Arawhata Wetland –

Conceptual Design Report

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Horizons Regional Council

Arawhata Wetland

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Contents

Executive Summary

Jacobs New Zealand Limited (Jacobs) were engaged by Horizons Regional Council (HRC) to develop conceptual designs for water quality treatment wetlands in the Arawhata Catchment, west of Levin. The Arawhata catchment drains to Lake Horowhenua and has poor water quality, with some of the highest nutrient concentrations recorded in surface water in New Zealand and high sediment loads during storm events.

HRC want to improve the water quality discharging to the lake from the Arawhata, and this project explores the efficacy of wetland treatment in the catchment as one of the options to improve lake quality, although the changes to lake quality as a result of the catchment mitigations are not covered by this report. This work will inform the wider project for the Ministry for the Environment Jobs for Nature programme - Mahi mo te Taiao. Alongside this report is a similar report by Tonkin & Taylor (Ferguson, 2020) exploring options water quality improvements within the wider drainage network.

Conceptual designs have been developed for wetlands across three adjacent areas of land in the catchment. These areas are the Kane Farm, two blocks of the Woodhaven Gardens property and the Hokio Beach Road Sediment trap. Kane Farm, the largest area covers approximately 70 ha and is currently an operational dairy farm. The Farm is located within the boundary of the historic Arawhata Swamp. Restoring this historic wetland is one of the goals of this project.

There is a strong focus in the conceptual designs around the treatment of groundwater. This is because historical monitoring has shown that the nutrient load in the Arawhata catchment is predominantly transported in groundwater, much of which emerges in the Arawhata Drain.

Using Jacobs internal wetland modelling tools, the efficacy of the conceptual wetland design options to treat water to a quality better than the current lake quality has been demonstrated. The designs presented are modular and do not all need to be built together. They provide options to increasing treatment capacity and quality as time and project funds allow. The options are:

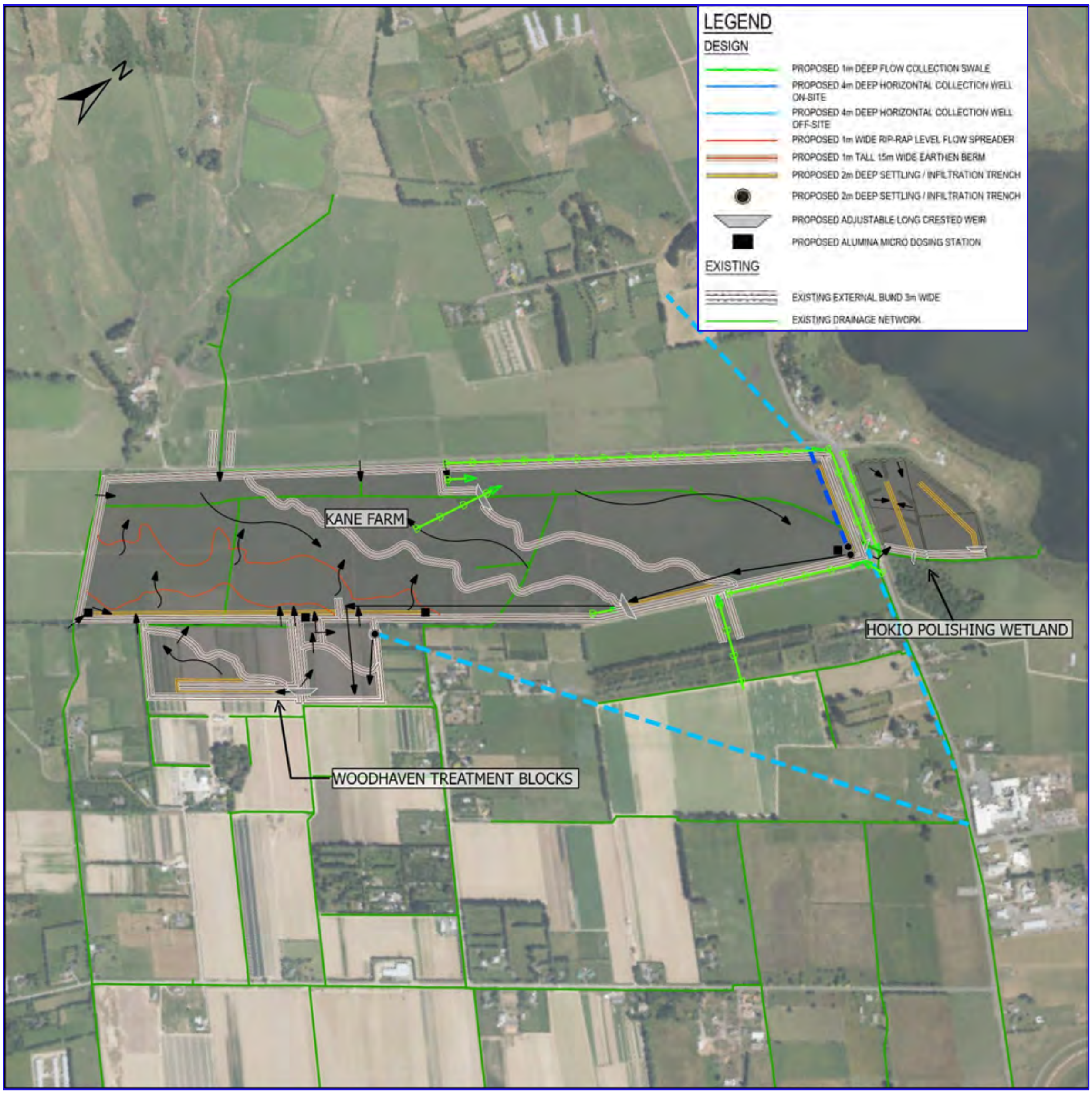
- **Kane Farm Wetlands**. This is the base case, and the other options would be in addition to this. The main wetland would cover approximately 70 ha of the existing Farm. Water entering the wetland from the drainage network flows through deep settling basins. There are 5 cells of wetlands surrounded by 1.5 m high bunds that follow the natural contours of the ground, minimising the need for excavation and replicating as much as possible the historic wetland form. The first two cells would be forested swamp wetlands dominated by kahikatea, pukatea and other swamp forest species. The next cells would contain emergent wetland species (sedges, rushes, raupo etc.) increasing in depth before discharging to the Hokio Polishing Wetlands.

- **Hokio Polishing Wetlands**. These are constructed in place of the existing sediment trap which would be redundant as the Arawhata Drain is removed in all scenarios. This cell would provide additional groundwater recharge of fully treated water near the lake and would discharge surface flow into the bottom of the Arawhata Drain then into the lake.

- **Woodhaven Treatment Blocks (WTB)**. These blocks occupy the highest elevation area and provide a higher level of treatment to the three main drains flowing through the Arawhata catchment and in Option 2, to groundwater drawn from withing the catchment. These cells could also be located on similar elevation land either within, or south of, the Kane Farm Wetlands:

    - In WTB Option 1, which is primarily natural treatment, the WTB area is occupied by initial 2 m deep settling basins in a serpentine covering 0.5 ha followed by a 4 ha Biochemical Reactor (BCR). About half of the WTB site is Undulating Kahikatea Forested Wet Meadow Overland Flow.

    - WTB Option 2 adds in an extra capacity to treat groundwater via an additional BCR. It also incorporates a pump station to recycle groundwater through the wetland and also three alumina micro-dose injection stations, one to each of the main drain before they enter Kane Farm.



A large increase in treatment performance is provided in Option 2 by adding a 4 m deep horizontal well that spans the Arawhata catchment in a west to east transect and draws groundwater to a lift pump station at the WTB. The groundwater is low in turbidity and high in nutrients, which is ideal for treatment in a BCR. This configuration could remove up to 90 percent of the total nitrogen in the groundwater on a very small footprint plus remove most of the metals and organic compounds. The modelling has demonstrated that the wetlands can provide a significant water quality treatment capacity based on the average flow conditions observed at Hokio Beach Rd to date:

- For the average influent constituent concentrations of NO2-NO3-N, with drain flow only the wetlands model runs showed mass reduction of 90% mass for the 87.5 ha combined farm sites.

- The addition of recirculated water flow to the drain water volume resulted in a mass reduction of the NO2-NO3-N of 68% for the combined 87.5 ha area

- For the drain water only on the 87.5 ha site, the total nitrogen mass was reduced from a load of 2.2 kg/ha/day in to the mass load out of 0.2 kg/ha/day, while the same area wetlands with drain flow plus recirculated groundwater water reduced the total mass in from 4.4 kg/ha/day to 1.4 kg/ha/day mass load out.

- For the 87.5 ha site wetlands with only drain water, phosphorus mass reduction was 78% without alumina and 93% to 96% with Alumina addition.

- Adding recirculated groundwater flow to the drainwater flow on the 87.5 ha site wetlands, phosphorus mass reduction was 47% without alumina and 78% to 92% with Alumina addition.

The treatment wetlands are designed for maximum performance for the current average flow rate in all drains. The 10 year 24-hour storm event can be treated in the wetlands with the normal flow path. The 10 year 24-hr storm would be contained within the within the perimeter berms but would overtop the interior berms at the internal spillways next to each weir. Further hydraulic assessment is required to ascertain the maximum design event.

High level cost estimates for the wetlands have been prepared and provide a useful indication of project capital costs. The costs presented in the table below. Please refer to Section 9 for costing exclusions and assumptions.

Preliminary Cost Estimates (NZD, rounded to nearest thousand)

Option	Cost Estimate (NZD)	-15% (NZD)	+50% (NZD)
Kane Farm Wetlands	$6,047,000	$5,140,000	$9,071,000
Hokio Polishing Cells	$242,000	$206,000	$364,000
Woodhaven Treatment Wetland Option 1	$3,357,000	$2,853,000	$5,036,000
Woodhaven Treatment Wetland Option 2 (incl. groundwater diversion)	$3,226,000	$2,743,000	$4,840,000

In summary, this exercise has demonstrated that the concept of large-scale natural wetland treatment system in the Arawhata catchment has real merit. The wetlands would significantly reduce nutrient and sediment loads into Lake Horowhenua with minimal impact on land use within the catchment. Additionally, the restoration of the Arawhata Swamp Wetland would likely provide significant environmental and ecological benefit to the area.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to develop a conceptual wetland design in accordance with the scope of services set out in the contract between Jacobs and Horizons Regional Council ('the Client'). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate, or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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1. Introduction

1.1 Background

The Arawhata Wetland Project is a concept to construct engineered treatment wetlands and to restore drained natural wetlands in the Arawhata catchment of Lake Horowhenua, south of Levin as shown below on Figure 1-1. Horizons Regional Council (HRC) has engaged Jacobs New Zealand Limited (Jacobs) to develop the conceptual design and a preliminary cost estimate for the project.

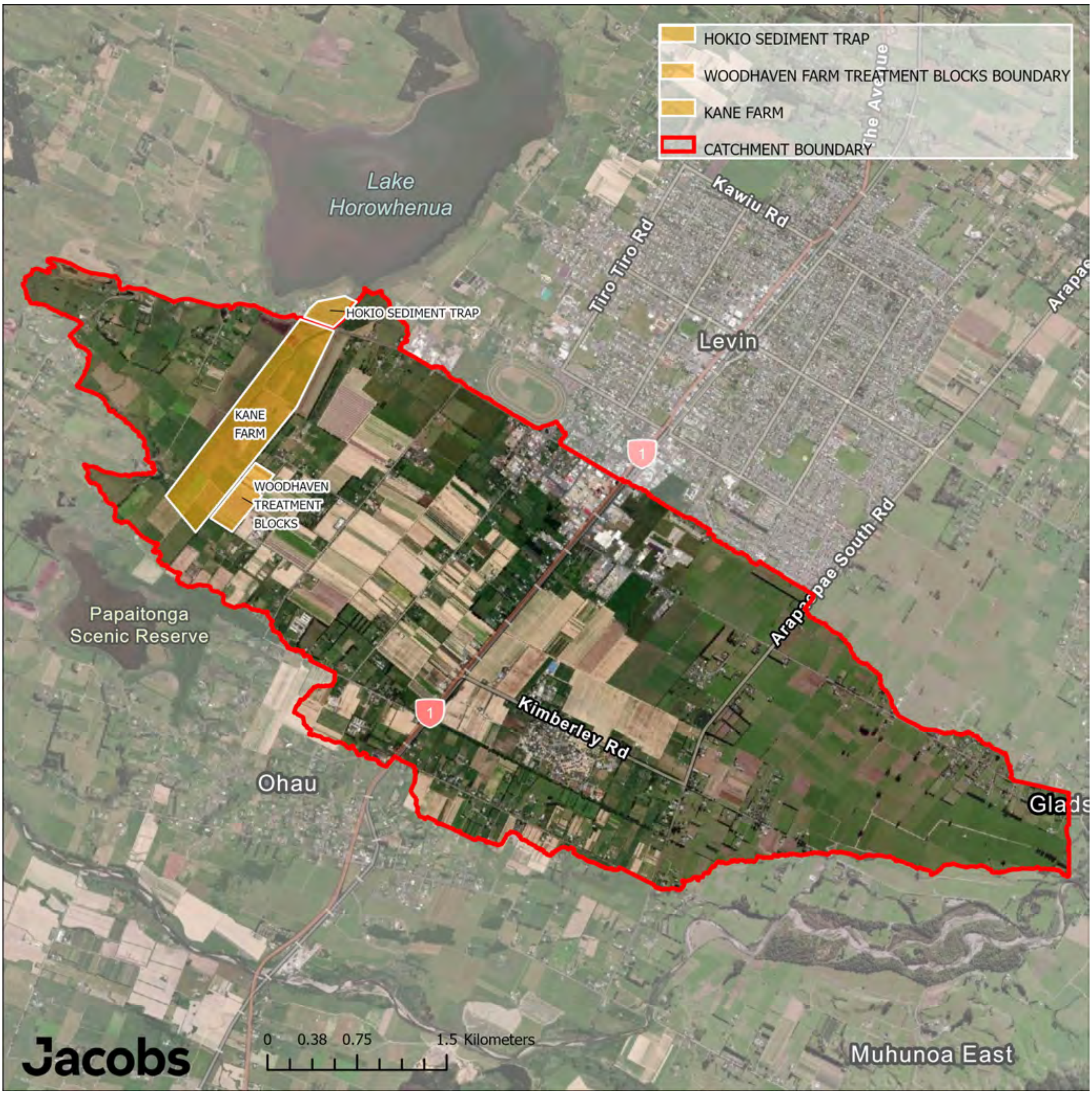

Figure 1-1: Arawhata catchment location

The Arawhata catchment has long been identified as a major contributor of nutrients and sediment that degrade water quality in Lake Horowhenua. The intensive horticulture and agriculture in the catchment has very high economic value to the local area, however, to maintain maximum production the nutrient inputs are relatively high. Runoff from this area can be treated by each individual contributor but the cost is much greater than a consolidated regional water treatment facility.

The Arawhata main drain flows across the bottom of the catchment though an area that was historically natural wetland surrounded by natural riparian forests and wetland forests. This report presents the capacity of water treatment that is possible with the restoration of the Arawhata wetlands plus options to add greater engineering control for greater water treatment efficiency.

1.2 Scope

The scope of work for this project was outlined in the Jacobs proposal dated 18 May 2020. The overall scope was to provide Horizons Regional Council (and other key stakeholders) with a document that presents treatment options (conceptual) for the Arawhata Catchment that can be used to inform a detailed design process.

Three areas of land were put forward by HRC for consideration in the conceptual design – Kane Farm, the Arawhata Sediment Trap and two Blocks of land owned by Woodhaven Farms. The focus, and largest area of land, is the Kane Farm.

In addition, a preliminary cost estimate (capital works only) is presented and is intended to be used to inform future project funding discussions.

Lastly, a preliminary planning assessment is presented to provide an overview of the likely regulatory requirements triggered by the conceptual design presented in this report.

1.3 Project Goals

Preliminary project goals were initially presented in the Jacobs proposal document and have been used to inform the conceptual design are as follows. The preliminary project goals are:

- To restore the Arawhata wetlands to near historic conditions for natural water quality enhancement and habitat;
- To design a cost-effective wetland enhancement system that maximises nutrient and sediment removal from surface water drains;
- To design an enhanced engineered natural treatment system that could be added to the restored wetlands to provide greater control over variables that remove nutrients; and
- To intercept and treat shallow groundwater that contains a large portion of the total nutrient load that would otherwise move under the wetlands and into the lake.

1.4 Water Quality Improvement Requirements

The conceptual design process estimates what water quality improvements could be obtained by developing wetlands on the identified blocks of land, rather than designing wetlands to meet an overall water quality objective. The primary requirements for the system design include the following:

- To improve the quality of surface water in the Arawhata drainage to a level better than the lake water quality before it discharges to the lake;
- To improve the quality of shallow groundwater flowing downgradient of the agricultural area to a level better than the lake water quality before this groundwater reaches the lake; and
- To minimise O&M requirements of the wetlands.

Specific water quality improvement targets and wetland discharge limits are not expected to be required and do not form part of the design objectives; that is, no water quality limits have been set. However, the current hydraulic and constituent loading has been entered into the Jacobs Wetlands Treatment Model to determine calculated anticipated outflow concentrations.

2. Conceptual Design Overview

This report presents a conceptual design and preliminary cost estimate for two treatment options for wetland development across the Kane Farm, Woodhaven Treatment Blocks, and HRC sediment trap land.

The design intent of the wetlands is to maximise water quality improvement while maintaining the natural beauty and habitat values of wetlands. This report presents two options:

1. Passive wetlands. This approach optimises land use to minimise pumping, matching the topography with natural wetlands, overland flow forested wet meadows, and deep settling fens. This approach mimics nature in layout and shapes (and historic form) with components linked together with natural channels to control flow for optimised treatment.

2. Engineered wetlands. Engineered wetlands provide much higher levels of treatment on the same footprint as the passive wetlands. The appearance should be as "natural" as passive wetlands. This increased capacity is provided by increased groundwater capture and recirculation, small biochemical reactors using woodchips and grass hay, and geochemical augmentation with alumina micro-dosing to bind phosphorus to surface soils.

The two approaches are complementary. If passive wetlands provide enough sediment and nutrient removal, then the lower cost passive approach is likely the best path forward. The much greater treatment power of the engineered wetland is really an intensification of the passive wetland. Thus, the passive approach informs the engineered approach. The engineered wetlands components can be sized to remove nearly all the available nutrients but should be most cost effective if the land available is occupied by an optimal combination of passive and engineered wetlands systems.

The engineered approach removes nutrients directly from shallow groundwater via a pumping system. The engineered natural treatment systems have an optimal design nutrient removal rate that is not used to the fullest benefit treating surface water during periods of low flow or reduced nutrient loadings. These systems have excess capacity for surface water treatment during much of the year that can be utilised for recycling contaminated shallow groundwater at a variable rate to run the engineered treatment systems at optimal capacity continuously. A low head pumping station is required to lift water to the engineered treatment cells, but the balance of the flow is by gravity. Treated groundwater can be routed through restored wetlands to match any desired hydrological regime and can mimic historical natural wetlands hydrology. This has the benefit of keeping the wetlands operating at optimal flows.

A wetland park can be a valuable local and regional recreational and educational asset. Both options for development include berm tops that can be used for trails through the wetland complex. Additional features that are not included in the estimates of cost but could be added include information kiosks, boardwalks, boat/kayak/canoe launches, and an educational centre. A bike path linking along the lake front and to nearby Donnelly Park in Levin would increase access to the wetland trails and could utilise existing parking at Donnelly Park.

Every treatment wetland, however passive, requires modelling of key parameters, hydraulics, and hydrology. The Jacobs design models were used, drawing upon firmwide experience for each approach. Turbidity, suspended solids, phosphorus, and nitrogen concentration reduction predictions are provided in the treatment basis of design. Water quality data readily available for other nutrients, pesticides, metals, and other contaminants of concern are modelled to indicate potential for additional water quality improvement if they are present or if urban stormwater is diverted through the wetlands.

Conceptual sizing of the passive approach relies on gravity flow and watershed models for hydraulic design. There is ample natural fall across the catchment as shown in Figure 2-1. The engineered wetlands use low-head, high-flow pumps for recirculation of water to accelerate nitrogen removal and to transfer groundwater from a horizontal collection well at the down-gradient end of the watershed to a higher location for treatment in the wetland. Both design options are assumed to use the existing drainage system around the perimeter of the wetlands and upgradient to the greatest extent possible. The proposed wetlands footprint has seepage interceptor ditches outside the perimeter berms in the lower areas to minimise impact to adjacent farmland. The deep main drain that follows the bottom of the valley would cause a short circuit to the flow through the wetland cells and in our modelling has been considered to be removed (abandoned and filled). The flow capacity of the proposed wide shallow wetlands is many times greater than the main drain.

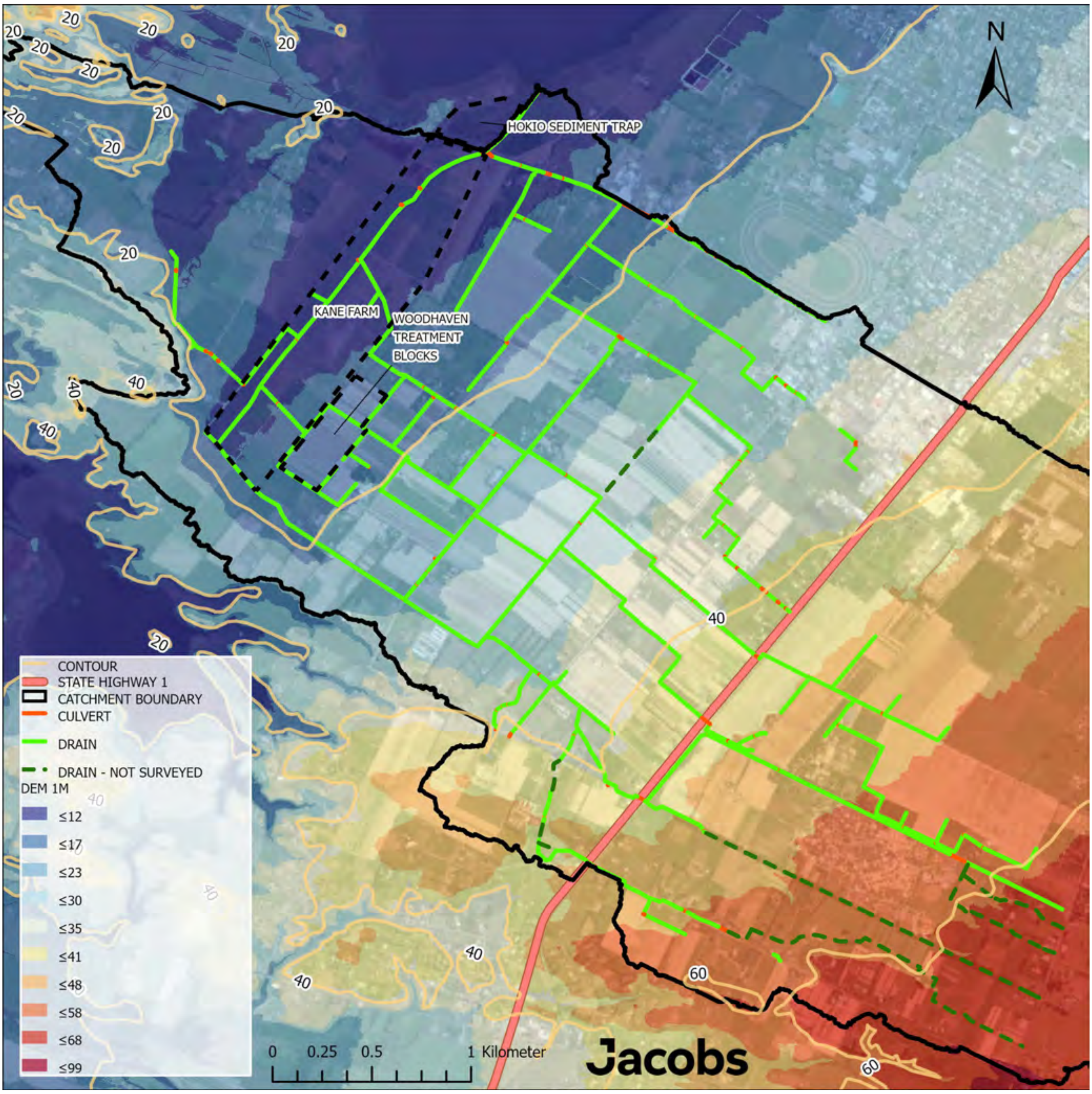

Figure 2-1: Site topography

Approximately half of the nutrient load from the Arawhata catchment is carried in groundwater. Therefore, both design options include a groundwater interceptor drain four metres (m) deep parallel to the Hokio Beach Road near the lowest portion of the watershed. If the drain can be extended outside the wetland's footprint on both sides, it could capture a large portion of the groundwater flow near the lake.

In the engineered system, extraction of regional groundwater flow from south to north is also included for discharge into wetlands for treatment. The groundwater flow is low in turbidity and organic particles and high in nitrogen, which makes it an ideal water source for treatment in a biochemical reactor (BCR). The engineered system BCR includes a cell filled with organic media to add carbon to the groundwater for nitrogen treatment like a wood chip trench but with much greater capacity and treatment efficiency. Water discharging the organic media cell passes through an aeration cell for oxygen addition and then through a subsurface flow rock media bed to complete the nitrogen treatment. Water exiting the BCR should have 90 percent of total nitrogen removed before discharge to the wetlands for final treatment.

The upper area of the Kane Farm wetlands would be forested overland flow wet meadows for sediment deposition and nutrient reduction. This higher elevation area of the site would have a high rate of infiltration with near surface soil treatment and further nutrient removal. Jacobs' experience with groundwater seepage wetlands demonstrates that wetland soils have a very high capacity to remove nitrate and other contaminants. Extraction of wetland seepage and recirculation back into the wetland is accomplished by the groundwater extraction horizontal well parallel to Hokio Beach road. Geochemical augmentation of wetland waters and soils is used to provide permanent phosphorus removal. Alumina micro-dosing stations are recommended at the upper end of the Kane Farm wetlands to chemically bond phosphorus without forming a flock or sludge. The alumina addition would enhance sediment removal early in the wetlands to allow most of the wetlands volume to contain relatively clear water. Concentrating the sediment deposit in the upper forested wetlands is a benefit where topographic undulation caused by sediment deposits creates diversity in vegetation and micro-niches of biological treatment processes.

The Jacobs wetland and natural treatment systems modelling tool and cost estimating database was used to bring in actual performance data and construction and operations costs from dozens of other projects with an adjustment to local conditions. The estimated conceptual costs for the two options were developed. An initial high-level evaluation of ongoing operation and maintenance (O&M) requirements is also presented.

3. Design Criteria

The following section presents the design criteria used to develop the design concept and details of the enhanced wetland system and associated groundwater treatment. The detailed hydrological assessment that supports the information presented in this section is provided in Appendix A.

3.1 Surface Drain Flow Rate

The derived flow of the Arawhata catchment is based on flow record from the HRC flow site located at Hokio Beach Road. Data from the site were provided to Jacobs in excel format on 13 August 2020.

Due to the high rate of infiltration and evaporation during part of the year over the large footprint of the wetlands, the actual wetlands discharge may vary from the drain gauging data. The shallow groundwater would be intercepted and treated at a variable rate during the year to optimise the treatment capacity of the wetlands and to meet the hydrologic needs of the forested wetlands and free water surface wetlands, which changes seasonally. All surface water flow up to the 2 yr 24 hr storm flow are treated. Groundwater could be treated at a rate that when combined with surface flow equals the hydrological requirements of a thriving wetland. Alternatively, the groundwater flow that is treated could be the difference between the surface water flow and the maximum flow that can be optimally treated in the wetland system. This alternative to maximise treatment is the alternative presented for both of the Options analysed.

Table 3-1 shows the peak flows for different rainfall events in each sub-catchment and at Hokio Beach Road Outlet locations (see

Figure 3-1) obtained from the Arawhata Wetland hydrological model (Appendix A). The rainfall data used to obtain the peak flows was extracted from NIWA High Intensity Rainfall Design System (HIRDS) V4 for the 100-year, the 10-year, and the 2-year Annual Recurrence Interval (ARI). The temporal design storm methodology

(NIWA, HIRDS V4, August 2018) was applied to obtain the input cumulative hyetographs for different storm durations to obtain the critical storm duration for each rainfall event and for each sub-catchment.

The 10-year ARI peak flows are used for sizing of conveyance and bypass structures. In the event of a flood, the wetland is designed to cope with high flows without experiencing significant structural damage. The 2-year ARI peak flow is used for sizing of the normal base flow conveyance facilities. It indicates the maximum surface water flow that the engineered wetland is designed to treat. The historical mean monthly flows have been used to determine an appropriate range of surface flows that the wetland treatment has been optimised for.

Table 3-2 and Table 3-3 show, respectively, the average monthly flows and the minimum flow at Hokio Beach Road. These numbers were obtained from monitored flows from August 2017 to June 2020. The short period of data collection means that the mean monthly flows are not reliable and may change with a longer period of data collection.

Table 3-1: Modelled design peak flows (m^3/s) in each drain for different scenarios for the critical duration. ARI = Annual Recurrence Interval.

Rainfall Event	Sub-catchment 1 Peak Flow (m^3/s)	Sub-catchment 2 Peak Flow (m^3/s)	Sub-catchment 3 Peak Flow (m^3/s)	Sub-catchment 4 Peak Flow (m^3/s)	Hokio Beach Road Peak Flow (m^3/s)
100-year ARI	9.25	9.28	4.99	2.35	21.50
10-year ARI	0.7	0.69	0.39	0.10	1.63
2-year ARI	0.25	0.44	0.23	0.13	1.10

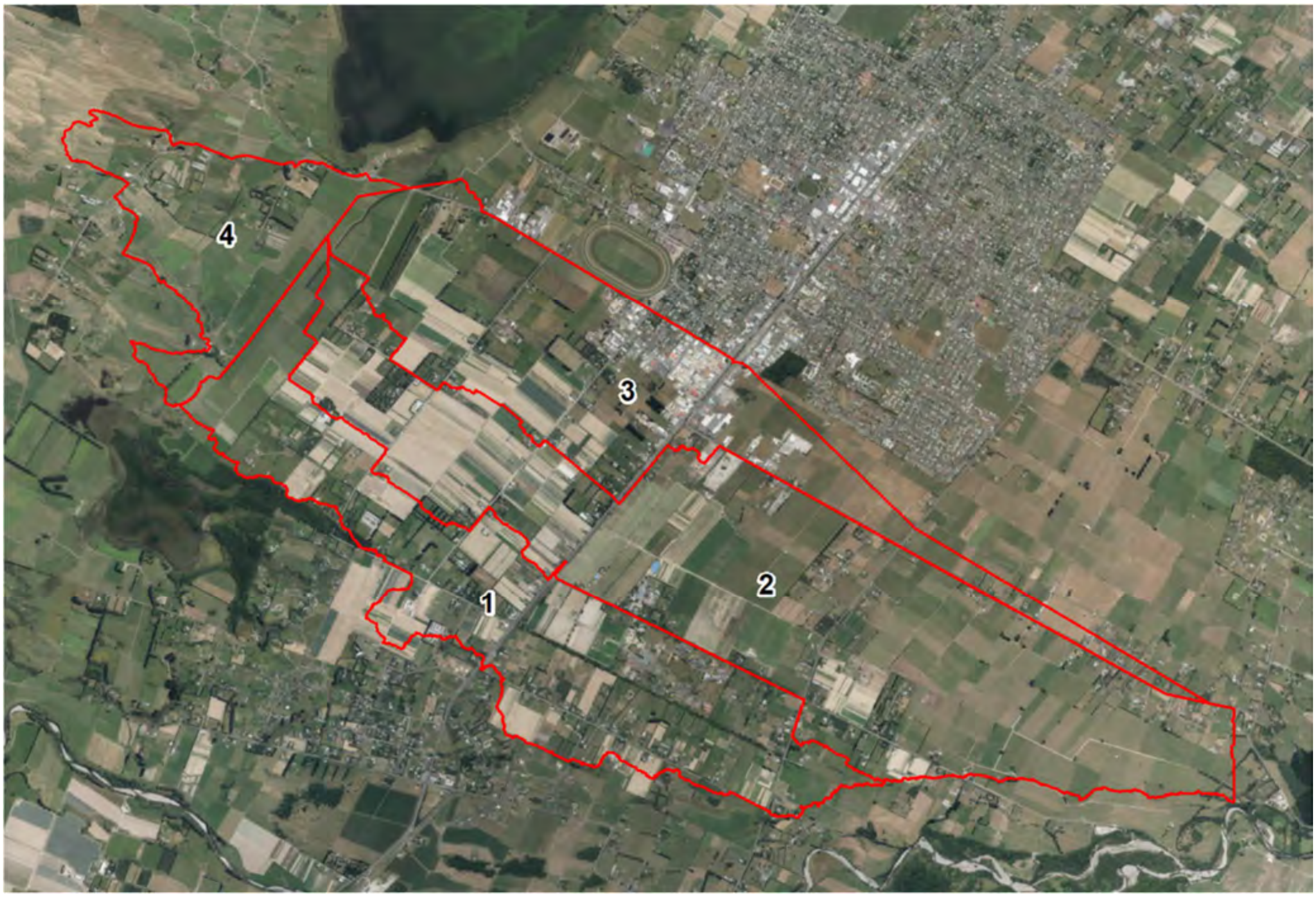

Figure 3-1: Sub-catchment boundaries for hydrological assessment.

Table 3-2: Historical monthly mean flows (m3/s) between August 2017 and June 2020 at Arawhata Drain at Hokio Beach Road. NA = Not Available.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2017	NA	NA	NA	NA	NA	NA	NA	0.51	0.40	0.31	0.20	0.14
2018	0.09	0.11	0.13	0.17	0.19	0.22	0.39	0.37	0.28	0.20	0.19	0.16
2019	0.14	0.12	0.11	0.13	0.15	0.23	0.31	0.48	NA	0.23	0.25	0.25
2020	0.18	0.14	0.12	0.12	0.14	0.19	NA	NA	NA	NA	NA	NA
Mean	0.14	0.12	0.12	0.14	0.16	0.21	0.35	0.45	0.34	0.25	0.21	0.18

Table 3-3: Minimum historical flow (m^3/s) between August 2017 and June 2020 at Arawhata at Hokio Beach Road.

Location	Minimum Flow (m^3/s)
Hokio Beach Road	0.047

3.2 Groundwater Inflow Rate

Groundwater flow into the wetland area was estimated using a baseflow separation approach that is detailed in Appendix A. Whilst not a hydrogeological modelling approach, the Arawhata catchment is quite unique in that all surface water and a significant component of shallow ground flow appear to emerge into the Arawhata Drain. For the purposes of this report it has been assumed that the baseflow component of the Arawhata Drain is the shallow groundwater component that requires treatment.

This method of groundwater flow estimating is appropriate for a concept level design only and a more accurate groundwater flow model is required for final design. Under these conditions, the model calculates a groundwater baseflow into the drain of 200 L/s, or 17,280 m3/day.

The groundwater interception horizontal drain wells predicted inflow rates and capture efficiencies were applied to the overall hydrological budget for the wetland system. Option 1 has a single horizontal drain well parallel to Hokio Beach Road that should capture 30 percent of the Arawhata catchment shallow groundwater if it only transects the site under the wetland footprint. The capture rate is predicted to increase to 40 percent if the horizontal drain well is extended beyond the wetland site footprint to approximately double its length. Option 2 adds a second horizontal drain well that is outside the wetlands footprint and runs east to west from Hokio Beach Road to the Woodhaven Treatment Blocks property. This horizontal drain well is predicted to capture an additional 40 percent of the groundwater flow that ultimately flows from the Arawhata watershed to the Lake. A maximum of 80% of the shallow groundwater that flows under the Arawhata watershed could be captured and treated in the Option 2 wetland design.

3.3 Wetland Inflow Water Quality

The Assessment of Opportunities to Address Water Quality Issues in Lake Horowhenua (Gibbs, 2011) states that the Arawhata stream contributes about 50 percent of the total external surface water nitrogen load to the lake at approximately 50 tons/year. Water quality data were reviewed and selected as the range of water quality that is expected to flow into the wetland system.

Only limited water quality data are available for the drains that contribute to the main Arawhata Drain. Most of this data comes from a single sampling event completed by Horizons on 13 August 2019. These data showed that nitrate-nitrogen ranged from 0.17 to 11.9 mg/L and ammoniacal nitrogen ranged from 0.001 to 0.38 mg/L. The median results were 1.7 and 0.03 mg/L respectively.

Table 3-4 presents the range of water quality for select parameters used to design the system. These results were all from the Hokio Beach Road site. Groundwater contributes approximately an equal amount of nitrogen as surface water. Phosphorus and sediment in surface water are greater than in groundwater and are contributed primarily by the main drain.

Table 3-4: Historical Surface Water Quality Data at Hokio Beach Road (1998 – 2019)

Parameter	Concentration Range		Units
	Low	High	
Ammoniacal Nitrogen	0.001	0.303	mg/L
Dissolved Organic Carbon	0.9	10.0	mg/L
Dissolved Reactive Phosphorus	0.005	0.229	mg/L
Nitrate	1.7	18.6	mg/L
Nitrite	0.002	0.162	mg/L
Total Nitrogen	3.56	20.0	mg/L
Total Oxidised nitrogen	0.045	16.633	mg/L

Parameter	Concentration Range Low	High	Units
Total Kjeldahl nitrogen	0.6	27.4	mg/L
Total Phosphorus	0.015	2.91	mg/L
Total Suspended Solids	0.0	3920	mg/L
Turbidity	0.055	2880	NTU

mg/L = milligram per litre.

The Arawhata Drain has high E.coli counts with a 5-year median of 680 n/100ml according to the LAWA website. Faecal source tracing has not occurred in the catchment so the source of this bacteria is unknown, however the Kane Farm is a operational Dairy farm and is likely to contribute to this count. Other contributors would be avian sources and potentially septic tanks. E.coli treatment is not considered in the wetland design. As the current source of E.coli is unknown, predicting what will happen to bacteria counts if the wetland is developed is difficult and uncertain. However there is a potential that with increased birdlife in and around the proposed wetland, avian sourced E.coli counts count increase.

3.4 Wetland Discharge Quality

No discharge water quality criteria are proposed for the wetland system. However, the wetland system was modelled using Jacobs wetland modelling tools to determine the expected reduction of selected constituents. The expected improved quality water would discharge from the final segment of the main drain. It would disperse and percolate into the lake and ground through deep sediment capture trenches in the wetland cells, which act as infiltration beds, and from the bottom in the final open water area. The goal is to discharge water that is higher quality than in the lake to improve the lake water quality rather than to degrade it. A description of the wetlands water quality modelling and the results of water discharge quality are detailed in Appendix B.

3.5 Climate

Historical meteorological data, available the Levin AWS station was selected for climatic design information as it relates to the enhanced wetland design because it is nearby and is located at a similar elevation to the site (15 m RL)., it is nearby and it has the longest data record available.

Based on historical data climate stations, the site receives an average total of 1060 millimetres (mm) of precipitation per year. Table 3-5 presents the temperature and precipitation distribution. The monthly precipitation depth ranges from a low of 66 mm in March to a high of 100 mm in June. The mean daily temperature ranges from 8.7 to 16.3 degrees Celsius (°C) over the year. The climate is ideal for establishment and easy maintenance of a wide range of wetland plants and would support thriving micro-organism populations to provide natural water treatment.

Table 3-5 : Monthly Temperature and Precipitation Distributions

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Daily Temperature (°C)	16.6	16.7	14.8	12.8	10.3	7.6	7.0	7.6	10.1	11.9	12.8	15.3
Daily Maximum Temperature (°C)	26.0	28.0	25.5	25.0	21.0	18.9	16.4	16.0	21.6	21.0	24.0	28.0
Daily Minimum Temperature (°C)	4.1	4.0	2.5	-1.3	-3.5	-6.9	-6.0	-5.2	-1.0	0.3	1.5	2.4
Mean Monthly Precipitation (mm)	66.0	79.3	65.7	84.6	91.3	102.6	94.4	88.9	93.1	97.3	92.9	96.6

3.6 Site Constraints

The design of the enhanced wetland considers a number of site constraints, including adjacent roads and drains, shallow groundwater (noting depths are unknown), a riparian buffer zone and seasonally saturated soils. The following sections describe these constraints.

3.6.1 Existing site drains

Based on observations from the aerial photography there appears to be an extensive network of cut drains and potentially tile drains across the Kane Farm. There are also anecdotal reports of pumped drains on the Farm. Where these drains lie within the wetland footprint they would be required to be disabled or removed and where required backfilled to the design levels of the wetland.

3.6.2 Adjacent Roads and Drains

The wetland system is to be constructed in close proximity of existing roads, in particular Hokio Beach Road. Integrity of these structures must be maintained. The site is accessed via Hokio Beach Road on the northeast and is within a 5-minute drive of Levin. The Arawhata Road is adjacent to the northwest edge of the site and Butler road is near the southwest edge. Each road has a drainage swale along each side that must continue to drain into the wetland. A minimum amount of work would be required to deepen some drains and add small berms along some drains to contain the road shoulder drainage without impact to the roads or increasing the potential for roadway flooding. Similar deepening and berming, is required along agricultural drains near their discharge to the wetlands to contain flow. Small wetland perimeter drains are required to maintain adequate drainage to some adjacent agricultural fields.

3.6.3 Terrain and Soils

The water elevation along the length of the wetland system drops approximately 7 m from south to north, which allows for gravity flow through the system components.

The depth of soils onsite is not known. The area is former wetland and organic, possibly peat rich soils are expected. This soil needs to be retained for plant growth so if not found at depth, would be stockpiled and then re-spread. The depth to alluvium is currently not known; however, based on data from drilling locations in the vicinity of the proposed wetland area, which indicate alluvium at 1-2 m below ground level. There is a potential it could be encountered requiring consideration of construction methodologies.

A comprehensive shallow soil and groundwater survey is required for the site.

3.6.4 Shallow Groundwater

The groundwater table at the wetland system location is assumed to be just below the ground surface. While constructing the wetland system, the main drain would be preserved during construction to maintain adjacent soil conditions dry enough for earthwork. The shallow depth to groundwater is ideal for groundwater capture over a large area with the use of a horizontal drain collector well. The well could be constructed with multiple parallel perforated drainpipes stacked in a single deep trench to collect seepage from the soil and convey it to a lift pump station. Groundwater dewatering during construction may be required for installation of the horizontal collector wells and the pump station structures. Other earthwork should be possible with low ground pressure equipment during the dry season.

3.6.5 Environmentally and Culturally Sensitive Area

The wetland system is located in an environmentally sensitive area within the area of a historic wetland and adjacent to Lake Horowhenua; however, with removal of the main drain, restoration of the enhanced wetland would assist with recovery of the native conditions. It is possible that surface soil grading over the large area of the wetlands may unearth taonga from historical shoreline inhabitants. Final design should include an archaeologist and a cultural impact assessment to minimise impacts to sensitive areas.

3.6.6 Seasonally Saturated Soils and Construction Season

The wetland system is designed to operate year-round. Since the goal of this design is to construct an enhanced natural wetland system, piping would be limited where possible. However, where piping or other conveyance structure is required, it would be installed in seasonally saturated or saturated soil and may require dewatering during construction. Any piping under the wetland area would consider floatation as a design criterion for backfill.

4. Wetland Flows

The model developed for the concept design has been used for the hydrological and hydraulic analyses of the wetlands. This section summarises design considerations for the wetland flows. Please refer to Appendix A for further detail.

4.1 Design Flow

The wetlands have been be designed for the following flow conditions:

- Low Flows: Mimic status quo discharge flows during the dry period (i.e. ~ 200 L/s); flow consistent with monitoring data. Distributing the existing flow over a much larger wetland footprint increases ET and infiltration to a point that drain water discharge to the lake could be minimal during the low flow period. Groundwater would be captured and added to the upper end of the wetland complex to increase the discharge to the lake with clean treated water even during the lowest flow months. The rate of groundwater pumping would be variable with the highest pumping rates during the dry season and the lowest groundwater pumping rates during the wet season.

- Peak Flows: Peak flows associated with a recurrence interval of 2 years; for this design, a 2-year return period is used for sizing of the normal base flow conveyance facilities (~1.1 m^3/s).

- Flood Flows: Flood level for a 10-year return period is used (~1.63 m^3/s). The predicted maximum instantaneous flow from the model based on the 10-year precipitation is used for sizing of conveyance and bypass structures. Existing highway culverts and offsite drain canals can be used even if they are not sized for the 10-year event. The vast volume of the wetlands help to buffer the peak flows so that the flow that must pass through the highway culverts can be reduced from the peak that would occur if the wetlands were not developed. The wetlands perimeter berms are sized to contain the 10-year event flows and discharge them at the Hokio Road culvert at a flow rate equal to the current 10-year event flood flow rate without the wetlands so that downstream flooding is not be increased by the wetlands. It is worth noting that there is limited understanding of drain flows in the catchment (especially in flood events) and this area requires further investigation.

In reality, the proposed wetland is likely to be capable retaining greater than the 10-year event within the bunds, however given the limited knowledge of drain flows, this cannot be determined at this stage and requires further data collection and hydraulic modelling.

4.2 Flow Bypass During Wetlands Construction

During the construction period for the wetlands, the flow discharge from under the highway would need to be diverted into the sediment trap or final wetland Cell 6 before upstream construction to minimise sediment discharge to the Lake. The proposed improvements to the final cell and the outlet channel to the lake should be constructed first to provide treatment of all water discharged during construction.

A trapezoidal cross-section channel from the Hokio Beach Highway to the lake is proposed to convey the various design flow conditions. The existing channel is expected to meet the required specifications (trapezoidal channel with a uniform longitudinal slope, 2-3 m bottom width, 2.0 m depth and 3:1 side slope), however this would be confirmed during detailed design.

4.3 Channel Alignment and Gradient

Arawhata Wetland flow would be discharged to the lake in the existing alignment of the main drain channel, which may require improvement to have increased capacity. The new average channel gradient for the alignment is 0.005 metre per metre (m/m), which provides good capacity and allows any remaining sediment to settle except during high flows.

4.4 Bank Protection

Bank protection, stabilization, and erosion control measures would be implemented for the banks and channels subject to excessive shear forces. Riprap is be used only in areas near hydraulic control structures such as weirs, berm spillways, and culverts. All other channels and banks would be protected by vegetation plantings.

4.5 Wetland Perimeter/Wetland Separation Berms

A full site perimeter 1.5-m high wetland berm would be constructed with a slope no steeper than 3 horizontal to 1 vertical (3H:1V), separating the wetlands from the surrounding features. Note that detailed design aims for a cut-fill balance that may require an increase in berm size to achieve balance. 1.5 m height bunds have been chosen as they provide a good balance between maximising flood retention capacity and allowing for a cut and fill balance to be achieved on site.

The purpose of this berm is to divert storm flows past the wetlands to drain channels that enter the wetlands at controlled locations. The perimeter berms provide freeboard for accumulation of peak flows in the wetlands without risk of overtopping. No stability issues are expected based on the embankment incorporating a 3H:1V slope and minimum width of the top of the berm of 3 m. Internal wetland berms are 1 m high with a maximum of 3H:1V slopes with 3 m berm tops. Many areas of the separation berms would have flatter side slopes to provide mud flats, and shallow wide beach areas to support vegetative diversity. The wetlands will be designed with balanced cut and fill with excess soil from land levelling cuts used to create diversity in berm widths and side slopes in close proximity to each area of cut to minimise soil transportation. Most earthwork will be done with dozers and scrapers, which are lower cost than loading, hauling, and dumping with trucks and loaders.

The internal berms have a 0.2 m depressed section near each water level control weir that is armoured with riprap as an emergency spillway for peak flows. This allows storm flows to overtop the interior banks and flow into the next downslope wetland by way of controlled overflows at riprapped depressions in the wetland cell separation berms. Due to the storage available with the elevation change in the cascading wetlands, the storm and flows are not expected to create peak flows at the lake discharge and highway culverts that exceed the existing condition.

4.6 Uplift Buoyancy Analysis

The relationship between pipe bedding thickness and the maximum allowable groundwater elevation should be calculated for all pipelines in the final design. The cost estimate for the concept design assumes full buoyancy control for all pipelines and pump stations with groundwater at the soil surface.

4.7 Water Control Weirs

The wetlands would have multiple water diversion structures comprised of flash boards to create a long-crested weir with adjustable crest elevation. The weir at the drain canal discharges into the wetlands uses a large size weir to pass high flows down the channel and has a submerged culvert through the weir head wall that allows for a relatively constant normal flow to enter the wetland cell through a sediment trap deep fen basin and level spreader to distribute the flow. The high flows that go over the weir crest will bypass the deep fen settling basins and discharges directly to the wetlands. The water level control weirs at the outlet of each wetland cell consist of a similar flash board weir without the submerged culvert and would be of a smaller size that will have flow over the weir crest at all flow rates. The weirs at the outlet of Cell 5 and the inlet and outlet of Cell 6 would be large size weirs.

See Appendix C for indicative weir design details and sizes. The depth of water in the wetland cells is controlled by the level of the flash boards. The channel diversion weirs are sized for a 2-year 24-hour storm, which corresponds to a flow of 1.1 m3/s to be diverted through the submerged culvert into the wetland, and all higher flows overflow the weir and enter the wetlands directly through the drain channel without sediment capture. There is a minimum 0.3 m of freeboard allowance between the top of the channel berm and the high-water level.

5. Wetland Configuration and Components

The following Section should be read in conjunction with the Drawings provided in Appendix C.

5.1 Wetland Configuration

5.1.1 Wetland Shape

The proposed wetland features blend into the existing landscape in terms of geometric design and the plant communities it supports. The wetlands have been designed with a minimum of 4:1 length to width ratio to promote mixing and minimise short circuiting of flows. The wetland cells would have perimeter berms that generally follow the natural contours and are natural in shape except at the perimeter that is defined by straight property lines and highways. The enhanced wetland system design configuration contains the following key features that facilitate the treatment:

- The upper slopes of the Kane Farm in the southwest corner of the site would have swamp forest wet meadow planted with native wetland trees with a hydrology focused to support Kahikatea trees (in addition to Puketea, swamp Maire, Cabbage tree). The sediment that enters this area of the site would contribute to soil building in an undulating topographic form. This cell is referred to as Cell 1- Undulating Kahikatea Forested Wet Meadow Overland Flow. This area has minimal or no land levelling to take advantage of the existing undulating topography to provide a range of slopes that result in a range of depths in the overland flow of wetland water. The soil surface is protected from erosion by a dense cover of wet meadow ground cover and emergent vegetation. Trees are planted on higher ground that has the appropriate hydrology. Tree islands would be created as needed to provide enough area with appropriate topography to support target tree species. This area is at elevation 13 to 14 m with overland flow 0.5 to 2.5 centimetres (cm) deep on 5 hectares (ha). See Drawing IZ060501-001 in Appendix C.

- The next lower elevation area in the southwest corner is Cell 2-Pukatea Forested Wetland with tree islands on a relatively flat sloped 15 ha area from elevation 12 to 13 m with flow 1 to 5 cm deep. The soil surface is vegetated in wet meadow species with a canopy of Pukatea trees and other tree species with similar hydrologic needs.

- Cell 3 is the uppermost emergent free water surface (FWS) wetland on 15 ha with flow 15 cm deep on average. This cell is located at elevation 11 to 12 m and has enough land levelling to maintain flow depths between 5 and 25 cm to support a wide variety of emergent wetland plants.

- Cell 4 is a wetland similar to Cell 3 in size but would have an average water depth that is twice as deep and contains some areas deep enough to support open water habitat and greater settlement. The Cell 4- Emergent FWS wetland covers 15 ha with an average water depth of 30 cm and a range of depths from 20 cm to 60 cm between the 10 m to 11 m topography bands.

- Cell 5 is an emergent FWS wetland cell between elevations 9 to 10 m covering 20 ha with an average depth of 30 cm.

- Cell 6 is located at the Hokio Sediment Trap property and is an emergent FWS on 6 ha 50 cm deep. This cell provides groundwater recharge of fully treated water near the lake and discharges surface flow into the lake.

- The water entering the Kane Farm wetlands and overland flow areas from the southeast agricultural area would pass through an initial deep settling basin with 2:1 side slope and a bottom 2 m below the soil surface elevation. The settlement basins are long narrow basins with adjacent berms having berm top roads to support dump trucks and long reach excavators used to clean the sediment from the basins. The basins are designed to capture solids and minimise impacts to further downstream units. Similar deep settling basins are used at the outlet of Cell 5 and the inlet and outlet of Cell 6.

- The Woodhaven Treatment Blocks (WTBs) occupy the highest elevation area of the treatment wetland complex. This area is used for the major upgrades in treatment provided by the Option 2 engineered treatment. The facilities proposed for the Woodhaven Treatment Blocks could be located between the Kane Farm and Lake Papaitonga or on the highest elevation area of Kane Farm. The limitation of how far the facilities could be moved is limited by gravity flow from the existing surface drain canals. However, since the groundwater treatment facilities are supplied by a pump they could be moved to a higher elevation. The discussion of the facilities presents them at WTBs but they could be moved to other areas with similar elevation.
    - For Option 1 which is primarily natural treatment, the WTB area is occupied by initial 2 m deep settling basins in a serpentine covering 0.5 ha followed by a 4 ha BCR 1.5 m deep. About half of the WTB site is Undulating Kahikatea Forested Wet Meadow Overland Flow.
    - The 4 ha BCR is a subsurface cross flow unit filled with compostable organic material that promotes anaerobic sulphate reduction, which in turn precipitates trace metals (for example, cadmium, copper, arsenic, cyanide, and zinc) and retain them in the substrate as stable, insoluble metal sulphides. The compostable organic matter bed unit is designed to mimic the peat zones common in historical wetlands. The organic matter mix contains wood chips, sawdust, grass hay, and a small amount of horse manure to inoculate it with bacteria for anaerobic treatment of nutrients, organic chemicals, and metals.
    - With Option 1, the base flow through the BCR is 5 m^3/minute of groundwater
    - With Option 2, the base flow for additional groundwater treatment BCR is 10 m^3/minute.
    - Option 2 also incorporates a recycle pump station to deliver up to 10 m^3/minute of surface water from Cell 5 to recycle through the BCR to remove approximately 90 percent of the nutrients and nearly all of the organic compounds and metals to provide a clear low nutrient water stream into the rest of the wetlands complex.
- The Kane Farm wetlands, which are composed of overland flow forested wetlands and marshes planted with emergent wetland vegetation and deep, open-water zones, are designed to promote oxidation of the effluent from the anaerobic BCR unit, remove any excess dissolved organic matter (that is, biological oxygen demand), and to remove any suspended particulate through tortuous path filtration in the shallow vegetated zones and quiescent settling in the deep zones.
- Finally, there is an outlet channel from Cell 6 with a berm directly adjacent to the wetlands that allows infiltration and hyporheic discharge along the full length of the berm as well as controlled outlet from the discharge weir structure. This exfiltration zone at the end of the system is designed to allow seamless blending of the wetland effluent back into Arawhata Main Drain downstream of the wetlands.
- In the engineered wetlands Option 2, the WTBs are the primary area of intensification. In Option 2, three alumina micro-dose injection stations are added with one at the point that each of the three large drains in this area discharge into the Kane Farm. Each micro-dose station consists of a 1-m^3 chemical tote and a small metering pump discharging alumina at a controlled rate into a turbulent flow stream in the deep settling basins. The turbulent stream can be created by a small pump, with alumina injected into the discharge pipe, which lifts about 500 m3/day of water about 1 m and discharges it onto the water surface to mix and spread the alumina.
- A large increase in treatment performance is provided in Option 2 by adding a 4-m-deep horizontal well that spans the Arawhata watershed in a west to east transect and draws groundwater to a lift pump station at the WTB. The groundwater is low in turbidity and high in nutrients, which is ideal for treatment in a BCR. In Option 2, the BCR capacity is increased with a second BCR in the northeast 1/3 of the WTB dedicated to groundwater treatment. This BCR has Organic Media on 2 ha 1.5 m deep followed by a Tidal Flow Aeration Cell with Rock Media on 0.2 ha 1 m deep that discharges to a Subsurface Flow

Wetland with Rock Media on 2 ha 1 m deep. This configuration should remove 90 percent of the total nitrogen in the groundwater on a very small footprint plus remove most of the metals and organic compounds.

The entire enhanced wetland system would be protected on the perimeter by 1.5 m high berms that limits or prevent high capacity flood and storm event flows from entering the wetland system. As noted previously, the height of the interior berms gradually decreases near the water level control berms, allowing high flow (for example, floods) to flood the wetland through designed hydrologic breaks. This allows the area to maintain some floodwater storage during high flow events in an effort to keep the downstream hydrologic impacts similar to current conditions.

The treatment wetlands are designed for maximum performance for the current average flow rate in all drains. The 10 year 24-hour storm event can be contained and treated in the wetlands with the normal flow path. Larger events are likely be contained within the perimeter berms but may overtop the interior berms at the internal spillways next to each weir. The limitation on the amount of water entering the wetlands is the capacity of the drain canals and the limitation on outlet capacity is the culvert under Hokio Beach Road. The perimeter berms are 1.5 m high to contain water that enters the wetlands during the 10-year+ event until it can flow to the lake. The earthwork balances cut and fill with excess soil used in berms. At high flows treatment is reduced.

The preliminary layout of the wetland system is shown in the Drawing Package provided in Appendix C. The configuration of each wetland unit within the overall wetland system has been designed to allow gravity flow from south to north. The water level in each of the FWS wetlands is controlled by the containment berms. The overflow level spreaders of each of the first two cells and at the downstream edge of each of the deep sediment basins would be covered in riprap and be underlain by a geofabric liner for erosion protection. There are options to direct other drains into either the Kane Farm Wetland or the Woodhaven Treatment Blocks – ultimately the design has been based on the flows observed at Hokio Beach Road, so where drains input into the treatment system does not have a large effect on treatment efficacy.

All wetland units are designed to encourage the upwelling of groundwater into the deep zones. Each wetland is an unlined excavated impoundment. The layout requires minimal earthwork by configuring the wetland cells parallel to the contours with drop from contour band to contour band over adjustable weir structures. The following sections provide detailed information about the wetland design, and the flow conveyance and control structures.

5.2 Wetland System Components

5.2.1 Wetlands Pump Stations

A horizontal groundwater collection well parallel to Hokio Beach Road is used in both options to collect an estimated 5 m^3/minute of shallow groundwater near the lowest elevation area of the watershed. Water collected in the well is pumped to the WTB BCR. The engineered enhanced wetland Option 2 has an additional horizontal groundwater collection well that transects the watershed just south of the wetlands and discharges into the BCR in the WTB for high efficiency nutrient removal from a large volume of groundwater. The capture estimate in this horizontal well is 10 m^3/minute. A recycle pump station adjacent to the groundwater pump station in Cell 5 can recycle a variable flow rate up to 10 m^3/minute of treated surface water from Cell 5 near the outlet. The recycle water is piped to an aeration structure in Cell 4 and discharged at this location for additional treatment in Cells 4, 5, and 6. Option 2 extends the recycle pipeline to the new BCR at the WTBs. The Option 2 recycle pump station has an intake screen to remove debris that could clog the BCR. The recycle pipeline in Option 2 would have valving to allow discharge at the Cell 4 aeration structure or an additional aeration structure at Cell 2 or to the new BCR inlet. Flow can go completely to any of these alternate outlets or can be distributed at various rates to all of them at once to match season hydrology needs and treatment targets.

5.2.2 Compostable Organic Media Beds

Each of the BCRs in the WTBs would have a vertical downflow compostable organic media bed (COMB) (similar to a peat bed) at the inflow. The flow path in the BCR is by way of a perforated pipe inflow network on the media surface and a drain system to a set of infiltrator laterals at the bottom of the COMBs. The conveyed water is then distributed and downflow through the organic media. The BCR outflow overtops the riprapped berm and cascade into the forested wet meadow overland flow wetland unit. The cascade and thin film overland flow of open water provides aeration. In Option 2, the engineered option would have one BCR for groundwater flow from the Hokio Beach Road groundwater collection well, as described above, and would have a second BCR for groundwater flow captured in an additional horizontal collection well southeast of the site plus recycled surface water from Cell 5. The Option 2 groundwater BCR discharges into a tidal flow rock media bed that has the water level cycled from high to low with the use of automated weir gates. The tidal flow discharges into a subsurface flow rock media wetland through a second automated weir gate. Tephra could be substituted for rock. The BCRs can aid e.coli. removal.

5.2.3 Permeable Bottom Layer

The wetland bottom layer consists of non-compacted native soil as a permeable layer to promote the upwelling or percolation of groundwater into and out of the wetland system. An east-west oriented separation berm between each wetland reduces the potential for flow to short-circuit and forces the flow to run parallel to the contour berms or infiltrate as hyporheic discharge and up well in the next lower wetland cell. The flow through soil increase the microbial diversity that contacts the water and provides treatment.

5.2.4 Water Level

The water surface of the wetland would be just above the surrounding groundwater elevation during most seasons. Water level can be adjusted in each wetland cell.

5.2.5 Flow Conveyance

Conveyance would be by gravity from wetland to wetland and includes conveyance through the berms with adjustable flash board weirs. Only groundwater and recycle water is proposed to be pumped and conveyed to higher elevations in pipelines.

5.2.6 Surface Stormwater Flow Control/Diversion

As noted previously, the northwest side of wetlands would be separated from Arawhata Wetlands with a berm 1.5 m high to the crest to keep storm flows from overtopping from the wetlands and reducing the potential for washing out settled solids. Wetlands are be designed to allow controlled overflows between the wetlands into the next downstream wetland during storm flows. The controlled overflows would be lined with geotextile and covered with riprap and/or interlocking erosion control blocks.

Another berm would be constructed along the southeast side of the Wetlands to limit surface runoff from the catchment area to the southeast entering these wetlands. A shallow 0.5-m-deep swale would be excavated along the eastern flank and used to construct a low 0.5- to 0.75- meter high berm on the east side of the swale to divert surface water runoff from the catchment area to a drain where it can pass through the perimeter berm. Details of the berm are provided in Attachment 2.

5.2.7 Water Level Control

During the wetland vegetation's grow-in period, vegetated wetland cells require the water level to remain relatively constant at an average of about a 2 to 3 cm water depth. This can be accomplished by level control through the removal or addition of stop logs. Details of the weir are provided in Attachment 2.

5.2.8 Wetland and Wetlands Access

A 3-m-wide access road is proposed to be constructed on the top of all berms. The road provides ease of access to allow for monitoring and maintenance of the wetland. The berm tops and roads adjacent to the deep settlement basins are 4 m wide to allow access by dump trucks and long reach excavators used to clean the basins.

6. Restoration

6.1 Environmental Overview

Underpinning this whole concept is the goal to restore the Arawhata area to a wetland resembling as close to as possible the original vegetation of the area. Work by local surveyor George Leslie Adkin (b1888-d1966) document the historical extent of the Arawhata Swamp. This historic boundary aligns well with the Kane Farm block of land and is shown in Figure 6-1 below.

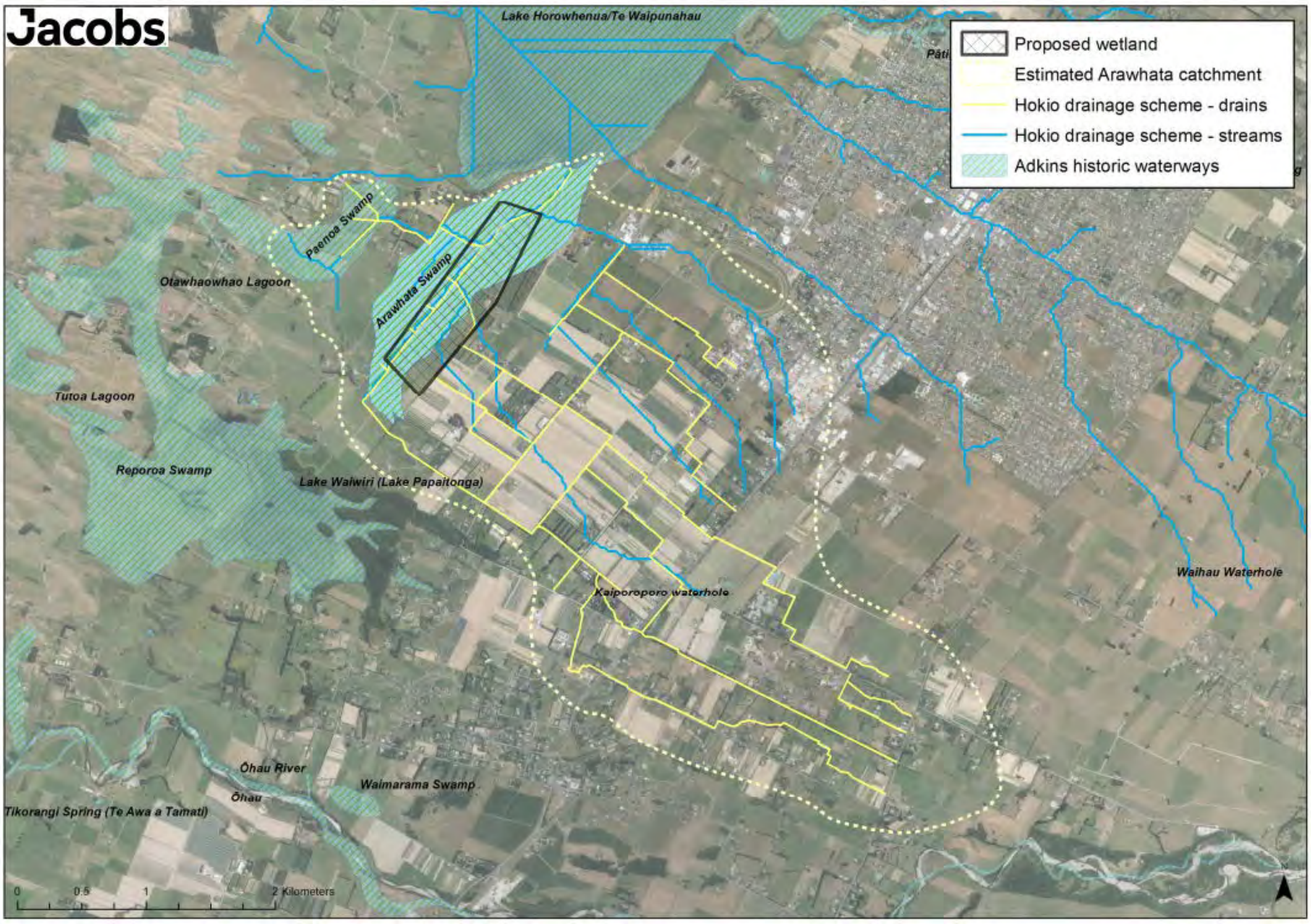

Figure 6-1: Extent of historic Arawhata Swamp pre 1900.

6.2 Key Environmental Considerations

Jacobs's background review yielded the following information:

- The forested swamp wetland is considered a high value ecological community (Special Concern)
- High Value Wildlife habitat areas do not currently occur within the project area
- The site provides an opportunity to develop a high value ecological corridor between the Lake Papaitonga Scientific Reserve and Lake Horowhenua.

6.3 Restoration Objectives

The restoration objectives for the wetland enhancement area and associated wetlands include the following:

- Restoring suitable vegetation cover beneficial to a wide variety of aquatic (fish, amphibians, and reptiles) and wildlife (birds and mammals) species
- Using vegetation planting prescriptions for both the enhanced wetland and natural wetland options with the intent to return the Arawhata Wetlands site to an ecological state that contains features for fish and wildlife habitat, including vegetation species and composition that occur within the historical forested wetland swamp
- Improving benthic invertebrate habitats to increase production and food supply and nutrient flow downstream
- Improving water quality to the downstream lake

6.4 Restoration Methods

A pre-construction field assessment is recommended to assess, and inventory local vegetation, wildlife, and fish habitat resources associated with Arawhata Wetlands and forested swamp habitat to inform final restoration plans and allow for evaluation of restoration performance against existing conditions.

As part of the construction process, when the surface soils are removed to construct the wetland, the organic layer and underlying mineral soil would be stockpiled separately and redistributed onto the surface of the wetland marsh and riparian zones to take advantage of rhizomes, root fragments, plants, and the existing seed bank to kickstart revegetation. Soils would be scarified and non-compact prior to revegetation activities.

The wetland marsh, wetland berms and transitions, wetlands, and upland areas would be revegetated with an appropriate wetland plant and grass seed mix and native plants for structure and stabilization purposes. This includes revegetating the wetland edges with suitable native trees, shrubs, herbs, and grasses to restore structure and composition for wildlife habitat movement along the wetland’s corridor. In general, planting densities are posed to be a minimum of one plant per square metre. In the wetland marsh areas, plantings can be at a higher density (i.e., three plants per square metre). In addition, seeds would be distributed in the wetland marsh areas to encourage rapid revegetation.

After construction, the enhanced wetland and Arawhata Wetland restoration areas would initially be seeded with a wetland emergent species and grass cover crop for sediment and erosion control, as well as to suppress the introduction of invasive plant species. The enhanced wetland marsh, berms, uplands, and wetlands would be seeded and planted immediately after construction with vegetation similar to that found in local marsh and riparian communities suited for the climatic region. Riparian shrub staking, dormant plug/container plantings, and fish habitat structure will be used to supplement the revegetation process and fish habitat rehabilitation.

Jacobs suggests the following restoration components/zones and vegetation (after organic layer/soil salvage replacement):

1. Wetland Marsh: emergent wetland plants, grasses, and herbs suitable for very wet soil moisture conditions (emergent vegetation).
2. Wetland Berm/Transitions: initial grass seed mix, live-stakes, herbs, and shrubs suitable for moist to wet soil moisture conditions (transitional vegetation).
3. Riparian/Wetlands (0 to 5 m from wetlands): initial grass seed mix, live-stakes, herbs, shrubs, and trees suitable for moist to wet soil moisture conditions (transitional vegetation).
4. Upland (more than 5 m from wetlands): initial grass seed mix, herbs, shrubs, and trees suitable for dry to moderate soil moisture conditions.

5. Forested Marsh: trees on high hummocks and small mounds or tree islands surrounded by water. Emergent wetland plants, grasses, and herbs suitable for very wet soil moisture conditions (emergent vegetation). Soil is dry to saturated with a wide range of flow depths but generally thin film overland flow.

7. Start-up, Operations, and Maintenance

The wetland is designed for minimal O&M requirements, but, during the initial system start-up period in the first full season of operation, more frequent site activities would be required.

7.1 System Start-up

The wetland requires a lowered water level during the initial grow-in period. For this period, the wetland would have saturated soils, and a temporary water level control system would be established, as noted in Section 4. These level control structures would be set to the normal operational levels once the vegetation is fully established.

The grow-in period is expected to be 6 to 8 weeks and would be weather dependent. Planting should take place outside of summer, including distribution of the salvaged organic layer, live staking, dormant plantings, and grass seed mixes. The wetland system should operate at the design water elevation through the wet period. The wetland operating water elevation would be lowered to promote seed germination that is expected to occur early to mid-growing season. The water level would need to remain lowered for 6 to 8 weeks following this to allow for plant growth to achieve an acceptable height. It is important to note that following planting and start-up, there is likely to be a period of elevated colour, biochemical oxygen demand (BOD), and low dissolved oxygen (DO) discharging from the BCR units.

Strategies to encourage early grow-in after construction include the following:

- Use grass cover crop/native grass seed mix
- Spread salvaged organic layer on marsh areas—seed to be in place for regrowth
- Use live staking—these sprout/root early in the growing season

Attachment 3 has a detailed description of the BCR including operational adjustments.

7.2 Water Quality Sampling

To get a sense of the water quality improvement afforded by the wetland, Jacobs recommends sampling the last deep zone of Cell 6. During the start-up period, weekly or monthly water quality samples are recommended. Once the water quality parameters have stabilised, sampling frequency may be reduced to quarterly.

7.3 Maintenance Requirements

The O&M required for the system would be specified as part of the O&M manual for the site-wide water quality improvement system components in the next phase of design. There are likely to be special O&M requirements during the first 4 to 8 weeks following start-up. In general, the typical O&M requirements in the first growing season after seeding/planting are to maintain the water level at about 2 to 3 cm, to allow plants to germinate and grow. Within about 4 to 6 weeks of germination, water level control can be at normal levels. Future O&M efforts would be focused on monitoring the vegetative growth/density and overall health.

8. Planning Considerations

An initial planning assessment considering the conceptual plans presented in this report has been prepared by Jacobs Planners. The assessment is presented in Appendix D.

The Planning Assessment provides summary information on the process and likely resource consents required from the Horizons Regional Council (HRC) and Horowhenua District Council (HDC), affected parties, and consenting risks.

Based on initial information regarding the proposed wetland, it is considered likely that regional resource consents (as a discretionary activity) will be required from Horizons Regional Council, with the potential for additional land use consents also being required from Horowhenua District Council.

It is recommended that as the design is confirmed, a Consent Strategy be prepared that sets out the proposal and the required consents, as well as considering the most appropriate pathway to obtain consents for the proposal, including engagement with mana whenua and stakeholders.

9. High Level Cost Estimate

A high-level cost estimate has been prepared for the conceptual design and options presented above. The cost estimate has been prepared using standard costing techniques and NZ rates by the Jacobs ANZ Cost Estimation Team.

Costs are high level preliminary cost estimates (Class 4). A cost is provided, and an industry standard range of -15% to +50% is provided to account for uncertainty and the conceptual nature of the designs. An additional 5% for Miscellaneous costs is included within each item. Increased certainty in costs requires a detailed design process. It is evident that earthworks are the largest contributor to project costs. Detailed design would improve on the accuracy of the earthworks calculations by:

- Including a detailed site-specific topographical survey
- Developing the design in 3D, allowing for accurate cut and fill balance estimates
- Providing soil and geological data allowing informed decisions on the re-use of soils onsite

The preliminary cost estimate is presented below in Table 9-1 and the full itemised costs in Appendix E.

Table 9-1: Preliminary Cost Estimate (NZD)

Option	Cost Estimate (NZD)	-15% (NZD)	+50% (NZD)
Kane Farm Wetlands	$6,047,559	$5,140,425	$9,071,338
Hokio Polishing Cells	$242,736	$206,326	$364,104
Woodhaven Treatment Wetland Option 1	$3,357,069	$2,853,509	$5,035,603
Woodhaven Treatment Wetland Option 2 (incl. groundwater diversion)	$3,226,958	$2,742,914	$4,840,437

The costs presented above do not include professional fees (i.e. detailed design, project management, consenting). These could typically range from 2.5% to 10% of capital costs. Given that these are relatively simple civil works, a cost at the lower end of that range would seem reasonable.

10. Recommendations and Next Steps

10.1 The next steps

The designs presented in this report are conceptual in nature, and while they are founded on proven water quality modelling and existing hydrological information, there remain significant gaps in the knowledge of hydrological and hydraulic processes within the catchment. Moving forward into the detailed design phase with only the current data knowledge would be present significant risk to the ability of the project to achieve the desired outcomes and could result in unnecessary financial burden and time constraints on the project.

As such, it is critical that careful consideration is given to what further data and assessments are required to allow the detailed design phase for the treatment wetlands (and for the drainage improvements discussed in the T+T report[1]) to be implemented. The following paragraphs discuss the key recommendations for filling the data and knowledge gaps and are listed in order of priority.

10.1.1 Collection of finer scale flow data

The knowledge of flow withing the drainage network is limited. The only available information is a single gauging event during a storm in August 2019. Understanding the flow within each of the smaller drain systems is important and allows for correct sizing of culverts and weirs, correct bund height and also allows for better understanding of the treatment efficacy.

The drainage network mitigations proposed in the T+T report could result in increased flow velocity from the drainage network entering the wetland. Understanding the hydraulics and hydrology across the entire catchment is critical as there are hydraulic linkages between all mitigations and they need to be considered holistically, not independently.

Data collection will likely require the installation of temporary flow measuring devices in the main Arawhata drainage network, upstream of Arawhata Drain. These could be v-notch type weirs, simple weir boards or small boarded culverts.

10.1.2 Development of a catchment scale hydraulic model

The limited understanding about the timing and size of flows form the drainage network intothe proposed wetland, and the interdependency between future drainage network modifications and the proposed wetland highlights the importance of develop a robust hydraulic model for the full catchment. This requirement is also discussed in the T+T report.

Whilst most of the data required for the model exists, development of a robust model would be dependent on the collection of good quality flow data as discussed above.

It is worth noting that a hydraulic model of the upper Arawhata catchment (above SH1) is currently being developed by Jacobs NZ for Horizons Flood Management Team. While the purpose of this model is somewhat different from the requirements.

10.1.3 Soil and shallow groundwater survey across proposed wetland areas

Limited soil property and shallow groundwater data exists across the footprint of the proposed wetlands. The following data are required to be collected:

- Basic soil mapping across the site

[1] Integrated Sediment, Nutrient, and Drainage Management Plan for the Arawhata Catchment (Draft), T+T, December 2020.

- Soils chemical properties
- Soil physical properties including hydraulic conductivity
- Shallow groundwater level

The survey could be combined with a shallow geotechnical assessment to understand the soil and geological conditions in the top 5 m of the site. The survey would likely use a combination of hand-dug/augered pits, machine excavated test pits and machine boreholes.

10.1.4 Additional topographical Survey

Good quality Lidar and some drain survey data exist for the site. Further survey of the Kane Farm site is required including all of the on-farm drainage network. This information will also help assess the response of groundwater levels to drain removal across the site.

10.1.5 Piezometric Survey and Groundwater Quality survey

A piezometric (groundwater level survey) across the catchment will provide valuable information on groundwater flow paths and hydraulic gradients. This data is required to further understand catchment groundwater processes and would be used in the development of any future groundwater models.

At the same time, a groundwater quality survey should be completed to delineate vertical and horizontal extent of high nutrient concentrations in groundwater.

10.1.6 Ecological, Social and Cultural Input

A key driver for the wetland project is the ability to restore what was once a large natural wetland. The story of this natural wetland and ecological benefits are important, and the following items are recommended to help strengthen the meaning and value of the project:

- Further research the likely original composition of the Arawhata Swamp, and refining the species list that would be used for the wetland planting
- Understanding the benefits of an eco-corridor between Lake Papaitonga and Lake Horowhenua. This would likely involve engaging with DOC
- Engage with local iwi and understand history of the land, complete a Cultural Impact Assessment
- Engage with local council and iwi, explore the potential for recreational and educational elements (currently excluded) to the project to strengthen funding opportunities. Such opportunities include walkways through the wetland, education elements such as signage or even an educational centre, linking the wetland through to the lake front and other recreational amenities.
- Explore options for eco-sourcing seeds and plants and requirements for new nursery capacity. The nursery could be run locally, strengthening the ties of the project to the community.

10.2 Detailed Design

The detailed design process is likely to be a 3 to 6-month process that will be very dependent on the availability of the data discussed above. It is envisaged that a full Civil 3D model would be built which will allow for refinement of cut and fill balances (and therefore cost) and is also able to be passed directly to the contractor.

In the intermediate period, when data are being collected and modelling undertaken, there is opportunity to do some forward design and project management works that will keep the project moving and not delay the programmes. These tasks include such things as preparation of tender documentation and subcontractor agreements, due diligence on suitable contractors, forward planning on native seed and seedling supply amongst other things.

References

Ferguson, R. (2020). Integrated Sediment, Nutrient, and Drainage Management Plan for the Arawhata Catchment (Internal Draft). Not in Press.

Gibbs, M. (2011). Assessment of Opportunities to Address Water Quality Issues in Lake Horowenewa . NIWA.

Appendix A. Hydrological Assessment

Jacobs

Memorandum

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Subject	Modelled Inflows at Arawhata Wetland	Project Name	Arawhata Wetland Project
Attention	<Name>	Project No.	IZ060501
From	Claudia Zucco		
Date	December 18, 2020		
Copies to	<Name>		

1. Purpose

The purpose of this report is to provide inflow data for the conceptual design of the Arawhata Wetland.

This memorandum documents the development, calibration and simulation results from the modelling exercise undertaken using the selected HEC-HMS model. The loss model chosen is the Soil Moisture Accounting (SMA) method, this method is appropriate for continuous simulation of flow and uses three layers that represent the soil to simulate interflow and quick flow processes.

2. Data input

2.1 Flow Gauges

Continuous flow records were provided by Horizons Regional Council (HRC) in XML format and processed by Jacobs using Hilltop software. The flow gauge location is at Arawhata Drain at Hokio Beach Road dating from 1 August 2017 00:00 to 30 July 2020 00:00. The flow records have a resolution of 1 hour.

2.2 Rainfall

Rainfall for input to the calibration and simulation models was extracted from the CliFlo website developed by NIWA. The rain gauge location is at Levin AWS Station. The rainfall data records are available from 2 November 1990 08:00 to 30 August 2020 09:00 on an hourly timescale.

3. Delineation of Sub-catchments

The Arawhata Wetland catchment extent was provided by Tonkin+Taylor (T+T) and it was used (for consistency purposes) to define the sub-catchments draining into the 4 different drains that feed into the main Arawhata drain. The delineation of these sub-catchments was based on the catchment topography (slope) and on the existing stormwater network, both datasets provided by T+T. The catchment topography was defined from a 1m resolution DEM. It should be noted that the catchment extents are subject to change do to lack of survey data of the stormwater network and study area at the time when the model was built.

Figure 3-1 shows the extents of the sub-catchments and Table 3-1 shows the area for each of the sub-catchments.

Figure 3-1: Arawhata Wetland sub-catchment extents delineated in red.

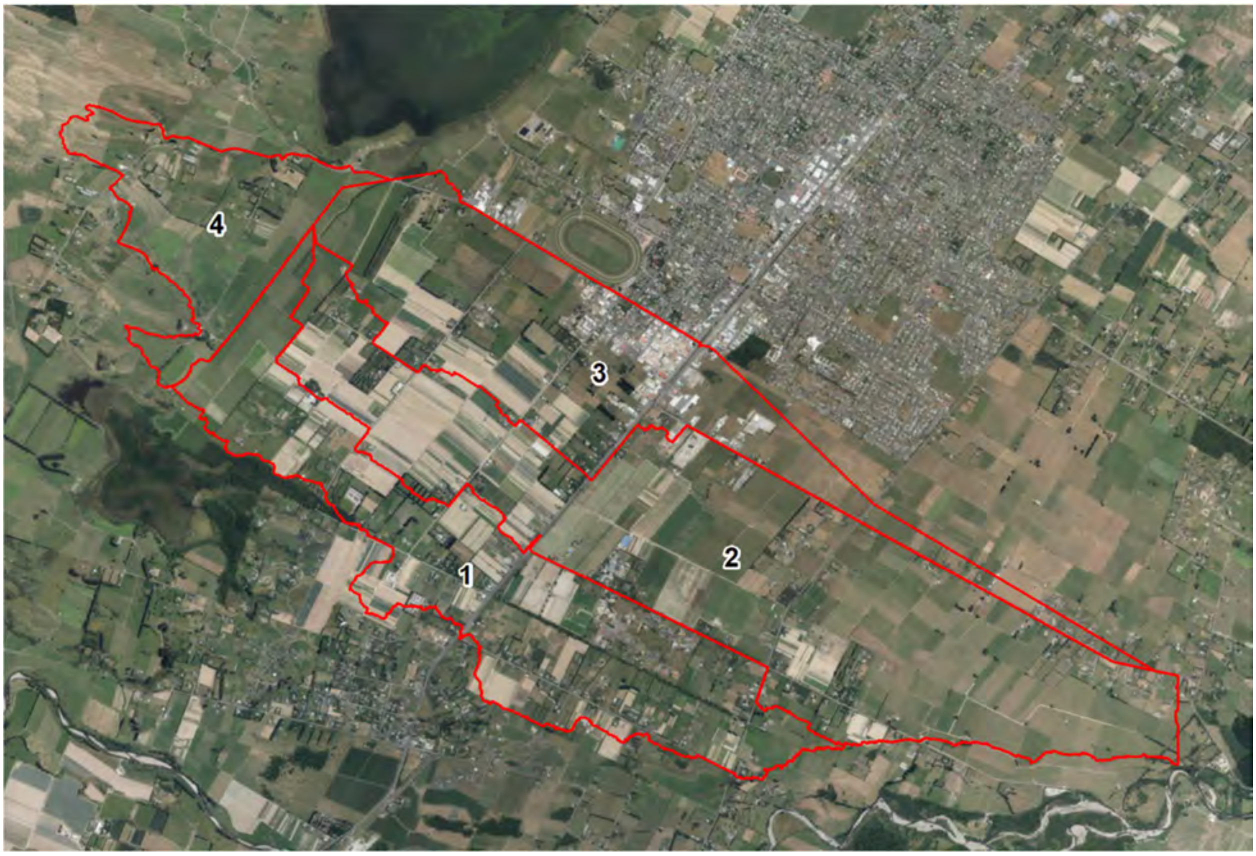


Table 3-1: Arawhata Wetland sub-catchment areas.

Sub-catchment No.	Area (km^2)
1	4.91
2	8.31
3	4.57
4	2.15

4. Losses

A summary of the parameters used in the SMA model is provided in Table 4-1.

Table 4-1: Summary of SMA model parameters.

Parameter	Units	Description
Canopy storage capacity	mm	Depth of water potentially held by the canopy storage zone.

Parameter	Units	Description
Surface storage capacity	mm	Depth of water potentially held by the surface storage zone. This is essentially the initial loss and becomes less influential with increasing flood magnitude.
Maximum infiltration	mm/hr	Upper limit to the soil infiltration rate. Actual infiltration capacity is scaled based on the soil moisture deficit.
Impervious area	%	Impervious proportion of the catchment connected to drainage channels.
Soil storage capacity	mm	Depth of water potentially held in the soil moisture storage zone. Equal to tension zone storage plus upper zone storage.
Tension zone capacity	mm	Depth of water potentially held in the tension zone compartment of soil moisture storage. Must be less than or equal to the soil storage capacity.
Maximum soil percolation rate	mm/hr	Upper limit of the rate of percolation to GW1. Actual percolation is limited based on the GW1 storage deficit and the amount of soil moisture storage.
GW1 storage capacity	mm	Depth of water potentially held in GW1.
GW1 percolation rate	mm/hr	Upper limit of the rate of percolation from GW1 into GW2. Actual GW1 percolation is limited based on the storage values of GW1 and GW2.
GW1 coefficient	hr	Determines the proportion of storage in GW1 that is routed to stream flow in each time step.
GW2 storage capacity	mm	Depth of water potentially held in GW2.
GW2 percolation rate	mm/hr	Upper limit of the rate of percolation from GW2 out of the system (i.e. deep percolation). Actual GW2 percolation is limited based on the storage value of GW2.
GW2 coefficient	hr	Determines the proportion of storage in GW2 that is routed to stream flow in each time step.

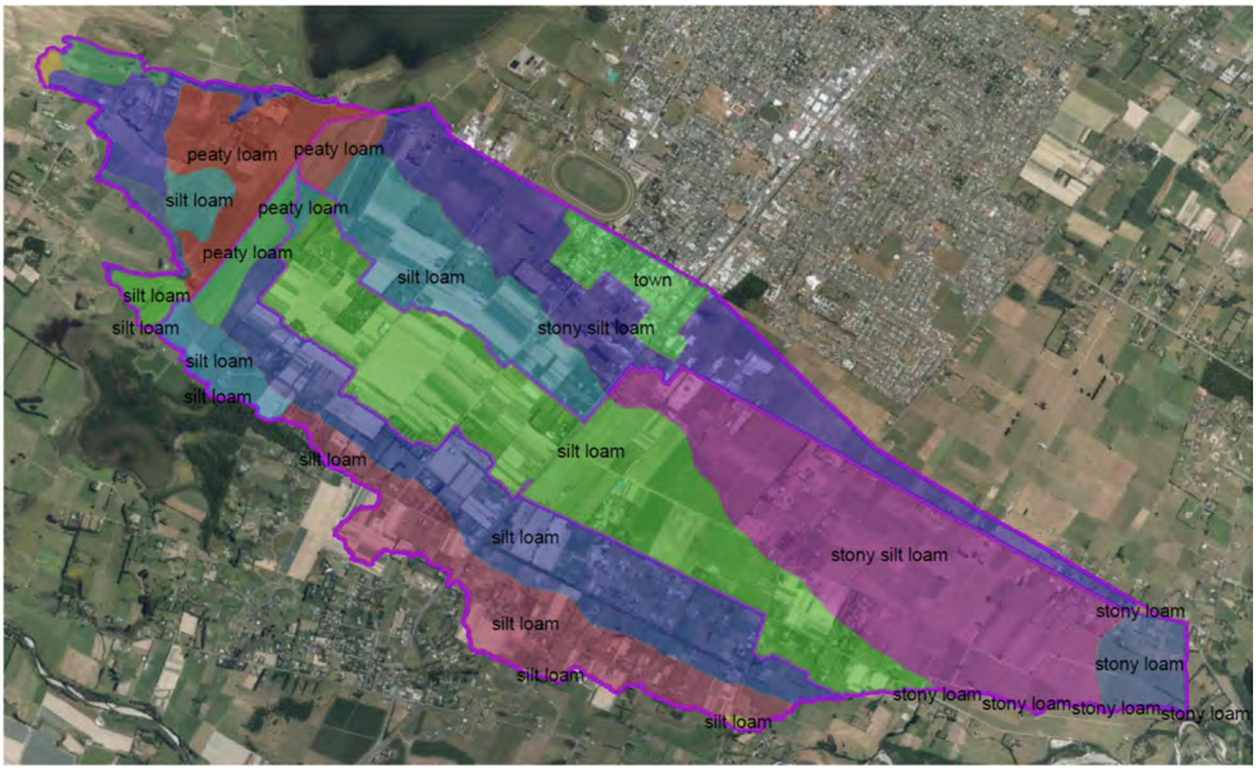
The parameters defined for the sub-catchments were subject to variation during the calibration process. We used a period of the final values used are listed in Table 4-2. The initial storage was assumed to be 0% (initially empty). The tension storage capacity was defined based on potential routing depth and microporosity. The values used for each sub-catchment were extracted from the FSL North Island (all attributes) SHP file downloaded from the LRIS Web Portal and the soil storage parameter was defined based on spatially averaged potential rooting depth held in the NZLRI database and from the Soil Spatial Variability in Northern Manawatu, New Zealand Thesis (Asoka Senarath, Massey University, 2003). Figure 4-1 shows the soil type distribution for each sub-catchment.

Table 4-2: Calibrated model parameters for each sub-catchment.

Sub-catchment No.	Soil (%)	GW 1 (%)	GW 2 (%)	Max Infiltration	Impervious (%)	Soil Storage (mm)	Tension Storage (mm)	Soil Percolation (mm/h)	GW 1 Storage (mm)	GW 1 Percolation (mm/h)	GW 1 Coefficient (h)	GW 2 Storage (mm)	GW 2 Percolation (mm/h)	GW 2 Coefficient (h)
1	35	0	0	15	0	238	77.35	1.6	400	0.24	150	700	0	1000
2	35	0	0	15	0	234	74.55	1.6	400	0.24	150	700	0	1000

Sub-catchment No.	Soil (%)	GW 1 (%)	GW 2 (%)	Max Infiltration	Impervious (%)	Soil Storage (mm)	Tension Storage (mm)	Soil Percolation (mm/h)	GW 1 Storage (mm)	GW 1 Percolation (mm/h)	GW 1 Coefficient (h)	GW 2 Storage (mm)	GW 2 Percolation (mm/h)	GW 2 Coefficient (h)
3	35	0	0	15	0	208	67.2	1.6	400	0.24	150	700	0	1000
4	35	0	0	15	0	180	48.125	1.6	400	0.24	150	700	0	1000

Figure 4-1: Arawhata Wetland soil types.



5. Transformation

Surface runoff output from the SMA routine is routed through a runoff routing model. The SCS Unit Hydrograph method was chosen for this study. The time of concentration used for each sub-catchment is listed in Table 5-1 below.

Table 5-1: Time of concentration used for each sub-catchment.

Sub-catchment No.	Time of Concentration (min)
1	42.2
2	98.48

Sub-catchment No.	Time of Concentration (min)
3	101.67
4	96.95

6. Calibration

The calibration approach undertaken for this study consisted in running a number of simulations to obtain a graph of simulated flows that is comparable to the observed flows at Hokio Beach Road in terms of peak flows and volumes. The simulated period chosen was between 20 July 2017 15:00 and 13 May 2020 08:00 with a peak flow of 0.848m^3/s on 18 June 2018 at 20:00. The SMA parameters were varied throughout the different simulation runs until the shape and peak of the output flow graph was comparable to the observed flows graph.

A monthly baseflow of 0.2m^3/s was input as a constant flow in each sub-catchment to represent the current groundwater dominated conditions of the Arawhata Drain.

A graph showing the comparison between the simulated flows and the observed flows at Hokio Beach Road and a summary of peak flows obtained from the model (Table 7-1) are attached in Appendix A.

7. Conclusion and limitations

The simulated flows obtained at each drain and at Hokio Beach Road are indicative and suitable for conceptual design purposes only. It should be noted that the results obtained should be refined when more accurate data such as flow rates in individual drain, soil type, monitored groundwater flows and levels, topographical survey, etc. is made available and, therefore, it is subject to change. Recommendations for data collection and collation are made in the main Arawhata Wetland Conceptual Design report.

Appendix A: Simulated flows Vs. Observed flows at Hokio Beach Road.

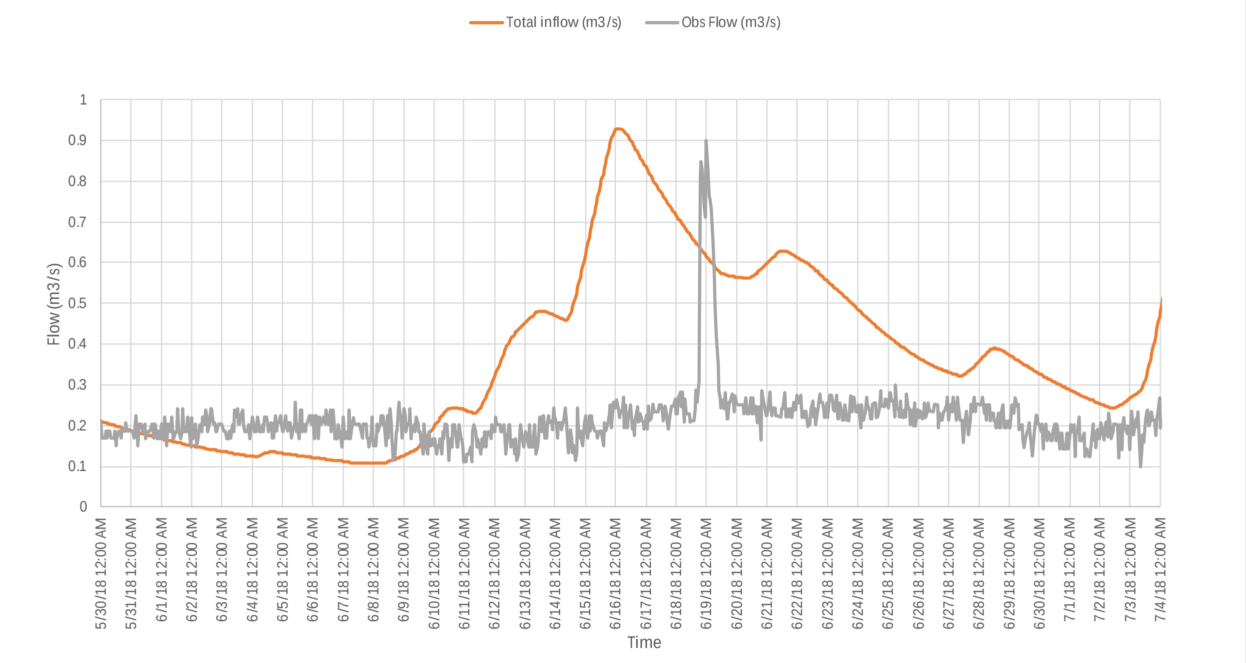


Table 7-1: Summary of peak flow obtained from the HEC-HMS model.

Sub-catchment No.	Peak Flow (m^3/s)
1	0.215
2	0.364
3	0.2
4	0.093
Arawhata at Hokio Beach Road	0.93

Appendix B. Water Quality Modelling and Outputs

Options Analysis for Wetlands Water Quality Modelling Results

The wetlands water quality evaluation was conducted for several configurations of proposed wetlands using Jacob's Treatment Wetlands Design and Analysis Model. The model used the monthly average flow rates and water quality data from the Arawhata Drain at Hokio Beach Road, to determine nutrient removal through the wetlands cells.

Input parameters for the wetlands modelling included assumed inflows to the wetlands, local climatic conditions, an assumption of infiltration characteristics typical of wetlands, and the proposed layouts of the wetlands, discussed in Sections 3, 4 and 5. Climate data for precipitation, air temperature, and Penman ET were obtained from 1990 through 2020 from the Levin AWS Metservice.

The Treatment Wetlands Design and Analysis Model was used to identify the water quality improvements that can be obtained through the wetlands for water flowing through the Kane Farm, Woodhaven Treatment Block, and the Hokio Sediment Trap combined, and Kane Farm and the Hokio Sediment Trap individually. The water quality parameters modelled included nitrate-nitrite as nitrogen and phosphorus, which are parameters of general and specific interest. The model utilises a robust database as well as specific field tests related to treatment performance for these typical parameters. Phosphorus reductions with alumina additions is modelled using low and high reduction factors to bracket anticipated performance of the wetlands.

Model parameters and assumptions, including the areas of the wetlands, the flow volumes going through the wetlands areas, and the constituent loads to the wetlands are presented in Table 1. Projected load outflows and percent reductions are summarised in Table 2.

For the average influent constituent concentrations of NO2-NO3-N, with drain flow only the wetlands model runs showed mass reductions ranging from of 18% for 6 ha at the Hokio Sediment trap to 90% mass reduction for the 87.5 ha combined farm sites. The addition of recirculated water flow to the drain water volume resulted in a mass reduction of the NO2-NO3-N of 8% for the 6 ha Hokio sediment trap area and 68% reduction for the combined 87.5 ha area. When only drain water was used in the model on the 87.5 ha site, the total mass was reduced from a load of 2.2 kg/ha/day in to the mass load out of 0.2 kg/ha/day, while the same area wetlands with drain flow plus recirculated groundwater water reduced the higher total mass in from 4.4 kg/ha/day to 1.4 kg/ha/day mass load out.

For the 87.5 ha site wetlands with only drain water applied, phosphorus mass reduction was 78% without alumina and 93% to 96% with Alumina addition. Adding the recirculated groundwater flow to the drain water flow on the combined 87.5 ha site wetlands, phosphorus mass reduction was 47% without alumina and 78% to 92% with Alumina addition.

Table 1-1. Parameter & Assumptions

Parameters/Assumptions	Combined Kane Farm, Woodhaven Blocks 1-4, Hokio Sediment Trap	Kane Farm only	Hokio Sediment Trap only
Area, ha	87.5	70	6
Average Monthly Flow, Hokio Drain Flow only, m^3/day	19,246	19,246	19,246
Monthly Flow with Hokio Drain Flow and Groundwater Recirculation Pumping, m^3/day	38,966	38,966	38,966
NO2-NO3-N Load in with Hokio Drain Flow only, kg/ha/day	2.2	2.7	32
NO_2-NO_3-N Load in with Hokio Drain Flow and groundwater recirculation, kg/ha/day	4.4	5.6	64.8
DRP Load in with Hokio Drain Flow only, kg/ha/day, kg/ha/day	0.007	.009	0.101
DRP Load in with Hokio Drain Flow and groundwater recirculation, kg/ha/day, kg/ha/day	0.014	0.018	0.205

Parameters	Combined Kane Farm, Woodhaven Blocks 1-4, Hokio Sediment Trap	Kane Farm	Hokio Sediment Trap
NO2-NO3-N Mass Load Out with Arawhata Drain Flow only, kg/ha/day	0.2	0.4	26.4
NO2-NO3-N Percent Concentration Reduction with Arawhata Drain Flow only, %	79%	73%	15%
NO2-NO3-N Percent Mass Reduction with Arawhata Drain Flow only, %	90%	84%	18%
NO2-NO3-N Mass Load Out with Arawhata Drain Flow and groundwater recirculation, kg/ha/day	1.4	2.2	59.8
NO2-NO3-N Percent Concentration Reduction with Arawhata Drain Flow and groundwater recirculation, %	57%	50%	6%
NO2-NO3-N Percent Mass Reduction with Arawhata Drain Flow and groundwater recirculation, %	68%	60%	8%
DRP Mass Load Out with Arawhata Drain Flow only, kg/ha/day	.00155	.00273	0.09248
DRP Percent Concentration Reduction in, with Arawhata Drain Flow only, %	54%	46%	5%
DRP Percent Mass Reduction with Arawhata Drain Flow only, %	78%	68%	8%
DRP Mass Load Out with Arawhata Drain Flow and groundwater recirculation, kg/ha/day	.00746	.01067	0.19646
DRP Percent Concentration Reduction with Arawhata Drain Flow and groundwater recirculation, %	29%	24%	2%
DRP Percent Mass Reduction with Arawhata Drain Flow and groundwater recirculation, %	47%	39%	4%
DRP Mass Load Out with Arawhata Drain Flow only and alumina addition, kg/ha/day	0.00026 to 0.00051	0.00043 to 0.00095	0.05455 to 0.07795
DRP Percent Concentration Reduction with Arawhata Drain Flow only and alumina addition, %	85% to 92%	81% to 91%	20% to 44%
DRP Percent Mass Reduction with Arawhata Drain Flow only and alumina addition, %	93% to 96%	89% to 95%	23% to 46%
DRP Mass Load Out , with Arawhata Drain Flow and groundwater recirculation and alumina addition, kg/ha/day	0.00116 to 0.00315	0.00192 to 0.00515	0.15157 to 0.18186
DRP Percent Concentration Reduction , with Arawhata Drain Flow and groundwater recirculation and alumina addition, %	70% to 89%	63% to 86%	10% to 25%
DRP Percent Mass Reduction , with Arawhata Drain Flow and groundwater recirculation and alumina addition, %	78% to 92%	71% to 89%	11% to 26%

Appendix C. Wetland Designs

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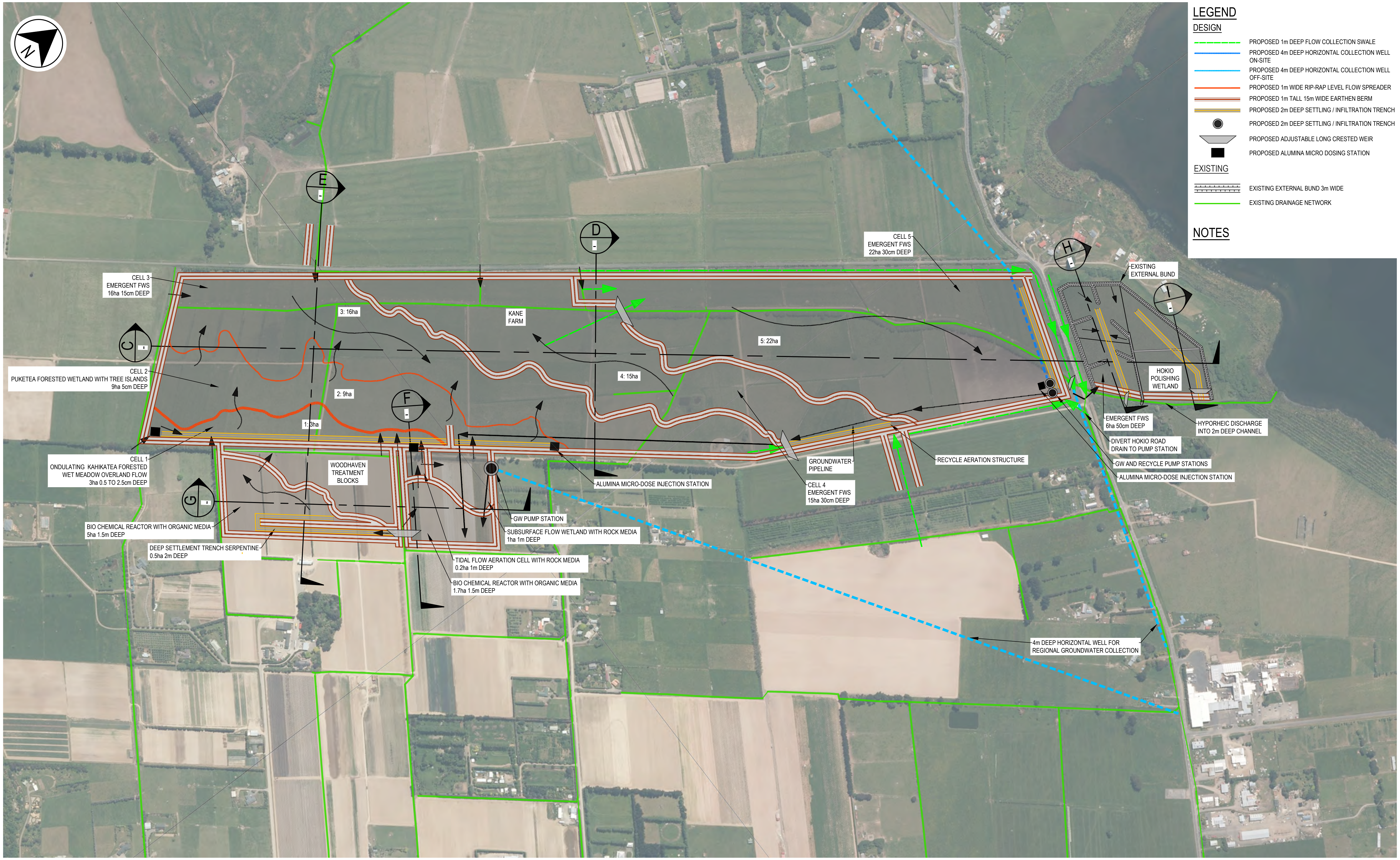

PLAN - HOKIO BEACH ROAD, KANE FARM AND WOODHAVEN TREATMENT BLOCKS
SCALE 1:4000

0 50 100 150 200m
SCALE 1:4000 (A3)

FOR INFORMATION ONLY

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0	11/12/20	CZ	AD	TB	ISSUE FOR INFORMATION	IZ060501-001	

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CLIENT HORIZONS REGIONAL COUNCIL
PROJECT ARAWHATA WETLAND PROJECT

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
CZ	TB	DA	TB
DESIGNED	DESIGN REVIEW		
MM	EH	DATE 11/12/2020	DATE 11/12/2020

TITLE
HOKIO BEACH ROAD, KANE FARM AND WOODHAVEN TREATMENT BLOCKS PLAN

SCALE AS SHOWN
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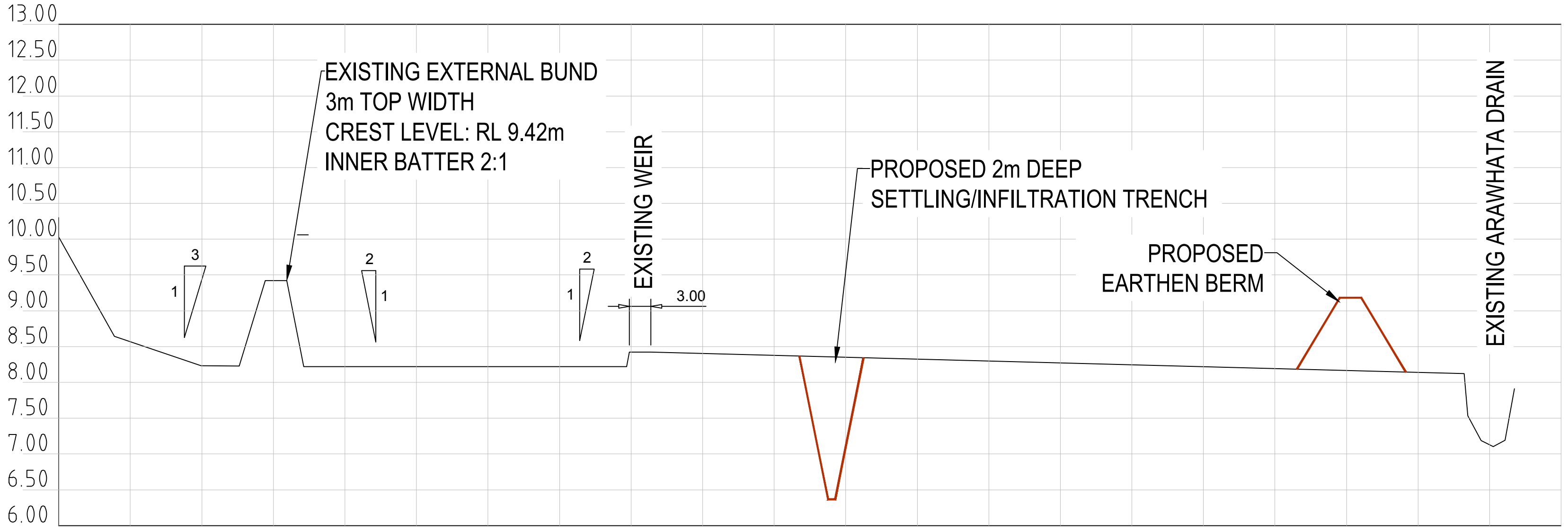
REV 1



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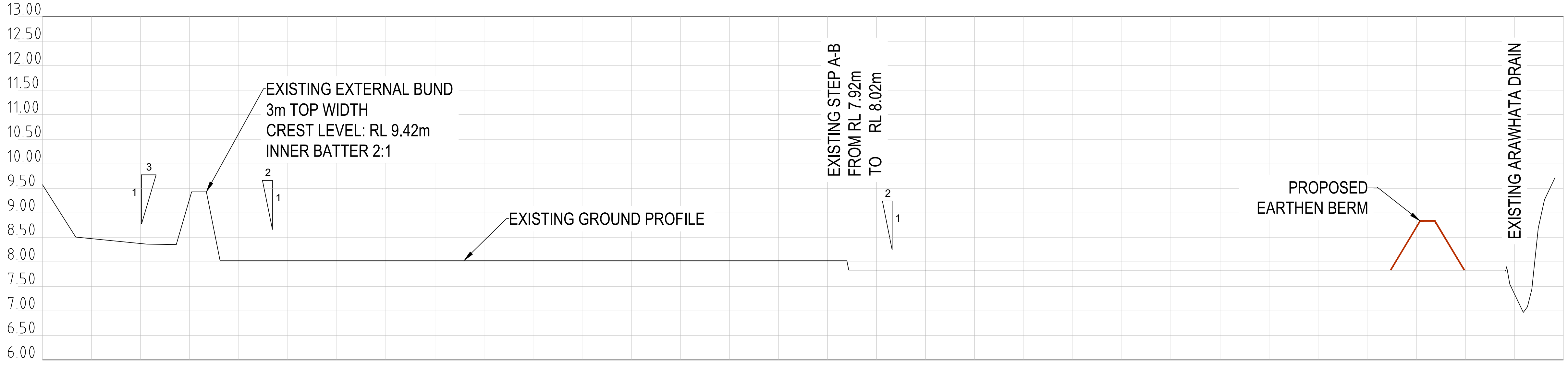

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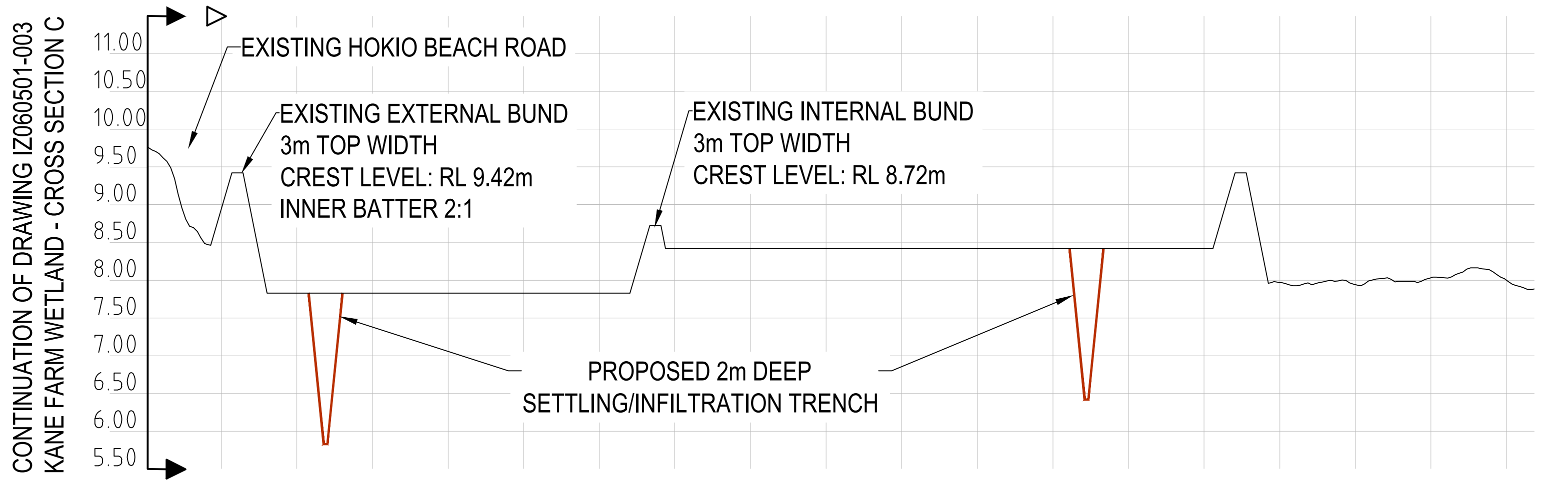

SECTION C
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LEGEND

EXISTING

EXISTING GROUND PROFILE

DESIGN

PROPOSED GROUND PROFILE

NOTES

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SCALE 1:500 (A3)

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SCALE 1:1000 (A3)

HOKIO BEACH ROAD POLISHING WETLAND - CROSS SECTIONS

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0	11/12/20	CZ	AD	TB	ISSUE FOR INFORMATION	IZ060501-002	HOKIO BEACH ROAD POLISHING WETLAND - CROSS SECTIONS C, H AND I

horizons regional council

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CLIENT: HORIZONS REGIONAL COUNCIL
PROJECT: ARAWHATA WETLAND PROJECT

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
CZ	TB	DA	TB
DESIGNED	DESIGN REVIEW	DATE 11/12/2020	DATE 11/12/2020
MM	EH		

TITLE: HOKIO BEACH ROAD
POLISHING WETLAND
CROSS SECTIONS C, H & I

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AS SHOWN	IZ060501-002	0

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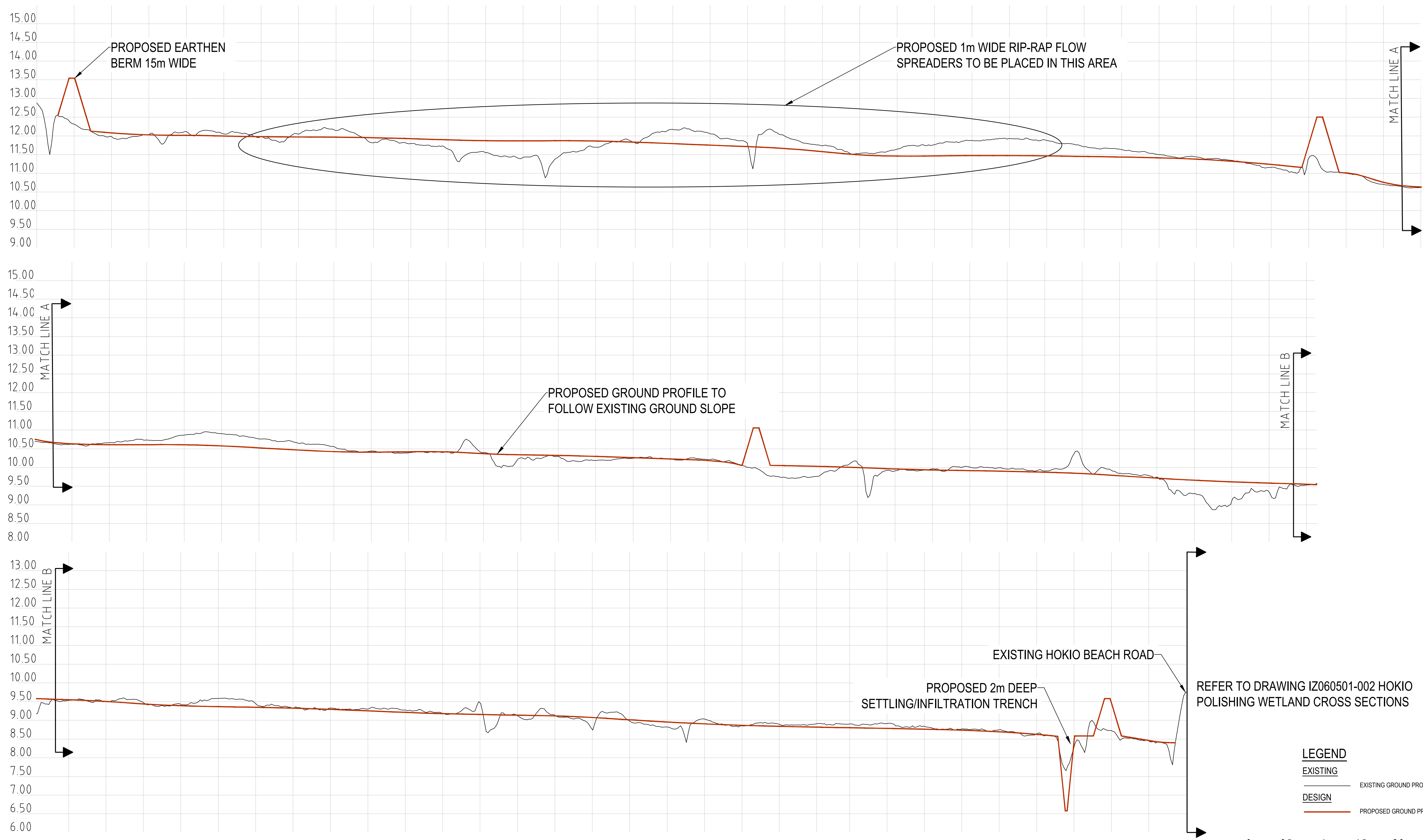

REFER TO DRAWING IZ060501-002 HOKIO POLISHING WETLAND CROSS SECTIONS

LEGEND
EXISTING
EXISTING GROUND PROFILE
DESIGN
PROPOSED GROUND PROFILE

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SCALE 1:50 (A3)
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SCALE 1:1000 (A3)

SECTION C -
SCALE 1:1000H 1:50V

KANE FARM WETLAND - LONGSECTION

FOR INFORMATION ONLY

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CLIENT HORIZONS REGIONAL COUNCIL
PROJECT ARAWHATA WETLAND PROJECT

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
CZ	TB	DA	TB
DESIGNED	DESIGN REVIEW	DATE 11/12/2020	DATE 11/12/2020
MM	EH		

TITLE KANE FARM WETLAND LONGSECTION C

SCALE AS SHOWN | DRAWING No IZ060501-003 | REV 0

LEGEND

EXISTING

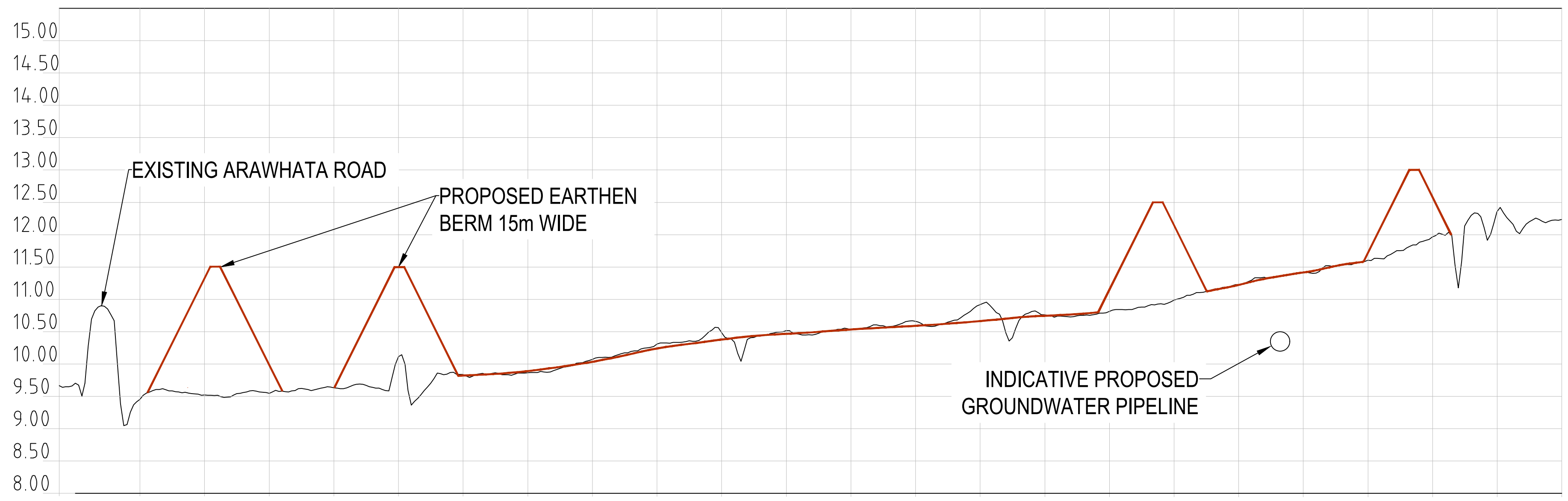
EXISTING GROUND PROFILE

DESIGN

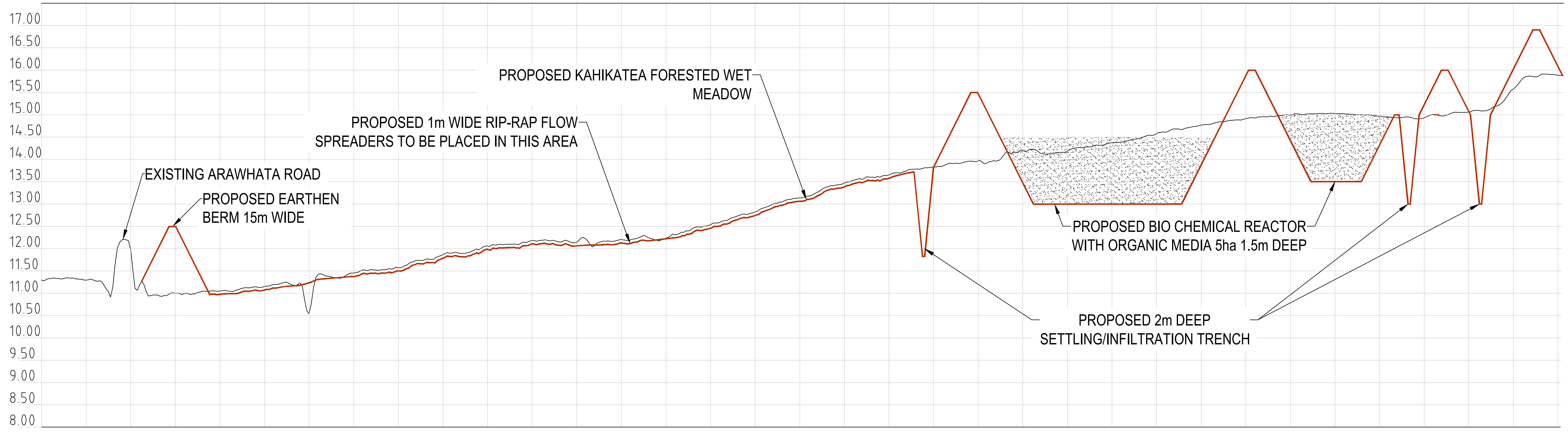
PROPOSED GROUND PROFILE

PROPOSED ORGANIC MEDIA FILLING

NOTES



SECTION D
SCALE 1:1000H 1:50V



SECTION E
SCALE 1:1000H 1:50V

0 0.5 1 1.5 2.0 2.5m
SCALE 1:50 (A3)

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

KANE FARM WETLAND - CROSS SECTION

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REV	DATE	DRAWN	REV'D	APP'D	REVISION	DRAWING NUMBER	REFERENCE DRAWING TITLE
0	11/12/20	CZ	AD	TB	ISSUE FOR INFORMATION	IZ060501-004	KANE FARM WETLAND - CROSS SECTIONS D AND E

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PROJECT ARAWHATA WETLAND PROJECT

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DESIGNED MM	DESIGN REVIEW EH	DATE 11/12/2020	DATE 11/12/2020

TITLE KANE FARM WETLAND CROSS SECTIONS D AND E

SCALE	DRAWING No	REV
AS SHOWN	IZ060501-004	0

LEGEND

EXISTING

EXISTING GROUND PROFILE

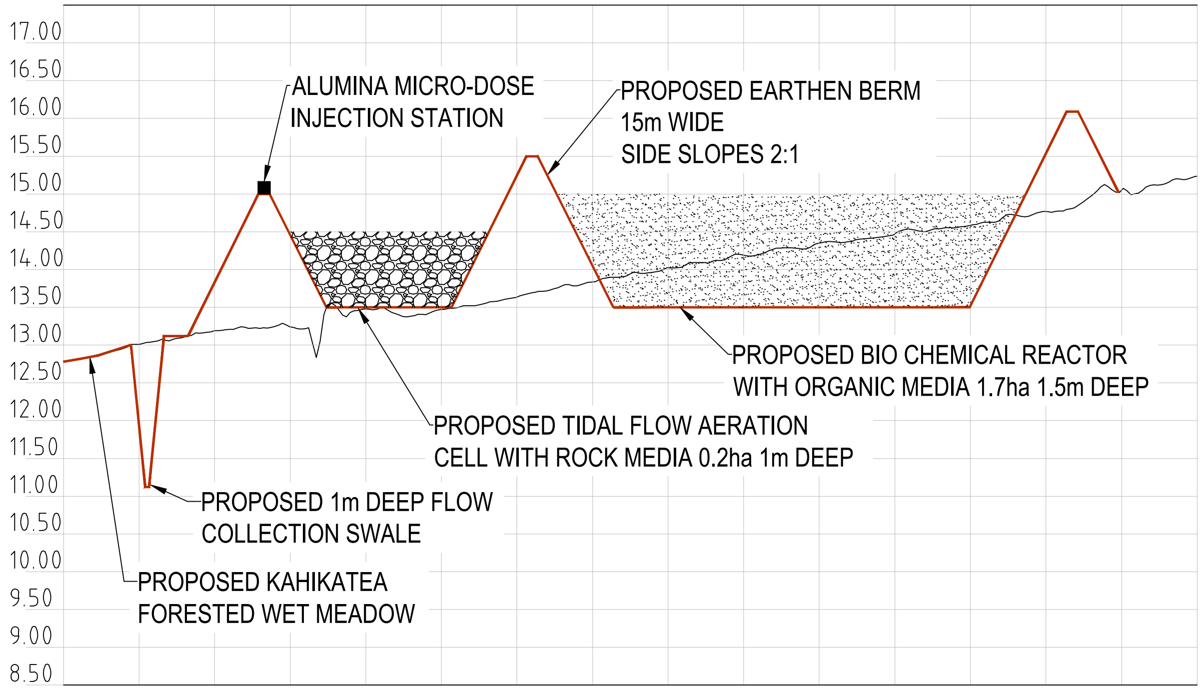
DESIGN

PROPOSED GROUND PROFILE

PROPOSED ROCK MEDIA FILLING

PROPOSED ORGANIC MEDIA FILLING

NOTES



SECTION F
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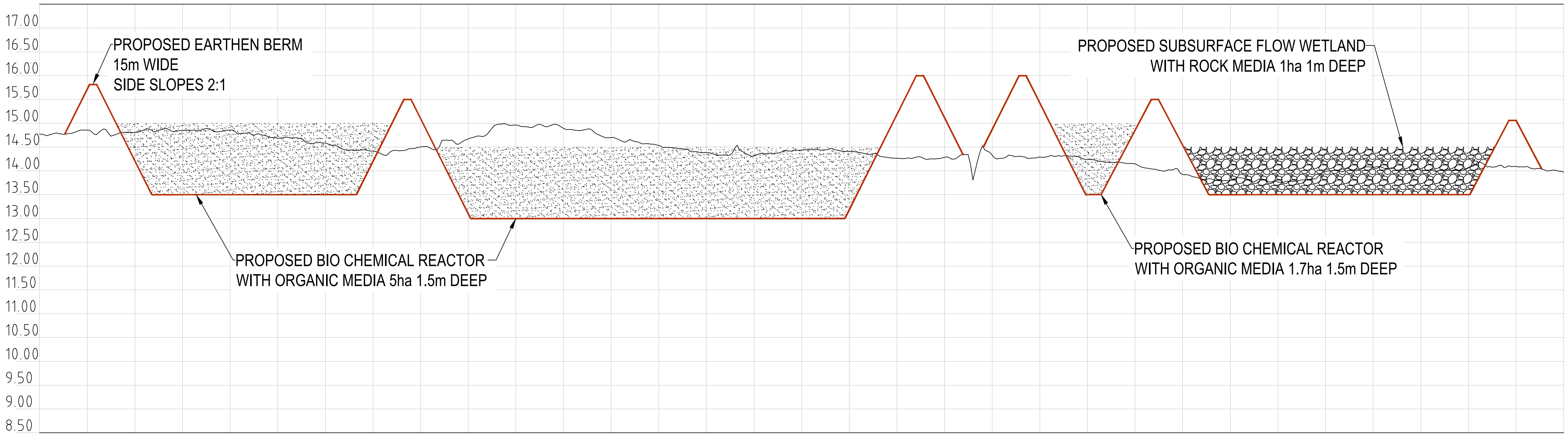

SECTION G
SCALE 1:1000H 1:50V

0 500 1000 1500 2000 2500mm

SCALE 1:50 (A3)

0 10 20 30 40 50m

SCALE 1:1000 (A3)

WOODHAVEN TREATMENT BLOCKS WETLAND - CROSS SECTIONS F & G

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REV	DATE	DRAWN	REV'D	APP'D	REVISION	DRAWING NUMBER	REFERENCE DRAWING TITLE
0	11/12/20	CZ	AD	TB	ISSUE FOR INFORMATION	IZ060501-005	WOODHAVEN TREATMENT BLOCKS WETLAND - CROSS SECTIONS F AND G

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TITLE WOODHAVEN TREATMENT BLOCKS WETLAND CROSS SECTIONS F AND G

SCALE	DRAWING No	REV
AS SHOWN	IZ060501-005	0

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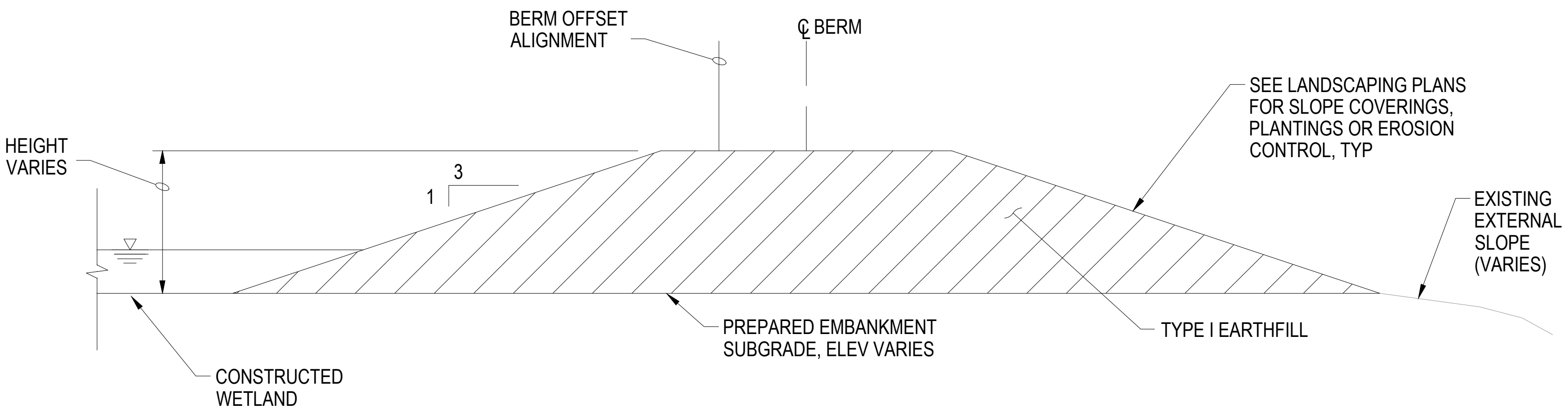
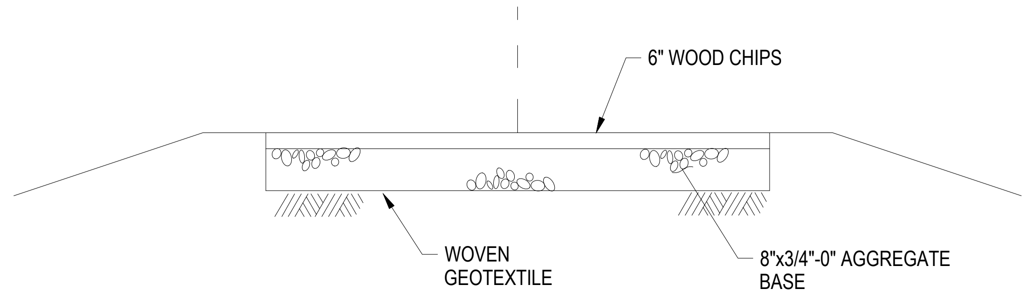
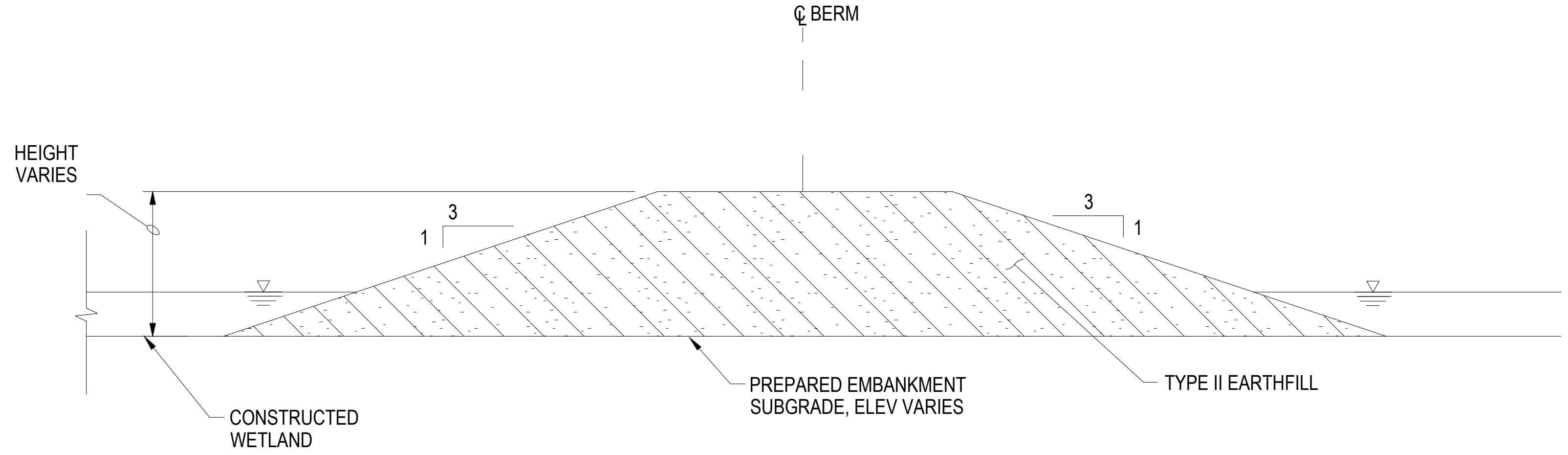


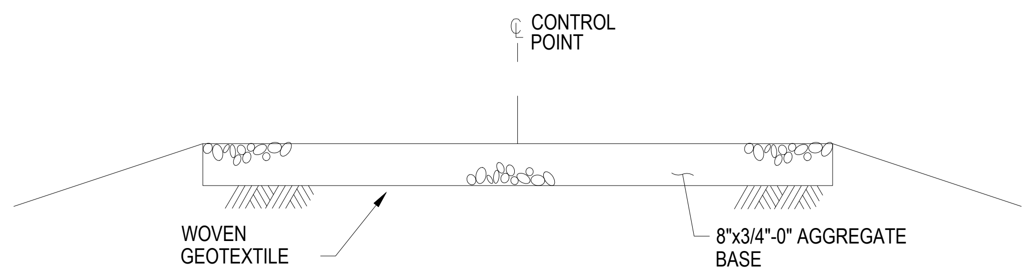
TYPE I EARTHFILL BERM SECTION



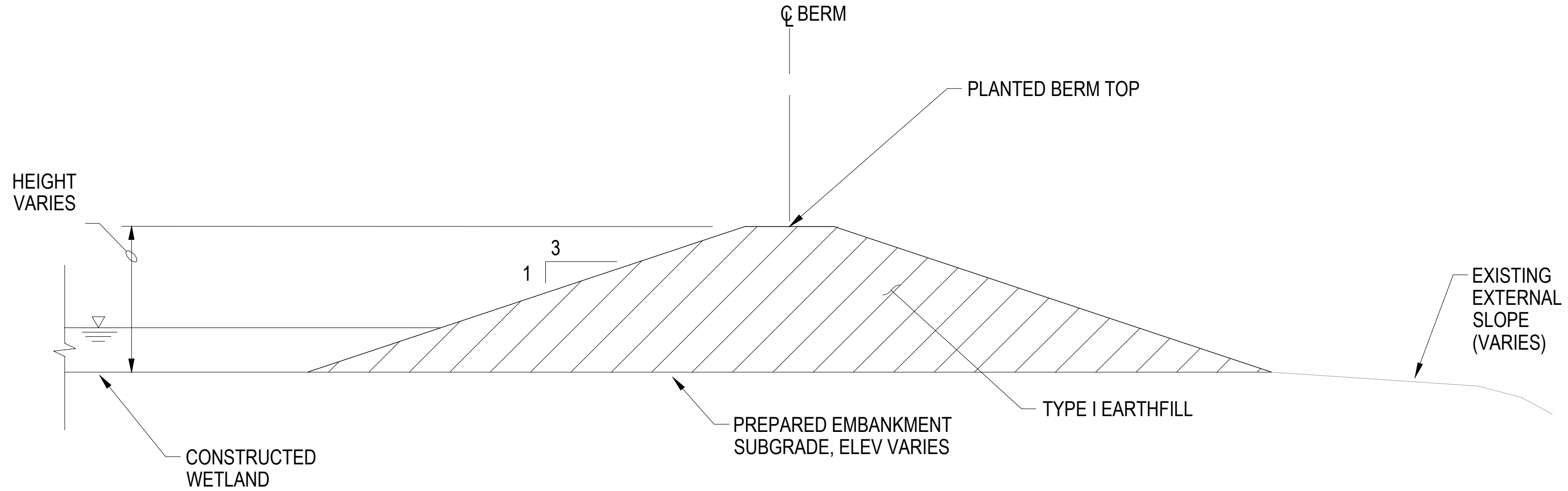
SOFT PATH



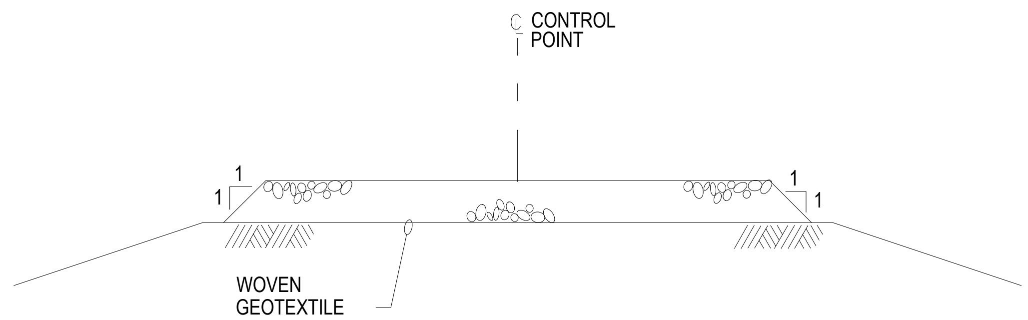
TYPE II EARTHFILL BERM SECTION



VEHICLE ACCESS



TYPE I EARTHFILL BERM SECTION (NO TRAIL)



INTERIOR BERM WALKING TRACK

TYPICAL BERM SECTIONS
NOT TO SCALE

TYPICAL BERM PATH CONSTRUCTION DETAILS
NOT TO SCALE

NOTE: TYPYCAL DETAILS ARE SHOWN FOR CONCEPT DESIGN PURPOSES. DIMENSIONS IN U.S. CUSTOMARY UNITS WILL NEED CONVERSION TO SI.

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REV	DATE	DRAWN	REV'D	APP'D	REVISION	DRAWING NUMBER	REFERENCE DRAWING TITLE
0	12/02/21	CZ	AD	TB	ISSUE FOR INFORMATION	IZ060501-006	TYPICAL DETAILS - SHEET 1 OF 4

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PROJECT: ARAWHATA WETLAND PROJECT

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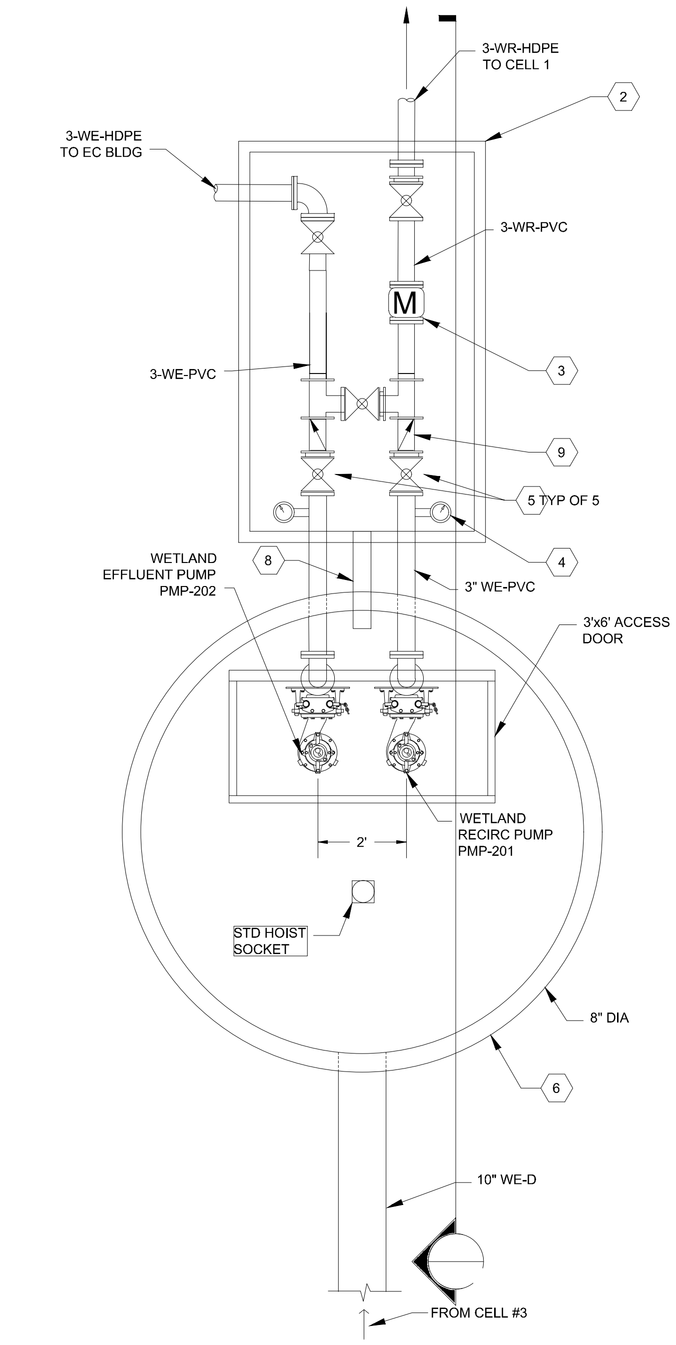
DESIGNED	DESIGN REVIEW		
MM	EH	DATE 15/01/21	DATE 15/01/21

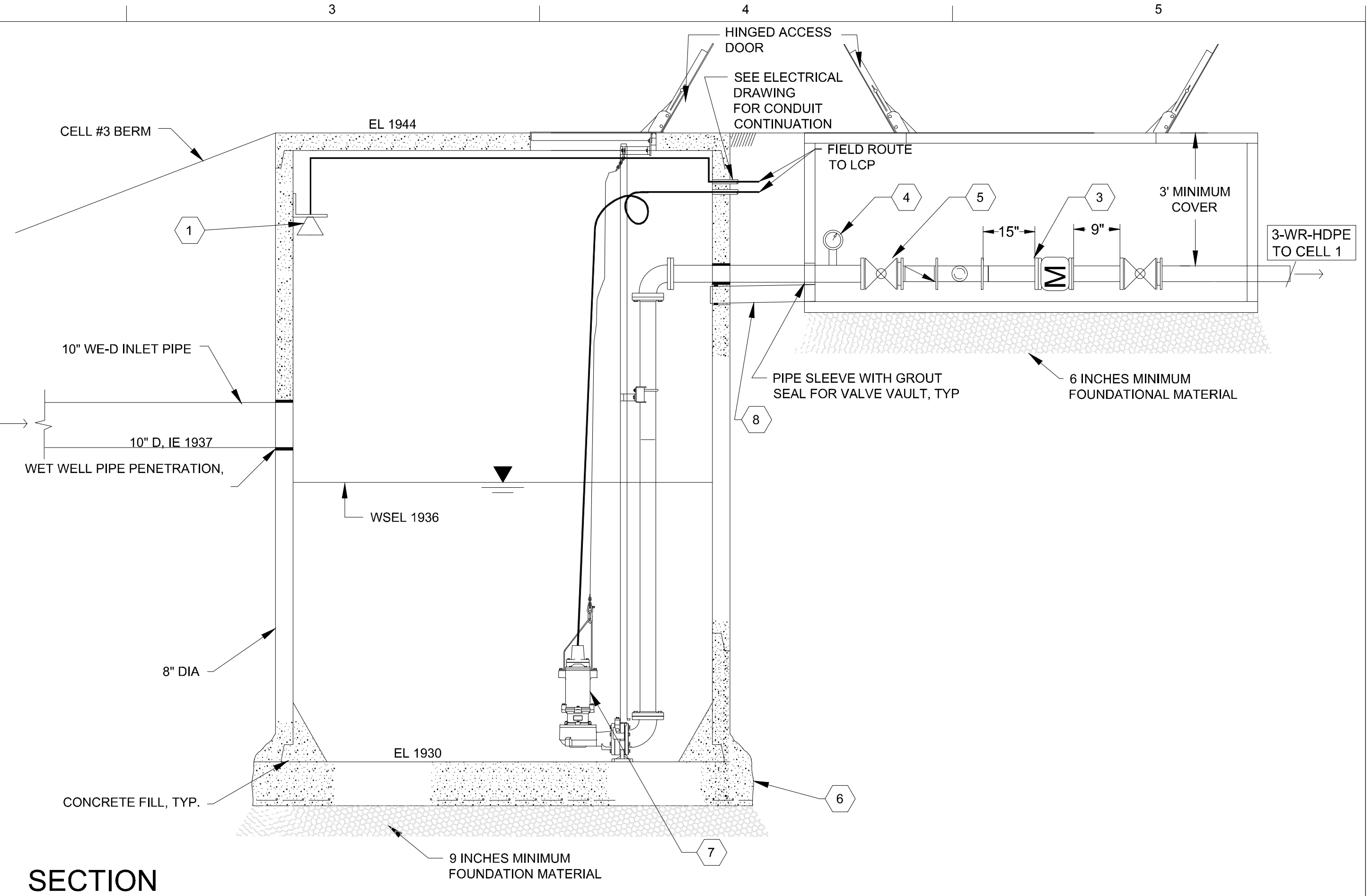
TITLE: TYPICAL DETAILS
SHEET 1 OF 4

SCALE: N.T.S. | DRAWING No: IZ060501-006 | REV: 0



PUMP STATION PLAN

NTS



SECTION

NTS

WETLAND EFFLUENT SUMP PUMP SCHEDULE

PMP-201 WR SUMP PUMP 75 GPM AT 19 FT TDH MAX GOULDS 3WD51E3AA, 1HP, 230V/3PH MOTORS WITH VFD POWER SUPPLY
(50 GPM AT 10 FT TDH TYP)
PMP-202 WE SUMP PUMP 75 GPM AT 19 FT TDH MAX GOULDS 3WD51E3AA, 1HP, 230V/3PH MOTORS WITH VFD POWER SUPPLY
(50 GPM AT 17 FT TDH TYP)

SUBMERSIBLE PUMP TESTING REQUIREMENTS:

3.01 FIELD QUALITY CONTROL

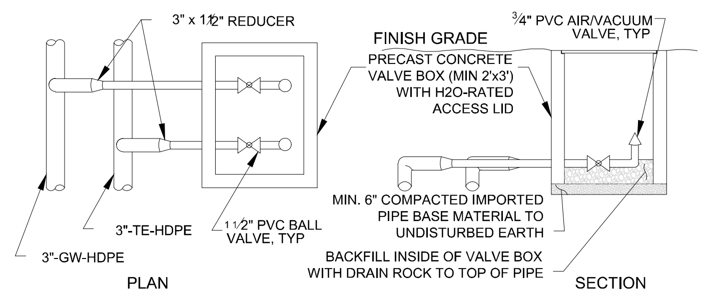
A. FUNCTIONAL TEST: CONDUCT ON EACH PUMP.

1. ALIGNMENT: TEST COMPLETE ASSEMBLIES FOR CORRECT ROTATION, PROPER ALIGNMENT AND CONNECTION, AND QUIET OPERATION.
2. FLOW OUTPUT: MEASURED BY PLANT INSTRUMENTATION AND/OR WET WELL VOLUME.
3. TEST FOR CONTINUOUS 30-MINUTE PERIOD, MINIMUM.

B. PUMP TEST:

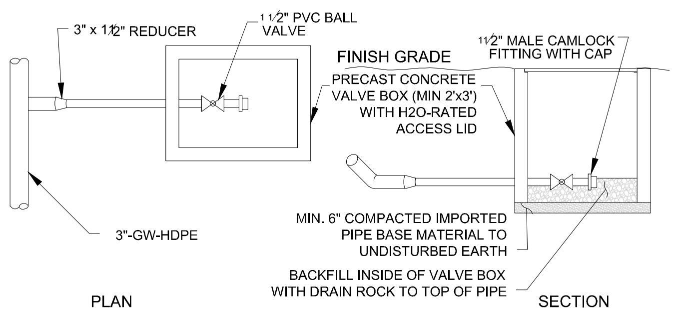
1. GENERAL:
   a. CONDUCT ON EACH PUMP PROVIDED.

2. ROUTINE PRODUCTION TESTS:
   a. CHECK IMPELLER, MOTOR RATING AND ELECTRICAL CONNECTIONS FOR COMPLIANCE TO SPECIFICATION OR INDUSTRY STANDARD.
   b. TEST MOTOR AND CABLE INSULATION FOR MOISTURE CONTENT AND INSULATION DEFECTS.
   c. PRIOR TO SUBMERGENCE, RUN PUMP DRY TO ESTABLISH CORRECT ROTATION AND MECHANICAL INTEGRITY.
   d. CONDUCT ABBREVIATED THREE-POINT OPERATIONAL PERFORMANCE TEST.



5 AIR/VACUUM RELEASE VALVE ASSEMBLY

NTS



6 BLOWOFF STATION

NTS

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0	12/02/21	CZ	AD	TB	ISSUE FOR INFORMATION	IZ060501-007	TYPICAL DETAILS - SHEET 2 OF 4

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PROJECT ARAWHATA WETLAND PROJECT

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MM	EH		

TITLE TYPICAL DETAILS
SHEET 2 OF 4

SCALE N.T.S. DRAWING No IZ060501-007 REV 0

DATE: 2/12/2021 4:53:22 PM NAME: ZUCCO, CLAUDIA
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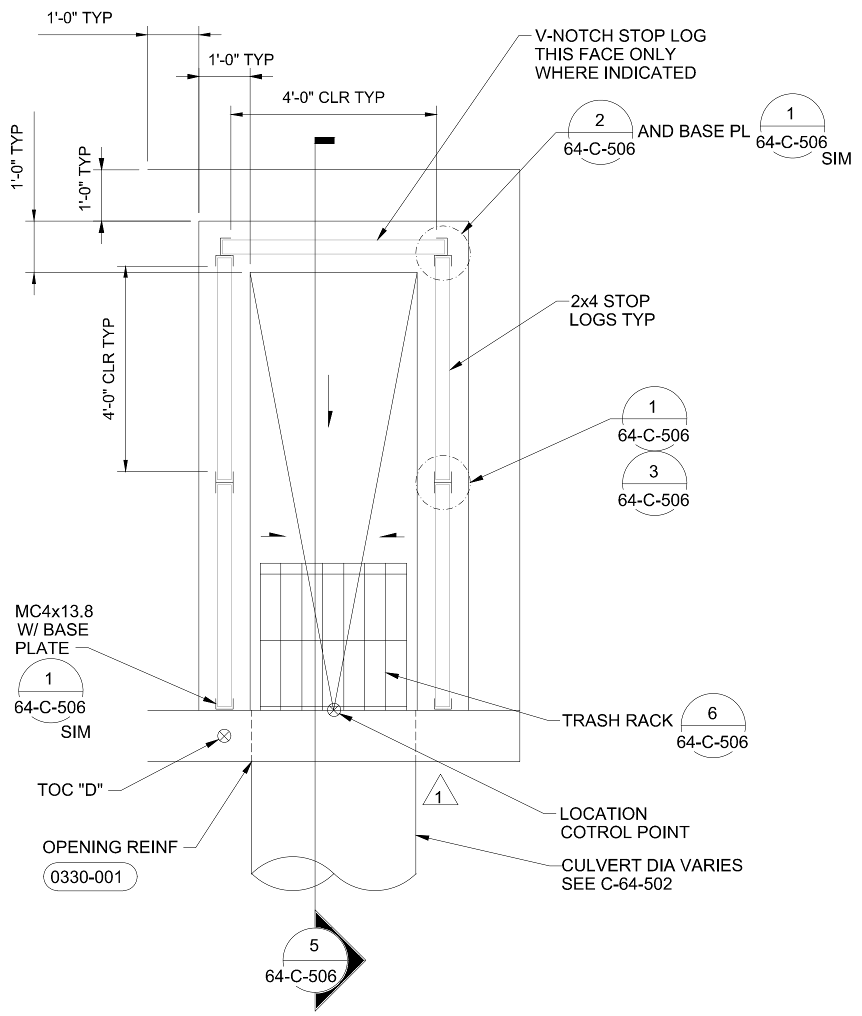
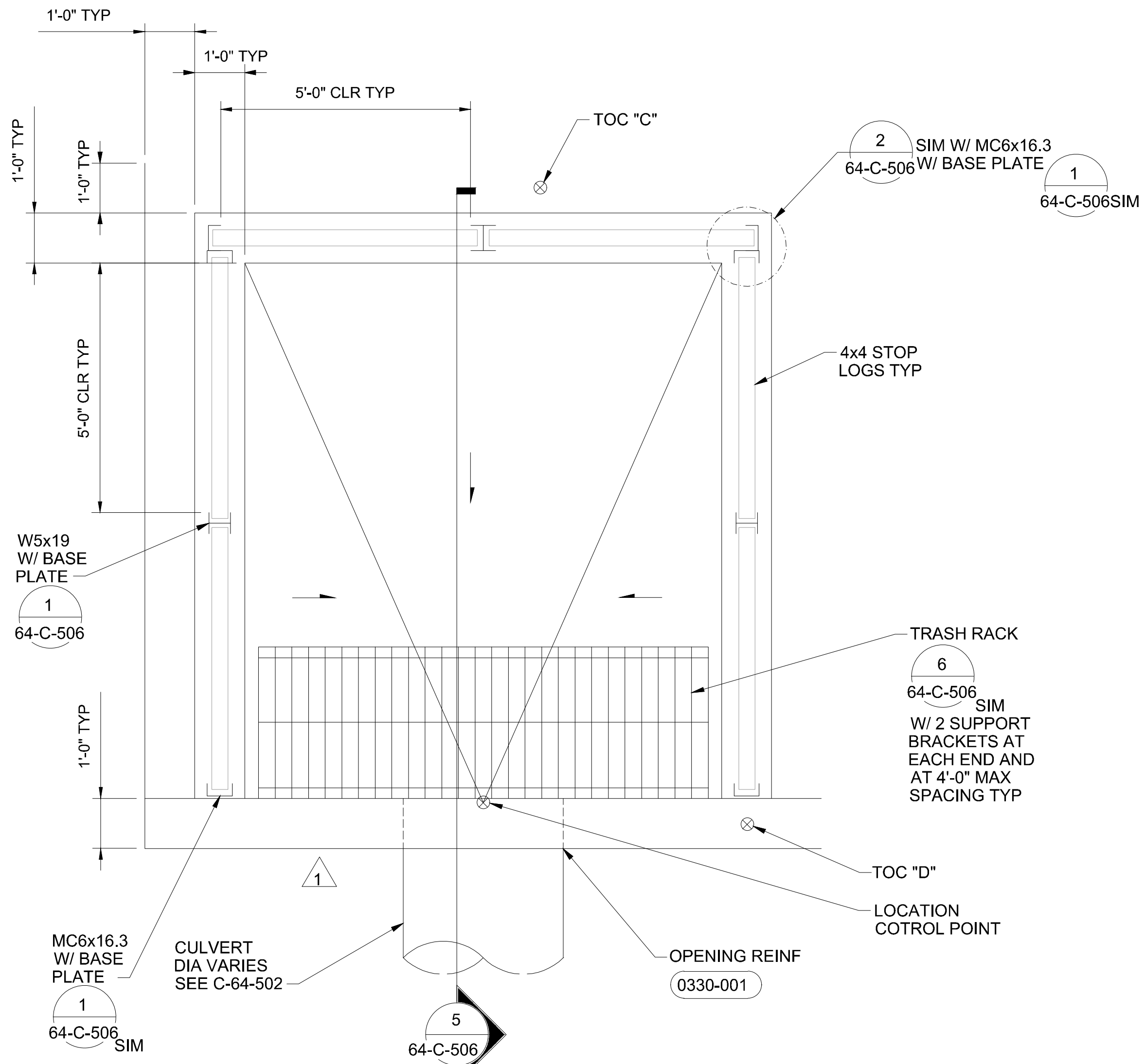


1 TYPE I (SMALL) WEIR STRUCTURE
NTS



2 TYPE II (LARGE) WEIR STRUCTURE
NTS

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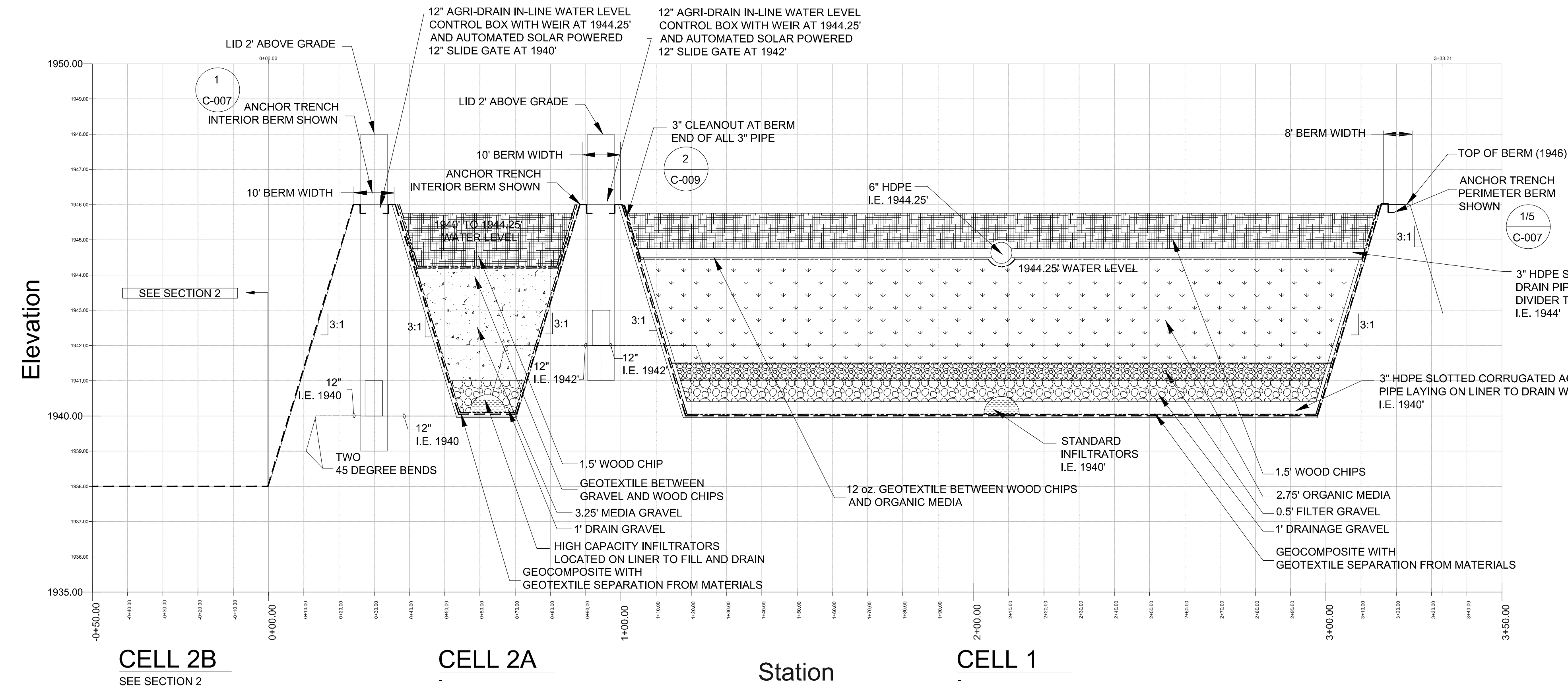
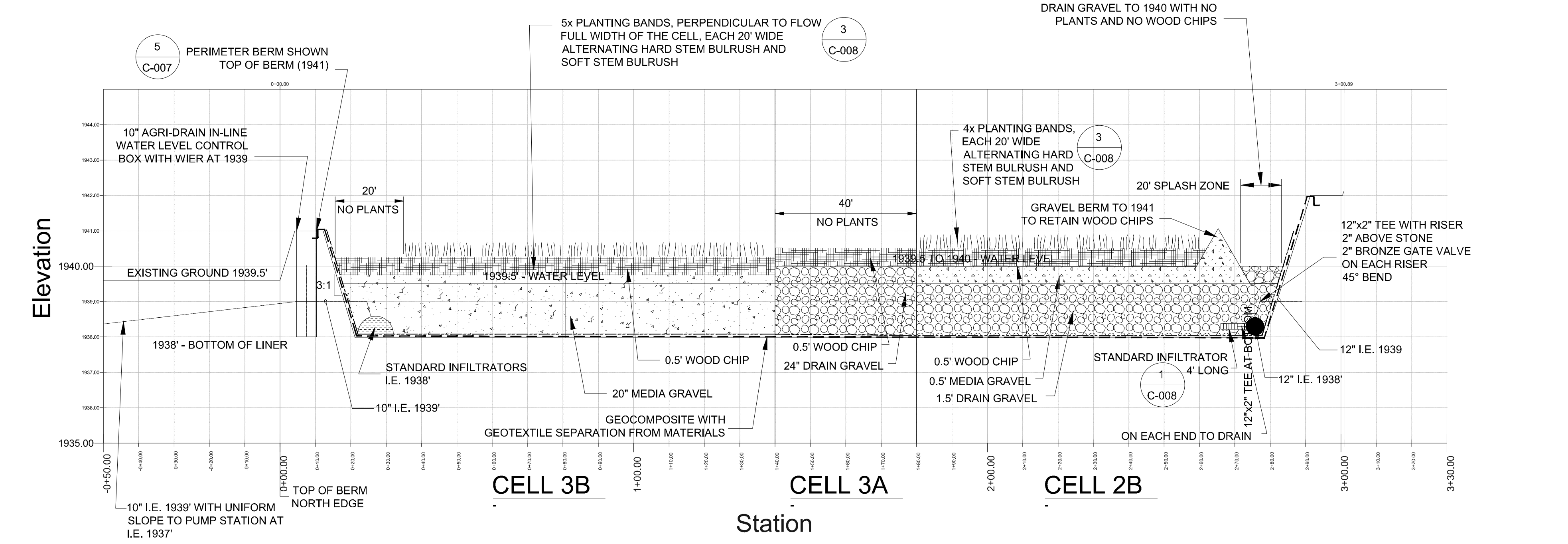
MM	EH		

TITLE TYPICAL DETAILS SHEET 3 OF 4

SCALE N.T.S. | DRAWING No IZ060501-008 | REV 0



1 CELL 1-2A CROSS SECTION DETAIL
BIO-CHEMICAL REACTOR (BCR) - NTS



2 CELL 3-2B CROSS SECTION DETAIL
HORIZONTAL SUBSURFACE FLOW WETLAND (SSF) - NTS

NOTE: TYPYCAL DETAILS ARE SHOWN FOR CONCEPT DESIGN PURPOSES. DIMENSIONS IN U.S. CUSTOMARY UNITS WILL NEED CONVERSION TO SI.

LEGEND

- WOOD CHIPS (100%)
- ORGANIC MEDIA (65% WOOD CHIPS, 25% SAWDUST, 9% GRASS HAY, AND 1% COMPOSTED HORSE MANURE BY VOLUME)
- FILTER GRAVEL (1" ROUNDED RIVER ROCK)
- MEDIA GRAVEL (3/4" ANGULAR BASALT)
- DRAIN GRAVEL (1 1/2" ROUNDED RIVER ROCK)
- 12 oz. NON-WOVEN GEOTEXTILE
- COMPOSITE GEOMEMBRANE - (GCL)

ROCK SPECS

1 1/2" DRAINAGE GRAVEL ROUNDED RIVER ROCK

SIZE	PASSING
2"	100%
3/4"	MAX 10%
FINES	<2%

1" FILTER GRAVEL ROUNDED RIVER ROCK

SIZE	PASSING
1 1/2"	100%
1/2"	MAX 10%
FINES	<2%

3/4" GRAVEL MEDIA CRUSHED ANGULAR BASALT

SIZE	PASSING
1"	100%
1/2"	MAX 10%
FINES	<2%

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MM	EH		

TITLE: TYPICAL DETAILS SHEET 4 OF 4
SCALE: N.T.S.
DRAWING No: IZ060501-009
REV: 0

Appendix D. Planning Assessment

Jacobs

Memorandum

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Subject	Consenting Requirements	Project Name	Arawhata Wetland
Attention	Horizons Regional Council	Project No.	IZ060501
From	Nick Cooper		
Date	November 23, 2020		
Copies to	Tim Baker		

1. Introduction

Horizons Regional Council has engaged Jacobs New Zealand Ltd to undertake the design of a wetland as a method to remediate nitrogen enriched groundwater before it flows into Waipunahau / Lake Horowhenua via the Arawhata Drain.

This memorandum provides summary information on the process and likely resource consents required from the Horizons Regional Council (HorRC) and Horowhenua District Council (HDC), affected parties, and consenting risks.

2. Scope of Work

The advice in this memorandum is based upon a review of a preliminary design and discussions with Tim Baker, Jacobs' hydrogeologist. The object of the proposal is to capture groundwater enriched with high levels of nitrogen and to remove the nitrogen by way of physical, chemical and biological processes before the water flows into Lake Horowhenua.

The site for the proposal is rural land 1 kilometre south and west of Levin, between Lakes Papaitonga and Horowhenua. The site is a semi rectangular area on a northeast to southwest alignment and is approximately 1.25kms in length and 0.2kms in width. It is currently pastoral land with a smaller area of horticultural land on the south eastern corner (Figure 1 below). There is an elevation change of approximately 7m from the south west to the north east (Hokio Beach Road) of the site.

The main part of the site contains 2 main farm drains and lateral drains. The project intent is to create a series of four semi terraced wetlands with groundwater captured by a cut off drain (blue line marked as 'B', Figure 1), passed through a treatment zone (Area A, Figure 1) before entering the terraced sequence of wetlands to flow towards lake Horowhenua.

Figure 1: Location Plan of Arawhata project.

The proposed works involve;

- Reclamation of drainage channels;
- Installation of new drainage features;
- Re-contouring of land to form sequential and semi terraced treatment zones;
- A subsurface cut off drain;
- Pumping station and biological or chemical treatment systems; and
- Potential amenity works including landscape planting and recreational features

3. Statutory context

The site is located within the administrative areas of the Horowhenua District Council (HDC) and the Horizons Regional Council (HorRC).

HorRC has an operative Regional Policy Statement and Regional Plan (the One Plan) as of December 2014 with subsequent plan changes in 2016 and 2018. The One Plan has identified the location of the site (situated between Lake Horowhenua and Lake Papaitonga) as significant as follows:

- The site is listed in the One Plan Schedule A Water Management Zones as part of Hoki_1 (Lake Horowhenua) and West_8 (Lake Papaitonga).
- The site has Surface Water Management Values as described in the One Plan Schedule B: Surface Water Management Values relating to ecology, biodiversity, flood control, and amenity.

The impact of these values is addressed in the discussion on resource consents under the One Plan below.

HDC has an operative District Plan as of 3/06/2015 with Plan changes 1 and 2 operative as at 1/11/2018. The site is zoned Rural, with parts of the site subject to 'Versatile Land' and 'Flood Hazard Area' overlays. Lake Horowhenua and the Hokio Stream are identified under Schedule 12 of the District Plan as "Priority water bodies" in terms of natural, ecological, recreational, and cultural values. Works critical to the project are likely to be permitted by the District Plan. This is further addressed in the discussion on resource consents under the District Plan section below.

The National Policy Statement for Freshwater Management 2020 (NPS-FM) is relevant to the assessment of the activities.

The concept of Te Mana o Te Wai is central to the NPS-FM. Te Mana o Te Wai recognises the interdependence between the health and mauri of water, the quality of the wider environment and the health and mana of the community that relies on it. The NPS-FM has also further recognised and provided for tangata whenua as active participants in planning, decision-making and monitoring in the freshwater management space.

Two proposed National Policy Statements in relation to Highly Productive Land and Indigenous Biodiversity may also need to be considered in assessing the impact of the activities for the project.

At this time there are no other NPS's, National Environmental Standards or Regulations that are relevant to the proposal as described.

4. Resource consents from HorRC under the One Plan

The proposal incudes the following activities that are subject to Rules in the One Plan

- Earthworks and ground disturbance;
- Reclamation of watercourses;
- The temporary (during construction) and permanent diversion of surface water and ground water;
- The discharge of contaminants to land and fresh water (including sediment and aluminum flocculant); and,
- Disturbance of identified habitat

The Rules that relate to these activities are found within the One Plan Chapters as follows:

- Chapter 13: Land disturbance including earthworks;
- Chapter 14: Discharges to Land and Water;
- Chapter 16: Takes, Uses and Diversions of Water, and Bores; and,
- Chapter 17: Activities in Artificial Watercourses, Beds Of Rivers and Lakes, and Damming.

A list of the relevant rules is provided as Appendix 1. An assessment of the overall activity status of the project under the listed rules is that it would be a discretionary activity.

5. Resource consents from HDC

At this preliminary assessment stage, it is possible that some, if not all of the primary land use elements associated with the proposal could be permitted activities under the HDC District Plan. The types of activities within the Rural Zone that are permitted are;

- Open space;
- Earthworks, except in association with a heritage setting, or an outstanding natural feature or landscape;
- Maintenance of flood control, erosion control, or drainage works by or on behalf of the Manawatu-Wanganui Regional Council within the Manawatu River Estuary, Coastal and Lake Horowhenua Outstanding Natural Features and Landscapes.

There are no activities associated with the Arawhata wetland proposal that would be either a controlled or restricted discretionary under the HDC District Plan.

The types of activities that would be potentially associated with the proposal which would require resource consent as discretionary activities include:

- New community facilities or external additions and alterations to existing community facilities (including education facilities and grounds) for community activities, including services having a social, community, ceremonial, cultural, educational, recreational, worship, or spiritual purpose.

Subject to a review of a final design, there could be resource consent required if there is any non-compliance with standards in relation to:

- Works within the flood hazard overlay;
- Noise; and,
- Odour.

An updated assessment of likely consents required would be provided when a definite preliminary or detailed design has been decided upon.

6. Other types of approvals

There are a significant number of recorded archaeological sites in the vicinity of the site location as per the excerpt from the Archsite public GIS webmap below. There is the potential that earth disturbance resulting from the proposal would uncover further archaeological remains. Archaeological sites are protected under the Heritage New Zealand Pouhere Taonga Act (2014). It is recommended that the areas of earthworks for the proposal are assessed by an Archaeologist. Depending upon their findings a general authority for the works may need to be obtained from Heritage New Zealand Pouhere Taonga.

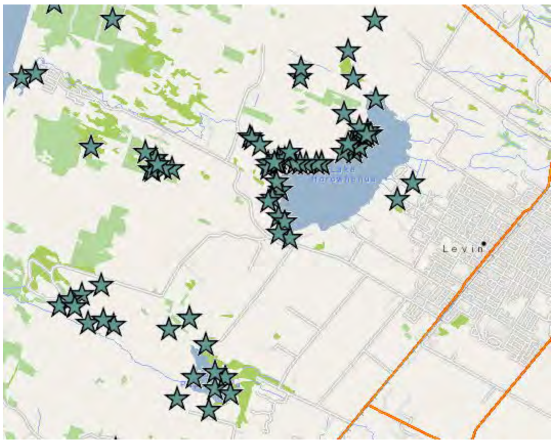

Figure 2: Excerpt from Archsite webmap showing recorded archeological sites in the vicinity of the project site.

7. Types of environmental approval process

Different types of resource consent or approval processes are potentially available as described below.

Standard resource consent: Applications for separate resource consents can be made to HoRC and / or HDC and subject to RMA statutory provisions

Fast Track Consent Process: Application process set up under the COVID-19 Recovery (Fast-track Consenting) Act 2020. An application for a fast track process is made to the Environmental Protection Agency (EPA) and is decided by the Minister for the Environment. If accepted the fast tracked resource consents would be processed by the EPA and referred to an expert consenting panel.

Direct Referral: An applicant can make a request to a council that the notified resource consent is decided directly by the Environment Court.

Notice of Requirement: A Notice of Requirement (NoR) provides for a Requiring Authority (defined under Section 166 of the RMA) to designate land for a certain purpose by notifying the relevant territorial local authority (Horowhenua District Council). A NoR would be notified and maybe subject to a Hearing if there are submissions. It is good practice for the requiring authority to liaise with affected land owners at an early stage which will ensure that they are well aware of the notice of requirement.

Table 1: Summary of Types of Environmental Approvals

Type of Approval	Advantage	Disadvantage
Standard Resource Consent	Resource consent applications can be processed either jointly or separately by HoRC and HDC.	Decision making process by Consent Authority maybe appealed and re heard in Environment Court
Fast Track Consent Process	No public notification. Application processed by the Environmental Protection Agency. Application is considered by expert panel.	3 step process Project must satisfy set of criteria before accepted by Minister for Environment Act is only in place until July 2022. Significant time constraints to lodge

Type of Approval	Advantage	Disadvantage
	HoRC could apply by an Order in Council to undertake activities for project as permitted without resource consent after fast track decision.	applications with sufficient information before then?
Direct Referral to Environment Court	One hearing process by Environment Court at request of applicant to processing consent authority.	Applies only to notified resource consent applications.
Notice of Requirement	HoRC are a Requiring Authority. Land ownership is not required for NoR/Designation. Allows for future changes without need for resource consent from HDC	Two step process. New NoR would be notified. Future works not covered by NoR/Designation may still require resource consent from HoRC.

Further detailed information relating to the proposal is required before a recommendation on a specific approval pathway as outlined above.

8. Affected Parties

At this stage there has been no detailed assessment of potentially affected parties. We provide some general comments about parties or persons who could be considered as potentially affected as follows.

8.1 Tāngata Whenua

The following tāngata whenua are recognised as mana whenua in the area[1] and must be considered as partners in the delivery of this project in accordance with the principles of Te Tiriti o Waitangi, the provisions of the NPS-FM and the provisions of the Horizons One Plan:

- Muaūpoko;
- Ngāti Raukawa; and
- Rangitāne.

It is understood that iwi have been involved in the early stages of the project planning. It is recommended that mana whenua continue to be involved as the consenting phase progresses.

It is likely that a cultural impact assessment (CIA) will be required as part of the consent process. CIAs are prepared by mana whenua and assist the Council in the consideration of an application.

8.2 Adjacent landowners

Given the scale of works, and the potential effect upon ground or surface water, any immediately adjacent landowners who are not involved in the project may be determined to be affected parties by the respective Council (acting in their regulatory capacity) as part of the processing of the applications.

[1] Horowhenua District Plan 2015 Chapter 1 Tangata Whenua

8.3 Consent and Consultation Strategy

It is likely that the proposal would have a high level of public interest and would be of a scale that public notification may be desirable or considered necessary by the Councils.

For these reasons it is recommended that a consent strategy be developed for the project, which considers the appropriate consenting pathway, identifies risks, stakeholders and affected parties, provides a communications strategy, and discusses time frames would be useful to HoRC and stakeholder groups.

9. Conclusion

Based on initial information regarding the proposed wetland, it is considered likely that regional resource consents (as a discretionary activity) will be required from Horizons Regional Council, with the potential for additional land use consents also being required from Horowhenua District Council.

It is recommended that as the design is confirmed, a Consent Strategy be prepared that sets out the proposal and the required consents, as well as considering the most appropriate pathway to obtain consents for the proposal, including engagement with mana whenua and stakeholders.

Nick Cooper

Senior Planner

23 November 2020

Horizons Regional Council One Plan Rules

Chapter 13: Land disturbance including earthworks

- Rule 13-1: Small scale land disturbance – permitted - Up to 2,500m^2 per property, per 12 month period, along with any associated water diversion, and a discharge of sediment into water, subject to meeting conditions….
- Rule 13-2: Large scale land disturbance – controlled - Greater than 2,500m^2 per property, per 12 month period, along with any associated water diversion, and a discharge of sediment into water, subject to meeting conditions….

Chapter 14: Discharges to Land and Water

- Rule 14-12: Discharges^ of water^ to water – permitted - The discharge^ of water^ into water^ pursuant to s15(1) RMA (excluding drainage water^ which is regulated by Rules 16-10 and 16-11.
- Rule 14-19 Discharges^ of stormwater to surface water^ or land not complying with Rule 14-18 – restricted discretionary. The discharge^ of stormwater into surface water^ pursuant to s15(1) RMA or onto or into land^ pursuant to ss15(1) or 15(2A) RMA, which does not comply with Rule 14-18, and any ancillary takes or diversions of stormwater pursuant to s14(2) RMA forming part of the stormwater system.
- Rule 14-30 – discretionary- The discharge^ of water^ or contaminants^ into surface water^ pursuant to s15(1)(a) RMA or discharge^ of contaminants^ onto or into land^ pursuant to ss15(1)(b), 15(1)(d) or 15(2A) RMA which are not regulated by other rules^ in this Plan, or which do not comply with the permitted activity^, controlled activity^ or restricted discretionary activity^ rules^ in this chapter.

Chapter 16: Takes, Uses and Diversions of Water, and Bores

- Rule 16-5: Takes and uses of surface water^ complying with core allocation - controlled
- Rule 16-11: New drainage – permitted (The take, diversion or discharge^ of drainage water^, and any ancillary damming of water^, or discharge^ of sediment or other contaminants^ in the drainage water^ into water^ or onto or into land^ pursuant to s14(2) and ss15(1) or 15(2A) RMA arising from the establishment and operation* of new land^ drainage)
- Rule 16-12: New diversions – permitted (The following activities where they are associated with the establishment and operation* of a new diversion, except as expressly provided for by other rules^ within this Plan:

  (a) the take, diversion or discharge^ of water^ and any ancillary damming of water^ pursuant to s14(2) and ss15(1) or 15(2A) RMA

(b) any ancillary discharge^ of sediment or other contaminants^ in the water^ into water^ or onto or into land^ pursuant to ss15(1) or 15(2A) RMA

(c) any ancillary excavation or disturbance of the bed^ of a river^ pursuant to ss13(1) and 13(2) RMA.

- Rule 16-13: Diversions that do not comply with permitted activity^ and controlled activity^ rules^ - discretionary
- Rule 16-14 - The drilling, construction or alteration of any bore* and any ancillary discharge^ of water^ or contaminants^ - controlled

Chapter 17: Activities in Artificial Watercourses, Beds Of Rivers and Lakes, and Damming

- Table 17.2 General conditions for permitted activities and controlled activities involving the beds^ of rivers^ and lakes
- Rule 17-3 Structures^ and disturbances involving a reach of river^ or its bed^ with Schedule B Values of Natural State, Sites of Significance - Aquatic and Sites of Significance – Cultural an activity such as excavation, damming, diversion, placement of structures, the discharge of sediment laden water is a discretionary activity

Appendix E. Cost Estimate Tables

Arawhata Constructed Wetlands (Schematic Design) - Kane Farm

New Zealand

Description	Quantity (NZ Jacobs Team)	Units	Unit Rate (NZD)	Subtotal (NZD)	Indirect Rate 15%	Fee 12%	Total Cost	Notes
Preconstruction Activities								
Preconstruction Submittals	1	LS	$ 6,000	$ 6,000	$ 900	$ 720	$ 7,620	Including Excavation Plan, H&S Plan/AHAs, Storm Water Pollution Prevention Plan, Schedule/updates
Permitting	1	LS	$ 5,000	$ 5,000	$ 750	$ 600	$ 6,350	Allowance for permits for Excavation, Grading, and discharge
Mobilization	1	LS	$ 25,000	$ 25,000	$ 3,750	$ 3,000	$ 31,750	
Survey	4	day	$ 5,000	$ 20,000	$ 3,000	$ 2,400	$ 25,400	2 person crew, equipment and office support.
Independent Utility Locate	1	LS	$ 1,000	$ 1,000	$ 150	$ 120	$ 1,270	
Site Preparation	73	Ha						Erosion Controls, temp facilities
Clearing and Topsoil Stripping								
Clearing and grubbing	4	Ha	$ 11,545.00	$ 42,139	$ 6,321	$ 5,057	$ 53,517	
Topsoil Stripping	2,110	m3	$ 8.80	$ 18,568	$ 2,785	$ 2,228	$ 23,581	
Erosion and Sediment Control								
Sediment Basin	2	ea	$ 9,545.00	$ 19,090	$ 2,864	$ 2,291	$ 24,244	
Check dams rock	100	m3	$ 190.25	$ 19,025	$ 2,854	$ 2,283	$ 24,162	
Silt / sediment fence	2,300	m	$ 11.59	$ 26,657	$ 3,999	$ 3,199	$ 33,854	
Temporary Fencing	4,606	m	$ 6.15	$ 28,325	$ 4,249	$ 3,399	$ 35,973	Fence installation, removal at end of project. RSMeans.
Setup Stockpile/Dewatering Area	500	m2						Lined area to stockpile/dewater excavated materials
Topsoil Stripping - 100mm thick topsoil, stockpiled locally	50	m3	$ 7.19	$ 360	$ 54	$ 43	$ 457	
Dewatering area berm	120	m	$ 44.64	$ 5,357	$ 804	$ 643	$ 6,803	
Membrane Layer	500	m2	$ 8.31	$ 4,155	$ 623	$ 499	$ 5,277	
Drainage Sump	1	ea	$ 6,515.00	$ 6,515	$ 977	$ 782	$ 8,274	
Construction Activities								
<u>Excavation</u>								
Kane Farm Wetland Excavation .3 m deep - 15ha+15ha+22 ha	63,246	m3	$ 8.76	$ 554,035	$ 83,105	$ 66,484	$ 703,624	
								Wetland Excavation material used to construct the berm.
Kane Farms Berm - ground surface treatment	105,410	m2	$ 0.82	$ 86,436	$ 12,965	$ 10,372	$ 109,774	
Kane Farms Berm construction - 1 m tall, 5 or more m wide	65,356	m3	$ 25.71	$ 1,680,304	$ 252,046	$ 201,636	$ 2,133,986	Berm constructed from the wetland excavation material and covered with material set aside as topsoil on the berm
Construct Perimeter Road Access	4,606	m	$ 16.45	$ 75,764	$ 11,365	$ 9,092	$ 96,220	grubbing, road alignment, rough grading, and rolling. No road base inlcuded.
<u>Planting</u>								
Hydroseeding berms	5	Ha	$ 12,000	$ 54,000	$ 8,100	$ 6,480	$ 68,580	
Wetlands plant in container - 1m x 1 m - 32 HA	320,000	ea	$ 2.63	$ 841,600	$ 126,240	$ 100,992	$ 1,068,832	
Tree in container - 3mx3m on 20 HA	22,222	ea	$ 6.00	$ 133,333	$ 20,000	$ 16,000	$ 169,333	
Plant installation	122,222	ea	$ 2.00	$ 244,444	$ 36,667	$ 29,333	$ 310,444	
Plant warranty (10% of containers)	1	LS	$ 121,938	$ 121,938	$ 18,291	$ 14,633	$ 154,861	
<u>Pumping and Injection</u>								
Groundwater pump station kane farm outlet- X hp	1	ea	$ 40,000	$ 40,000	$ 6,000	$ 4,800	$ 50,800	
Alumina Injection Station - Kane farms	2	EA	$ 30,000	$ 60,000	$ 9,000	$ 7,200	$ 76,200	
<u>Collection System:</u>								
Diversion from Hokio drain to Pump station	100	m	$ 140	$ 14,000	$ 2,100	$ 1,680	$ 17,780	
Collection boxes (12" Agri-Drains)	12	ea	$ 5,000	$ 60,000	$ 9,000	$ 7,200	$ 76,200	
recycle aeration structure - Kane farms edge	1	LS	$ 15,000	$ 15,000	$ 2,250	$ 1,800	$ 19,050	
<u>Distribution and Collection System</u>								
DN100 flow-control solenoid valve	6	ea	$ 1,200	$ 7,200	$ 1,080	$ 864	$ 9,144	Grainger, 120VAC Brass Solenoid Valve, 2
Groundwater pipeline from bottom to top of Kane Farm	1,300	m	$ 140	$ 182,000	$ 27,300	$ 21,840	$ 231,140	
DN100 PVC Schedule 40 for mainline	100	m	$ 160	$ 16,000	$ 2,400	$ 1,920	$ 20,320	
250mm SDR 21, HDPE for pumping	20	m	$ 325	$ 6,500	$ 975	$ 780	$ 8,255	
Misc. Fittings (<80mm) (768 tees, end caps, elbows)	1,000	ea	$ 24.00	$ 24,000	$ 3,600	$ 2,880	$ 30,480	
Misc. Fittings (250mm)	4	ea	$ 520	$ 2,080	$ 312	$ 250	$ 2,642	
Mechanical Installation allowance	1	LS	$ 50,000	$ 50,000	$ 7,500	$ 6,000	$ 63,500	Allowance
Electrical allowance	1	LS	$ 50,000	$ 50,000	$ 7,500	$ 6,000	$ 63,500	Allowance
SUB-TOTAL CAPITAL COSTS							**$ 5,484,666**	
Misc	5%	of	$ 11,257,864	$ 562,893			$ 562,893	
							$ 6,047,559	

Arawhata Constructed Wetlands (Schematic Design) - Woodhaven Wetlands

New Zealand

Description	Quantity (NZ Jacobs Team)	Units	Unit Rate (NZD)	Subtotal (NZD)	Indirect Rate 15%	Fee 12%	Total Cost	Notes
Preconstruction Activities								
Preconstruction Submittals	1	LS	$ 6,000	$ 3,000	$ 450	$ 360	$ 3,810	Including Excavation Plan, H&S Plan/AHAs, Storm Water Pollution Prevention Plan, Schedule/updates
Permitting	1	LS	$ 5,000	$ 2,500	$ 375	$ 300	$ 3,175	Allowance for permits for Excavation, Grading, and discharge
Mobilization	1	LS	$ 25,000	$ 12,500	$ 1,875	$ 1,500	$ 15,875	
Survey	2	day	$ 5,000	$ 10,000	$ 1,500	$ 1,200	$ 12,700	2 person crew, equipment and office support.
Independent Utility Locate	1	LS	$ 1,000	$ 500	$ 75	$ 60	$ 635	
Site Preparation	6	Ha						Erosion Controls, temp facilities
Clearing and Topsoil Stripping								
Clearing and grubbing	-		$ -	$ -	$ -	$ -	$ -	
Topsoil Stripping - 100mm thick topsoil, stockpiled locally	6,000	m3	$ 8.80	$ 52,800	$ 7,920	$ 6,336	$ 67,056	
Erosion and Sediment Control								
Sediment Basin	1	ea	$ 9,854.00	$ 4,927	$ 739	$ 591	$ 6,257	
Check dams rock	25	m3	$ 190.25	$ 4,756	$ 713	$ 571	$ 6,040	
Silt / sediment fence	440	m	$ 11.59	$ 5,100	$ 765	$ 612	$ 6,476	
Temporary Fencing	880	m	$ 3.08	$ 2,710	$ 407	$ 325	$ 3,442	Fence installation, removal at end of project. RSMeans.
Construction Activities								
<u>*Excavation*</u>								
Woodhaven Treatment Blocks Excavation	65,839	m3	$ 8.76	$ 576,750	$ 86,512	$ 69,210	$ 732,472	
Woodhaven - ground surface treatment	22,798	m2	$ 0.82	$ 18,695	$ 2,804	$ 2,243	$ 23,742	
Woodhaven Berm construction	14,659	m3	$ 25.71	$ 376,871	$ 56,531	$ 45,224	$ 478,626	Berm constructed from the wetland excavation material and covered with material set aside as topsoil on the berm
Replace Topsoil	4,500	m3	$ 15.50	$ 69,750	$ 10,463	$ 8,370	$ 88,583	Replace topsoil across the wetland area as
<u>Treatment System Option 1</u>								
Woodhaven block -Deep settlement trench - serpentine, 0.5 ha, 2 m deep	574	m	$ 8.76	$ 5,024	$ 754	$ 603	$ 6,381	
Woodhaven - biochemical reactor, organic media - 4.0 ha 1.5 m deep	60,000	m3	$ 20.89	$ 1,253,400	$ 188,010	$ 150,408	$ 1,591,818	
Construct Perimeter Road Access	880	m	$ 16.45	$ 14,476	$ 2,171	$ 1,737	$ 18,385	grubbing, road alignment, rough grading, and rolling. No road base inlcuded.
<u>*Planting*</u>								
Wetlands plant in container - 1m x 1 m - 2 HA	20,000	ea	$ 2.63	$ 52,600	$ 7,890	$ 6,312	$ 66,802	
Hydroseeding berms	3	Ha	$ 12,000	$ 30,000	$ 4,500	$ 3,600	$ 38,100	
Wetlands Seed purchase - 4 kg/HA on 5 HA	10	Kg	$ 100	$ 1,000	$ 150	$ 120	$ 1,270	
SUB-TOTAL CAPITAL COSTS							**$ 3,046,178**	
Misc	5%	of	$ 6,217,823	$ 310,891			$ 310,891	
							$ 3,357,069	

Arawhata Constructed Wetlands (Schematic Design) - Woodhaven Wetlands												
New Zealand Description	Quantity (NZ Jacobs Team)	Units		Unit Rate (NZD)		Subtotal (NZD)		Indirect Rate 15%		Fee 12%		Total Cost	Notes
Preconstruction Activities													
Preconstruction Submittals	1	LS	$	6,000	$	3,000	$	450	$	360	$	3,810	Including Excavation Plan, H&S Plan/AHAs, Storm Water Pollution Prevention Plan, Schedule/updates
Permitting	1	LS	$	5,000	$	2,500	$	375	$	300	$	3,175	Allowance for permits for Excavation, Grading, and discharge
Mobilization	1	LS	$	25,000	$	12,500	$	1,875	$	1,500	$	15,875	
Survey	2	day	$	5,000	$	10,000	$	1,500	$	1,200	$	12,700	2 person crew, equipment and office support.
Independent Utility Locate	1	LS	$	1,000	$	500	$	75	$	60	$	635	
Site Preparation	6	Ha											Erosion Controls, temp facilities
Clearing and Topsoil Stripping													
Clearing and grubbing	-		$	-	$	-	$	-	$	-	$	-	
Topsoil Stripping - 100mm thick topsoil, stockpiled locally	6,000	m3	$	8.80	$	52,800	$	7,920	$	6,336	$	67,056	
Erosion and Sediment Control													
Sediment Basin	1	ea	$	9,854.00	$	4,927	$	739	$	591	$	6,257	
Check dams rock	25	m3	$	190.25	$	4,756	$	713	$	571	$	6,040	
Silt / sediment fence	440	m	$	11.59	$	5,100	$	765	$	612	$	6,476	
Temporary Fencing	880	m	$	3.08	$	2,710	$	407	$	325	$	3,442	Fence installation, removal at end of project. RSMeans.
Construction Activities													
<u>*Excavation*</u>													
Woodhaven Treatment Blocks Excavation	18,946	m3	$	8.76	$	165,967	$	24,895	$	19,916	$	210,778	
Woodhaven - ground surface treatment	18,301	m2	$	0.82	$	15,007	$	2,251	$	1,801	$	19,059	
Woodhaven Berm construction	10,298	m3	$	25.71	$	264,760	$	39,714	$	31,771	$	336,246	Berm constructed from the wetland excavation material and covered with material set aside as topsoil on the berm
<u>Treatment System Option 2</u>													
Tidal Flow aeration basin with rock - 0.2HA, 1m deep	2,000	m3	$	70.00	$	140,000	$	21,000	$	16,800	$	177,800	
Woodhaven - biochemical reactor, organic media - 1.7 ha 1.5 m deep	25,500	m3	$	20.89	$	532,695	$	79,904	$	63,923	$	676,523	
Woodhaven - subsurface flow with rock media - c media - 1 ha 1 m deep	10,000	m3	$	70.00	$	700,000	$	105,000	$	84,000	$	889,000	
<u>*Pumping and Injection*</u>													
Groundwater pump station woodhaven block outlet- X hp	1	ea	$	40,000	$	40,000	$	6,000	$	4,800	$	50,800	
Alumina Injection Station - Woodhaven	2	ea	$	30,000	$	60,000	$	9,000	$	7,200	$	76,200	
<u>*Groundwater Diversion*</u>													
Refer to separate sheet for detail											$	491,490	
SUB-TOTAL CAPITAL COSTS											**$**	**2,927,895**	
Misc	5%	of	$	5,981,258	$	299,063					$	299,063	
											$	**3,226,958**	

Arawhata Constructed Wetlands (Schematic Design) - Polishing Wetlands								
New Zealand Description	Quantity (NZ Jacobs Team)	Units	Unit Rate (NZD)	Subtotal (NZD)	Indirect Rate 15%	Fee 12%	Total Cost	Notes
Preconstruction Activities								
Preconstruction Submittals	1	LS	$ 6,000	$ 6,000	$ 900	$ 720	$ 7,620	Including Excavation Plan, H&S Plan/AHAs, Storm Water Pollution Prevention Plan, Schedule/updates
Permitting	1	LS	$ 5,000	$ 5,000	$ 750	$ 600	$ 6,350	Allowance for permits for Excavation, Grading, and discharge
Mobilisation	1	LS	$ 25,000	$ 25,000	$ 3,750	$ 3,000	$ 31,750	
Survey	4	day	$ 5,000	$ 20,000	$ 3,000	$ 2,400	$ 25,400	2 person crew, equipment and office support.
Independent Utility Locate	1	LS	$ 1,000	$ 1,000	$ 150	$ 120	$ 1,270	
Erosion and Sediment Control								
Sediment Basin	1	ea	$ 9,854.00	$ 9,854	$ 1,478	$ 1,182	$ 12,515	
Check dams rock	25	m3	$ 190.25	$ 4,756	$ 713	$ 571	$ 6,040	
Silt / sediment fence	130	m	$ 11.59	$ 1,507	$ 226	$ 181	$ 1,914	
Temporary Fencing	267	m	$ 3.08	$ 822	$ 123	$ 99	$ 1,044	Fence installation, removal at end of project. RSMeans.
Construction Activities								
Excavation								
Hokio polishing wetlands Excavation - .5 m deep - 6 ha	4,520	m3	$ 8.76	$ 39,593	$ 5,939	$ 4,751	$ 50,284	Wetland Excavation material used to construct the berm.
Polishing Wetlands - ground surface treatment	3,649	m2	$ 0.82	$ 2,992	$ 449	$ 359	$ 3,800	
Sediment Trap Berm construction	3,479	m3	$ 25.71	$ 89,434	$ 13,415	$ 10,732	$ 113,581	Berm constructed from the wetland excavation material and covered with material set aside as topsoil on the berm
Dewater System Operation for Sedmient trap	35	day	$ 322.63	$ 11,292	$ 1,694	$ 1,355	$ 14,341	Includes labor, materials, and equipment to operate the system 24/7 prior to and during excavation activities.
Construct Perimeter Road Access	267	m	$ 16.45	$ 4,392	$ 659	$ 527	$ 5,578	grubbing, road alignment, rough grading, and rolling. No road base inlcuded.
Planting								
Hydroseeding berms	0.4	Ha	$ 12,000	$ 4,427	$ 664	$ 531	$ 5,623	
Hydroseeding wetlands	3	Ha	$ 6,000	$ 15,468	$ 2,320	$ 1,856	$ 19,644	
Wetlands Seed purchase - 4 kg/HA on 3 HA	12	Kg	$ 100	$ 1,200	$ 180	$ 144	$ 1,524	
Site Restoration Allowance	2%	of	$ 308,278	$ 6,166			$ 6,166	
Safety Allowance	2%	of	$ 308,278	$ 6,166			$ 6,166	
SUB-TOTAL CAPITAL COSTS							**$ 226,706**	
	5%	of	$ 320,609	$ 16,030			$ 16,030	
							$ 242,736	

Arawhata Constructed Wetlands (Schematic Design) - Groundwater Diversion								
New Zealand					Indirect Rate	Fee	Total Cost	
Description	**Quantity (NZ Jacobs Team)**	**Units**	**Unit Rate (NZD)**	**Subtotal (NZD)**	**15%**	**12%**		**Notes**
Preconstruction Activities								
Preconstruction Submittals	1	LS	$ 6,000	$ 6,000	$ 900	$ 720	$ 7,620	Including Excavation Plan, H&S Plan/AHAs, Storm Water Pollution Prevention Plan, Schedule/updates
Permitting	1	LS	$ 5,000	$ 5,000	$ 750	$ 600	$ 6,350	Allowance for permits for Excavation, Grading, and discharge
Mobilisation	1	LS	$ 10,000	$ 10,000	$ 1,500	$ 1,200	$ 12,700	
Survey	4	DY	$ 5,000	$ 20,000	$ 3,000	$ 2,400	$ 25,400	2 person crew, equipment and office support.
Independent Utility Locate	1	LS	$ 1,000	$ 1,000	$ 150	$ 120	$ 1,270	
Site Preparation	16,000	m2	$ 3.0	$ 48,000	$ 7,200	$ 5,760	$ 60,960	Erosion Controls, temp facilities
Temporary Fencing	1,640	m	$ 60	$ 98,400	$ 14,760	$ 11,808	$ 124,968	Fence installation, removal at end of project. RSMeans.
Setup Stockpile/Dewatering Area	-	m2	$ -	$ -	$ -	$ -	$ -	Lined area to stockpile/dewater excavated materials
Construction Activities								
Collection and Pumping								
Groundwater pump station	-	ea	$ -	$ -	$ -	$ -	$ -	incl in Woodhaven Wetlands
Ground water bores	5	EA	$ 30,000	$ 150,000	$ 22,500	$ 18,000	$ 190,500	
Buried Pipework	800	m	$ 140	$ 112,000	$ 16,800	$ 13,440	$ 142,240	
Electrical allowance	5	LS	$ 25,000	$ 125,000	$ 18,750	$ 15,000	$ 158,750	Allowance per bore
SUB-TOTAL CAPITAL COSTS							**$ 491,490**	
Misc	5%	of	$ 730,758	$ 36,538			$ 36,538	
							$ 528,028	

horizons

REGIONAL COUNCIL

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