HBRC Stormwater Pump Stations D&B

Preliminary Design Report - Awatoto

Brian Perry Civil Limited

12 March 2026

→ **The Power of Commitment**

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The Power of Commitment

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1. Introduction

1.1 Purpose of this report

The purpose of this report is to detail the applicable preliminary design works, referred to as the 30% Design, associated with the Hawke's Bay Regional Council (HBRC) Pump Station Design and Build Land Category Flood Resilience Programme project as per Principals Requirements.

This report includes design information for both the Awatoto and Pakowhai pump stations. However, this version report only includes the preliminary design of the Awatoto pump station, with the Pakowhai pump station still a work in progress. This report is intended to be reissued as a new revision when the Pakowhai preliminary design is complete.

1.2 Scope and limitations

This report has been prepared by GHD for Brian Perry Civil and may only be used and relied on by Brian Perry Civil for the purpose agreed between GHD and Brian Perry Civil as set out in section 1.1 of this report, including for the submission of this report to Hawkes Bay Regional Council for its information.

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1.3 Key reference documents

List of key reference documents as follows:

- Request for Proposal (RFP) released by HBRC on 11 November 2024
- Principal's Requirements (PRs) document that was an appendix to the RFP noted above, including information attached to this document as appendices
- Notices to Tenderers (NTT01 to NTT10)
- Digital CPT and survey data from HBRC
- Substantiation Safe Eel Passage – Bosman Water Management
- Concept Design Report (GHD, dated 25 March 2025)
- Geotechnical Interpretative Reports:
  - Pakowhai (GHD, dated 03 March 2025)
  - Awatoto (GHD, dated 29 August 2025)

2. Proposed Design Solutions

Hydraulic, hydrologic and mechanical design inputs used in the development of the preliminary design is appended in a Project Description Schedule. The following sections summarise the key inputs and basis of design for the Awatoto and Pakowhai Pump Stations.

The Brookfields Pump Station was originally included in the HBRC Pump Station Design and Build Land Category Flood Resilience Programme project, and in the first revision of the Concept Design Report. However, the project scope has since been reduced due to the available CIP funding to exclude the Brookfields Pump Station, and to reduce the capacity of the Awatoto Pump Station.

2.1 Overall Design Approach and Context

The overall stormwater pumping station design aims to provide a resilient, simplified, fish friendly and cost-effective solution that meets the Principal's Requirements. The simplified design follows the design philosophy of "*the best part is no part*" to provide a solution that is easy to operate and maintain with minimal complexity. This approach focuses on the following five key drivers:

<u>Seismic Resilience</u>

The pump station sites are all on poor to very poor founding material. The free face of the drainage channel, together with the stopbank's load surcharge, further exacerbates the risk of lateral spread at both sites. Our design provides a ground improvement approach with cost-efficiency guiding design decisions, together with careful siting of the pump stations to utilise existing ground support, and maximise distance from the stopbank, where possible, to reduce the risk of seismic damage at each structure.

<u>Pump Station Performance</u>

The design provides a range of dependable and industry proven pumps that meet the required maximum and minimum flow rate requirements at each site, with discharge velocities that are less than the maximum velocity currently installed to limit scour in the estuary and hydraulic design considerations associated with high velocities. Only two pump models from the same supplier (lead and flood/main pumps) are used across the two pump stations to achieve the required range of flows, which provides for consistency in the pump maintenance regime, availability of spare parts and other critical equipment.

The pumps operate at a high level of efficiency under the different pumping scenarios considered. Each pump has its own Variable Speed Drive (VSD) and rising main which allows automated pump station operation with a very wide range of pump rates and programmable pump transitions and duty rotations, based on water level control.

<u>Fish Welfare</u>

The design provides for bidirectional fish passage of both long and shortfin eels and inanga at the Pakowhai Pump Station, and downstream only migration at the Awatoto Pump Station. The original concept design included an upstream migration solution at the Awatoto Pump Station, but this has subsequently been deemed a provisional item that is not currently included in the design.

With advancements in fish-friendly pumping technology, the need for fish screening is avoided with a design that incorporates fish-friendly pumps for safe downstream fish passage. This approach avoids the inherent risks and maintenance requirements of effectively operating fish screens and provides a simpler pump station system with fewer moving parts. This, in turn, provides increased dependability especially during flood conditions, without the need for a fish screen bypass system that represents another potential point of failure during a flood event.

The existing gravity by-pass pipeline at the Pakowhai Pump Station is proposed to be maintained and fitted with a fish-friendly flap gate to improve upstream and downstream fish passage at that site.

<u>Simplified, Repeatable Design</u>

The two pump station designs presented only use two pump sizes, all from a single manufacturer with an established and proven manufacturing and performance history, and established support in New Zealand.

A modular pump station design is proposed that makes use of precast panels and is repeated for both pump stations, and is generally repeatable for future HBRC stormwater pump station sites. This repeatability allows for more cost effective construction due to the benefits of repetition and economy of scale.

<u>Flood Risk Reduction during Construction</u>

The design provides a solution that retains the existing pump station functionality for the full construction period until the new pump stations are commissioned, thereby removing the risks and costs associated with operating and maintaining a temporary pumping arrangement.

2.2 Awatoto Pump Station

Awatoto Pump Station consists of three VSD equipped Bosman fish-friendly pumps connected to 2 x DN1200 and 1 x DN600 PE discharge pipelines respectively, as well as an optional (Provisional) DN600 fish passage pipeline for upstream migrating inanga and eels. A concept design illustration is provided in Figure 1.

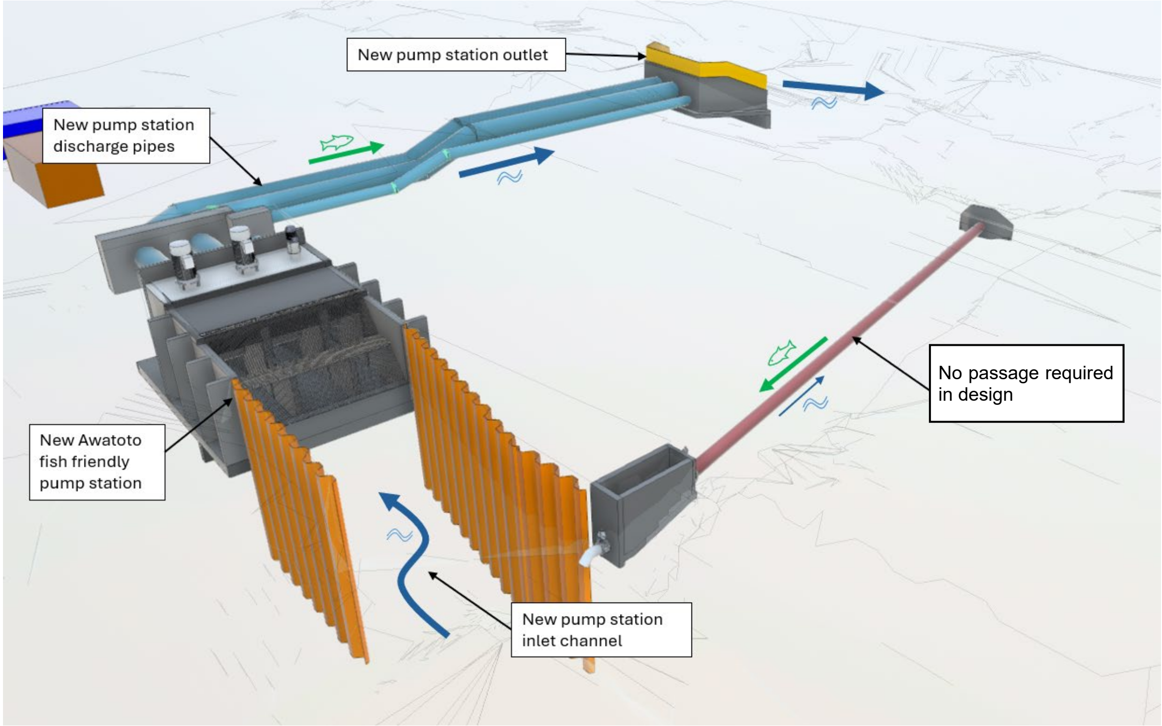

Figure 1 Awatoto Pump Station – Concept Illustration

3. Key design criteria

The key design criteria for all SWPSs are outlined in the below sections, with additional criteria provided in the Project Description Schedule in Appendix A. Where key design criteria differ between pump stations, a table is provided indicating the differences per pump station.

3.1 Design life

Design lives adopted for the project from the HBRC RFP and PRs are as follows:

- Mechanical – 25 years
- Concrete structures – 100 years for durability (50 years for seismic actions)
- Steel structures – 50 years, 25 years to first maintenance
- Electrical and control plant – 25 years

3.2 Construction Type

The proposed designs include compact and braced rectangular structures which aim to provide structural robustness, simplicity and repeatability. Using precast elements where possible for efficient construction, the proposed approach will provide a reduced construction programme and shorter excavation durations (note that this also improves safety during construction).

Where practicable, the wall system will comprise precast concrete panels supported on perimeter and/or foundation beams, with vertical load transfer provided through the bearing interface to the beams. The in-situ base slab is then constructed to tie into the wall line from the wall face. Adjacent precast panels will be connected using in-situ stitch pours incorporating appropriate bar development (and/or mechanical couplers) to achieve structural continuity and robustness once the stitches are cast. In-situ concrete will also be used at locations where design, site tolerances, construction sequencing, or watertightness performance are critical, including closure pours at interfaces, wet well walls and slab, wall and slab penetrations. This construction arrangement supports tolerance management during panel erection and provides repeatable detailing. Interfaces will be detailed to minimise construction complexity, manage tolerance accumulation and reduce waterproofing vulnerability.

Pipework is mostly proposed to be lightweight HDPE pipelines, which can be pre-welded into longer sections for efficiency in high-risk areas, such as installation through the stopbank, to limit the length of reduced level of service for flood protection assets. Pipe penetrations through stopbanks are also raised slightly to limit the risks associated with excavation duration and depth, high-groundwater levels and poor ground conditions.

3.3 Key Materials & Colours Proposed

The design limits above ground infrastructure. For items inside the pump station site, stakeholder and iwi engagement will determine appropriate colour selection of elements seen above ground to mould the structures into the existing landscape. It is envisaged that landscaping, planting and decorative/artistic input will be used in this regard.

3.4 O & M Considerations

Several key Operations and Maintenance (O&M) considerations influenced the design decisions, summarised as follows:

- As already described in this report, the inclusion of fish-friendly pumps in lieu of a fish screens, is itself one of the most significant O&M considerations. Removing the requirement to inspect and maintain the fish screens and bypass gates on a regular basis, reduces O&M risk and cost. Removing the risk associated with blocked fish screens, debris clearing and bypass gates reduces the overall pump system operational risk during floods.
- Pump motors will be installed in the open but equipped with weatherproof covers. They will therefore be easily accessible for operation and maintenance. Emergency stop switches will be installed adjacent to each pump (these will also be connected to the SCADA system).
- Pumps will be installed in dry chambers accessible by lifting an FRP grate and descending into the chamber using a permanent ladder. Pump chambers are not expected to require frequent access, so working space around the pumps is minimised and the area will be a confined space requiring a safe operating procedure. A small sump pump will remove leak and rainwater runoff within the chambers (one pump for all chambers with an interconnecting drain between chambers). Anchor points and handrails on side walls will be shown in detailed design.
- Manual trash screen cleaning and accessibility is allowed for by providing an interim screen platform, accessible by ladder, to limit rake length to around 3 m. Heavier objects can be removed by an excavator with up to 20-ton capacity.
- Stoplogs are allowed for in the design to achieve isolation of one of the pump station forebays at a time, except at Awatoto, where stoplogs are provided for one main pump bay and the lead (jockey) pump bay due to their differing widths. Three sets of stoplogs will therefore be required across the two pump stations (two at Awatoto and one at Pakowhai, stored on site). The same wide bay stoplog may, however, be useable at both Awatoto and Pakowhai stations, which will reduce the requirement to only two stoplogs. Note that the structural design has only considered flotation with one large bay isolated by stoplogs.

Being exposed, pumps and motors may produce noise that exceed the district plan acoustic limits. An acoustic assessment will be carried out during the detailed design stage to determine whether any acoustic treatment is required for the pump station. Acoustic treatment, such as motor covers, timber or concrete block walls or earth bunds (where possible) may be required to mitigate noise. The pumps have the following stated manufacturer readings at 1 m for each pump station:

- Vision 45MC 75 kW @ 396 rpm = 54.0 dB(A) – Awatoto (1 pump)
- Vision 90MC 630 kW @ 340 rpm = 62.1 dB(A) – Awatoto (2 pumps)
- Vision 90MC 560 kW @ 308 rpm = 57.0 dB(A) – Pakowhai (2 pumps)

Although not expected to be above council noise limits, the MCC room will be constructed from 190 mm block and will be roofed with an insulated ceiling to provide acoustic attenuation for the noise emitted by the VSD's.

3.5 Pump and rising main design

A range of eight hydraulic scenarios were investigated to inform the design pumping envelope. Several hydraulic design scenarios are not considered realistic to occur, such as pumping at maximum pump station flow from an upstream 1% AEP water level to a downstream Mean Low Water Springs (MLWS) water level. The envelope of feasible/realistic hydraulic design scenarios is indicated in Table 1.

Table 1 Pump Station Operational Design Scenarios

		Downstream Levels		
		Low: Downstream Discharge Pipe IL	**Medium:** 70% of difference between 1%AEP Riverside and MLWS	**High:** 1%AEP
Upstream Levels	**High High:** 1%AEP Landside	Not considered realistic	Accounted for within other scenarios	6 Max. Pump Flow Rate
	High: Drain level at max design flowrate	Not considered realistic	Accounted for within other scenarios	7 Max. Pump Flow Rate
	Medium: Main Pump Start	1 Min. < Pump Flow Rate < Max.	Accounted for within other scenarios	8 Max. Pump Flow Rate
	Low: Main Pump Stop	2 Min. < Pump Flow Rate < Max.	4 Min. < Pump Flow Rate < Max.	Not considered realistic
	Low Low: Lead Pump Stop	3 Min. Pump Flow Rate	5 Min. < Pump Flow Rate < Max.	Not considered realistic

We considered the following pump types for each SWPS to meet the required design flows and pressures:

- Archimedes Screw (large flows only)
- BBA high-volume flood pumps
- Bedford SAF fish friendly axial flow pumps
- Bosman Vision fish friendly axial flow pumps

The NPSHa (Net Positive Suction Head available) values were calculated and found to comply with the PR's NPSH requirements for the majority of the design pumping scenarios. However, at peak flows (i.e. Scenario 8 in Table 1 above) the NPSHa at the current Awatoto PS designs do not comply with the N_{ss} (Suction Specific Speed) check formula in the PRs. We consider that the current design should be sufficient to provide a resilient solution, however, further consideration of the specific Bosman pump design requirements and operational data will be assessed during detailed design to confirm whether additional pump submergence is required. To achieve the required NPSHa compliance values, if required, the pump station intake floor and pump design levels will be lowered by the amounts shown in Table 2.

Table 2 Nss and NPSH Values

	Awatoto (Lead Pump)	Awatoto (Main Pump)	Pakowhai
NPSHa (calculated)	10.91 m	10.90 m	11.12 m
NPSHr (from pump supplier curves)	7.90 m	9.40 m	9.00 m
Nss *(RPM.sqrt[QBEP]/NPSHr^0.75)*	81	103	88
NPSHa / NPSHr *(PR requires >=1.2 for Nss below 165)*	1.38	1.16	1.24
NPSHa-NPSHr *(PR requires >1.5m for Nss below 165)*	3.01 m	1.50 m	2.12 m

	Awatoto (Lead Pump)	Awatoto (Main Pump)	Pakowhai
Floor Amount to be lowered by to meet full PR requirements	Nil	0.38 m	Nil

The pumps will be controlled automatically using level control, as set out in the PRs. Pump start will always be at full downturn flow with VSD ramping rates determined by level control sampling. To minimise fish mortality, assist pump start will be initiated prior to the duty pump maximum flow rate. Duty and assist pump operation will be rotated (excluding the Awatoto PS Lead Pump).

The pumping operational levels specific to each pump station are provided in Table 3 & Table 4**Error! Reference source not found.**.

Table 3 SWPS START / STOP levels

Levels	Awatoto	Pakowhai	Assumptions
Pump 1 / Lead Pump Start	-0.84	-0.24	
Pump 2 Start	-0.74	-0.14	100 mm above Pump 1 / Lead Pump Start
Pump 3 Start	-0.54	N/A	200 mm above Pump 2 Start
Pump 1 / Lead Pump Stop	-1.03	-0.65	
Pump 2 Stop	-0.89	-0.29	150 mm below Pump 2 Start
Pump 3 Stop	-0.64	N/A	100 mm below Pump 3 Start

Table 4 SWPS pump station upstream and downstream operation levels

SWPS	Upstream		Downstream	
	Min: Pump Stop Levels	Max: 1%AEP Landside mRL	Min: Downstream discharge CL	Max: 1% AEP flood level
Awatoto (Main Pumps)	-0.89 mRL Pump 2 STOP	0.77 mRL	2.10 mRL	4.70 mRL
Awatoto (Lead Pump)	-1.03 mRL PUMP 1 STOP	0.77 mRL	1.80 mRL	4.70 mRL
Pakowhai	-0.65 mRL PUMP 1 STOP	2.40 mRL	2.03 mRL	5.90 mRL

Given the use of VSDs to ramp pump flows up and down as required by the pump station control logic, the pump start and stop levels presented in Table 8 and 9 do not reflect the levels at which the pumps will be operating at maximum flow rate, as both start and stop flow rates will occur at maximum downturn (or minimum) pump flow rates. To this end, the following preliminary table of proposed pump control water levels was developed to determine the likely scenario representing the minimum water level at which the Awatoto Pump Station will be operating at its maximum flow rate of 6,500 L/s. This scenario, which occurs at a water elevation of -0.28 mRL, as indicated in the red box in the table below, will form part of the CFD modelling regime. Further refinement of this table of control elevations will be carried out during detailed design.

Table 5 Preliminary Awatoto Pump Station operating and ramping levels

Increasing Water Level	**mRL**	**Depth Change (m)**	**P1 (L/s)**	**P2 (L/s)**	**P3 (L/s)**	**Total Flow (m^3/s)**	**Flow Increase (m^3/s)**	**Water Depth (m)**
P1, P2 and P3 max	-0.24	0.05	500	3000	3000	**6500**	210	2.99
P1 ON min. P2 & P3 max	-0.29	0.05	290	3000	3000	**6290**	290	2.94
P2 & P3 max	-0.34	0.10	0	3000	3000	**6000**	2000	2.89
P2 and P3 mid-turnup	-0.44	0.10	0	2000	2000	**4000**	2000	2.79
P1 OFF, P2 min and P3 ON min	-0.54	0.10	0	1000	1000	**2000**	0	2.69
P1 ON max & P2	-0.64	0.10	500	1500	0	**2000**	1000	2.59
P1 OFF, P2 ON min	-0.74	0.00	0	1000	0	**1000**	500	2.49
P1 max	-0.74	0.10	500	0	0	**500**	210	2.49
P1 ON	-0.84		290	0	0	**290**		2.39
Decreasing Water Level	**mRL**	**Depth Change (m)**	**P1 (L/s)**	**P2 (L/s)**	**P3 (L/s)**	**Total Flow (m^3/s)**	**Flow Reduction (m^3/s)**	**Water Depth (m)**
Peak Flood Level (1% AEP)	0.77		500	3000	3000	**6500**		4.00
P1 turndown starts, P2 & P3 max	-0.28	1.05	500	3000	3000	**6500**	0	2.95
P1 min. P2 & P3 max	-0.34	0.06	290	3000	3000	**6290**	-210	2.89
P1 OFF P2 & P3 max	-0.34	0.00	0	3000	3000	**6000**	-290	2.89
P2 and P3 mid-turndown	-0.49	0.15	0	2000	2000	**4000**	-2000	2.74
P2 and P3 min	-0.64	0.15	0	1000	1000	**2000**	-2000	2.59
P3 OFF, P1 ON max & P2	-0.64	0.00	500	1500	0	**2000**	0	2.59
P1 min, P2 min	-0.74	0.10	290	1000	0	**1290**	-710	2.49
P2 OFF, P1 max	-0.89	0.15	500	0	0	**500**	-790	2.34
P1 OFF	-1.03	0.14	290	0	0	**290**	-210	2.20

3.5.1 Pump Station CFD Modelling

As part of the preliminary design, CFD modelling of the proposed formed suction intake (FSI) Awatoto Pump Station design was carried out by the Contractor's pump supplier, Prime Pumps. This modelling has yet to be completed together with a full modelling report. Initial modelling resulted in some amendments to the pump station structure and FSI geometry which are captured in the Preliminary Design drawing set.

Once the CFD modelling has been completed, this report and the Preliminary Design drawings will be updated with the results, where and if required.

3.5.2 Valve Selection

Fish welfare guidelines in the United Kingdom no longer allow inline non-return valves and discharge flap gates on fish friendly pumped rising mains. We have therefore included rubber duckbill non-return valves on the rising main discharges plus actuated full bore isolation valves at the pump station. Although not in accordance with the required non-return valves stipulated in the PRs, we consider it similar in function and materials to the required WaStop valve model, and a suitable end of pipe, fish-friendly non-return design solution.

3.5.3 Flow Measurement

As a departure from the Principal's Requirements, no flowmeters will be installed (refer to Table 17). Instead, flow metering at the pump station will be achieved by calibrating each of the installed pumps, based on their operating speed and water levels, to provide an estimated flow rate.

In lieu of the above flow rate calibration or full-bore electromagnetic flowmeters on each rising main, probe-type or strap-on flowmeters can be considered. There are locations for such metering with sufficient straight lengths upstream and downstream as recommended by the manufacturer (TBC, the design currently considers straight lengths of 5 x diameter upstream and 2 x diameter downstream).

3.5.4 Thrust Blocks

Fully welded PE100 pipe is proposed for all rising mains. With sufficient buried length, such pipes can withstand thrust forces and bends without the need for thrust blocks. However, at the connection of the discharge mains to the pump station, a series of spigot and socket flexible connections are proposed to minimise the effects of differential pipe/structure settlement as well as minimise damage during a seismic event.

In addition, both pump stations have horizontal bends in close proximity to the pump station structure, and will require inline reinforced concrete thrust blocks adjacent to the pipe bends at the pump station structures.

3.6 Fish Passage

Refer to Section 4 for a discussion on the basis of the fish passage and welfare design.

3.7 Civil design

3.7.1 Trash screens

Debris/trash screens will be provided at each pump station inlet to mitigate damage and blockage risks to pumps. The selected pumps have free ball passage (solids handling capacity) of:

– Awatoto Pump Station: 200 mm (Vision 45MC) and 400 mm (Vision 90MC)
– Pakowhai Pump Station: 400 mm (Vision 90MC)

Trash screens' design criteria are consistent across all pump stations and are based on the following:

– Bar sizes: 100 to 120 mm x 10 mm at 150 mm centres (ie clear spacing of 140 mm)
– Maximum flowthrough velocity: 0.5 m/s at peak design flowrate

– Blockage rate at design flowrate: 20% (including bars and debris blockage)
– Screen angle from horizontal plane: 50° to 55°
– Manual raking lengths varying between 2 to 3 m
– Screens set in ~2.5 m wide panels.

The proposed trash screen total widths at the forebay inlets are noted below:

– Awatoto Pump Station: 7.6 m
– Pakowhai Pump Station: 5.5 m

Given the pumps' free ball passage capacity, potentially larger clear spacing could be considered for the Pakowhai pump station during the next design stage, up to a maximum of 200 mm as required by the PRs.

3.7.2 Buried pipelines

New buried rising main pipelines are proposed to be HDPE PE100 spiral wound SN16 pipelines (except for fittings, valves, flowmeter, pipe spools, etc.), with welded joints throughout except at the connection to the pump station structure where double rubber ring joints will be installed to provide flexible joints. A minimum cover of 750 mm will be provided above pipelines in trafficable areas.

The use of flexible pipes with the proposed jointing method aims to provide a resilient pipeline able to accommodate differential settlement and land movement. The extent of flexible joint movement will be optimised during detailed design to suit the expected seismic design movement as far as possible. The use of welded joints through the stopbank reduces the risk of joint openings (and associated internal scouring risk to the stopbank) in case of land movement. Pipe penetration through the stopbank will generally be constructed in accordance with the Bay of Plenty Stopbank Design and Construction Guidelines (2021).

3.7.3 Access ways and hardstand areas

Appropriate access to the pump stations, as well as hardstand areas for parking and operation & maintenance activities shall be provided. These areas will have a minimum freeboard of 500 mm above the 2% AEP water level on the landward side of the stopbank, except for Pakowhai pump station where the hardstand area will be above the 1.25 mRL level. Around the proposed Pakowhai pump station, the ground level is raised to around 2.5 mRL to provide sufficient freeboard above the 1% AEP flood level for electrical and controls infrastructure.

Access tracks will mostly be graded to a maximum 8% longitudinal grade, with a 3.5 m minimum width and minimum 3% crossfalls. In certain areas, where less regular vehicular access is required, longitudinal grades may increase to 15% over short distances, however these accesses will be stabilised and still considered appropriate for occasional use.

Hardstand areas will mostly consist of gravel surfacing (AP20) and be graded to shed water towards the receiving stormwater drains / channels, with typically 3% to 5% crossfall grades, except for hardstand areas for lifting pumps which will be concrete pavement. Geometry will be developed to allow an 11.5 m long rigid truck accessing and manoeuvring near the structures and pump station. Assessment of crane outrigger use will be carried out during the next design phase to confirm pavement requirements over pipeline locations.

A preliminary tracking assessment at the Awatoto Pump Station (shown on the drawings) indicates that due to limited space availability, truck access to the pump station wet wells is likely to require reversed access.

3.7.4 Sheet pile retaining walls

Where required (e.g. extension of existing channels), permanent sheet pile walls will be constructed to act as a retaining structure. The sheet piles will need to be at least 9 m deep, with a likely maximum depth of 15 m. The sheet pile wall design life is 50 years, as per section 3.9.3.

3.7.5 Interface with stopbank and surrounding ground level

The proposed works interface with the future stopbank levels (to be increased by others towards the river at Awatoto pump station). All our pipelines will be buried within the stopbank and future stopbank raising works should not, therefore, impact pump station operation.

The ground will be shaped to provide sufficient cover to buried infrastructure (e.g. pipes) or levelled access to the pump station, and trafficable slopes where an access track needs to be maintained (e.g. on the river side). Typically, in other locations, battered slopes will not exceed 1V:4H for grassed slopes or 1V:3H for planted areas. Any steeper slopes may require stability support in the form of rock wall or engineered solutions (to be confirmed in detail design).

Channels will be upgraded or created at the pump station discharge locations, with scour protection in the form of riprap, to accommodate the new flows and/or discharge locations.

3.7.6 Site drainage

Site drainage will be designed to accommodate design events (10% AEP for the primary system, 2% AEP for the secondary system / overland flow paths). Site drainage will preferentially consist of open drains where possible, and be designed in the detail design phase to discharge back into the pump station intake area (either channel or forebay).

Where practicable, stormwater runoff on hardstand areas will be treated via vegetated swales or vegetated filter strips prior to being discharged into the drainage channels or into the pump station intake structures.

3.7.7 Scour protection

Scour protection will be provided where high flow velocities are expected (e.g. at the rising main discharge locations) to protect new and existing ground against uncontrolled scouring. Scour protection will be designed in the detail design phase in accordance with the HEC-14 Hydraulic Design of Energy Dissipaters for Culverts and Channels. The preliminary design allows for rock rip rap layers on geotextile protection.

3.7.8 Fencing

Due to the open nature of the pump station, with pump motors being located above ground, security fencing (compliant with the PRs) with lockable gates will be installed at all pump stations to protect the infrastructure.

Safety railings will also be required at different structures, including:

- Pump station wet wells and pump motor platforms.
- Concrete outlet headwalls.
- Retaining walls where a fall from height is possible.

3.8 Geotechnical design

Given the inherent risk posed by the ground conditions, full Geotechnical Interpretive Reports (GIR) were compiled for each site to provide additional concept design confidence and certainty. These are provided as a separate submission for geotechnical design of Awatoto and Pakowhai pump stations. A brief summary of the geotechnical design is presented below.

Geotechnical interpretation for tender design has been based on the existing geotechnical investigations made available at each pump station location. The general geological setting of the two pump stations is relatively consistent, located within the Holocene alluvial (gravel, sand, silt, and mud) and estuarine deposits (poorly consolidated silt, mud, peat, and sand).

Liquefaction assessment has been carried out for each pump station based on Importance Level 2 structures, with a seismic design life of 50 years. The assessment indicates that liquefaction is likely to occur extensively at various depths beneath the site during both an “intermediate” 1/100-year return period event, and the ULS seismic event. The effects of this for the pump station and associated infrastructure include but are not limited to liquefaction induced settlement, bearing capacity failure, uplift, lateral spread and slope instability with associated permanent displacement.

To mitigate against adverse effects of liquefaction on the foundation performance, ground improvement works have been specified. The ground improvement works are designed to mitigate liquefaction effects up to and including a 1 in 100-year return period (i.e., intermediate level seismic event). The proposed ground improvement works comprise of a 1.2 m thick geogrid reinforced gravel raft at the base of the pump station (shallow ground improvement), in combination with a deeper ground improvement in the form of an array of driven treated timber piles for densification of predominantly sandy liquefiable soil lenses.

The shallow ground improvement aims to provide a stiffened shallow foundation that reduces the potential for damaging differential flexure of the structure through settlement and lateral movement, by constructing a non-liquefiable surface 'crust', whilst the deep ground improvement aims to eliminate (or greatly reduce) the liquefaction potential at design levels of shaking. It is envisaged that with the implementation of proposed ground improvement, the pump station (and its associated infrastructure) will remain operational up to and including the intermediate seismic event, acknowledging that under ULS event, substantial structural and non-structural damage is possible, though expected to be repairable within a reasonable timeframe.

Additional geotechnical investigations were completed during the preliminary design stage to inform in the subsequent detailed design phase. Refer to section 7.1 for further details in this regard.

3.9 Structural design

Walls and foundations are site specific structural engineering design for this project as detailed in the sections following.

3.9.1 Standards, codes and guidelines Used

The structures will be designed in accordance with the New Zealand Building Code (NZBC), clause B1 – Structure and clause B2 - Durability. The following codes of practice and sources of references used for the structural design are provided in Table 6:

Table 6 Design standards and references

Subject	Code Reference
General	NZ Building Code (NZBC), Parts B1 and B2
Loading	AS/NZS 1170.0 Structural design actions, Part 0: General Principles AS/NZS 1170.1 Structural design actions, Part 1: Permanent, imposed and other actions NZS 1170.5 Structural design actions, Part 5: Earthquake actions – New Zealand TS 1170.5:2004 Technical Specification. NZ Draft Standard. Structural Design Actions Earthquake Actions NZGS Module 6 – Earthquake resistant retaining wall design
Reinforced concrete	NZS 3101 Concrete structures standard NZS 4671 Steel reinforcing materials NZS 3109 Concrete construction NZS 3106 Design of concrete structures for the storage of liquids
Steelwork	NZS 3404 Steel structures standard NZS 5131 Steel Fabrication and Erection Standard HERA design guides (various) AS/NZS 1554.1:2014. Structural steel welding - Part 1: Welding of steel structures SCNZ Report 14 Steel Connect Structural Steelwork Connections Guide
Foundations	NZS 3101 Concrete structures standard NZS 3109 Concrete Construction Standard NZBC – Verification Method B1/VM4 Foundations
Corrosion Protection	SNZ TS 3404: 2018 Durability requirements for steel structures and components

Subject	Code Reference
	AS/NZS 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings AS/NZS 4792:2006 Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process AS/NZS 4680:2006 Hot dip galvanized (zinc) coatings on fabricated ferrous articles AS/NZS 1214 Hot-dip galvanized coatings on threaded fasteners
Walkways	NZS/AS1657 Fixed platforms, walkways, stairways and ladders. Design, construction and installation

3.9.2 Loads

a) In accordance with NZS 1170.1:2002 the following dead loads (self-weights) have been adopted:

- Concrete 24 kN/m³
- Steel 77 kN/m³
- Water 10 kN/m³
- Natural fill 18 kN/m^3
- Engineered fill 20 kN/m^3

All dead loads are calculated using a gravity constant of 9.81 m/s².

b) The platform personnel access to the equipment at the top of the dry well are intended for pedestrian loading only.

Imposed loads have been determined in accordance with NZS 1170.1:2002, project requirements and are summarised in the Table 7 below.

Table 7Imposed load summary

Area	Use	Live load	Basis of Load
Dry well	Walkways	3.0 kPa	AS/NZS 1170.1 AS 1657
Concrete roof	Excavator, cleaning	200 kN	

c) The lateral earth loads from static earth backfill pressure have been considered in the design of retaining structural elements. Due to the relative stiffness of the wall structures, at-rest earth pressures have been adopted. The external walls will be backfilled with 4.5 m of engineered fill.

d) Seismic incremental earth pressures on the external walls have been derived in accordance with NZS 3106 CA2.6 assuming “Rigid” wall type response using PGAs (Peak Ground Accelerations) from the TS 1170.5.2024.

e) The structural design of the pump station structure is based on the anticipated water level conditions as per hydraulic design levels. During regular operation, each cell will typically be filled with water at normal operating level.

f) A vehicle surcharge of heavy vehicles (HN-HO-72) is considered in the design of the structure retaining walls.

g) In accordance with the structural PR, the pump station is classified as Importance Level 2 structure with a design life of 50 years in accordance with AS/NZS 1170.0:2011. The return periods adopted for the purposes of determining loadings have been summarised in Table 8.

Table 8Return periods

Action	SLS1	ULS
Seismic	1 in 25	1 in 500

h) In accordance with NZS 1170.5:2004 and TS 1170.5:2024, the following design parameters provided in Table 9 have been adopted.

Table 9Seismic load coefficient parameters to NZS 1170.5:2004

Parameter	Value
Importance Level	2
Design Life	50 years
Period, T	<0.4 s
Sp	1.0
R	1.3 (ULS) 0.25 (SLS1)
Ductility	μ = 1.00
Short Period Spectral Acceleration	$S_{a.s}$ =1.26 (ULS) $S_{a.s}$ =0.34 (SLS1)
Peak Ground Acceleration	PGA = 0.61 (ULS) PGA = 0.15 (SLS1)
Site Classification	VI
Near-fault Factor	N(T,D) = 1

i) Pump station structures will be designed for overall seismic performance and are designed for static loading and seismic loading. Refer to the Geotech report for site parameters.

j) Wind, snow and ice loadings are not critical to the pump stations. Wind actions for the MCC room have been determined from AS/NZS 1170.2:2021. Wind design parameters are summarised in Table 10.

Table 10 Wind load parameters to AS/NZS 1170.2:2021

Parameter	MCC Room
Region	NZ2
VR (ULS)	46 m/s
VR (SLS1)	39 m/s
Md, wind direction multiplier	1.0
Terrain category	TC2.0
Height, z	3.2 m
Mz,cat, terrain multiplier	0.91
Ms, shielding multiplier	1.0

3.9.3 Serviceability Criteria

The following serviceability criteria was considered in the design of the structures.

Liquid Tightness

Crack widths have been limited to 0.2 mm for the structure with B2 exposure in accordance with the provisions of NZS 3101. Hydrophilic seals will be provided on construction joints to reduce ingress of water and reduce likelihood of corrosion of reinforcement.

Durability Provisions

The durability design life of the structure is 100 years. The materials need to be durable to withstand the environment for that period of time.

Design Life

- Foundation and Walls 100 years minimum
- Steel work 50 years minimum

Note: non-structural elements specification is not covered by this report.

Durability of Structural Elements

The reinforced concrete elements are designed for a 100-year design life for durability. This is achieved through design to the durability requirements of NZS 3101. The structure is subject to water (non-aggressive) exposure to surfaces.

A summary of the parameters adopted for durability and water tightness are provided in Table 11.

Table 11 Durability Design Parameters

Parameter	Value	Basis
Exposure category	A2 – Structure retaining walls and base slab underside in contact with ground	NZS 3101 as soil is not considered as contaminated or aggressive
	B2 – Internal surfaces which are below the typical top water level	NZS 3101 table 3.1
Allowable Crack Width	0.2 mm	Based on NZS 3101
Typical Cover	50 mm	50 mm required by NZS 3101 for B2 exposure.
Cover other	75 mm	75 mm required when cast against ground
Cover other	50 mm	Minimum concrete cover for slab in contact with soil with additional sealing membrane

Structural Steel

The structural steel elements are designed for a 50-year design life for durability. The surface treatments are provided in Table 12.

Table 12 Steel Elements Surface Treatment Requirements

Element	Surface Treatment	Time to First Maintenance	Basis
Steel work, Base plates	Hot Dip Galvanized HDG600 alternative Thermal Sprayed Zinc-TSZ-100 with special quality assessment/assurance	25 years	Corrosivity category C3
Handrail	Hot Dip Galvanized HDG600 or alternative Thermal Sprayed Zinc-TSZ-100 with special quality assessment/assurance	25 years	Corrosivity category C3
Fixings	Galvanized bolts		

3.9.4 Material Properties (Typical)

Concrete

- Foundations 40 MPa
- Walls 40 MPa
- Roof 40 MPa
- Site concrete 10 MPa

Reinforcing Steel

Unless noted otherwise within the drawings, all steel reinforcement shall be in accordance with the following:

- Wall reinforcing 500 MPa
- Foundation reinforcement 500 MPa
- Wall and Foundation stirrups 300 MPa and 500 MPa

Structural Steel

- Rolled Steel Sections 300 MPa – Grade 300 to AS/NZS 3679.1*
- Steel Flats 300 MPa – Grade HA300 to AS/NZS 1594
- Steel Plate 350 MPa – Grade HA350 to AS/NZS 1594
- SHS Hollow Sections AS 1163 – 350 MPa – Grade C350 L0
- Bolt Grades Grade 4.6 mild steel, Grade 8.8 high strength (general)
- Tensioning requirements for 8.8 bolts S, TB and TF as required.

  *note: for all hot-rolled UB and UC sections, steel grade shall be Grade 300S0 in accordance with AS/NZS 3791.1 unless noted otherwise on the drawings.

3.10 Electrical and Control Design

MCC Room

The Control Room is designed to house all critical electrical and control equipment, including the main switchboard, active harmonic filtration, VSDs, SCADA control panel, and a heat pump for climate control. This state-of-the-art facility ensures easy access for operators at any time of day or night, with a user-friendly layout that prioritizes safety and efficiency.

The building will be a concrete block structure with steel roof and insulated ceiling and will include two entry/egress doors. It will be equipped with climate control to maintain optimal conditions for the sensitive equipment, ensuring reliable performance and minimal downtime. The design of the room allows for seamless operation and quick intervention when necessary, enhancing operational reliability and supporting 24/7 monitoring and control of the entire system.

Backup Generator Capability

Resilience is built into the design with backup generator connections available at each pump station, with the ability of the operator to supply to site a correctly sized mobile/portable generator with an easy plug connection. In the event of a power failure, each site is equipped with a manual changeover switch that will enable the site to be changed over to run off a generator. A specific area adjacent to the MCC room will be designated as a park for a generator and will be equipped with a blanked-off spare cable duct leading into the MCC room control cabinet, should a permanent generator installation be considered in future.

As an option, permanently installed backup generator power at each pump station can be offered, with capacity to operate all stormwater pumps at the peak required flow rates continuously for 24 hours based on a 1% AEP event. If this option is implemented, in the event of a power failure, the site will be equipped with motorized main and generator switches that will automatically switch the power supply to the generator. This seamless transition will enable continuous power to the site, minimizing any downtime. The system will allow the generators to take over immediately, providing uninterrupted power to the pumps and other equipment until the main power supply is restored.

Harmonic Filters

Active Harmonic Filtering technology has been integrated into the design to improve overall power quality critical to resilience and effects of large events. The active harmonic filter not only prevents the negative impacts of harmonic distortion on electrical equipment but also enhances energy efficiency by reducing power losses caused by these distortions. This leads to significant cost savings and extends the operational lifespan of the equipment.

Pump Operation

The operation of the pumps is controlled by the water levels in the facility, which are continuously monitored using level transducers - one located in the inlet bay and another upstream of the trash rack. The level transducers feed real-time data to a Kingfisher RTU, which acts as the central control unit for the site. The Kingfisher RTU processes the data from the transducers and makes decisions regarding the activation and operation of the pumps.

The SCADA system, integrated with the Kingfisher RTU, uses this water level data to control the duty and assist pump. In normal operation, one pump is selected as the duty and the other as the assist pump (not applicable at Awatoto PS where duties will rotate amongst assist pumps as the Lead pump will always be the duty pump). This is usually selected by the pump run hours. As the water level rises, the Kingfisher RTU evaluates the input from the level transducers to determine whether additional pumping capacity is needed.

- **Duty Pump:** This pump is the first to start when the water level reaches a set threshold. It serves as the primary pump in normal conditions and it will start at its full downturn (minimum) flow rate. At Awatoto PS this is always the Lead Pump.
- **Assist Pump:** As the water level continues to rise and the duty pump reaches a preset interim flow rate (prior to its full operational capacity), the Kingfisher RTU triggers the assist pump to operate. The RTU will bring on the additional pump as required, varying flow rates as required, based on the water level readings, so that the system can handle increased demand without overwhelming the duty pump.

The Kingfisher RTU uses a water level approach to optimize the number of pumps in operation. By monitoring the differential between the two-level transducers (the one in the water gallery and the upstream transducer), the RTU can identify if the screen is blocked, indicating a problem with the water flow. In such cases, the RTU will adjust the pump operation and trigger an alarm.

Once the water level decreases, the RTU will gradually deactivate the assist pumps first, leaving the duty pump in operation, whilst keeping flow rates as low as possible to benefit fish welfare. If the water level falls below the minimum channel water level threshold, the RTU will shut down the duty pump and all assist pumps.

This automated control process through the Kingfisher RTU, utilizing real-time data from the level transducers, will let the pumps operate efficiently, responding to fluctuating water levels and maintaining optimal performance with fish welfare in mind. Additionally, backup high and low-level transducers are in place to provide monitoring and alarm so that the system continues to operate correctly even if some level transducers experience a fault.

I/O (Input/Output) Control System Overview

The control system for the site will include various hardwired controls, analogue and digital signals, and local and remote-control functionalities to provide efficient operation and manual override capabilities.

Variable Speed Drives (VSDs):

- **Hardwired Controls:**
  - **Speed Reference (Analog Output):** Each VSD will receive an analogue signal for the speed reference. This allows the system to control the speed of the pumps based on the water level data processed by the Kingfisher RTU and SCADA.

- **Running and Fault Signals (Digital Inputs):** Hardwired running and fault signals from each VSD will be connected to the system for real-time monitoring of pump status. These signals will be used to trigger alarms or notifications on the HMI or SCADA system in case of faults.

- **Local Control on Switchboard:**
  - **Selector Switch (Local/Off/Remote):** A local/off/remote selector switch on the switchboard will allow operators to select the desired mode of operation for the pumps.
  - **Start/Stop Buttons:** Local start and stop buttons will be provided for manual control of the pumps when operating in local mode. Pumps will also have adjacent emergency stop switches that override automatic operation.
  - **Run and Fault Signal Lights:** Visual indicators (run and fault signal lights) will be installed on the switchboard to show the current status of each pump. A fault reset pushbutton will be provided to reset faults manually when needed.

Rotork Actuators:

- **Control and Feedback:**
  - **Position Feedback (Analog Input):** Each Rotork actuator will have an analogue input for position feedback, allowing real-time monitoring of the valve position.
  - **Open/Close Digital Controls:** Digital inputs will be used to control the open and close actions of the Rotork actuators, which can be set to regulate the flow, if required.
- **Local Control:**
  - **Local/Off/Remote Switch:** The switchboard will include a local/off/remote selector switch for the manual operation of the valves.
  - **Open/Close Buttons:** Push buttons for manually controlling the valve's open and close actions will be available for local operation.

Flow Measuring and HMI Integration:

- **Flow Rate Display:** A calibrated estimation of the pumped flow rate will be displayed on the HMI for real-time monitoring. Additionally, the estimated total volume of water pumped out will be totalized and sent to the SCADA system for reporting and analysis.
- **Modbus Communication:**
  - **Monitoring Signals:** Modbus communication will be used to monitor key parameters of the generators, such as operational status, load, and fault conditions, which will be sent to the SCADA system for remote monitoring.

Level Transducers and Level Switches:

- **Analog Inputs:** The level transducers will provide analogue inputs to the control system, allowing precise monitoring of the water levels.
- **Digital Inputs:** Digital inputs will be used for the low-level probe switches, which serve as a backup for the level transducers to provide fail-safe pump stop functionality.

4. Fish Welfare Provisions

The presented preliminary design provides for bidirectional fish passage at the Pakowhai pump station, in compliance with the PRs. The preliminary design provides for downstream fish passage at the Awatoto pump station using fish friendly pumps. An option to achieve upstream fish migration using an innovative piped fish passage system was developed in concept, but is not being progressed as part of the preliminary or detailed design.

A significant assessment of various pump types and fish screen options was carried out before the team settled on a solution that we believe provides a resilient, easy to operate and maintain system while providing a significant and demonstrable increase in fish passage and welfare compared to the existing system.

While it is noted that a fish and fish passage report provided by HBRC considers fish screening, actuated gates and the WALE system as more fish-friendly than fish-friendly pumps or fish-friendly flap gates, we are proposing the use of fish-friendly pumps in lieu of screening, and the use of fish-friendly flap gate valves, for the following reasons:

- Advancements in fish-friendly pumping technology now provides a proven low mortality rate and significantly increases the fish welfare attributes of the existing system.
- Omission of a fish screen reduces system complexity and removes inherent operational and maintenance H&S risks and ongoing expenditure. Additionally, none of the screen suppliers contacted could provide a dependable bypass solution at the time.
- Due to the stormwater pump stations being situated at a “dead end”, fish screens for this project will not meet the NIWA fish screen design guidelines that require a sweep velocity at the screen, potentially resulting in small fish/fry mortality at the screens.
- Installation of riverside electrical valve/gate actuation introduces significant risks due to flood damage and vandalising potential on equipment that is not within the pump station security area. Any issue with such a more complex installation increases the risk of landside flooding.
- The WALE system is unproven and does not allow for upstream migrating inanga where the landward water level is lower than the riverside water level, for example at Awatoto Pump Station.

The proposed Bosman pumps are designed and tested in the Netherlands and come with extensive third-party testing of fish welfare and mortality rates. The tests performed include eels of up to 1.2 m in length and 80 mm thick, and pump heads exceeding this project’s maximum head requirements. Please refer to Appendix B for information on the fish welfare testing undertaken for the Bosman pumps.

All the pumps proposed for the two pump stations achieve <8% mortality at peak flow rates, and <2% at downturned (minimum) flow rates. As the mortality rate is directly linked to pumping rate and impeller rpm, the pump stations’ control will be set to start an assist pump before the duty pump reaches its maximum pump rate to minimise the time any pump will operate at peak flow rate.

As with Awatoto pump station, Pakowhai will also be equipped with fish friendly pumps (the same model), for downstream migrating fish.

An existing DN1500 pipeline is assumed to provide sufficient fish passage for both upstream and downstream migrating inanga and eels. The single design change to the existing structure is to replace the existing riverside flap gate with a new fish-friendly flap gate.

It should be noted that it has not been possible to confirm the downstream invert level of this pipe and the downstream discharge level may not fall within the required 150 mm below MLWS as in the PRs. From observations on site, however, the pipeline appears to be located at a sufficiently low elevation, given the low river level during the formal bid site visit. No peak flow velocities through this pipeline have been estimated or calculated and may exceed the 0.3 m/s stated in the PRs.

5. Resource Consenting Approach

As indicated in the PRs, resource consenting shall be managed by Stradegy, and obtained via the Order in Council (OiC) application process. However, inputs shall be required as part of the application process and we have allowed for the provision of the following items:

– Pump Station design drawings that include plans, cross sections, indicative earthworks, vegetation requirements / habitat disturbance, construction area
– Preliminary Design Report
– Geotechnical / Groundwater Assessment
– Landscaping Effects Study and Mitigation Plan
– Transport Assessment (including impact on nearby roads, construction access, visibility etc.)
– Acoustic Assessment (during design and post-construction)
– Input into the Construction Environmental Management Plan (CEMP), as required

Please note that a flood modelling report is excluded from this scope due to not receiving the required information at the time of tender.

In addition to the above requirements:

- We have allowed for liaison between Stradegy and GHD planners who have experience working with HBRC, in the event that planning review / assistance is required.
- The simplicity of the proposed design presents an opportunity to incorporate Ngati Parau influence into the architectural and landscaping design of the pump stations.

6. Pump Station Resilience

The seismic design prioritizes both ULS and SLS1 criteria to ensure structural integrity and operational continuity.

- ULS (1 in 500 years): This condition addresses the structure's behaviour under severe seismic events. The focus is on preventing collapse and ensuring life safety.
- SLS1 (1 in 25 years): This condition focuses on maintaining operational functionality after moderate seismic events, minimizing damage and downtime. The design should minimize cracking and other forms of damage to structural and non-structural components. Critical systems, such as pumps and control equipment, must remain functional after the seismic event. The structure should be safe for immediate occupancy and continued operation without major repairs. Limiting the deformations of the structure, and especially the foundation is very important to keep the equipment operational.

Structural Challenges and Considerations:

The buried nature of the pump station and the site's poor soil conditions present unique challenges:

- **Foundation:** The infeasibility of a piled foundation renders the structure vulnerable to sliding, overturning, and differential settlement. This necessitates robust foundation design to mitigate these risks.
- **Soil-Structure Interaction:** A comprehensive 3D analysis is crucial to accurately model the interaction between the soil and the structure. This analysis should account for:
  - Liquefaction effects, which can significantly alter soil properties and induce excessive settlement.
  - Induced forces on the structure due to seismic wave propagation and soil deformation.

- **Structural Components:**
  - Foundation Slab, External Walls, and Internal Walls: Under ULS conditions, these components are expected to sustain significant damage, potentially requiring replacement. The design must ensure adequate reinforcement and detailing to manage cracking and prevent collapse.
- **Equipment and Walkways:**
  - These non-structural elements are anticipated to experience severe impacts during a ULS event, necessitating extensive repairs or replacement. Proper anchorage and seismic restraint are essential.

7. Additional Investigation Requirements

7.1 Geotechnical Investigations

The following additional geotechnical investigations were carried out post-award for each pump station as part of the Preliminary Design. These investigations complement the previous geotechnical investigations undertaken by WSP, which were provided by HBRC for Tender Design purposes. The results of the investigation are attached in Appendix E.

- 1 no. machine drilled borehole at each pump station location, to a maximum depth of 19.95 m below ground level (BGL), with selected laboratory testing (PSD & Atterberg limits)
- 1 no. machine drilled borehole at each outlet headwall location, to a maximum depth of 20 m BGL, with selected laboratory testing (PSD & Atterberg limits)
- 1 no. Cone Penetrometer Test (CPT) at each pump station location, to a maximum depth of 20 m BGL
- 1 no. CPT at each outlet headwall location, to a maximum depth of 20 m BGL
- 2 no. hand auger boreholes at stopbank toe (one per side).

We consider the results of these additional investigations are generally consistent with the subsurface conditions described in the Geotechnical Interpretation Report (GIR) completed by GHD during Tender Design. The additional investigation data has enabled refinements to the interpretation of the ground model presented in the aforementioned GIR; however, we consider that these updates to our understanding of the ground conditions will not likely result in significant changes to the geotechnical design assumptions or recommendations adopted for Preliminary Design. We consider the recommendations presented in the aforementioned GIR remain applicable at this stage of design progression.

GHD are updating the GIR previously submitted during Tender Design stage to incorporate the findings of the latest investigation works and the refined ground model interpretations. The updated GIR will be re-issued as a separate revised version for the purposes of the Preliminary Design.

Due to the proposed liquefaction mitigation strategy, the following geotechnical investigation is likely to be required at each pump station during the construction stage of the proposed pump station works, primarily for verification purposes for the ground improvement works:

- Nominally, 1 no. CPT (target depth of 15 m) per 100 m^2 of ground treatment area, with a minimum of 3 no. CPTs per pump station footprint.

7.2 Topographical survey

Additional topographical survey of site-specific items is envisaged. These include (but are not necessarily limited to) the following:

- Confirmation of inlet and outlet channels depth and geometry in the area of the works
- Confirmation of the existing Pakowhai bypass pipe outlet IL

7.3 Water level monitoring

Water level monitoring is proposed to be undertaken at each site's outlets. This information will confirm expected water level at the pump station discharge, including MLWS and tidal influence at each site. This will inform:

– Pump stations hydraulics
– Fish passage design parameters (e.g. new pipe invert level at Awatoto) or expected fish passage availability / duration at Pakowhai with the existing DN1500 gravity discharge pipe.

8. Temporary and Enabling Works

Temporary Works provisions required for this project are noted below:

- *Sheet piled coffer dam* - Constructed SP4W sheet piles with 310 UC walers (where required) to provide working area near or around channels. Survey points monitored on sheet piles.
- *Sump pump dewatering arrangements* - Flow rates to be verified on site, likely requirements of two 4" pumps.
- *Interaction with existing infrastructure* - ensure adequate monitoring, protection and temporary solutions are planned and verified where interfacing with existing Pump stations, O/H Utilities, Underground infrastructure (new and existing).
- *Crane platforms* - Verified geotechnical data analysed to ensure stability of plant used on site.
- *Formwork and False work & Propping* - identified early and adjusted through detailed design for changes. Designed and verified before use with ongoing monitoring where required. Seismic influence heavily considered.
- *Demolition plan and sequence* - verified prior to commencement.
- *Bunded coffer dam and stream diversions* - designed with relevant engineering controls and checked.
- *Concrete curing time* - constraints for construction sequence and staging provided for protection on new infrastructure and safe outcomes.

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