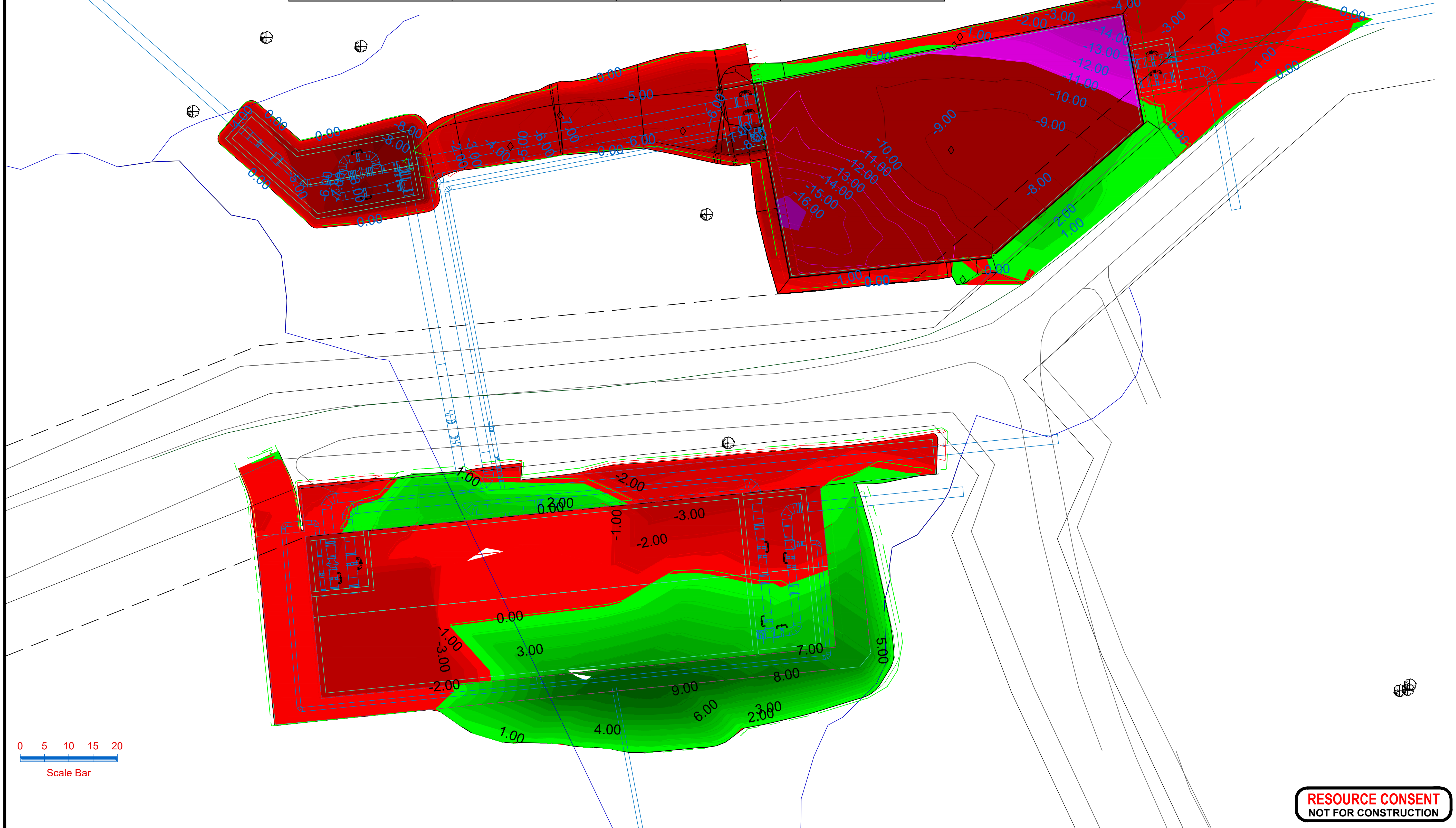
Watercare

HUIA WATER TREATMENT PLANT REPLACEMENT
TREATED WATER STORAGE RESERVOIR
RESERVOIR 1 CROSS SECTIONS ALONG WEST EAST ALIGNMENT

DRAFT

CAD FILE 3255336–K133
DATE 17–05–19
ORIGINAL SCALE A3 1:500
CONTRACT No. –
REF No.
DWG No. 35255336.K133
ISSUE 0B

Work site	Cut Volume	Fill Volume	Balance
Valve Chamber	4,000m^3	0	4,000m^3
Reservoir 1	40,000m^3	400m^3	39,600m^3
Reservoir 2	6,000m^3	11,000m^3	-5,000m^3



DESIGNED	SB	05-19		
DES. APPROVED	Design Approved	mm-yy		
DRAWN	Drawn	mm-yy		
DWG. APPROVED	Drawing Approved	mm-yy		
WSL DESIGN MGMT.	WSL Design Mgmt.	mm-yy		
WSL PROJ. LEAD	WSL Proj. Lead	mm-yy		
	BY	DATE		

ISSUE	DATE	AMENDMENT	BY	APPD.
OB	17.05.19	ISSUED FOR CONSENT	GT	

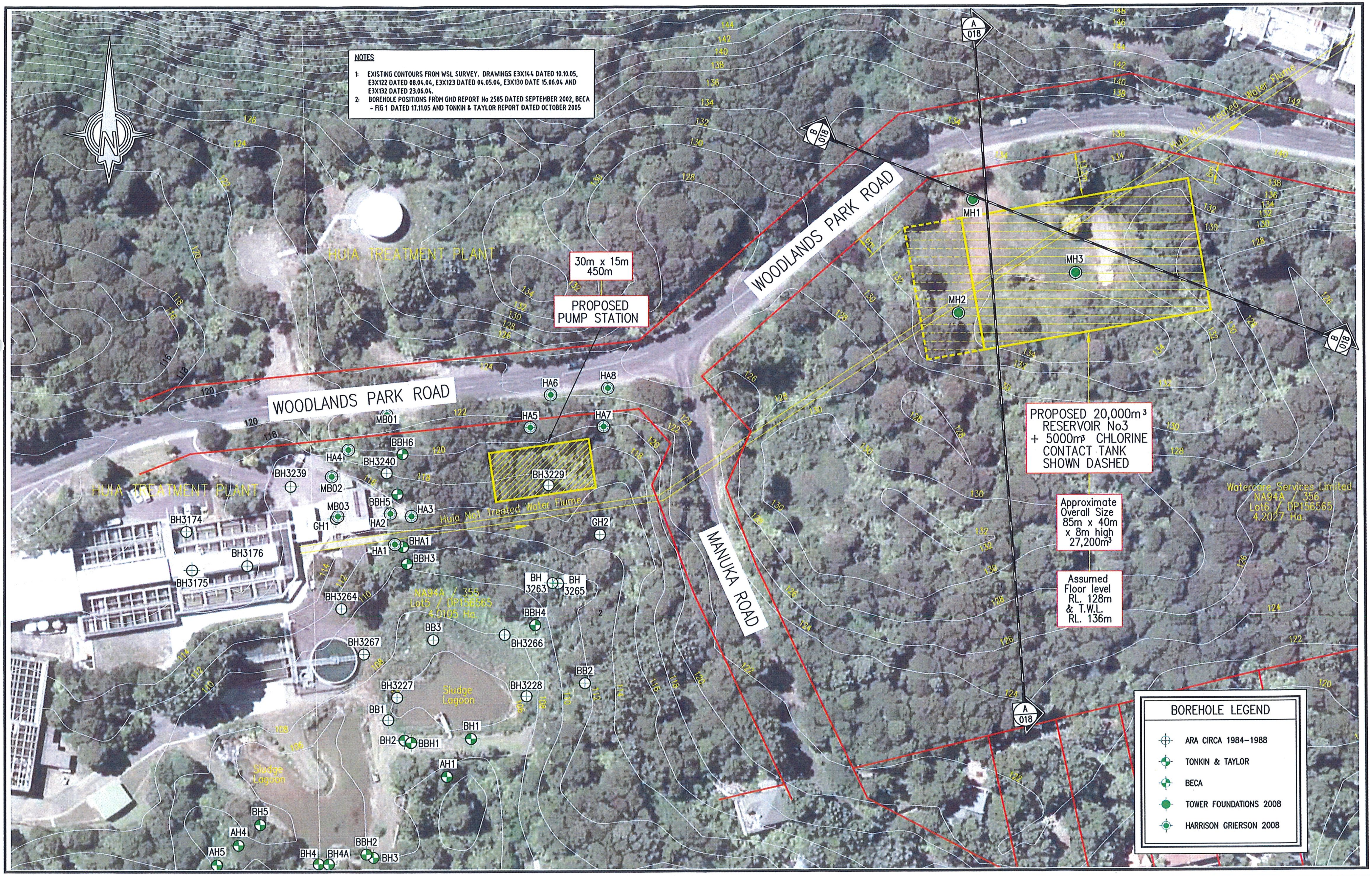
Watercare

HUIA WATER TREATMENT PLANT REPLACEMENT
TREATED WATER STORAGE RESERVOIR
RESERVOIR 1 & 2 AND VALVE CHAMBER LAYOUT – CUT FILL INFORMATION

DRAFT

CAD FILE 3255336-K119 | DATE 17-05-19
ORIGINAL SCALE A3 1:500 | CONTRACT No. –
REF No.
DWG No. 35255336.K119 | ISSUE OB

Appendix C: Geotechnical Plans



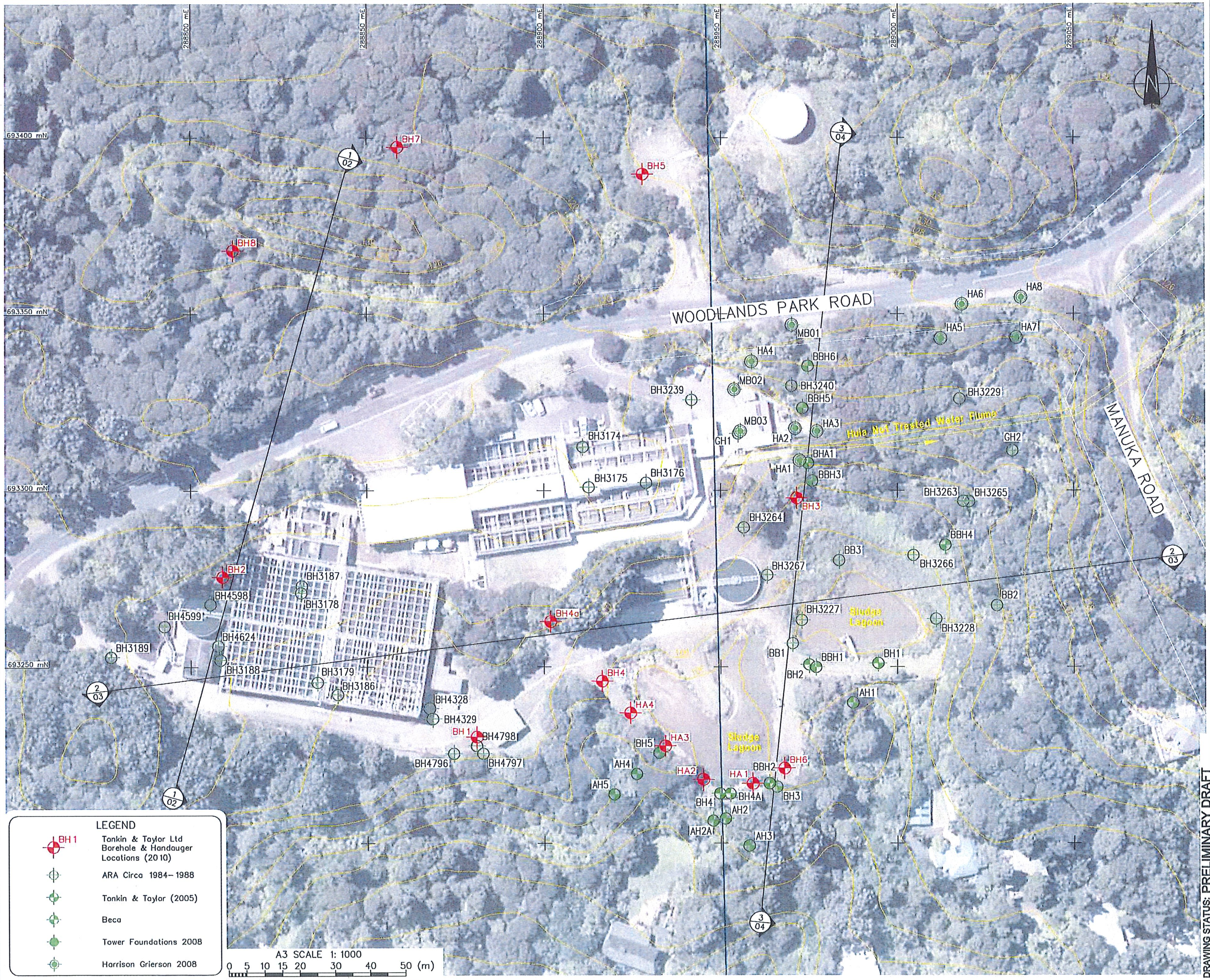
					DESIGNED	T.C.	7-08	
					DES. CHECKED	J.P.	7-08	
					DRAWN	G.B.	7-08	OPERATIONS
					DWG. CHECKED	I.M.	7-08	
					PROJECT LEADER	T.C.	7-08	
–	7:08	FOR CLIENT CONSIDERATION	G.B.	T.C.	AM APPROVED	A.S.	7-08	ASSET MANAGEMENT
ISSUE	DATE	AMENDMENT	BY	APPD.		BY	DATE	

watercare services limited

PROPOSED TITIRANGI RESERVOIR No3
RESERVOIR SITING – SCHEME 11
BOREHOLE LOCATION PLAN – SHEET 1

CAD FILE 2005523.017 DATE 9-09-08
ORIGINAL SCALE A1 1:500 (A1)
CONTRACT No. –
DRAWING No. 2005523 .017
ISSUE –

P:\27064\27064.001\WorkingMaterial\27064.001-01.dwg, 01, 15/07/2010 11:13:34 a.m., amm, 1:1



NOTES :

1. All dimensions are in metres unless noted otherwise.
2. Existing contours from WSL survey. Drawings E3X 144 dated 10.10.05, E3X 122 dated 08.04.04, E3X 123 dated 04.05.04, E3X 130 date 15.06.04 and E3X 132 dated 23.06.04.
3. Borehole positions from GHD report No. 2585 dated september 2002, BECA – Fig 1 dated 17.11.05 and Tonkin & Taylor Ltd report dated October 2005.

REVISION DESCRIPTION	BY	DATE
0 First Issue		
DESIGNED :	STMM	Jun. 10
DRAWN :	LJD	Jun. 10
DESIGN CHECKED :		
DRAFTING CHECKED :		
REFERENCE :		

CADFILE : \\27064.001-01.dwg

APPROVED : NOT FOR CONSTRUCTION

This drawing is not to be used for construction purposes unless signed as approved

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
Tel. (09) 355 6000 Fax. (09) 307 0265
www.tonkin.co.nz

WATERCARE SERVICES LTD

HUIA WATER TREATMENT PLANT INVESTIGATION PROPOSED INFRASTRUCTURE UPGRADE T&T 2010
Site Investigation Location Plan

DRAWING STATUS: PRELIMINARY DRAFT

SCALES (AT A3 SIZE) AS SHOWN

DWG. No. 27064.001-01

REV. 0

Manuka Road Reservoirs- Proposed Investigations

(Revision 2: CPT added at rectangular tank site, BH13/12 moved south)

Key

BH = Borehole (nominally 15 m deep, except BH 13/08 at 30 m)
CPT = Cone penetration test (to refusal)
TP = Trial pit (2 m to 4 m deep depending on requirements)

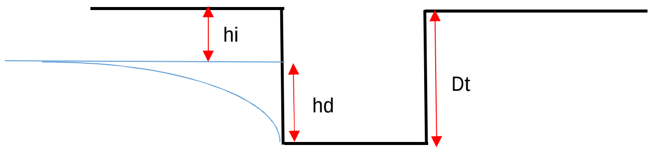
Note

All investigation sites approximate only- to be located on site by measurement. Test sites that are inaccessible (e.g. due to terrain or water) will be relocated nearby.

Opus Borehole Plan (2013)

Appendix D: Supporting Calculations

Calculation of effects of trenching on local groundwater system
Based on CIRIA Report 113 Control of GW for temporary works



North Face

Depth of excavation (Dt)	15	m
Depth to initial groundwater level (hi)	5	m
depth of water drawdown (hd)	10	
Permeability - Expected	2.00E-07	m/sec
Permeability - upper estimate	5.00E-06	m/sec

Radius of Influence (Ro) = 3000 x hd x k^0.5

Radius of Influence

Drawdown hd (m)	Ro k (m/s) expected	Ro k (m/s) Upper
10	13.4	67.1

South Face

Depth of excavation (Dt)	15	m
Depth to initial groundwater level (hi)	7	m
depth of water drawdown (hd)	8	
Permeability - Expected	2.00E-07	m/sec
Permeability - upper estimate	5.00E-06	m/sec

Radius of Influence (Ro) = 3000 x hd x k^0.5

Radius of Influence

Drawdown hd (m)	Ro k (m/s) expected	Ro k (m/s) Upper
8	10.7	53.7

Tunnel Shaft

Depth of excavation (Dt)	13	m
Depth to initial groundwater level (hi)	5	m
depth of water drawdown (hd)	8	
Permeability - Expected	2.00E-07	m/sec
Permeability - upper estimate	5.00E-06	m/sec

Radius of Influence (Ro) = 3000 x hd x k^0.5

Radius of Influence

Drawdown hd (m)	Ro k (m/s) expected	Ro k (m/s) Upper
8	10.7	53.7

West Face

Depth of excavation (Dt)	12	m
Depth to initial groundwater level (hi)	5	m
depth of water drawdown (hd)	7	
Permeability - Expected	2.00E-07	m/sec
Permeability - upper estimate	5.00E-06	m/sec

Radius of Influence (Ro) = 3000 x hd x k^0.5

Radius of Influence

Drawdown hd (m)	Ro k (m/s) expected	Ro k (m/s) Upper
7	9.4	47.0

East Face

Depth of excavation (Dt)	15	m
Depth to initial groundwater level (hi)	5	m
depth of water drawdown (hd)	10	
Permeability - Expected	2.00E-07	m/sec
Permeability - upper estimate	5.00E-06	m/sec

Radius of Influence (Ro) = 3000 x hd x k^0.5

Radius of Influence

Drawdown hd (m)	Ro k (m/s) expected	Ro k (m/s) Upper
10	13.4	67.1

Huia WTP Upgrade. Settlement due to groundwater drawdown

Reservoir 1 - Northern Wall

Excavation depth	15	m
Depth of groundwater	5	m
Groundwater drawdown	10	m
Surface settlement	53	mm

Layer	Depth	Depth	Geology	Initial Effective Unit Weight	Final Effective Unit Weight	Initial Effective Stress Base of Layer	Final Effective Stress Layer	Delta P	Ed	Settlement per layer	Settlement per layer	Cumulative Settlement
	m	m		kn/m3	kn/m3	kPa	kPa	kPa	kPa	m	mm	mm
1	0	1	Colluvium	18	18	18	18	0	7000	0.000	0	0.0
2	1	2	Colluvium	18	18	36	36	0	7000	0.000	0.0	0.0
3	2	3	Colluvium	18	18	54	54	0	7000	0.000	0.0	0.0
4	3	4	Colluvium	18	18	72	72	0	7000	0.000	0.0	0.0
5	4	5	Colluvium	18	18	90	90	0	7000	0.000	0.0	0.0
6	5	6	Colluvium	8	18	98	108	10	7000	0.001	1.4	1.4
7	6	7	Colluvium	8	18	106	126	20	7000	0.003	2.9	4.3
8	7	8	Colluvium	8	18	114	144	30	7000	0.004	4.3	8.6
9	8	9	Colluvium	8	18	122	162	40	7000	0.006	5.7	14.3
10	9	10	Colluvium	8	18	130	180	50	7000	0.007	7.1	21.4
11	10	11	CW-HW Cornwallis	10	20	140	200	60	30000	0.002	2.0	23.4
12	11	12	CW-HW Cornwallis	10	20	150	220	70	30000	0.002	2.3	25.8
13	12	13	CW-HW Cornwallis	10	20	160	240	80	30000	0.003	2.7	28.4
14	13	14	CW-HW Cornwallis	10	20	170	260	90	30000	0.003	3.0	31.4
15	14	15	CW-HW Cornwallis	10	20	180	280	100	30000	0.003	3.3	34.8
16	15	16	CW-HW Cornwallis	10	20	190	300	110	30000	0.004	3.7	38.4
17	16	17	CW-HW Cornwallis	10	10	200	310	110	30000	0.004	3.7	42.1
18	17	18	CW-HW Cornwallis	10	10	210	320	110	30000	0.004	3.7	45.8
19	18	19	CW-HW Cornwallis	10	10	220	330	110	30000	0.004	3.7	49.4
20	19	20	CW-HW Cornwallis	10	10	230	340	110	30000	0.004	3.7	53.1
			Rock									

Reservoir 1 - West Wall

Excavation depth	12	m
Depth of groundwater	5	m
Groundwater drawdown	7	m
Surface settlement	44	mm

Layer	Depth	Depth	Geology	Initial Effective Unit Weigh	Final Effective Unit Weight	Initial Effective Stress Base of Layer	Final Effective Stress Layer	Delta P	Ed	Settlement per layer	Settlement per layer	Cumulative Settlement
	m	m		kn/m3	kn/m3	kPa	kPa	kPa	kPa	m	mm	mm
1	0	1	Colluvium	18	18	18	18	0	7000	0.000	0	0.0
2	1	2	Colluvium	18	18	36	36	0	7000	0.000	0.0	0.0
3	2	3	Colluvium	18	18	54	54	0	7000	0.000	0.0	0.0
4	3	4	Colluvium	18	18	72	72	0	7000	0.000	0.0	0.0
5	4	5	Colluvium	18	18	90	90	0	7000	0.000	0.0	0.0
6	5	6	Colluvium	8	18	98	108	10	7000	0.001	1.4	1.4
7	6	7	Colluvium	8	18	106	126	20	7000	0.003	2.9	4.3
8	7	8	Colluvium	8	18	114	144	30	7000	0.004	4.3	8.6
9	8	9	Colluvium	8	18	122	162	40	7000	0.006	5.7	14.3
10	9	10	Colluvium	8	18	130	180	50	7000	0.007	7.1	21.4
11	10	11	CW-HW Cornwallis	10	20	140	200	60	30000	0.002	2.0	23.4
12	11	12	CW-HW Cornwallis	10	20	150	220	70	30000	0.002	2.3	25.8
13	12	13	CW-HW Cornwallis	10	10	160	230	70	30000	0.002	2.3	28.1
14	13	14	CW-HW Cornwallis	10	10	170	240	70	30000	0.002	2.3	30.4
15	14	15	CW-HW Cornwallis	10	10	180	250	70	30000	0.002	2.3	32.8
16	15	16	CW-HW Cornwallis	10	10	190	260	70	30000	0.002	2.3	35.1
17	16	17	CW-HW Cornwallis	10	10	200	270	70	30000	0.002	2.3	37.4
18	17	18	CW-HW Cornwallis	10	10	210	280	70	30000	0.002	2.3	39.8
19	18	19	CW-HW Cornwallis	10	10	220	290	70	30000	0.002	2.3	42.1
20	19	20	CW-HW Cornwallis	10	10	230	300	70	30000	0.002	2.3	44.4
			Rock									

Reservoir 1 - Southern Wall

Excavation depth	15	m
Depth of groundwater	7	m
Groundwater drawdown	8	m
Surface settlement	83	mm

Layer	Depth	Depth	Geology	Initial Effective Unit Weight	Final Effective Unit Weight	Initial Effective Stress Base of Layer	Final Effective Stress Layer	Delta P	Ed	Settlement per layer	Settlement per layer	Cumulative Settlement
	m	m		kn/m3	kn/m3	kPa	kPa	kPa	kPa	m	mm	mm
1	0	1	Colluvium	18	18	18	18	0	7000	0.000	0.0	0.0
2	1	2	Colluvium	18	18	36	36	0	7000	0.000	0.0	0.0
3	2	3	Colluvium	18	18	54	54	0	7000	0.000	0.0	0.0
4	3	4	Colluvium	18	18	72	72	0	7000	0.000	0.0	0.0
5	4	5	Colluvium	18	18	90	90	0	7000	0.000	0.0	0.0
6	5	6	Colluvium	18	18	108	108	0	7000	0.000	0.0	0.0
7	6	7	Colluvium	18	18	126	126	0	7000	0.000	0.0	0.0
8	7	8	Colluvium	8	18	134	144	10	7000	0.001	1.4	1.4
9	8	9	Colluvium	8	18	142	162	20	7000	0.003	2.9	4.3
10	9	10	Colluvium	8	18	150	180	30	7000	0.004	4.3	8.6
11	10	11	Colluvium	8	18	158	198	40	7000	0.006	5.7	14.3
12	11	12	Colluvium	8	18	166	216	50	7000	0.007	7.1	21.4
13	12	13	Colluvium	8	18	174	234	60	7000	0.009	8.6	30.0
14	13	14	Colluvium	8	18	182	252	70	7000	0.010	10.0	40.0
15	14	15	Colluvium	8	18	190	270	80	7000	0.011	11.4	51.4
16	15	16	CW-HW Cornwallis	10	10	200	280	80	30000	0.003	2.7	54.1
17	16	17	CW-HW Cornwallis	10	10	210	290	80	30000	0.003	2.7	56.8
18	17	18	CW-HW Cornwallis	10	10	220	300	80	30000	0.003	2.7	59.4
19	18	19	CW-HW Cornwallis	10	10	230	310	80	30000	0.003	2.7	62.1
20	19	20	CW-HW Cornwallis	10	10	240	320	80	30000	0.003	2.7	64.8
21	20	21	CW-HW Cornwallis	10	10	250	330	80	30000	0.003	2.7	67.4
22	21	22	CW-HW Cornwallis	10	10	260	340	80	30000	0.003	2.7	70.1
23	22	23	CW-HW Cornwallis	10	10	270	350	80	30000	0.003	2.7	72.8
24	23	24	CW-HW Cornwallis	10	10	280	360	80	30000	0.003	2.7	75.4
25	24	25	CW-HW Cornwallis	10	10	290	370	80	30000	0.003	2.7	78.1
26	25	26	CW-HW Cornwallis	10	10	300	380	80	30000	0.003	2.7	80.8
27	26	27	CW-HW Cornwallis	10	10	310	390	80	30000	0.003	2.7	83.4
			rock									

Reservoir 1 - East Wall

Excavation depth	15	m
Depth of groundwater	5	m
Groundwater drawdown	10	m
Surface settlement	66	mm

Layer	Depth	Depth	Geology	Initial Effective Unit Weigh	Final Effective Unit Weight	Initial Effective Stress Base of Layer	Final Effective Stress Layer	Delta P	Ed	Settlement per layer	Settlement per layer	Cumulative Settlement
	m	m		kn/m3	kn/m3	kPa	kPa	kPa	kPa	m	mm	mm
1	0	1	Colluvium	18	18	18	18	0	7000	0.000	0.0	0.0
2	1	2	Colluvium	18	18	36	36	0	7000	0.000	0.0	0.0
3	2	3	Colluvium	18	18	54	54	0	7000	0.000	0.0	0.0
4	3	4	Colluvium	18	18	72	72	0	7000	0.000	0.0	0.0
5	4	5	Colluvium	18	18	90	90	0	7000	0.000	0.0	0.0
6	5	6	Colluvium	8	18	98	108	10	7000	0.001	1.4	1.4
7	6	7	Colluvium	8	18	106	126	20	7000	0.003	2.9	4.3
8	7	8	Colluvium	8	18	114	144	30	7000	0.004	4.3	8.6
9	8	9	Colluvium	8	18	122	162	40	7000	0.006	5.7	14.3
10	9	10	Colluvium	8	18	130	180	50	7000	0.007	7.1	21.4
11	10	11	Colluvium	8	18	138	198	60	7000	0.009	8.6	30.0
12	11	12	Colluvium	8	18	146	216	70	7000	0.010	10.0	40.0
13	12	13	CW-HW Cornwallis	10	20	156	236	80	30000	0.003	2.7	42.7
14	13	14	CW-HW Cornwallis	10	20	166	256	90	30000	0.003	3.0	45.7
15	14	15	CW-HW Cornwallis	10	20	176	276	100	30000	0.003	3.3	49.0
16	15	16	CW-HW Cornwallis	10	10	186	286	100	30000	0.003	3.3	52.3
17	16	17	CW-HW Cornwallis	10	10	196	296	100	30000	0.003	3.3	55.7
18	17	18	CW-HW Cornwallis	10	10	206	306	100	30000	0.003	3.3	59.0
19	18	19	CW-HW Cornwallis	10	10	216	316	100	30000	0.003	3.3	62.3
20	19	20	CW-HW Cornwallis	10	10	226	326	100	30000	0.003	3.3	65.7
			Rock									

Woodlands Park Road

Depth of groundwater	9	m
Groundwater drawdown	7	m
Surface settlement	73	mm

Layer	Depth	Depth	Geology	Initial Effective Unit Weight	Final Effective Unit Weight	Initial Effective Stress Base of Layer	Final Effective Stress Layer	Delta P	Ed	Settlement per layer	Settlement per layer	Cumulative Settlement
	m	m		kn/m3	kn/m3	kPa	kPa	kPa	kPa	m	mm	mm
1	0	1	Colluvium	18	18	18	18	0	7000	0.000	0	0.0
2	1	2	Colluvium	18	18	36	36	0	7000	0.000	0.0	0.0
3	2	3	Colluvium	18	18	54	54	0	7000	0.000	0.0	0.0
4	3	4	Colluvium	18	18	72	72	0	7000	0.000	0.0	0.0
5	4	5	Colluvium	18	18	90	90	0	7000	0.000	0.0	0.0
6	5	6	Colluvium	18	18	108	108	0	7000	0.000	0.0	0.0
7	6	7	Colluvium	18	18	126	126	0	7000	0.000	0.0	0.0
8	7	8	Colluvium	18	18	144	144	0	7000	0.000	0.0	0.0
9	8	9	Colluvium	18	18	162	162	0	7000	0.000	0.0	0.0
10	9	10	Colluvium	8	18	170	180	10	7000	0.001	1.4	1.4
11	10	11	Colluvium	8	18	178	198	20	7000	0.003	2.9	4.3
12	11	12	Colluvium	8	18	186	216	30	7000	0.004	4.3	8.6
13	12	13	Colluvium	8	18	194	234	40	7000	0.006	5.7	14.3
14	13	14	Colluvium	8	18	202	252	50	7000	0.007	7.1	21.4
15	14	15	Colluvium	8	18	210	270	60	7000	0.009	8.6	30.0
16	15	16	Colluvium	8	18	218	288	70	7000	0.010	10.0	40.0
17	16	17	CW-HW Cornwallis	10	10	228	298	70	30000	0.002	2.3	42.3
18	17	18	CW-HW Cornwallis	10	10	238	308	70	30000	0.002	2.3	44.7
19	18	19	CW-HW Cornwallis	10	10	248	318	70	30000	0.002	2.3	47.0
20	19	20	CW-HW Cornwallis	10	10	258	328	70	30000	0.002	2.3	49.3
21	20	21	CW-HW Cornwallis	10	10	268	338	70	30000	0.002	2.3	51.7
22	21	22	CW-HW Cornwallis	10	10	278	348	70	30000	0.002	2.3	54.0
23	22	23	CW-HW Cornwallis	10	10	288	358	70	30000	0.002	2.3	56.3
24	23	24	CW-HW Cornwallis	10	10	298	368	70	30000	0.002	2.3	58.7
25	24	25	CW-HW Cornwallis	10	10	308	378	70	30000	0.002	2.3	61.0
26	25	26	CW-HW Cornwallis	10	10	318	388	70	30000	0.002	2.3	63.3
27	26	27	CW-HW Cornwallis	10	10	328	398	70	30000	0.002	2.3	65.7
28	27	28	CW-HW Cornwallis	10	10	338	408	70	30000	0.002	2.3	68.0
29	28	29	CW-HW Cornwallis	10	10	348	418	70	30000	0.002	2.3	70.3
30	29	30	CW-HW Cornwallis	10	10	358	428	70	30000	0.002	2.3	72.7
			Rock									

Tunnel Shaft

Excavation depth	13	m
Depth of groundwater	5	m
Groundwater drawdown	8	m
Surface settlement	91	mm

Layer	Depth	Depth	Geology	Initial Effective Unit Weigh	Final Effective Unit Weight	Initial Effective Stress Base of Layer	Final Effective Stress Layer	Delta P	Ed	Settlement per layer	Settlement per layer	Cumulative Settlement
	m	m		kn/m3	kn/m3	kPa	kPa	kPa	kPa	m	mm	mm
1	0	1	Colluvium	18	18	18	18	0	7000	0.000	0	0.0
2	1	2	Colluvium	18	18	36	36	0	7000	0.000	0.0	0.0
3	2	3	Colluvium	18	18	54	54	0	7000	0.000	0.0	0.0
4	3	4	Colluvium	18	18	72	72	0	7000	0.000	0.0	0.0
5	4	5	Colluvium	18	18	90	90	0	7000	0.000	0.0	0.0
6	5	6	Colluvium	8	18	98	108	10	7000	0.001	1.4	1.4
7	6	7	Colluvium	8	18	106	126	20	7000	0.003	2.9	4.3
8	7	8	Colluvium	8	18	114	144	30	7000	0.004	4.3	8.6
9	8	9	Colluvium	8	18	122	162	40	7000	0.006	5.7	14.3
10	9	10	Colluvium	8	18	130	180	50	7000	0.007	7.1	21.4
11	10	11	Colluvium	8	18	138	198	60	7000	0.009	8.6	30.0
12	11	12	CW-HW Cornwallis	10	18	148	216	68	30000	0.002	2.3	32.3
13	12	13	CW-HW Cornwallis	10	18	158	234	76	30000	0.003	2.5	34.8
14	13	14	CW-HW Cornwallis	10	10	168	244	76	30000	0.003	2.5	37.3
15	14	15	CW-HW Cornwallis	10	10	178	254	76	30000	0.003	2.5	39.9
16	15	16	CW-HW Cornwallis	10	10	188	264	76	30000	0.003	2.5	42.4
17	16	17	CW-HW Cornwallis	10	10	198	274	76	30000	0.003	2.5	44.9
18	17	18	CW-HW Cornwallis	10	10	208	284	76	30000	0.003	2.5	47.5
19	18	19	CW-HW Cornwallis	10	10	218	294	76	30000	0.003	2.5	50.0
20	19	20	CW-HW Cornwallis	10	10	228	304	76	30000	0.003	2.5	52.5
20	20	21	CW-HW Cornwallis	10	10	238	314	76	30000	0.003	2.5	55.1
21	21	22	CW-HW Cornwallis	10	10	248	324	76	30000	0.003	2.5	57.6
21	22	23	CW-HW Cornwallis	10	10	258	334	76	30000	0.003	2.5	60.1
22	23	24	CW-HW Cornwallis	10	10	268	344	76	30000	0.003	2.5	62.7
22	24	25	CW-HW Cornwallis	10	10	278	354	76	30000	0.003	2.5	65.2
23	25	26	CW-HW Cornwallis	10	10	288	364	76	30000	0.003	2.5	67.7
23	26	27	CW-HW Cornwallis	10	10	298	374	76	30000	0.003	2.5	70.3
24	27	28	CW-HW Cornwallis	10	10	308	384	76	30000	0.003	2.5	72.8
24	28	29	CW-HW Cornwallis	10	10	318	394	76	30000	0.003	2.5	75.3
25	29	30	CW-HW Cornwallis	10	10	328	404	76	30000	0.003	2.5	77.9
25	30	31	CW-HW Cornwallis	10	10	338	414	76	30000	0.003	2.5	80.4
26	31	32	CW-HW Cornwallis	10	10	348	424	76	30000	0.003	2.5	82.9
26	32	33	CW-HW Cornwallis	10	10	358	434	76	30000	0.003	2.5	85.5
27	33	34	CW-HW Cornwallis	10	10	368	444	76	30000	0.003	2.5	88.0
27	34	35	CW-HW Cornwallis	10	10	378	454	76	30000	0.003	2.5	90.5
			Rock									

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