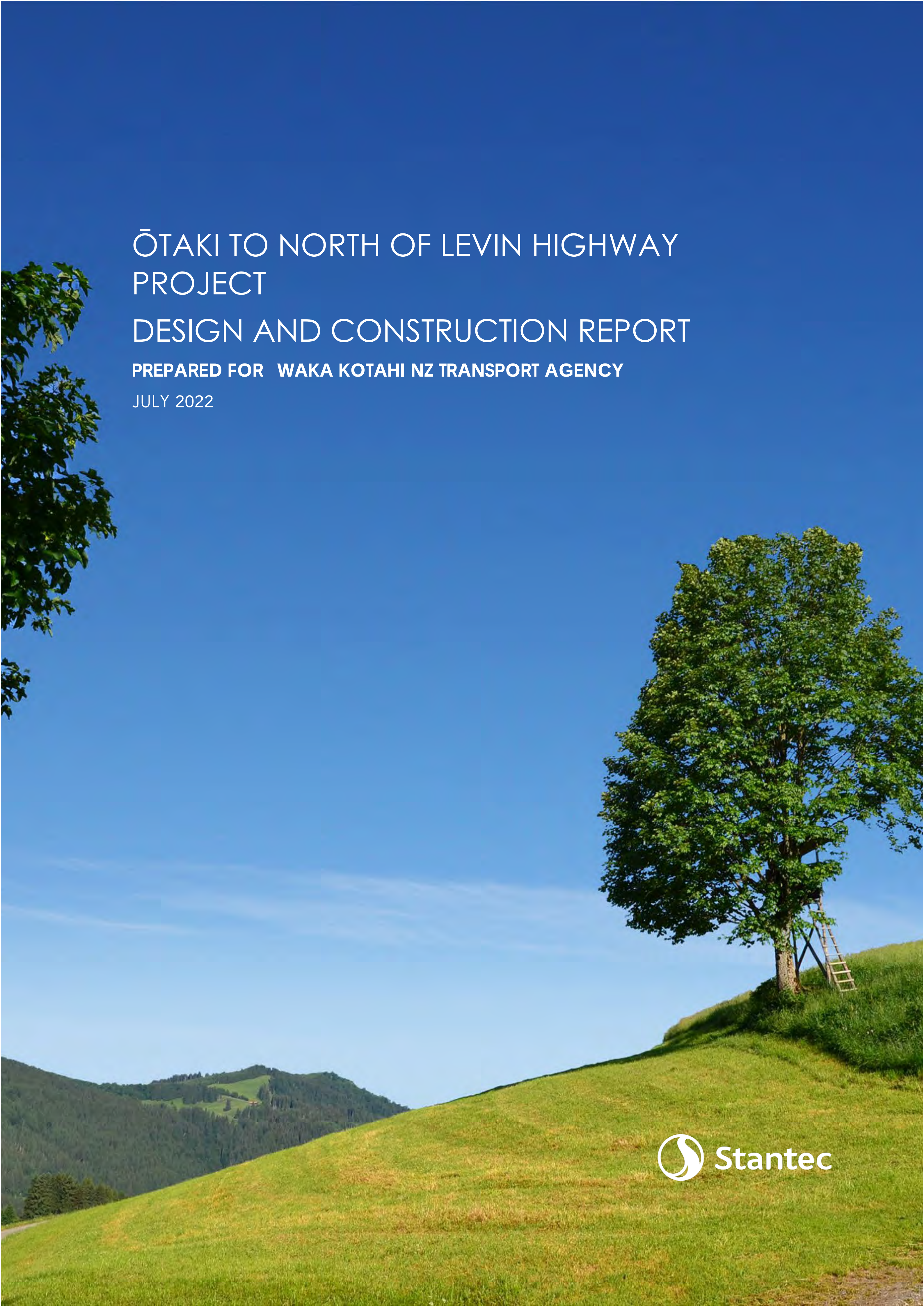
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

DESIGN AND CONSTRUCTION REPORT

PREPARED FOR WAKA KOTAHI NZ TRANSPORT AGENCY

JULY 2022



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DESIGN AND CONSTRUCTION REPORT

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1. Introduction

1.1. Overview

Waka Kotahi NZ Transport Agency (Waka Kotahi) is seeking Resource Management Act 1991 (RMA) authorisations (designation and resource consents) to construct and operate the Ōtaki to North of Levin Highway Project (Ō2NL Project or Project). The Ō2NL Project will deliver a significantly improved state highway connection between State Highway 1 (SH1) at Taylors Road north of Ōtaki, and SH1 just north of Levin. At the southern end, the Ō2NL Project will tie-in with the Peka Peka to Ōtaki (PP2Ō) highway, currently under construction.

SH1 is New Zealand's most important highway, but the section between Ōtaki and Levin is afflicted by a number of serious safety, efficiency, and resilience problems. State Highway 57 (SH57) which connects Wellington and Levin to Palmerston North, also has significant safety issues. The importance of this section of SH1 is characterised by its function in connecting Wellington and the South Island to the upper North Island, where no other resilient route exists. SH1 and SH57 also together provide an essential economic connection to Palmerston North, the largest freight node in central New Zealand.

The Ō2NL Project route is located to the east of the existing SH1 and SH57. In summary, and heading north, the proposed new highway will extend from the northern end of PP2Ō (which is located approximately 2 km north of the Ōtaki township) and will re-connect into SH1 and SH57 to the north of Levin.

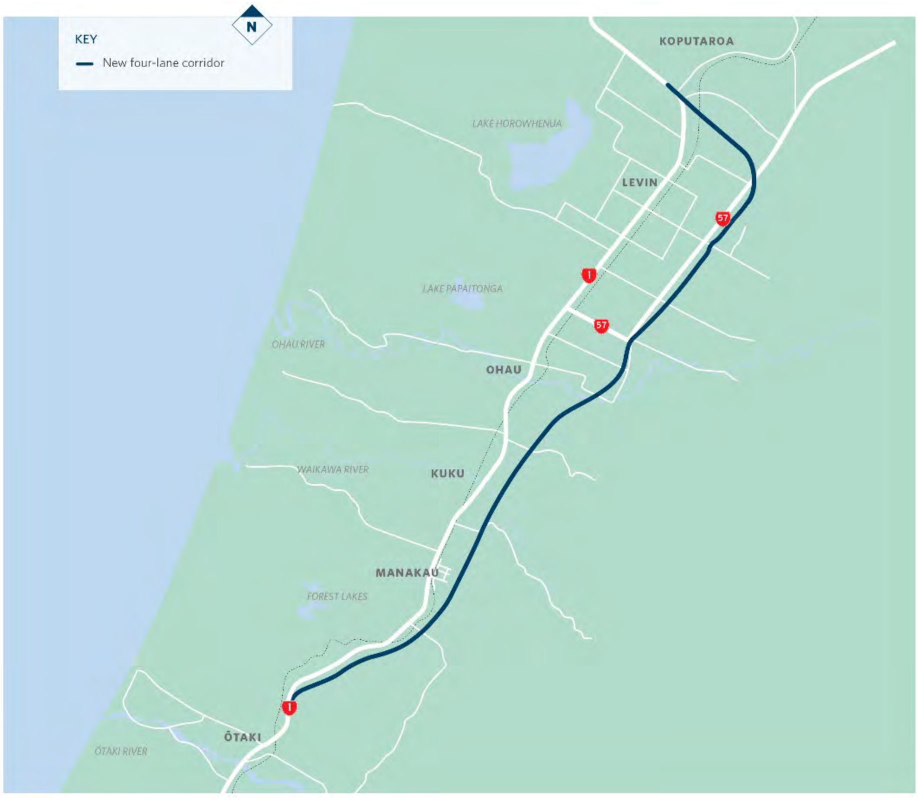

Figure 1: Schematic of the new Ō2NL Highway

The concept design of the Ō2NL Project is shown on the drawings and plans provided in Volume III and includes the following key elements:

- Approximately 24km four-lane (two lanes in each direction), median divided new highway between Taylors Road north of Ōtaki, linking with PP2Ō, and ending just north of Levin, where it connects back into the existing SH1 and to SH57 towards Palmerston North
- Built to the east of the current State highways and east of the Manakau, Ohau and Levin townships
- Access to the new highway being limited, and provided only as follows:

- Grade separated diamond interchange at Tararua Road (CH18200)[1], and a half diamond interchange with south-facing ramps near to Taylors Road (CH34200).
  - At-grade roundabouts at SH57 (CH13100) and SH1 north of Levin (CH10300).
- Bridges over the Waiauti (CH30400), Waikawa (CH26500) and Kuku (ST23800) Streams, the Ohau River (CH22600) and the North Island Main Trunk rail line (CH10700).
- Underpasses[2] near to Taylors Road (CH34200) for connectivity to the existing SH1 where Ō2NL connects with PP2Ō, and at South Manakau Road (CH30200).
- Overpasses[3] at Manakau Heights Drive (CH29000), North Manakau Road (CH27100), Kuku East Road (CH24000), Muhunoa East Road (CH21500), and Queen Street East (CH15600).
- New local road links as follows:
  - Realignment of part of Kuku East Road (CH23900)
  - Realignment of part of Muhunoa East Road (CH21600)
  - New link provided between McLeavey Road and Arapaepae Road South (west of new highway)(CH20000-20500)
  - New link provided between Kimberley Road and Arapaepae Road South (east of new highway)(CH19600-20200)
  - New link provided between Kimberley Road and Tararua Road South (east of new highway) (CH18200-19600)
  - New link provided to connect Waihou Road with Macdonald Road and SH57 (CH13200-14000)
  - Extension of Sorenson Road to the south (CH11100)
  - New link provided between Koputaroa Road and Heatherlea East Road, with access onto the new highway roundabout (CH10100)
  - Realignment of current SH1 (The Ave) to connect to northern roundabout (CH10300)
- Upgrading of the current SH1 and Tararua Road intersection in urban Levin, to become a signalised crossroad intersection, with integration of rail signalling and barriers.
- A separated shared use path (SUP) for walking and cycling along the entire length of the new highway (but deviating away from being directly adjacent to the new highway in some locations) that will link into shared path facilities built as part of PP2Ō (and further afield to the existing Mackays to Peka Peka (M2PP) shared path).
- Stormwater treatment wetlands, stormwater swales, drains, sediment traps (refer to the Stormwater plans provided in Volume III
- Culverts to reconnect streams crossed by the proposed works and stream diversions to recreate and reconnect streams.
- Spoil sites at various locations.
- Four Material Supply Sites at various locations.

1.2. Purpose of this Report

The DCR describes the concept design (including operational features) of the Ō2NL Project and describes the works necessary to construct the Project. The basis for the design and construction is described below and, in particular, has been informed by the Cultural and Environmental Design Framework (CEDF) (provided as Appendix Three to Volume II).

The concept design has been prepared for the highway to demonstrate that the designations are sound and to help provide an envelope of effects. The designations do not fix the highway design but provide flexibility of alignment and design that will be finalised as part of detailed design. The concept design has

[1] 'CH18200' refers a station or 'chainage' referencing system used (notated on plans at 100m intervals) measured along the centre line of the new highway to assist in describing locations and features of the proposed design

[2] Underpass is defined as being where the local road passes beneath the new highway

[3] Overpass is defined as being where the local road passes above the new highway

been used as a practical basis to understand the nature and scale of the actual and potential effects on the environment that result from the Ō2NL Project. Consideration of effects and mitigation at a fine scale will be addressed through an Outline Plan of Works. The technical effects assessments are provided in Volume IV.

The construction methodology described within this DCR (including the proposed staging) represents a realistic and feasible methodology from which the anticipated effects on the environment of these activities can be identified and assessed for consenting. As is normally the case with large infrastructure projects, further refinement will occur as the Ō2NL Project progresses into the detailed design and construction phase enabling optimisation of the design and construction methodologies.

This DCR is to be read in conjunction with the Drawings and Plans provided in Volume III and the Technical Assessments provided in Volume IV.

1.3. Report Structure

This report is structured to describe an overview of the Ō2NL Project, relevant physical works, construction methodologies and other considerations relevant to the Ō2NL Project:

Section 1: Introduction

Section 2: Design Overview

Section 3: Design Description

Section 4: Construction

Appendices

4.1 Geotechnical Design Summary Report

4.2 Stormwater Management Design Report

4.3 Erosion and Sediment Control Technical Report

4.4 Spoil Sites Report

4.5 Material Supply Sites Report

4.6 Schedule of design refinements

4.7 Potential sources of construction water

1.4. Project Objectives

The Ō2NL Project objectives, including for the purposes of section 171(1)(c) of the RMA, are:

- Enhance safety of travel on the state highway network.
- Enhance the resilience of the state highway network.
- Provide appropriate connections that integrate the state highway and local road network to serve urban areas.
- Enable mode choice for journeys between local communities by providing a north-south cycling and walking facility.
- Support inter and intra-regional growth and productivity through improved movement of people and freight on the state highway network.

2. Design Overview

2.1. Consenting / Concept Design

The Ō2NL Project has been designed to a level of detail suitable for seeking designations and resource consents. It is not yet at a stage of progression to allow construction. This next level of detail will be completed in subsequent phases (which may include a Specimen Design and also a final Detailed Design).

The stage of design presented provides sufficient certainty to appropriately quantify potential environmental effects for the RMA consenting and designation process. The advancement of different design elements has been targeted to ensure adequacy for consenting. For example, stormwater and earthworks have been well advanced, whereas for other items, such as subsurface and road furniture (barriers, lighting poles etc.), designs are at an early stage only in light of the limited potential effects associated with those elements.

2.2. Cultural Values and Design Framework Principles

Through the partnership process with our Iwi Partners (Muaūpoko Tribal Authority and hapū of Ngāti Raukawa ki te Tonga), the core (overarching) principles developed for the Ō2NL Project and the CEDF (provided as Attachment Three to Volume II) are to:

- **Tread Lightly, with the whenua**
  - Me tangata te whenua (treat the land as a person)
  - Kia māori te whenua (let it be its natural self)
- **Create an Enduring Community Legacy**
  - Kia māori te whakaaro (normalise māori values)
  - Me noho tangata whenua ngā mātāpono (embed the principles in all things)
  - Tū ai te tangata, Tū ai te whenua, Tū ai te Wai (elevate the status of the people, land and water.

These core principles flow from Tikanga Māori and Te Ao Māori cultural values. These values define the framework for interaction between those working on the Ō2NL Project and for the relationship between the project team, the Ō2NL Project itself, and the natural world.

The values endorsed within the partnership include:

- **Te Tiriti** (spirit of partnership)
- **Rangatiratanga** (leadership – professionalism – excellence)
- **Ūkaipotanga** (care – constructive behaviour towards each other)
- **Pukengatanga** (mutual respect)
- **Manaakitanga** (generosity – acknowledgement – hospitality)
- **Kaitiakitanga** (environmental stewardship)
- **Whanaungatanga** (belonging- teamwork)
- **Whakapapa** (connections)

The partnership process throughout the development of the Ō2NL Project has assisted in the route selection for the corridor and provided critical insight for the detailed location of the alignment and various design features. Those matters include interfaces with watercourses and stormwater management and the overarching aim of fitting the new highway sensitively into the landscape.

Key changes to the physical alignment of the concept design of the Ō2NL Project have been made in response to feedback from iwi partners and these include:

- Design of the new State highway east of Levin was modified to avoid adverse effects on the land and on groundwater, by keeping the highway close to the existing ground level instead of being below ground in an earthworks cutting
- Inclusion of a new active mode path over the new State highway at Queen Street East to retain the connections between the Tararua Range and Punahau / Lake Horowhenua
- Pulling back the new State highway alignment from Pukehou as much as practicable and design changes to allow reinforcement of watercourses and connection from Pukehou through to Waiwaro and Otepua Swamps.
- Aligning the new State highway to avoid the feet of the important ridgelines of Ōtarere, Poroporo and Hanawera

- Aligning the new State highway to avoid Punaoho Spring at Koputaroa
- Selecting material supply sites on the basis of fitting with the landscape and where they can provide a positive legacy outcome such as providing new walking access to the whenua and awa at Waikawa, and by creating wetland and open water habitats along the Ohau River
- Ensuring the shared use path provides appropriate walking connections to awa, particular at the Ohau River
- Designing an ecological response package to complement existing known iwi aspirations and plans, and aligning with cultural values

The partnership arrangement is intended to endure for the life of the Project. The precise nature of the involvement of iwi partners in the next phases of the Project (investigation and then implementation (construction)) is being developed and is expected to include the following:

- Ongoing involvement in detailed design phases of all aspects of the Project including:
    - Designs of stream diversions and culverts
    - Design of integrated planting plans, incorporating stormwater swales and pond treatment devices planting, rehabilitation of cut and fill slopes, material supply and spoil sites, ecological and natural character planting and landscape planting
    - Designs of bridges, local road connections and shared use path
    - Mahi toi strategy including interpretive signs / story boards
    - Design of legacy rehabilitation of material supply sites
- Ongoing involvement in construction including
    - Onsite kaitiaki involved with cultural monitoring and maintenance
    - Advice on construction methodologies especially as relates to water and eco-systems, and implementation plan development eg construction environmental management plan, planting plans, ecology management plans, erosion and sediment control plans
    - Ongoing cultural health monitoring (start prior to and extend beyond road opening).

2.3. Engineering Design Principles

Guiding the ongoing Ō2NL Project design are several engineering design principles. In addition to ensuring that the Project is designed to safely and appropriately accommodate transport demand, the key design principles and associated elements adopted are summarised in Table 2-1 below.

Table 2-1: Key engineering design principles

Design Principle	**Design approach**
Safety in Design	Application of Safety in Design (SiD) across the Project, for the full lifecycle of the Project, in accordance with Waka Kotahi Zero Harm, Health and Safety in Design standards.
Maintenance in Design	Application of Maintenance in Design principles so that maintenance of assets can be undertaken safely, at a low whole-of-life cost, with as little disruption to the road operations and in the safest way possible.
Road Geometry	• Designed in accordance with Waka Kotahi and Austroads standards and guidance • Meet the principles of Safe System design. • Meet the requirements for a safe and resilient state highway • Provide appropriate access onto and off of the new highway, including providing appropriate local connectivity • Enhance walking and cycling connectivity and safety.

Bridges and Structures	• Structures that will be durable, low maintenance and economical • Fully integral design adopted where possible to minimise whole-of-life costs by removing the need for costly expansion joint and bearing replacements • Mechanically Stabilised Earth (MSE) abutments used on single span bridges as they are quick to construct and perform very well seismically • Piled foundations used on the larger Waikawa Stream and Ohau River bridges to prevent any long-term scour issues
Earthworks Design	• Provision of resilient cut / fill slopes which have appropriate seismic resilience, low maintenance, and mitigation against slope face erosion. • In some constrained areas, use of geogrid reinforcement within the fill to increase the fill slope gradient up to 1:1 (vertical : horizontal). • Where practicable; balance cut / fill volumes along the route, maximize borrow sources from within the designation, and provide frequent spoil sites, to avoid large spoil areas and long haul distances.
Geology	• Appropriate investigations and interpretation of geological features to influence the engineering design outcomes and inform risk. • Ongoing instrumentation and monitoring to verify design assumptions.
Stormwater and Hydrology	• Main watercourse crossings designed to accommodate the 1:100 AEP event with climate change (RCP6.0 to 2130) • Stormwater run-off collection and conveyance systems are designed to manage up to a 1:100 AEP event, including climate change. The initial surface and collection systems are designed to accommodate a 10 minute duration storm event (as per NZTA P46 Stormwater Specification[4]) • Cross culverts of existing flow paths inclusive of fish passage provision and construction of new stream channels where needed • Attenuation of road runoff stormwater to below pre-development catchment responses; the overall pond areas will have a holding volume up to the 24 hour duration, 1:100 AEP event magnitude (with climate change) • Treatment of road runoff will be by a treatment train approach based on current established passive systems incorporating landscape and ecological benefits, and will seek to provide coverage to over 90% of the road surface area • Ground soakage disposal following treatment will be specified where suitable soils exist and where disposal to surface water is not available.
Lighting	• Location, spacing and lighting levels, where required, to be in accordance with NZTA M30[5] and AS/NZS 1158[6]. • Maintain the rural nature of the locality. • Provided at key conflict points and critical locations only

3. Concept Design Description

3.1. Overview

The following drawings (provided in Volume III) show how the Project could be realised in the proposed road corridor. The drawings depict a concept level of design for the consenting process.

[4] https://www.nzta.govt.nz/assets/resources/p46-nz-transport-agency-state-highway-stormwater-specification/NZTA-P46-State-Highway-Stormwater-Specification-Ver-1-April-2016.pdf
[5] https://www.nzta.govt.nz/assets/resources/specification-and-guidelines-for-road-lighting-design/docs/m30-road-lighting-design.pdf
[6] https://www.standards.govt.nz/shop/asnzs-1158-3-12020/

Table 3-1: Drawing Register

Plan Series	Number			Description
Overall Site	001	G	0001	Cover Sheet
Overall Site	001	G	0002	Drawings Index
Overall Site	001	G	0100	Site Layout Plan
Overall Site	001	G	0200	Land Requirement Plans
Overall Site	001	G	0300	Designation Plans
Geometrics	100	C	1000	General Arrangement Plans
Geometrics	100	C	1500	Plan and Long Sections
Geometrics	100	C	2000	Typical Cross Sections
Geometrics	100	C	3000	Intersection (SH1 / Tararua)
Geotech	200	C	9000	Typical Details
Stormwater	300	C	1000	Drainage Layout Plans
Stormwater	300	C	2000	Catchment Plans
Stormwater	300	C	3000	Culvert Schedule
Stormwater	300	C	9000	Typical Details
Structures	400	S	100	Bridge and Underpass Location Plans
Structures	405-490	S	1000	Bridge Plan and Sections
Temporary Works	500	C	1000	Accommodation Works
Erosion and Sedimentation Control	600	C	1000	Erosion and Sedimentation Overview Plans
Erosion and Sedimentation Control	600	C	1100	Site Specific Erosion and Sedimentation Plans
Planting	700	C	1000	Planting Plans – identifying proposed landscape and planting works
Ecology	750	C	1000	Construction buffer and existing landscape vegetation and habitat type

3.2. Highway Elements

The new highway will provide a road that is high standard and able to accommodate high speeds safely. It will be generally flat, other than at the northern and southern extents where the terrain is more rolling, and the road will have a gentle gradient. The horizontal alignment will be a combination of straight sections and large radius smooth horizontal curves.

The new road will have a limited number of access points to the wider road network, with connections to local roads either through grade-separated interchanges or at-grade roundabouts. Where the new highway crosses existing local roads, they will be realigned or bridged to retain connectivity. A number of watercourses, and the North Island Main Trunk rail line, are also bridged.

The highway will be four lanes and employs a three barrier system (median and both sides) to provide an extremely high standard of safety performance.

A SUP will also be provided for the full length of the Ō2NL Project and is described further in Section 3.6.

3.2.1. Alignment

The overall road concept alignment is shown on the General Arrangements plan sets DWG-100-C-1000 and DWG-100-C-1500 (provided in Volume III).

The proposed state highway road layout consists of the following elements:

- A median divided four-lane highway, with two lanes in each direction
- Safety barrier provided within the median and along the outer edges for the full extent
- A grade-separated half diamond interchange located to the north of Taylors Road
- A grade-separated diamond interchange at Tararua Road

- At-grade roundabout at the SH57 intersection north-east of Levin
- At-grade roundabout at the Heatherlea East Road / The Avenue intersection at the northern extent where the road connects to the existing State Highway 1.

3.2.2. Cross Section

The indicative Project design is based on the following cross section:

- A central median typically 3.0 m wide (but with widening of an additional 1.5 m where required for sight distance)
- Traffic lanes typically 3.5 m wide (lanes become slightly wider on curves and dimensions vary on the approaches to intersections and roundabouts)
- Sealed shoulders 3.0 m wide with widening of up to an additional 0.5 m where required for sight distance
- Sealed shoulders on longer watercourse bridges may be reduced to 2.0 or 2.5 m
- Longitudinal drainage swales of varying width
- Landscaping areas of varying widths
- A SUP for walking and cycling which typically is 3.0m width, with 0.5m buffers on each side (width may vary where land is not available and across structures - addressed in more detail below)
- Maintenance (and/or police enforcement) bays located around every 1-2 km on each side of the new highway.

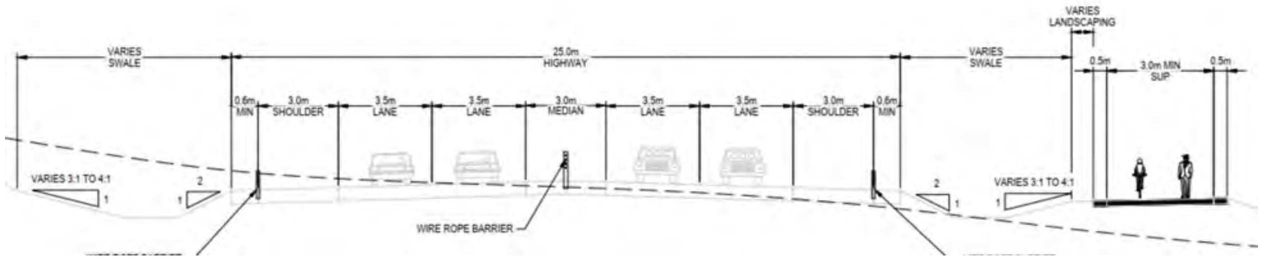

Figure 2: Typical cross section of new highway

Typical cross sections are shown on plan set DWG-100-C-2000 (provided in Volume III).

3.2.3. Geometry, Design Speed and Sight Distance

The road geometry is shown on plan set DWG-100-C-1500 (provided in Volume III).

As for most new state highways, (and for the other newly completed parts of the Northern Corridor[7]) a design speed of 110 km/h has been adopted and 80 km/h for interchange ramps. A Stopping Sight Distance (SSD) of 209m has generally been adopted, other than in areas that would result in an excessively deep cutting, or in the case of sight distance past barriers shoulder widths greater than 3.5 m, then some small reductions in SSD have been included.

In order to accommodate the speed and stopping distance requirements the alignment provides a smooth geometric layout:

- horizontal curve radius of (approximately) 700m or greater meaning the horizontal geometry is appropriate for this type of road and speed, and beyond minimum standards.
- vertical profile mostly flat with gentle grades mostly between 1-3%. The exceptions to this are in the northern and southern end of the Project where the terrain is more undulating and the new road has needed to include gradients of up to 6% (which are in accordance with roading design standards[8]). Steeper sections may be accommodated in detailed design if necessary[9].

[7] Mackays to Peka Peka, Te Ara Nui o Te Rangihaeata/Transmission Gully and Peka Peka to Ōtaki (due to be completed soon)
[8] Austroads Guide to Road Design Part 3: Geometric Design, Table 8.3.
[9] Te Ara Nui o Te Rangihaeata/Transmission Gully has gradients of up to 8%

The posted legal speed for the new highway will be either 100km/h or 110km/h (this is not yet confirmed and so the upper speed limit has been used for basis of the noise and vibration assessment for example as part of a conservative approach).

The vertical road geometry is shown on plan set DWG-100-C-1500.

3.3. Pavement and Surfacing

The precise pavement design for the Project is subject to ground conditions and detailed design but at this stage it is anticipated that the new highway alignment pavement and surfacing will generally be comprised of the following:

- Open Grade Porous Asphalt (OGPA) surfacing on main alignment
- Chipseal / waterproofing trafficked for a year then OGPA sits on top of this layer
- Various depths of basecourse and subbase materials (chipseal on top of this layer).

Similarly, at locations of increased pavement stress due to acceleration and braking, such as interchanges and mainline roundabouts, the pavement design will generally be comprised of the following:

- Stone Mastic Asphalt (SMA) surfacing
- Chipseal surfacing – two coat 2/4 trafficked for a year then overlaid (SMA on top of this layer)
- Various depths of basecourse and subbase materials (chipseal on top of this layer)

New local road pavements are likely to be as follows (noting this may be modified during detailed design stages to respond to adjacent road construction, council requirements and ground conditions):

- Chipseal surfacing
- Various depths of basecourse and subbase materials

3.4. Structures

The structural works are shown on plan set DWG-400-S-100 and DWG-405-490-S-1000 (provided in Volume III).

The Project includes several key structures, described below (from north to south):

Table 3-2: New structures (road, rail, watercourse)

Ref #	Structure name	Location on Ō2NL Project (approximate)	Highway under/over	Structure length (approximate)
1	NIMT Rail Overbridge	CH10700	Highway over NIMT railway line	25-30 m
2	Queen Street East Overbridge	CH15600	Highway at-grade, local road over	30-35 m
3	Tararua Interchange	CH18250	Highway at-grade, local road over	30-35 m
4	Muhunoa East Road Overbridge	CH21500	Highway under local road	30-35 m
5	Ohau River Bridge	CH22600	Highway over river	160-180 m
6	Ohau River Flood Relief Bridge	CH22435	Highway over river	20-25 m
7	Kuku Stream Bridge	CH23820	Highway over stream	15-20 m
8	Kuku East Road Bridge	CH24000	Highway in cut, local road over	30-35 m
9	Waikawa Stream Bridge	CH26500	Highway over stream	130-150 m
10	North Manakau Road Overbridge	CH27100	Highway in cut, local road over	30-35 m
11	Manakau Heights Drive Overbridge	CH28900	Highway in cut, local road over	30-35 m
12	Manakau Stream Bridge	CH30200	Highway over stream and local road	25-30 m
13	Waiauti Stream Bridge	CH30350	Highway over stream	15-20 m
14	SH1 Crossing near Taylors	CH34300	Highway over local road (at grade)	25-30 m
15	PP20 Culvert No. 1 Extension (Greenwood Stream)[10]	CH34600	Highway over stream	2-10 m

In addition to the above key structures, there are likely to be numerous other minor structures and underpasses in the form of short span bridges or single or multi-cell box culverts as and where required. Proposed new underpasses are listed in the table below.

Table 3-3: New subway / underpass (for access or SUP)

Description	Location on Ō2NL Project (approximate)	Highway under/over	Structure length (approximate)
SUP underpass	CH10400	Highway over	25-35 m
Sorenson underpass	CH11100	Highway over	25-35 m
SUP underpass	CH13010	Highway over	Two 25-35 m (through roundabout structure)
SUP underpass	CH18200	Highway over	25-35 m
Access underpass	CH31200	Highway over	25-35 m

[10] PP2O Culvert 1 is included in this Table because the size of the culvert meets the definition of a major culvert as defined in the Bridge Manual SP/M/022 (Third edition up to and including Amendment 3, October 2018, New Zealand Transport Agency). This culvert is part of the PP2Ō project, however, it is likely to require some extension to accommodate the Ō2NL Project.

Access underpass	CH32900	Highway over	25-35 m

Watercourse culverts are described in Section 3.9.

3.5. Safety Barriers

The Project will include median and side protection barriers on the state highway in accordance with the Safe System philosophy.

Barrier design parameters that are being adopted into the Project design include:

- MASH testing level compliant median wire rope barrier throughout (no bridge piers in median);
- TL-5 side barriers (these are referred to as concrete barriers in Mr Michael Smith's Noise and Vibration Assessment provided as Technical Assessment B in Volume IV) on interchange bridges, railway bridge, and river bridges;
- 1.1 m sway allowance from toe of barrier to face of bridge column or retaining walls;
- MASH testing level compliant wire rope or w-section barriers on the new highway for outside shoulder protection;

3.6. Walking & Cycling

A SUP for cyclists and pedestrians will be provided for the full length of the new highway, but not necessarily always following the exact horizontal and vertical alignment of the new highway. It will be a facility that is appropriate for recreational and commuter use and will be easily and conveniently accessible by adjacent communities.

The SUP will be provided on one side of the new highway, mostly on the western side of the new highway to serve the existing communities at Manakau and Ohau. East of Levin the SUP is located on the eastern side of the new highway to serve the future Tara-Ika development. The SUP is generally located close to the new highway but located further away in the vicinity of Forest Lakes to provide better connectivity and to reduce earthworks and stream impacts on the main alignment. The SUP will also provide access to and interface with existing paths and future paths along local roads.

The SUP is designed with reference to the Waka Kotahi Cycle Network Guidance (CNG)[11] and Pedestrian Planning Guide[12] (PPG) and the Austroads Guides for walking and cycling[13].

3.6.1. Route location

The SUP location has been selected to account for considerable community and user group feedback.

The proposed shared path alignment has been located as follows:

Table 3-4: SUP Location Summary

Location	**Connection Details**
Northern commencement to new SH57 Roundabout ST9900-13000	North of the new roundabout, the SUP begins where the roundabout departure kerbing ends to provide a suitable transition point from the existing highway for cyclists coming from the north. At the new northern roundabout, raised platforms will be provided on the Heatherlea East Road and The Avenue roundabout legs. At the new northern roundabout a new underpass is proposed under the southern leg so that pedestrians and cyclists do not need to cross the new highway. East of this point, the SUP will run along the south-west side of the new highway. At Sorenson Road, a new underpass is provided beneath the new highway. This allows SUP users to cross the new highway via a grade-separated connection into Sorenson Road.

11 Designing a cycling facility | Waka Kotahi NZ Transport Agency (nzta.govt.nz)
12 Pedestrian planning and design guide | Waka Kotahi NZ Transport Agency (nzta.govt.nz)
13 AGRD06A-17 | Austroads

New SH57 Roundabout to Tararua Road ST 13000-18200	At the new SH57 roundabout the SUP will cross from the western to the eastern side of the new highway. This connection is required to cross 4 highway lanes and therefore a subway underpass will be provided to safely grade-separate this movement. Separate connections onto SH57 to the north and south of the new roundabout will also be provided off the SUP. The SUP continues along the eastern side of the new highway, using new local road links where available.
Tararua Road to Muhunoa East Road ST18200-21500	At the Tararua interchange, a subway underpass will be provided to grade-separate cyclists and pedestrians from interchange traffic so that the SUP can continue on the eastern side of the new highway. South of the interchange, the SUP will be provided alongside the new parallel local road.
Muhunoa East Road to Kuku East Road ST21500-24000	At Muhunoa East Road, the SUP crosses from eastern side of the new highway (north of Muhunoa East Road) to the western side, via the new local road bridge. This provides full connectivity on and off the SUP and allows path users to access Muhunoa East Road and Ohau to the east. South of Muhunoa East Road, the SUP remains alongside the western side of the new highway for this entire section, on a relatively flat grade. As with other sections, the SUP will generally seek to be offset as much as possible from the traffic lanes (i.e. at top of cuts or bottom of fills from the earthworks for the new highway). At the new Ohau River bridge, the SUP and road bridge will be an integrated single structure for efficiency and to reduce the overall environmental footprint.
Kuku East Road to North Manakau Road ST24000-27100	The SUP remains alongside the western side of the new highway for this entire section, on a relatively flat grade. As with other sections, the SUP will generally seek to be offset as much as possible from the traffic lanes (i.e at top of cuts or bottom of fills from the earthworks for the new highway). At Kuku East Road, the SUP connects onto the side road to provide access onto/off the path. At the new Waikawa Stream bridge, the SUP and road bridge will be an integrated single structure as this is more efficient than two separate bridges.
North Manakau Road to Manakau Heights Drive ST27100-29000	The SUP remains alongside the western side of the new highway for this entire section, on a relatively flat grade. At North Manakau Road, the SUP connects onto the side road to provide access onto/off the path. To the east of Manakau village there is an opportunity to provide a linkage into the village from the SUP, through to Mokena Kohere Street and through to the school, civil defence, hall, bowling club and other local facilities. This is a significant opportunity raised by the community that is going to be delivered by the Project.
Manakau Heights Drive to South Manakau Road ST29000-30200	The SUP runs alongside the new highway on the western side travelling at the bottom of the fill embankment to provide some separation to the highway traffic lanes. At the Manakau Heights Drive bridge connection the SUP climbs up the embankment to provide access to Manakau village and the Manakau Heights areas.
South Manakau Road to Pukehou rail overbridge ST 30200-31300	From the northern side of the bridge crossing both Manakau Stream and South Manakau Road, a SUP access path is provided down from the south side to access South Manakau Road. The SUP continues along the western side using the next combined bridge at the Waiauti Stream. The SUP then joins the old SH1 route at south of Staples Bush blocks avoiding the (existing) constrained Pukehou rail overbridge.

South of Pukehou rail overbridge to Forest Lakes ST 31300-33000	The SUP is proposed to run alongside the old SH1 here, as it is anticipated to offer improved amenity and attractiveness given the reduced volumes (<20% of new highway) and fewer heavy vehicles. The SUP is generally located on the eastern side of old SH1, crossing no side roads and only a small number of private accessways. There are some moderate grades through this section of around 4.5% in places. There are no local roads crossing the new highway between Pukehou rail bridge and Taylors Road (3.2km length) so providing the SUP on the old highway improves access for the properties on the old highway here and within Forest Lakes Road.
Peka Peka to Ōtaki expressway connection ST33000 - 34800	The SUP will run on the eastern side of the existing state highway, and also at the eastern boundary (i.e. the rear) of the rest areas in order to avoid conflicts with vehicles using rest areas and the turnaround facilities being proposed as part of the Safe Network Programme upgrade of the existing highway corridor. Near to Taylors Road, the SUP will pass alongside the new SH1 roundabout (crossing no roundabout legs), and will cross from west of the new highway, using the on-ramp underpass, to the east. The SUP will continue alongside the new southbound on-ramp from the Taylors half interchange and will tie into the PP2Ō SUP at the southern end of the realigned Taylors Road connection.

The schematic representation of the SUP and how its design is proposed to respond to different elements / structures along the proposed highway are shown diagrammatically below. The schematic is not a north-south representation of the SUP, but rather highlights standard design treatments. Ultimately, the final design of the SUP will depend on precise site conditions, land availability and user requirements.

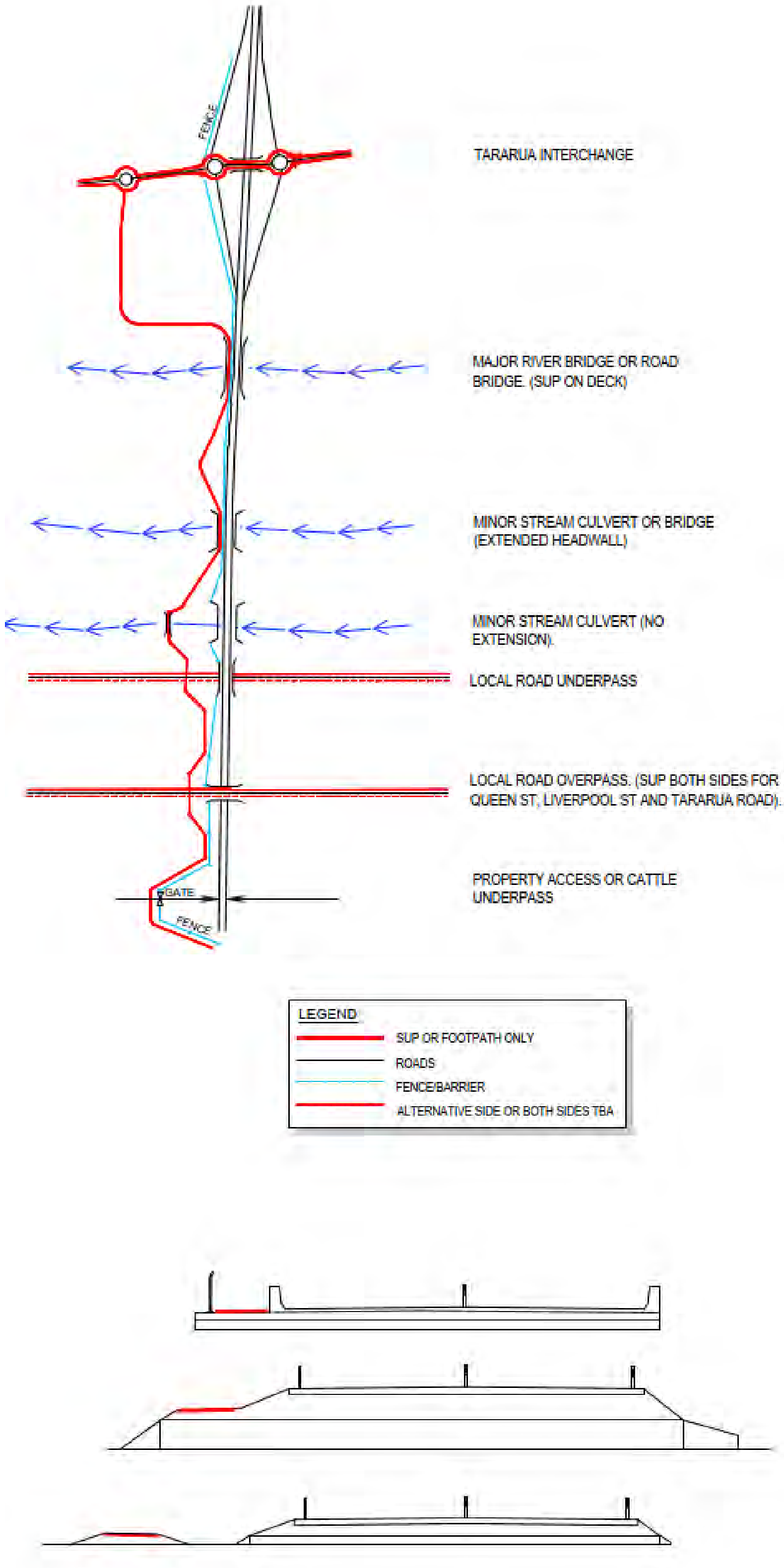

Figure 3: Integration of the SUP and structures (schematic – not north-south representation)

Connections to the shared path will be provided at all public road crossings and residential accesses that are open to the public. Where the SUP crosses a local road at-grade, the design intent is to provide a raised safety platform to enhance safety of path users by improved visibility / oversight and the vertical level change for crossing vehicles to reduce approach speeds.

3.6.2. Cuttings and Embankments

The general philosophy is to follow the tops of cuttings and the toes of fill embankments as much as possible to avoid placing the SUP directly next to the new highway. This will improve the amenity value of the shared path. This approach also limits the associated earthworks by keeping the path close to the existing ground levels in order to tread lightly on the environment. In some locations the SUP cannot sit on the existing terrain as the levels or gradients are too severe, requiring additional earthworks to achieve path design requirements.

3.6.3. Community Connections

The aim for the SUP is that it becomes a high quality and well-used community facility, which provides for multi-modal trips for recreational and employment purposes. To do this, the following connections will be provided for local communities to gain access to, and from, the SUP.

Table 3-5: SUP Community Connections

Location	Connection Details
Manakau and Manakau Heights Drive community	The SUP connects to South Manakau Road and provides access from the eastern side of the new highway to the shared path via possible footpaths along Manakau Heights Drive, Mountain View Drive, and South Manakau Road. Since Manakau Heights Drive will be severed by the new highway, a community bridge primarily for walking and cycling but shared with low speed passenger car use is provided to reconnect this local road. Access is provided to the shared path at the western end of the bridge. An additional connection to the SUP directly from Manakau village is included to facilitate access to the school via Mokena Kohere Street.
Ohau community	The Ohau community accesses the shared path via Muhonoa East Road
Speldhurst Country Estate and Arapaepae Road	The SUP was initially proposed to run along Arapaepae Road between McLeavey Road and the proposed SH57 roundabout north of Levin to provide good direct access to the path for a larger number of existing residents than if the path were routed along the new highway. In subsequent discussions HDC and some members of the walking and cycling community requested the SUP be located on the eastern of the new highway to serve the Tara-Ika development. So, the path crosses from west to east at Muhunoa East Road and stays east of the new highway through to the new SH57 roundabout (a distance of around 8 km). It is understood that HDC intend to extend the existing Arapaepae Road shared path to provide additional walking and cycling facilities for Kimberley and Arapaepae Road communities (the timing of the development of this facility is not known).
Sorenson Road residents	The SUP will connect to the Sorenson Road subway access.
Koputaroa Road and Avenue North residents	Although motor vehicle access to the new SH1 will be closed at Koputaroa Road and Avenue North, walking and cycling access between the shared path and the two roads will be maintained.
SH1 connection north of Levin	The SUP, which would be on the western side of SH1 north of Heatherlea Road, will end at roughly The Avenue North. Beyond Avenue North it will provide a connection back onto the shoulder of the existing SH1 predominantly for one-way cycling. The reintroduction of cyclists onto the road shoulder must be in the shelter of a kerbed return. At Koputaroa Road, only a southbound walking and cycling one-way exit ramp from the SH1 to Koputaroa Road will be possible as crossing SH1 at this point could be unsafe. Full connection to the SUP can be provided via the Heatherlea East Road roundabout pathways and the underpass.
Roundabouts	Grade-separated underpasses are provided at both new highway roundabouts (SH57 and Heatherlea East Road). Pedestrian and off-road cycling shared paths will

	be provided around the perimeter of roundabouts. Some approaches may require raised table and/or zebra crossings.

3.6.4. SUP Cross-section

The SUP is expected to be sealed for its full extent to ensure ride quality and reduce maintenance needs. The surfaced width is a minimum of 3.0 m, plus a 0.5 m buffer strip that is flat and free of all hazards and obstructions (including vegetation) on both sides of the path. The buffer strip may be paved or surfaced with concrete, asphalt, or gravel, or it can be an extension of the path surfacing and demarcated with a different colour or with a white line where necessary.

This path width has been designed in accordance with Austroads Guidance[14] for shared path design, with a path of 3. 0 m width able to comfortably accommodate (for example) 40 pedestrians and 400 cyclists per peak hour (two-way, 50:50 directional split), which is in excess of predicted use demands for this SUP. The 0.5 m minimum buffer is also in accordance with this design guide.

On bridges the width between railings is 3.0 m with no buffers.

The crossfall (i.e. camber / tilt of the path) is generally limited to a maximum of 2%.

The SUP may be fenced along some sections of the corridor, with locations confirmed in later stages on design.

3.6.5. Horizontal and Vertical Alignment

The minimum horizontal radius (as in, the sideways curve) of the shared path will be approximately 25 m other than in slower speed environments such as when crossing local roads.

The path gradient is targeted as up to 3% for ease of use and comfort, however, more significant grades will be required in some locations. Grades of up to 8% will be limited where practicable to (approximately) 100 m lengths.

3.7. Utilities

3.7.1. General

No major trunk network communication or utility services will be affected by the Ō2NL Project.

East of Levin on Queen Street, Kimberley Road, Tararua Road and on Waihou Road, there are council water services that will be disrupted; these are fairly small minor submains for potable water and are straightforward to relocate / reconnect.

HDC is currently in the process of extending services for the proposed Tara-Ika subdivision which will also include reticulated waste water services. Waka Kotahi will continue to work with HDC to seek to minimise the need to relocate any of these new services in future.

There are existing minor overland flow stormwater channels that flow east to west and will be traversed by the new highway. Clean water cut-off drains will be provided that collect these overland flows and convey them across the new highway via culverts. These are designed so that catchments to retain these flow path networks do not affect/ alter existing catchments.

Investigations are currently progressing and legal water bores will either be retained or relocated if they are impacted by Project works. These discussions and work will occur as part of the Public Works Act property process with individual land owners and users. There are three larger private water supply schemes that are affected (but will be retained) – the Glenmorgan water scheme in Manakau Heights, and the Pukehou North and South water scheme in the area around Forest Lakes and Pukehou.

New services such as those for Intelligent Transportation System type technology are likely to be provided within the road corridor. These are likely to be contained in a combined service trench on one side of the highway (outside of the sealed shoulder). The provision of other new services within the corridor is not desirable given future access requirements and disruption to road users that may result.

[14] AGRD06A-17 | Austroads Figure 5.4

3.7.2. KiwiRail

The Ō2NL Project has two interfaces with the KiwiRail network.

The Ō2NL Project includes an upgrade to the SH1/Tararua Road intersection in Levin to a traffic signal layout. This will include extending Tararua Road westwards (across the rail line) through to current SH1 (Main Road South), and then introducing a new rail level crossing that is integrated with the traffic signals. As part of this work, the existing Tararua Road intersection with Cambridge Street South and associated level crossing will be closed.

The second interface is a new road bridge over the NIMT Rail Line west of Sorensons Road. This will be designed and constructed to provide the required clearance over the rail corridor including for any future overhead electrification lines, and a span suitable for double-tracking.

3.8. Geotechnical

Refer to Appendix 4.1 of this Report.

3.8.1. Spoil Sites

The process for identifying, assessing and selecting spoil sites is provided in Appendix 4.4. The approach has been to have spoil sites located along the length of the Project in order to minimise haulage distances, and spoil sites have been located where they can blend into the landscape, or the proposed road and avoid water courses and native habitats (identified in Technical Assessments J (Terrestrial Ecology) and K (Freshwater Ecology)).

The locations identified for spoil sites do not have known land instability issues, but additional geotechnical investigations and detailed geotechnical assessments and geotechnical designs of the spoil sites will be required prior to construction.

The design of the spoil sites will be carried out based on the requirements of the Waka Kotahi Bridge Manual for earthworks and the TNZ/F1 Specification. The localised stability of the spoil embankment will be examined for all design loading cases included in the Bridge Manual, including earthquake loading and elevated groundwater conditions in case of storm events.

All spoil sites will be appropriately contoured in the detailed design to optimise spoil volume capacity and ensure good integration with the earthworks of the alignment, to smoothen fill embankments and soften the edges of cuttings into natural landscape.

The general design of the spoil embankments will be with maximum slope angles of 1 vertical to 2.5 to 3 horizontal (about 18 to 22 degrees) and with intermediate benches for slopes greater than 10 m height. Spoil sites placed in the vicinity of road cuts need to have adequate buffer from the crest of the cuts (minimum 10 m).

Exclusion zones will be applied for the spoil sites where they are in the vicinity of road cuttings, drainage elements of the alignment and natural streams and watercourses. The exclusion zone width should consider the potential displacements during earthquake loading or potential localised failures that could affect the adjacent constraints.

Measures to enhance the stability of the spoil embankment and reduce seismic displacements could include adopting shallower slope angles or reinforcing the spoil embankment with geogrid, or interlayers of free draining more competent material.

Further detail on Spoil Sites is included in section 4.7.6.6 and Appendix 4.4.

3.8.2. Material Supply Sites

Four material supply sites have been identified as part of the Project. An early stage 3D excavation has been designed, which will be further developed and refined in future stages.

Further work will include:

- Erosion and sediment control measures.
- Vegetation controls and removal.
- Site access for plant and material haulage.

- Temporary and permanent drainage requirements including groundwater interaction. This will include further investigation to confirm the surface water/groundwater interactions so that these can subsequently be enhanced and promoted.

Further detail on Material Supply Sites is included in section 4.7.6.5 and Appendix 4.5.

3.9. Stormwater

Refer to Appendix 4.2 of this Report.

The design of stormwater management and treatment for construction and operation of the Ō2NL Project is aligned with the design specification requirements of Waka Kotahi. The proposed design has been developed in consultation with iwi partners as described in the CEDF (Appendix Three to Volume II), as well as other stakeholders and regulators. Key elements are described below for transverse and longitudinal stormwater management respectively.

3.9.1. Transverse Flow Path Connections

3.9.1.1. Bridges

The Ō2NL Project runs predominantly north/south while most of the watercourses run east to west from the mountains to the sea. Therefore, the Ō2NL Project crosses a number of watercourses within various catchment sizes. Details of the proposed significant bridge structures over watercourses are provided in the Structures Drawings (set 310203848-400 and provided in Volume III) and comprise the Ohau River (including flood relief bridge on northern floodplain), Kuku Stream, Waikawa Stream, Manakau Stream and Waiauti Stream (the Manakau being a combined bridge over the stream and local road). All these rivers and streams have gravel beds and significant stream power relative to their erodible bank material and, therefore, have some potential to migrate within their floodplain, which has been considered in the design. Bridges are the preferred solution for these streams, to minimize hydraulic impacts and provide uninhibited fish passage. The design of the bridges has been informed by:

- A freeboard of at least 0.6m has been set between the soffit of the bridge and the 1:100 AEP event with climate change (RCP6.0 to 2130)[15];
- For the Ohau River and Waikawa Stream, additional width has been provided to allow for some meandering of the river within the natural floodplain. Piers are piled to ensure a robust structure with minimized impact of stream migration. End abutments for these two bridges are spill-through abutments with hard landscaping (rip-rap) embedded to prevent scour around the foundations.
- All other stream bridges are proposed to have 90-degree wing walls, with space for buried scour protection around the abutments and through the throat of the bridge. With the scour protection below existing stream bed surface, this provides for the passage of natural sediment substrate movement, and minimises impacts on fish passage and the passage of flood debris.
- In the case of the Manakau and Waiauti streams, minor stream realignments are proposed to provide a stationary long term bridge location for these smaller meandering watercourses.

3.9.1.2. Culverts

There are various sizes of flow paths (permanent, intermittent and ephemeral) that cross the route of the highway. Culverts are sized in accordance with P46 and the Bridge Manual (for sizes >3.4m^2), to retain near-normal stream flow conditions during low to medium flows (avoiding surcharge up to 1:10 AEP) and allow surcharging in major storm events. Increases in upstream water level are limited to less than 1.5m in the 1:100 AEP event at 2130 with climate change (P46 allows for surcharge of up to 2m above culvert soffit). However, a lower threshold has been selected to allow natural substrate to be retained with the culvert, where the higher threshold would lead to comparatively higher water velocities that may mobilise substrate.

Culverts are sized and designed to meet the minimum hydraulic capacity requirements and other functions of culverts in accordance with regulation 70 of the NES-FM, for example:

- continuity of geomorphic processes (such as the movement of sediment and debris) from one side of the highway to the other;

[15] The freeboard helps mitigate the risk of reduced performance as trees, rocks or gravel that may pass downstream during major flood events or after earthquakes or landslips.

- provision of fish passage; and
- energy dissipation and scour protection downstream as required, without hindering fish passage.

To achieve these outcomes, in line with the NES-FM, culverts are embedded by 25% of their height and backfilled with substrate (void-filled) to maintain continuity of sediment transport and fish passage.

Culvert design and effects are discussed in detail in Technical Assessment F (Hydrology and Flooding) and Technical Assessment K (Freshwater Ecology) in Volume IV.

A summary of culverts for watercourse crossings is provided in the Stormwater Drawings provided in Volume III and in particular drawings 310203848-01-300-C3000.

3.9.1.3. Stream Diversions and Culvert Lengths

Due to the existing natural topography crossed by the proposed corridor, it will be necessary to construct temporary and/or permanent stream diversions in order to maintain ecological connectivity. Culvert lengths are generally kept as short as practicable (as culverts detract from habitat diversity compared to open channel). However, there is balanced judgement required as a short culvert solution may result in greater loss of overall stream length/habitat if the existing streambed was a meandering form and may also increase velocities and associated risk of scour.

Indicative locations for stream diversions and culvert placements are shown on drawing 310203848-01-300 (Volume III). Discussion on loss of stream length and proposed mitigation/offset is discussed in Technical Assessment K (Freshwater Ecology) provided in Volume IV.

3.9.2. Longitudinal Stormwater Management

Stormwater runoff in the Ō2NL Project corridor is contained and conveyed within the construction footprint, and then treated and attenuated through outlet facilities at low points in the alignment.

The proposed stormwater management concept design for the Ō2NL Project is described in the Stormwater Management Design Report provided as Appendix 4.2.

The key principles of low impact stormwater management include removing energy and removing contaminants from water. Both principles are accomplished through the design and placement of stormwater management facilities which are made up of three main components: sediment forebay, constructed wetland and attenuation basin.

The design philosophy for stormwater management is:

- Maximise drainage opportunities through vegetated open channels in preference to below-ground pipelines as a more-natural method of water conveyance through the Project in accordance with underlying principles described in the CEDF (Appendix Three to Volume II).
- Provide attenuation basins and throttled outlet discharges to reduce peak discharge from the Project alignment into the receiving environment to be equal to, or less than, pre-development flow rates.
- Provide a treatment train stormwater approach over each section of the Project alignment as part of a best management practice. Road runoff from each internal catchment of impervious surface will pass through some or all of the following before leaving the Project alignment: planted slopes, vegetated swales, sediment forebays, and constructed wetlands. These facilities will maximise the capture and management of waterborne contaminants and sediments from the highway surface within the Project construction footprint prior to ultimately entering the receiving environment.
- Provide water sensitive design elements that slow the speed of runoff drainage to maximise opportunities for returning water to the ground such as treatment swales with shallow gradients and wide bases, constructed wetlands with long detention times, and attenuation basins with ground soakage fields where soils are favourable to long-term soakage performance.
- Provide erosion protection measures between the Project outlets and the receiving environment (such as rock lined and planted pools and riffles, and reduced stream gradients along with wider flow cross sections to slow stream velocity and energy) to manage potential scour effects of the Project on stream beds and banks.

3.9.2.1. Stormwater Capture, Conveyance and Discharge

The Ō2NL Project's stormwater run-off collection and conveyance systems are designed to manage discharge up to a future climate 1%AEP event. This design includes allowance for future climate change design rainfall based on NIWA guidance referred to as RCP8.5, 2080-2100[16]. The full construction footprint area of the corridor is accounted for in the design. This represents stormwater management within the Ō2NL Project footprint for at least 99% of all rainfall events over the life of the asset (nominally considered to be 100 years).

Removing the energy from stormwater runoff is enabled through long, low-gradient open channels that are well-vegetated followed by detention in an attenuation basin and final release from the Ō2NL Project at a restricted discharge rate. This philosophy of stormwater management reduces downstream channel erosion, reduces downstream peak discharge and subsequent flooding effects, and provides a longer opportunity for ground infiltration to occur to reduce downstream surface water volumes.

The Ō2NL Project footprint crosses numerous small sub-catchments. While the principle of not mixing waters of different catchments is achieved overall, due to earthworks and geometry constraints on the road, the design does result in some minor adjustments to smaller sub-catchments close to the corridor, which then balance out within a short distance downstream as tributaries converge. Ground soakage opportunities are increased along swales to offset sealed road surface areas, and flows are detained in basins to be released at an attenuated discharge rate below the pre-development runoff rate - both aspects have a moderating influence on the effects of displaced catchment areas.

3.9.2.2. Stormwater Treatment

The proposed stormwater management facilities remove and capture contaminants from road runoff and contain the contaminant accumulations within the Ō2NL Project footprint where it can be maintained over the design life. This manages and practicably minimises accumulated contaminants spreading into the receiving environment.

Stormwater treatment for the Ō2NL Project follows NZ best practice design guidelines as described in Waka Kotahi Stormwater Treatment Standard for State Highways[17] and in Auckland Council GD01[18]. By following the guidance, including providing a treatment train series of strategies, over 75% capture of total suspended solids (TSS) and similar capture rates of soluble metals, hydrocarbons, plastics, litter and contaminants can be achieved for 90% of all rainfall events based on magnitude – with reduced contaminant capture rates still expected to be available for the remaining 10% of greater rainfall events.

Stormwater treatment is best achieved with a varied and diverse range of imperfect approaches in series to capture road contamination in all its forms, i.e. the treatment train approach. For the Ō2NL Project this includes sheetflow runoff moving through vegetated batter slopes, followed by flows moving through vegetated swales, followed by stilling in a forebay and bio-filtration through a constructed wetland to settle out sediments and provide time for biological uptake. In addition, the whole treatment train process slows the flow and provides time for infiltration to occur through the soils which provides a filtration process for water disposed to the ground.

Some portions of the Ō2NL Project corridor will need to be serviced by pipelines and minimal batter slopes (due to topography) that then discharge into constructed wetlands for treatment. This is still a high standard of capture for many contaminants but a less efficient treatment strategy for some contaminants. Further detailed design of stormwater management facility dimensions will be adapted to compensate for a smaller treatment train so that treatment can still be robust.

Practically, the containment of accumulated contaminants in swales, constructed wetlands and basins within the footprint of the Ō2NL Project means that monitoring and maintenance efforts can be realistically specified for defined areas. Future renewal of treatment components will then be programmed on the basis of the information gained from monitoring and identifying performance trends over time.

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16 Used as a proxy for RCP6.0 extrapolated out to 2130.

17 https://www.nzta.govt.nz/assets/resources/stormwater-management/docs/201005-nzta-stormwater-standard.pdf

18 https://content.aucklanddesignmanual.co.nz/regulations/technical-guidance/Documents/GD01%20SWMD%20(Amendment%202).pdf

3.10. ITS

The installation of Intelligent Transportation System (ITS) assets and communications facilities will form part of the Ō2NL Project. ITS refers to a suite of information and communication technologies used in transportation and traffic management systems to improve the safety, efficiency, and sustainability of transportation networks, to reduce traffic congestion and to enhance drivers' experiences. ITS assets used for operational purposes are likely to be connected back to the Wellington Traffic Operations Centre (WTOC) with other assets such as traffic counting technology connected back to Waka Kotahi back-end systems.

The roadside ITS equipment is likely to consist of:

- CCTV for transport operations
- Variable Message Signs for traveller information
- Web cameras for traveller information
- Ducting with fibre along the length of the alignment
- Traffic counting sites
- Cabinets to house required safety and operational equipment

Further work on ITS requirements and design will be undertaken in subsequent stages of the Project.

3.11. Lighting

Lighting will be provided at traffic conflict points which include interchanges, on/off ramps, roundabouts and lane merges/diverges. Full highway standard lighting will be provided at:

- Taylors Road half interchange
- Tararua interchange
- SH57 / new highway roundabout
- New highway / Heatherlea East Road / SH1 roundabout

Each of these locations are likely to require 50-60 lighting columns to light the approaches and intersection / conflict points. The exact quantities of columns/luminaires, as well as the design of the lighting arrangements for each location, will be confirmed during detailed design. Lighting at these locations will be category V in accordance with NZTA standard M30[19] and AS/NZS 1158.1.1.

New lighting may also be provided at new local road intersections and /or conflict points.

For the new highway it is likely that column heights 12m with 1m, 2m and/or 3m arms. Light luminaries will be LED type in the order of 75W to 120W depending on number of lanes and carriageway widths and final position of the columns. Lux levels are expected to be 7.5 Lux (min) on carriageway surfaces at the intersections and roundabouts; and luminance levels need to be 0.75 cd along the straight road sections.

Lower levels of lighting will also be provided on the SUP in specific locations such as where the SUP crosses local roads, sections identified through CPTED assessments or identified key conflict points. This will be to category P (pedestrian area lighting) levels in accordance with Waka Kotahi standard M30 and AS/NZS 1158.3.1.

Where any pathways (or sections of pathways) such as the SUP deviate away from the road corridor specific lighting calculations will be completed in accordance with AS/NZS 1158.3.1 Table 2.2 (lighting subcategories for pedestrian and cyclist paths). The applicable subcategory (PP1 to PP5) will be assessed based on selection criteria (levels of pedestrian/cycle activity and Crime Prevention Through Environmental Design (CPTED) Assessment) prior to the commencement of detailed design.

The proposed lighting specifications are consistent with Technical Assessment J and Technical Assessment K.

[19] https://www.nzta.govt.nz/assets/resources/specification-and-guidelines-for-road-lighting-design/docs/m30-road-lighting-design.pdf

3.12. Signs & Markings

Traffic signs and road markings will be required throughout the extent of the works.

The main traffic signage will be advance direction signs to provide drivers with information on the approaches to intersections/interchanges and this can be either map or stack type layout format to convey information. These signs will include state highway and regional destinations. As the purpose of these signs is to provide drivers with sufficient information to make decisions and (if necessary) reposition their vehicle before the intersection, the distance that a sign is located from an intersection relates to the approach speed.

For grade-separated interchanges, the advance direction signage would generally be provided 1km and 2km in advance of the interchange. For at-grade intersections such as roundabouts, this would be reduced to 180-400m depending on site specific factors.

Signs may be ground mounted or overhead mounted (using gantry fixings). Advance direction signs are normally located at the roadside (left edge) but in some circumstances are mounted overhead if there is a specific need (for example a ground mounted sign is deemed to provide insufficient conspicuity). No specific need for overhead mounted signs has currently been identified; but this will be further reviewed in subsequent design stages.

Other signs will also be required for the Project including regulatory and general information signs.

Road markings will be required throughout the Project (for example to define traffic lanes, shoulders, merge and diverge tapers and limit lines).

Traffic signs and road markings will be provided in accordance with the MOTSAM[20] and the TCD[21].

3.13. Local Roads

The following works are generally proposed to local roads:

Table 3-6: Local road connections (at-grade)

Local Road	Required Works
Koputaroa Road (ST10100)	Stopped at SH1, and reconnected with a new 160m link to Heatherlea East Road
Heatherlea East Road (ST10200)	Stopped at SH1. Connected to Koputaroa Road.
Sorenson Road (ST11100)	Extended with new underpass beneath new highway fill
Arapaepae Road (between Roslyn Road and new SH57 roundabout) (ST13100)	Partially realigned to provide appropriately balanced approaches to new roundabout
McDonald Road (ST13300)	250m from SH57 intersection removed, reconnected through to SH57
Waihou Road (ST14000)	Both east-west sections severed and accessed from Arapaepae Road. North-South section connected through to McDonald Road
Kimberley Road East (ST19600)	Connected to a new north-south link road east of new highway to both Tararua Road (north) and Arapaepae Road (south)
Arapaepae Road South (ST20000)	Severed, and reconnected on east side of new highway to McLeavey Road, reconnected west side of highway to Kimberley Road

[20] https://www.nzta.govt.nz/resources/motsam/part-1/
[21] https://www.nzta.govt.nz/resources/traffic-control-devices-manual/

In addition, the following local road reconnections are proposed:

Table 3-7: Local road connections (grade-separated bridge connections)

Local Road	Required Works
Queen Street (ST15600)	Local road realigned northwards and reconnected to Arapaepae Road via grade separated bridge (over new highway)
Tararua Road (ST18200)	Reconnected via grade separated bridge (part of interchange)
Muhunoa East Road (ST21700)	Reconnected via grade separated bridge
Kuku East Road (ST24000)	Reconnected via grade separated bridge
North Manukau Road (ST27100)	Reconnected via grade separated bridge
Manakau Heights Drive (ST29000)	Reconnected via grade separated bridge
South Manakau Road (ST30200)	No change from existing (new highway is raised over local road)

Any local roads that are reconnected though bridge structures are described in further detail in section 4.7.5.

Table 3-8: New local roads

Local Road	Required Works
Southern Tie-in, East Side (ST34900-33200)	1.7km length of new access road, eastern side of the new highway, linking back to the current / existing SH1 between the Waitohu Stream and Taylors Road, to provide property access
Kuku Connection, East Side (ST25500-24000)	1.5km length of new access road, eastern side of the new highway, linking Kuku East Road to properties to the south
Manakau Heights / Eastern Rise Connection, East Side (ST29100-28700)	0.4km length of new access road, eastern side of the new highway, linking Manakau Hights Drive / Eastern Rise to properties to the north

The final design standards and layouts of local roads will be agreed with the respective council Road Controlling Authorities during final detailed design to allow for future council vesting. Design standards and specifications will suit the conditions and the number of properties served in accordance with NZS4404:2010[22].

4. Construction

4.1. Overview

This section provides a description of the proposed construction methodology for the Project. It provides a broad overview of anticipated construction across the Project and methodologies for key elements of the Project relevant for the RMA authorisations sought.

The construction methodology described in this section is a realistic and feasible methodology from which the anticipated effects on the environment of these activities can be identified. The purpose of this description is to provide sufficient detail of the proposed construction activities to allow assessment of

22 https://www.standards.govt.nz/shop/nzs-44042010/

potential effects on the environment from construction, and subsequently to allow identification of appropriate measures to avoid, remedy or mitigate these effects.

Different contractors will have different methods for establishing and constructing the contract works. The intent of this chapter is to allow sufficient flexibility for differing approaches to construction within the confines of the RMA authorisations.

The Project-wide construction description contained in the following sections describes:

- Construction duration and sequencing;
- Construction access;
- Construction compound and laydown areas; and
- Construction activities and methodology

4.2. Construction duration and sequencing

The construction of the Ō2NL Project is expected to be completed within approximately five years from the commencement of the main construction works, which are anticipated to commence in 2025. Establishment construction works would commence in 2024 and are works that are required to allow construction of the main works to proceed in a timely and efficient manner. Establishment works are described in section 4.3. The target date for opening the new road is by end of 2029.

In order to achieve the target completion date, many elements of the Ō2NL Project will likely need to be undertaken concurrently during the construction period, including the completion of works in sections. That is, the construction sequence is generally expected to be adhered to for each section. The construction works are likely to be undertaken in the general sequence set out in the following Figure 4.4, noting there may be some variance to this standardised sequencing and that some tasks can be undertaken concurrently. In addition, enabling works may be tailored / geared to benefit the overall construction activities or programme and so could adjust the sequence shown.

Figure 4: Possible/indicative construction sequence

While there are some dependencies between construction elements, the specific staging of the work is subject to land acquisition, the availability of construction contractors and other resources (such as materials and construction equipment).

The construction programme is also based on assumed typical working hours between 7am and 6pm. Specific activities outside of these times may be required to minimise disruption and provide additional safety (e.g. night works for road closures at roundabout tie-ins to the local roading network). Extended working times between 5am and 10pm resulting in double shifts may be needed to achieve the construction programme dates, critical path items or in respect of some works where night work is unavoidable, e.g. works that interface with the current state highway network or NIMT.

The ecological response package works (as described in Technical Assessments J and K and comprising mitigation, offsetting and compensation) as well as natural character planting (Technical Assessment D) can be implemented independently of the above sequence.

4.3. Establishment works

The proposed conditions (attached as Appendix Six to Volume II) require the preparation of management plans to appropriately manage construction activities. These management plans will be prepared alongside the development of the detailed design to inform subsequent outline plan or outline plans and construction activities. Management plans are not proposed or considered to be necessary for establishment works (described below) and instead any effects are proposed to be managed through specific enabling works conditions where necessary and relevant (attached as Appendix Six to Volume II). Management Plans relate to managing the effects of the main construction works.

The Project may progress with establishment works in advance of the main Project works. These establishment construction works are anticipated to be carried out in advance of the main works and consist of the following:

- Site-wide geotechnical investigations;
- Topographical surveys;
- Ecological, cultural, archaeological and heritage surveys/ baseline monitoring, exploration and assessments including relocation and stabilisation activities;
- Contaminated land testing;
- Relocation of accesses to properties;
- Protection and relocation of utilities;
- Formation of site access and haul roads, including temporary stream crossings;
- Development of construction access tracks and / or reconfiguration of existing access tracks, and development of the construction yards and main site offices including site compounds and laydown areas;
- Works associated with the abstraction of water needed to construct the Project and associated reservoirs (for storage);
- Property fencing and demarcation of areas where construction activities will not occur;
- Installation of erosion and sediment control measures associated with establishment works;
- Clearance of vegetation associated with establishment works (and clearing buildings and other features including relocation of wildlife); and
- Management plan production.

4.4. Construction access/egress

Construction access and egress is primarily required for:

- transport of site sourced material such as earthworks;
- transport of material from off-site sources such as culvert pipes; and
- access and egress by construction staff.

The transport of site sourced material such as earthworks will generally be on haul routes within the alignment of the Ō2NL Project. Short sections required to provide access to road legal delivery vehicles may be formed using imported aggregate.

The primary exception to such on-site haul routes may be for earthworks required for the initial and partial construction of the northern embankment for the NIMT Rail Overbridge. This location is isolated from the source of the fill material (southern cuts) by the railway tracks. Material must consequently be carted by road truck and trailer until such time as access is possible across the overbridge and partially completed northern and southern embankments. There is a possibility that KiwiRail may grant approval for a level crossing under an approved stand over arrangement (by a KiwiRail representative) to avoid on-road cartage, but that has not been assumed at this stage. It is noted that haul may also be needed to support commencement of other bridges and will also need to cross local roads (until bridges are constructed) and this activity will be subject to temporary traffic management measures.

Access for the supply of material from off-site sources, as well as for construction staff, will be most effectively achieved by minimising the length of travel on slow and uneven site access tracks. Site access points (SAPs) will be located, designed and constructed with the safety of all road users and construction staff in mind. It is expected that these SAPs may be categorised, as follows:

- Access from SH1 at both the northern and southern tie-in locations;
- Access from SH57 at various points associated with intersections, local road connections and cross overs of the new highway, and coordinated with any construction of the Tara-Ika development;
- Access from local roads that intersect with the construction corridor; and
- Infrequent SAP/s from SH1 where the distance between other SAPs, described above, is excessive. It is anticipated that at least one SAP will be required (between the SH1 southern tie-in and the access at South Manakau Road).

These anticipated SAPs are expected to be formed so that they may be trafficked by road legal vehicles. Management of site access will be through the Construction Traffic Management Plan.

Expected SAPs are described in the table below.

Table 4-1: Construction site access points (SAPs)

Access from State highways	
SH1 northern tie-in	Safe access may be provided by the early construction of the northern roundabout
SH1 southern tie-in	Safe access may be provided by the early construction of the southern roundabout
SH57	This intersection of the construction zone with a live state highway will be used by construction traffic including heavy dump trucks. It is likely to be managed by temporary traffic signals to facilitate the crossing of non-road legal construction traffic.
SH1 between southern tie-in and South Manakau Road	This construction length is approximately 4km long and offers no site access between these two site access points. Provision will likely be made for a safely designed intermediate SAP off SH1 along this length.
Access from local roads	
Heatherlea East Road	These local roads will provide easy access to the road corridor for access to site compounds, for material deliveries and for access by construction staff. They will also provide access to bridge sites for efficient delivery of specialised bridge construction plant, precast beams, ready mixed concrete, over dimensioned vehicles, etc.
Sorensen Road	
MacDonald Road	
Waihou Road *(southern E-W leg only)*	
Queen Street East	
Tararua Road	
Kimberley Road	
Arapaepae South Road	
Muhunoa East Road[23] *(excluding via Bishops Road due to the standard of existing rail level crossing here, unless suitably upgraded)*	

[23] The existing restricted height rail crossing (3.6m) on Muhunoa East Road would physically restrict usage by larger construction traffic.

Kuku East Road	
North Manakau Road	
Manakau Heights Drive (including Eastern Rise)	
South Manakau Road	

4.5. Compounds and Laydown areas

Construction site compounds will be required at several locations that are convenient for each main work area. The potential locations of these compounds are shown on drawings DWG-500-C-1000.

Site compound locations that may be used have been identified as follows (in close proximity to the new highway alignment, and are generally located within the area subject to the proposed designations):

- Northern end roundabout
- New SH57 roundabout
- Tararua Road
- Kuku East Road
- North Manakau Road
- South Manakau Road
- Southern tie-in (near to Taylors Road)

In addition to these locations, further small site compounds will be required at all of the bridge locations to facilitate bridge construction works during the period of bridge construction activities. Bridge locations are described in section 4.7.5.

Site compounds will typically include the following temporary facilities:

- site offices, lunch rooms and portable toilet facilities (including associated temporary power, telecommunication/fibre connections and water supplies);
- refuse and recycling facilities;
- laydown areas and secure storage containers;
- vehicle parking, refuelling, wheel wash and cleaning facilities;
- facilities for fabrication and pre-casting products such as headwalls;
- laboratory facilities for materials testing and design validation;
- plant and equipment storage;
- workshops and plant/equipment maintenance facilities;
- cabins for temp accommodation and after-hours guards;
- site testing facilities and possible nursery areas for landscaping; and
- stockpiling of aggregates.

Compounds will be designed to provide for the appropriate management of stormwater runoff and will include measures such as:

- perimeter bunds to prevent clean water run-on from areas outside of compound areas and to prevent dirty water run-off onto adjacent land;
- the collection and treatment of stormwater;

- bunding of fuel storage facilities to a volume sufficient for full containment in the event of a spill (rainwater collected in these areas will be removed and disposed of at an appropriate facility); and
- provision of emergency spill kits to be used in the event of any oils, greases or chemicals being accidentally spilt.

It is anticipated that 5 to 7 main compound areas will be established along the length of site. These are likely to vary in size from 5,000m² to 10,000m² for satellite compounds and 20,000m² to 30,000m² for the head office / main compound.

In addition, it is likely that smaller temporary compounds will be established at each of the bridge sites to specifically support the construction of the bridges. These are likely to vary in size from 400m² to 4,000m² for the larger bridges. Compounds for constructing bridges may be located at either abutment of the bridge, or both.

4.6. Stockpile sites

It is expected that some cut material may be suitable for the construction of the lower pavement layers. While a portion of this material may potentially be sequenced to be placed directly from cut in one area to pavement construction in other, it is more likely that the greater proportion of this material will need to be temporarily stockpiled to suit the logical construction sequencing.

The extent of this reuse of cut material for pavement construction, and the number and locations of the potential stockpile areas, will be determined in the final design and construction methodology of the contractor.

Some general / bulk material excavated from cut sites or early procurement of quarry sourced aggregates may also require stockpiling prior to filling and pavement operations due to sequencing or the requirement to condition the materials.

The potential impacts of any temporary stockpiles will be mitigated as for any other earthworks activity. Mitigation measures will include effective erosion and sediment controls, and dust suppression, as described in the following sections.

4.7. Construction Activities & Methodology

This section provides an overview of the main construction activities. Activities covered in this section are:

- Site preparation
- Erosion and Sediment Control;
- Temporary crossings of streams;
- Drainage (culverts, swales and ponds);
- Bridge construction;
- Earthworks;
- Aggregate Supply;
- Pavements;
- Local Road realignments;
- Planting and landscaping; and
- ITS/Lighting/Gantry's/Barriers/Road markings (Traffic services).

4.7.1. Site Preparation

The following site preparation works will be undertaken:

- 1. Fencing – Staged fencing of the works area will be required with landowner consultation to maintain access where required or until the area is required to be used.
- 2. Staged and progressive installation of erosion and sediment control measures in accordance with the certified Erosion and Sediment Control Plan (ESCP) / Site-Specific Erosion and Sediment Control Plans (SSSESCP).

- 3. Staged and progressive site clearance and set out - to be undertaken in accordance with the CEMP and associated management plans (particularly the Ecological Management Plan).

Generally, the site set out will involve the following steps:

- The extent of earthworks will be set out by the Project surveyors.
- The boundaries of all natural wetlands within the construction buffer will be marked out to physically and visually delineate the wetland areas (the intention is to avoid wetlands where practicable).
- Vegetation clearance will be undertaken adhering to the necessary environmental controls as conditioned (e.g. fauna and flora salvage and relocation).
- Topsoil will be stripped to use in perimeter bunds and in construction of other environmental controls. The stripped area will be kept to a minimum until all controls in the area have been completed. Excess topsoil will be stockpiled on site in nominated locations. Topsoil will be reused on site at the end of the earthworks as part of rehabilitation of worked areas (cuts, fill/ spoil and decommissioning).

4.7.2. Erosion and sediment control and dust

The Erosion and Sediment Control report attached as Appendix 4.3 to this report describes the approach to managing erosion and sediment control whilst undertaking any earthworks. Concept sediment control drawings are provided in Volume III. These provide an overview of management techniques and measures that will be used, including outline methodologies and management techniques that will be used.

The Erosion and Sediment Control design approach for the Project is illustrated in the Figure below:

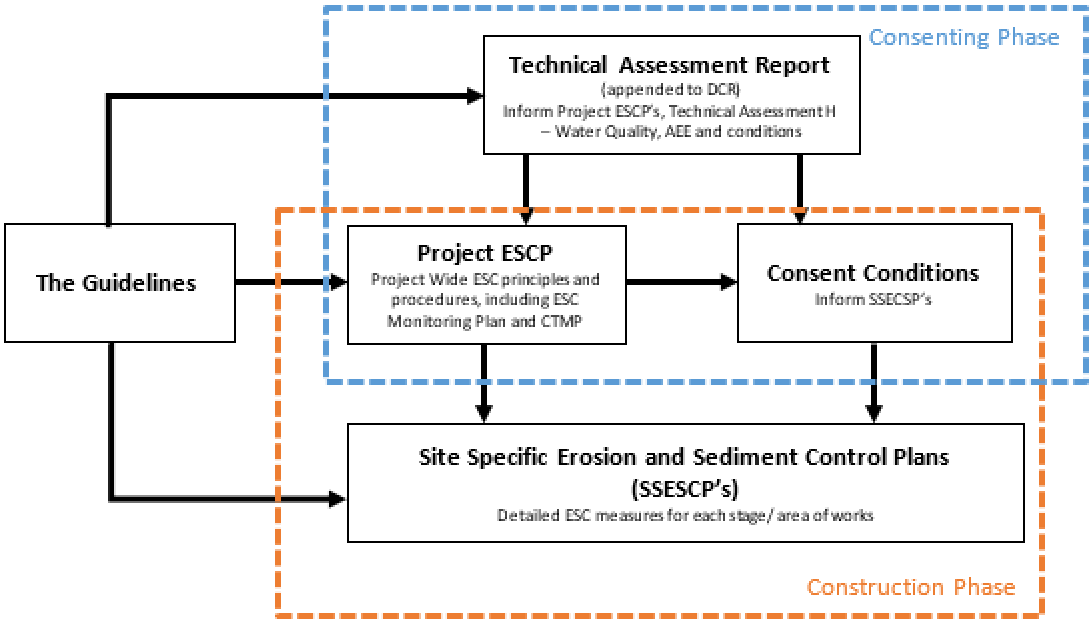

Figure 5: Erosion and Sediment Control design approach

The Project's construction methodology will seek to minimise dust nuisance occurring beyond the proposed designation boundary. Management techniques to manage potential dust effects are provided in the air quality assessment provided in Technical Assessment C in Volume IV.

4.7.3. Temporary river and stream crossings

The earthworks for the Project require the cartage of cut material across rivers and streams. To facilitate cartage of material it is necessary to construct a haul road and a separate access track to allow safe movement of all vehicles along the construction footprint. Where the haul road and access track need to cross a water course then either culverts will be installed or for larger water courses, bridges will be constructed. There are a number of scenarios as to how this might occur, and these are described below:

4.7.3.1. Culverts

Where practicable culverts will be installed as per the detailed design requirements i.e. the permanent culverts as envisaged for the new highway will be installed. However, in most instances it will be necessary to install temporary culverts to allow earthworks to occur to then enable the permanent larger culverts to be formed/ placed consistent with the final design. Where temporary culverts are installed at watercourses identified as requiring fish passage, then the temporary culvert will also be designed to maintain and not impede fish passage through the temporary structure.

Generally, it is expected that temporary culverts will be constructed on stream length that is expected to be affected by the permanent construction requirements of the Project. However, in some instances it might be desirable to construct temporary culverts offline, and to then later remove the temporary culverts and reinstate water courses. Where this occurs the re-instatement of the streams will be in accordance with stream diversion design principles, i.e. natural stream channels constructed with riparian planting.

Any temporary culverts will need to be designed, generally they are expected to be smaller sized in terms of hydraulic capacity than permanent culverts and will allow for overtopping in the case of a significant rainfall events. The size of the culvert will depend on how long it is needed to be used for before it is either removed or replaced with the permanent culvert (needed for the highway) using a risk-based approach, where typically temporary culverts are designed to accommodate a 1:10 AEP storm event, but where culverts are only needed for short periods of time e.g. 6 months or a year then lower specifications would be appropriate. Temporary culvert lengths will vary by location but are expected to be on average approximately 15 m long to allow for a 10 m wide haul road.

4.7.3.2. Bridges

The length of temporary bridge crossings will vary from 15m for minor crossings, to up to 45m for the crossings of the average flow channels for the Ohau River and Waikawa Stream bridges.

Any temporary bridges will need to be designed in later stages. Generally, they will be smaller sized in terms of hydraulic capacity (and reduced total span) than permanent bridges typically being designed to accommodate a much reduced storm event (such as 1:5 AEP event). They may allow for overtopping in the case of significant rainfall events. Temporary bridges are often accessed by a gravel access track that can also be washed away with limited environmental impact in the event of a major flood event.

All temporary river and stream crossings of permanently flowing waterways will allow for the free passage of fish. Further detail of temporary bridge crossings is provided in Section 4.7.5.4. below.

4.7.4. Stream Works

The construction of permanent stream diversions and culverts will be required to maintain existing flow paths and for the proposed stormwater design. Any stream works will be undertaken in accordance with the SSESCPs.

Stream works will be sequenced with earthworks to keep the disturbance footprint to a minimum. Where practicably possible stream works will be undertaken offline from the main stream 'in the dry' i.e: flows will be diverted around the works site or the works will be away from the flows.

The construction of permanent stream diversions and culverts will be required to maintain existing flow paths and for the proposed stormwater design. Any stream works will be undertaken in accordance with the SSESCPs. Construction works will take place 'in the dry' and 'offline', i.e. with flows diverted around the works site.

4.7.4.1. Permanent stream diversions

The permanent diversions will be constructed and stabilised with geotextile lining and rip rap. Once constructed, flows from the original channel will be diverted using methods that may include sand bags, rip rap and compacted fill, and the existing channel will be isolated from the diversion.

For all permanently flowing waterways, the Project ecologist (in collaboration with iwi partners) will then undertake fish salvage at appropriate times directly before and during construction. The now offline section of stream will be dewatered to the now diverted stream. This water may require sediment to be removed prior to this occurring and in this instance will be dewatered to a sediment control device then into the stream. The original channel will be cleaned out, with material suitable for re-use in future stream diversions retained for that purpose and any unsuitable material will be transported to the nearest spoil site.

The redundant section of the original channel will then be filled in and compacted as described for earthworks.

4.7.4.2. Permanent Culverts

Where proposed culvert crossings are aligned within the existing stream, a temporary diversion will be constructed as for a permanent stream diversion. The preparation of the stream bed will follow the same methodology as for stream diversions and will include the installation and backfill of the culvert, and the redirection of flows into the culvert.

Where proposed culvert crossings are aligned outside of the existing stream, the new culvert may be constructed in competent foundation materials without the need to potentially undercut existing stream beds. On completion of the culvert construction, the existing stream may be realigned to pass through the new culvert this may require sections of permanent stream diversions.

The following methodologies will generally be applied:

- Direct crossings (when a fill structure crosses a stream at 90 degrees (or close) resulting in the installation of a culvert to provide cross drainage)

  Method: Construct culvert offline and tie back to original stream diverting water from original stream into the culvert. Fill in original stream.

- Sidling crossing (when a fill structure crosses a stream at an oblique angle causing installation of culvert and a stream diversion)

  Method: Construct culvert offline at 90 degrees (or close) across the fill, construct new stream from culvert inlet /outlet along foot of proposed batter / fill slope to original stream. Tie into original stream diverting water from existing stream into the culvert. Fill in original stream.

- Sidling fill (when a fill structure causes parts of a stream to be filled but does not cross the stream)

  Method: construct stream diversion offline at foot of proposed batter / fill and then tie back to original stream diverting water from original stream into the stream diversion. Fill in original stream.

There will also be opportunities for some low flow and ephemeral streams to complete the culvert works during dry conditions when there is no flow within the watercourse, avoiding the need to divert existing watercourses. As this reduces construction and environmental/ecological complexity, this is the preferred approach to construct low flow / ephemeral culvert works. This may require some undercutting of underlying materials to provide a suitable bedding for the culvert.

4.7.5. Bridges

Typically bridge construction works will progress once an all-weather access track has been constructed to the bridge site. The bridge construction comprises of the following activities:

- Site set up (laydown areas, site facilities, ESC)
- Pile construction
- Abutments, settlement slabs and associated retaining walls
- Fabrication of precast beams (usually off site)
- Lifting and placing of precast bridge beams
- Completion of concrete deck works including final surface and barriers
- Placement of fill behind retaining walls and abutments will be completed progressively
- Placement of scour protection

Laydown areas and small site facilities will be set up adjacent to the bridge sites.

ESC will be set up, mobilisation of plant and equipment to site for the abutment construction may include drilling and piling machinery. Storage of material will be considered to allow access for the construction works. Access tracks will be required to deliver plant, materials and equipment to site and this may include a series of over dimensioned loads if cranes and precast elements need to be delivered. Deliveries may be scheduled for off peak times such as weekends and overnight. Night construction works will be required for specific activities such as lifting and placing of bridge beams over operational roads.

Access for concrete truck deliveries will also be required.

The forms of the bridges have been designed to be as consistent as possible, and essentially are of two types of construction, namely hollow core and super Tee precast beams. However, the key differences in the bridge construction methodologies relate to the location of the bridges, whether they are in cut (blue) or fill (white) or multi-span bridges across floodplains (green), and the types of physical barriers that they span. These are tabulated below.

Table 4-2: Indicative bridge construction methods

Ref	Structure name	Structure location	Highway under/over	Spans and beams	Characteristics for construction consideration
1	NIMT Rail Overbridge	CH10700	Highway over NIMT railway line	One span SHC beams	Accessible at-grade. MSE abutment walls constructed in fill.
2	Queen Street Overbridge	CH15600	Highway in limited cut, local road over	One span 1525 S/Tee	Constructed in cut top-down construction could be considered
3	Tararua Interchange	CH18250	Highway at-grade, local road over	One span 1525 S/Tee	Constructed in cut top-down construction could be considered
4	Muhunoa East Road Overbridge	CH21500	Highway under local road	One span 1525 S/Tee	Both local road and mainline in fill. MSE abutment walls constructed in fill
5	Ohau River Bridge	CH22600	Highway over river	5x35m spans 1525 S/Tee	Four spans accessible from at grade. Channel flow below southern span only.
6	Ohau River Flood Relief Bridge	CH22435	Highway over river	One span SHC beams	Accessible at-grade. MSE abutment walls constructed in fill
7	Kuku Stream Bridge	CH23820	Highway over stream	One span SHC beams	Accessible at-grade. MSE abutment walls constructed in fill
8	Kuku East Road Bridge	CH24000	Highway over local road (at grade). Highway in cut, local road over	One span 1525 S/Tee	Constructed in cut top-down construction could be considered
9	Waikawa Stream Bridge	CH26500	Highway over stream	4x35m spans 1525 S/Tee	Four spans accessible from at grade. Channel flow below northern span only.
10	North Manakau Road Overbridge	CH27100	Highway in cut, local road over	One span 1525 S/Tee	Constructed in cut top-down construction
11	Manakau Heights Overbridge	CH28900	Highway at grade, local road over. Highway in cut, local road over	One span 1525 S/Tee	Constructed in cut top-down construction could be considered
12	South Manakau Road (incorporating Manakau Stream)	CH30200	Highway over stream and local road	One span 1525 S/Tee	Accessible at-grade MSE abutment walls constructed in fill
13	Waiauti Stream Bridge	CH30350	Highway over stream	One span SHC beams	Accessible at-grade. MSE abutment walls constructed in fill.
14	SH1 Crossing near Taylors Road	CH34300	Highway over local road (at grade)	One span SHC beams	Constructed in cut top-down construction could be considered (no TTM benefits of top-down)
15	PP20 Culvert No. 1 Extension	CH34600	Highway over stream	2800 oval multiplate	Construction as per culverts

	(Greenwood Stream)				

The proposed bridge construction methodologies are grouped accordingly in the sections below.

4.7.5.1. Bridges constructed in fill

These bridges are expected to be constructed as follows;

- Construct the MSE abutment walls, including tie-backs, as an integral component of the fills immediately behind the abutments.
- Construct the abutment footings on the fills.
- Install beams using cranes positioned either end at natural ground level or on fills.
- Construct deck, barriers and other components.

Temporary traffic management will be required to allow for the construction of these structures, to ensure that local access is maintained. The following specific temporary traffic management aspects will be managed through the CTMP.

- The NIMT Rail Overbridge, the Ohau River Flood Relief Bridge, the Kuku Stream Bridge and the Waiauti Stream Bridge are essentially 'greenfields off-line' construction and so no specific road traffic management is needed.
- The Muhunoa East Road Overbridge will likely require a controlled temporary crossing of the construction alignment. Once the bridge and approaches have been completed, Muhunoa East Road traffic may be diverted over the bridge and the temporary crossing removed.
- The South Manakau Road / Manakau Stream Bridge provides for to the local road to pass below the bridge on the northern bank of the Manakau Stream. Road traffic may remain in place during the construction of the southern abutment. However, South Manakau Road is likely to need to be closed during the construction of the northern abutment and bridge deck, with traffic temporarily diverted along Manakau Heights Drive.

4.7.5.2. Bridges constructed in cut

These bridges are currently shown as being constructed with MSE abutment walls that would require excavations for their construction and so temporary traffic management measures in accordance with the CTMP will be needed to maintain local road access. This may include temporary roadway diversions or stop/go controls through the construction site under supervision.

SH1 Crossing near Taylors is constructed off-line and so no traffic management is predicted to be needed.

4.7.5.3. Multi-span bridges across floodplains

This group includes the Ohau River Bridge and the Waikawa Stream Bridge (shown in green in the table above). Both bridges will be constructed off-line from existing roads and will therefore have no traffic impact.

Both bridges have a river flow channel below an end span, with a raised flood plain river bank consisting of deposited river gravels that will provide access at ground level for construction purposes. This includes conventional piling, substructure and superstructure construction with beams lifted into place with a crane or cranes.

The span across the river flow is the only aspect, which is slightly more complex than the other spans, but is still regarded as standard construction practice. The methodology for these 'over water' spans is as follows:

- Create a level piling platform on both sides of the river channel. Fish salvage may be required if creation of the platform involves diverting the low flow river channel.
- Install piles and substructure, including columns and crossheads (pier caps).
- Lift beams into position, most likely using a tandem lift of two cranes with one crane positioned on each side of the river. The logistics of this lift will require a detailed lift plan.
- Construct deck, barrier and other bridge components.

4.7.5.4. Temporary bridges

The detailed analysis of the optimal earthworks sequencing will determine the sequencing and timing of bridge construction. While the sequencing of bridges and spans over land is less critical to the overall sequencing, the spans across water channels are likely to be fundamentally determined by the earthworks critical path activities.

For some 'over water' spans it may be practicable to complete the bridge decks and approach earthworks prior to carting earthworks across the watercourses. However, it is more likely that the barriers created by these watercourses will require early temporary crossings in order to expedite the earthworks critical path. In addition, these temporary bridges will provide:

- 'cross water' access for efficient bridge construction on either river bank
- temporary staging from which construction materials may be lifted into place by crane, e.g. bridge beams, formwork reinforcing steel, concrete and other materials.

Temporary bridges would not interrupt the main channel flow.

Most major contractors will likely have stocks of materials that have been designed and customized for such temporary crossings or stagings. This staging would likely be constructed progressively, span by span, across the channel, as follows:

- Install temporary pile casings using a piling rig.
- Construct cross heads and beams to the first span.
- Fix timber decking to the first span.
- Move piling rig onto the completed first span and repeat the process for successive spans.
- Extract the casings on completion by reversing the above process.

4.7.6. Earthworks

Typically, earthworks throughout the site will comprise of the following activities:

- stripping and stockpiling of topsoil
- haul roads and temporary culverts
- ground improvements and foundation treatments
- Preparation of material supply sites and the excavation of materials for fill operations
- bulk excavation for cut to fill and borrow to fill (including the excavation of stormwater/wetland ponds)
- placement of engineered fill including potential conditioning of material prior to placement
- placement of landscape fill, or spoil, using excess materials
- temporary stockpiling of cut material for potential reuse in pavement construction
- conditioning of earthworks material in order to achieve suitable material properties for re-use (such as drying out to reduce moisture content)
- Testing and surveying to assure quality
- replacement of topsoil and grass on cut and fill batters.

A progressive approach to stabilisation of earthworks surfaces will be undertaken with surfaces being covered with erosion-resistant materials as soon as practicable.

ESC controls will be adapted throughout the earthworks operation to allow for the changing levels and open area footprints

The Project construction footprint will be approximately 580 ha. The total quantity of earthwork volume is calculated on an indicative basis to be approximately 5 million cubic metres (m^3) of cut material which includes allowance for:

- Undercuts

- Material supply sites
- Topsoil strip and re-spread
- Wetlands, ponds, swales, stream diversions

This overall Project earthworks volume of the current concept design is summarised below:

Table 4-3: Indicative earthwork volumes

Cut to structural fill	1.0-2.0M m^3
Borrow to structural fill (material supply sites)	0.5–1.5M m^3
Cut to waste (including undercut and unsuitable)	0.5-1.5M m^3

Table Note: The volumes presented are in-situ rounded volumes and do not account for material bulking.

The greater proportion of the earthworks will be undertaken in the drier summer months. However, the nature of the in-situ spoils is generally of a sandy nature. For this reason, it is expected that some earthworks activities will be undertaken during the winter periods when site conditions permit this to occur, and noting that work in the winter is more likely to provide desirable / optimal moisture content needed for some areas of earthwork. Key benefits of earthworks operations during the wetter season are:

- As the earthworks is the most important critical path item, longer earthworks programme availability will reduce the overall construction duration.
- In-situ earthworks materials will be closer to optimum moisture content, requiring substantially less addition of water for compaction purposes.
- The potential for dust generation will be substantially reduced.

As with other projects of this scale and nature, it is anticipated that work during the winter will be able to be undertaken with the appropriate management measures in place. The key measures will be providing appropriate erosion and control.

The following earthworks methodologies will be employed:

4.7.6.1. Cut methodology, including excavation from material supply sites

- Motor scrapers will be used to cut and transport material over short haul distances and using excavator and dump trucks over longer haul distances.
- Cut material will be transported to fill areas placed and recompacted in layers to the underside of the pavement formation, as described in Fill methodology below.
- Excess and unsuitable material from the cuts will be transported to spoil sites, placed in layers and track rolled with dozers.
- Blasting is not anticipated.
- Progressive stabilisation will be applied particularly in higher cuts where stabilisation methodologies may be limited by height of application

4.7.6.2. Fill methodology

- Mass haulage routes will be used to transport equipment and material to the fill sites. These will generally be located within the Project construction footprint, except where barriers exist such as the NIMT railway line. In this case material will be carted by road to the relatively small section of the works located between the northern SH1 tie-in and the NIMT line. Crossings of watercourses will generally be achieved within the project construction footprint by means of temporary bridge crossings or early construction of the smaller bridges.
- Following stripping, undercutting of embankments will be carried out.
- Culverts will generally be constructed offline, as described in section 4.7.4
- Fill materials will be placed in layers.
- At the end of each day fill surfaces will be shaped to provide positive draining off the fill and sealed using a smooth drum roller or rubber tyred machine.

- Exposed fill surfaces will be permanently or temporarily stabilised (by rolling or other techniques described in the ESCP) as soon as possible to minimise potential scouring and erosion of newly placed fill.
- Any erosion that should occur on the fill areas will be reinstated with suitable structural fill.
- Fill will be compacted with appropriate plant and equipment to achieve the necessary compaction standards.
- Cohesive fill that is wet of optimum moisture content (i.e. too wet) will be mechanically dried by disking and air drying. Little cohesive material is anticipated.

4.7.6.3. Earthwork finishing works

- Following the completion of earthworks, topsoil will be re-spread on the batters and berms.
- All exposed topsoil will be either hydro seeded or mulched as soon as practicably possible.
- For larger batters, top soiling will be carried out progressively to minimise the risk of erosion and dust.
- Vegetation planting will progressively be undertaken as construction works are completed in each area.
- Efforts to remediate all impacted natural wetlands within the construction buffer will be implemented, including actions such as applying topsoil and undertaking planting and pest plant control.

4.7.6.4. Paving and finishing works

- Once cuts and fills reach pavement formation level, final trim of the subgrade surface will be carried out followed by construction of the road pavements and shared user path.
- Construction of stormwater management devices such as basins, swales and culverts form part of the Project's bulk earthworks activities and will follow the general construction methodology outlined above.

4.7.6.5. Material Supply

It is currently estimated that approximately 2.5 million cubic metres of bulk fill material is needed to be sourced in order to construct the Project (this could be sourced directly from cut material, or from the identified material supply sites with the project designation). This is due to:

- the topography of the Project;
- the need to stay above flood levels;
- the desirability to reduce cuts in locations to manage potential cultural and landscape effects;
- bridging streams and to allow local roads to be built across (and over) the Project and;
- some material that is cut is unlikely to be able to be used as structural fill.

A range of Material Supply Sites have been identified along the route to supply the Project. These sites will potentially make material available for fills from closer locations than distant cut locations or from quarries outside of the project area. This will reduce the amount of haul required on the Project. A reduction in overall haul will have the following environmental benefits:

- Reduced risk of dust generation and associated potential impact on the surrounding environment;
- Reduced demand for water (for dust control);
- A potential reduction in the carbon footprint caused by plant use.

The following is an anticipated standard construction methodology for the extraction of material for each of the preferred Material Supply Sites:

- Removal of vegetation, ecological works and mitigations works (i.e. stormwater management systems where proposed).

- Set up on site – access and laydown area preparation including establishment of erosion and sediment controls; parking; haul roads; boundary fencing, etc.
- Removal and stockpiling of topsoil (for use in the later rehabilitation of the site to identified location(s))
- Extraction of materials to agreed contours using earthworks 'cut' methodology provided (as per section 4.7.6.1) and repeated below:
  - Motor scrapers will be used to cut and transport material over short haul distances and using excavator and dump trucks over longer haul distances.
  - Any unsuitable material encountered will be stockpiled within the construction footprint and re-used for final contouring.
  - Cut material will be transported to fill areas placed and recompacted in layers to the underside of the pavement formation, as described in Fill methodology below.
  - Excess and unsuitable material from the cuts will be transported to spoil sites, placed in layers and track rolled with dozers.
  - Blasting is not anticipated.
- Re-contouring of the Material Supply Site to finished levels; and
- Rehabilitation of Material Supply Site area where materials removed via placement of topsoil and undertaking planting.

When the material excavation activities are complete, these sites offer considerable opportunity to support an enduring community legacy and further details of rehabilitation proposals and outcomes sought for the geographical area areas used as Materials Supply Sites are provided in the CEDF.

4.7.6.6. Spoil Sites

Refer to Appendix 4.4 of this report for additional information on spoil sites including the selection and assessment process, further design and more detailed location information. The information set out in Appendix 4.4 and summarised below, in terms of the design and number of spoil sites and volume of material they will need to accommodate, is indicative.

The volume of material that will be cut, but deemed unsuitable / not necessary for re-use, is estimated to be approximately 0.5-1.0M m^3 (subject to change when additional geotechnical testing is completed in later stages). These initial estimated figures include the following allowances:

- 10% additional volume to accommodate variability and contingency.
- 10% compaction factor as a net reduction in available cut due to compaction.

The excess material will be disposed of at identified spoil sites,.

Spoil sites are shown on General Arrangement drawings provided in Volume III and include areas of embankments where excess material may be placed as buttress fills to extend the embankment batter slopes on a flatter gradient.

Spoil sites have been located frequently throughout the alignment to reduce haul distances and to keep earthworks within their catchments. Their approximate capacity has been assessed and is anticipated to be cumulatively sufficient for the estimated spoil volumes.

The following indicative methodology will be used in relation to the spoil disposal areas:

- Erosion and Sediment Control - compliant erosion and sediment controls for each of the disposal sites will be installed prior to spoiling operation beginning (approved by way of SSESCPs). This will likely include cut-off drains to be used as clean water diversions. Additionally, watercarts and other measures will be used to manage dust.
- The disposal site will be opened in stages as required. Topsoil strip, clean water diversions and erosion and sediment controls will be progressively installed and expanded in stages ahead of the spoil placement to limit the amount of open area.

- Stripped topsoil, where possible, will be put to the edges of the disposal areas to be reused to progressively close and remediate disposal areas as they are infilled.
  - Disposed material will be placed in layers and dozers and rollers will be used to shape and compact the material. Grade will be maintained on the disposal surface to direct water to the sediment and erosion control devices.
  - The finished surface of the disposal will be contoured to generally match / fit into the existing topography, and to direct water to appropriate watercourses or discharge points. Topsoil will be progressively re-spread on the disposal slopes and planted to enable progressive closure.
  - Vegetation in the form of hydro mulching or topsoil and hydro-seeding placement must be undertaken on the slopes and top surfaces of the spoil site, to embed the spoil site into the natural environment. Vegetation will be restored at some spoil sites as directed by the landscaping and terrestrial planting plans.

4.7.6.7. Dust suppression

The potential for dust generation arises:

- Primarily from haul of material and people along the Project; and
- Because of the sandy nature of the soils, the substantial cut to fill volumes, and the long haul distances.

Construction dust effects are assessed in the Air Quality Assessment (Technical Assessment C, provided in Volume IV). Mitigation is proposed to include the following:

- Progressive opening and stabilising (as soon as practicable) of open areas.
- Continuous stabilisation of completed earthworks to minimise dust generation.
- Primarily use water to suppress dust (water requirements are discussed in section 4.7.6.8, below).
- Where practicable, use of commercially available dust suppressants such as lignosulfonate and calcium, sodium, and magnesium chloride.

4.7.6.8. Construction water

Water for construction purposes will inter alia be required for the following reasons:

- For dust suppression to meet compliance requirements (as described in section 4.7.6.7), and for the health and safety of workers;
- To achieve maximum compaction density of pavements and fills;
- To condition any fill to meet geotechnical requirements;
- To hydrate and activate cement for stabilisation processes; and
- For lubrication of machine rollers so that the material does not stick.

The overall strategy will be to adopt construction methods that will consider how to minimise need for water. While abstraction from watercourses is likely to be the main source of construction water, opportunities to re-use water collected on site through construction activities notably from ESC devices and dewatering, will be explored and used ahead of water from streams and rivers. Water may also be able to be secured from operational boreholes located on properties traversed by the Project and will be used where practicable.

Refer to Appendix 4.7 for more details of potential sources of surface water and how the construction water requirements are proposed to be managed. The details set out in Appendix 4.7, and summarised below, and are indicative based on current design details. As the design of the Project is developed and finalised, these details may change. Construction water requirements are also weather dependent.

The indicative anticipated water demand for the Project is on average 2,350m^3/day with a maximum of 3,900m^3/day. As at this stage it is not known how much water may be available for re-use on site or from bores on site. Therefore, approvals are sought to abstract water for construction as described in Tables 4-4 and 4-5 below.

The maximum abstraction rate is based on the maximum daily take (m^3/day) over the course of 12 hours and taking into consideration minimum and median flow rates. Hence, while only 409m^3/day is proposed to be taken from the Ohau River, this is proposed to be abstracted at up to rates of 70L/s, which is less than 10% of minimum flow Level in the Ohau River.

The total take is not a sum of the proposed maximum abstraction rates, rather it is the proposed maximum abstraction rate across all streams as a total; abstraction rates from individual streams are still limited to the proposed maximum rate per stream in Table 4-4.

Table 4-4: Proposed water abstraction watercourses (for construction purposes)

Water Course	**Proposed Maximum Abstraction Volume (m^3/day)**	**Proposed Maximum Abstraction rate (L/s)**	**Minimum Flow (L/s) which, if at or below, abstraction would cease**
Koputaroa Stream	231	6	**see note*
Ohau River	409	70	820
Waikawa Stream	2,998	70	220
Manakau and Waiauti Stream	102	6	40
Waitohu Stream	2,160	50	140

** It is proposed to take 10% of the Koputaroa Stream flow estimated at McDonald Road, based on the recorded flows at Tavistock Road. Water take would cease on the Koputaroa Stream when Manawatū River is below 12,240L/s*

Multiple take points are proposed to help reduce need to transport water, and to help keep water within the catchment from which it was sourced. In addition, in order to fill the water storage facilities proposed (Table 4-5), water is proposed to be taken in excess of the maximum abstraction volume when flows in water courses are above the median. During these period water will only be taken at a rate of up to 10% of the flow.

Water storage is also proposed to allow water-cart vehicles to be filled at a rapid rate from a pond, while the pond itself would be filled up at a much slower rate from a nearby stream. Storage ponds will be located either side of a stream and offset by a practical pumping distance to increase the number of water supply points and thereby reduce cartage.

Preference will be given to using stormwater ponds as water storage facilities; these can be lined during construction to enable water storage and converted to stormwater ponds post construction, minimising earthworks. Other ponds may need to be located closer to the abstraction point, and to provide for overlaps when stormwater ponds are needed to become operational to treat stormwater from the completed road surface.

Proposed locations of the construction water ponds are shown on the accommodation drawings (provided in Volume III) and provides the following storage per stream. The table also provides an estimate of how long water will remain available if there are dry periods (refer to Appendix 4.7 for additional detail).

Table 4-5: Proposed water abstraction storage per water course (for construction purposes)

Water Course	**Proposed storage capacity (m^3)**	**Estimated consecutive days per year when below Minimum Flow**
Koputaroa Stream	11,800	5 (10-yr ARI) 12 (20-yr ARI)
Ohau River	28,500	2 (10-yr ARI) 6 (20-yr ARI)
Waikawa Stream	23,100	2 (10-yr ARI) 5 (20-yr ARI)
Manakau and Waiauti Stream	8386	14 (10-yr ARI) 20 (20-yr ARI)

Waitohu Stream	8566	13 (10-yr ARI) 18 (20-yr ARI)
Total take	80,352	

Pumping equipment will be installed outside of the live channel of the water course and at locations that minimise effects on vegetation. Some minor earthworks and ground stabilising / concrete works may be required to create platforms for pumps and generators. The pump will be located so that it is able to withstand up to an AEP 1:10 flood event and at located at least 10m (horizontally) from stream or wetland. Generators will be located at least 20 metres from a stream or natural wetland and within a containment bund. Pipes from the pump to the water course will be laid above ground and so effects on vegetation is generally anticipated to be avoided but in some instances trimming of vegetation may be required.

Water will be abstracted from the streams and rivers with the use of pumps fitted with flow meters. The intake screen of the pumps will be designed in accordance with Rule 16.1 of the Horizons Regional Council's One Plan. The intake screen will have a mesh aperture size not exceeding 3mm in diameter and an intake velocity of less than 0.3 m/s. No physical works are generally anticipated to be needed within the bed of the water courses. The pump intake would not be fixed to the bed of the river and will be generally located so that the intake screen is fully submerged. The location of the intake is likely to need to adjust during the construction period in response to changes in water course conditions (as shown on the Accommodation Works drawings in Volume III).

The water will be pumped at low rates (relative to water volumes in the water course) into storage ponds for future use. Watercarts will then be filled up from these storage locations and distributed on site, as required.

Water taken will be carefully managed against construction requirements and is not proposed to be taken when streams are at or below Mean Annual Low Flow (recorded as Minimum Flow in Table 4-4 above).

4.7.6.9. Earthworks Finishing Works

Swales and ponds will be constructed and then when logical sections are completed they will be stabilised and planted. Sequencing will be related to main earthworks and position of the drainage in relation to cut and fill.

- Following the completion of earthworks, topsoil will be re-spread on the batters and berms.
- Any residual fill material which is deemed suitable by the Project ecologist, will be made available for ecological works.
- Batters will be trimmed and may be finished with topsoil and/or hydroseed depending on batter angles and material types
- Where topsoil is applied it will be placed to mitigate erosion and may be done progressively to minimise risk of erosion
- All exposed topsoil will be stabilised in accordance with the ESCP (as specified in conditions attached as Appendix Five to Volume II)
- When top soiling swales (conveyance swales and treatment swales) for network drainage, additional stabilisation measures such as biodegradable matting may be used to prevent erosion until grassing has been established Earthwork areas will be progressively stabilised.

4.7.7. Aggregate Supply

The Project will require the importation of aggregate over a 4-5 year period. Project aggregates are expected to come from several local quarries that will be negotiated by the construction contractor, or from suitable on-site material.

Where material is found on site, that material may need to be processed using a mobile rock crusher.

A summary of the indicative Project-wide imported aggregate supply is provided in the table below:

Table 4-6: Indicative aggregate volumes

Temporary works / access track material	150,000-200,000m³

Drainage material (incl. riprap)	30,000-50,000m³
Pavement / Surfacing aggregate	350,000-500,000m³

Table Note: The volumes presented will change depending on the material properties and suitability for re-use of cuttings and borrow sites.

4.7.8. Pavement and Surfacing

In general, the pavement and surfacing works will be completed in stages as the earthworks and drainage is completed. The precise form or design of the pavement is not known and will be determined during the contract. However, the design may include some of the following options, or combination of options:

Table 4-7: Pavement materials

Pavement	• Granular unbound aggregate • Granular bound (stabilised) aggregate • Foam bitumen stabilisation of granular aggregate • Asphaltic concrete
Surfacing	• Chipseal • Open graded porous asphalt (OGPA) • Stone mastic asphalt (SMA) typically laid on concrete bridge decks

Activities for the pavement and surfacing include:

- Grading and placement of granular aggregate materials,
- Conditioning and compaction of granular materials (adding water or drying back)
- Potentially cement or bitumen stabilisation of some of the pavement materials,
- Spraying of bitumen, and spreading / compaction of aggregate chip
- Laying of OGPA and/or SMA by spreading and compaction

OGPA surfacing is generally laid on a chipseal membrane layer after typically a period of 12 months subsequent to the laying of the chipseal membrane. During this interim period, the road is installed with all the necessary traffic services, including signs and roadmarkings and the road is fully opened to normal traffic. This means that the road is fully operational during this interim period. The reasons for this delay in application of the final OGPA surfacing layer are twofold:

a) The OGPA is designed to be porous. The chipseal membrane acts to adhere the OGPA to the underlying layer and to improve the waterproofing of the underlying pavement structure. While some compaction is provided to the chipseal layer during construction, full embedment and orientation of the stone ships is only achieved after some months of vehicle trafficking. Without this full embedment and orientation of the chip to a flat, horizontal inclination, the adherence and performance of the OGPA would be compromised.

b) Earthworks embankments often incur residual settlement up to 12 months following construction, particularly if constructed on weak in-situ foundations. Such settlement has the potential to damage OGPA if this is laid prior to the dissipation of these residual settlements.

4.7.9. Local road realignments

Construction of realigned local roads will generally occur at the beginning of construction of any section of the main alignment, in order to transfer local road traffic away from the main construction works. Some local roads may be staged to retain access for local properties. The Contractor will be required to liaise with local property owners in this respect.

Construction of local road alignments may require temporary short to medium term road closures or detours. Temporary detours may run alongside the existing local road alignments or they may be detoured along another road. Closures and detours will comply with the approved Construction Traffic

Management Plans that will be prepared in accordance with CoPTTM[24], Waka Kotahi's Code of Practice for Temporary Traffic Management.

Construction activities such as cut and fill operations, drainage, pavement and surfacing will follow the same processes as for the main alignment works, albeit of a smaller scale.

4.7.10. Planting and Landscaping

Planting and landscaping will take place progressively as sections or areas of the works are completed.

Various stabilising measures will be adopted in line with industry best practice to manage erosion and sediment and this may include the progressive hydroseeding or mulching of recently completed earthworks.

Where planting is required for erosion control, for example in swales or overland flow paths, these will be phased as early as practicably possible to enable early establishment of the plants.

Planting for mitigation and landscaping will also be sequenced with earthworks but some areas may be outside of the construction footprint and therefore are not reliant of construction phasing.

Sourcing of plants will be done locally as best as is practical and it is likely that nurseries will need to be set up to manage the growth of plants required. This may include a programme of local cultivation and seed capture.

There may be some plants that are relocated to other areas such as removing plants from established wetlands that are in the construction footprint to new wetlands or to improve the condition of other existing wetlands.

Areas of spoil and fill will be landscaped to be in keeping with the local environment and this may mean that rounding of stockpiles (for example) will be done.

4.7.11. Traffic Services

Traffic services include lighting, overhead sign gantries, other signage, traffic barriers and road markings. These will generally be included in the works at the time of, or immediately after the pavement and surfacing have been constructed. The works consist of ducting, erection of hardware, and painted or other road markings.

4.7.12. Other construction related activities

The following activities will occur generally across the Project area, within the designation. These are generally associated with specific requirements of pavement and bridge construction and so will need to be located close to where activity is needed and may in some instances entail mobile plant:

- concrete batching plant: including hoppers to contain the four key constituent parts of concrete (aggregate, sand, cement, water). The four components are weighed and mixed on site to the specified concrete design mix requirements and batch tested before being dispatched into concrete agitator trucks for delivery. RMA approvals will be sought for this activity at a later stage, once more detail of construction methodology and staging is understood.
- pug mill processing: A pug mill also known as a pugmill mixer or paddle mixer, is a type of horizontal, continuous mixer used to combine solid and liquid feed components into a homogeneous mixture. In the context of road building, they are used to cement stabilise road aggregate producing a uniform product that that can then be placed into the pavement structure for curing.
- facilities for pre-casting: comprising large temporary weatherproof buildings founded on temporary reinforced concrete slabs. The pre-casting process itself involves fixing reinforcement, placement and fixing of cover blocks, erecting formwork, pouring concrete and vibrating the concrete to improve its density and durability by expelling air. On-site pre-casting facilities are typically used for smaller precast elements such as MSE concrete panels; L-shaped retaining walls, small box culverts, manhole lids etc. Larger pre-cast items that require specialist prestressing or steam curing such as bridge beams will likely be manufactured offsite and transported to site.

[24] Code of Practice for Temporary Traffic Management: https://www.nzta.govt.nz/roads-and-rail/code-of-practice-for-temporary-traffic-management/code-of-practice/copttm-document/

- mobile asphalt plant: A mobile asphalt plant is an asphalt plant that can be assembled close to the aggregate supplies or near to the construction site. This has the advantage that transport of materials can be minimised and it significantly reduces transportation times and therefore the asphalt has less chance to cool prior to compaction. The plant itself is designed to heat and dry aggregate and to mix aggregate with bitumen to produce asphalt. RMA approvals will be sought for this activity at a later stage, once more detail of construction methodology and staging is understood.
- Screening of quarry materials: materials sourced on site may be of a grade that is appropriate for use during construction. If this material is discovered and is able to be used then the need to import material will reduce. It will allow material sourced on site to be processed on-site and therefore reduce cartage of material to an off-site facility for sorting. Materials sourced may need to be put through a conveyor and screen system to grade the materials by size. This allows for the material to be sorted into different products for use on site. The plant itself will require a quarry manager to operate it. The material supply sites are the most likely source of this type of material.

Appendix 4.1 Geotechnical Design Summary Report

SH1 Ōtaki To North Levin Highway Project Appendix 4.1 - Geotechnical Consenting Design Report

PREPARED FOR WAKA KOTAHI NZ TRANSPORT AGENCY
July 2022

We design with community in mind

Stantec

Revision Schedule

Rev No	Date	Description	Signature of Typed Name (documentation on file)			
			Prepared by	**Checked by**	**Reviewed by**	**Approved by**
A	24.09.21	Draft report with "Skeleton" content	JG/KC	KC/EG	EG	JP
B	22.06.22	Final Draft for Comment	KC	EG	JP	JP
C	27.07.22	Final	KC	JG	JP	JP

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Executive Summary

The Ōtaki to North Levin (Ō2NL) Highway Project comprises the construction of a 24-kilometre length four-lane highway from Ōtaki to north of Levin. The proposed route passes through rural land in the Horowhenua lowlands, between the foothills of the Tararua Range and the sea.

This report provides a summary of the geotechnical investigations and reporting completed to date, presents a description of the geological environment of the project, and outlines (at a high level) the geotechnical design philosophy.

The geotechnical components of the (Ō2NL) Highway Project will designed in accordance with Waka Kotahi, NZ Transport Agency's Bridge Manual (3rd Ed. Amendment 3, October 2018).

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1 Introduction

Stantec has been engaged by the Waka Kotahi NZ Transport Agency (Waka Kotahi) to undertake geotechnical investigations and reporting for the Ōtaki to North Levin Highway Project (the Project).

The intent of this report is to:

- Provide a summary of the geotechnical investigations and reporting completed to date
- Present a description of the geological environment of the Project
- Outline (at a high level) the geotechnical design philosophy
- Provide a geotechnical summary report to support consenting.

2 Geotechnical Investigations

A three-stage geotechnical investigation program has been completed for the Project to date. This includes a desktop study (which compiled existing knowledge) and geotechnical site investigation programs completed in 2020, 2021 and 2022.

The scope for each investigation was developed to enable the development of a project wide geo-model. This subsequently allows initial quantification and mitigation of key geotechnical risks within the early phases of the Project.

The subsurface has been investigated at generally 250 - 400m intervals along entire length of the proposed highway alignment, with a greater density of investigations at significant structural sites. The test pits generally extend only 2-4m below the ground surface, while the boreholes are up to 35m deep, although generally to a depth of about 25m.

In total, the following quantities of investigations have been completed:

- 63 Boreholes
- 86 Test pits
- 36 Cone Penetrometer Tests (CPT's)
- 5 Geophysical Surveys
- Lab testing regime consisting of testing over 260 samples.

3 Geological Environment of Project

3.1 Site Description

The proposed highway alignment is approximately 24km long and extends from North of Ōtaki to North of Levin see Figure 4.1.1 below.

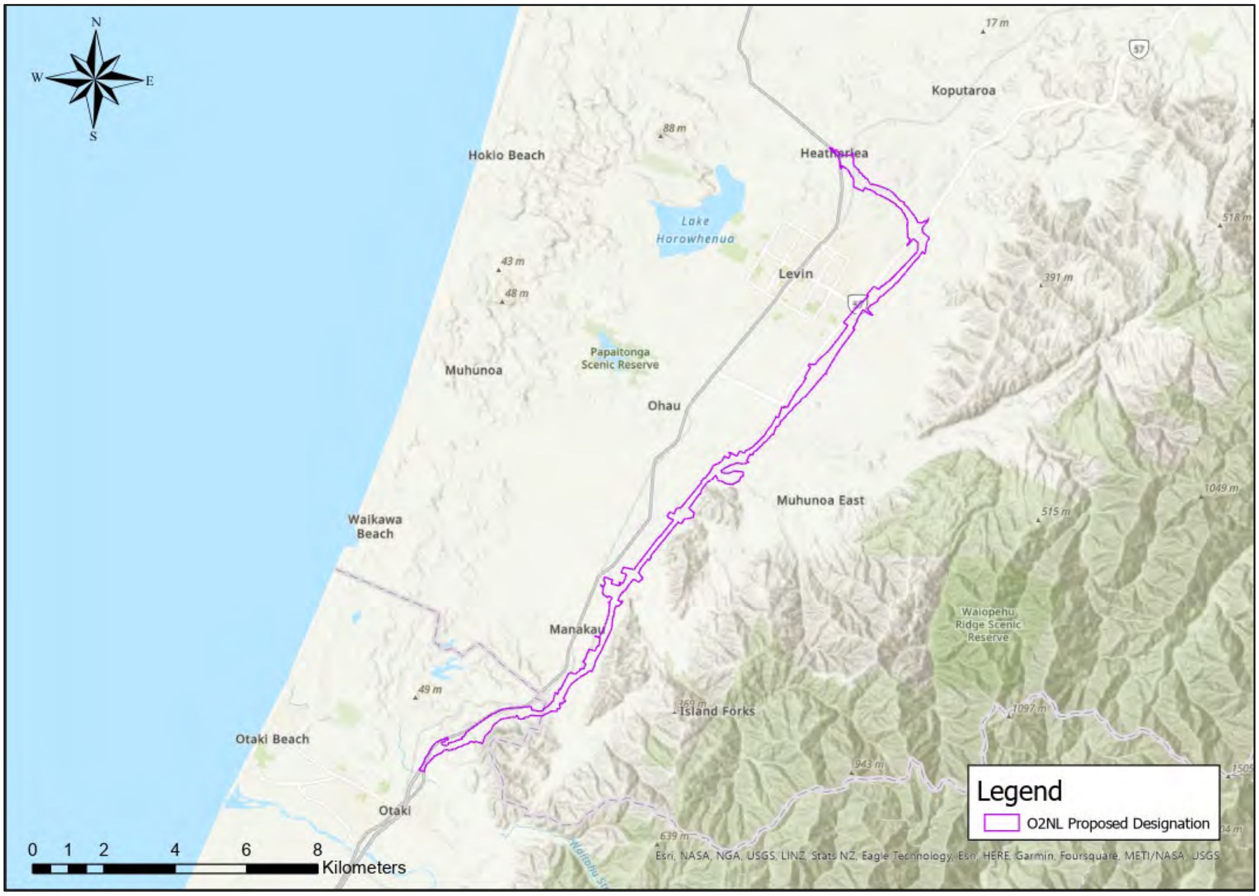

Figure 4.1.1: Site overview

The alignment starts in the north at the proposed State Highway 1 (SH1) intersection approximately 1.5km north of Levin. From here, the corridor extends south-east, passing over the NMIT railway and across land with moderately sloping gullies for approximately 3km to the existing State Highway 57 (SH57).

Then the alignment turns south-west and runs parallel to the existing SH57 over relatively flat farmland plains, crossing McDonald Road, Waihou Rd, Queen Street, Tararua Road and Kimberley Road.

Past SH57 the corridor is positioned to the East of the current SH1 until it terminates at the Waitohu Stream, just north of Ōtaki. This section is the main stretch of the Ō2NL Project corridor, and it is characterised by alluvial plains to the east of the Tararua Ranges. The alignment crosses many streams and rivers through this section, including the Waikawa Stream, Kuku Stream and Ohau River, which have shaped the local topography. Near the southern end, the corridor crosses some large gullies between SH1 and the Tararua Range.

The alignment has been broken into zones based on the Project concept design, geology, topography and a potential construction zoning system. The zones are summarized in Table 4.1.1 below.

Table 4.1.1: Alignment Zone Breakdown

No.	Zone Start	Zone Finish	Ch Start (Approx.)	Ch Finish (Approx.)	Length (m)
1	Northern end (SH1)	Arapaepae / Macdonald (SH57)	10000	13300	3300
2	Arapaepae / McDonald (SH57)	Queen Street	13300	16100	2800
3	Queen Street	Property Boundary	16100	19100	3000
4	Property Boundary	Ohau River	19100	22600	3500
5	Ohau River	North Manakau Road	22600	27100	4500
6	North Manakau Road	Regional Boundary	27100	30900	3800
7	Regional Boundary	Southern End	30900	34900	4000

3.2 Geological Conditions

3.2.1 Geological setting

The Project area is predominately characterised by alluvial deposits transported from the Tararua range during the late Pleistocene and Holocene interglacial periods. A large alluvial basin has been formed, which extends along the middle part of the project area from the eastern plains and towards the coast and has overlain or incised older shoreline and dune sand deposits. The alluvial deposits form localised fans and terraces around the existing and historical waterways, such as the Ohau River and Waikawa River.

Late Pleistocene shoreline deposits consisting of beach and aeolian deposits are exposed to the north and south near Levin and Ōtaki at the surface, as elevated sandy hills capped with loess. Through the middle of the project area these materials are found at depth, underlying the late Pleistocene and Holocene alluvium. Older, middle Pleistocene alluvium has been encountered below the shoreline deposits in some areas.

Wellington Greywacke is the basement rock in the area and is generally expected to be at depths exceeding 40 – 50 m along the alignment. Greywacke was encountered at depths of approximately 20 – 30m near the Ohau River and Tararua Ranges, close to the existing quarry.

3.2.2 Published geology

The published geological map[1] of the area indicates the site is predominately underlain by Quaternary period alluvium and shoreline deposits.

The geological units, as defined by the regional geological map and encountered within the project area are shown in Table 4.1.2.

[1] 1:250,000 Institute of Geological and Nuclear Sciences (INGS) Geology of the Wellington Area, Map 10.

Table 4.1.2: Summary of Geological Units

Regional map Unit Code	Strata Name	Description	Period	Approximate Age (ma)
Q1a	Holocene river deposits	Alluvial gravel, sand, silt, mud, and clay with local peat, includes modern riverbeds.	Quaternary	0 - 0.012
Q2a	Late Pleistocene River deposits	Poorly to moderately sorted gravel with minor sand or silt underlying terraces; minor fan gravels are included.	Quaternary	0.012 - 0.024
Q3a	Late Pleistocene River deposits	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces.	Quaternary	0.024 - 0.059
Q5b	Late Pleistocene shoreline deposits	Beach deposits consisting of marine gravel with sand and dune sand; commonly underlying loess and fan deposits.	Quaternary	0.071 -0.128
Q6a	Middle Pleistocene River deposits	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces.	Quaternary	0.128 - 0.186
Tt	Basement rock (Wellington Greywacke)	Alternating sandstone and mudstone, poorly bedded sandstone with minor coloured mudstone, conglomerate, basalt, chert.	Triassic	142 - 248

3.2.2.1 Project geological model

A geological model for the proposed corridor has been developed based on the interpretation of the regional geology and site investigations at point locations. A geological section along the proposed highway corridor is presented in Appendix A.

The geological units presented within the published geological map have generally been adopted for simplicity and consistency. These units have been further detailed to include Stantec's observations and interpretations and additional subunits have been included to characterise relevant geotechnical properties and project specific requirements.

Project specific geological units have been developed based on the published geology and interpretation of field investigations. A breakdown of the Project geological units is presented in Table 4.1.3 below.

The following sections provide further details to the zone and site-specific geological models.

Table 4.1.3: Project Geological Units

Unit No.	Unit Code	Geological Unit	Sub-unit	Typical Field Description	QMAP Key Name	QMAP Simple Name	QMAP Description	QMAP Age	Typical Extent (Zone)
1	Q1a	Q1a Holocene Alluvium	-	Silty sandy clayey GRAVEL and silty CLAY with organics.	OIS1 (Holocene) river deposits	Q1 Holocene River deposits	Alluvial gravel, sand, silt, mud, and clay with local peat, includes modern riverbeds.	0 - 0.012	2, 4, 5, 6
						Q1 Holocene River deposits	Well sorted floodplain gravels.	0 - 0.014	
2	Q5b*	Loess	-	Silty CLAY stiff to very stiff, moderate to high plasticity.	*Not Present on IGNS QMAP*				1,2, 4, 5, 6, 7
3	Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium	3a. Q2a/Q3a Aggradational Fan Gravel	Clayey GRAVEL with some cobbles, dense to very dense.	OIS2 (Late Pleistocene) river deposits	Q2 Late Pleistocene River deposits	Poorly to moderately sorted gravel with minor sand or silt underlying terraces; includes minor fan gravel.	0.012 - 0.024	3
			3b. Q2a/Q3a Sandy Gravel	Sandy GRAVEL, some silt, dense to very dense.					3, 4
			3c. Q2a/Q3a Undifferentiated Alluvium	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	OIS3 (Late Pleistocene) river deposits	Q3 Late Pleistocene River deposits	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggregational surfaces.	0.024 - 0.059	2, 3, 4, 5, 6, 7
4	Q5b	Q5b Pleistocene Shoreline Deposits	-	Fine to medium SAND, some silt, medium dense to very dense. Density typically increases with depth.	OIS5 (Late Pleistocene) ocean beach deposits	Q5 Late Pleistocene shoreline deposits	Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits.	0.71 -0.128	1, 2, 3, 4, 6, 7
5	Q6a	Q6a Pleistocene Alluvium	-	Interlayered stiff SILT/CLAY, and medium dense to very dense silty GRAVEL and silty SAND.	OIS6 (Middle Pleistocene) river deposits	Q6 Middle Pleistocene River deposits	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggregational surfaces.	0.128 - 0.186	6, 7
6	Tt	Tt Rakaia Terrane Greywacke	-	Highly to slightly weathered, interbedded SILTSTONE & SANDSTONE. Fractured.	Undifferentiated Rakaia terrane Triassic sandstone and mudstone	Basement (Eastern Province) sedimentary rocks	Alternating sandstone and mudstone, poorly bedded sandstone with minor coloured mudstone, conglomerate, basalt, chert.	142 - 248	4 (Ohau River crossing only)

*Loess has been coded as Q5b as it typically overlies Q5b Pleistocene Shoreline Deposits, however it also overlies alluvial units in some areas.

3.2.3 Ground models along alignment (generalised by zone)

The alignment has been divided into seven project design zones illustrated on Figure 4.1.2 below.

This section of the report provides a description and a generalized ground model for each alignment zone based on the results of the geotechnical investigations and published geological maps.

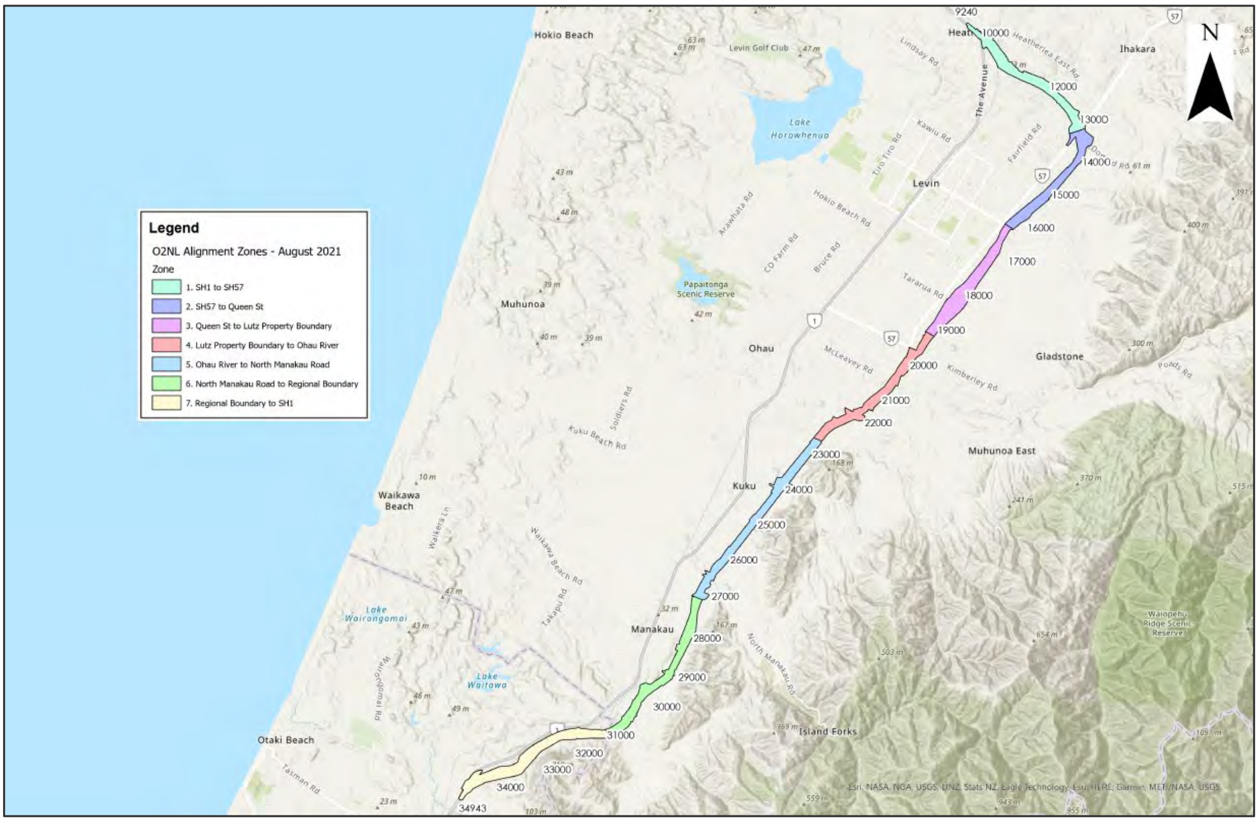

Figure 4.1.2: Alignment by zone

3.2.4 Zone 1 - Northern End to SH57 Intersection (Ch 10000 to 13300)

3.2.4.1 Site description

This zone runs east to west, and the topography is defined by undulating, moderately sloping hills to approximately Ch 12000 where it flattens out. The hills have been incised to form low gullies with minor streams and wetlands.

Natural and existing cut slopes of heights up to 15 m generally perform satisfactorily up to 45 degrees.
The NIMT railway line runs parallel to SH1 near the north of Levin and the area is predominately used as grazing farmland with housing closer to SH1 and the railway.

3.2.4.2 Subsurface conditions and geological interpretation

Based on the published geology, the area is underlain by Q5b Shoreline Deposits consisting of beach and dune sands underlying loess and fan deposits.

The geotechnical site investigations are consistent with the mapped geology and predominately encountered sand materials underlying a fine-grained loess cap. Alluvial deposits were also encountered near existing and historical waterways.

The expected ground conditions for the zone are presented within Table 4.1.4 below.

Table 4.1.4: Zone 1 Expected Ground Conditions

Chainage		Unit Code	Geological Unit	Generalised Material Description	Typical Depth to Top of Layer (m bgl)	Typical Depth to Bottom of Layer (m bgl)	Typical SPT N Range
From	To						
10000	13300	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1 - 3	-
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense. Density typically increases with depth.	1 - 3	20+	10 – 50+

3.2.5 Zone 2 - SH 57 Intersection to Queen Street (Ch 13300 to 16100)

3.2.5.1 Site description

From the Arapaepae State Highway 57 (SH57) intersection the alignment turns southward and runs parallel to the existing highway to Queen Street, crossing several roads. The topography is generally flat, sloping gently from north to south at approximate 1%. The Koputaroa Stream is located to the east of the SH57 intersection flowing down from the Tararua Ranges before turning northwards.

The area is predominately farmland with occasional residential dwellings and lifestyle blocks.

3.2.5.2 Subsurface conditions and geological interpretation

Based on the published geology the area is underlain by Q5b Shoreline Deposits consisting of beach and dune sands underlying loess and fan deposits. The area around the Koputaroa Stream to the north is described as Q1a Holocene River deposits consisting of alluvial gravel, sand, silt, mud and clay with local peat and modern riverbeds. Q2a/Q3a Pleistocene alluvium was also encountered within this area in the site investigations, below the Holocene deposits.

The geotechnical site investigations are consistent with the mapped geology and predominately encountered sand materials underlying a fine-grained loess cap. Alluvial deposits were encountered near the Koputaroa Stream.

The expected ground conditions are summarised within Table 4.1.5 below.

Table 4.1.5: Zone 2 Expected Ground Conditions

Chainage		Unit Code	Geological Unit	Generalised Material Description	Typical Depth to Top of Layer (m bgl)	Typical Depth to Bottom of Layer (m bgl)	Typical SPT N Range
From	**To**						
13300	14000	Q1a	Q1a Holocene River deposits	Silty CLAY stiff to very stiff, moderate to high plasticity.	0	1.5	-
		Q1a	Q1a Holocene River deposits	Sandy clayey GRAVEL, very dense.	1.5	7	40 - 50
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Undifferentiated	Interlayered fine SAND, silty CLAY, and clayey GRAVEL, loose to very dense.	7	12	6 - 42
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense. Density typically increases with depth.	12	20+	50+
14000	16100	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1.5 - 2	-
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, Medium dense to very dense.	1 - 3	20+	30 - 50+

3.2.6 Zone 3 - Queen St to Property Boundary (Ch 16100 to 19100)

3.2.6.1 Site description

From Queen Street the alignment continues south, parallel to the existing SH57, crossing Tararua Road. The topography is generally flat with no significant water bodies. The land is predominately used for farming.

3.2.6.2 Subsurface conditions and geological interpretation

The published geology describes most the area as underlain by Q2a Pleistocene alluvium consisting of poorly to moderately sorted gravel with minor sand or silt underlying terraces; minor fan gravels are included.

The geotechnical site investigations are consistent with the mapped geology and encountered sequences of alluvial deposits consisting of predominantly gravels.

The expected ground conditions along this zone are summarised within Table 4.1.6 below:

Table 4.1.6: Zone 3 Expected Ground Conditions

Chainage		Unit Code	Geological Unit	Generalised Material Description	Typical depth to top of layer (m bgl)	Typical depth to bottom of layer (m bgl)	Typical SPT N range
From	To						
16100	19100	Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Aggradational Fan Gravel	Clayey GRAVEL with some cobbles, dense to very dense.	0	0.5 - 1.5	30 - 50
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Sandy Gravel	Sandy GRAVEL, some silt, dense to very dense.	0.5 - 1.5	5 - 30	50+
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Undifferentiated	Silty GRAVEL, some clay, dense to very dense.	10 - 30+	-	50+
16100	16500	Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense. Density typically increases with depth.	3 - 8	20+	30 - 50+

3.2.7 Zone 4 - Property Boundary to Ohau River (Ch 19100 to 22600)

3.2.7.1 Site description

From the south end of the property boundary the alignment continues south past SH57, towards the Ohau River crossing Kimberley Road, McLeavy Road and Muhunoa East Road.

The topography is generally flat until McLeavy Road where the alignment crosses an elevated dune sand feature before moving into the Ohau River alluvial fan. From the southern side of McLeavy road to Ohau River the topography becomes terraced with hummocks between terraces and the river.

The land in this zone is currently being used as grazing farmland.

3.2.7.2 Subsurface conditions and geological interpretation

Based on the published geology the area between the property boundary and Muhunoa East Road is underlain by Q2a and Q3a Pleistocene alluvium consisting of poorly to moderately sorted gravel with minor sand or silt underlying terraces; minor fan gravel is included. The elevated hill feature on McLeavy Road is described as Q5b Shoreline Deposits consisting of beach and dune sands underlying loess and fan deposits.

From Muhunoa East Road to the Ohau River the geology is described as Q1a Holocene River deposits consisting of well sorted floodplain gravels.

The geotechnical site investigations are consistent with the mapped geology.

The expected ground conditions along this zone are summarised within Table 4.1.7 below.

Table 4.1.7: Zone 4 Expected Ground Conditions

Chainage		Unit Code	Geological Unit	Generalised Material Description	Typical Depth to top of Layer (m bgl)	Typical Depth to Bottom of Layer (m bgl)	Typical SPT N Range
From	To						
19100	20400	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1.5 - 2	-
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Sandy Gravel	Sandy GRAVEL some silt, dense to very dense.	0.5 - 1.5	5 - 30+	50+
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Undifferentiated	Silty GRAVEL, some clay, dense to very dense.	1.5- 30+	-	50+
20400	21000	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1.5 - 3	-
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense.	0 - 3	20+	30 – 50+
21000	21200	Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Sandy Gravel	Sandy GRAVEL some silt, dense to very dense.	0 - 3	3	-
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense.	3	4+	-
21200	22600	Q1a	Q1a Holocene Alluvium	Silty clayey GRAVEL, with cobbles, medium dense to very dense.	0	4 - 10	15 - 50
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Undifferentiated	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	4 - 10	24 - 27	0 - 50

3.2.8 Zone 5 - Ohau River to North Manakau Road (Ch 22600 to 27100)

3.2.8.1 Site description

From the Ohau River the alignment continues south-southwest adjacent to SH1 to North Manakau Road, crossing the Kuku and Waikawa Streams. Between the Ohau River and Waikawa, the alignment runs close to the Otarere and Poroporo Ridge and the rivers have formed incised valleys between the ranges.

The ground topography slopes gently to the west from the eastern hills but is generally flat within the proposed alignment corridor. There are minor terraces around the Kuku Stream banks. Steeply sloped terraces up to 10m high define the historical flood plain on the northern and southern sides of the Waikawa Stream, at CH26100 and CH26500, respectively.

Currently the land is used as grazing farmland and crop horticulture except for the aggregate and crushed rock quarry at the Ohau river.

3.2.8.2 Subsurface conditions and geological interpretation

The published geology indicates Q1a Holocene River deposits consisting of well sorted floodplain gravels from the Ohau River to Kuku East Road, and around the Waikawa stream. Between these areas and south of the Waikawa Stream the geology is described as Q2a Pleistocene alluvium consisting of poorly to moderately sorted gravel with minor sand or silt underlying terraces; minor fan gravel is included.

The findings of the geotechnical site investigations are generally consistent with the mapped geology. A surficial loess layer also overlies much of the zone.

The expected ground conditions are summarised within Table 4.1.8 below.

Table 4.1.8: Zone 5 Expected Ground Conditions

Chainage		Geo Code	Geo Unit	Generalised Material Description	Typical depth to top of layer (m bgl)	Typical Depth to Bottom of Layer (m bgl)	Typical SPT N Range
From	To						
22600	23900	Q1a	Q1a Holocene Alluvium	Silty clayey GRAVEL, with cobbles, loose to very dense.	0	5 - 12	10 - 50+
		Q2a/Q3a	Q2a/Q3a Late Pleistocene River deposits - Undifferentiated	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	5 - 12	20+	0 - 50+
23900	27100	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1.5 - 2	-
		Q2a/Q3a	Q2a/Q3 Late Pleistocene River deposits - Undifferentiated	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	1.5 - 2	20+	0 - 50+
26100	26550	Q1a	Q1a Holocene Alluvium	Silty clayey GRAVEL, with cobbles, loose to very dense.	0	5 - 6	10 - 50+
		Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Undifferentiated	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	4 - 10	30+	0 - 50+

3.2.9 Zone 6 – North Manakau Road to the Regional Boundary (Ch 27100 to 30900)

3.2.9.1 Site description

From North Manakau Road the alignment continues south, south-southwest adjacent to SH1, close to the Manakau township and down to the Wellington regional boundary.

The topography slopes gentle from east to west and numerous shallow streams are observed, which flow down from the ranges towards the sea. Man-made drains which intercept the stream flows are also present locally.

The Waiauti Stream, located near South Manakau Road, flows southeast to northwest, and has formed a small basin between the hills to the south and a raised ridge near Mountain View Drive.

3.2.9.2 Subsurface conditions and geological interpretation

The published geology indicates that most of the area, including the elevated terrace near Mountain View Drive is underlain by Q2a and Q3a Pleistocene alluvium consisting of poorly to moderately sorted gravel with minor sand or silt underlying terraces; minor fan gravels are included. Around the Waiauti Stream, between the regional boundary and Hanawera Ridge Road, Q1a Holocene River deposits are encountered, consisting of well sorted floodplain gravels.

The findings of the geotechnical site investigations are generally consistent with the mapped geology. A surficial loess material is present in most of the zone. Q5b Pleistocene shoreline deposits and older Q6a Pleistocene alluvium were also encountered in depth, below the Q2a and Q3a Pleistocene alluvium.

The expected ground conditions along the zone are summarised within Table 4.1.9 below.

Table 4.1.9: Zone 6 Expected Ground Conditions

Chainage		Unit Code	Geological Unit	Generalised Material Description	Typical Depth to Top of Layer (m bgl)	Typical Depth to Bottom of Layer (m bgl)	Typical SPT N Range
From	To						
27100	29400	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1.5 - 2	-
29400	30600	Q1a	Q1a Holocene Alluvium	Silty sandy GRAVEL and silty CLAY with organics.	0	1.5 - 3	2 - 50+
27100	30600	Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium - Undifferentiated	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	1.5 - 2	18 - 22	10 - 50+
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense.	12 - 22	18 - 26	10 – 50+
		Q6a	Q6a Pleistocene Alluvium	Interlayered stiff SILT/CLAY, and medium dense to very dense silty GRAVEL and silty SAND.	18 - 26	35+	15 - 50+
30600	30900	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1 - 3	4
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, Medium dense to very dense.	1 - 3	20+	10 – 50+

3.2.10 Zone 7 – Regional Boundary to SH 1 (Ch 30900 to 34500)

3.2.10.1 Site description

From the regional boundary the alignment continues southwest until it ties-in to the new SH1 alignment near the Waitohu Stream, north of Ōtaki.

The topography is defined by undulating terrain with moderately sloping hills extending down from the ranges to the east which have been historically incised by rivers to form steep gullies.

From Ch 34000 to the end, the alignment is on a flat terrace which extends to the northern edge of the Waitohu Stream.

3.2.10.2 Subsurface conditions and geological interpretation

Based on the published geology Q5b Pleistocene shoreline deposits and Q2a Pleistocene alluvium are encountered along this zone.

The findings of the geotechnical site investigations are consistent with the mapped geology. The Q5b unit was encountered on the terraces with a loess capping layer, while Q2a/Q3a alluvium is infilling the gullies. Older Q6a Pleistocene alluvium was also encountered in depth, near the southern end of the zone, below the Q5b deposits.

The expected ground conditions are summarised within Table 4.1.10 below.

Table 4.1.10: Zone 7 Expected Ground Conditions (Name)

Chainage		Geo Code	Geo Unit	Generalised Material Description	Typical Depth to Top of Layer (m bgl)	Typical Depth to Bottom of Layer (m bgl)	Typical SPT N range
From	To						
30900	34500	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1 - 3	6 - 11
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, loose to very dense.	1 - 3	20+	5 – 50+
34000	34500	Q5b	Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1 - 3	3
		Q2/Q3a	Q2/Q3a Pleistocene Alluvium - Undifferentiated	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	3	8	50+
		Q5b	Q5b Pleistocene Shoreline Deposits	Fine to medium SAND, some silt, medium dense to very dense.	2- 8	26	10 – 50+
		Q6a	Q6a Pleistocene Alluvium	Interlayered stiff SILT/CLAY, and medium dense to very dense silty GRAVEL and silty SAND.	26	30+	20 - 50+

3.3 Groundwater

Hydrogeological, geotechnical, and ecological field investigations undertaken between May 2020 and March 2022 provided information that has greatly increased the understanding of groundwater beneath and immediately adjacent to the Project. Fifty-six (56) monitoring bores were installed beneath and adjacent to the Project, to gain a better understanding of depths to groundwater, groundwater level variations with depth, maximum high groundwater levels and dominant sources of groundwater recharge.

Groundwater levels vary along the route (0.5m to 25m bgl) and fluctuate seasonally. This hydrogeological knowledge is summarized within Technical Assessment G (Hydrogeology and Groundwater) found in Volume IV[2]. A groundwater level interpretation is provided upon the geological section presented in Appendix 4.1.1.

4 Geotechnical Design Philosophy

4.1 General

The geotechnical aspects of the project will be designed in accordance with Waka Kotahi, NZ Transport Agency's Bridge Manual (3rd Ed. Amendment 3, October 2018). This includes the assessment of seismic ground deformation (liquefaction and lateral spreading), and the design of foundations, embankments, cuttings and retaining structures. The design will ensure the seismic resilience and adequate performance of the Expressway under earthquake loading.

4.2 Seismicity

The Ōtaki to Levin area is situated within a region of high seismicity related to the ongoing movement of the Pacific Plate subducting under the Australian Plate beneath the lower North Island. Minor earthquakes show a pattern of increasing depth of earthquake source heading westwards, which relates to the deepening of the Pacific Plate as it subducts westwards.

Table 4.1.11 and Figure 4.1.3 presents the active faults in the vicinity of the project and summarizes their characteristics, based mainly on work carried out by IGNS and supplemented by recent publications[3,4]. No active faults are mapped passing directly through the project corridor; however, it is possible that off-shoots of these major faults are present. The most significant active fault in the project area is the Northern Ohariu Fault, which trends northeast-southwest exiting the Tararua Ranges near the Ohau River east of Levin and trends south traversing the foothills and the coast. Several other northeast-southwest trending active faults could also impact the area as they are all capable of producing damaging earthquakes.

A site-specific probabilistic seismic hazard analysis for Ōtaki to North Levin (Ō2NL) Transport Corridor has been completed which provides recommendations of seismic parameters for design use, taking into account the seismic risk induced to the Project by the regional seismicity outlined above as a minimum.

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[2] Otaki to North Levin Highway – Hydrogeology and Groundwater Investigation, Stantec, July 2022
[3] Stirling, M.; McVerry, G.; Gerstenberger, M.; Litchfield, N.; Van Dissen, R.; Berryman K.; Barnes, P.;Wallace, L.; Villamor, P.; Langridge, R.; Lamarche, G.; Nodder, S.; Reyners, M.; Bradley, B.; Rhoades, D.; Smith, W.; Nicol, A.; Pettinga, J.; Clark, K. and Jacobs, K (2012). National Seismic Hazard Model for New Zealand: 2010 Update. Bulletin of the Seismological Society of America, Vol. 102, No. 4, pp. 1514-1542, August 2012.
[4] Van Dissen, R., Abbott E., Zinke R., Ninis, D., Dolan, J.F., Little T.A., Rhodes E.J., Litchfield N.J., Hatem A.E. (2020). Slip rate variations on major strike-slip faults in central New Zealand and potential impacts on hazard estimation. NZSEE 2020 Annual Conference

Table 4.1.11: Active Faults in the Wellington Area

Fault Name	Approximate Distance to Corridor	Fault Sense / Type	Average Recurrence Interval (years)	Estimated Characteristic Magnitude Mw	Slip Rate	Estimated Single Event Displacement (m)
Northern Ohariu Fault	1.6km East	Dextral strike-slip	2550	7.4	Moderate	3.8
Poroutawhao Fault	2.2km West	Reverse	5110	6.8	Low	1.5
Central Ohariu Fault	1km Southeast	Dextral strike-slip	2040	7.2	Moderate	3.1
Ōtaki Forks Fault	12.2km east	Dextral strike-slip	6770	7.5	Low	4.7
Wellington Fault	19.5km East	Dextral strike-slip	880	7.5	High	5
Wairarapa	40km East	Dextral strike-slip	1200	8.2	Very high	11

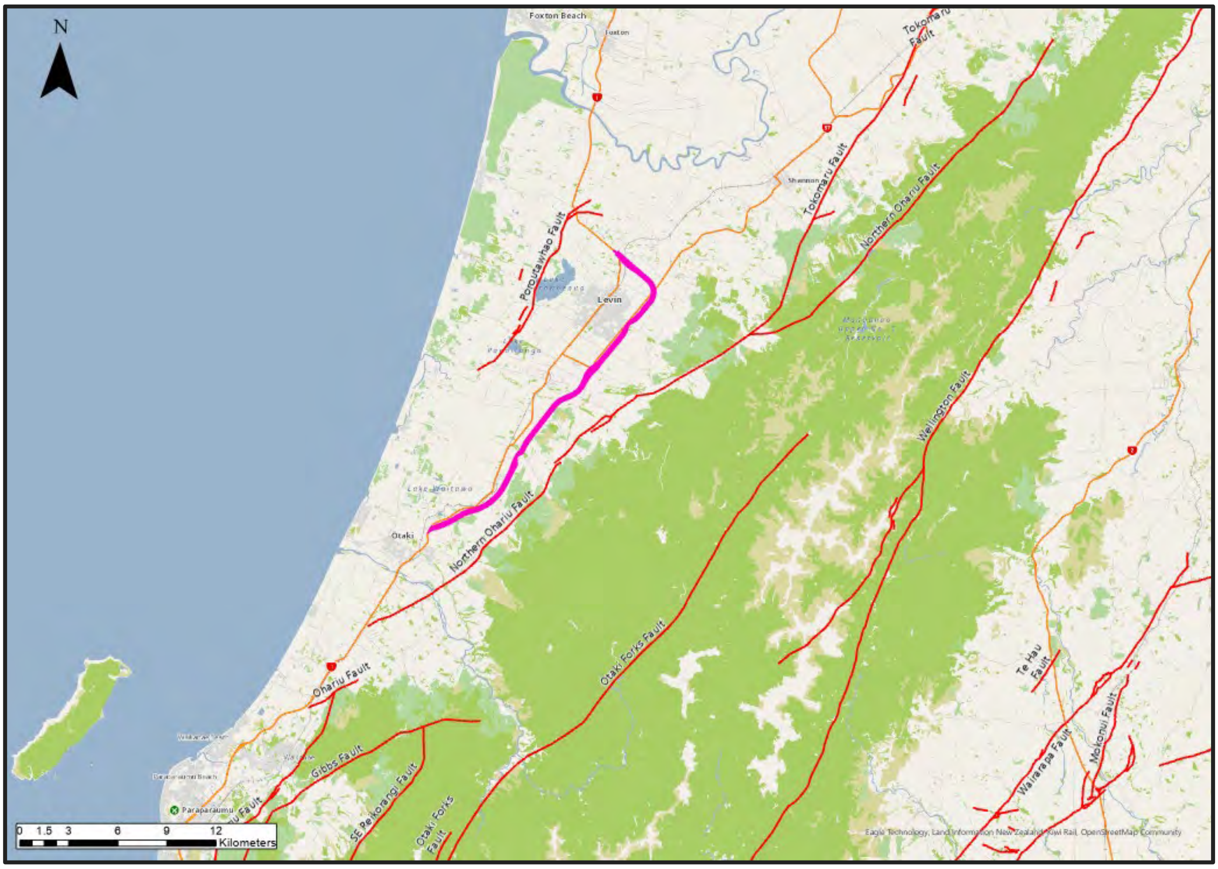


Figure 4.1.3: Active Fault Map

4.3 Topsoil Stripping and Undercutting

Geotechnical investigations suggest topsoil thickness is typically 0.2 – 0.3m along the route. It is expected that topsoil will be stripped and stockpiled, and then respread and vegetated at the completion of the works.

Generally, once the topsoil has been stripped, the underlying surface will be suitable for road embankment or pavement construction. Localized areas, especially areas in the vicinity of major structures may require additional undercutting of unsuitable material.

4.4 Cut Slope Design

Preliminary cut slope angles (for design modelling purposes) have been recommended considering the following:

- A study of the existing performance of currently existing cut and natural slopes within the area,
- The tabulated geological models of each zone (in which the route was sectionalized per similar subsurface material and terrain)
- Preliminary and generic slope stability modelling (where investigations are present), assuming seismic deformation within acceptable limits specified by the Bridge Manual.

Recommended cut slope angles for preliminary design modelling are shown in Table 4.1.12.

Table 4.1.12: Preliminary Cut Slope Angles for Design Modelling Purposes

Section No.	CH Start	CH Finish	Cut Slope
1	10000	13300	2.5H:1V
2	13300	16100	2.5H:1V
3	16100	19100	2.0H:1V
4	19100	22600	2.0H:1V
5	22600	27100	2.5H:1V
6	27100	30900	2.5H:1V
7	30900	34900	2.5H:1V

In reality, final cut slope design will consist of a combination of two angles with an inflection point at the surficial material contact. This surficial (typically 0.5 to 4.0m bgl) material is present along the route and is typically cohesive in nature and will likely require cutting to a shallower angle.

Additional targeted site investigation, cut slope stability assessment and detailed cut design is expected to occur during detailed design. This is particularly relevant where large cuts are proposed.

4.5 Embankment Slope Design

Generally, embankment fill slopes of 1V:3H have been assigned throughout the project.

Fill slope angles are likely be refined during detailed design once embankment fill material properties are further understood. Geogrids could be potentially utilized if required to achieve the performance targets set out by the Bridge Manual. Fill slopes could be steepened with the use of additional geogrid and Reinforced Soil Structures (RSS) face retaining options, if required from space restrictions or other factors.

Mechanically Stabilized Earth (MSE) walls will be utilized as an alternative to fill slopes, especially around bridges and other major structures where space is confined.

4.6 Material Re-use

Where feasible, the intent is to re-use the material excavated from cuttings as fill within embankments. However, fill material is required to have certain geotechnical properties and this restricts the re-use potential of some excavated materials. A preliminary assessment of the reusability of the expected material along the highway route has been undertaken.

4.7 Material Supply (Borrow) and Spoil Sites

4.7.1 Material Supply (Borrow) Sites

Material Supply (Borrow) sites are required to source fill material for the construction of embankments required for the project. Borrow sites typically consist of:

- Cuttings along the route (potentially widened to gain additional material).
- Dedicated Material Supply (Borrow) sites within the corridor designation.
- Material from existing commercial sources.

Fill material and engineered aggregates can also be sourced from existing and new commercial quarry sites.

Ideally, Material Supply (Borrow) sites are located evenly along the route with haul distances minimized and mass haul balances maintained. However, borrow materials are required to have certain geotechnical properties and therefore options are restrained based on geological conditions.

A Material Supply (Borrow) study was undertaken between October 2021 and June 2022 and documented within Appendix 4.5, attached to the Design and Construction Report (provided as Appendix Four to Volume II).

A simplified summary of the process is presented below:

1. Quantification of borrow material requirements (volume take-off and re-use evaluation concluded there was a shortfall of material available from cuttings along the route and dedicated Material Supply (Borrow) sites were required).
2. Identification of potential Material Supply (Borrow) sites.
3. Evaluation of longlist and development of shortlist (the process involved input from Iwi partners and technical experts using a range of criteria).
4. Initial Geotechnical Assessment (predominantly Stage 3 investigations, with material supply site documentation captured within Technical Memorandums appended to the Material Supply Study report).
5. Four Material Supply (borrow) sites to be advanced for consenting (as presented within Table 4.1.13).

Table 4.1.13: Summary of Material Supply (Borrow) Sites

Site ID	Site Name and Approx. Chainage	Material Type	Geotechnically Summarised Within
#15	South of Waikawa Stream (Ch. 26800)	Alluvial Gravels	Material Supply (Borrow) Sites located at the South/North of Waikawa Stream and the Northeast of Ōhau River Memorandum
#19	North (west) of Waikawa Stream & North (east) of Waikawa Stream (Ch. 26100)	Alluvial Gravels	Material Supply (Borrow) Sites located at the South/North of Waikawa Stream and the Northeast of Ōhau River Memorandum
#36	North (west) of Ohau River (Ch. 22400)	Alluvial Gravels	Material Supply (Borrow) Sites located at the South/North of Waikawa Stream and the Northeast of Ōhau River Memorandum
#34a	Koputaroa (Ch. 11900)	Shoreline Deposits (Sands)	Q5b Shoreline Deposits (Sands) Memorandum*

* Memorandum not specific to Site #34a

The final extents of the four Material Supply (Borrow) Site are presented on the drawings provided with Volume III.

4.7.2 Spoil sites

Spoil sites are required to dispose of cut material which have unsuitable properties to reuse as embankment fill. Due to the anticipated ground conditions, it is expected that this will be a significant volume and therefore numerous spoil sites located evenly along the route are proposed.

A Spoil Site Selection study was undertaken between October 2021 and June 2022 and documented within Appendix 4.4, attached to the Design and Construction Report (provided as Appendix Four to Volume II).

A simplified summary of the process is presented below:

1. Quantification of the likely spoil volumes expected
2. Identification of potential long list of spoils sites based on the following general criteria:
    a. Proximity to the alignment and within the future road designation as possible.
    b. Easy access
    c. Good spread along the alignment and especially at the areas where spoil sites are expected to be mostly needed.
    d. Opportunities for landscaping interventions without impact to the natural environment (i.e., landscaping road embankments within the road reserve or unused land within intersections).
    e. Opportunities provided by geomorphological features (e.g., natural terraces) to level off or provide more usable land to farms or adjacent properties.
    f. No effect on environmental, archaeological, cultural, or other constraints, as known from the design team at this stage.
3. Evaluation of longlist and development of shortlist (the process involved input from Iwi partners and technical experts)
4. Over one hundred spoil sites have been advanced for consenting.

The final extents of the Spoil Sites are presented on the drawings provided with Volume III.

4.8 Liquefaction

Liquefaction potential varies along the route. To date, assessment has been focused on significant structure sites, as this is where seismically induced ground deformation has the potential to have the largest consequence. At other locations, like under road embankments, it is typical to accept some deformation risk, but mitigate where the liquefaction susceptibility/consequence is particularly high, and mitigation is financially feasible. The time expected to restore the desired level of service to the route post event is typically taken into account for this decision to be made.

A preliminary liquefaction triggering assessment has been completed and free field settlements have been predicted. This assessment enables decisions on whether ground improvements are required to limit deformations and achieve the Bridge Manual performance requirements. This preliminary liquefaction triggering assessment is documented within Stantec's Geotechnical Interpretative Report, with Table 4.1.14 presenting a selection of the results.

Table 4.1.14: Preliminary Liquefaction Triggering Assessment Outputs

No	Name	Relevant SI	V_{s30} (m/s)	LPI	Free Field Settlements (cm)	Liquefiable area
1	SH1 Crossing near Taylors	BH201	372	12	16	8.3 m - 14.3 m
		BH101	310	30	21	2.3 m - 12.8 m
		CPT101	288	10	5	7.8 m - 10.5 m
		CPT201	312	1	0	2.6 m - 2.8 m
		CPT202	333	36	13	2.0 m - 2.5 m & 3.3 m - 10.5 m
2	Waiauti Stream Bridge South	BH206	357	6	10	11.3 m - 14.3 m
		BH207	383	4	4	5.3 m - 7.5 m
		CPT211	355	2	1	8.5 m - 9.5 m & 12.5 m - 13.7 m
		CPT212	299	3	1	9.5 m - 11.8 m
3	Waiauti Stream Bridge North	BH105	398	4	5	8.3 m - 11.3 m
		BH208	416	3	5	11.3 m - 14.3 m
		CPT213	390	0	0	n/a
4	Honi Taipua	BH106	337	18	17	5.3 m - 6.8 m & 8.3 m - 14.3 m
		BH107	256	11	9	5.3 m - 8.3 m
		BH224	315	0	0	n/a
		CPT103	284	4	1	2.65 m - 4.3 m
		CPT214	254	6	1	12.0 m - 15.0 m
		CPT215	247	5	0	12.8 m - 15.0 m
5	North Manakau Road	BH109	340	1	2	9.8 m - 11.3 m
		BH210	402	0	0	n/a
		CPT104	293	1	0	n/a
		CPT217	508	0	0	n/a
6	Waikawa Stream Bridge	BH111	401	1	2	12.8 m - 14.3 m
		BH211	393	7	7	6.8 m - 8.3 m & 12.8 m 14.3 m
		BH212	414	1	3	14.3 m - 15.8 m
		CPT218	384	6	1	n/a
		CPT219	373	2	0	n/a
		CPT219A	481	3	1	2.78 m - 3.0 m
7	Kuku East Road Bridge	BH112	349	7	10	5.6 m - 6.8 m & 9.8 m - 11.3 m & 14.3 m - 15.0 m
		BH213	298	18	18	5.3 m - 6.8 m & 9.8 m - 15.0 m
		MASW 2	#N/A	#N/A	#N/A	
		ERT 1	#N/A	#N/A	#N/A	
8	Kuku Stream Bridge	BH214	310	7	12	9.8 m - 14.3 m
		CPT221.1	297	2	1	9.8 m - 10.8 m
9	Ohau River bridge	BH113	337	2	3	14.3 m - 15.0 m
		BH216	378	12	17	5.3 m - 9.8 m & 14.3 m - 15.0 m
		BH217	#N/A	#N/A	#N/A	n/a
		MASW 7	#N/A	#N/A	#N/A	
		ERT 5	#N/A	#N/A	#N/A	
10	Muhunoa East Road Bridge	BH115	353	4	3	8.3 m -9.8 m
		BH218	373	0	0	n/a
		CPT105	422	3	1	1.75 m - 2.05 m
		CPT224	427	1	0	0.95 m - 1.1 m
11	Tararua Interchange	BH118	454	1	3	11.3 m - 12.8 m
		BH220	417	0	0	n/a
12	Queen Street East	BH119	369	4	7	11.3 m -12.8 m & 14.3 m - 15.0 m
		BH222	409	4	7	9.8 m - 11.3 m
		CPT225	546	2	0	n/a
13	Rail Bridge	BH123	353	0	0	n/a
		BH124	391	1	2	n/a
		CPT108	336	20	7	2.3 m - 7.45 m
		CPT231	440	6	2	4.3 m - 6.8 m

5 Significant Structures Foundations

Significant structure sites are bridges, structural interchanges and overpasses which are expected to have significant construction costs. These are delineated from other major structures such as box underpasses and culverts.

Due the scale and importance of the structure sites, the subsurface conditions have been investigated, geological ground models compiled, and preliminary liquefaction triggering assessment completed. This has informed the preliminary foundation solution at each site, and ground improvement recommendation (if deemed required). These are shown on Table 4.1.15.

Additional investigation will be required prior to detailed design and foundation solutions may evolve based on an increased understanding of subsurface conditions.

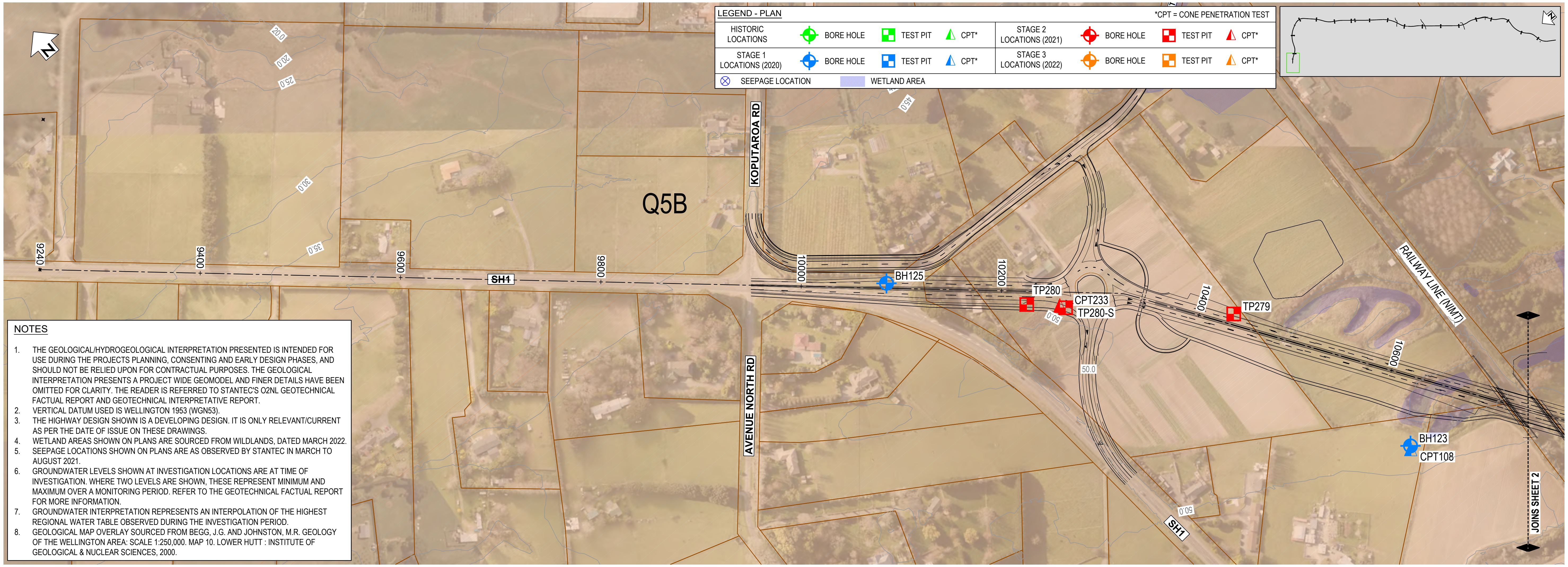
Table 4.1.15: Significant Structures Preliminary Foundation Solutions and Ground Improvements Recommendations

Significant Structure Name	Chainage (approx.)	Preliminary Foundation Solution	Preliminary Ground Improvement Recommendation
SH1 Crossing near Taylors	34300	MSE bank seat abutments	Surficial (0 - 2m) ground improvements Allowance has been made for a grid of deep vibratory compaction ground improvement to 12m bgl (100m long under embankment).
Waiauti Stream Bridge South	30350	MSE bank seat abutments	Surficial (0 - 2m) ground improvements.
Waiauti Stream Bridge North	30200	MSE bank seat abutments	Surficial (0 - 2m) ground improvements.
Honi Taipua	28900	MSE bank seat abutments	Surficial (0 - 2m) ground improvements.
North Manakau Road	27100	MSE bank seat abutments	Surficial (0 - 2m) ground improvements.
Waikawa Stream Bridge	26500	Piled Foundations (to ~10m bgl)	No ground improvements expected to be required, however intent is marginal subsurface conditions on the southern bank are removed when excavation of the proposed vertical Expressway alignment.
Kuku East Road Bridge	24000	MSE bank seat abutments	Surficial (0 - 2m) ground improvements. Allowance has been made for a grid of stone columns ground improvement to 15m bgl (each side).
Kuku Stream Bridge	23750	MSE bank seat abutments	Allowance has been made for a grid of stone columns ground improvement to 15m bgl (each side).
Ohau River bridge	22600	Piled foundation, keyed into rock at ~27m bgl. MSE bank seat abutments	Allowance has been made for a grid of stone columns ground improvement to 15m bgl (each side).
Muhunoa East Road Bridge	21500	MSE bank seat abutments	Surficial (0 - 2m) ground improvements.
Tararua Interchange	18200	MSE bank seat abutments	Not required.
Queen Street East	16100	MSE bank seat abutments OR Piles	Surficial (0 -2m) Ground improvements.
Rail Bridge	10700	MSE bank seat abutments	Surficial (0 - 2m) ground improvements

Appendices

We design with community in mind

Appendix 4.1.1 Geological Model Drawings



NOTES

1. THE GEOLOGICAL/HYDROGEOLOGICAL INTERPRETATION PRESENTED IS INTENDED FOR USE DURING THE PROJECTS PLANNING, CONSENTING AND EARLY DESIGN PHASES, AND SHOULD NOT BE RELIED UPON FOR CONTRACTUAL PURPOSES. THE GEOLOGICAL INTERPRETATION PRESENTS A PROJECT WIDE GEOMODEL AND FINER DETAILS HAVE BEEN OMITTED FOR CLARITY. THE READER IS REFERRED TO STANTEC'S O2NL GEOTECHNICAL FACTUAL REPORT AND GEOTECHNICAL INTERPRETATIVE REPORT.
2. VERTICAL DATUM USED IS WELLINGTON 1953 (WGN53).
3. THE HIGHWAY DESIGN SHOWN IS A DEVELOPING DESIGN. IT IS ONLY RELEVANT/CURRENT AS PER THE DATE OF ISSUE ON THESE DRAWINGS.
4. WETLAND AREAS SHOWN ON PLANS ARE SOURCED FROM WILDLANDS, DATED MARCH 2022.
5. SEEPAGE LOCATIONS SHOWN ON PLANS ARE AS OBSERVED BY STANTEC IN MARCH TO AUGUST 2021.
6. GROUNDWATER LEVELS SHOWN AT INVESTIGATION LOCATIONS ARE AT TIME OF INVESTIGATION. WHERE TWO LEVELS ARE SHOWN, THESE REPRESENT MINIMUM AND MAXIMUM OVER A MONITORING PERIOD. REFER TO THE GEOTECHNICAL FACTUAL REPORT FOR MORE INFORMATION.
7. GROUNDWATER INTERPRETATION REPRESENTS AN INTERPOLATION OF THE HIGHEST REGIONAL WATER TABLE OBSERVED DURING THE INVESTIGATION PERIOD.
8. GEOLOGICAL MAP OVERLAY SOURCED FROM BEGG, J.G. AND JOHNSTON, M.R. GEOLOGY OF THE WELLINGTON AREA: SCALE 1:250,000. MAP 10. LOWER HUTT : INSTITUTE OF GEOLOGICAL & NUCLEAR SCIENCES, 2000.

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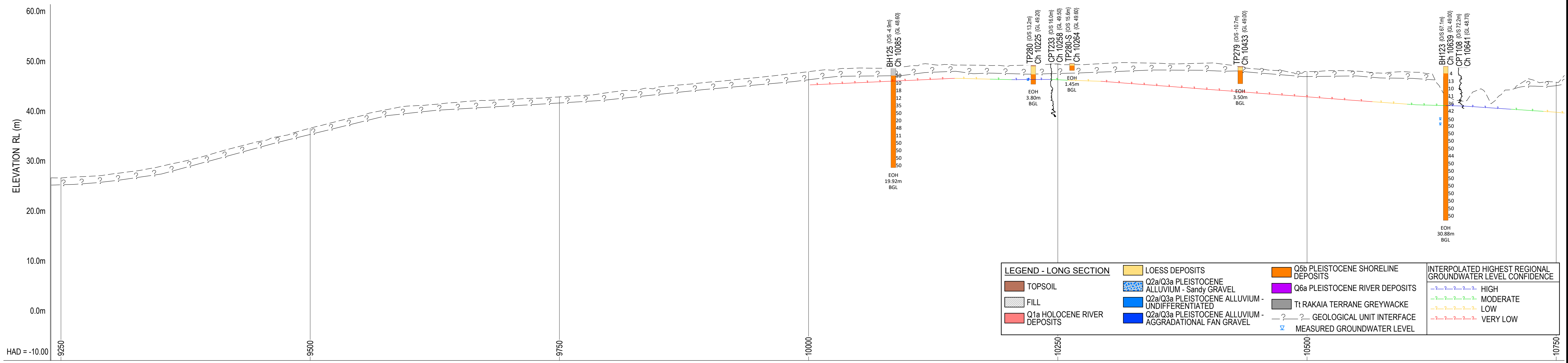

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NOTES

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APPROVED	Ken Clapcott	29.04.22
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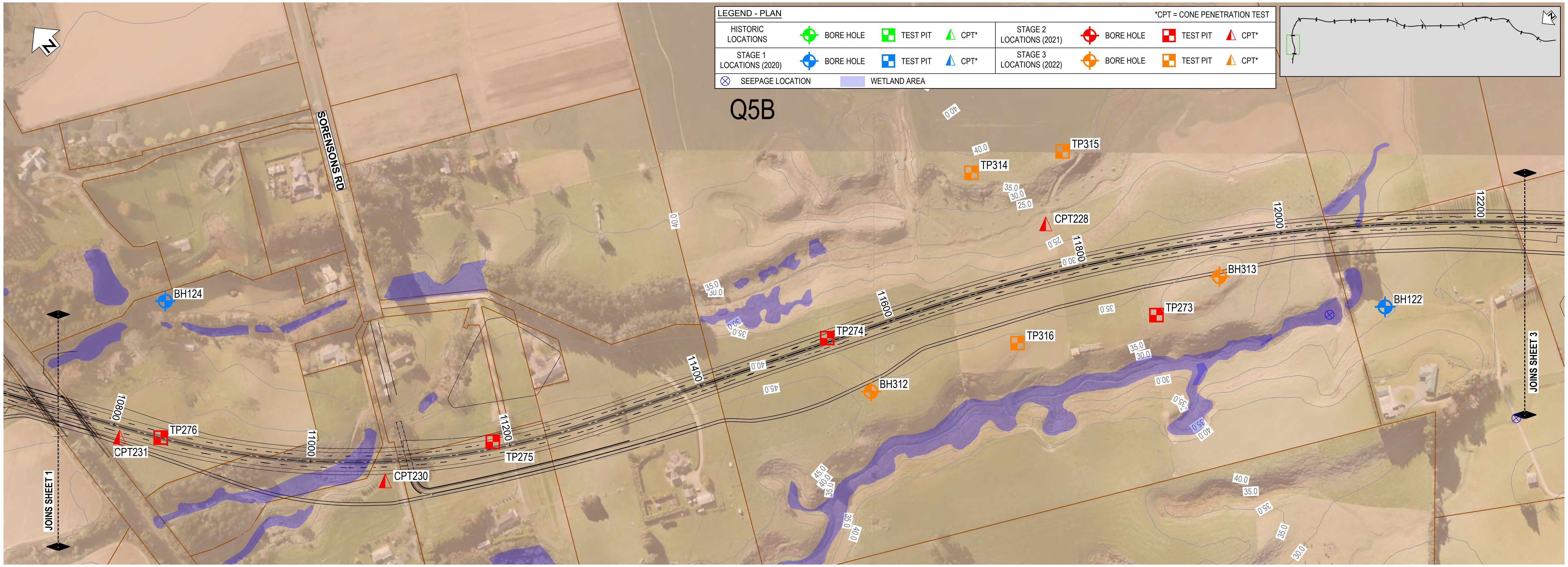

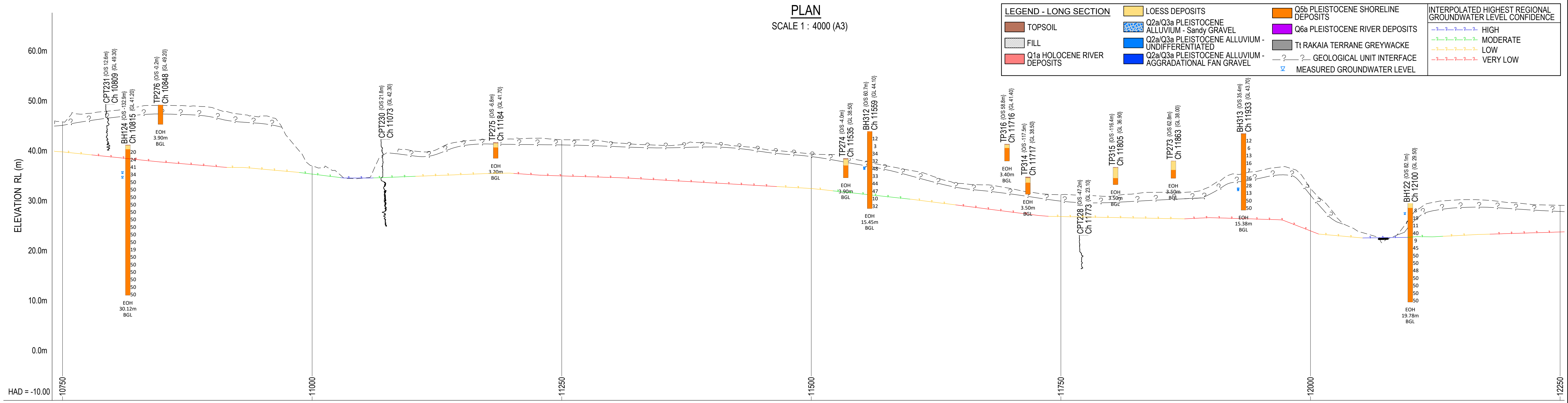

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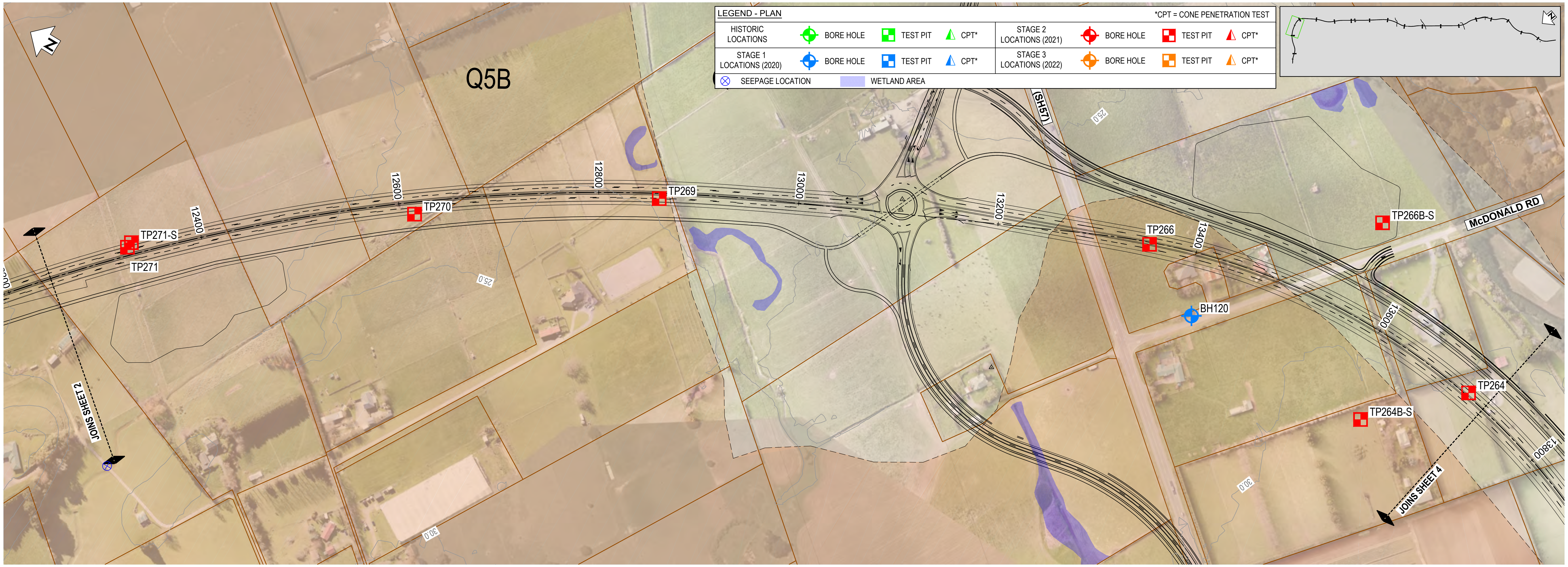

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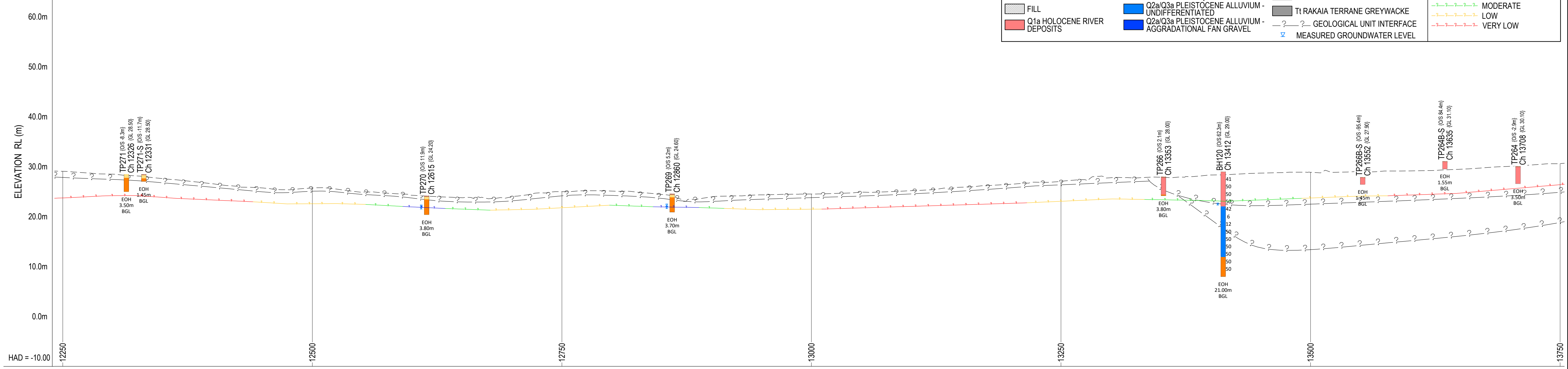
LEGEND - LONG SECTION

TOPSOIL	LOESS DEPOSITS
FILL	Q2a/Q3a PLEISTOCENE ALLUVIUM - Sandy GRAVEL
Q1a HOLOCENE RIVER DEPOSITS	Q2a/Q3a PLEISTOCENE ALLUVIUM - UNDIFFERENTIATED
	Q2a/Q3a PLEISTOCENE ALLUVIUM - AGGRADATIONAL FAN GRAVEL
Q5b PLEISTOCENE SHORELINE DEPOSITS	
Q6a PLEISTOCENE RIVER DEPOSITS	
Tt RAKAIA TERRANE GREYWACKE	
GEOLOGICAL UNIT INTERFACE	
MEASURED GROUNDWATER LEVEL	

INTERPOLATED HIGHEST REGIONAL GROUNDWATER LEVEL CONFIDENCE
- HIGH
- MODERATE
- LOW
- VERY LOW



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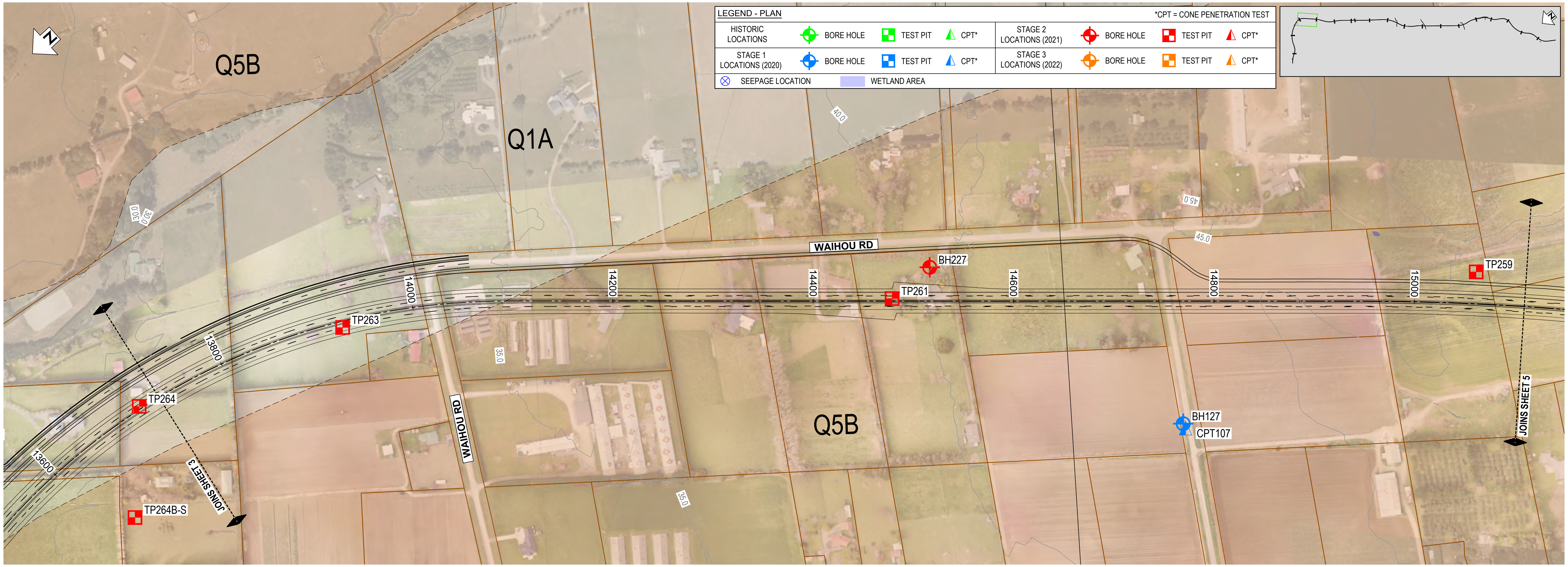

PLAN

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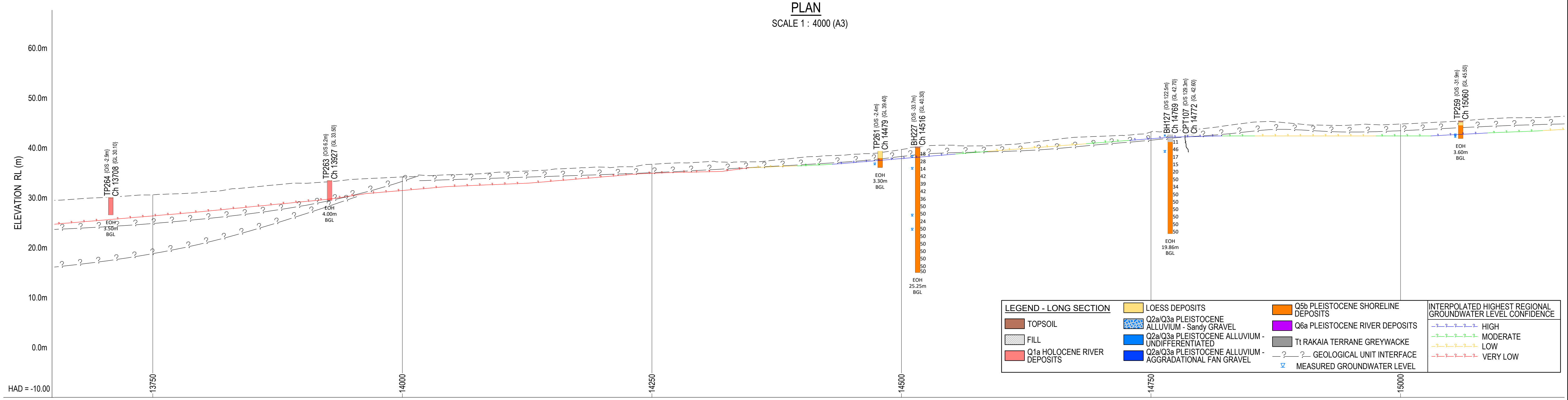

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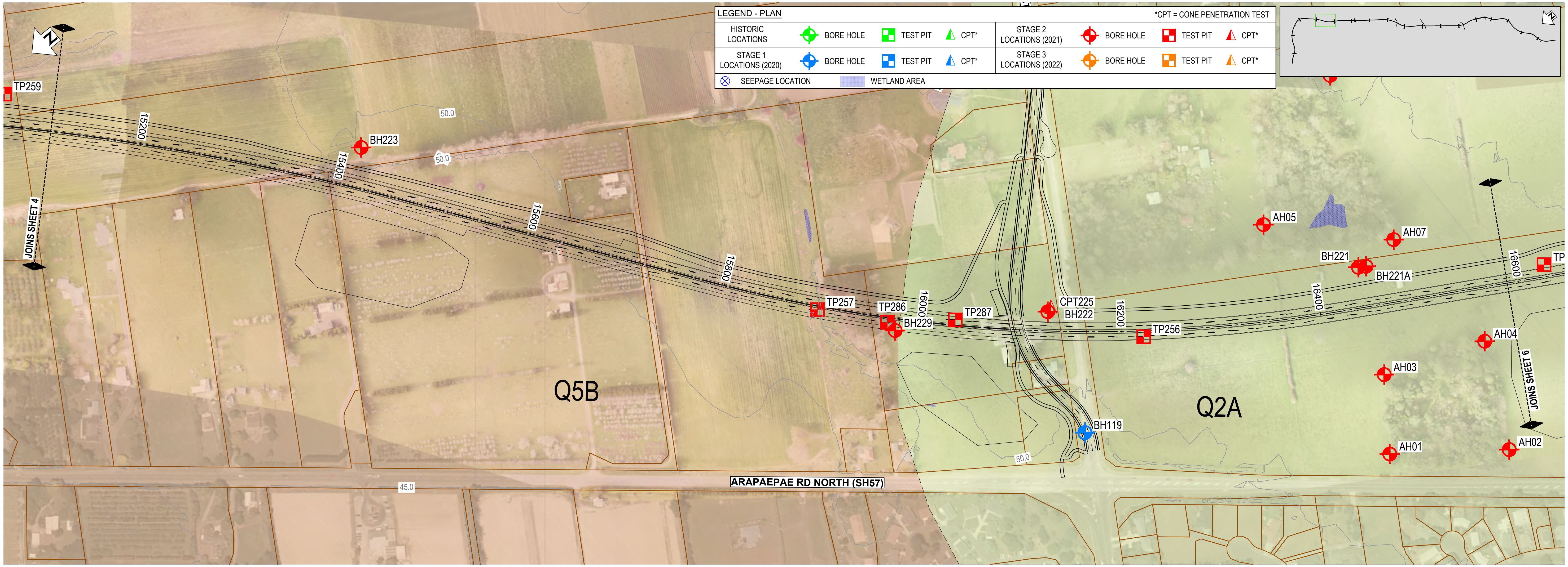
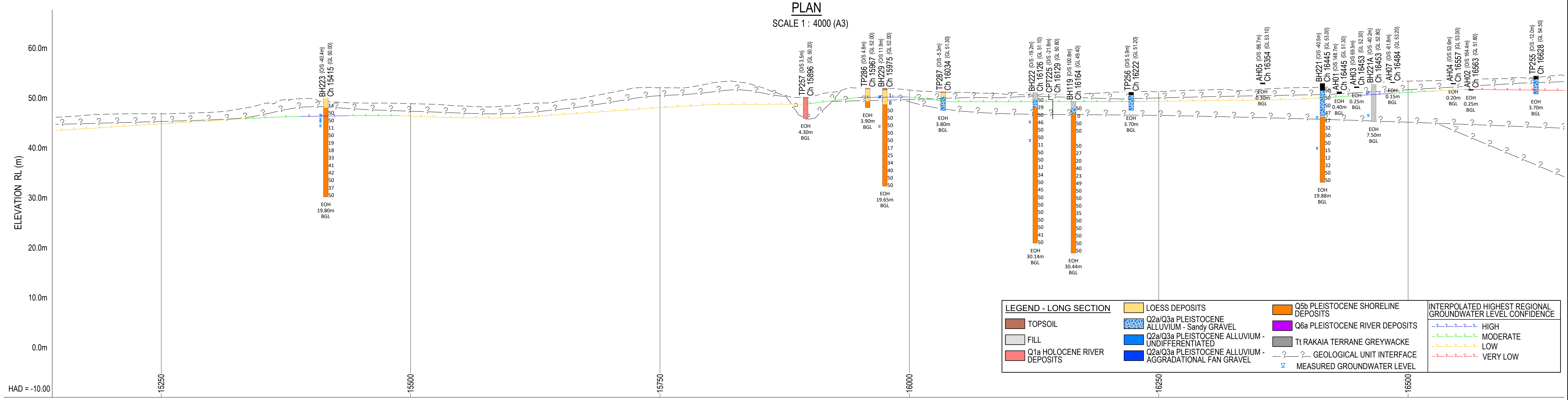


PLAN

SCALE 1 : 4000 (A3)



SCALE 1:4000 (A3)

SCALE 1:800 (A3)

NOTES
1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
C	INCLUDES STAGE 3 (2022) INVESTIGATIONS AND GROUNDWATER INTERPRETATION	SS	EG	KC	29.04.22
B	ISSUED IN CONJUNCTION WITH GEOTECHNICAL INTERPRETIVE REPORT REVISION C	SS	EG	KC	16.12.21
A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
DESIGNED	Jayden Gesche	09.07.21
DRAWN	Steve Sutton	09.07.21
CAD REVIEW	Steve Sutton	16.08.21
DESIGN CHECK	Jayden Gesche	09.07.21
DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 5

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1004
Rev.: D

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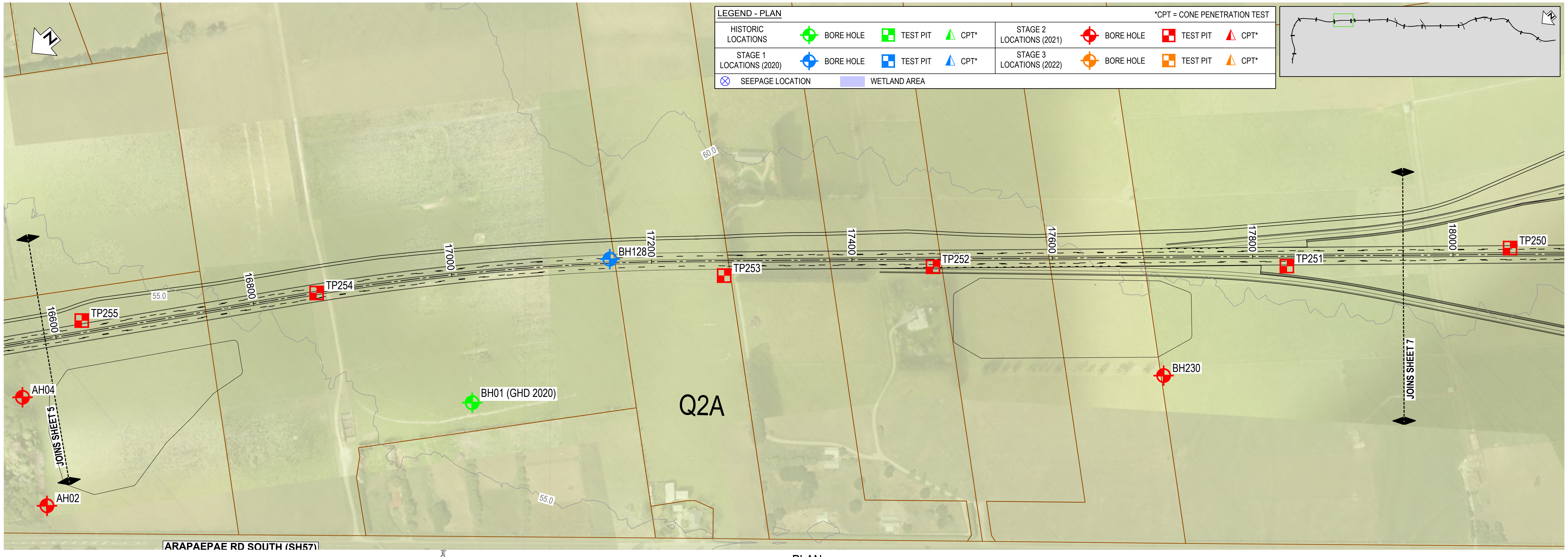
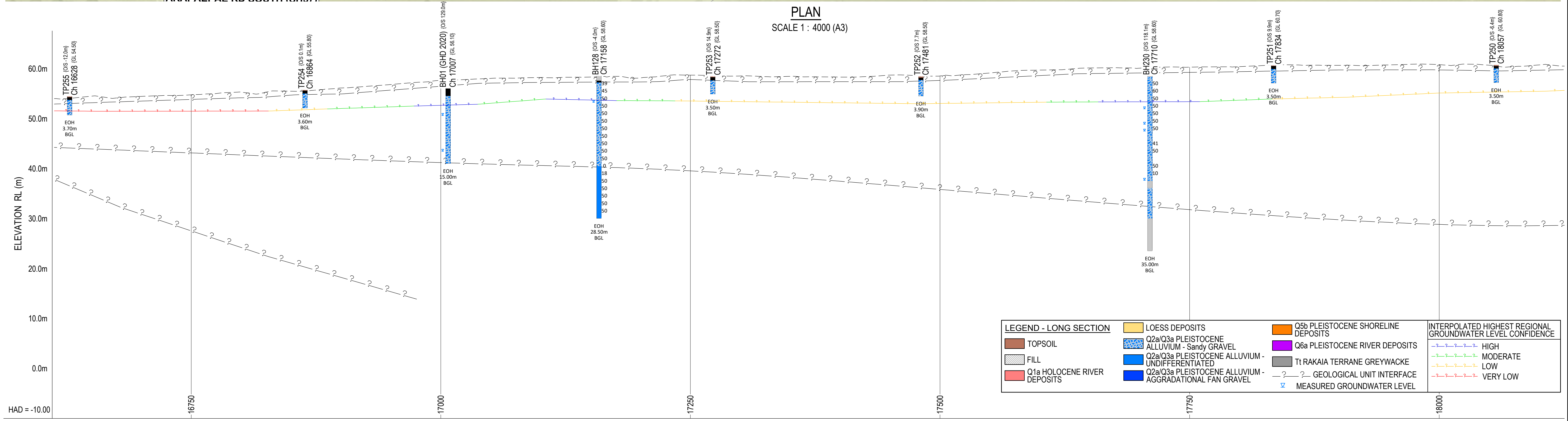


PLAN

SCALE 1 : 4000 (A3)



SCALE 1:4000 (A3) — 50, 0, 50, 100m

SCALE 1:800 (A3) — 10, 0, 10, 20m

NOTES
1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
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LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
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B	ISSUED IN CONJUNCTION WITH GEOTECHNICAL INTERPRETIVE REPORT REVISION C	SS	EG	KC	16.12.21
A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
DESIGNED	Jayden Gesche	09.07.21
DRAWN	Steve Sutton	09.07.21
CAD REVIEW	Steve Sutton	16.08.21
DESIGN CHECK	Jayden Gesche	09.07.21
DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 6

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1005
Rev.: D

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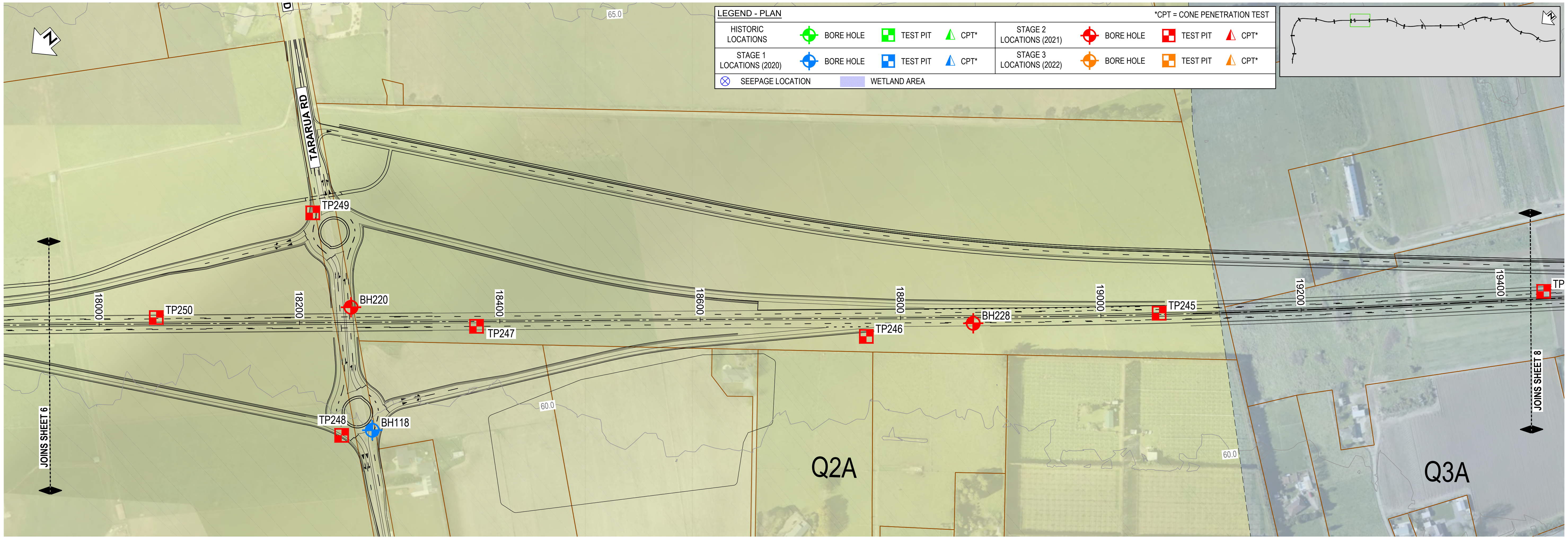
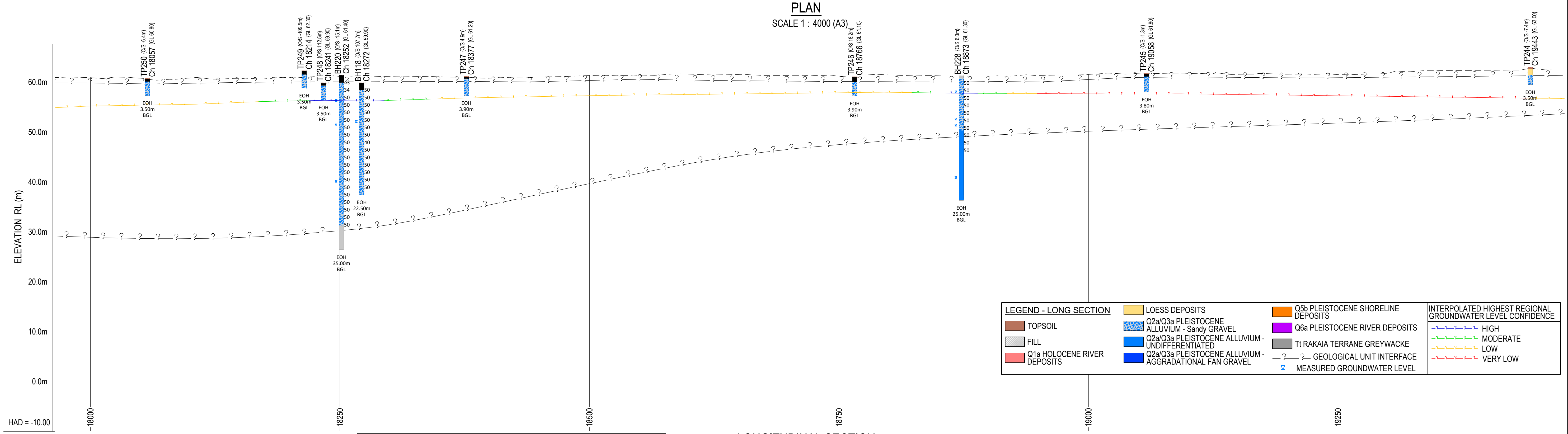


PLAN

SCALE 1 : 4000 (A3)



SCALE 1:4000 (A3) — 50 0 50 100m

SCALE 1:800 (A3) — 10 0 10 20m

NOTES
1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
C	INCLUDES STAGE 3 (2022) INVESTIGATIONS AND GROUNDWATER INTERPRETATION	SS	EG	KC	29.04.22
B	ISSUED IN CONJUNCTION WITH GEOTECHNICAL INTERPRETIVE REPORT REVISION C	SS	EG	KC	16.12.21
A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
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DRAWN	Steve Sutton	09.07.21
CAD REVIEW	Steve Sutton	16.08.21
DESIGN CHECK	Jayden Gesche	09.07.21
DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

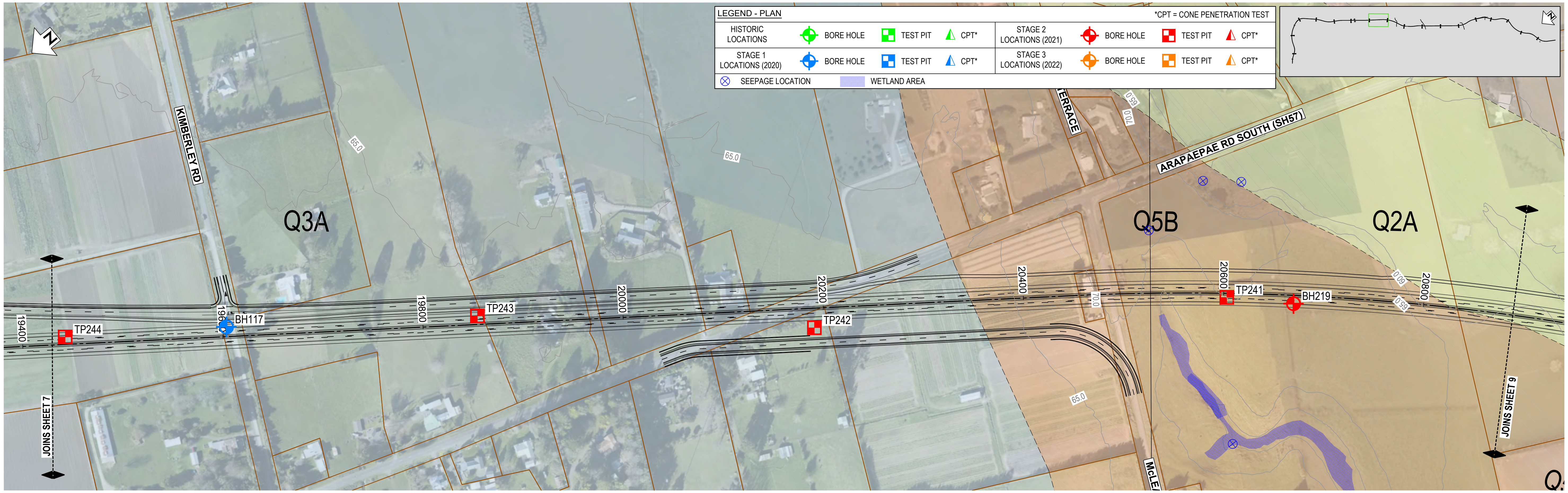
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 7

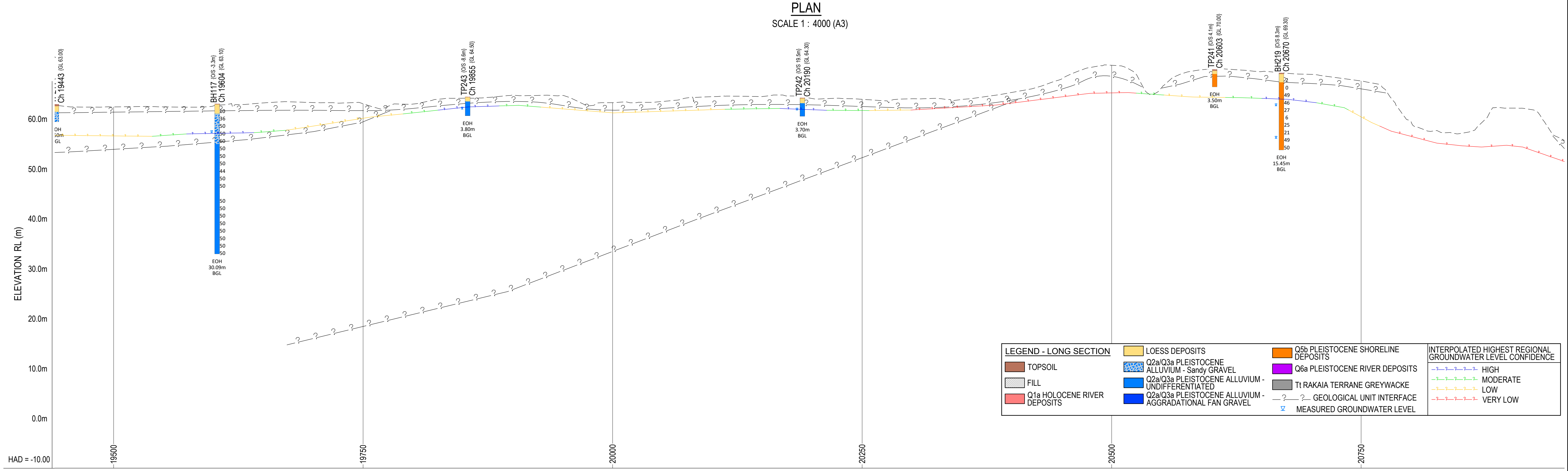
Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1006
Rev.: D

pw:\\stantec-ap-pw.bentley.com:stantec-ap-pw-01\Documents\New Zealand Clients\NZTA (New Zealand Transport Agency)\310203848 - Otaki to North of Levin DBC\01 - O2NL\200 - Geotech\310203848-01-200-C1006



PLAN

SCALE 1 : 4000 (A3)



SCALE 1:4000 (A3)

SCALE 1:800 (A3)

NOTES

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LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
C	INCLUDES STAGE 3 (2022) INVESTIGATIONS AND GROUNDWATER INTERPRETATION	SS	EG	KC	29.04.22
B	ISSUED IN CONJUNCTION WITH GEOTECHNICAL INTERPRETIVE REPORT REVISION C	SS	EG	KC	16.12.21
A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
DESIGNED	Jayden Gesche	09.07.21
DRAWN	Steve Sutton	09.07.21
CAD REVIEW	Steve Sutton	16.08.21
DESIGN CHECK	Jayden Gesche	09.07.21
DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 8

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1007
Rev.: D

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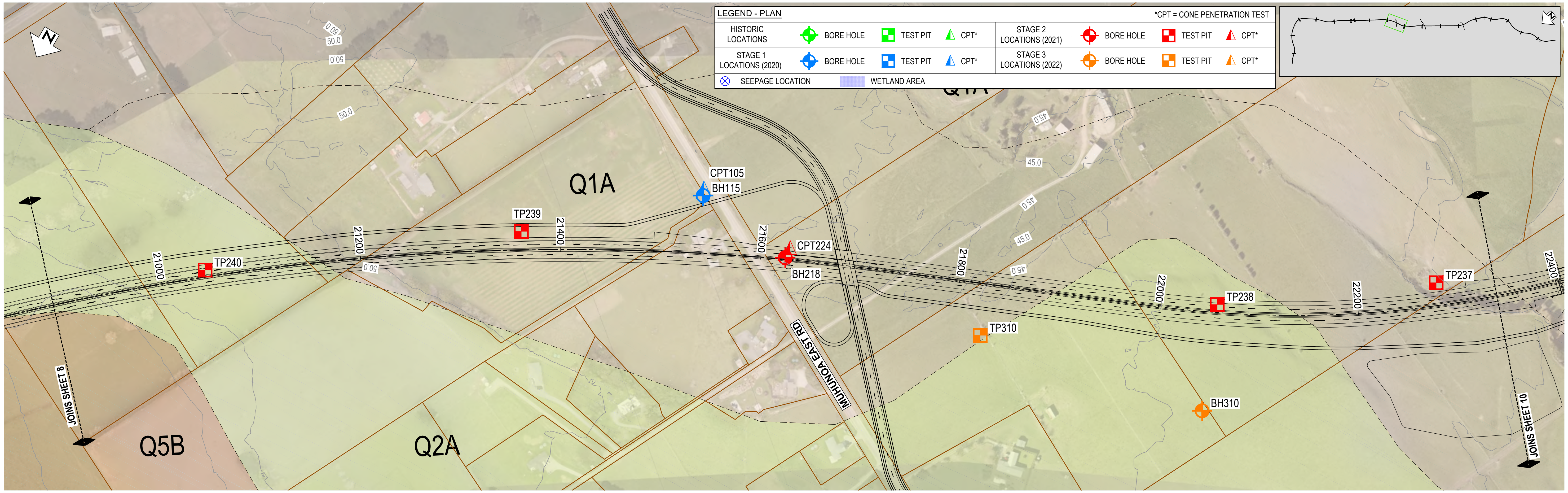
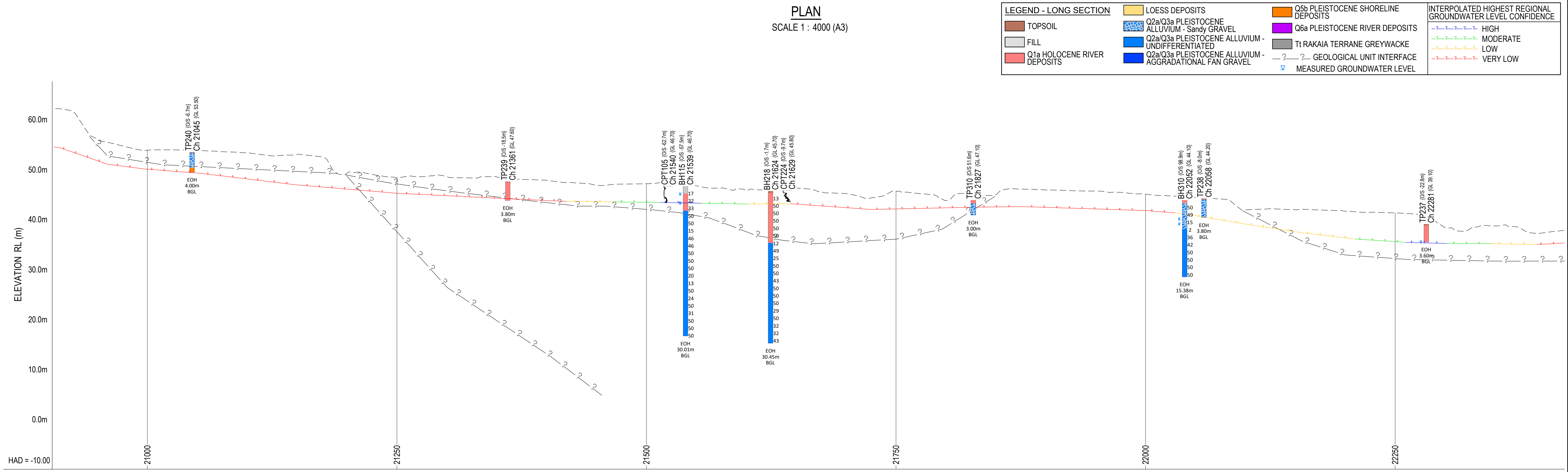


PLAN

SCALE 1 : 4000 (A3)



SCALE 1:4000 (A3) SCALE 1:800 (A3)

NOTES

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2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
C	INCLUDES STAGE 3 (2022) INVESTIGATIONS AND GROUNDWATER INTERPRETATION	SS	EG	KC	29.04.22
B	ISSUED IN CONJUNCTION WITH GEOTECHNICAL INTERPRETIVE REPORT REVISION C	SS	EG	KC	16.12.21
A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
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CAD REVIEW	Steve Sutton	16.08.21
DESIGN CHECK	Jayden Gesche	09.07.21
DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 9

Status Stamp: **WORKING PLOT**

Date Stamp: **16.08.21**

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1008

Rev.: D

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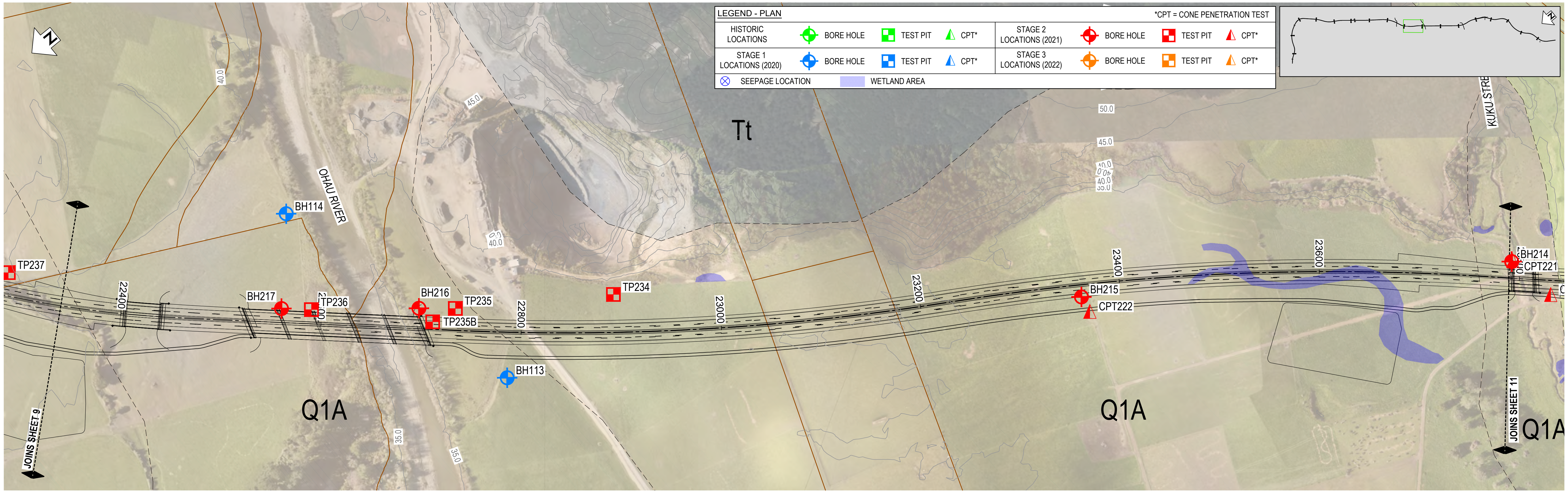
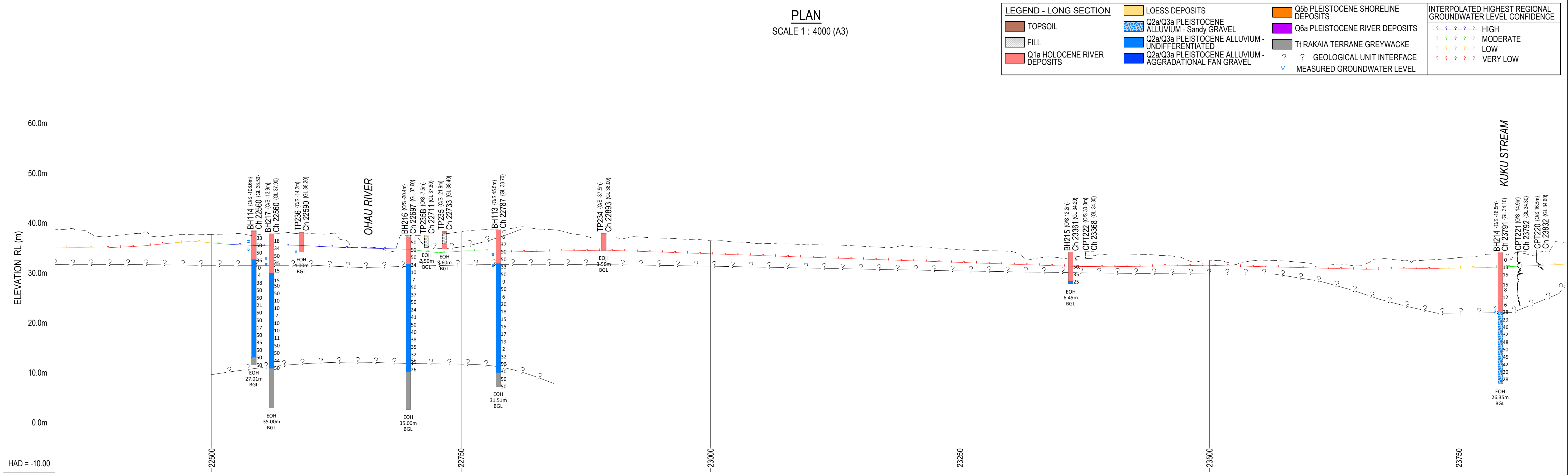


PLAN

SCALE 1 : 4000 (A3)



LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

SCALE 1:4000 (A3)

SCALE 1:800 (A3)

NOTES
1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
C	INCLUDES STAGE 3 (2022) INVESTIGATIONS AND GROUNDWATER INTERPRETATION	SS	EG	KC	29.04.22
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DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 10

Status Stamp: WORKING PLOT

Date Stamp: 16.08.21

Scales: AS SHOWN

Drawing No. 310203848-01-200-C1009

Rev. D

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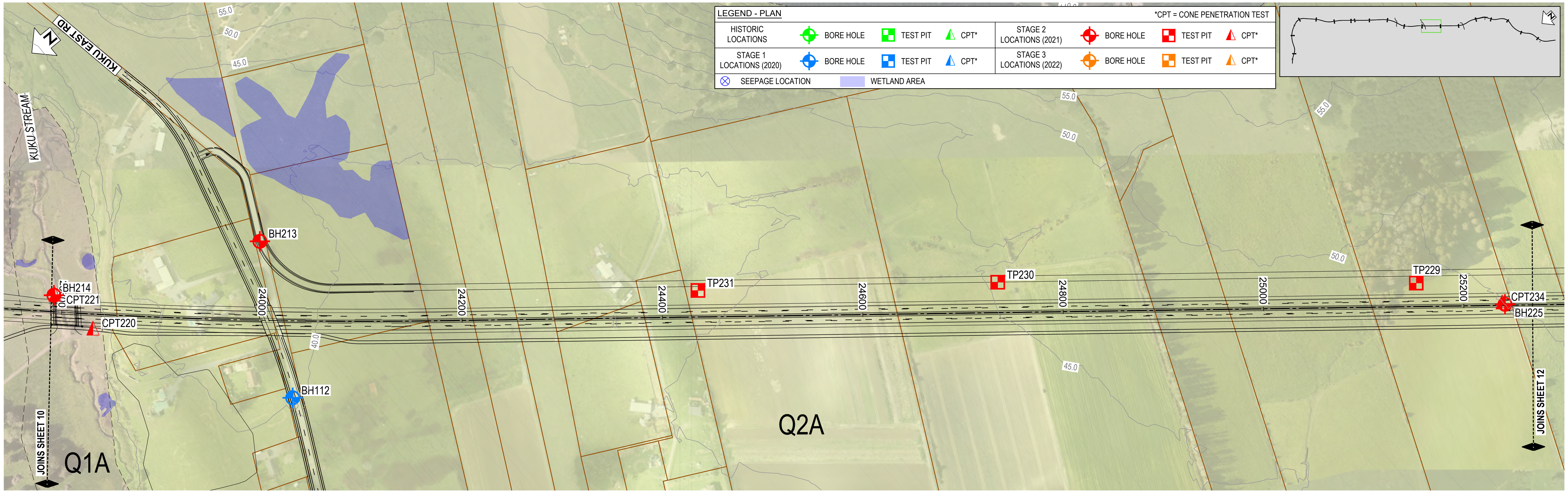
LEGEND - PLAN							*CPT = CONE PENETRATION TEST
HISTORIC LOCATIONS	BORE HOLE	TEST PIT	CPT*	STAGE 2 LOCATIONS (2021)	BORE HOLE	TEST PIT	CPT*
STAGE 1 LOCATIONS (2020)	BORE HOLE	TEST PIT	CPT*	STAGE 3 LOCATIONS (2022)	BORE HOLE	TEST PIT	CPT*
SEEPAGE LOCATION	WETLAND AREA						



PLAN
SCALE 1 : 4000 (A3)

LEGEND - LONG SECTION			INTERPOLATED HIGHEST REGIONAL GROUNDWATER LEVEL CONFIDENCE
TOPSOIL	LOESS DEPOSITS	Q5b PLEISTOCENE SHORELINE DEPOSITS	HIGH
FILL	Q2a/Q3a PLEISTOCENE ALLUVIUM - Sandy GRAVEL	Q6a PLEISTOCENE RIVER DEPOSITS	MODERATE
Q1a HOLOCENE RIVER DEPOSITS	Q2a/Q3a PLEISTOCENE ALLUVIUM - UNDIFFERENTIATED	Tt RAKAIA TERRANE GREYWACKE	LOW
	Q2a/Q3a PLEISTOCENE ALLUVIUM - AGGRADATIONAL FAN GRAVEL	GEOLOGICAL UNIT INTERFACE	VERY LOW
		MEASURED GROUNDWATER LEVEL	

SCALE 1:4000 (A3)

SCALE 1:800 (A3)

NOTES
1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

LONGITUDINAL SECTION
SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
C	INCLUDES STAGE 3 (2022) INVESTIGATIONS AND GROUNDWATER INTERPRETATION	SS	EG	KC	29.04.22
B	ISSUED IN CONJUNCTION WITH GEOTECHNICAL INTERPRETIVE REPORT REVISION C	SS	EG	KC	16.12.21
A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
DESIGNED	Jayden Gesche	09.07.21
DRAWN	Steve Sutton	09.07.21
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DESIGN CHECK	Jayden Gesche	09.07.21
DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

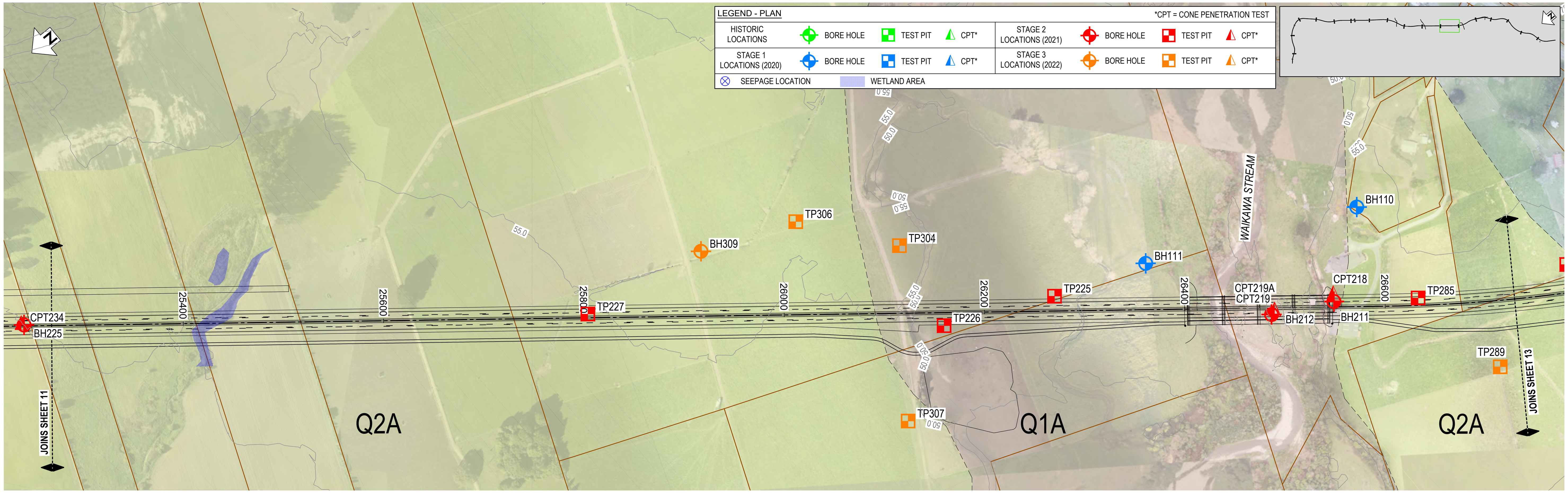
Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 11

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1010
Rev.: D



LEGEND - PLAN *CPT = CONE PENETRATION TEST

HISTORIC LOCATIONS	BORE HOLE	TEST PIT	CPT*	STAGE 2 LOCATIONS (2021)	BORE HOLE	TEST PIT	CPT*
STAGE 1 LOCATIONS (2020)	BORE HOLE	TEST PIT	CPT*	STAGE 3 LOCATIONS (2022)	BORE HOLE	TEST PIT	CPT*
SEEPAGE LOCATION	WETLAND AREA						

PLAN

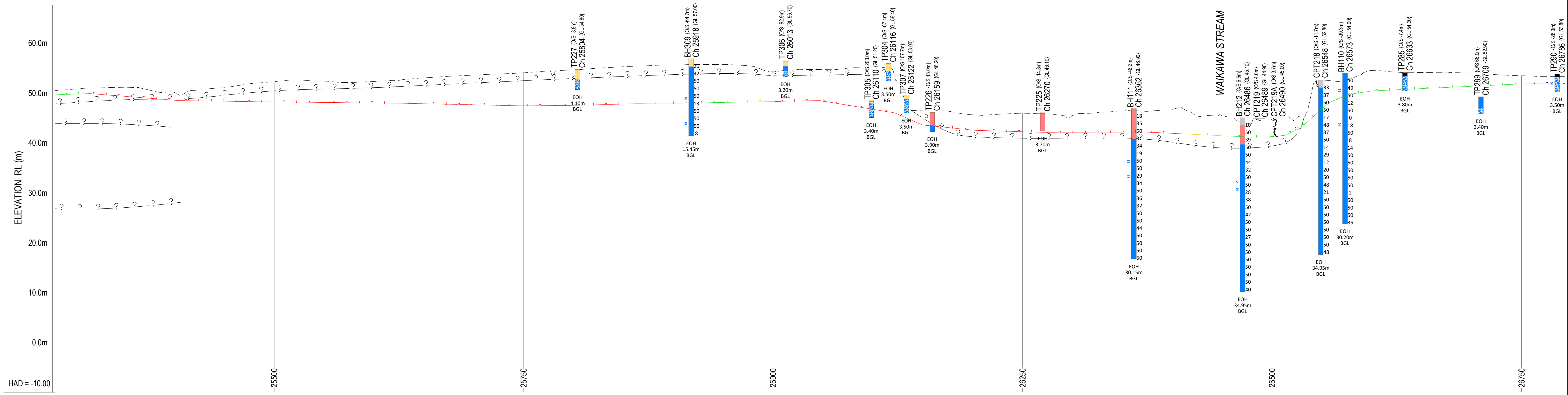
SCALE 1 : 4000 (A3)

LEGEND - LONG SECTION

- TOPSOIL
- FILL
- Q1a HOLOCENE RIVER DEPOSITS
- LOESS DEPOSITS
- Q2a/Q3a PLEISTOCENE ALLUVIUM - Sandy GRAVEL
- Q2a/Q3a PLEISTOCENE ALLUVIUM - UNDIFFERENTIATED
- Q2a/Q3a PLEISTOCENE ALLUVIUM - AGGRADATIONAL FAN GRAVEL
- Q5b PLEISTOCENE SHORELINE DEPOSITS
- Q6a PLEISTOCENE RIVER DEPOSITS
- Tt RAKAIA TERRANE GREYWACKE
- GEOLOGICAL UNIT INTERFACE
- MEASURED GROUNDWATER LEVEL

INTERPOLATED HIGHEST REGIONAL GROUNDWATER LEVEL CONFIDENCE

- HIGH
- MODERATE
- LOW
- VERY LOW



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

SCALE 1:800 (A3) 10 0 10 20m

NOTES

1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
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APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 12

Status Stamp: **WORKING PLOT**

Date Stamp: **16.08.21**

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1011 Rev.: D

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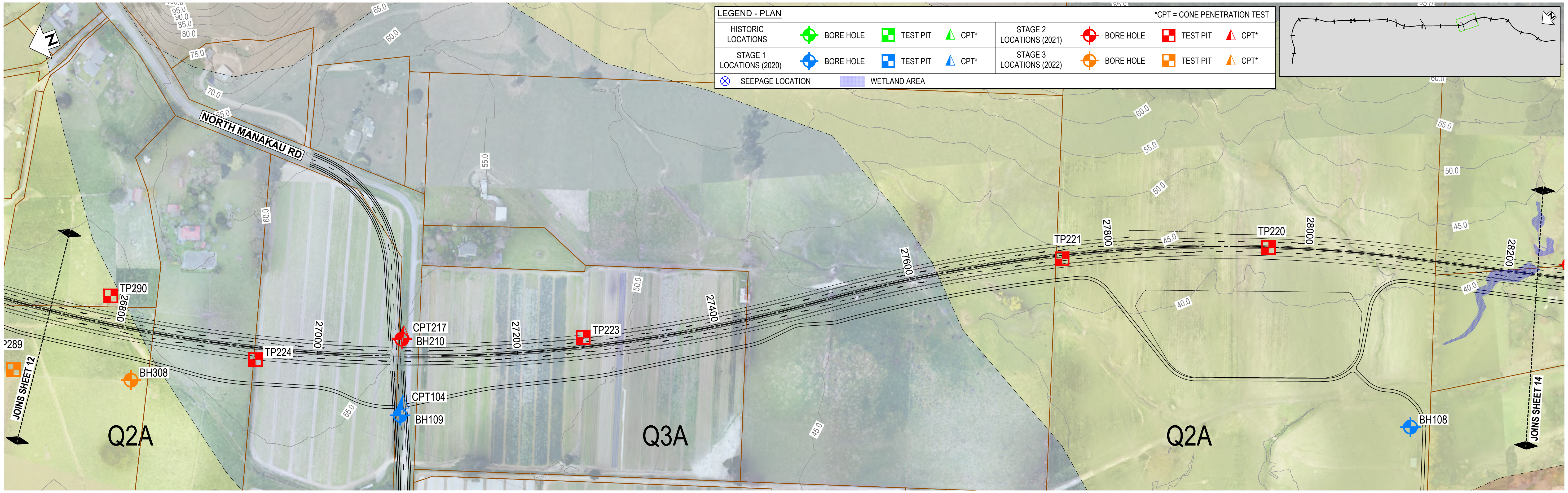
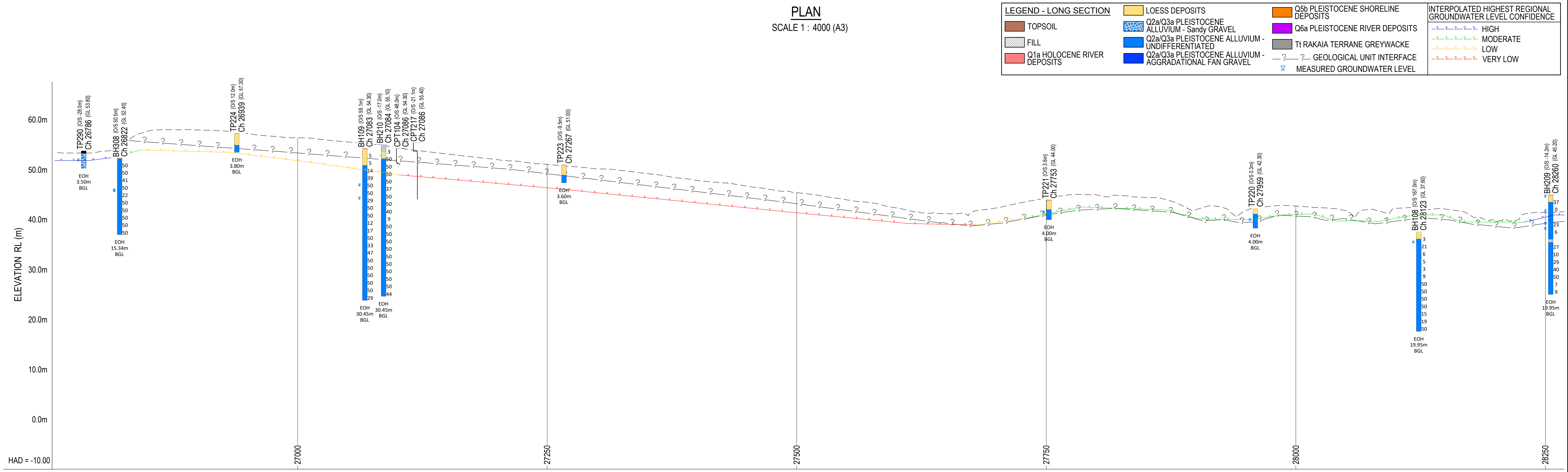


PLAN

SCALE 1 : 4000 (A3)



LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

SCALE 1:4000 (A3) — 50 0 50 100m

SCALE 1:800 (A3) — 10 0 10 20m

NOTES
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2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

FOR INFORMATION ONLY

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DRAWN	Steve Sutton	09.07.21
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DESIGN REVIEW	Eleni Gkeli	16.12.21
APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 13

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1012
Rev.: D

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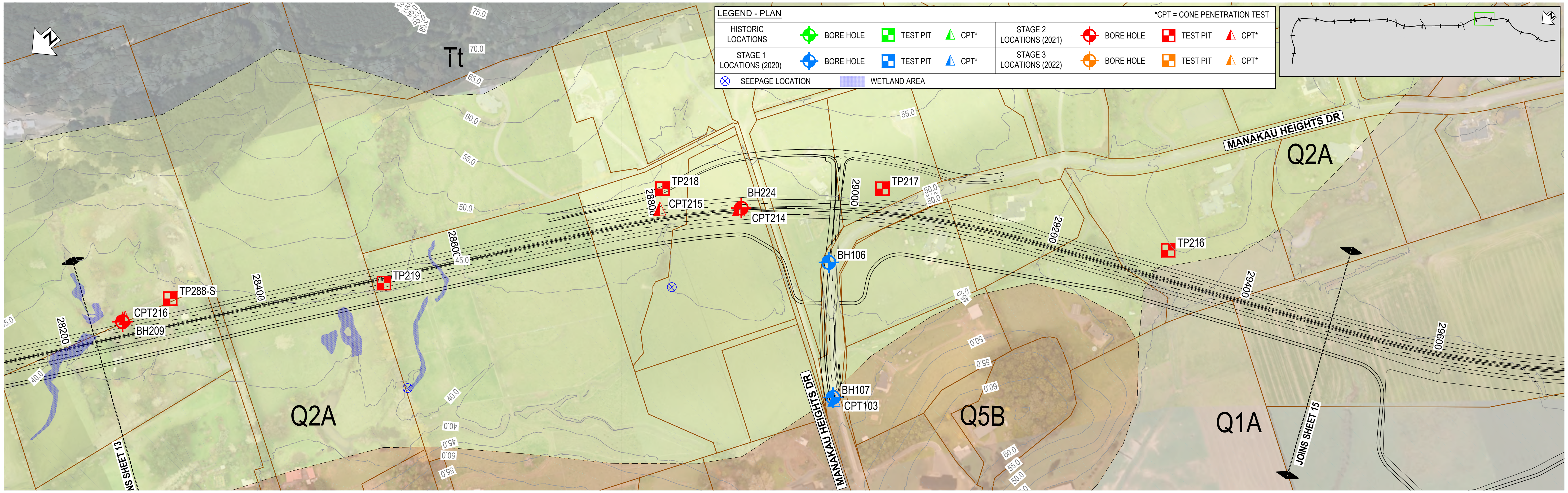


PLAN

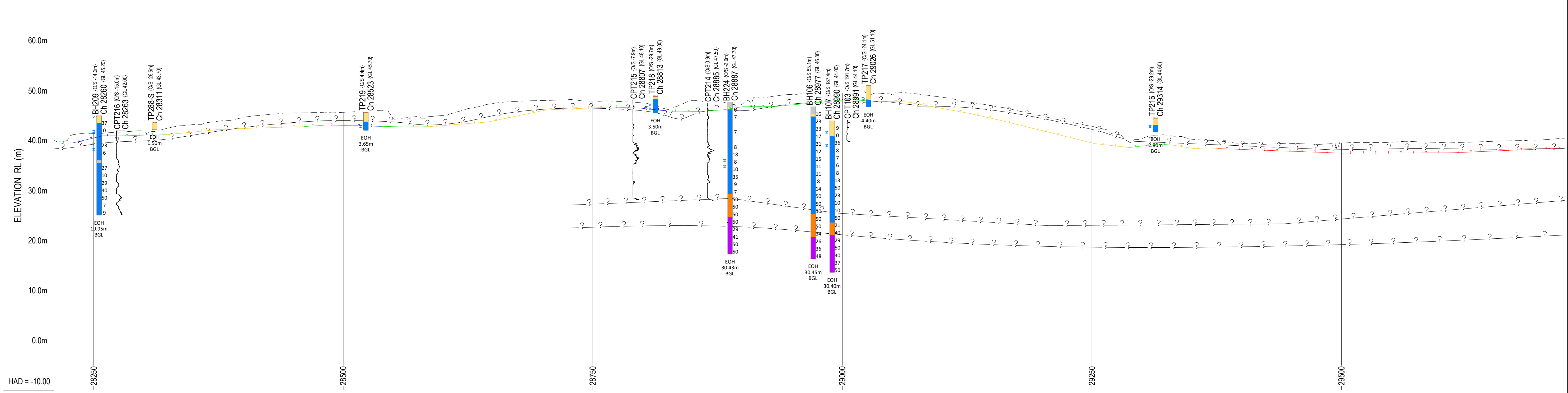
SCALE 1 : 4000 (A3)

LEGEND - LONG SECTION

- TOPSOIL
- FILL
- Q1a HOLOCENE RIVER DEPOSITS
- LOESS DEPOSITS
- Q2a/Q3a PLEISTOCENE ALLUVIUM - Sandy GRAVEL
- Q2a/Q3a PLEISTOCENE ALLUVIUM - UNDIFFERENTIATED
- Q2a/Q3a PLEISTOCENE ALLUVIUM - AGGRADATIONAL FAN GRAVEL
- Q5b PLEISTOCENE SHORELINE DEPOSITS
- Q6a PLEISTOCENE RIVER DEPOSITS
- Tt RAKAIA TERRANE GREYWACKE
- GEOLOGICAL UNIT INTERFACE
- MEASURED GROUNDWATER LEVEL

INTERPOLATED HIGHEST REGIONAL GROUNDWATER LEVEL CONFIDENCE

- HIGH
- MODERATE
- LOW
- VERY LOW



SCALE 1:4000 (A3)

SCALE 1:800 (A3)

NOTES

1. THE EXISTING GROUND LEVEL SHOWN IS ALONG THE DESIGN CENTRE LINE.
2. THE DESIGN ALIGNMENT SHOWN IS DESIGN FREEZE F5 AS OF 26.07.2022.

LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
V 1 : 800 (A3)

FOR INFORMATION ONLY

REV	REVISIONS	DRN	CHK	APP	DATE
D	UPDATED TO SHOW LATEST DESIGN	SS	KC	KC	27.07.22
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A	WORKING PLOT FOR DISCUSSION	SS	JG	KC	16.08.21

SURVEYED		
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APPROVED	Ken Clapcott	29.04.22
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 14

Status Stamp: WORKING PLOT

Date Stamp: 16.08.21

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1013

Rev.: D

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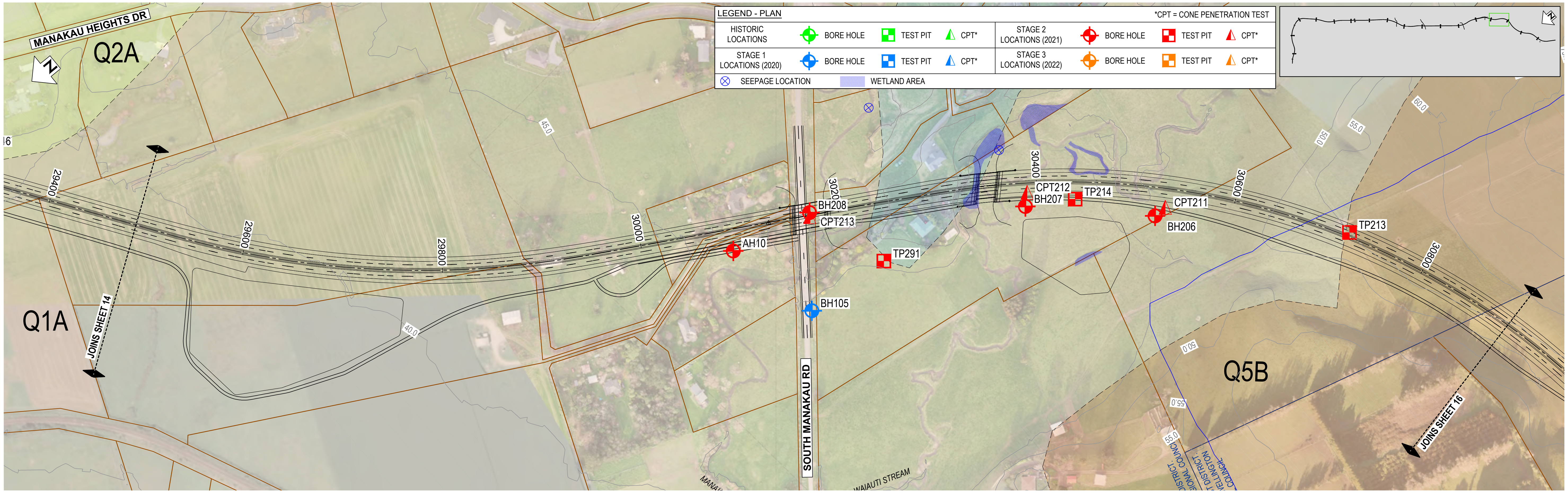

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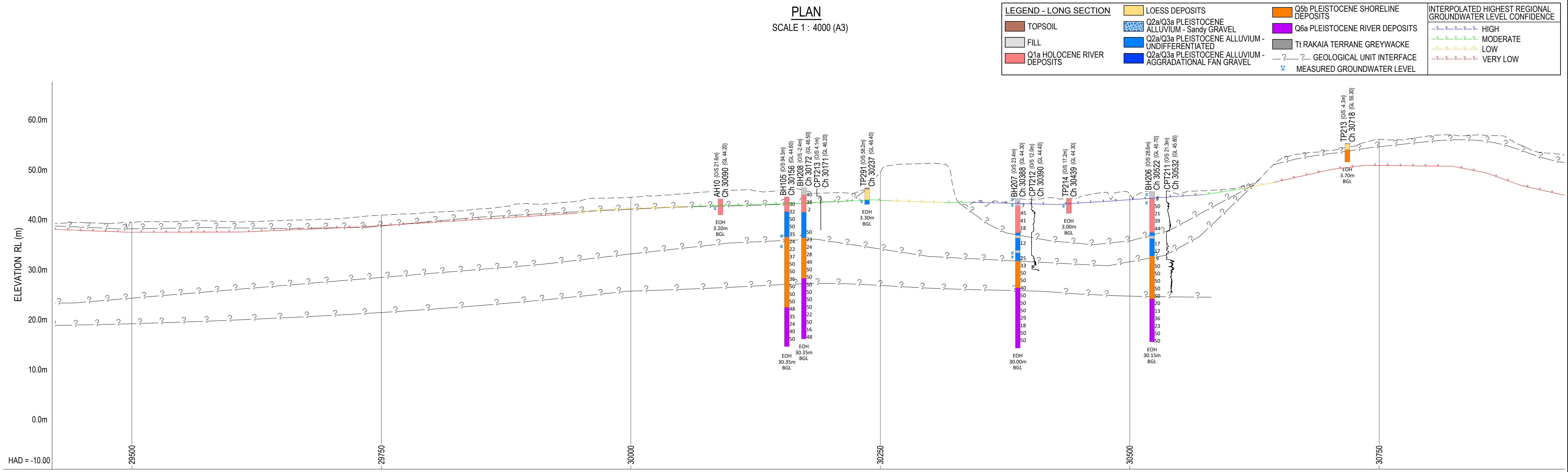

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GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 15

Status Stamp: WORKING PLOT
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Rev.: D

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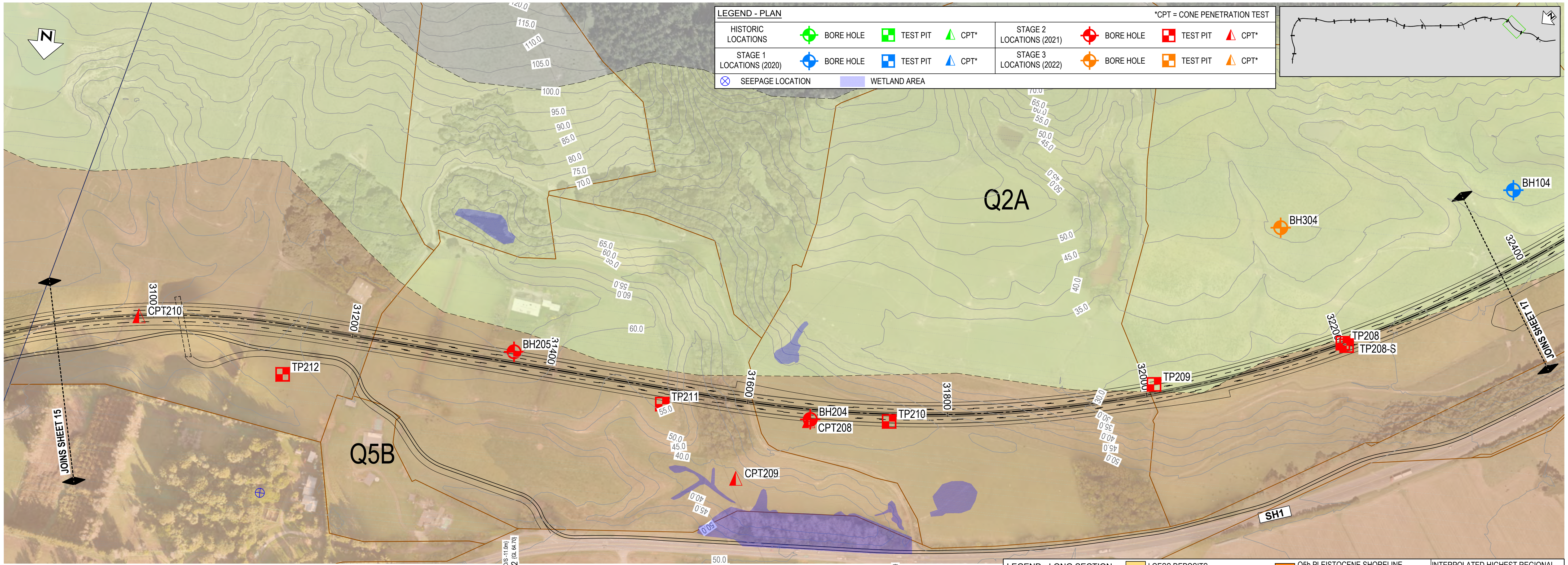

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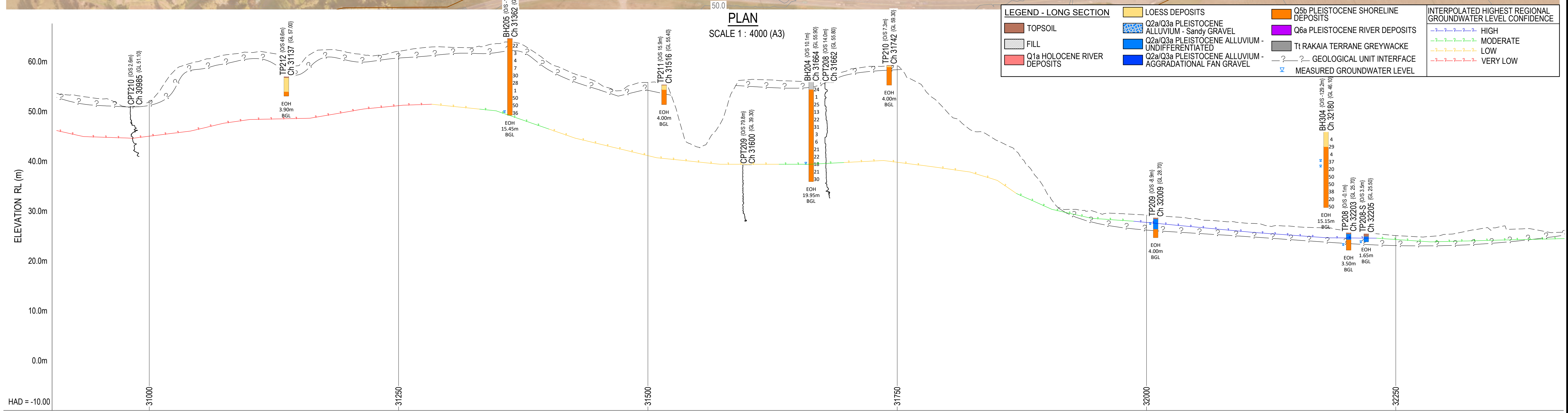

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SHEET 16

Status Stamp: WORKING PLOT

Date Stamp: 16.08.21

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1015

Rev.: D

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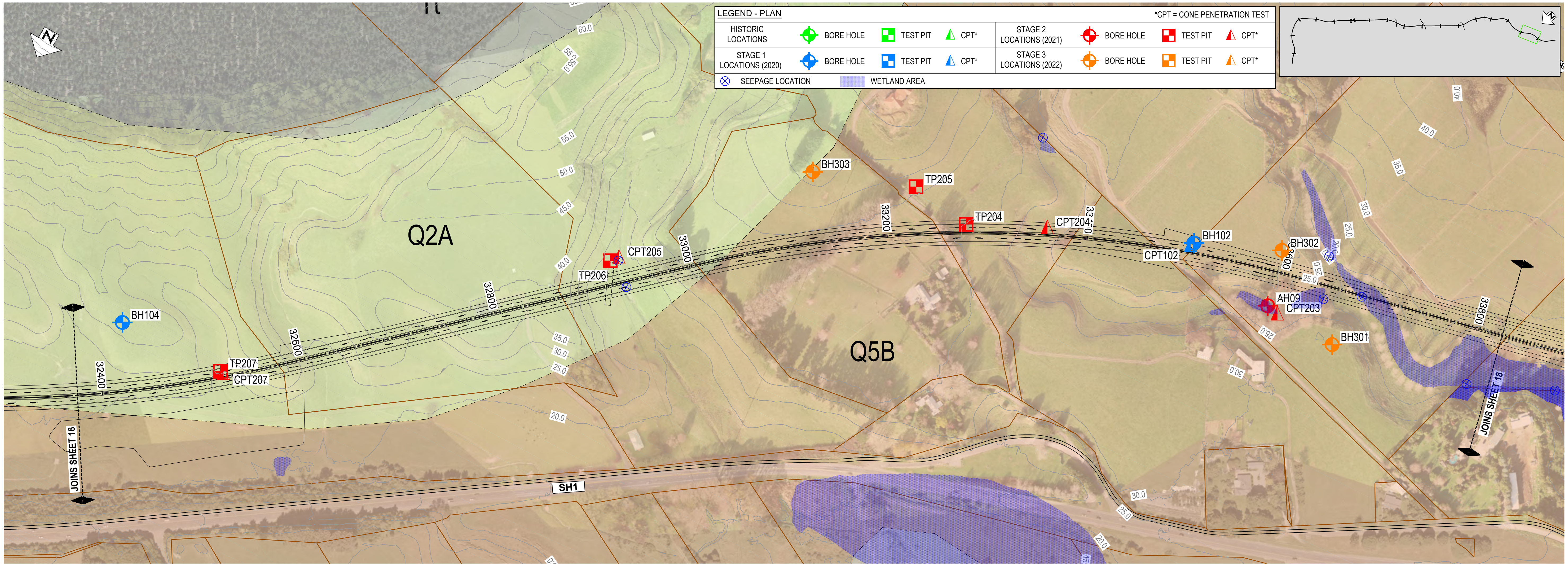

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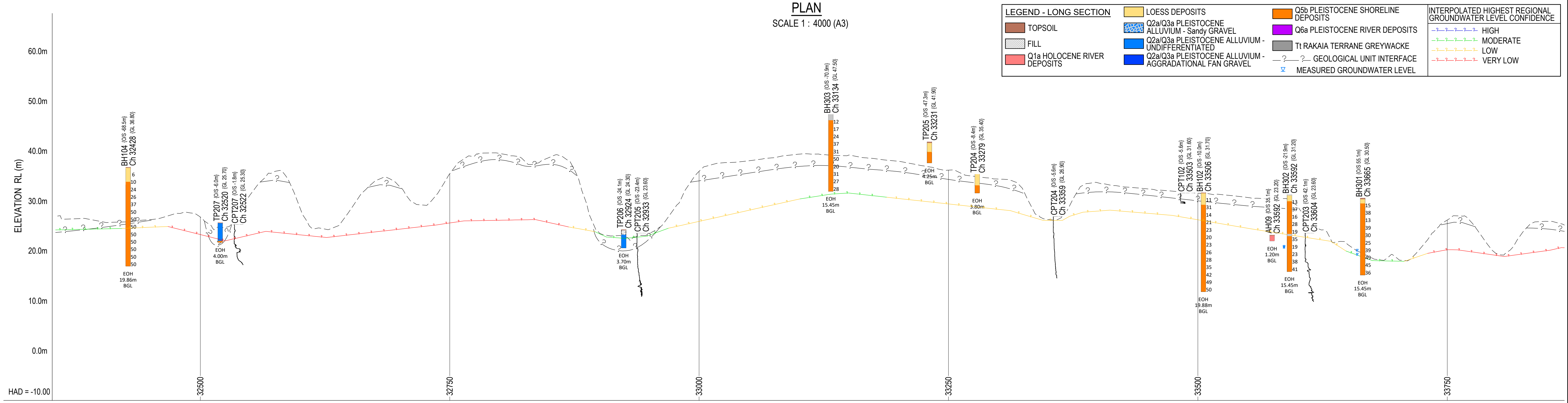

50 0 50 100m
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10 0 10 20m
SCALE 1:800 (A3)

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Stantec

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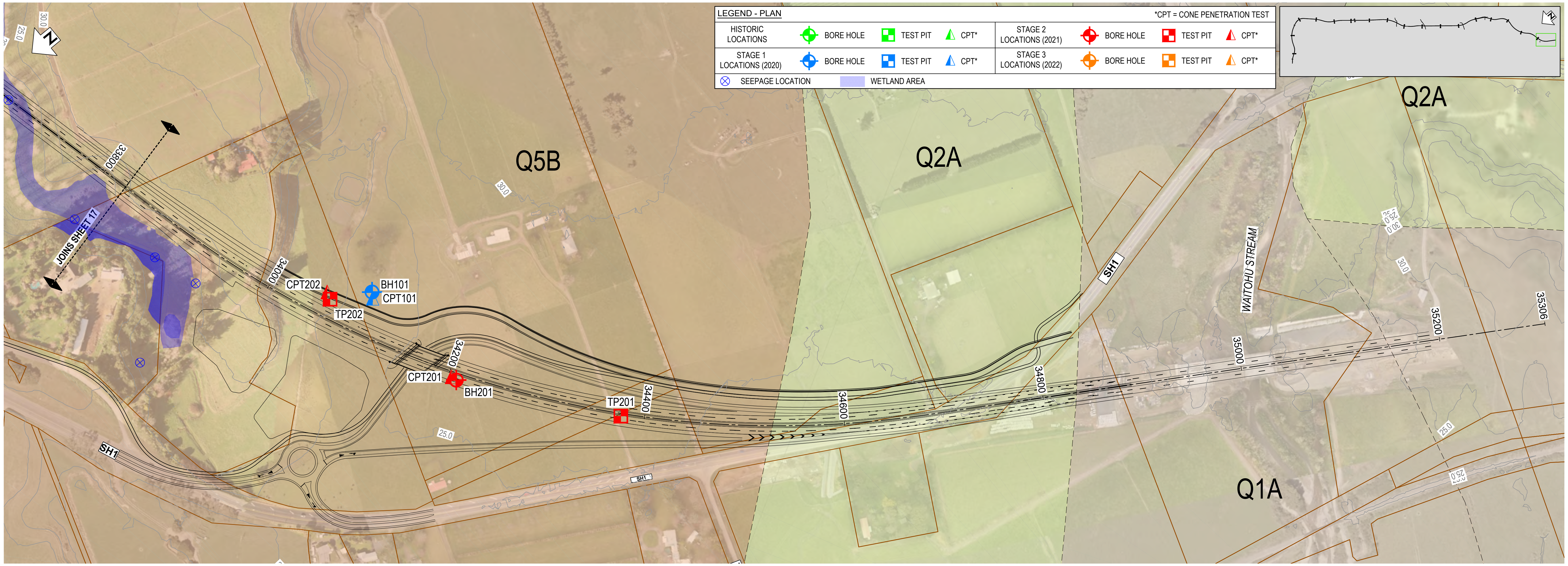
WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 17

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1016
Rev.: D



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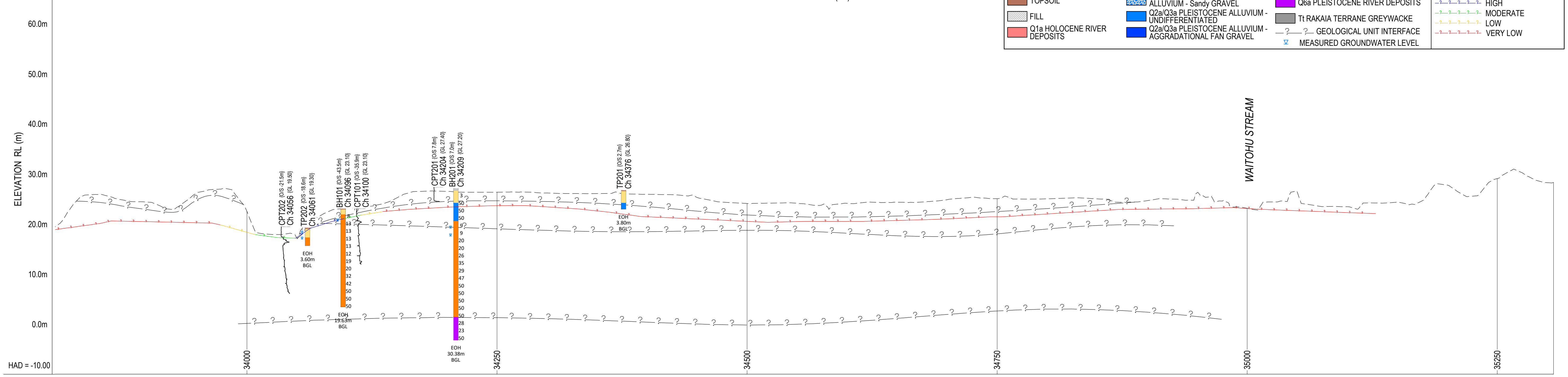

LONGITUDINAL SECTION

SCALES - H 1 : 4000 (A3)
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SCALE 1:4000 (A3) — 50, 0, 50, 100m

SCALE 1:800 (A3) — 10, 0, 10, 20m

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Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 18

Status Stamp: WORKING PLOT

Date Stamp: 16.08.21

Scales: AS SHOWN

Drawing No. 310203848-01-200-C1017 | Rev. D

CREATING COMMUNITIES

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of belonging. That's why at Stantec, we always **design with community in mind**.

We care about the communities we serve—because they're our communities too. We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

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Alexandra, Auckland, Balclutha, Christchurch, Dunedin, Gisborne, Greymouth, Hamilton, Hastings, Napier, Nelson, Palmerston North, Queenstown, Tauranga, Wellington, Whangārei

Level 15, 10 Brandon Street, Wellington 6011
PO Box 13-052, Armagh, Christchurch, 8141
New Zealand: +64 4 381 6700| www.stantec.com

Appendix 4.2 Stormwater Technical Assessment Report

IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	applications for resource consents and notices of requirement in relation to the Ōtaki to North of Levin Project
BY	**WAKA KOTAHI NZ TRANSPORT AGENCY**
	Applicant

ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

APPENDIX 4.2: STORMWATER MANAGEMENT DESIGN

BUDDLE FINDLAY

Barristers and Solicitors
Wellington

Solicitor Acting: **David Allen / Thaddeus Ryan**
Email: david.allen@buddlefindlay.com / thaddeus.ryan@buddlefindlay.com
Tel 64 4 462 0423 Fax 64 4 499 4141 PO Box 2694 DX SP20201 Wellington 6011

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. The Ōtaki to north of Levin highway Project ("**Ō2NL Project**" or "**Project**") involves the construction, operation, use, maintenance and improvement of approximately 24 kilometres of new four-lane median divided state highway (two lanes in each direction) and a shared use path ("**SUP**") between Taylors Road, Ōtaki (and the Peka Peka to Ōtaki expressway ("**PP2Ō**") and State Highway 1 ("**SH1**") north of Levin.

2. The proposed stormwater management system, a consent design, is based on:

   (a) compliance with industry guidelines and standards for stormwater management from highways including Council policies and objectives;

   (b) engineering and scientific inputs from other project disciplines;

   (c) site investigations;

   (d) topographical surveys; and

   (e) aerial photographs.

3. The Project spans two regional councils (Greater Wellington Regional Council ("**GWRC**") and Manawatū-Whanganui Regional Council ("**Horizons**")) and two district councils (Horowhenua District Council ("**HDC**") and Kāpiti Coast District Council ("**KCDC**")). The policies and objectives in the relevant planning instruments related to stormwater runoff from the highway intend to minimise the impacts of the Project on the upstream and downstream environment (both natural and built environments).

4. The approach that has been taken with the concept design is to apply well-understood stormwater effects mitigation strategies to the road design in a conservative manner to ensure the effects are under a low threshold. For stormwater runoff from the Project, this means attenuation of peak discharge with large basins and a robust contaminant capture and treatment regime using swales, planting and constructed wetlands throughout the Project length.

5. The proposed design has been developed to consider and avoid, remedy or mitigate the potential stormwater effects on the receiving environment, including cumulative effects, based on understandings captured in current

New Zealand industry best practice. The concept design Ō2NL Project highway stormwater management system is designed to:

(a) Provide stormwater runoff treatment over more than 90% of road surface area in the Project.

(b) Provide a treatment train approach that can capture and treat 75-90% of total suspended solids, oils and soluble metals (copper and zinc) from road runoff for 90% of storms. The treatment train includes vegetated batter slopes, treatment swales and constructed wetlands before discharge into the receiving environment.

(c) Manage flood risk through attenuation basins sized to decrease proposed road surface discharge rates from the road to pre-construction rates. The basins will accommodate storms (up to the 1%AEP, 24 hour duration event with allowance for future climate) including climate change, to buffer downstream flood risk impacts and receiving environments from an increase in peak flows and downstream flood levels. Ground soakage disposal will be used where feasible.

(d) Manage 90% of storm events in terms of water quality and 99% of storms in terms of water quantity. Exceedance events are relegated to the largest 10% of storms in terms of water quality but effectively still treat the "first flush" portion of even those events. In terms of water quantity, exceedance events are 1% of storms and the design will manage the first part of such an event before activating emergency bypass facilities which are designed to minimise erosion effects on the environment.

6. The design will be an asset that is functional and maintainable over proposed the long term. Blockage and malfunction of the stormwater management facilities can still occur, but this risk can be managed with normal maintenance activities and built-in bypass and overflow components in the facilities. The stormwater facilities will have safe access for monitoring and maintenance equipment.

7. The proposed concept design stormwater management system has been developed in consultation with iwi partners (as described in the cultural and environmental design framework ("**CEDF**") (Appendix Three to Volume II) and consists of highly functional facilities that align with iwi values, with

benefits including a natural aesthetic, improved amenity, and potential opportunities for community recreational involvement.

INTRODUCTION

8. My full name is Nicholas John Keenan.

9. I am a Senior Civil Engineer for Stantec, where I have worked for 16 years in the Water Group. I have worked in the Wellington, Perth, Auckland and Dunedin offices. Prior to that, I was employed by Connell Wagner for three years, Truebridge Callender Beach Ltd for three years and Hastings District Council for two years.

10. I specialise in stormwater infrastructure implementation, hydraulic modelling and flood risk, and rivers engineering. I generally work within a project team providing drainage and stormwater technical design for roading and infrastructure projects.

11. I am familiar with the area that is covered by the Ō2NL Project and since January 2021 have been involved with developing the Project's stormwater management design – focussing on stormwater discharge management and treatment from the road surface.

12. I have had primary responsibility for the development of a concept drainage design for the indicative alignment to assist the effects assessment process as is reported in the various technical assessment reports, notably **Mr Andrew Craig**'s Technical Assessment F (Hydrology and Flooding), **Dr Jack McConchie**'s Technical Assessment G (Groundwater and Hydrology) and **Mr Keith Hamill**'s Technical Assessment H (Water Quality), all provided in Volume IV. The concept drainage design provides a feasible concept design for the management of carriageway drainage and stormwater management (treatment and detention). The concept design is shown in the drawings and plans provided in Volume III - Drawings.

Qualifications and Experience

13. I am a member of Engineering New Zealand, and I am a Chartered Professional Engineer.

14. I have the following qualifications and experience relevant to this assessment:

    (a) BE (Civil), University of Canterbury, 1992.

(b) CPEng (Chartered Professional Engineer) and MEngNZ (Member of Engineering New Zealand). RPEQ Registered Professional Engineer Queensland.

(c) 24 years of stormwater engineering for clients and consultants in New Zealand, Australia and Samoa.

15. I have been involved with Waka Kotahi NZ Transport Agency ("**Waka Kotahi**") state highway safety improvement and upgrade projects on the Kapiti Coast, Wellington, Wairarapa, Whanganui, Rotorua, Canterbury and Otago since 2006.

16. Recent projects in which I have been involved demonstrate my experience in the assessment of effects and design of stormwater management systems for roading projects, including:

(a) State Highway 58 ("**SH58**") road safety improvements, 2020 to present. My role was lead stormwater engineer, detailed design and reporting. The project involved road widening safety works over 5.5km between the Hutt Valley and Porirua. Drainage works included culvert extension works, longitudinal drainage, stormwater treatment, erosion protection, fish passage, design departure and risk assessment documentation, and stormwater technical report for the resource consent application.

(b) Big Kuri Creek, SH1 Hampden and SH87 Kokonga, Taieri River, Gravel and Flood Management Plans, Waka Kotahi, 2016 – Present. My role was to prepare gravel management plans for the Otago bridge site resource consent applications, involving river works and hydraulics assessments and liaison with Otago Regional Council flood hazard team. This also included stakeholder engagement for support of easement agreements.

(c) Frankton Flats Stormwater Strategy, Queenstown Lakes District Council, 2015 to 2019. My role was lead stormwater engineer for modelling, design and reporting for a future growth strategy. The project included the design of 3-Waters pipelines and transport infrastructure expansion, costing, tender and risk. My involvement followed on from the completion of Eastern Access Road design and implementation behind Queenstown Airport and was intended to be in advance of State Highway 6 ("**SH6**") improvements along Kawarau Road leading into the Kawarau Bridge.

(d) SH1 Paekakariki to Waikanae WRB Safety Improvements, SH1 Otaihanga to Waikanae WRB Detailed Design, NZTA, 2010 to 2011. The project was part of a minor safety upgrade of black spots along 14km of SH1. I provided drainage design inputs to help determine the road width increase needed to accommodate the installation of a central median wire rope barrier and lane and shoulder widening.

(e) Route 52: Waipukurau – Porangahau, Resilience and Strengthening Works (Provincial Growth Fund), Central Hawke's Bay Council, NZ, 2020-Present. My role was to determine existing level of service of the Route 52 road crossing at Flaxmill Bridge. This included assessment of characteristics of the floodplain and bridge configuration, assessment of multiple levels of investment in upgrade scenarios to improve level of service, cost estimation and cost/benefit assessments of options. Further, the preparation of feasibility design, technical report, liaise with client, stakeholder consultation.

Code of Conduct

17. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

18. This assessment describes how the stormwater from the Ō2NL Project can be managed and includes details of the:

(a) anticipated hydrology runoff volumes and discharges;

(b) approach to and design of water quality treatment; and

(c) anticipated character of final discharge into the receiving environment.

19. The stormwater management design is shown in Project drawings (Volume III – Drawings):

(a) 300-C-1000 series Drainage Layout Plans;

(b) 300-C-2000 series Catchment Plans;

(c) 100-C-2000 series Typical Cross Sections; and

(d) 300-C-9000 series Typical Details – Stormwater Drainage.

20. The concept design has been developed cognisant of:

(a) design standards (refer to Stormwater Management References at the end of this assessment);

(b) Te Mana o te Wai and related cultural imperatives;

(c) hydraulic neutrality principles, where changes to hydrology and stormwater are to be managed so that current systems continue to function as they are now, with and without the Project, allowing for climate change.

21. In preparing the stormwater design I have ensured that my work is coordinated with other parts of the design team including cross-corridor catchment stormwater management and flooding, and the requirements of the Project overall. In addition I have developed a concept design cognisant of potential effects on hydrology and hydrogeology, on eco-systems and on the landscape.

22. This assessment provides an overview of the stormwater management elements of the Ō2NL Project's design for which I have been responsible. This concept design is not the only design configuration that could provide acceptable stormwater management and the final design will be based on intimate detail that is not yet available. The concept design demonstrates the scope of components and feasibility of stormwater management over this Project. In particular, this assessment provides:

(a) the relevant stormwater management design parameters including rainfall, climate change, and external standards and guidance that have been applied;

(b) an overview of the proposed design, including:

(i) the network drainage collection and conveyance system;

(ii) stormwater quality and quantity management; and

(c) limitations and exceedance considerations.

23. This assessment should be read in conjunction with the following documents:

(a) Design and Construction Report ("**DCR**") by **Mr Jamie Povall**;

(b) **Mr Gregor McLean**'s Erosion and Sediment Control ("**ESC**") report attached to the DCR (provided as Appendix Four to Volume II) ;

(c) **Mr Andrew Craig**'s Technical Assessment F (Hydrology and Flooding);

(d) **Dr Jack McConchie**'s Technical Assessment G (Groundwater and Hydrology);

(e) **Mr Keith Hamill**'s Technical Assessment H (Water Quality);

(f) **Mr Nick Goldwater**'s Technical Assessment J (Terrestrial Ecology); and

(g) **Dr Alex James**' Technical Assessment K (Freshwater Ecology).

PROJECT DESCRIPTION

24. The Ō2NL Project involves the construction, operation, use, maintenance and improvement of approximately 24 kilometres of new four-lane median divided state highway (two lanes in each direction) and a SUP between Taylors Road, Ōtaki (and the PP2Ō and SH1) north of Levin. The Ō2NL Project includes the following key features:

(a) a grade separated diamond interchange at Tararua Road, providing access into Levin;

(b) two dual lane roundabouts located where Ō2NL crosses SH57 and where it connects with the current SH1 at Heatherlea East Road, north of Levin;

(c) four lane bridges over the Waiauti, Waikawa and Kuku Streams, the Ohau River and the North Island Main Trunk ("**NIMT**") rail line north of Levin;

(d) a half interchange with southbound ramps near Taylors Road and the new Peka Peka to Ōtaki expressway to provide access from the current SH1 for traffic heading south from Manakau or heading north from Wellington, as well as providing an alternate access to Ōtaki;

(e) local road underpasses at South Manakau Road and Sorenson Road to retain local connections;

(f) local road overpasses to provide continued local road connectivity at Honi Taipua Road, North Manakau Road, Kuku East Road, Muhunoa East Road, Tararua Road (as part of the interchange), and Queen Street East;

(g) new local roads at Kuku East Road and Manakau Heights Road to provide access to properties located to the east of the Ō2NL Project;

(h) local road reconnections connecting:

  (i) McLeavey Road to Arapaepae South Road on the west side of the Ō2NL Project;

  (ii) Arapaepae South Road, Kimberley Road and Tararua Road on the east side of the Ō2NL Project;

  (iii) Waihou Road to McDonald Road to Arapaepae Road/SH57;

  (iv) Koputaroa Road to Heatherlea East Road and providing access to the new northern roundabout;

(i) the relocation of, and improvement of, the Tararua Road and current SH1 intersection, including the introduction of traffic signals and a crossing of the NIMT;

(j) road lighting at conflict points, that is, where traffic can enter or exit the highway;

(k) median and edge barriers that are typically wire rope safety barriers with alternative barrier types used in some locations, such as bridges that require rigid barriers or for the reduction of road traffic noise;

(l) stormwater treatment wetlands and ponds, stormwater swales, drains and sediment traps;

(m) culverts to reconnect streams crossed by the Ō2NL Project and stream diversions to recreate and reconnect streams;

(n) a separated (typically) three metre wide SUP, for walking and cycling along the entire length of the new highway (but deviating away from being alongside the Ō2NL Project around Pukehou (near Ōtaki)) that will link into shared path facilities that are part of the PP2Ō expressway (and further afield to the Mackays to Peka Peka expressway SUP);

(o) spoil sites at various locations along the length of the Project; and

(p) five sites for the supply of bulk fill /earth material located near Waikawa Stream, the Ohau River and south of Heatherlea East Road.

STATUTORY CONSIDERATIONS

25. Objectives and policies from regional and district plans under the Resource Management Act 1991 ("**RMA**") relevant to flood risk and stormwater quality for a new highway development are summarised below (**Table 1**). These provide guidance for the proposed concept design.

Table 1: Relevant Policies and Objectives to Flood Risk and Stormwater Quality

Stormwater Runoff – Flood Risk	
Horowhenua District Plan	**Design Response**
Objective 8.1.1 and policy 8.1.5 intend to avoid the establishment of any new structure or activity, or any increase in the scale of any existing structure or activity, within the identified areas at significant risk from flood events.	Covered in Technical Assessment F (Hydrology and Flooding).
Policy 8.1.8 intends to avoid where practicable, the siting of new critical infrastructure and services within areas of significant risk from natural hazard events.	
Objective 8.2.1. and policy 8.2.3 intend to avoid structures and activities that are likely to reduce the effectiveness of existing works, structures, natural landforms or other measures which serve to mitigate the effects of natural hazard events.	Minimise peak runoff and attenuate or retain runoff volumes.

Stormwater Runoff – Flood Risk	
Horizons Regional Policy Statement	
Objective 9-1 intends to avoid adverse effects of natural hazard events on people, property, infrastructure and the wellbeing of communities.	Minimise peak runoff and attenuate or retain runoff volumes.
Horizons One Plan	
Objective 17-1 and policies 17-1 and 1-2 intend to avoid, where reasonably practicable, any adverse effects on any other lawful activity in, on, under or over the bed of the river or lake, including existing structures; and avoid adverse effects on any significant ecosystems intrinsic to the artificial watercourse.	Minimise peak runoff and attenuate or retain runoff volumes.
KCDC Proposed District Plan	
Objective 2.5 intends to ensure the safety and resilience of people and communities by avoiding exposure to increased levels of risk from natural hazards, while recognising the importance of natural processes and systems.	Minimise peak runoff and attenuate or retain runoff volumes.
Policy 9.3 intends to avoid development or will be managed in a way that avoids increasing risks from natural hazards.	
Policy 9.12 intends to avoid development in the river corridor, stream corridor, overflow path, and residual overflow path areas unless the 1% AEP hazard can be mitigated on-site to avoid damage to property or harm to people.	
GWRC Proposed Natural Resources Plan	
Objective O21 and Policy P28 intend to avoid hard hazard engineering mitigation and protection methods, except where it is necessary to protect existing development from unacceptable hazard risk, assessed using the risk-based approach.	Minimise peak runoff and attenuate or retain runoff volumes.

Stormwater Runoff – Flood Risk	
GWRC Freshwater Plan	
Policy 7.2.7 intends to avoid any adverse effects on the structural integrity and effectiveness of lawful flood mitigation structures and works in riverbeds and on floodplains from the adverse effects of subdivision, use, and development.	Minimise peak runoff and attenuate or retain runoff volumes.

Stormwater Runoff –Water Quality	
Horizons Regional Policy Statement	**Design Response**
Objective 4-2 intends to avoid as far as reasonably practicable accelerated erosion and increased sedimentation in water bodies (with resultant adverse effects on people, buildings and infrastructure) caused by vegetation clearance, land disturbance, forestry, or cultivation.	Treat and attenuate peak runoff from the new hard surfaces of the highway.
Objective 13-1 intends to avoid accelerated erosion and any associated damage to people, buildings and infrastructure and other physical resources of regional or national importance, and increased sedimentation in water bodies as a result of human activity.	Treat and attenuate peak runoff from the new hard surfaces of the highway.
Horizons One Plan	
Objective 14- 1 and policy 14-1 intend to avoid adverse effects where a discharge is onto or into land, adverse effects on surface water or groundwater; and avoiding discharges which contain any persistent contaminants that are likely to accumulate in a water body or its bed.	Treat and attenuate peak runoff from the new hard surfaces of the highway (See Technical Assessment K (Freshwater Ecology) and G
Objective 16-1 and policies 16-2 and 16-3 intend to avoid any adverse effects on other lawful activities, particularly on other surface water takes, including takes allowed by s14(3)(b) of the RMA, and groundwater takes from properly constructed, efficient and fully-functioning bores; and for diversions and drainage.	

Stormwater Runoff –Water Quality	
Objective 17-1 and policies 17-1 and 1-2 intend to avoid where reasonably practicable any adverse effects on any other lawful activity in, on, under or over the bed of the river or lake, including existing structures; and avoid adverse effects on any significant ecosystems intrinsic to the artificial watercourse.	(Hydrogeology and Groundwater)).
GWRC Regional Policy Statement	
With regards to fresh water, objective 13 and policies 18 and 43 intend to protect the aquatic ecological function of water bodies.	Treat runoff from the new hard surfaces of the highway (See Technical Assessments H (Water Quality) and K (Freshwater Ecology)).
Objective O6, policy P9 intend to protect fresh water and the values of estuaries and sites with significant mana whenua values.	Treat runoff from the new hard surfaces of the highway.
Objective O24 and policies P24 and P35 aim to protect indigenous fish and kōura populations.	
Policy 39 intends to avoid the adverse effects of use and development on outstanding water bodies and their significant values identified in Schedule A (outstanding water bodies).	Treat and attenuate peak runoff from the new hard surfaces of the highway.
Policy P41A intends to avoid more than minor adverse effects of activities on the indigenous fish species known to be present in any water body identified in Schedule F1 (rivers / lakes) as habitat for indigenous fish species, and or Schedule F1b (inanga spawning habitats).	Treat and attenuate peak runoff from the new hard surfaces of the highway.
Policy P42 intends to protect and restore ecosystems and habitats with significant indigenous biodiversity values by avoiding cumulative adverse effects on, and	

Stormwater Runoff –Water Quality	
the incremental loss of the values of these ecosystems and habitats.	
Policy P110 relates to the National Policy Statement for Freshwater Management requirements for water takes, damming and diversion, and the extent to which it is feasible and dependable that any adverse effect on the life-supporting capacity of fresh water and of any associated ecosystem resulting from the change would be avoided.	
GWRC Freshwater Plan	
Objective 4.1.2 intends to protect the mauri of water bodies and river and lake beds.	Treat and attenuate peak runoff from the new hard surfaces of the highway.
Objective 4.1.6 and policies 4.2.9, 4.2.10, 4.2.13, **4.2.16** intend to protect significant indigenous aquatic vegetation and significant habitats of freshwater fauna in water bodies.	
KCDC Proposed District Plan	
Policy 11.17 intends to manage effects of stormwater runoff to ensure the protection of riparian vegetation.	Treat and attenuate peak runoff from the new hard surfaces of the highway.

26. The ‘treat’ design response means filtering out road contaminants in a controlled, best practice manner and at contained discrete locations in the highway corridor (using a stormwater treatment facility such as swales and constructed wetlands that can receive ongoing responsibility, care and maintenance).

27. The ’attenuate peak runoff’ design response means detaining (or retaining in cases of soakage disposal to ground) rainfall runoff in basins for slow release through constricted outlets into the receiving environment.

EXISTING ENVIRONMENT

28. The catchments crossed by the Ō2NL Project are shown in 300-C-2000 series Catchment Plans (Volume III – Drawings).

29. The land use upstream of the Ō2NL Project footprint is predominantly pastural farming, bush or forestry. Downstream land use is more intensively farmed and includes the built-up areas of Levin, Ohau and Manakau, plus the railway corridor and existing SH1 alignment.

POTENTIAL HIGHWAY RUNOFF EFFECTS

30. Post-construction, the potential adverse water quantity effects from a new highway surface are:

    (a) Increased surface water runoff and volume from new impervious areas and reduced natural infiltration to ground, resulting in increased discharge and flood levels which, if unmitigated, pose a risk to people, property, waterway stability and infrastructure downstream of the highway.

    (b) Increased runoff discharge rates directed into downstream networks which, if unmitigated, may exceed the capacity of existing stormwater infrastructure resulting in increased flooding.

    (c) Increased flow velocity, energy and volume which, if unmitigated, could lead to bank erosion and bed scour in streams downstream of the highway.

    (d) Catchment areas displaced by the construction footprint. The road corridor catchments will subtract from many pre-development catchments by draining along the footprint to outlet locations, and then add to pre-development catchments at outlets. This will lead to changes in the natural flow regime in local catchments immediately downstream of the highway, but the effect diminishes with increasing distance away from the highway as more catchment areas enter the stream.

31. Potential adverse water quality effects on receiving waterways and aquatic ecosystems could include, if unmitigated:

    (a) Long-term accumulation of vehicle-related contaminants carried by stormwater runoff from the road corridor. Contaminant sources include:

(i) vehicles - with rubber, engine oils and hydrocarbons, copper and zinc, other metals, plastics, brake linings and litter;

(ii) road-related - with fine aggregates wear and tear, bitumen pavement leaching, sedimentation of silt from batter slopes, dust and aggregates from resurfacings, paint, corrosion of posts and wire, weed controls (pesticides and herbicides); and

(iii) accidents - with fire retardants, spills, and rubbish.

(b) Increased temperature of road runoff resulting in reduced oxygen in the water and reduced habitable water.

DESIGN OVERVIEW

Cultural and Environmental Design Framework - General Design Principles

32. As discussed in the DCR (Appendix Four to Volume II),[1] the key principles of low impact stormwater management include removing energy and removing contaminants from water. Both principles are accomplished through the design and placement of stormwater management facilities which are made up of three main components: sediment forebay, constructed wetland and attenuation basin.

33. The concept design of stormwater management has been informed by the four values (create, enhance, restore, preserve) described in the CEDF (Appendix Three to Volume II).

34. The stormwater design aims to respond to these values by:

(a) improving water quality from the road surface through a treatment train stormwater approach (including planted slopes, vegetated swales, sediment forebays and constructed wetlands), so that road run-off passes through some / all of the components of that treatment train before leaving the indicative alignment;

(b) slowing water down through attenuation basins and water-sensitive design elements, and settling water to allow suspended solids to fall out, providing time for returning water into the ground through infiltration and soakage;

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[1] In section 3.9.2 (Longitudinal Stormwater Management).

(c) encouraging water to interact with vegetation to enhance growth and filter impurities, including through vegetated open channels (in preference to below-ground pipelines);

(d) providing pathways ('lifeways') for aquatic life; and

(e) providing erosion protection measures between the Project outlets and the receiving environment.

35. The stormwater management design overlaps with other disciplines: water quality, ecology, environmental design, groundwater and wetlands, geomorphology and landscape architecture. The design also considers safety for recreational passers-by, construction workers and maintenance people over the long-term life of the asset.

Stormwater Management – Discharge

36. The water quantity design parameters are summarised in Table 2 (basis of concept design) and the sections below describe the long-term discharge quantity outcomes expected from the Project by applying the design standards.

37. Stormwater management minimises the effects of increased discharge from a wide range of rainfall patterns. Rainfall lands on the road corridor (ie, the trafficable road surface, median strips, safety margins, cut and fill batter slopes, conveyance swales, basins, and other landscaped areas) in all magnitudes from gentle rainfall to normal seasonal rainfall, to extreme storm rainfall, and for short, intense thunderstorm events to long, extended duration rainfall patterns that may extend over days or weeks.

38. The proposed stormwater management within the Ō2NL Project includes the following (Refer to Drawing series DWG-300-C-1000 to 9000 provided in Volume III – Drawings):

(a) Defining highway catchments based on longitudinal high and low points according to the proposed road profile and super-elevations.

(b) Defining highway catchments according to road crossfall and flow paths to the treatment and attenuation facilities.

(c) Appropriate road runoff collection – kerblines, swales, sumps and pipes, as well as 'clean' and 'dirty' water channels at the base of batter slopes where applicable.

(d) Specifying slope stabilisation in the form of grass cover or vegetation, to allow sheet flow to the base of slopes with minimal erosion.

(e) Longitudinal conveyance channels or pipelines.

(f) Stormwater attenuation basins to manage peak discharge into the receiving environment or to ground soakage disposal systems.

(g) Soakage systems where ground conditions allow.

(h) Outlet structures and channels to convey treated flows into the receiving environment and protect against local erosion or scour.

Stormwater Management – Water Quality Treatment

39. The water quality design parameters are provided in Table 2 below. The sections below describe the treatment outcomes expected from the Project by applying the design standards.

40. Proposed runoff treatment train (swales followed by constructed wetlands) covers more than 90% of road surface area in the Project, for 90% of all rainfall events, to a removal rate of at least 75-90% capture of total suspended solids, zinc and copper. Nutrients (nitrates and phosphates) are not expected from the road surface.

41. In the long term, accumulations of contaminants are captured and concentrated near to the highway footprint in specific areas of the stormwater treatment system (primarily the swales, sediment ponds and constructed wetlands of the treatment train) so that maintenance and renewal activities of the facilities can be effective. This treatment facility significantly reduces contaminant accumulations outside the roadside footprint in the natural receiving environment.

42. Treatment is more assured and robust with a treatment train approach which combines more than one treatment category in series.

43. The stormwater management treatment train applied within the Ō2NL Project is described as follows, from upstream to downstream:

(a) Contaminated stormwater runoff is shed from the highway surface as sheet flow and is filtered through landscaping on the road shoulder and batter slopes before entering vegetated swales. In some locations, due to site constraints (ie, where the amount of width available is limited), the use of grey infrastructure (kerblines, sumps and pipelines) is necessary to capture and convey runoff.

(b) Flows are conveyed along the highway corridor in vegetated swales to a low point in the longitudinal profile where a stormwater treatment and attenuation facility is located. Flow velocities are slowed by the planting in swales and shallow swale gradients, allowing pre-treatment in terms of bio-filtration and some ground infiltration to occur.

(c) At the downstream low point of the swale, flows are discharged into a sediment forebay, where floating gross pollutants and coarse sedimentation are captured. Riprap lining may be provided at the forebay inlet to protect against scour.

(d) Flows are passed through to a constructed wetland. Flow slowly filters through the wetland's plantings and banded bathymetry. Within the constructed wetland, flows take in the order of 24 hours to pass completely through, giving the facility time to capture and remove contaminant loadings before discharging into the receiving environment.

(e) If the wetland design volume is exceeded during large storm events, flows are bypassed into the adjacent flood attenuation (or detention) basin for temporary storage and release over 1-3 days. The runoff volume is attenuated and released at a controlled, reduced discharge rate to avoid overloading the catchment downstream.

(f) Flows are discharged into the receiving environment via throttled outlets lined with riprap to slow velocities and minimise erosion and scour. Existing stream beds and banks will also be actively protected from erosion and scour effects where increased risk of scour is identified. This will include rock riprap for scour protection and/or additional planting to stabilise localised parts of the existing bed and banks.

(g) In locations where permeable soil conditions are present and groundwater recharge is desirable, soakage systems are proposed downstream of the throttled outlets from attenuation basis and constructed wetlands. Flows will be treated in the swales and wetlands prior to ground disposal to minimise soakage soil clogging, reduce maintenance, and extend asset design life.

Basis of concept design - summary

44. The basis of concept design for stormwater management is summarised in Table 2 below. The key parameters and references used in the concept design are listed. The final design of the Project may vary from these parameters and references, in response to particular requirements. An example stormwater management facility is provided for Pond 4 (a portion of the Project that drains into the Koputaroa catchment) to indicate the performance of the facility on catchment runoff.

Table 2: Basis of concept design – summary

Hydrology	
The definition of the rainfall runoff volumes for each catchment that makes up the Project.	
Design rainfall	NIWA's High Intensity Rainfall Design System (HIRDS) V4.
Climate change	RCP 8.5 for 2081-2100 (which is similar to RCP 6.0 extrapolated to 2130).
Hydrological calculation method	Standard Rational Method for critical peak flow (reference NZ Building Code, E1) and Modified Rational Method for maximum detention volume.
Catchment areas – pre and post development	Post development catchment area is the highway footprint width (including live lanes, shoulders, swales and fill / cutting slope length draining to swales) multiplied by the highway length. These areas drain to low points in the highway alignment. Pre-development catchment area is assumed to be the same area as post development. Constructed fill slopes not draining into swales are assumed to drain to the existing catchment and offer no net change in runoff effect.
Rational Method runoff coefficient	0.95 for impervious areas (Highway and shared used path) and 0.25 for pervious areas (swales and landscaping, cut and batter slopes).

Time of concentration, Tc	Minimum of 10 minutes, up to 60 minutes for longitudinal drainage. Based on an average of three empirical methods.
Swale slope	Average longitudinal slope of 0.5%.
Manning's roughness coefficient	0.025 for grass lined straight channels flowing full, 0.1 for vegetated swales flowing full and 0.013 for concrete pipework.
Peak design flow	Determined using rainfall intensity for duration equal to catchment time of concentration (reference NZTA P46 Stormwater Specification and Building Code E1). 1%AEP design flow in the swales as these act as secondary flow paths.
Vegetated swales	
Swales convey rainfall runoff along the road corridor.	
Side slope ratio	Minimum 1V:3H.
Dimensions	Base width = 1m. Depth varies but normally about 1m. Trapezoidal shape.
Calculations	Sizing undertaken using Manning's equation.
Lining	Grass or native vegetation to bed and banks.
Grey infrastructure	
Grey infrastructure is concrete kerb lines, sumps, pipes and manholes for conveyance where width is not available for swales.	
Road drainage systems	Conveyance systems sized using Colebrook-White tables, Mannings formula, HADES backwater calculation software, calculators and other software.
Open channel systems	Concrete lined open channels where width is constrained and conveyance important, with dimensions based on precast concrete products. Mannings equation and software.
Stormwater Management Facilities	

Stormwater management facilities are locations where rainfall runoff from the road corridor is treated and attenuated prior to discharge into the receiving environment. Each facility includes the three elements of sediment forebay, constructed wetland and attenuation basin plus flow controls between elements and the outlet. Typical concept design stormwater management facilities are shown in 300-C-9000 series Typical Details – Stormwater Drainage.	
Key references are Auckland Council, GD01.	
General positioning and shape	At low points in the longitudinal profile of the highway swale system, on one side of the highway (not both sides to minimise bird movement across the highway), a footprint shaped to fit available land constraint and integrated with other infrastructure such as shared user path, culverts, stream diversion channels, accessways and property boundaries (as appropriate).
Main components	Connection pipeline from swale low point, forebay, bathymetric constructed wetland, flood attenuation basin, pipe or weir connections between ponds and discharge to receiving environment, rock lining scour protection. Maintenance access with safety in design considerations. Vegetation and landscaping to maximise cultural, amenity and ecological values as well as providing safe design for operation and maintenance.
Sediment Forebay	
The sediment forebay concentrates the collection of heavier sediments prior to further water treatment through the constructed wetland. The forebay would be cleaned more regularly than the constructed wetland and has easy access for machinery and is robust. The forebay reserves the wetland volume to concentrate treatment on a finer fraction of the suspended sediment loading. The forebay also serves to bypass larger flows away from the constructed wetland into the attenuation basin.	
Depth	1.5m is a recommended minimum; deeper where possible.
Length-to-width ratio	Minimum 2L:1W.

Side slope ratio	Minimum 1V:3H.
Design volume	Between 10% and 15% of the combined forebay, wetland and flood attenuation basin volume.
Constructed Wetland	
The constructed wetland contains a lined, shallow depth of water (at varying depths) with intensive planting in the water and landscaping around the perimeter. Water moves slowly through the wetland volume and is controlled by inflow and outflow throttles to prevent large rainfall runoff events from remobilising captured sediment. Flows from large events are bypassed to the attenuation basin in the forebay.	
Depth	Assumed average depth of 0.5m to allow for banded bathymetry. Range between 0.3m and 0.75m water depth bands. The basin is clay lined to hold water for long periods of time.
Length-to-width ratio	Minimum 3L:1W; increased to 5L:1W for design.
Side slope ratio	Minimum 1V:4H below top water level ("**TWL**").
Design volume	Water quality volume ("**WQV**"), determined from the 90th percentile storm which is assumed to be equivalent to the 2-yr 1-hr storm with climate change.
Flood Attenuation Basin	
The attenuation basin serves to hold larger rainfall runoff event volumes for controlled release through a throttled outlet pipe that regulates peak flows to a magnitude that is equivalent to the pre-development peak discharge for events up to the 1%AEP 24-hr event. The basin also serves to allow sedimentation of heavier suspended solids and encourages ground infiltration where conditions allow. In places through the Project where discharge is into a sub-surface soakage chamber, basins provide a reduced discharge loading and a cleaned runoff to reduce clogging risk. The basins are landscaped for aesthetic and environmental benefits, and are fully drained between storm events so that there is no standing water.	

Depth	Average depth = 1.5m.
Length-to-width ratio	Between 3L:1W and 5L:1W.
Side slope ratio	Minimum 1V:4H.
Design volume	Net runoff volume (post-development minus pre-development) generated by the road corridor for the 100-yr ARI 24-hr duration storm.
Outlet to receiving environment	Laid at base of basin to fully empty detained volume. Detailed design may introduce staggered outlet levels or sizes to better match the runoff regime over a range of ARI events. Detention for Flood Management: Maximum discharge rate from the attenuation basin outlet plus constructed wetland outlet is less than the pre-development 100-yr ARI 24-hr duration peak flow from the natural catchments under the highway footprint. The combined downstream flooding effect of attenuation Ponds 1 to 4 (which all drain into the Koputaroa Stream) during a 100 year ARI 24 hour duration event is described in Technical Assessment F (Hydrology and Flooding).

Soakage and Infiltration

Soakage facilities are engineered sub-surface volumes designed to enhance transfer of surface water into ground water. The engineered process is to treat surface water via a constructed wetland and attenuation basin prior to contacting the below-ground soakage facility to minimise long term soil clogging with suspended sediments. This also serves to treat stormwater that is disposed to groundwater. The soakage gallery volume is made up of a gravel volume or a plastic gallery void, wrapped in geofabric and in contact with the high-permeability gravel / sand layer.

Infiltration is considered to be surface water moving through the topsoil and upper layer of the soil column down into the deeper more uniformly graded soils. Over time, topsoil and upper soil layers have initial saturation rates but then naturally smaller rates of infiltration due to fine particles and organic components in the soil mixture.

Rates of soakage and infiltration are initially informed from field characterisation of the soil and with literature ranges, then factored down to account for the effects of long-term silting prior to maintenance renewal. Key design references are: Auckland Council documents GD01 Stormwater Management Devices in the Auckland Region (2017), GD07 Stormwater Soakage and Groundwater Recharge in the Auckland Region (2021); NZ Building Code Clause E1 Surface Water. The concept designs (shown in Volume III - Drawings) are indicative and will be adapted to the site constraints of the Project.	
Locations	Only placed in locations where the sub-surface geology is known to be conducive to long term ground soakage, and/or where surface drainage is not readily available, or where groundwater recharge is preferred as an effects mitigation.
Topsoil infiltration rate	Infiltration rate is taken from literature review based on the soil description taken from borehole TP247 near Arapaepae Road / Tararua Road. 500mm depth of topsoil and silty gravel, with infiltration rates between 30mm/day and 300mm/day based on multiple hand auger tests of similar soils and depths through the Project, and literature information. The nominated infiltration design rate range chosen: a base rate of 5-10mm/hr (or 120mm/day to 300mm/day) and factored down by 1/5 (ie: 1/factor of safety) to allow for natural silt clogging over time to give 1 to 2mm/hr (or 24-48mm/day).
Subsurface soakage rate	Soakage rate is taken from literature review based on the soil description taken from borehole TP247 near Arapaepae Road / Tararua Road. Sandy gravel layers commenced at 0.5m depth down to greater depths (>4m). Literature indicates soakage rates in gravel between 25m/day and 2500m/day (Domenico and Schwartz, Physical and Chemical Hydrogeology (1998)). For consenting design, the soakage design rate chosen: a base rate of 150mm/hr (3.5m/day) and factored down by 1/5th to

	allow for natural silt clogging over time to give 30mm/hr (or 0.7m/day). Permeability testing at each location will be carried out during detailed design.
Sub-surface gallery volume	For consenting design, indicatively 10% of the 100-year return period, 24-hour event runoff volume (made up from plastic chamber voids or rounded river cobbles).

STORMWATER CONSTRAINTS AND LIMITATIONS

45. The Ō2NL Project has various constraints including existing landform, topography, underlying geology, soils, groundwater, receiving environments and consented future development plans. While the constraints limit the use of some stormwater management systems, in all cases, there are suitable alternatives that achieve an acceptable stormwater management outcome. Significant design constraints and limitations related to stormwater management are described below, together with the proposed design measures intended to address those constraints and limitations:

    (a) The Ō2NL Project is proposed in a largely greenfield area with land purchase required in many locations to accommodate the highway footprint. The proposed stormwater management design endeavours to stay within land parcels already identified for purchase to avoid additional Project cost, as far as reasonably practicable.

    (b) The greenfield nature of the catchment means that significant mitigation of effects is required through flow attention and treatment of runoff.

    (c) Ecologists have advised that layouts involving wetlands / basins located adjacent to each other on opposite sides of the highway should be avoided if possible due to the risk of bird strike (resulting from birds flying low across the highway between ponds). The design response to help manage this effect is to install basins on only one side of the highway and to ensure careful selection of plant species.

    (d) The location of stormwater treatment facilities is dependent on the highway geometry which defines high points (top of catchment) and low points (discharge locations). The highway geometry is in turn governed by intersection locations, serviceability criteria, road design standards and guidelines, topography and earthworks volumes.

(e) Roadside swale locations are dependent on the superelevation of the highway meaning pipework is required at some locations to transfer flows from a median drainage strip to the inside of the superelevation, or from one side of the highway to the other.

(f) For a section between Ohau (near McLeavey road) and northeast of Levin (near Waihou Road), the highway runoff will be treated first and then discharged to ground via large soakage and infiltration areas. This is so that direct rainfall on the road corridor can be treated and discharged to ground to drain via a subsurface gradient to Punahau / Lake Horowhenua as happens presently.

(g) In the southern transition area of the Ō2NL Project near Ōtaki, topography, streams and the geometric transition of the highway connection at Ōtaki impose alignment and drainage constrictions. For surface water drainage, piped infrastructure drainage is needed to convey longitudinal drainage into stormwater treatment facilities.

(h) Each roundabout intersection and bridge decks will involve pipeline infrastructure leading to stormwater treatment facilities.

(i) Local roads which are to be realigned or changed because of the Project works will be constructed to the existing standard of drainage infrastructure of that particular road.

Exceedance Events and Blockage Risk

46. The stormwater management system has limitations in terms of size, treatment capacity and discharge attenuation and therefore is subject to exceedance events and overdesign scenarios which, by definition, are rare events.

47. Treatment capacity is sized on the 90th percentile storm (see future climate explanation below) as per New Zealand industry best practice - described in Auckland Council GD01, for example. This means that, on average, 90% of storm events per year will be fully managed through the stormwater treatment facility. Effectively this manages the critical "first flush" stormwater discharge and volume which can be considered as a 10mm/hour rainfall intensity or the first 25mm of rainfall. On average, 10% of storms in a year

will exceed the 90th percentile rainfall intensity or rainfall depth and effectively begin to activate a bypass flow route into the attenuation basin to avoid remobilisation of trapped contaminants in the wetland. The runoff from a larger or longer rainfall event will typically be less contaminated than the initial “first flush” volume that filled the treatment facility, and the water quality effect on the receiving environment due to 10% of over-design storms post attenuation settlement is minor.

48. The attenuation basins for concept design are sized to the future climate 1%AEP, 24-hour duration, design rainfall event in line with attenuation basin design in Auckland. In a residual sense, there is a 1% probability every year that a rainfall event could generate rainfall depths or intensities greater than the design rainfall event. In a practical sense, the attenuation facility will still capture and detain runoff up to its storage volume capacity and only then the residual rainfall runoff will spill over the emergency spillway facility and into the receiving environment. In such a case, the stormwater management facility is protected from damage by the emergency spillway and erosion protection measures at the spillway. The downstream receiving environment will be buffered by the attenuation basin storage volume to a reasonable extent in line with New Zealand industry practice. In a practical sense, the rainfall intensity in a storm after 24 hours duration is not normally as high as the initial phases of a storm event therefore the attenuation basin will still provide attenuation and suppression of peak runoff to the downstream receiving environment even if an over-design event occurs.

49. During a residual exceedance rainfall event, over and above the capacity of the attenuation facility, the emergency overflow weir will operate to control extreme flows and volumes into the receiving environment. After the event, the attenuation facility and the constructed wetland will gradually drain down through controlled outlets minimising long-term vegetation damage due to prolonged drowning.

50. Blockage is always possible and protective grills and design considerations are required to minimise this risk. If blockage of a pipe outlet in the constructed wetland or attenuation basin does occur, spillways operating in a series, out of the forebay and over the emergency spillway, from the attenuation basin embankment will manage flows through the overall facility until the blockage can be resolved.

CONCLUSIONS

51. The concept design Ō2NL Project highway stormwater management system is designed to:

    (a) Stormwater runoff treatment over more than 90% of road surface area in the Project.

    (b) Provide a treatment train approach that can capture and treat over 75-90% of total suspended solids, oils and soluble metals (copper and zinc) from road runoff for 90% of storms. The treatment train includes vegetated batter slopes, treatment swales and constructed wetlands before discharge into the receiving environment.

    (c) Manage flood risk through attenuation basins sized to decrease proposed road surface discharge rates from the road to pre-construction rates. The basins will accommodate storms (up to the 1%AEP, 24 hour duration event with allowance for future climate) including climate change, to buffer downstream flood risk impacts and receiving environments from an increase in peak flows and downstream flood levels. Ground soakage disposal will be used where feasible.

    (d) Manage 90% of storm events in terms of water quality and 99% of storms in terms of water quantity. Exceedance events are relegated to the largest 10% of storms in terms of water quality but effectively still treat the “first flush” portion of even those events. In terms of water quantity, exceedance events are 1% of storms and the design will manage the first part of such an event before activating emergency bypass facilities which are designed to minimise erosion effects on the environment.

52. Blockage and malfunction of the stormwater management facilities can still occur, but this risk can be managed with normal maintenance activities and built-in bypass and overflow components in the facilities.

53. The proposed concept design stormwater management system has been developed in consultation with iwi partners (as described in the CEDF (Appendix Three to Volume II)) and consists of highly functional facilities that

align with iwi values, with benefits including a natural aesthetic, improved amenity, and potential opportunities for community recreational involvement.

Nick Keenan

[17 October 2022]

STORMWATER MANAGEMENT REFERENCES

The following standards and guidelines have been used to inform the stormwater design:

1. Stormwater Management Devices in the Auckland Region, Guideline Document 2017/001 (Auckland Council, December 2017)

2. Stormwater Soakage and Groundwater Recharge in the Auckland Region Guideline Document 2021/007 Version 1 (Auckland Council, 2021)

3. Water Sensitive Design for Stormwater: Treatment Device Design Guideline (Wellington Water, December 2019)

4. Stormwater Treatment Standard for State Highway Infrastructure (NZ Transport Agency, 2010)

5. Hydraulic Energy Management: Inlet and Outlet Design for Treatment Devices, Technical Report: 2013/018 (Auckland Council, July 2013)

6. P46 Stormwater Specification (Waka Kotahi, April 2016)

7. NIWA HIRDS version 4, online: https://niwa.co.nz/information-services/hirds/help.

APPENDIX 1: POND 4 – DETENTION FOR FLOOD MANAGEMENT - EXAMPLE DESIGN

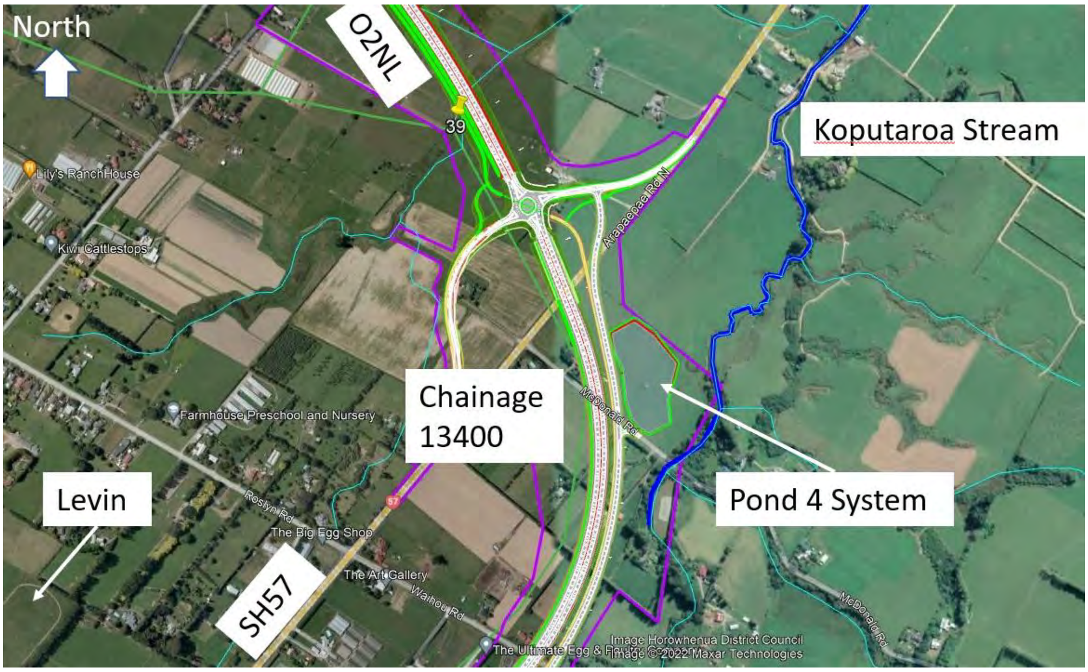

Figure 1: Pond 4 Location Plan

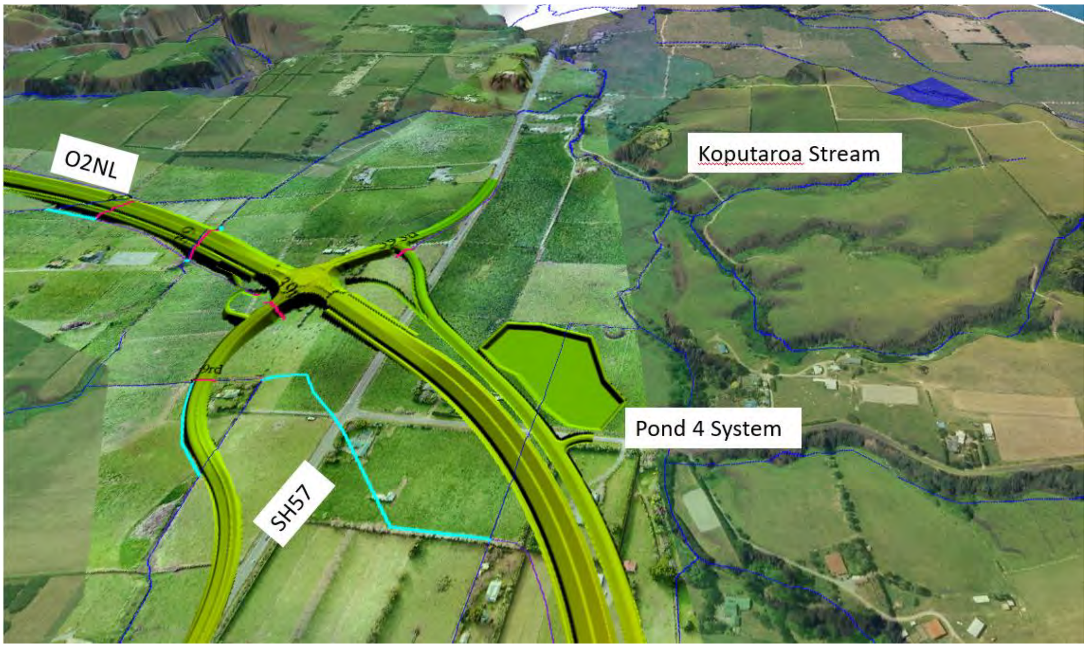

Figure 2: Perspective View of the Pond 4 location and proposed highway (vertical exaggeration applied)

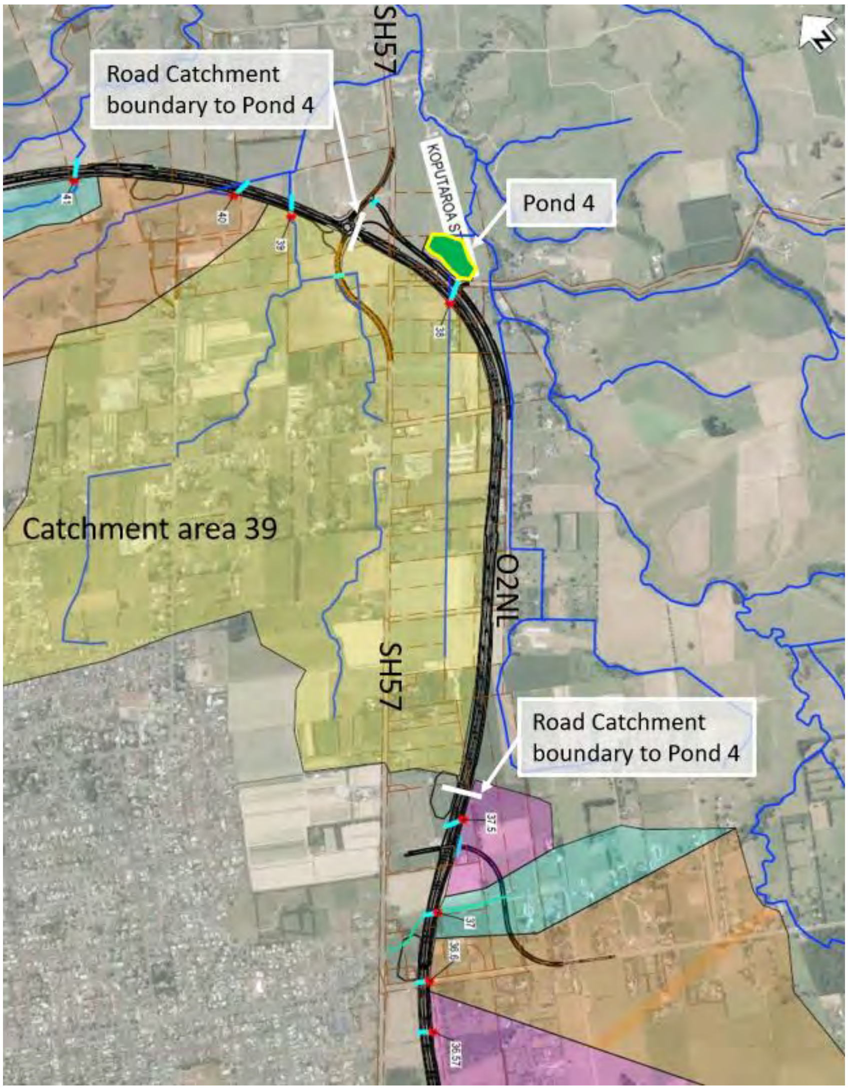

Figure 3: Catchment Areas near Pond 4 –indicating the length of road corridor that drains into Pond 4

Figure 4: Pond 4 100 year and 10-year ARI discharge including climate change for pre and post development hydrographs

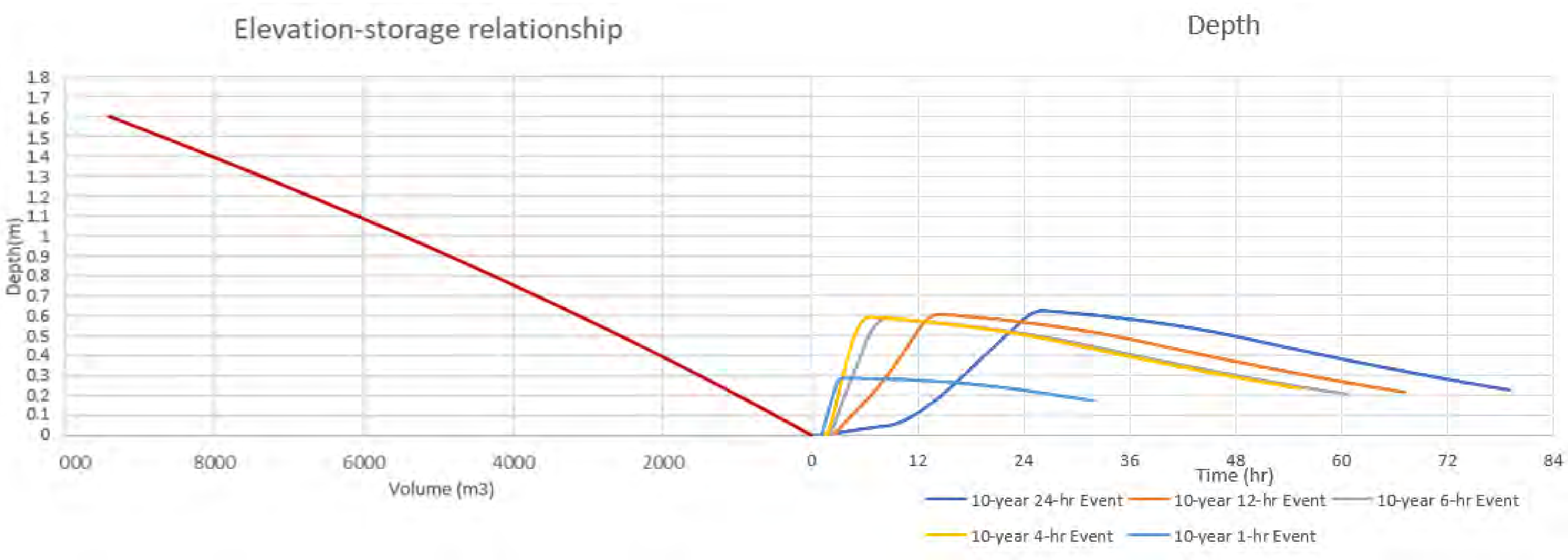

Figure 5: Pond 4: Depth, storage, time relationships

Appendix 4.3 Erosion and Sediment Control Technical Assessment Report

IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	applications for resource consents in relation to Ōtaki to North of Levin Project
BY	**WAKA KOTAHI NZ TRANSPORT AGENCY**
	Applicant

ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

APPENDIX 4.3: EROSION AND SEDIMENT CONTROL

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. The Ōtaki to North of Levin Highway Project (the Ō2NL Project or the Project) extends from Taylors Road, (to the north of Ōtaki) to Avenue North Road just north of Taitoko / Levin; an approximate distance of 24 km.

2. I have provided a design and assessment of the ESC measures and management approach to be implemented during the construction phase of the Project. My role has included the preparation of related management plans, namely the Erosion and Sediment Control Plan (ESCP) and its appendices.

3. The Ō2NL Project route will cross five major catchments, these are: Tributaries to the Waitohu Stream, the Waikawa River (including the Manakau Stream and Waiauti Stream), the Ohau River, the upper groundwater catchment of Punhaa / Lake Horowhenua, and the Koputaroa Stream (which is located in the Manawatū River catchment)) and multiple sub-catchments. The current water quality in these streams range from generally high (in the Ohau River and Waikawa Stream) to poor (in the Koputaroa Stream and tributaries to the Waitohu Stream).

4. The objectives of the ESC management of the Project are:

   (a) To minimise the potential for sediment generation and sediment yield by maximising the effectiveness of ESC measures associated with earthworks; and

   (b) To take all reasonable steps to avoid or minimise potential adverse effects on freshwater environments within or beyond the Project Area that may arise from the discharge of sediment during the construction of the Project.

5. I have prepared an ESC design approach based on Auckland Council Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region (GD05)[1], and Waka Kotahi Erosion and Sediment Control Guidelines for State Highway Infrastructure, September 2014 (the "**Guidelines"**). This approach represents industry best practice and will minimise the discharge of sediment during the construction phase to an acceptable extent and ensure that any potential adverse off-site effects are temporary.

[1] Horizons Regional Council refer to GD05 as the Guideline to be used when preparing Erosion and Sediment Control Plans.

6. The assessment of potential effects from the discharge of treated sediment laden runoff to the freshwater receiving environments has been based on estimates of sediment yield for various parts of the Project, using the Universal Soil Loss Equation (USLE). Having considered USLE estimates undertaken for other Waka Kotahi, infrastructure and land development projects that I am familiar with, and comparing those Project ULSE estimates with recorded sediment retention pond (SRP) performance within the other sites, I am satisfied that the sediment yield estimates undertaken for the Project are realistic and likely to be conservatively high, when compared to likely actual sediment yields that will occur during construction.

7. The ESC management of the Project will be guided by the ESCP which describes the overall principles and methodology to be adopted. The ESCP is supported by a range of management plans and procedures; including Concept ESC Drawings, a ChemTMP and the ESCMP, which details the extensive and ongoing monitoring and maintenance of ESC measures that will be implemented throughout the construction period.

8. The detail of the ESC measures to be implemented within a given area of the Project will be provided in Site Specific Erosion and Sediment Control Plans (SSESCPs). Those plans will provide the design detail of individual ESC measures to be implemented in an area and will be prepared and submitted to Councils for certification against the Guidelines and relevant consent conditions, prior to works commencing in that area.

9. The maintenance of best practice ESC will be driven by a dedicated Environmental Management Team, led by the Environmental Manager, and supported by an Environmental Technical Specialist, Environmental Coordinator, Environmental Supervisor. Day to day operation and maintenance of ESC measures will be undertaken by ESC Foremen and ESC Labourers.

10. The Project Environmental Management Team and Construction Management Team will work closely with Council’s compliance monitoring inspectors for the duration of the Project, to ensure a high standard of compliance and a no-surprises approach to design changes and site management.

INTRODUCTION

11. My name is Gregor John McLean.

12. I am a Director of Southern Skies Environmental Limited ("**SSEL**"), an environmental consultancy company specialising in erosion and sediment control ("**ESC**"), environmental management and planning.

13. This technical assessment will consider the erosion and sediment effects during the construction phase of the Ōtaki to North of Levin (Ō2NL) Project Accompanying this assessment are:

    (a) an overarching draft ESC Plan ("**ESCP**") (attached) and which includes (but not be limited to:

        (i) a draft ESC Monitoring Plan ("**ESCMP**"); and

        (ii) a draft Chemical Treatment Management Plan ("**ChemTMP**")

    (b) Concept ESC Drawings ("**Concept ESC Drawings**") which are provided in Volume III: Drawings and plans; and

    (c) three example Site Specific ESC Plans ("**SSESCPs**") which are also provided in Volume III: Drawings and plans. The remaining SSECPs are intended to be developed after consenting process but prior to construction of the relevant area of the Project.

Qualifications and experience

14. I have the following qualifications and experience relevant to this assessment:

    (d) I have a Bachelor of Arts degree in Planning and Geography from Massey University which I obtained in 1994.

    (e) I also have a Post Graduate Diploma in Resource Studies from Lincoln University which I obtained in 1996.

    (f) I am a member of the International Erosion Control Association, and am a Certified Professional in Erosion and Sediment Control (CPESC 7628).

    (g) I have worked for more than 25 years in environmental management.

    (h) I have spent the last 20 years as an environmental consultant at Southern Skies Environmental Limited. In this role I have:

(i) Provided advice to public and private sector clients about environmental projects including erosion and sediment control, chemical flocculation and adaptive management.

(ii) Provided advice to public and private sector clients on the preparation of resource consent applications, environmental management plans, flocculation management plans and erosion and sediment control plans.

(iii) Carried out environmental auditing for Greater Wellington Regional Council and Auckland Council.

(iv) Developed and delivered International Erosion Control Association 'Approved' Erosion and Sediment Control training courses, to contractors, consultants and councils throughout New Zealand since 2012.

(v) Been engaged as an independent erosion and sediment control expert for the Board of Inquiry - Transmission Gully Project and as an erosion and sediment control expert for Mill Creek Windfarm.

(vi) Provided project management services for a range of developments throughout Australasia.

(i) I am a co-author of the Erosion and Sediment Control Standard for the New Zealand Transport Agency (August 2010) and Auckland Council Erosion and Sediment Control Guideline (2015).

(j) Prior to working at Southern Skies Environmental Limited I worked for three years as a resource management consultant at Babington and Associates from 2000 to 2003. I was a planner at Opus International Consultants Limited from 1998 to 2000 and prior to that I worked for one year as a planner at New Plymouth District Council.

(k) I am a member of the Australasian CPESC Exam Marking Panel and am a volunteer for the Australasian IECA 2022 Awards Committee.

Code of conduct

15. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being

given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

16. I have been engaged to advise on and design the ESC methodology to be implemented during the construction phase of the Project and to provide a corresponding assessment of the likely erosion and sediment related effects associated with the Project's construction.

17. The scope of my assessment has involved:

    (l) a description and understanding of the receiving environment as it is relevant to my assessment;

    (m) identification and recommendation of ESC methods, practices and standards to be implemented and complied with as far as practicable during construction in order to avoid, remedy or minimise potential effects during construction of the Project;

    (n) an investigation and assessment of the potential sediment yields and sediment yield determining factors; and

    (o) development of the ESCP, ESCMP, ChemTMP, Concept ESC Drawings and example SSESCPs.

18. In the course of this work I have visited the Project Area twice.

19. This assessment should be read alongside the following:

    (a) **Mr Jamie Povall**'s Design and Construction Report ("**DCR**") (Appendix Four, Volume II, and to which this report is appended)

    (b) **Mr Andrew Curtis**'s Air Quality Assessment (Technical Assessment C in Volume IV)

    (c) **Mr Keith Hamill**'s Water Quality Assessment (Technical Assessment H in Volume IV)

    (d) **Mr Andrew Craig**'s Hydrology and Flooding Assessment (Technical Assessment F in Volume IV)

    (e) **Dr Alex James**'s Freshwater Ecology Assessment (Technical Assessment K in Volume IV)

Project Description

20. The Ōtaki to North of Levin Highway Project (the **"Ō2NL Project"** or the **"Project"**) extends from Taylors Road, (to the north of Ōtaki) to Avenue North Road just north of Taitoko / Levin; an approximate distance of 24 km.

21. The following sections are taken from the DCR. The design and construction of the Ō2NL Project is expected to be completed within approximately five years, with construction anticipated to commence in 2025 (advance works in middle of 2024). The target date for opening the new road is end of 2029.

22. In order to achieve the completion date, many elements of the Ō2NL Project are likely to need to be undertaken concurrently during the construction period, including the completion of works in sections. That is, the construction sequence set out below will generally be adhered to for each section. The construction works are likely to be undertaken in the general sequence set out as follows.

Figure 4.3.1: Indicative Construction Sequence

23. The Project will be divided into zones. Each zone will have a Zone Manager (who will liaise directly with the Environmental Management Team Project Engineer, Site Engineer, Site Supervisor and Foreman. The zone management approach allows the Project to be broken down into manageable sizes, for overall construction and environmental management. In addition, an Earthworks Manager will have overall responsibility for all earthwork's operations across all zones. The ESC management aspects are covered below in this report and in detail in the ESCP and the ESCMP.

24. The Project Engineer will have direct day to day responsibility for the operation and maintenance of the earthworks and ESC within their zone and will be supported and advised by the Environmental Management Team.

25. The Environmental Management Team will design the ESC (through the development of the SSESCPs) and advise during the construction of the devices with specific responsibility for the installation of the "hardware" (i.e. decants) and chemical treatment systems. The Environmental Management Team will have responsibility for the operation and maintenance of the chemical treatment systems and manage the ESC monitoring and auditing.

26. From an ESC perspective, the proposed construction methodology and sequence is a practical approach for carrying out the bulk earthworks required for the Project. This incorporates consideration of water management methodologies (to minimise use) and ESC implementation.

27. The construction staging approach provides a general sequence of works and has informed the preparation of this assessment, the ESCP, the Concept ESC Drawings and the example SSESCPs. Alternative construction staging would not lead to a particular need to adjust the ESCP.

28. Detailed ESC methodologies and associated details will be confirmed within the final SSESCPs which will be developed by the Project team and provided to the Regional Councils prior to associated construction works.

METHODOLOGY

29. This ESC Assessment covers the following:

    (a) existing environment

    (b) Overall Project Design to Avoid and Minimise Effects

    (c) erosion and sedimentation processes;

    (d) ESC management;

    (e) monitoring;

    (f) Sediment Yield Assessment;

    (g) assessment of sediment effects; and

    (h) conclusions.

EXISTING ENVIRONMENT

Topography

30. The alignment starts in the north at the proposed SH1(State Highway 1) intersection approximately 1.5km north of Levin. From here, the corridor extends south-east, passing over the NMIT railway and across rural and residential land with moderately sloping gullies for approximately 3km to the existing SH57. Then the alignment turns south-west and runs parallel to the existing SH57 over relatively flat farmland plains, crossing McDonald Road, Waihou Rd, Queen Street, Tararua Road and Kimberley Road.Past SH57 the corridor is positioned to the East of the current SH1 until it terminates at the Waitohu Stream, just north of Ōtaki. This section is the main stretch of the Ō2NL corridor, and it is characterised by alluvial plains to the east of the Tararua Ranges. The alignment crosses many streams and rivers through this section, including the Waikawa Stream, Kuku Stream and Ohau River, which have shaped the local topography. Near the southern end, the corridor crosses some large gullies between SH1 and the Tararua Ranges.

Geomorphology and Soils

31. The geomorphological setting and soils of the Alignment are described by Mr Clapcott[2], as ‘the project area is predominately characterised by alluvial deposits transported from the Tararua ranges during the late Pleistocene and Holocene interglacial periods. A large alluvial basin has been formed, which extends along the middle part of the project area from the eastern plains and towards the coast and has overlain or incised older shoreline and dune sand deposits. The alluvial deposits form localised fans and terraces around the existing and historical waterways, such as the Ohau River and Waikawa River.

32. Late Pleistocene shoreline deposits consisting of beach and aeolian deposits are exposed to the north and south near Levin and Ōtaki at the surface, as elevated sandy hills capped with loess. Through the middle of the project area these materials are found at depth, underlying the late Pleistocene and Holocene alluvium. Older, middle Pleistocene alluvium has been encountered below the shoreline deposits in some areas.

33. Wellington Greywacke is the basement rock in the area and is generally expected to be at depths exceeding 40 – 50 m along the alignment.

[2] SH1 Ōtaki To North Levin - Technical Report - Geotechnical, Section 3.2

Greywacke was encountered at depths of approximately 20 – 30m near the Ohau River and Tararua Ranges, close to the existing quarry.'

Freshwater Environment

34. Descriptions of the freshwater receiving environments of the Project are provided by Mr James[3] and Mr Hamill[4], and are adopted herein.

35. Five main surface water catchments are crossed by the Ō2NL Project, these are:

    (a) Waitohu Stream;

    (b) Waikawa Stream (including the Manakau Stream and Waiauti Stream):

    (c) Kuku Stream:

    (d) the Ohau River; and

    (e) Koputaroa Stream (tributary to the Manawatū River).

36. The Ō2NL Project also crosses the groundwater catchment of Lake Horowhenua / Punahau.

Existing Water Quality

37. As outlined in Mr Hamill's assessment, the current water quality in these catchments is variable, and largely dependent upon upstream land use, ranging from generally high (in the Ohau River and Waikawa Stream) to poor (in the Koputaroa Stream and tributaries of the Waitohu Stream).

Existing Freshwater Ecological Values

38. Mr James's Freshwater Ecology Assessment K assesses the ecological function of the streams within each of the catchments based on macroinvertebrate, fish and stream ecological valuation (SEV) data.

39. The ecological surveys indicated that the majority of sites were degraded by agricultural and/or horticultural land use. Based on flow permanence, SEV scores, habitat characteristics, macroinvertebrate community assemblages, and fish species present, the overall ecological values were:

    a) "High" – two sites (Ohau River and Waikawa River).

[3] Freshwater Ecology (Technical Assessment K)
[4] Surface Water Quality (Technical Assessment H)

b) “Moderate” – ten sites (Stream 39, Stream 39.1, Kuku Stream, Stream 29, Stream 27.1, Stream 19, Stream 17, Stream 18, Manakau Stream, and Waiauti Stream)

c) “Low” – all other permanently flowing streams.

d) “Negligible” – ephemeral waterways.

Overall Project design to avoid and minimise effects

40. As described in the DCR, determining the Alignment has taken account of a number of environmental, social and economic factors. I note in particular the bridges over the Waiauti, Waikawa, Kuku and the Ohau watercourses,. That will also reduce risk and complexity in terms of implementing ESC measures adjacent to those sensitive ecological environments.

EROSION AND SEDIMENTATION PROCESSES

41. Erosion occurs when the surface of the land is worn away (eroded) by the action of water, wind, ice or geological processes. Through the erosion process, soil particles are dislodged, generally by rainfall and surface water flow. As rain falls, water droplets concentrate and form small flows. As this flow moves down a slope, the combined energy of the rain droplets and the concentration of flows has the potential to dislodge soil particles from the surface of the land. The amount of sediment generated through erosion depends on the erodibility of the soil, the energy created by the intensity of the rain event, the site conditions (for example the slope and the slope length) and the area of bare earth or unstabilised ground open to rainfall (referred to as "open areas").

42. Sedimentation occurs when these soil particles are deposited. This occurs when runoff velocities become low enough for sediments to fall out of suspension. With the exception of filter socks and filter bags, sediment retention devices act as low velocity depositional environments by holding water back long enough for sediments to fall out of suspension.

43. The following terms represent the key aspects of ESC:

(f) Sediment generation – the process whereby erosion dislodges and mobilises soil particles. It is influenced by slope gradient, slope length, soils, rainfall, surface condition and erosion control factors; and

(g) Sediment yield – the amount of sediment that leaves the site and enters the receiving environment.

44. The purpose of ESC is to minimise sediment yield so as to appropriately limit off-site water quality and ecological effects during the earthworks phase of a project. Erosion control and sediment control must be implemented together to achieve these outcomes.

45. Erosion control is based on the practical prevention of dislodging and mobilising sediment in the first instance. If erosion control measures and practices are effective, then sediment generation will be minimised and the primary reliance on the sediment control measures is reduced.

46. Sediment control refers to management of the sediment after it has been generated. It is inevitable that sediment will be generated through land disturbance activities even with industry best practice erosion control measures in place. Sediment control measures are designed to capture this sediment to minimise any resultant sediment-laden discharges to waterways.

47. Reducing erosion will have the direct effect of reducing sediment generation and the sediment load carried in runoff. This improves the efficiency of sediment control devices and reduces the maintenance frequency required for those devices.

48. The overall effectiveness of the ESC management measures will have a direct effect on the sediment yield that discharges from the site and into the receiving environment.

ESC MANAGEMENT

49. This section provides an overview of the anticipated ESC management arrangements, noting that ultimately a constructor has yet to be appointed and hence titles and role split provided below may well differ.

50. A Project Environmental Management Team structure is described in the ESCP and is shown in Figure 4.3.2 below, comprising the Environmental Manager, supported by an Environmental Technical Specialist, Environmental Coordinator, Environmental Supervisor, ESC Foremen and ESC Labourers. As explained the constructor may have different titles or roles to these. However, it is expected that the overall scope of activities will be undertaken as generally described below, noting that these roles and activities are standard practice on major linear construction projects. The

ESC measures will be supervised by the Environmental Manager together with the Earthworks Manager.

51. The Environmental Manager will be responsible for ensuring that the Site-Specific Erosion and Sediment Control Plans (SSESCPs) are prepared in accordance with the Guidelines and this ESCP.

52. The Earthworks Manager will have overall responsibility of ensuring that the SSESCPs are complied with in terms of site operations, but with installation and management of the devices being undertaken by Zone Project Engineers with ESC technical support from the ESC Foremen and Labourers, under the direction of the Environmental Supervisor and management of the Environmental Manager.

53. A current and approved copy of all the SSESCPs will be on site and a copy will be held with the relevant Construction Zone Managers at all times.

54. The Environmental Technical Specialist will prepare SSESCPs and provide all technical specialist input into ESC management.

55. The Environmental Supervisor will maintain daily on-the-ground supervision of the ESC measures across the Project, supported by the ESC Foremen and Labourers, and construction teams.

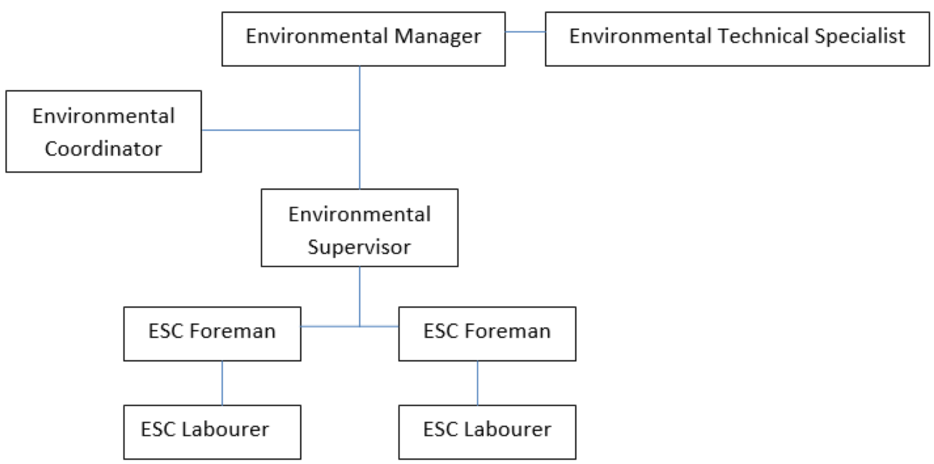

Figure 4.3.2: Indicative Project Environmental Management Team structure (Constructor may split roles and titles differently).

The ESC Guidelines

56. The ESC design approach is based on Auckland Council Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland

Region (GD05), and Waka Kotahi Erosion and Sediment Control Guidelines for State Highway Infrastructure, September 2014 (The Guidelines).

57. The Waka Kotahi Erosion and Sediment Control Guidelines for State Highway Infrastructure, September 2014, will be utilized solely for the sizing of sediment retention devices where the predominant soils are gravels.

Best practice ESC

58. All ESC measures will be designed, constructed and maintained in accordance with the Guidelines. It will be adopted throughout the Project's works and, for the reasons discussed herein and in supporting specialist assessments, is considered to appropriately manage and minimise potential adverse sediment related effects in the receiving environments.

59. Waka Kotahi has demonstrated a successful track record with respect to ESC associated with large infrastructure projects and the implementation and maintenance of the Guidelines and similar compliant controls and methodologies. This is typically based on an overarching ESC framework, provided through an ESCP coupled with SSESCPs or equivalent plans which focus on the management of specific sites and activities throughout the Project construction phase. This approach enables specific areas of high construction complexity to be identified, staged and successfully managed. The Project does not present any unique challenges and I anticipate that a high standard of ESC can be achieved, consistent with other projects.

Overall ESC objectives

60. As a minimum standard, all construction works will be undertaken in accordance with the Guidelines to:

    (h) minimise the potential for sediment generation and sediment yield while maximising the effectiveness of ESC measures associated with earthworks; and

    (i) take all reasonable steps to avoid or minimise potential adverse effects on freshwater environments within or beyond the Project Area that may arise from the discharge of sediment during the construction of the Project.

Key ESC management principles

61. ESC measures will be undertaken and implemented with a hierarchy and priority order as follows:

(j) Erosion control will be provided in all circumstances by minimising sediment generation through a range of structural (physical) measures and non-structural (methodologies and construction sequencing) measures.

(k) Sediment control will be implemented for all sediment laden discharges, primarily by chemically treated Sediment Retention Ponds (SRPs), which will be rationalised within the Project Area to ensure they are fully utilised, centralised, effective and do not create unnecessary earthworks in themselves.

62. The overarching ESC management framework is provided in the ESCP. All ESC methods will meet the minimum criteria of the Guidelines. In the unusual circumstance where some variation to the Guidelines approach is identified as the best option for a specific area or activity, that variation will be subject to the approval of the Council's through the relevant SSESCP.

63. The development of SSESCPs, in accordance with the direction and principles of the Guidelines and the ESCP, will allow for future flexibility and practicality of approach to ESC and will allow the ability to adapt appropriately to changing conditions.

64. Progressive and rapid stabilisation of disturbed areas using mulch, aggregate and geotextiles will be on-going during the construction phase. Temporary stabilisation will apply particularly with respect to spoil sites, material supply sites, stockpiles, ground improvement locations where topsoil is removed, concentrated flow paths and batter establishment. Permanent stabilisation will be carried out in accordance with the final design parameters and is likely to comprise establishing vegetation (e.g. topsoil and planting), placing mulch and exposed rock surfaces.

65. Stabilisation will need to be appropriate to the soil type, geology and time of year with the intent of achieving at least 80% vegetative cover or other non-erodible surface. Stabilisation is designed for both rainfall and wind erosion control (dust minimisation) and will be progressively implemented.

66. All SRPs and Decanting Earth Bunds (**"DEBs"**) will be chemically treated where bench testing confirms the effectiveness of chemical treatment for those soils. A ChemTMP has been prepared and is appended to the ESCP. The ChemTMP provides a management framework for the implementation of

chemical treatment within the Project Area. A schedule within the ChemTMP will be progressively updated as bench testing is undertaken throughout the Project works. The ongoing bench testing will establish the dose rate and set-up details for the dosing systems within each SSESCP catchment.

67. Stream works will be undertaken in a manner that recognises the higher risk of this activity, from a sediment generation and discharge perspective, and the sensitivity of the receiving environments. Proposed works within and close to streams (including placement of culverts and creation of stream diversions/ drains) are described in the DCR, Appendix Four to Volume II.

68. Works within active stream channels and any associated works will be undertaken in a 'dry' environment. This will be based upon diversion of flows around the area of works or undertaking construction 'off–line'. Consideration will also be given to peak fish spawning and fish migration periods (if relevant), during which time stream works will be carefully managed or avoided (refer to the Ecological Management Plan (EMP) as specified in conditions provided at Appendix Seven to Volume II).

69. Monitoring and management of all ESC measures will be undertaken by the Project's constructor (Environmental Management and Construction Management Teams (or equivalent)). Environmental management and ESC will form a key component of all construction planning. This monitoring and management are key factors that will determine the construction environmental success of the Project.

Site specific erosion and sediment control development

70. The inter-relationship between the ESC management documents is provided in the figure below.

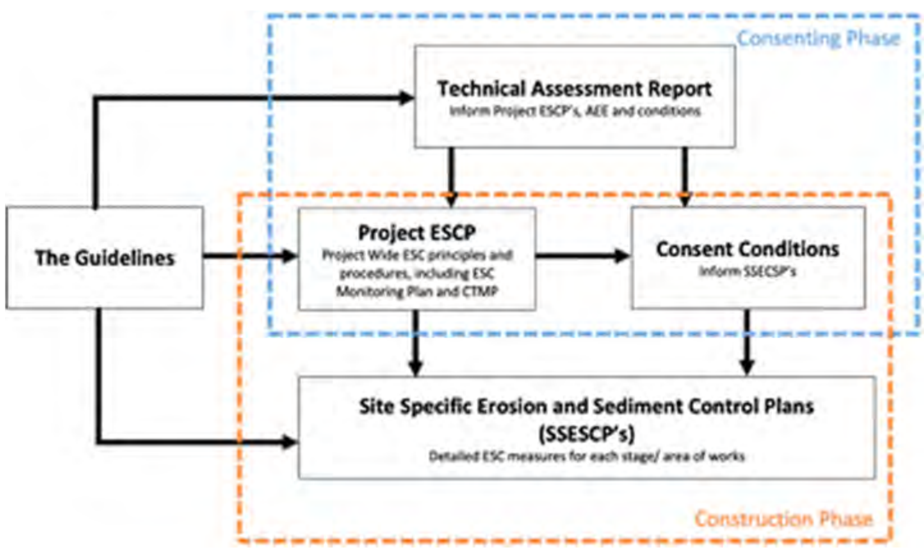

Figure 4.3.3: ESC management document structure

71. Prior to earthworks (or stream works) commencing at a given location, a detailed SSESCP will be prepared and submitted to the Councils for certification against the conditions, the Guidelines and the ESCP. The SSESCPs will be prepared in accordance with the Guidelines and specific consent conditions and will be informed by the principles of the ESCP. The SSESCPs will enable specific construction constraints and opportunities to be incorporated into the ESC design for the works at that location. Consistent with the adoption of this approach in other projects, it will allow for enhanced outcomes and the opportunity for implementing innovative practices, particularly in sensitive locations.

72. The SSESCPs will be succinct and focussed technical documents and will include drawings that will detail the ESC measures of that area.

73. The SSESCPs will take account of the following factors:

    (l) the specific construction activity to be undertaken;

    (m) the area and volume of earthworks, and/or the nature of the stream works at specific locations, and identification of the downstream receiving environment;

    (n) the locations of all earthworks and/or stream works;

    (o) methods for managing construction water effects for specific activities;

    (p) the duration of the earthworks and/or stream works;

    (q) the time of the year that the stream works are to be undertaken, and where applicable, the measures to be implemented to respond to any heightened weather risks at that time;

    (r) stabilisation methods and timing to reduce the open area at key locations to assist with a reduction in sediment generation; and

    (s) chemical treatment (flocculation) at SRPs and DEBs.

MONITORING

74. An ESCMP has been developed for the Project and is included in the ESCP. It provides a programme and methodology to ensure that ESC measures have been designed, installed and managed in accordance with the ESC management structure described above, and to monitor the effectiveness of ESC for the duration of the construction phases of the Project.

75. Environmental compliance and performance will be achieved through appropriate location, design, installation, as-built certification, maintenance, and monitoring of ESC devices. ESC management in this context is not restricted to physical structures but also includes work practices and methodologies.

76. As-built certification of devices is a critical element of effective site management. As-built checklists and/or drawings will be prepared for all controls to ensure that they have been installed as designed. Works within the catchment of an ESC device will not commence until the as-built document for the device (or devices) has been certified by a suitably experienced ESC practitioner.

77. Regular monitoring will be undertaken by the constructor (Environmental Management Team and ESC Foremen (or equivalents)) to ensure ESC devices are operating as designed and are maintained in accordance with guidelines and consent conditions. This monitoring underpins the successful implementation of the ESC management system, to achieve the anticipated environmental outcomes and ensure compliance with the resource consent conditions. This monitoring includes pre- and post-rainfall checks and maintenance and is considered "business as usual".

78. The monitoring will also provide continual feedback to ensure successful ESC performance and early detection of activities or problems that have the potential to result in an adverse environmental effect.

79. The frequency of the device monitoring will vary throughout the year and reflect areas of changing activity and risk within the Project Area. During active construction in any given area, the monitoring will be undertaken daily as well and pre- and post-rainfall events. Monitoring will report any repairs or issues that need to be addressed and the timeframe for completion of those actions.

80. The regular monitoring will be supported by monitoring of the chemical treatment systems, weather, rainfall trigger events, and will include wet weather responses and contingencies.

Weather forecasting, recording and responses

81. Weather forecast monitoring will form an important part of the Project's ESC management and will initiate pre-rain inspections as well as inform the timing of higher risk activities such as stream works.

82. Monitoring weather forecasts is also a critical tool in managing weather events and prompt site preparation for the event. The constructor (Environmental Management Team or equivalent) will utilise readily available forecast methodologies including metvuw.com and metservice.com. Forecast maps will be reviewed daily and assessed for periods of wet weather as required.

83. Rainfall will be recorded by telemetered rainfall monitoring stations that will be installed on site to provide real-time continuous rainfall intensity and volume data. That real-time data will be available via a range of platforms including mobile phone apps. Email and text notifications will be programmed to ensure relevant staff, including the Environmental Management Team, are alerted when rainfall trigger events occur.

84. Recorded rainfall will be compared to forecasts to assist more accurate rainfall prediction as the Project progresses.

85. Where more significant rainfall events are forecast, including trigger events (discussed below), additional site inspections will be undertaken by the constructor (Environmental Management Team or equivalent) to ensure all ESC measures are fully operational and identify any additional measures that could be installed, such as additional sediment sumps or contour drains.

Chemical treatment monitoring

86. A core part of chemical treatment management is monitoring to check that the systems are all working as anticipated and to provide information to facilitate ongoing management of the chemical treatment systems.

87. Monitoring and maintenance of the chemical treatment systems will be undertaken in accordance with the ChemTMP and the ESCMP. It will include a visual inspection of the chemical treatment system at least weekly and pre- and post-rainfall, and inspection of clarity of impounded water and discharges from SRPs and DEBs. All components of the treatment system will be checked, including the catch trays, inlet and outlet hoses, and chemical discharge location. The pH of the discharge will be checked to ensure that it is within the 5.5 to 8.5 range.

88. As required, the tanks will be drained of rainwater and the chemical reservoir will be refilled. The chemicals will be securely stored in drums contained in the sheds or in Immediate Bulk Containers ("**IBCs**") adjacent to the sheds, depending on the treatment system used at any given site.

89. Where clarity is less than 100mm, a suitably experienced ESC specialist will be contacted and the ESC system for that device will be reviewed. This may include re-testing of soils and adjusting the dose rate.

Trigger event monitoring

90. The objective of this monitoring is to understand the performance of the Project's ESC measures through a range of larger (but still relatively frequent) storm events.

91. Two rainfall response triggers will be adopted; being 15mm in one hour, and 50mm in 24 hours. These triggers have been adopted as intensities and durations above which a range of more significant outflows are likely to occur from SRPs and DEBs.

92. When a trigger event is forecast, a pre-rain inspection will be undertaken by the constructor (Environmental Management Team in conjunction with the Construction Management Team or equivalents). The purpose of the inspection will be to ensure that the site is fully prepared for the higher intensity and/or duration rainfall event and identify any additional measures that could be adopted to further minimise the risk of sediment discharges.

93. When a rainfall trigger occurs, the constructor (Environmental Management Team (or equivalents) members and key Construction Management Team members) will be notified via the telemetered rainfall monitoring stations and site monitoring will be initiated.

94. Rainfall triggered monitoring will be prioritised to the ESC devices in the following catchments, as follows.

- Catchment B (Waitohu),
- Catchment C (Waitohu),
- Catchment I (Mangahuia).
- Catchment M (Ohau River),
- Catchment J (Waikawa),
- Catchment L (Kuku Stream)
- Catchment F (Manakau)

95. The prioritisation of catchments has been determined by Mr Hamill's assessment as having both a high risk of sediment release from earthworks and high ecological values.

96. Manual clarity checks will be made at each SRP and DEB, using a Secchi disc or Clarity Tube.

97. Where the clarity of a device is less than 100mm, the following actions shall be undertaken.

- Within 24hrs of an exceedance, a full audit of the condition of the control device and its contributing catchment will be carried out and recorded in writing (refer Te Ahu a Turanga example at Appendix 4.3.A).
- Remedy and record any obvious causes on site that may have contributed to a threshold exceedance as soon as practicable.
- Identify any additional reasons for the exceedance and opportunities to modify the management of the site to improve overall efficiency which may include:
  - Consider additional ESC;
  - Refinement of chemical treatment systems;
  - Progressive stabilisation in sub-catchments;
  - Increase maintenance of controls; and
  - Amendments to methodologies and sequencing of works and refinement of controls necessary (check that a further approval is not required from Horizons.

98. In consultation with Councils, implement alterations to erosion and sediment control measures and methodologies.

Reporting

99. Details of the proposed reporting are provided in the ESCMP. An internal audit will be undertaken by the constructor (an Environmental Manager or Environmental Technical Specialist equivalent) at least weekly.

100. Details and timeframes will be issued by the constructor (Environmental Manager or Environmental Technical Specialist to the relevant ESC Foreman (or equivalent), with specific actions and closeout timeframes. The ESC Foreman (or equivalent) will report completion of those actions and the Environmental Manager or Environmental Technical Specialist (or equivalents) will inspect the works and close-out the items in the Management System.

101. For programmed Council inspections, a member of the Environmental Management Team or Environmental Technical Specialist (or equivalents) will accompany the Council inspector in all audits. Usually a member of the Construction Management Team will also be present.

102. As for internal audits, all ESC maintenance actions identified by the Council inspector will be recorded by the Environmental Manager or Environmental Technical Specialist (or equivalents), who will issue Work Instructions with details and timeframes to the ESC Foreman (or equivalent) in accordance

with the Council's instruction. The ESC Foreman will report back on the completion of those actions to the Environmental Manager or Environmental Technical Specialist, who will inspect and confirm the compliance of the works; and email confirmation to the Council inspector.

103. Following a rainfall trigger event, a site ESC summary of the performance of SRPs, DEBs and overall ESC system observed during the rainfall event will be provided to Council .

Annual report

104. An annual report containing monitoring results and an assessment of discharge performance will be provided to Council. This report will contain a summary of the results of all monitoring within that period, discussion on device performance, and a summary of responses to rainfall triggers. This report can be combined with other annual reporting requirements.

SEDIMENT YIELD ASSESSMENT

Approaches to Estimating Sediment Yield

105. For consenting purposes, the requirement to estimate sediment yield from earthworks projects has varied throughout New Zealand. The practice of forecasting likely sediment yield from construction sites began in the Auckland region during the 1990s and was used to assist in the design of ESC measures within a project. This approach allowed potential variability in sedimentation yield across a site to be identified as well as informing the construction industry of the indicative volumes of sediment that could be generated and discharged from earthworks if not appropriately managed.

106. With respect to more recent Waka Kotahi projects, various approaches to estimating sediment yield and associated effects have been applied. These have ranged from assessments based on typical earthworks catchments within a project area, to project-wide modelling and estimates using various assessment tools.

107. The most commonly used estimating tool has been the USLE. More sophisticated modelling tools have also been used, including the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model, which was applied to the Ara Tuono – Puhoi to Warkworth (P2WK) project, in conjunction with the USLE.

108. The P2WK project team in particular invested significant time and cost to derive estimates of sediment yield to a high degree of resolution, albeit subject to the uncertainty associated with the assumption inputs applied to the modelling.

109. For the recently consented Te Ara o Te Ara - Mt Messenger Bypass, the Waka Kotahi project team adopted the estimated hill country annual sediment yield value derived from the P2WK modelling, based on an assumption of sufficiently similar soil types and topography.

110. For the Huntly Bypass, the Waka Kotahi project team provided USLE calculations for three typical SRP catchments within the alignment (being steep (2.17ha), moderate (2.1ha) and low gradient (2.08ha)) as representative of the project without any further project-wide extrapolation.

111. For the Te Ahu a Turanga Project, the Waka Kotahi project team provided USLE calculations for eight typical SRP catchments within the alignment located across the steeper land, central plateau and flat land as representative of the project.

112. Waka Kotahi now have a breadth of experience in the performance of ESC management tools derived from monitoring undertaken on various roading projects[5]. This includes the data derived from P2WK as discussed below. This information allows greater confidence in estimating sediment yields and confirming the relevance (or otherwise) of the available prediction tools.

P2WK – Predicted and Actual Sediment Yield and ESC Performance

113. A Construction Water Assessment Report (CWAR) was prepared in the consenting phase of the P2WK project and provides an assessment of the anticipated construction water effects of that project. The CWAR provided an assessment of anticipated sediment yields for the two primary catchments across site – Mahurangi catchment and Puhoi catchment. Separate sediment yields were established for the Mahurangi hill country and Mahurangi flat country. Sediment yields within the CWAR were calculated using the USLE and a GLEAMS model. These predicted a construction sediment yield of 49.1 t/ha/year for the hill country and 22.9t/ha/year for the flat country.

114. Once construction commenced a suite of monitoring requirements were triggered by the resource consent conditions. The conditions require an analysis of trends in SRP performance in the monitoring data by comparison

[5] Including P2WK, Northern Gateway, SH16-SH18, SH16 Te Atatu and Lincoln Road, Waikato Expressway, Tauranga Eastern Link, East Taupo Arterial, Transmission Gully, Christchurch Southern and Northern Motorways.

with previous periods, different ponds and with the original estimated sediment yield calculation for each stage of works (as extrapolated from the yield predicted in the CWAR for the relevant focus areas).

115. The calculated sediment yield is used to determine the estimated tonne of sediment discharged during each stage of work. The CWAR, in comparison, assumes that the maximum area is open for the entirety of the works and the controls in place are operating at capacity.

116. Manual grab samples are taken at the outlet of all SRPs and selected DEBs during or immediately after rainfall events which exceed 25mm/24-hour period and/or 15mm/hour. The samples are sent to an accredited laboratory to determine the TSS concentrations. Over time a sediment yield is calculated using the TSS results and by estimating the quantity of water discharged from site via sediment controls. The sediment discharge (total sediment yield per hectare per year) is extrapolated using the results from each rainfall event and quarterly period.

117. Correspondingly, automated sampling of inflow and outflow TSS has been recorded at four sediment control devices and used to derive pond efficiencies.

118. The validity of a sediment yield derived from manual grab samples is limited as manual grab samples do not capture fluctuations in outlet TSS over the duration of the storm event. To address this the automated monitoring data from the four sediment controls has also been analysed to determine the difference between the outlet TSS at the time manual grab samples were taken and the peak outlet TSS measured during the storm. The worst case mean ratio has been applied as a “multiplier” to the manual grab sample sediment yields calculated.

119. Table 4.3.1 below provides the output of the analysis undertaken. It shows that the original values of sediment yield derived from the GLEAMS modelling and USLE calculations (49.1 t/ha/yr for hill country and 22.9 t/ha/yr for flat country) significantly overestimated the actual yields being produced by the P2WK project.

Table 4.3.1: Sediment yield ranges.

Catchment	Lowest range (best case) (t/ha/yr)	Highest range (worst case) (t/ha/yr)	Predicted (t/ha/yr)
Mahurangi flat country	0.41	6.18	22.9

Mahurangi hill country	2.99	16.9	49.1
Puhoi hill country	1.05	17.61	49.1

120. The data recorded to date at P2WK has shown that the predictive tools used to estimate sediment yield for that project significantly overestimated the yields in fact discharged from the site following implementation of industry best practice ESC measures.

121. Therefore, in my opinion, the USLE outputs derived specifically for this Project will not underestimate sediment yield and can be relied on by various experts to inform their assessment of likely downstream sediment-related effects of the Project.

Estimate of Sediment Yield for the Project

122. Three USLE estimates of sediment yield have been undertaken for typical SRP catchments within the Project. These are provided in **Appendix 4.3.B**.

123. Applying an estimate that best reflects the topography or soil type of given section of earthworks within the Project, USLE estimates have been applied to the footprint of earthworks within the main stream systems crossing the Alignment (including sub-catchments) to derive estimates of sediment load in tonnes from the Project for one year, being the first year of works within each given area. A full spreadsheet of the derived values is provided in **Appendix 4.3.1.1**.

124. To the greatest extent practicable, earthworks areas will be treated by chemically treated SRPs, which are the most efficient sediment retention device. Areas treated by DEBs and silt fences will be minimised as far as practicable and will not be a significant component of the overall treatment system within any area of works.

125. The USLE values reported above include the following assumptions:

(a) Soil composition based on geotechnical investigations.
   - 50% clay, 45% silt, and 5% sand.
   - 20% clay, 10% silt, and 70% sand
   - This is considered to be a conservative assumption for the site on the basis of available data.

(b) The catchment will be fully exposed for the full eight months of the earthworks period each year and is assumed to have a bare rough surface with a corresponding sediment delivery ratio of 50% which is the value typically adopted for that scenario. In practice some areas will be progressively stabilised, such as cut and fill batters, and progressive stabilisation of completed areas.

(c) No use of contour drains. In practice contour drains will be implemented to break up flow path lengths and correspondingly reduce sediment generation.

(d) Assumed 95% average treatment efficiency for chemically treated SRPs[6]. This value has been generally accepted for Waka Kotahi and other earthworks projects throughout New Zealand and is supported by real-time automated monitoring of ponds within various projects[7].

(e) Assumed 80% average treatment efficiency for chemically treated DEBs, based on the Guidelines design.

126. Table 4.3.2 below provides a summary of the estimated sediment yields (t/ha/yr) and loads (t/yr) derived from the USLE estimates for each stream system that crosses the Alignment, as identified in **Appendix 4.3.2**. It presents the sediment yield estimated for the initial year of works in each SRP catchment based on the footprint of earthworks within the catchment, a corresponding estimate of sediment yield for that same footprint under the existing land use, and presents the additional load that will result from the earthworks over that period. In addition, the existing landuse estimated sediment yields have been extrapolated to include the area of each catchment that lies beyond the works footprint.

[6] Auckland Regional Council Technical Publication 227 – *'The Use of Flocculants and Coagulants to Aid the Settlement of Suspended Sediment in Earthworks Runoff : Trials, Methodology and Design, June 2004'*
[7] P2WK; Milldale Development Stages 1 and 2

Stream	Earthworks area total (ha)	Indicative USLE Catchment	Sediment yield earthworks (t/ha/yr)	Sediment load earthworks (t/yr)	Sediment yield from existing land within earthworks footprint (t/ha/yr) (using same indicative USLE catchment)	Sediment load from existing land within Project earthworks footprint (t/yr)	Sediment load difference: earthworks minus existing (t/yr)	Stream Catchment (ha)	Catchment Sediment Load Before (t/yr) (based on USLE existing land assumptions)	Catchment sediment load during earthworks (t/yr) (catchment sediment load + sediment load difference)	Catchment Sediment Load Increase (t/yr)	% Increase catchment sediment load	Earthworks area as % of catchment
Greenwood WQ0	7.38	SRP Wetland 12	0.047	0.35	0.01	0.07	0.27						
Greenwood Stream Catchment WQ0	7.38							187	1.87	2.14	0.27	13%	3.95%
Waitohu Trib 2 WQ2	20.30	SRP 33700/ DEB 33650	0.9	18.27	0.13	2.64	15.63						
Waitohu Trib 2 Stream Catchment WQ2	20.30							144	18.72	34.35	15.63	46%	14.10%
Waitohu Trib 1 WQ5	22.70	SRP 33700/ DEB 33650	0.9	20.43	0.13	2.95	17.48						
Waitohu Trib 1 Catchment WQ5	22.70							127	16.51	33.99	17.48	51%	17.87%
Waitohu Trib 3 WQ11	8.57	SRP 33700/ DEB 33650	0.9	7.72	0.13	1.11	6.60						
Waitohu Trib 3 Catchment WQ11	8.57							27	4	10.11	6.60	65%	31.74%
Waiauti WQ14	11.75	SRP 33700/ DEB 33650	0.9	10.57	0.13	1.53	9.05						
Waiauti Stream Catchment WQ14	11.75							792	102.96	112.01	9.05	8%	1.48%
Manukau WQ15	2.73	SRP 33700/ DEB 33650	0.9	2.46	0.13	0.36	2.11						
Manukau Stream Catchment WQ15	2.73							750	98	99.61	2.11	2%	0.36%
Manukau Trib WQ17	9.59	SRP 33700/ DEB 33650	0.9	8.63	0.13	1.25	7.38						
Manukau Trib Catchment WQ 17	9.59							85	11	18.43	7.38	40%	11.28%
Manukau Trib WQ18	3.85	SRP Wetland 12	0.047	0.18	0.01	0.04	0.14						
Manukau Trib Catchment WQ 18	3.85							85	0.85	0.99	0.14	14%	4.53%
Mangahuia WQ19	28.87	SRP 11000	0.17	4.91	0.03	0.87	4.04						
Mangahuia Stream Catchment WQ19	28.87							202	6	10.10	4.04	40%	14.29%
Waikawa WQ27	7.35	SRP Wetland 12	0.047	0.35	0.01	0.07	0.27						
Waikawa Stream Catchment WQ27	7.35							3211	32	32.38	0.27	1%	0.23%
Waikokopu Kuku Trib WQ29	9.59	SRP Wetland 12	0.047	0.45	0.01	0.10	0.35						
Waikokopu Kuku Trib Stream Catchment WQ29	9.59							198	2	2.33	0.35	15%	4.84%
Kuku WQ32	29.14	SRP Wetland 12	0.047	1.37	0.01	0.29	1.08						
Kuku Stream Catchment WQ32	29.14							960	10	10.68	1.08	10%	3.04%
Ohau WQ33	27.94	SRP Wetland 12	0.047	1.31	0.01	0.28	1.03						
Ohau Stream Catchment WQ33	27.94							13687	137	137.90	1.03	1%	0.20%
East Levin	100.49												
East Levin	100.49								0	0.00	0.00	#DIV/0!	#DIV/0!
Koputaroa WQ39	43.75	SRP 11000	0.17	7.44	0.03	1.31	6.12						
Koputaroa Stream Catchment WQ39	43.75							1489	45	50.79	6.12	12%	2.94%
Koputaroa Trib WQ41	27.19	SRP 11000	0.17	4.62	0.03	0.82	3.81						
Koputaroa Stream Catchment WQ41	27.19							595	18	21.66	3.81	18%	4.57%

Table 4.3.2 – Estimated Sediment Yields

ASSESSMENT OF EFFECTS

Positive effects

127. The primary positive effects of the Project are transport related. The ESC methodology discussed in this report is mitigation for potential sediment-related adverse effects during construction.

Adverse effects

128. The sediment loads predicted are only a portion of the overall load that will enter a given stream during a rain event. While most of the stream catchments include forest and regenerating forest, all include significant areas of pastoral farming. Sediment sources within those catchments will include sediment laden runoff from existing pasture, forest, stream bank and stream bed erosion, land slips, farm tracking and sundry other sources.

129. The potential adverse effects of the predicted sediment yield from the Project on water quality and the freshwater receiving environments are assessed and reported on by Mr Hamill and Mr James (Technical Assessment H: Water Quality; and Technical Assessment K: Freshwater Ecology). I rely on those assessments to support my conclusion that with the implementation of the best-practice ESC methodology that I have described above, construction of the Project is unlikely to result in significant sediment-related adverse effects downstream of the Project Area.

130. The right-hand column of Table 4.3.1.2 provides the total area of each stream system and illustrates the proportion of each catchment that the earthworks will comprise. Sediment will continue to be generated from the existing landuses within those catchments, via surface water runoff, stream bank and bed erosion, and potential periodic land slips.

131. In my opinion, erosion and sediment control management can be achieved, operated and maintained to a high standard in accordance with the expectations of the Guideline and specifications document to minimise the sediment related effects of the Project. This conclusion is based on my personal experience of roading and other projects that have implemented the same standard of ESC practice, the Project emphasis on proactive monitoring to maintain the performance of all ESC devices and the conservatism in USLE estimates.

CONCLUSION AND RECOMMENDATIONS

132. A best-practice ESC management system will be an integral part of the construction team and will be implemented for the duration of the earthworks phase of the Project.

133. Suitably qualified ESC practitioners experienced in large scale roading projects in similar terrain as the Project will design and supervise the construction and management of ESC measures throughout the Project.

134. Comprehensive monitoring of the ESC management system is proposed to be undertaken to ensure that it performs as anticipated, and that off-site impacts remain within the envelope of effects predicted and assessed through this ESC Assessment.

135. Subject to the ongoing implementation of the proposed ESC management system, the sediment yield from the Project will be appropriately minimised and will not result in significant adverse downstream effects.

136. The resource consent conditions should include the requirement to implement and monitor the ESC measures described through the ESCP and its Appendices (in accordance with the Guidelines). This includes the Concept ESC Drawings, example SSESCPs and ESCMP.

DISCLAIMERS

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

We understand and agree that our client will submit this report in support of an application for resource consent and that Horizons Regional Council and Greater Wellington Regional Council as the consenting authorities will use this report for the purpose of assessing that application.

We understand and agree that this report will be used by Horizons Regional Council and Greater Wellington Regional Council in undertaking their regulatory functions in connection with resource consent applications associated with the Project.

APPENDIX 4.3.A - **TE AHU A TURANGA TRIGGER RESPONSE FORM**

APPENDIX 4.3.B - USLE

Universal Soil Loss Equation	**Project**	O2NL	**Total Estimated Sediment Yield**	0.2912
			Total Catchment Area (ha)	5.00

Sub-Catchment	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
SRP Wetland 12 - Pre development	38	0.10	0.48	0.02	1.00	5.00	1.00	0.1858	0.30	0%	0.0557
SRP Wetland 12	38	0.26	0.48	1.00	0.90	5.00	0.67	14.4904	0.30	95%	0.2174
SRP Wetland 12	38	0.26	0.48	0.15	1.00	5.00	0.33	1.2075	0.30	95%	0.0181

Sub-Catchment Description	SRP Wetland 12 - Pre develop	*Subcatchments must be named to be included in summary*			
Exposed Catchment Area (ha)			Exposed Area (ha)	5.000	
Average Catchment Slope (%)			Average Slope %	2.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Topsoil	User Defined	0.10	
Slope Length and Steepness Factor	LS	User defined Slope length		0.48	575
Ground Cover Factor	C		Pasture - undisturbed	0.02	
Roughness Factor	P		Pasture - undisturbed	1.00	
Sediment Delivery Ratio				0.30	
Sediment Control Measure Efficiency			Pre earthworks	0%	
Duration of Exposure			Months	12.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
SRP Wetland 12 - Pre development	38	0.10	0.48	0.02	1.00	5.00	1.00	0.19	0.30	0%	0.0557

Sub-Catchment Description	SRP Wetland 12	*Subcatchments must be named to be included in summary*			
Exposed Catchment Area (ha)			Exposed Area (ha)	5.000	
Average Catchment Slope (%)			Average Slope %	2.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.26	
Slope Length and Steepness Factor	LS	User defined Slope length		0.48	575
Ground Cover Factor	C		Bare Soil - rough irregular surface	1.00	
Roughness Factor	P		Bare Soil - rough irregular surface	0.90	
Sediment Delivery Ratio				0.30	
Sediment Control Measure Efficiency			Sediment Retention Pond - Chemical Treatment	95%	
Duration of Exposure			Months	8.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
SRP Wetland 12	38	0.26	0.48	1.00	0.90	5.00	0.67	14.49	0.30	95%	0.2174

Sub-Catchment Description	SRP Wetland 12	*Subcatchments must be named to be included in summary*			
Exposed Catchment Area (ha)			Exposed Area (ha)	5.000	
Average Catchment Slope (%)			Average Slope %	2.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.26	
Slope Length and Steepness Factor	LS	User defined Slope length		0.48	575
Ground Cover Factor	C		Mulch - on subsoil (3 month only)	0.15	
Roughness Factor	P		Mulch - on subsoil (3 month only)	1.00	
Sediment Delivery Ratio				0.30	
Sediment Control Measure Efficiency			Sediment Retention Pond - Chemical Treatment	95%	
Duration of Exposure			Months	4.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
SRP Wetland 12	38	0.26	0.48	0.15	1.00	5.00	0.33	1.21	0.30	95%	0.0181

Universal Soil Loss Equation **Project** O2NL

Total Estimated Sediment Yield 0.2912
Total Catchment Area (ha) 5.00

Sub-Catchment	R	K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
		USLE Parameters									
SRP Wetland 12 - Pre development	38	0.10	0.48	0.02	1.00	5.00	1.00	0.1858	0.30	0%	0.0557
SRP Wetland 12	38	0.26	0.48	1.00	0.90	5.00	0.67	14.4904	0.30	95%	0.2174
SRP Wetland 12	38	0.26	0.48	0.15	1.00	5.00	0.33	1.2075	0.30	95%	0.0181

Sub-Catchment Description		SRP Wetland 12 - Pre develop	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	5.000	
Average Catchment Slope (%)			Average Slope %	2.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Topsoil	User Defined	0.10	
Slope Length and Steepness Factor	LS	User defined Slope length		0.48	575
Ground Cover Factor	C		Pasture - undisturbed	0.02	
Roughness Factor	P		Pasture - undisturbed	1.00	
Sediment Delivery Ratio				0.30	
Sediment Control Measure Efficiency			Pre earthworks	0%	
Duration of Exposure			Months	12.00	

Catchment details	R	K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
		USLE Parameters									
SRP Wetland 12 - Pre development	38	0.10	0.48	0.02	1.00	5.00	1.00	0.19	0.30	0%	0.0557

Sub-Catchment Description		SRP Wetland 12	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	5.000	
Average Catchment Slope (%)			Average Slope %	2.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.26	
Slope Length and Steepness Factor	LS	User defined Slope length		0.48	575
Ground Cover Factor	C		Bare Soil - rough irregular surface	1.00	
Roughness Factor	P		Bare Soil - rough irregular surface	0.90	
Sediment Delivery Ratio				0.30	
Sediment Control Measure Efficiency			Sediment Retention Pond - Chemical Treatment	95%	
Duration of Exposure			Months	8.00	

Catchment details	R	K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
		USLE Parameters									
SRP Wetland 12	38	0.26	0.48	1.00	0.90	5.00	0.67	14.49	0.30	95%	0.2174

Sub-Catchment Description		SRP Wetland 12	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	5.000	
Average Catchment Slope (%)			Average Slope %	2.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.26	
Slope Length and Steepness Factor	LS	User defined Slope length		0.48	575
Ground Cover Factor	C		Mulch - on subsoil (3 month only)	0.15	
Roughness Factor	P		Mulch - on subsoil (3 month only)	1.00	
Sediment Delivery Ratio				0.30	
Sediment Control Measure Efficiency			Sediment Retention Pond - Chemical Treatment	95%	
Duration of Exposure			Months	4.00	

Catchment details	R	K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
		USLE Parameters									
SRP Wetland 12	38	0.26	0.48	0.15	1.00	5.00	0.33	1.21	0.30	95%	0.0181

Universal Soil Loss Equation **Project** O2NL

Total Estimated Sediment Yield 2.4053
Total Catchment Area (ha) 2.30

Sub-Catchment	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
SRP 33700 Pre Earthworks	38	0.15	2.59	0.02	1.00	2.00	1.00	0.5951	0.50	0%	0.2976
SRP 33700	38	0.47	2.59	1.00	0.90	2.00	0.67	55.9422	0.50	95%	1.3986
SRP 33700	38	0.47	2.59	0.15	1.00	2.00	0.33	4.6619	0.50	95%	0.1165
DEB33650 -Pre Earthworks	38	0.15	1.57	0.02	1.00	0.30	0.17	0.0090	0.50	0%	0.0045
DEB 33650	38	0.47	1.57	1.00	0.90	0.30	0.67	5.0883	0.50	80%	0.5088
DEB 33650	38	0.47	2.93	0.15	1.00	0.30	0.33	0.79	0.50	80%	0.08

Sub-Catchment Description		SRP 33700 Pre Earthworks	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	2.000	
Average Catchment Slope (%)			Average Slope %	7.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Topsoil	User Defined	0.15	
Slope Length and Steepness Factor	LS	User defined Slope length		2.59	300
Ground Cover Factor	C		Pasture - undisturbed	0.02	
Roughness Factor	P		Pasture - undisturbed	1.00	
Sediment Delivery Ratio				0.50	
Sediment Control Measure Efficiency			Pre earthworks	0%	
Duration of Exposure			Months	12.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
SRP 33700 Pre Earthworks	38	0.15	2.59	0.02	1.00	2.00	1.00	0.60	0.50	0%	0.2976

Sub-Catchment Description		SRP 33700	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	2.000	
Average Catchment Slope (%)			Average Slope %	7.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.47	
Slope Length and Steepness Factor	LS	User defined Slope length		2.59	300
Ground Cover Factor	C		Bare Soil - rough irregular surface	1.00	
Roughness Factor	P		Bare Soil - rough irregular surface	0.90	
Sediment Delivery Ratio				0.50	
Sediment Control Measure Efficiency			Sediment Retention Pond - Chemical Treatment	95%	
Duration of Exposure			Months	8.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
SRP 33700	38	0.47	2.59	1.00	0.90	2.00	0.67	55.94	0.50	95%	1.3986

Sub-Catchment Description		SRP 33700	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	2.000	
Average Catchment Slope (%)			Average Slope %	7.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.47	
Slope Length and Steepness Factor	LS	User defined Slope length		2.59	300
Ground Cover Factor	C		Mulch - on subsoil (3 month only)	0.15	
Roughness Factor	P		Mulch - on subsoil (3 month only)	1.00	
Sediment Delivery Ratio				0.50	
Sediment Control Measure Efficiency			Sediment Retention Pond - Chemical Treatment	95%	
Duration of Exposure			Months	4.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
SRP 33700	38	0.47	2.59	0.15	1.00	2.00	0.33	4.66	0.50	95%	0.1165

Sub-Catchment Description		DEB33650 -Pre Earthworks	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	0.30	
Average Catchment Slope (%)			Average Slope %	10.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Topsoil	User Defined	0.15	
Slope Length and Steepness Factor	LS	User defined Slope length		1.57	40
Ground Cover Factor	C		Pasture - undisturbed	0.02	
Roughness Factor	P		Pasture - undisturbed	1.00	
Sediment Delivery Ratio				0.50	
Sediment Control Measure Efficiency			Pre earthworks	0%	
Duration of Exposure			Months	2.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
DEB33650 -Pre Earthworks	38	0.15	1.57	0.02	1.00	0.30	0.17	0.01	0.50	0%	0.0045

Sub-Catchment Description		DEB 33650	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	0.30	
Average Catchment Slope (%)			Average Slope %	10.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.47	
Slope Length and Steepness Factor	LS	User defined Slope length		1.57	40
Ground Cover Factor	C		Bare Soil - rough irregular surface	1.00	
Roughness Factor	P		Bare Soil - rough irregular surface	0.90	
Sediment Delivery Ratio				0.50	
Sediment Control Measure Efficiency			T-Bar Decanting Earth Bund - Chemical Treatment	80%	
Duration of Exposure			Months	8.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
DEB 33650	38	0.47	1.57	1.00	0.90	0.30	0.67	5.09	0.50	80%	0.51

Sub-Catchment Description		DEB 33650	*Subcatchments must be named to be included in summary*		
Exposed Catchment Area (ha)			Exposed Area (ha)	0.30	
Average Catchment Slope (%)			Average Slope %	15.00	
Rainfall Erosion index	R		O2NL	38	*User Defined*
Soil Erodibility Factor	K	Bare Soil	User Defined	0.47	
Slope Length and Steepness Factor	LS	User defined Slope length		2.93	40
Ground Cover Factor	C		Mulch - on subsoil (3 month only)	0.15	
Roughness Factor	P		Mulch - on subsoil (3 month only)	1.00	
Sediment Delivery Ratio				0.50	
Sediment Control Measure Efficiency			T-Bar Decanting Earth Bund - Chemical Treatment	80%	
Duration of Exposure			Months	4.00	

Catchment details	R	USLE Parameters K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
DEB 33650	38	0.47	2.93	0.15	1.00	0.30	0.33	0.79	0.50	80%	0.08

Appendix 4.4 Spoil Sites Summary Report

Ōtaki to north of Levin Highway Project Appendix 4.4: Spoil Site Selection Report

PREPARED FOR WAKA KOTAHI, NZ TRANSPORT AGENCY | AUGUST 2022

We design with community in mind

Stantec

Revision schedule

Rev No	Date	Description	Signature of Typed Name (documentation on file)			
			Prepared by	**Checked by**	**Reviewed by**	**Approved by**
1	10/06/2022	Issue 1- for Client Comment	Eleni Gkeli	Ken Clapcott	Selwyn Blackmore	Jamie Povall
2	29/07/2022	Issue 2	Eleni Gkeli	Ken Clapcott	Phil Peet	Jamie Povall

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Quality statement

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Abbreviations

Enter Abbreviation	Enter Full Name
DBC	Detailed Business Case
Ō2NL	Ōtaki to North of Levin Highway Project
RMA	Resource Management Act 1991
SH1	State Highway 1
MCA	Multi Criteria Analysis
DCR	Design and Construction Report
CEDF	Cultural and Environmental Design Framework

1 Introduction

Waka Kotahi, New Zealand Transport Agency (Waka Kotahi) commissioned Stantec to undertake a DBC investigation for the Ōtaki to north of Levin new highway (Ō2NL). Waka Kotahi is also preparing RMA approvals (designation and resource consents) to construct, operate and maintain the Ō2NL Project. This report has been prepared as an attachment to the Design and Construction Report (DCR) to support the Preliminary Design and DBC for the Ō2NL Project, as well as the RMA applications.

The Ō2NL Project includes the final 24 km northern most section of the Wellington Northern Corridor and on its completion will provide improved capacity on the state highway and local road network and improved intra and inter regional connections to better support projected growth in the Horowhenua Region. The Project will also contribute to improvement of the economy of the of the lower North Island; it will improve safety and liveability in the surrounding area and the resilience and safety of accessibility of the Wellington Region.

The Project construction involves a considerable volume of bulk earthworks, including cuts and structural fills. The Design and Construction Report for the Ō2NL Project[1] estimated the total quantity of earthwork volume to be approximately 4 to 5 million cubic metres (m^3) of materials. This quantity also allows for undercuts, borrow (within or beyond designation), topsoil strip and re-spread and wetland ponds, swales and stream diversions.

In the current design of the Ō2NL Project[2] it is identified that the current amount of structural fill requirement is estimated between 2 and 3 million m^3. The volume of cut material suitable to be re-used as structural fill is between 1 and 2 million m^3. This creates a shortfall of 1 to 2 million+ m^3 of earth material being found (or imported) for structural embankment fill, and a surplus of cut material to waste between 0.5 and 1 million m^3.

Factors contributing to the unfavourable cut to structural fill balance include design constraints, notably grade separating local roads from the highway, topography, and geological and ground conditions. With respect to the ground conditions, in particular, and based on the current geotechnical knowledge, it is anticipated that part of the won material from the cuts along the alignment will be challenging to be re-used for structural fill without treatment and improvement and subsequently this could have implications on construction timeframes and cost.

The unfavourable cut - fill balance results in a volume of material targeted for disposal of the order of 1 million m^3 (a more detailed estimate is closer to 0.7 million m^3, but a higher quantity than that is targeted to allow for variability and contingency). In accordance with one of the Project's Core Principles (tread lightly), the volume of spoil is preferred to be kept within the Project catchment, at suitable locations along and adjacent to the proposed alignment in most cases and used positively to help merge the Project into the landscape, or as visual and noise mitigation bunds.

This report presents:

- Geotechnical information to justify the cut to waste assumptions;
- The process followed to select the spoil site locations;
- The proposed spoil site locations, their volume capacity, and comments on specific characteristics, where applicable;
- Recommendations for the next stages of design of the spoil sites.

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[1] Stantec, 2021: Ōtaki to North of Levin New Highway Design and Construction Report, Revision 4, August 2022.
[2] Stantec Design Revision DF5.0, dated July 2022

2 Core Principles and Values

Through Waka Kotahi's partnership with Mana Whenua, the core principles and values for the Ō2NL Project have been established. These are summarised below.

Core Principles

- Tread Lightly, with the whenua
  - Me tangata te whenua (treat the land as a person)
  - Kia māori te whenua (let it be its natural self)
- Create an Enduring Community Legacy
  - Kia māori te whakaaro (normalise māori values)
  - Me noho tangata whenua ngā mātāpono (embed the principles in all things)
  - Tū ai te tangata, Tū ai te whenua, Tū ai te Wai (elevate the status of the people, land and water)

Core Values

- Te Tiriti (spirit of partnership)
- Rangātiratanga (leadership – professionalism – excellence)
- Ūkaipotanga (care – constructive behaviour towards each other)
- Pukengatanga (mutual respect)
- Manaakitanga (generosity – acknowledgement – hospitality)
- Kaitiakitanga (environmental stewardship)
- Whanaungatanga (belonging- teamwork)
- Whakapapa (connections)

Together, the values and core principles bring a focus on the Project development and design response for positive, measurable outcomes. The same principles have been applied in the selection methodology of the locations to be used as spoil sites along or adjacent to the alignment.

3 Project Description

The proposed highway alignment is approximately 24km long and extends from North of Ōtaki to the North of Levin (Figure:4.4.1). For the purposes of investigation, assessment and reporting, the alignment has been broken into zones based on the Project design, similarity of ground conditions and topography. The zones are shown in Figure:4.4.1 and summarised in Table 4.4.1.

Table 4.4.1: Zones of Ō2NL alignment

Zone No.	Zone Start	Zone Finish	Ch. Start	Ch. Finish	Length (m)
1	Northern end (SH1)	Arapaepae / Macdonald (SH57)	10000	13300	3300
2	Arapaepae / McDonald (SH57)	Queen Street	13300	16100	2800
3	Queen Street	Property Boundary	16100	19100	3000
4	Property Boundary	Ohau River	19100	22600	3500
5	Ohau River	North Manakau Road	22600	27100	4500
6	North Manakau Road	Regional Boundary	27100	30900	3800
7	Regional Boundary	Southern End	30900	34900	4000

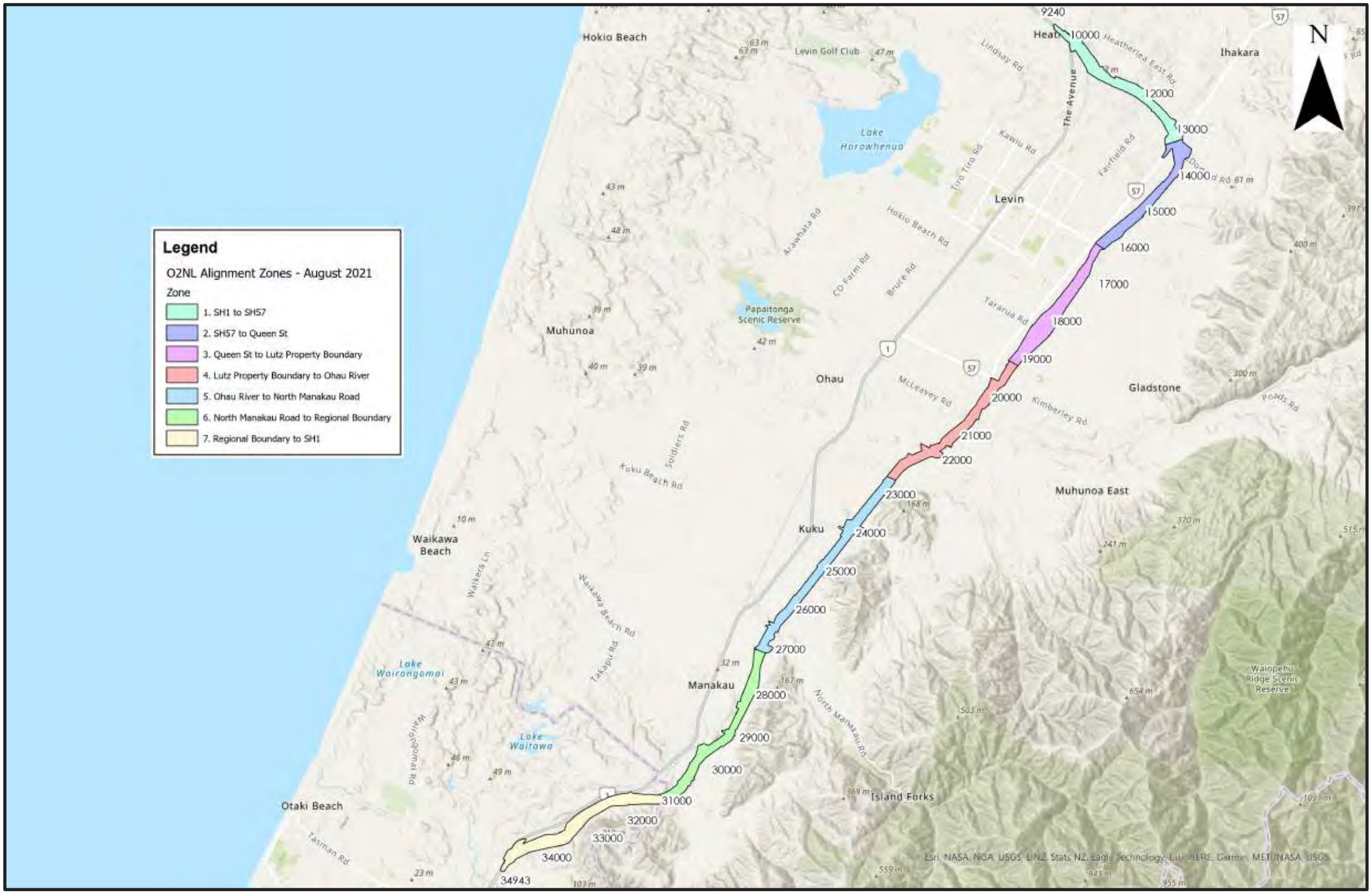

Figure:4.4.1 Overview of the alignment by Zone

4 Geology and Ground Conditions

The Project area is predominately characterised by alluvial deposits transported from the Tararua ranges during the late Pleistocene and Holocene interglacial periods. A large alluvial basin has been formed, which extends along the middle part of the Project area from the eastern plains and towards the coast and has overlain or incised older shoreline and dune sand deposits.

Late Pleistocene shoreline deposits consisting of beach and aeolian sands are exposed to the north and south near Levin and Ōtaki at the surface, in the form of elevated sandy hills capped with loess.

A three-stage geotechnical investigation has been completed along the alignment to date. Interpretation of subsurface ground conditions has been undertaken. More information with respect to the geological setting, the Project's geological model and the ground conditions is provided in the Geotechnical Consenting Design Report which is included in Appendix 4.1 of the DCR.

A summary of the geological units expected to be encountered along the alignment and the extent of each unit per zone are presented in Table 4.4.2.

Table 4.4.2: Summary of geological units along the Ō2NL alignment

Unit No.	Unit Code	Geological Unit	Subunit	Typical Field Description	Typical Extent (Zone)
1	Q1a	Q1a Holocene Alluvium	-	Silty sandy clayey GRAVEL and silty CLAY with organics.	2, 4, 5, 6
2	Q5b	Loess	-	Silty CLAY stiff to very stiff, moderate to high plasticity.	1, 2, 4, 5, 6, 7
3	Q2a/Q3a	Q2a/Q3a Pleistocene Alluvium	3a. Q2a/Q3a Aggradational Fan Gravel	Clayey GRAVEL with some cobbles, dense to very dense.	3
			3b. Q2a/Q3a Sandy Gravel	Sandy GRAVEL, some silt, dense to very dense.	3, 4
			3c. Q2a/Q3a Undifferentiated Alluvium	Interlayered soft to stiff SILT/CLAY and medium dense to very dense silty GRAVEL.	2, 3, 4, 5, 6, 7
4	Q5b	Q5b Pleistocene Shoreline Deposits	-	Fine to medium SAND, some silt, medium dense to very dense. Density typically increases with depth.	1, 2, 3, 4, 6, 7
5	Q6a	Q6a Pleistocene Alluvium	-	Interlayered stiff SILT/CLAY, and medium dense to very dense silty GRAVEL and silty SAND.	6, 7
6	Tt	Tt Rakaia Terrane Greywacke	-	Highly to slightly weathered, interbedded SILTSTONE & SANDSTONE. Fractured.	4 (Ohau River crossing only)

5 Suitability of Project Materials for Structural Fills

Geotechnical investigations, laboratory testing, assessment and interpretation have been carried out targeted the suitability of the materials encountered along the alignment for re-use as engineered fill. These works were focused on two of the geological units presented in Table 4.4.2, as they are expected to dominate the alignment:

- Subunit 3b, the Q2/Q3a sandy gravels
- Units 2 and 4, the Q5b loess deposits, usually encountered near the ground surface and the Q5b sands, usually encountered below the loess or at greater depths from ground surface.

The conclusions of the assessment were that:

- The Q2a/Q3a sandy gravel material was found to be suitable for re-use and therefore not targeted for disposal.
- The Q5b loess surficial material is challenging for re-use and therefore part of it has been targeted for disposal (current assumption is that 50% of this material will be spoiled).
- The Q5b sand material is expected to be suitable for fill with some or no processing. A portion of this material could potentially be problematic due to the high percentage of fines and water content expected locally. As fines content increases, the material will likely need conditioning, and as the water content increases the material is likely to require drying before use. Processing of the material may not be practical during construction; therefore, a reasonable quantity of this material has been conservatively targeted for disposal.

The re-use of the entire quantity of the Q5b material is a Project opportunity and needs to be examined with more investigation and testing in the next stages of design, in conjunction with a workability / compaction trial, to fully ascertain the reusability of this material.

More detailed information can be found in the Geotechnical Consenting Design Report, which is included in Appendix 4.1 of the DCR, and two technical memorandums specifically compiled by Stantec for the suitability assessment of the materials discussed above[3,4,5], included in Appendix 4.5 of the DCR.

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[3] Stantec NZ. (2021). Ōtaki to North Levin (ŌO2NL) Geotechnical Factual Memorandum for Q2a Gravels, Rev 1., dated 2 August 2021

[4] Stantec NZ. (2022). Ōtaki to North Levin (ŌO2NL) Geotechnical Assessment Memorandum for Material Supply (Borrow) Sites located at the South / Nortth of Waiakwa Stream and the Northeast of Ohau River, Rev 1., dated 30/05/2022

[5] Stantec NZ. (2022). Ōtaki to North Levin (ŌO2NL) Geotechnical Assessment Memorandum for Q5b Shoreline Deposits (Sands), Rev 2, dated 30/05/2022

6 Estimated Volume of Waste

Based on the assessed suitability of materials along the alignment and the current earthworks design, a conservative high-level estimate of the volume of waste material required to be disposed per Project zone is presented in Table 4.4.3

Table 4.4.3: Conservative High-Level Estimate of Volume of Waste Material

Zone No.	ST Start - ST Finish	Estimated volume of waste for disposal – base case assumption (m^3)	Estimated volume of waste for disposal – worst case reuse assumption (m^3)	Estimated volume of waste for disposal – best case reuse assumption (m^3)
1	10000 - 13300	168,200	270,000	72,600
2	13300 - 16100	29,900	55,500	13,700
3	16100 - 19100	4,400	36,200	--
4	19100 - 22600	18,500	61,150	11,100
5	22600 - 27100	79,600	165,000	20,400
6	27100 - 30900	43,400	75,500	23,200
7	30900 - 34900	268,400	434,500	110,000

7 Constraints and Opportunities

The constraints and opportunities used in the selection of the spoil site's locations were aligned with the CEDF Principles of the Project. The selection of the spoil sites followed a similar partnership process to that which has been used throughout the development of the Ō2NL Project. This partnership provided critical insights for identifying constraints and assessing the proposed spoil sites, including interfaces with watercourses and stormwater management and the overarching aim of fitting the new highway sensitively into the landscape.

Especially following the tread lightly principle, the spoil site selection's main objective was to identify sites within the Project catchment and in proximity to where the spoil is generated, with easy access from the Project corridor, and that would have minimum disruption to the natural environment and archaeological, heritage and cultural areas. This approach has cultural, environmental and economic advantages and supports reducing carbon impacts.

Suitable areas adjacent and close to the alignment, especially those with landscaping opportunities to blend the Project earthworks into the natural environment, were targeted with priority. In identifying and assessing the initial long list of the spoil sites the constraints and opportunities described in Table 4.4.4 were primarily considered.

Table 4.4.4: Constraints and opportunities considered when identifying sites

Constraint / Opportunity	Factors used for site identification
Constructability	Easy access, proximity to the spoil generation areas and alignment, avoid public roads for transportation of materials.
Road Design, Designation	Spoil site to be within designation and be able to support landscaping opportunities of road embankments, use of land within intersection and alignment / shared path.
Geotechnical – land stability	Suitability of the land to receive fill material (e.g., avoid areas with soft soils, ponding water, and known land stability issues, and areas close to the top of high cuts of the alignment or overhanging to avoid destabilisation and risks of inundation of the road with spoil material).
Landscape / Visual	Contouring opportunities to soften road embankments, roundabouts, and shared path. Unobtrusive locations preferred with low visibility from nearby alignment or residential areas or areas of natural and cultural value. Use topographical lows to soften natural terrain and expand residential or farming land.
Stormwater, wetlands, and waterways, aquatic, and terrestrial Ecology	Minimise impact on existing waterways, wetlands, floodplains, gullies, streams, and areas where additional stormwater provisions will be required. Sites with potential to improve flooding management are preferred. Also avoid areas of protected aquatic and terrestrial ecology, indigenous vegetation, or existing habitats.
Archaeology and Heritage	Avoid areas of known settlement, events, stories, trade, travel, mahinga kai.
Highly Productive Land Values	The alignment crosses highly productive land, ensure limited disruption as possible. Opportunities to expand farming land where possible were investigated.
Iwi Values	Minimise impact on whakapapa, named natural features, community and other identified sites including wahi tapu.

8 Spoil Selection Methodology

8.1 Long to short list of spoil sites

The first step in the spoil site selection process was to identify a long list of possible site locations for evaluation. The long list of potential spoil site locations was initially identified by members of the Project Design Team[6] based on the factors presented in Section 7.

The identification process for the long list of spoil sites was based on a desktop study. The Project Design Team carried out visual inspection of aerial photography and topographical contours highlighting the areas of interest at a high-level with hatching. The long list identification process resulted in 117 potential spoil site locations being identified. The next step in the process was for the long list to be further evaluated by technical specialist assessors and iwi partners using a “traffic light signal assessment” process.

To ensure consistency with the previous multi criteria analysis (MCA) processes, key technical specialist assessors were identified who had either previously undertaken MCA evaluations for the Ō2NL Project or who had undertaken assessment of effects. The MCA evaluation criteria and MCA assessor who contributed to the long list evaluation process are set out in Table 4.4.5 below.

Table 4.4.5: MCA Evaluation Criteria and MCA Assessors

MCA Evaluation	**MCA Assessor and Organisation**	Assessment criteria
Landscape / Visual	Gavin Lister, Lisa Rimmer, Isthmus	Assessment of how well the final form of the spoil site would fit into landscape or be able to be used as bund for visual and screening.
Terrestrial Ecology	Tim Martin, Wildland Consultants Ltd	Assessment of impact to existing terrestrial ecology.
Aquatic Ecology	Alex James EOS Ecology	Assessment of impact on existing waterways, wetlands, floodplains, gullies, streams, and areas where additional stormwater provisions will be required.
Archaeology	Daniel Parker, Insite Archaeology	Assessment of impact on sites of archaeological and heritage interest.
Highly Productive Land Values	Lachie Grant, Land Vision	Assessment of whether the site would affect the use of highly productive land.
Stormwater	Nick Keenan, Andrew Craig, Stantec	Assessment of impact to floodplains, flood levels, flood storage volumes, flow velocity and capacity in waterways, channel gradients
Iwi Values *(Muaūpoko Tribal Authority only)*	Di Rump, Muaūpoko Tribal Authority	Assessment of the impact on whakapapa, named natural features, community and other identified sites including wahi tapu.

[6] The Project Design Team consisted of Jamie Povall, Eleni Gkeli and Ken Clapcott

Following selection of the MCA assessors, each were given access to an ArcGIS website to record their traffic light signal evaluations for each long-listed spoil site location. This evaluation system enabled each MCA assessor to record whether they had low, medium or high-level concerns with any of the sites. Each traffic light signal assigned by the assessor, was translated into a score (from 1 to 3), to enable total scoring of each spoil site based on the MCA assessment, as follows:

- **Green** (or 3) if an option is likely to have only minor impacts or issues
- **Orange** (or 2) if an option is likely to have moderate impacts or issues, and
- **Red** (or 1) if an option is likely to have serious or significant negative impacts or issues.

From the long list assessment, the total scores of the spoil sites were calculated, and three categories of spoil sites have been identified based on their total scores, as shown in Table 4.4.6.

Table 4.4.6: Spoil Sites Categories Based on Total MCA Score

Colour.	Total Score Range
Red	≤ 15
Orange	16 – 18
Green	≥ 18

The total MCA assessment score category was the first and initial level of evaluation of each spoil site. For the spoil sites that scored in the orange or red category a second level of more detailed assessment was carried out by the Project Design team. The more detailed assessment specifically included design issues such as earthworks, stormwater, drainage, geotechnical as well as constructability issues, in terms of feasibility of geometry, capacity and accessibility. Using professional judgement, each spoil site was either excluded, modified or accepted as is, considering the constraints and negative effects identified and how easily these could be resolved or mitigated in the next stages of design and during construction.

The Project Design team assessed the spoil sites primarily based on the number, type and significance of the issues identified by the MCA assessors, i.e., on how many different MCA assessors flagged the spoil site as red, or orange for different issues / reasons.

For example, in some spoil sites different assessors flagged the spoil site as red or orange, but based on the same identified issue, e.g., proximity to a stream. In this case, if a mitigation was considered feasible to remedy the identified issue, this was applied to incorporate the assessors' comments and eliminate the adverse effect. Where possible, spoil sites were either moved to other locations along the alignment, or their footprints / boundaries were modified based on the comments of the MCA assessors. These spoil sites were kept in the list, but at a modified location or shape than initially suggested.

The spoil sites that

1. were flagged with too many **red,** or **orange** signals for different identified issues (e.g., proximity to a stream, possible encroaching into archaeological site and having adverse cultural impact), and
2. the potential mitigations either at this stage of assessment or in the next stages of design and during construction would not easily eliminate or reduce the adverse effects to acceptable levels,

were not pursued further and deleted from the options set.

Some spoil sites from the initial long list were either excluded or moved from their original location, or their footprint was modified regardless of their MCA evaluation result. This happened because the alignment design has changed, while the spoil sites MCA process was in progress.

The summary of the long list of spoil sites assessed in the MCA process is provided in **Appendix A** and the locations of the long list of spoil sites, including the ones deleted or modified through the MCA process are shown in the Plans included in **Appendix B**.

8.2 Zone 7 re-assessment

The first stage of MCA assessment resulted in a considerable number of the spoil sites within Zone 7 of the alignment (from chainage 30900 to chainage 34900) to be evaluated with **red**, or **orange** signals by the MCA assessors, based on the following constraints (listed in random order which does not denote order of significance):

- Proximity to complex stream network present at this area of the alignment.

- Potential archaeological sites on the terraces.
- Effects on terrestrial and aquatic ecology.
- Proximity to Pukehou Hill, area of high spiritual and cultural significance.

The adverse effects of these spoil sites were considered to be difficult to mitigate in this or the next stages of design and were therefore excluded from the initial long list.

Eight (8) new sites were explored and identified along Zone 7 of the Project, bringing the total long list of spoil sites examined to 125. A second round of MCA assessment was carried out and these new spoil sites have been assigned traffic light signals and further evaluated by the design team to be either excluded, modified or kept in the final list of spoil sites, in the same process explained in Section 8.1.

The summary of the MCA assessment of the excluded spoil sites of the initial long list in Zone 7 and the MCA assessment of the new spoil sites considered are included in **Appendix A**. The locations of the excluded and new spoil sites in Zone 7 are also included in the Plans of **Appendix B**.

8.3 Final short list of spoil sites

Based on the long list assessment evaluation outcomes explained in Sections 8.1 and 8.2, a number of potential spoil sites were discarded, as described in Table 4.4.7. This reduced the long list of 125 Spoil sites (including new Zone 7 sites) down to a short list of 92 (note that some sites have two adjacent sites counted as one, e.g., 46 and 46a, 98 and 98a).

The spoil sites modified, either moved to a different location or changed shape or footprint, based on recommendations provided by the MCA assessors or maintained with notes to be taken into account in the next stages of the detailed design are presented in Table 4.4.8.

Table 4.4.7 and Table 4.4.8 also include the spoil sites not pursued further in Zone 7 and some of the new identified and assessed spoil sites in Zone 7 that were modified, based on the experts' comments in the second round of MCA.
The final list of spoil sites is presented in **Appendix A** and the respective plans in **Appendix B**.

Table 4.4.7: Long List of Spoil Sites not Progressed Further

Spoil Site ID	Zone / approximate chainage	Traffic Light Signal Evaluation Score	Key Reasons for not progressing spoil site
11	1 (11100 – 11200)	19 (Orange to Green)	Due to change in road design, it is now coinciding with stormwater pond and cannot be extended to the other side of the pond due to presence of house and vegetated area.
11a	1 (11100 – 11200)	18 (Orange to Green)	Adjacent to house and waterway, area of terrestrial habitat, potential archaeology, needed careful design. Provided limited volume capacity so it was considered pointless to pursue further.
13	1 (11400 – 11500)	14 (Red to Orange)	In wetland gully that should be avoided, may be close to terrestrial habitat (EWH9d - Low), potential for archaeological sites, Ngā wai ora: healthy waterways constraints, outside proposed designation. Spoil site 13 currently presented in the maps is in a different location and combined with modified spoil site 12.
14	1 (11400 – 11500)	13 (Red)	Wetland, terrestrial and aquatic habitat, potential for archaeological sites, Ngā wai ora: healthy waterways disruption.
15	1 (11500 – 11700)	13 (Red)	Wetland terrestrial and aquatic habitat, potential for archaeological sites, Ngā wai ora: healthy waterways disruption.
27a	2 (13500)	15 (Red to Orange)	Coincides with pond in current design, close to Koputaroa Stream.
27b	2 (13700)	11 (Red)	Significant encroachment and adverse effects on Koputaroa Stream. Spoil site 27b currently presented in the maps is at a different location.

Spoil Site ID	Zone / approximate chainage	Traffic Light Signal Evaluation Score	Key Reasons for not progressing spoil site
27c	2 (13700)	17 (Orange)	Mostly out of proposed designation, and near ephemeral stream.
39	4 (20500 – 20600)	13 (Red)	Interferes with indigenous wetland.
50	4 (22300)	18 (Orange to Green)	Coincided with pond in the new road design.
54	5 (23300 – 23400)	15 (Red to Orange)	Wetland terrestrial habitat, indigenous vegetation.
57	5 (23800 – 23900)	18 (Orange to Green)	Potential archaeological site, adjacent to waterway, coincides with pond in new road design.
62	5 (24600 – 24700)	15 (Red to Orange)	Interferes with ephemeral stream, wetland habitat likely to be present.
63	5 (24700 – 24800)	16 (Red to Orange)	Adjacent to stream, wetland habitat likely to be present. Spoil site 63 currently presented in final map is in a new location to the south, away from the stream.
65	5 (25300 – 25400)	**14 (Red to Orange)**	Close to stream, wetland and terrestrial habitat.
67	5 (25500)	13 (Red)	Close to wetland, area proposed for natural character mitigation.
68	5 (25950 – 26100)	18 (Green)	Merged with 66
73	5 (25950 – 26100)	18 (Green)	The spoil site now coincides with the North of Waikawa Material Supply Site.
74	5 (26100)	16 (Orange)	The spoil site now coincides with the North of Waikawa Material Supply Site.
76a	6 (27100 – 27300)	15 (Red to Orange)	Stream, potential terrestrial habitat, villa and garden, mostly outside designation.
79	6 (27800 - 28000)	18 (Green)	Now coincides with pond.
80	6 (27900)	15 (Orange)	Adjacent to streams.
86	6 (28500 – 28700)	13 (Red)	Intended to fill an ephemeral watercourse. To achieve more positive effects the spoil volume of 86 was consolidated with spoil sites 83 and 84 against the highway fill batters.
100	6 (30200 – 30300)	13 (Red)	Spoil area overlies channel that links a series of dams upstream to the Manakau Stream. Although provides opportunity to accentuate height of small terrace to help embed highway in landscape, archaeological sites possibly more likely found on terrace and the streams are adjacent of Pukehou and are of high spiritual significance.
101	6 (30300 – 30400)	9 (Red)	Adjacent or encroaches into Waiauti Stream flood plain and would bury natural scarp and remnant oxbows. Would exacerbate adverse natural character effects. Important riparian revegetation zone where native soils for planting would be preferred. Adjacent to Pukehou - high spiritual significance, spiritual pathway.
104	7 (31100)	16 (Red to Orange)	Area earmarked to provide buffer planting to adjacent Staples Bush. Such planting is best to be in natural ground. Proximity to stream (Waiaute/Waiauti) which indicates potential archaeological significance. Adjacent to Pukehou.

105	7 (31100)	17 (Orange)	Close to ephemeral flow paths and wetlands. Updated road design brings initially proposed spoil site on top of a cut, not possible to avoid wetlands.
108	7 (32200 – 32300)	13 (Red)	Encroaches into wet gully near section that is proposed to be restored to address natural character effects. Low ecological value wetland swale that would need to be reinstated. Adjacent to Pukehou - high spiritual significance, spiritual pathway.
109	7 (32400)	13 (Red)	Encroaches into wet gully near section that is proposed to be restored to address natural character effects. Potentially affecting terrestrial and aquatic habitat, adjacent to Pukehou - high spiritual significance, spiritual pathway.
110	7 (32400 – 32500)	12 (Red)	Fills one of the gullies that are characteristic of the pattern of gullies and terraces around the toe of Pukehou. Potentially affecting terrestrial and aquatic habitat, wetland restoration area, adjacent to Pukehou - high spiritual significance, spiritual pathway.
117 - 118	7 (33300 – 33400)	12 (Red)	Fills one of the gullies that are characteristic of the pattern of gullies and terraces around the toe of Pukehou. Potentially affecting terrestrial and aquatic habitat, adjacent to Pukehou - high spiritual significance, spiritual pathway.
119	7 (33400)	14 (Red to Orange)	Disrupts the pattern of gullies and terraces around the toe of Pukehou, area of high spiritual significance. Would have adverse landscape and natural character effects. Potential archaeological site. Low ecological value wetland swale.

Table 4.4.8: Long List of Spoil Sites Modified after the MCA Assessment (requiring additional design and review at detailed design stage)

Spoil Site ID	Zone / approximate chainage	Traffic Light Signal Initial Evaluation Score	Changes to incorporate MCA assessors' comments
10a	1 (10900 – 11000)	17 (Orange)	Northern extent coming close to pond and area of terrestrial ecology interest (OW). Northern extent was moved away from pond and the spoil site was unified with number 10. In the detailed design final area and contouring will eliminate disruption to adjacent wetland.
12	1 (11200 – 11400)	17 (Orange)	Detailed design required to integrate with natural character mitigation in this area between stormwater pond and restored gully wetland.
28	2 (13500 – 13550)	17 (Orange)	Shape and location modified to be away from stream channel.
52	5 (23100 – 23150)	18 (Orange)	Moved closer to alignment and area reduced to be further away from vegetated area. In detailed design care to regenerate indigenous vegetation possibly disturbed.
53	5 (23300 – 23500)	18 (Orange)	Geometry modified and area reduced to be out of stream and pond and spoil site integrated with #51.
55	5 (23700 – 23800)	17 (Orange)	Geometry modified and area reduced to be further away from terrace.
61	5 (24300 – 25000)	17 (Orange)	Southern end modified not to interfere with stream - extended to the north.
63	5 (24900 – 25050)	16 (Red to orange)	Original #63 deleted. New location further to the south and modified to be away from stream.
81	6 (27950 – 28000)	17 (Orange)	Geometry modified to be away of streams.

Spoil Site ID	Zone / approximate chainage	Traffic Light Signal Initial Evaluation Score	Changes to incorporate MCA assessors' comments
84	6 (28600 – 28700)	17 (Orange)	Southern tip modified to be away from stream.
89	6 (28850 – 28950)	17 (Orange)	Northern tip modified to be away from stream.
91	6 (29250 – 29300)	17 (Orange)	Proximity to house - Potential to form contoured bund around house to screen highway. Geometry modified to be away from stream.
95	6 (29300 – 29400)	17 (Orange)	Geometry modified at the southern end to be away from the stream.
96	6 (29350 – 29500)	16 (Red to orange)	Geometry at the northern end has been modified to be away from the stream
97	6 (29600 – 30150)	16 (Red to orange)	Geometry at the northern end has been modified to be away from the stream
106a	7 (31300 – 31600)	15 (Red to orange)	Geometry to be carefully designed in the detailed design to be away from wetlands and integrate with naturalising of watercourse between terrace and batter.
112	7 (32700 – 32800)	**17 (Orange)**	Geometry modified to be moved away from waterway and mimic existing terrain - geometry likely needed to be modified further in detailed design to tie well with earthworks and landscape.
116	7 (33350-33370)	16 (Red to orange)	Geometry modified to be moved away from terrace and waterway and be closer to the road and tie in with road embankment - geometry likely needed to be modified further in detailed design to tie well with earthworks and landscape.
124	7 (34350 – 34800)	18 (Orange)	Spoil split in two parts to provide environmental offset.
126	7 (33050 – 33150)	18 (Orange)	Location and geometry to be refined in detailed design for better integration into landscape and ensure environmental control. Confirmation that it does not coincide with archaeological site.
127	7 (32600 – 32700)	17 (Orange)	Geometry modified to be away from Stream 10. Vegetation restoration will be addressed in detailed design of the spoil site. Good opportunity to contour spoil against toe slope immediately to SE or against spur to SW.
128	7 (31100 – 31300)	17 (Orange)	Geometry modified to tie with shared path design. Extension of culvert may be required, vegetation rehabilitation.
130	7 (30700 – 30850)	19 (Green)	Geometry modified to tie with shared path design and be away from stream.

9 Estimated Spoil Sites Capacity

The capacity of the spoil sites per Zone of the Project and a comparison with the demand is shown in Table 4.4.9. The calculation of the volume of the spoil sites, since no detailed contouring design of each location has been carried out, is based on a typical trapezoidal shape of a spoil embankment with heights ranging from 2 m to 5 m and slope angles 3H:1V.

Table 4.4.9: High-Level Estimate of Spoil Sites Capacity and Comparison with Base Case Demand (for worst- and best-case demand refer Table 4.4.3)

Zone No.	ST Start - ST Finish	Number of spoil sites	Total combined footprint (m^2)	Estimated volume capacity of proposed spoil sites (m^3)	Estimated base case volume of waste for disposal (m^3)
1	10000 - 13300	20	113,000	172,000 – 390,000	168,200
2	13300 - 16100	6	35,000	50,000 – 115,000	29,900
3	16100 - 19100	6	26,000	31,000 – 71,000	4,400
4	19100 - 22600	12	84,000	103,000 – 242,000	18,500
5	22600 - 27100	18	125,000	161,000 – 375,000	79,600
6	27100 - 30900	22	109,000	114,000 – 262,000	43,400
7	30900 - 34900	14	88,000	175,000 – 410,000	268,400
	Total	**98**	**580,000**	**806,000 – 1,866,000**	**612,400**

Based on the results shown in Table 4.4.9 , the overall volume of the proposed spoil sites is estimated to provide capacity for the base case estimated demand. Some of the individual Project zones may present deficiencies if the worst-case scenario eventuates (e.g., Zone 1 or Zone 7). The deficiencies of these zones could be accommodated by the excess in capacity provided in adjacent zones.

10 Recommendations for Future Stages of Design

10.1 Walkover assessment

The selection of the spoil sites at this stage of design has been largely based on desktop study. In the next stages of design, refinement of the locations, extents, and geometries of some of the spoil sites, especially the ones noted in Table 4-8, will be carried out by walk over surveys and on-site assessments.

10.2 Geometric design

All spoil sites will need to be appropriately contoured in the detailed design to optimise spoil volume capacity but also ensure good integration with the earthworks of the alignment, to smoothen fill embankments and soften the edges of cuttings into natural landscape. The geometrical design of the spoil sites will need to follow the CEDF Principles of the Project, by:

- keeping the spoil sites relatively close to the highway level or existing ground level, apart where required to act as visual and noise barriers,
- rehabilitation of slopes by appropriate planting, and
- realising opportunities to better integrate the spoil sites with the natural environment, where possible, in areas such as terraces.

10.3 Spoil and site stability – geotechnical investigations

The initial locations suggested for spoil sites do not have known land instability issues at this stage.
Additional geotechnical investigations and detailed geotechnical assessments and geotechnical designs of the spoil sites will be required in the next stages of design.

All spoil sites should be further evaluated from an overall and localised stability point of view and appropriate modifications of the design or localised land stability mitigation measures should be implemented, indicatively removal and replacement of soft soils at the foundation of the spoil embankment, benched excavation on inclined ground, shear keys, adequate compaction of spoil material and reinforcement of the spoil embankment with geogrids to enhance stability.

The design of the spoil sites will be carried out based on the requirements of the Waka Kotahi Bridge Manual[7] for earthworks or as otherwise required by the principal's requirements. The localised stability of the spoil embankment will be examined for all design loading cases included in the Bridge Manual, including earthquake loading and elevated groundwater conditions in case of storm events.

The general design of the spoil embankments should be with maximum slope angles of 1 vertical to 2.5 to 3 horizontal (about 18 to 22 degrees) and with intermediate benches for slopes greater than 10 m height. Spoil sites placed in the vicinity of road cuts need to have adequate buffer from the crest of the cuts (minimum 10 m) and the detailed design should ensure the stability of both spoil embankment and cut in the vicinity of the embankment.

Where the spoil sites affect permanent works of the alignment, e.g., when they are founded on fill embankments or on top of cuttings, the impact of the spoil embankments on the permanent works will be assessed for all design loading cases.

Exclusion zones should be applied for the spoil sites when they are in the vicinity of road cuttings, drainage elements of the alignment and natural streams and watercourses. The exclusion zone width should take into account the potential displacements during earthquake loading or potential localised failures that could affect the adjacent constraints.

[7] Waka Kotahi NZ Transport Agency (2022): Bridge Manual, Third Edition, Amendment 4, May 2022.

Mitigation measures to enhance the stability of the spoil embankment and reduce seismic displacements could include adopting shallower slope angles or reinforcing the spoil embankment with geogrid, or interlayers of free draining more competent material, etc.

10.4 Drainage design

Subsoil drains, drainage blankets or intermediate layers with increased permeability within the body of the spoil embankment are recommended to be adopted in the detailed design of the spoil sites to ensure adequate drainage of the spoil embankment and surrounding area.

Subsoil drains and drainage blankets can be installed at the boundary of the residual cut level and the new fill placed on site to prevent the possible future build-up of hydrostatic pressures beneath the fill which could potentially cause slope instability. Foundation drainage could be placed at regular intervals beneath the foundation, and all drainage must be directed or connected to any swale or existing permanent works drains. Where spoil is placed against existing alignment embankment fill, all existing subsurface drains should be connected to the new foundation drains.

The spoil embankments should have adequate surface drainage measures such as drainage channels or cut off drains to manage surface water runoffs and minimise scour and erodibility of the spoil surface.

Where Spoil Sites have been introduced near the alignment the following needs to be considered in the detailed design:

- Erodibility and potential for scour of Spoil Sites. Rip rap or other scour protection can be examined where there is potential for scour of the spoil embankment.
- Settlement of drainage elements built on Spoil Sites.
- Maintenance of drainage elements associated with Spoil Sites (where local failures may occur).
- Impact of Spoil Sites on contributing catchment areas and assumed runoff coefficients.
- Potential for stormwater contamination and detailing allowable fill materials.
- Additional landscaping requirements.

10.5 Other

The spoil design will need to follow good practices in accordance with the CEDF of the Project for rehabilitation of slopes and landscape design, construction sequence and methodology and erosion and sediment control. These practices are in detail described in the DCR.

Appendices

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Appendix 4.4.1 Tables

A1: Long List of Spoil Sites Assessed in MCA Process

Spoil Site ID	Visual Assessment	Terrestrial Assessment	Aquatic Assessment	Highly Productive Soils Assessment	Archaeology and Heritage Assessment	Stormwater Assessment	MTA Assessment	Ngati Raukawa 1 Assessment	Ngati Raukawa 2 Assessment	Ngati Raukawa 3 Assessment	Score	Stantec comment 3/12/2021 and 6/04/2021 (GIS Map action)
01	Contouring opportunity to soften roundabout. No landscape constraints.	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date					keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
02	Contouring opportunities to soften roundabout. No landscape constraints.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date					keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
03	Contouring opportunities to soften roundabout. No landscape constraints.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date					keep - shape modified to match new road design - connected with #5 and #6
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
04	Contouring opportunity to soften roundabout. No landscape constraints,	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date				0	keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
05	Would be out of place mound in flat paddock that might be better returned to farming. Better to extend the spoil disposal sites adjacent to roundabout.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Highly modified farming to date				0	changed - shape modified to match new road design - connected with #5 and #6
	Orange	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
06	No landscape constraints.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Highly modified farming to date					keep - shape modified to match new road design - connected with #5 and #6 (named 6a on the GIS map)
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
07	Would be out of place: would compromise cropping paddock and disrupt landscape pattern.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.						Keep - no change
	Orange	Green	Green	Not Completed	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	

09	Anchored against fill embankment.	ETF4 (Low)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - cannot be extended - no change	
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18		
10	Anchored against fill embankment.	ETF4 (Low)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Proximity to significant rivers, streams, springs, wetlands and lakes; need to tread carefully				0	Keep - geometry refined to match new road design - proximity to waterways to be addressed in design	
	Green	Green	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15		
10a	Anchored against fill embankment. Could be contoured in conjunction with parallel spoil disposal site.	Within 10 metres of OW (Moderate) MTF5 (Low) ETF4 (Low)	The northern extent of spoil area come close to pond. If you tweaked northern extent of the area to be further away from pond, then this one would likely be "green".		There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Proximity to wetland and waterways. Need to tread carefully.					Northern extent modified to be away from pond and waterways. Will be contoured with #10, detail of shape and distance from waterways will be addressed in design	
	Green	Orange	Orange	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	9		
11	No landscape constraints. Adjacent to stormwater pond.				There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Proximity to wetland and waterways. Need to tread carefully.					deleted - it is now coinciding with stormwater pond and cannot be extended on the other side, there is a house and a vegetated area	Where is 11a? 11a does not make much sense, I recommend deleting and replacing with extension of road embankment
	Green	Green	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15		
11a	Adjacent to house. Small. Seems pointless?	Within 10 metres of EWH9d (Low) EHG (Negligible)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Proximity waterway. Need to tread carefully.					Deleted - small volume capacity and pointless	
	Orange	Orange	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	12		
12	Care required but could be integrated with natural character mitigation proposed in this area between stormwater pond and restored gully wetland.	Within 10 metres of IWSe1-SPG (Moderate)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Proximity to wetland and waterways. Need to tread carefully.					keep - shape modified to match new road design - environmental and stormwater issues to be addressed in design	
	Orange	Orange	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	9		
13	In wetland gully that highway was aligned to avoid. Would be better on terrace immediately to north adjacent to highway.	May contain EWH9d (Low)	This one does come close to what looks like a wetland, so effects on that wetland will need to be considered.		There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This would involve channel diversion of small, existing, streams that are draining paddocks with zero vegetation shade and low ecological health compared to a stream set back from a working, cropping, farming operation. Mounds could be shaped to avoid concentrated flow paths, and a full perimeter bund to trap sediments in the vegetation establishment phase.	Amber-Red - Site visit needed to better assess Wetlands - site would disturb the natural drainage and soakage capacity of the soil Ngā wai ora: healthy waterways					previously proposed #13 deleted. Now moved at the north side of the highway and combined with #12.	
	Red	Orange	Green	Orange	Green	Orange	Red	Not Completed	Not Completed	Not Completed	8		

14	Presume shape is meant to be in gully heads approximately 60m to west. Unobtrusive location. Low visibility. May enhance adjacent cropping land.	IWSe1-SPG (Moderate) is present	Much of spoil extent overlies wetland habitat.		There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This would involve channel diversion of small, existing, streams that are draining paddocks with zero vegetation shade and low ecological health compared to a stream set back from a working, cropping, farming operation. Mounds could be shaped to avoid concentrated flow paths, and a full perimeter bund to trap sediments in the vegetation establishment phase.	Amber-Red - Site visit needed to better assess Wetlands - site would disturb the natural drainage and soakage capacity of the soil Ngā wai ora: healthy waterways					Deleted - many issues to be addressed - could be reconsidered with appropriate assessment and design if more volume of spoil sites is required
	Green	Red	Red	Orange	Green	Orange	Red	Not Completed	Not Completed	Not Completed	9	
15	Presume shape is meant to be in gully head 60m to north-west. On that assumption, site is unobtrusive. Would fit terrace landform and paddock pattern.	IWSe1-SPG (Moderate) likely present	Spoil area looks to overlie hillslope seep wetland.		There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This would involve channel diversion of small, existing, streams that are draining paddocks with zero vegetation shade and low ecological health compared to a stream set back from a working, cropping, farming operation. Mounds could be shaped to avoid concentrated flow paths, and a full perimeter bund to trap sediments in the vegetation establishment phase.	Amber-Red - Site visit needed to better assess Wetlands - site would disturb the natural drainage and soakage capacity of the soil Ngā wai ora: healthy waterways					Deleted - many issues to be addressed - could be reconsidered with appropriate assessment and design if more volume of spoil sites is required
	Green	Red	Red	Orange	Green	Orange	Red	Not Completed	Not Completed	Not Completed	9	
16	On terrace, against highway low fill batter. No landscape constraints.				There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Sitting on the highpoint					keep - modify to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
18	Flat land adjacent to highway. However, may be better aligned parallel to highway where it would provide some screening and reduce encroachment into pattern of paddocks.	EHG (Negligible)			Low level potential, but overlooks Waikarito stream	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Farmland to date					keep - reshaped to match new road design and be within designation
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
19	Anchored against highway fill batter. Unobtrusive		Southern end just clips stream channel. This one could be green if tweaked slightly to clear stream channel.		Low level potential, crosses probably path linking Horowhenua to northern regions.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - reassess southern end - extended slightly to the north
	Green	Green	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
20	Flat land adjacent to highway. Opportunity to provide contoured mound to screen existing house.		Southeast edge within 20 m of stream channel. Could be green if boundary tweaked to further away from stream.		Low level risk, approaches edge of Waitaiki stream	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Farmland to date					keep - southern edge modified to be away of stream channel - extended slightly to the north and connected to highway embankment
	Green	Green	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
21	Contouring opportunities to soften roundabout	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - modified to match new road design and connected with #24
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	

22	Contouring opportunities to soften roundabout, and separate roundabout from realigned McDonald Road.	EHG (Negligible)				Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow flow paths to be formally diverted and managed.	Farmland to date					keep - modified to match new road design and connected with #25
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
23	Contouring opportunities to soften roundabout.		Southern tip just touches stream channel. Could be green with slight boundary tweak.		Low level risk, approaches edge of Waitaiki stream	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - southern tip modified to be away from stream - geometry modified to follow new road design - connected with #26
	Green	Green	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
24	Opportunity for contouring between SUP and roundabout					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - geometry modified to match new road design - connected to #21
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
25	Would be integrated with adjacent spoil disposal site 22.	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Farmland to date					keep - previous #25 was integrated with #22. New #25 is at the south side of the roundabout, connected to road embankment.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
26	Opportunity to contour between SUP and roundabout.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - geometry modified to match new road design - connected to #23
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
27	Unobtrusive location and could be integrated with naturalisation of stormwater detention area. (But could impede reconfiguring area for agriculture)	EHG (Negligible)			Probably Green, but land court records indicate low level possibility that there may be a cultivation ground/clearing in this area.	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.						keep - although weird shape, must have been left over from previously location of pond. Further examine if more of this section of land can be used if more volume is required.
	Green	Green	Green	Orange	Orange	Green	Green	Not Completed	Not Completed	Not Completed	15	
27a	Opportunity to contour in conjunction with stormwater wetland. Avoid encroaching into riparian vegetation along Koputaroa Stream.		Southern tip is within main stem of Koputaroa Stream. Could be made green by tweaking boundary away from stream.		Sources indicates shell midden and ovens are found along the banks of this stream. Small possibility of cultivation ground/clearing in this area too.	90% acceptable but issues arise over the eastern 10% with negative impacts removing established vegetation and overlapping a larger natural stream path.	Proximity to significant waterway Te Awa A Te Tau o Koputaroa stream					Within flood plain. Deleted.
	Green	Green	Red	Orange	Orange	Orange	Orange	Not Completed	Not Completed	Not Completed	7	
27b	Is over Koputaroa Stream (would have significant adverse effects)	EHG (Negligible)	Much of this area overlies main stem of Koputaroa Stream.		Sources indicates shell midden and ovens are found along the banks of this stream. Small possibility of cultivation ground/clearing in this area too.	Inappropriate placement over established riparian margin and important stream path. Natural floodplain filled in, raising flood levels in surrounding areas including highway in a flood event.	Going over a significant waterway Te Awa A Te Tau o Koputaroa stream					Previous 27b deleted. New location of 27b, drawn ton the west side of the road, within the same land section as 27.
	Red	Green	Red	Orange	Orange	Red	Red	Not Completed	Not Completed	Not Completed	7	
27c	Unobtrusive location parallel with highway. But would disrupt agricultural land use and landscape pattern.	EHG (Negligible)	Looks to overlie an ephemeral flow path.		Probably Green, but land court records indicate low level possibility that there may be a cultivation ground/clearing in this area.	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.						Previous 27c deleted as mostly out of designation. Examine the use of more of the land section at 27 and 27b if more volume is required.
	Orange	Green	Orange	Orange	Orange	Green	Green	Not Completed	Not Completed	Not Completed	9	

28	Unobtrusive location parallel with highway. Could provide some screening.	EWH5 (Low)	Area is very close to stream channel.		Close proximity to small creek, low level potential for sites.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Adjacent to overland run off - streams					keep - shape and location modified to follow new road design - now further away from stream channel.
	Green	Orange	Orange	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	9	
29	Unobtrusive location parallel with highway. Could provide some screening.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Adjacent to degraded stream					keep - shape and location modified to follow new road design - now further away from stream channel.
	Green	Green	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15	
30	Unobtrusive location parallel with highway. Could provide some screening. Shortening southern end might better enable agricultural land use and landscape pattern.				Close proximity to small creek, low level potential for sites.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
31	Contouring opportunity to soften intersection.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
32	Contouring opportunity to soften intersection.	EHG (Negligible)										original #32 deleted - now coincides with stormwater pond. New #32 at the east side of motorway, contouring roundabout embankment.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
33	Contouring opportunity to soften intersection.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.					0	Original #33 deleted and modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
34	Contouring opportunity to soften intersection.											Original #34 deleted and modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
35	Contouring opportunity to soften intersection.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Original #35 deleted and modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
36	Contouring opportunity to soften intersection. (opportunity for large spoil disposal site opposite between the south-bound on-ramp and new local link road?)					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Original #36 deleted and modified to match new road design, and based on landscape comments.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	

37	Unobtrusive location but would disrupt agricultural land use and landscape pattern.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Keep - geometry modified to match new road design and be within designation
	Orange	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
38	Unobtrusive location. Would help separate highway from local road.		Covers wetland.			This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Keep - geometry modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
39	Dry gully head. Acceptable from landscape perspective but may be better locations that avoid such ephemeral watercourses.	Upper arm of Te Waiaruhe Swamp MWG3 - Low	Covers wetland.		Potential for archaeological sites a head of named creek (Te Waiaruhe). Nothing observed in geotech test pit in immediate vicinity, but possibility for archaeological materials at this location	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Indigenous wetland					deleted.
	Orange	Red	Red	Orange	Green	Green	Red	Not Completed	Not Completed	Not Completed	9	
41	Parallel with highway. Anchored against fill batter. Potential screening opportunity.	ETF4 (Low)				Diversion channel could go around eastern side of fill site. This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
42	Parallel with highway. Anchored against fill batter. Potential screening opportunity.	ETF4 (Low)			Low level risk of late 1880s house in this area, but I suspect it is situated outside of the designation.	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design and be within designation.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
43	Parallel with highway. Anchored against fill batter. Potential screening opportunity.				Low level risk of late 1880s house in this area, but I suspect it is situated outside of the designation.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape modified to match new road design and be within designation.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
44	Unobtrusive location in angle between highway and over bridge. Minor fill site. Anchored against fill batters.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design and be within designation.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
45	Unobtrusive location in angle between highway and over bridge. Anchored against fill batters. Opportunity to soften over bridge.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design and be within designation. Slightly extended.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
46	Unobtrusive location in angle between highway and over bridge. Anchored against fill batters. Opportunity to soften over bridge.					Pipeline extension to accommodate new footprint over. This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design. New 46a at the east side of ramp.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
47	Unobtrusive location in angle between highway and over bridge. Anchored against fill batters. Opportunity to soften over bridge.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	

48	Unobtrusive. Parallel with highway. Anchored against fill batter. Planting spoil disposal site would tie in with storm water wetland.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
49	Parallel with highway. Anchored against fill batter. Unobtrusive. Opportunity for screening from house to NW.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design. Extended to make up for #50.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
50	Unobtrusive location. But would interrupt potential agricultural land use and landscape pattern. Would be better to increase volume of site 49.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.						deleted - now coincides with pond. #49 was extended
	Orange	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	16	
51	Unobtrusive. Parallel with highway. Anchored against fill batter. But interrupts potential agricultural land use and landscape pattern. Better to integrate with Site 53.					Diversion channel could go around western side of fill site. This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - extended to the south to integrate with #53.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
52	Unobtrusive. Parallel with highway. Anchored against fill batter. Fills in left over land between highway and hill.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow flow paths to be formally diverted and managed.	Regenerating indigenous vegetation					keep - moved closer to new alignment and now further away from vegetated area.
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16	
53	Unobtrusive. Parallel with highway. Anchored against fill batter.	EWH9 (Low)	Southern tip of area may overlay ephemeral flow path. Could be green if boundary tweaked to avoid flow path.			Diversion channel could go around western side of fill site. This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape was modified to be out of stream and pond and integrated with #51.
	Green	Orange	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	12	
54	As drawn, shape encroaches on small stream. Could be configured to flat land between highway and stream. However, would a separate mound and not integrated with highway earthworks. OK, but not first choice.	ITS1d (Moderate) ETF3 (Low)				This would involve channel diversion of a small, existing, stream with thin/minimal riparian margin that is adjacent grazing farmland paddocks and marginal ecological health compared to a forested stream set back from a farming. Diversion channel would need to replicate or enhance riparian health and thickness. Some stream reach not overlain by fill will experience less water flow due to diversion. Mounds could be shaped to avoid concentrated flow paths, and a full perimeter bund to trap sediments in the vegetation establishment phase.	Regenerating indigenous vegetations					deleted - too many constraints.
	Orange	Orange	Green	Red	Green	Orange	Orange	Not Completed	Not Completed	Not Completed	7	
55	OK. On terrace. But separate from highway.	ITS1d (Moderate) Wetland habitat likely to be present based on desktop assessment.			Potential for archaeological sites on terrace over looking Kuku Stream	Out of primary river terrace. Better if further back from terrace.	Indigenous scrub - avoid vegetation Adjacent to stream					keep - geometry modified to be further away from terrace and occupy smaller area.
	Green	Orange	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	

56	Unobtrusive. Potential for replanted site to be integrated with storm water wetland.				Probably Green, but Lindsay indicated possible battle passing through this area where victims were left where they fell (at the time he wasn't 100% certain if the Kuku was the right location, but that was the information he had at the time). Low level risk of finding human remains in this area?	Out of floodplain. Out of primary river terrace.						keep - modifies to be closer to alignment and follow new road embankment.
	Green	Green	Green	Red	Orange	Green	Green	Not Completed	Not Completed	Not Completed	16	
57	Unobtrusive. Anchored by over bridge. Some potential for screening. Could be contoured as terrace landform.				Probably Green, but Lindsay indicated possible battle passing through this area where victims were left where they fell (at the time he wasn't 100% certain if the Kuku was the right location, but that was the information he had at the time). Low level risk of finding human remains in this area?	Sited on higher ground out of floodplain	Adjacent to waterway					deleted - now coincides with pond.
	Green	Green	Green	Orange	Orange	Green	Orange	Not Completed	Not Completed	Not Completed	12	
58	Unobtrusive. In angle between highway and over bridge. Opportunity to soften over bridge.	EHG (Negligible)			Probably Green, but Lindsay indicated possible battle passing through this area where victims were left where they fell (at the time he wasn't 100% certain if the Kuku was the right location, but that was the information he had at the time). Low level risk of finding human remains in this area?	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modify to match new highway embankment.
	Green	Green	Green	Red	Orange	Green	Green	Not Completed	Not Completed	Not Completed	16	
59	Unobtrusive. In angle between highway and over bridge. Opportunity to soften over bridge.				Low level risk, close to unnamed stream/creek	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - could be extended to the south?
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
61	Unobtrusive. Parallel with highway. Anchored against fill batter. Potential for screening and softening of highway formation.		Southern end overlays existing stream. Could be green with tweak to boundary to avoid stream.			This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Make sure to bund off around stream					keep - southern end modified not to interfere with stream - extended to the north.
	Green	Green	Red	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	17	
62	Unobtrusive. Parallel with highway. But would be bund separated from highway formation by local access. Encroaches into ephemeral watercourse. May be better to integrate fill with spoil site 61 on opposite side of highway.	Wetland habitat likely to be present based on desktop assessment.	Area looks to overlie existing stream.		Low level risk, adjacent to unnamed stream/creek	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Adjacent to stream north part of Spoil site would be ok, not south					deleted, too many constraints. #61 extended to the north.
	Green	Orange	Red	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	11	
63	unobtrusive. Parallel with highway. But would be bund separated from highway formation by local access. May be better to integrate fill with spoil site 61 on opposite side of highway.	Wetland habitat likely to be present based on desktop assessment.	Area comes within 20 m of existing stream. Could be green if boundary tweaked away from stream.		Low level risk, adjacent to unnamed stream/creek	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Adjacent to stream north part of Spoil site would be ok, not south					Original #63 deleted. New location further to the south and modified to be away from stream.
	Green	Orange	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	10	
64	Unobtrusive. Parallel with highway. Anchored against fill batter. Potential for screening and softening of highway formation. Integrate with spoil site 61 to the north.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
65	Unobtrusive. Parallel with highway. Anchored against fill batter. Potential for screening and softening of highway formation. As drawn, shape encroaches into flood plain of tributary stream. However, could be adjusted and integrated with spoil sites 61 and 64 to the north.	Within 10 metres of MWG1d	Southern tip close to stream. Could be green if boundary tweaked away from stream.		Low level risk, adjacent to Waikokopu stream	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Wetland					deleted, too many constraints. #61 extended to the north
	Orange	Orange	Orange	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	8	
66	Unobtrusive. Parallel with highway. Potential for screening and softening of highway formation.	Within 10 metres of MWG1d (Moderate)				This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - volume increased.
	Green	Orange	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	

67	Encroaches into edge of tributary stream in area for proposed natural character mitigation. Could be moved and integrated with spoil site 72 to south.	MWG1 (Moderate)	Currently close to existing channel, but this is to be diverted during construction to be further away from this spoil area.		Low level risk, adjacent to Waikokopu stream	70% acceptable but issues arise over the eastern 30% with negative impacts removing established vegetation and riparian area. Stream diversion of new channel from the south. Replacement planting needed.	Wetland					deleted, too many constraints.
	Orange	Red	Green	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	9	
68	Unobtrusive. Parallel with highway. Anchored against low fill batter, Potential for screening and softening of highway formation. Integrate with spoil site 66 to the north.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - integrated with #66
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
69	Unobtrusive. Parallel with highway. Anchored against low fill batter. Potential for screening and softening of highway formation.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design - integrated with #70 and #71
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
70	Unobtrusive. In angle between highway and local access track. But will be a separate mound separated by swale.											keep - shape modified to match new road design - integrated with #69 and #71
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
71	Unobtrusive. Parallel with highway. Anchored against low fill batter. Potential for screening and softening of highway formation. Integrate with spoil site 69 to north.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design - integrated with #69 and #70
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
72	Unobtrusive location alongside highway. But would be a mound separate from highway. It would interrupt agricultural land use and landscape patterns. Priority should be given to sites against the highway.				Low level risk, adjacent to Waikokopu stream							keep - shape slightly modified
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
73	Unobtrusive location. However will be an isolated mound on the plain where highway is in shallow cut.											keep - above cut so not recommended to be moved closer to the highway - low preference option from a geotech point of view, could be deleted if enough volume of spoil sites is available.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
74	Extension of spoil site 73. Unobtrusive location. However will be an isolated mound on the plain where highway is in shallow cut. Southern end will be perched above terrace scarp.				Probably Green, but archaeological sites more likely to be found here than adjacent spoil site.	Assume riparian planting at perimeter. Bunding to catch sediments off the mound during planting establishment.						keep - above cut so not recommended to be moved closer to the highway - low preference option from a geotech point of view, could be deleted if enough volume of spoil sites is available.
	Green	Green	Green	Red	Orange	Green	Green	Not Completed	Not Completed	Not Completed	16	
75	Unobtrusive location anchored against over-bridge ramp. Opportunity to soften ramp.											keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
76	Unobtrusive location anchored against over-bridge ramp. Opportunity to soften ramp.											keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
76a	Would require removal of villa and garden that may otherwise be retained. Southern end would encroach into watercourse. Spoil would appear as isolated mound on plain, adjacent to where highway is in a box cut. Would disrupt agricultural land use and landscape pattern. Would be better to increase volume of spoil sites 78 and 79 on opposite side of highway.	EHG (Negligible)	Southern tip of spoil area overlies stream channel (uncertain if ephemeral or permanently flowing at this point). This area could be made green if southern boundary was tweaked to be away from the stream.		1880s Whiley house is likely to be located in this vicinity, most likely in close proximity to N. Manakau Road							deleted, too many constraints.
	Orange	Green	Red	Orange	Red	Green	Green	Not Completed	Not Completed	Not Completed	11	
77	Unobtrusive location anchored against over-bridge ramp. Opportunity to soften ramp.				Former Whiley house could be in this location (suspect much less likely than in Red spoil site) as this was also part of the parcel formerly owned by Whiley.							keep - shape modified to match new road design.
	Green	Green	Green	Orange	Orange	Green	Green	Not Completed	Not Completed	Not Completed	15	

78	Good location. Unobtrusive. Anchored against fill batter. Opportunity to contour to soften highway.				Probably low risk, but approaches edge of Mangahuia Stream.							keep - shape modified to match new road design.	
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18		
79	Good location. Unobtrusive. Anchored against fill batter. Opportunity to contour to soften highway. Could be expanded to north to merge with spoil site 78.		Cuts across some ephemeral flow paths, but road itself is altering drainage of these, so spoil not likely to have major change in hydrology of these channels. Hence green assigned rather than amber.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to streams					deleted - now coincides with pond	Comment superseded: Keep as is - was not connected to 78 because of the streams. To be further examined if #78 and #79 can be extended closer to stream if appropriate design.
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16		
80	OK. Unobtrusive location. (Would be better for mitigation of visual effects to assign volume to spoil sites 78 and 79 on opposite side of highway).						Adjacent to streams					Deleted.	
	Green	Green	Green	Not Completed	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15		
81	Unobtrusive location. Anchored against low fill batter. (May be better for visual mitigation to assign volume to an expanded spoil site 79 on opposite side of highway).		Southern tip comes close to permanently flowing stream. Site could be made green with tweak of boundary to move away from stream.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to streams					keep - shape modified to be away of streams.	
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13		
83	Anchored against fill batter. Opportunity to tie in with naturalisation of Mangahuia Stream diversion.	Within 10 metres of EWG8 (Low) EHG (Negligible)			Probably low risk, but proximity to Mangahuia Stream and spring?		Adjacent to wetland to the south					keep - modified to be away from streams	
	Green	Orange	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13		
84	Anchored against low fill batter. Opportunity to soften highway.		Southern tip of spoil area comes close to permanently flowing stream. Could be green with tweak of boundary to move away from stream.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to wetland and Manakau stream (each end of the spoil site - possibility to implement 10-20 m buffers?)					keep - shape modified to match new road design and increase capacity. Southern tip modified to be away from stream.	
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13		
86	Appears intended to fill an ephemeral watercourse. Would have more positive effects to consolidate the spoil volume with spoil sites 83 and 84 against the highway fill batters.				Probably low risk, but approaches edge of Mangahuia Stream and probable spring?		Adjacent to wetland				0	Deleted. #84 extended.	
	Orange	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13		
87	Good location. Separates local road from highway. Opportunity to soften views from house to east. Could be merged with spoil site 89 to south.				Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to stream					keep - modified to match new road design.	
	Green	Green	Green	Not Completed	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15		
88	OK. Adjacent to highway and over-bridge. Could be contoured to soften Project.		Northern tip of spoil area comes close to permanently flowing stream. Could be green with tweak of boundary to move away from stream.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to stream					keep - modified to match new road design. Proximity to stream can be addressed in design.	
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13		
89	Good location. Separates local road from highway. Opportunity to soften views from houses to east. Could be merged with spoil site 87 to north. Could be featured into over-bridge ramp to south.				Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to stream					keep - modified to match new road design. Proximity to stream can be addressed in design.	
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16		
90	Unobtrusive location. Anchored against fill batter opposite over-bridge. Opportunity to soften views from houses to east.										0	keep - geometry modified to match new road design	
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19		
91	In front of house. Potential to form contoured bund around house to screen highway.	EHG (Negligible)	Southern tip of spoil area comes close to permanently flowing stream. Could be green with tweak of boundary to move away from stream.		Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel		Adjacent to waterway				0	keep - southern end has been shortened slightly to be away from the stream	
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13		

92	Unobtrusive location in angle between highway and over-bridge. Anchored against over bridge fill batter. Opportunity to feather earthworks.				Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel		Adjacent to stream				0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16	
93	OK. Adjacent to highway and over-bridge. Could be contoured to soften Project.				Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel						0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
94	Unobtrusive location in angle between highway and over-bridge. Anchored against over bridge fill batter. Opportunity to feather earthworks.				Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel						0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
95	Would be on terrace in front of house. Potential to form in contoured bund around house to screen highway.	Open water and wetland habitat appear to be present based on desktop assessment.	Spoil area encroaches on fenced "spring-head"/wetland and comes close to constructed outlet channel of this wet area. Could be made green by tweaking boundary away from these features.		No known sites in this area, but cannot be entirely ruled out.						0	keep - geometry modified to match new road design and location of pond - southern end has been shortened slightly to be away from the stream
	Green	Orange	Orange	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	13	
96	Unobtrusive location. Anchored against fill batter. Southern end should be trimmed to avoid water course. Note that spoil sites on opposite side of highway are higher priority for potential mitigation.		Northern tip of spoil area comes close to permanently flowing stream and southern tip overlies permanent stream. Could be green with tweak of boundaries to move away from stream.		No known sites in this area, but cannot be entirely ruled out.		Adjacent to waterway protect existing stream and enhance				0	keep - geometry modified to match new road design and location of pond - northern end has been shortened slightly to be away from the stream
	Green	Green	Red	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	14	
97	Good location. Anchored against hill fill batters. Opportunity to contribute to softening of highway. This should be priority location of spoil to mitigate adverse visual effects. Widening footprint to designation boundary would be beneficial.	ITT02 (Moderate) - Within construction buffer so assumed to be lost any way. EHG (Negligible)	Northern tip of spoil area overlies permanently flowing stream. Could be green with tweak of boundary to move away from stream.		No known sites in this area, but cannot be entirely ruled out.		Adjacent to waterway protect existing stream and enhance				0	keep - geometry modified to match new road design - northern end has been shortened to be away from the stream
	Green	Green	Red	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	14	
98	Unobtrusive location. Anchored against fill batter. Southern end should be trimmed to avoid water course. Note that spoil sites on opposite side of highway are higher priority for potential mitigation.				No known sites in this area, but cannot be entirely ruled out.						0	keep - geometry modified to match new road design, a new 98a has been added between side road and main alignment
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
99	Unobtrusive location. Anchored against fill batter. Opportunity to contribute to screening from properties to west. Opportunity to merge with spoil site 98 to north.	ITT04 (Low)			No known sites in this area, but cannot be entirely ruled out.						0	keep - increased to make up for deletion of #101 and #100
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
100	Opportunity to accentuate height of small terrace to help embed highway in landscape.	Within 10 metres of EWRs1 (Low) EHG (Negligible)	Spoil area overlies channel the links a series of dams upstream to the Manakau Stream. Could be made green by shrinking size of spoil area to avoid this channel.		Close proximity to named stream, archaeological sites possibly more likely found on terrace.		Connection to streams Adjacent to Pukehou - high spiritual significance, spiritual pathway Waterways and wetlands				0	deleted - too many constraints.
	Green	Orange	Red	Red	Orange	Green	Red	Not Completed	Not Completed	Not Completed	9	

101	Would encroach on Waiauti Stream flood plain and bury natural scarp and remnant ox bows. Would exacerbate adverse natural character effects, and undermine proposed mitigation. There may be opportunity to extend spoil site 100 by forming a contoured bund on top of the terrace (outside designation) to mitigate visual effects for houses on Mountain View Drive. Such an approach would accentuate existing landforms.	IWSe1 (moderate) EWRs1 (Low)	Impedes on area proposed for potential stream realignment and an important riparian revegetation zone where we would prefer to have native soils in which to plant. Also overlies areas of wetland.		Close proximity to named stream, archaeological sites possibly more likely found on terrace.	Footprint encroaches (pushes) into a floodplain, raising upstream flood levels and increasing head and discharge through proposed bridge and downstream. Effects should be put into a hydraulic model to see if flood impacts are significant before filling here.	Adjacent to Pukehou - high spiritual significance, spiritual pathway Waterways and wetlands				0	deleted - too many constraints.
	Red	Red	Red	Red	Orange	Orange	Red	Not Completed	Not Completed	Not Completed	5	
102	Anchored against approximately 6m high fill batter. Opportunity to create knoll on higher land immediately south-west (CH30660-30800) that would accentuate existing landforms and help embed highway in landscape.				Proximity to named stream (Waiaute/Waiauti) which indicates potential archaeological significance. May be Green, ideally would conduct geophysical survey in this area		Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - geometry modified to match current alignment and designation
	Green	Green	Green	Red	Orange	Green	Orange	Not Completed	Not Completed	Not Completed	13	
104	This area earmarked to provide buffer planting to the adjacent Staples Bush. Such planting will do best in natural ground.				Low level potential for archaeological sites to be found on terraces over looking gullies.		Wetlands				0	deleted
	Orange	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	14	
105	Unobtrusive location. Anchored against fill batter. Opportunity to feather batter.	ITT03 (Low)	Overlies and comes close to ephemeral flow paths. You'll need to check that won't cause any drainage issues.		Low level potential for archaeological sites to be found on terraces over looking gullies.		Wetlands				0	deleted - on top of cut, out of context based on new alignment and cannot avoid wetlands
	Green	Green	Orange	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	14	
106	Unobtrusive location. Anchored against fill batter. Opportunity to feather batter.				Low level potential for archaeological sites to be found on terraces over looking gullies.		Wetlands				0	no change at this stage - wetlands seem to be further away from spoil site, as spoil site is suggested on the terrace
	Green	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	17	
106a	On terrace. Potential to accentuate terrace to help embed highway. Integrate with naturalising of watercourse between terrace and batter. Take care to maintain sightlines to SUP.	EWG4 (Low)	Northern tip looks to overlie wetland. Potential could be green if boundary tweaked away from this area (check with Wildlands).		Could also be Amber, low level potential for archaeological sites to be found on edge of terraces overlooking gully		Wetlands				0	no change at this stage - will need modification in detailed design to tie well with landscape and avoid the mentioned potential constraints
	Green	Orange	Orange	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	11	
107	Unobtrusive location. On sloping terrace. Anchored against fill batter.				Low level potential for archaeological sites, but higher concentrations of charcoal were observed here during geotech test pitting. This area was beyond Pukehou geophysical survey.		Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - no modification at this stage
	Green	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	17	
108	Encroaches into wet gully near section that is proposed to be restored to address natural character effects. Some spoil could be anchored against fill batter. However, greater potential to integrate with spoil site 112 and extend the terrace spur landform to the south.		Northern corner overlies permanently flowing stream. Whole area is in zone that could potentially be a wetland restoration area.			Encroaching into a floodplain. The effect (flood water level rise) is offset by extra storage upstream of Highway, but hydraulic model needed for overall floodplain effects . Area overlays a low ecological value wetland swale that would need to be reinstated closer to existing SH1 road.	Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	deleted - it is now coinciding with stormwater pond
	Orange	Green	Red	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	9	
109	Encroaches into wet gully near section that is proposed to be restored to address natural character effects. Potential instead to integrate with spoil site 112 and extend the terrace spur landform immediately to the south.	Within 10metres of MWG1d (Low)	Whole area is in zone that could potentially be a wetland restoration area.			Some small encroachment into floodplain. Hydraulic floodplain modelling needed to assess effects. Assessed in conjunction with the two adjacent fill sites	Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	deleted - too many constraints.
	Orange	Orange	Orange	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	5	
110	Fills one of the gullies that are characteristic of the pattern of gullies and terraces around the toe of Pukehou. Would have adverse landscape and natural character effects. Potential instead to integrate with spoil site 112 and extend the terrace spur landform immediately to the south.	ITS1d (Moderate), North-western edge overlays scrub edge.	Very close of permanently flowing stream and area west of farm track is in zone that could potentially be a wetland restoration area.		Low level risk that archaeological materials could be found in gully	Encroaching into a floodplain to a low level. The effect (flood water level rise) is offset by extra storage upstream of Highway, but hydraulic model needed for overall floodplain effects . The area could be trimmed back so western edge is further away from the stream.	Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	deleted - too many constraints.

	Orange	Orange	Red	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	6	
112	While the site is a small drainage course, it is part of a terrace spur. The landscape has a pattern of terraces and gullies around the toe of Pukehou. Potential to extend this terrace landform (CH32650-32750) while retaining the gully watercourses. Could incorporate spoil sites 108, 109 and 110. This would mimic landform pattern and help embed highway in landscape.				Previously covered by geophysical survey. No obvious archaeological signs, but some patterns in geophysical results that were unexplained.		Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - geometry modified to be moved away waterway and mimic existing terrain - geometry likely needed to modified further in detailed design to tie well with earthworks and landscape
	Green	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	17	
116	On low terrace spur. Anchored against low fill batter. Opportunity to extend spoil site further east on terrace spur and incorporate volume from spoil sites 117, 118, and 119.				Small possibility for archaeological material in this area, most likely to be found on edge of terraces overlooking gully.	Encroaches into a flow path and floodplain. Ok if upstream fills not placed. Not so ok if upstream fills not placed as well.	Wetlands and Gully's Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - geometry modified to be moved away from terrace and waterway and be closer to the road and tie in with road embankment - geometry likely needed to modified further in detailed design to tie well with earthworks and landscape
	Green	Green	Green	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	14	
117	Fills one of the gullies that are characteristic of the pattern of gullies and terraces around the toe of Pukehou. Would have adverse landscape and natural character effects. Potential instead to integrate with spoil site 116 and extend on the terrace spur to the north-east.	EWG5 (Low) ETF4 (Low)	Spoil site fills ephemeral flow path.		Small possibility for archaeological material in this area, most likely to be found on edge of terraces overlooking gully.	Mound sited in a wide wetland swale type watercourse. Pipeline could be installed under mound but mound location is in the wrong place.	Wetlands and Gully's Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	deleted - too many constraints.
	Orange	Orange	Orange	Red	Green	Red	Red	Not Completed	Not Completed	Not Completed	6	
118	Fills one of the gullies that are characteristic of the pattern of gullies and terraces around the toe of Pukehou. Would have adverse landscape and natural character effects. Potential instead to integrate with spoil site 116 and extend on the terrace spur to the north-east.	Likely to contain exotic wetland vegetation (desktop assessment not include in the field surveys to date)	Boundary may need tweaking to ensure area does not encroach on ephemeral flow path.		Small possibility for archaeological material in this area, most likely to be found on edge of terraces overlooking gully.	Mound fills in a watercourse. A pipeline could be included, but if blockage the flow would divert left or right. Outside project footprint.	Wetlands and Gully's Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	deleted - too many constraints.
	Orange	Orange	Orange	Red	Green	Red	Red	Not Completed	Not Completed	Not Completed	6	
119	Fills gully. Disrupts the pattern of gullies and terraces around the toe of Pukehou. Would have adverse landscape and natural character effects. Potential instead to integrate with spoil site 116 on opposite side of highway and fill terrace spur.		Spoil site fills ephemeral flow path.		Probably Green, but possibly Orange. Geophysical survey indicated possible archaeological site on edge of terrace above this site. There is potential for archaeological material to be present in the gully.	Encroachment into floodplain with increased flood levels possible (to be determined if significant with hydraulic flood model). Some loss of low ecological value wetland swale. Diversion channel needed.	Wetlands and Gully's Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	deleted - too many issues
	Orange	Green	Orange	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	8	
121	Unobtrusive location. In angle between highway and ramps. Anchored against low fill batter.				Low risk, parts previously covered by geophysical survey. Some iron fragments, expected to be modern farming waste.						0	keep - no modification needed
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
122	Unobtrusive location. In angle between local road and highway. Opportunity to soften highway and interchange.				Low risk, parts previously covered by geophysical survey. Some iron fragments, expected to be modern farming waste.						0	keep - no modification needed
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
123	Pasture. Flat. Opportunity to contour (overfill) against new local road. Adjacent to house 82 SH1 (Stantec # 7). Owned by Waka Kotahi. Opportunity to contour as bund buffer.	Site occurs on flat pasture with no indigenous habitats.	Site well away from any waterways.		Low potential for archaeological sites, geophysical survey of paddocks to the north did not detect anything of interest.	Minimal stormwater issues						Keep
	Green	Green	Green	Green	Green	Green	Green				21	

124	Pasture. Flat terrace. Opportunity to contour (overfill) against new local road. Adjacent to house 114 SH1 (Stantec #27). Ō2NL would already have 'high' adverse visual effects for house. Opportunity to contour spoil as bund to help buffer effects.	Site occurs on flat pasture with no indigenous habitats. Will require removal of some exotic tree land, which provides marginal habitat for bird species.	Cuts across Stream 0 (permanently flowing) and zone of proposed riparian planting directly upstream of culvert. This would require culvert extension, which is not desirable and would need to be offset elsewhere. This could be reduced to "Green" if site were to split in two to avoid stream and provide minimum 20 m buffer between edge of spoil and stream channel.		Low potential for archaeological sites, geophysical survey of paddocks to the north did not detect anything of interest.	Spoil crosses over a small meandering watercourse. Environmental offset likely, culvert placement required, potential upstream flooding. May need a gap in the spoil mound for the waterway.	Requires buffer from the stream					keep - Site 124 split in two parts to be 20 m away from stream
	Green	Green	Red	Green	Green	Orange	Green				16	
125	Pasture. Relatively flat terrace above Ō2NL and between Ō2NL and Pukehou. Reasonably elevated. Opportunity to mimic terrace surface and tie in to small scarp at back of site (designation boundary could be shifted to SE to increase the area of this site). Adjacent to a house 170 SH1 (Stantec #19). Ō2NL would already have 'high' adverse visual effects for house. Opportunity to contour spoil as bund to help buffer effects.	Site occurs on flat pasture with no indigenous habitats.	Site away from waterway but would need strict erosion and sediment controls due to adjacent steep-sided gully with Stream 3 at the bottom.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues						Keep
	Orange	Green	Green	Green	Green	Green	Green				18	
126	Pasture. Terrace spur above incised gully and above Ō2NL. Reasonably elevated. Close to Pukehou (between Ō2NL and Pukehou).s Limited opportunities to contour into landform.	Site occurs on flat pasture with no indigenous habitats.	Site away from waterway but would need strict erosion and sediment controls due to adjacent steep-sided gully with the ephemeral Stream 5 at the bottom. This stream is directly linked to wetland downstream of existing SH1, hence we want to avoid elevated sediment runoff.		Probably Green, but there are some unusual geophysical signals here that could be archaeological. If archaeological, impact would likely be Orange.	Minimal stormwater issues	S& E control looks too tight, environmental effects risk is elevated. Avoid if possible.					Keep
	Red	Green	Green	Green	Green	Green	Orange				16	
127	Pasture. Flat gully floor. Adjacent to watercourse identified for natural character and ecological restoration and upstream of culvert under existing SH1. Care would be needed to avoid encroaching on stream and rehabilitation area. However, good opportunity to contour spoil against toe slope immediately to SE or against spur to SW.	Site occurs on flat pasture/cropping field with no indigenous habitats. Borders strip of mahoe-karamu scrub which may be vulnerable to draw down of groundwater during excavation. Potential to disturb indigenous birds roosting or foraging in the vegetation.	Site comes very close (~5 m) of Stream 10 (permanently flowing) and encroaches on proposed riparian planting. There is also other drainage channels near northern and southern edges of site. This could be reduced to "Green" if site were reshaped to provide minimum 20 m buffer for Stream 10 and other adjacent channels. This stream is directly linked to wetland downstream of existing SH1, hence we want to avoid elevated sediment runoff. Strict erosion and sediment controls would be required.		No comment	Minimal stormwater issues	Close to waterways, requires stream planting around site to compensate for effects.					Keep - Spoil site footprint modified to be away from Stream 10. All other issues raised will be addressed in detailed design of the spoil site.
	Orange	Orange	Orange	Green	Green	Green	Orange				9	
128	Pasture. Middle of site is a flat-topped spur, and northern part is a shallow head of a gully above a fill embankment. Suitable for contoured spoil, although care should be taken to avoid spilling into head of gully in south part of the site.	Site largely occurs on flat pasture. At least three exotic trees will need to be removed, although the level of effect will be very low.	Site is over top of the ephemeral Stream 12. This is directly linked to the Waiauti Stream. Careful drainage design and strict erosion and sediment controls required here to avoid elevated fine sediment inputs into Waiauti Stream. Could require extension of Andrew Craig's Culvert 12.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues	Filling in paleochannels, requires planting compensation.					Keep - Extension of culvert 12 may be required.
	Green	Green	Orange	Green	Green	Green	Orange				15	
129	Pasture. Relatively flat terrace. Not adjacent to Pukehou or streams. Potential to contour spoil to fit terrace and to soften top of cut.	Site occurs on flat pasture with no indigenous habitats.	Site away from waterway but would need strict erosion and sediment controls due to proximity to Waiauti Stream.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues	Filling in paleochannels, requires planting compensation.					Keep
	Green	Green	Green	Green	Green	Green	Orange				18	

130	Pasture. Sloping terrain – side and head of small gully. Potential for spoil to be contoured along top of cut and against works at head of gully.	Site occurs on flat pasture with no indigenous habitats.	Site comes close to ephemeral channel that links directly to Waiauti Stream. This could be reduced to "Green" if site were reshaped to provide minimum 20 m buffer with ephemeral channel and use of strict erosion and sediment controls.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues	Filling in paleochannels, requires planting compensation.					Keep - Reshaped to be ~20 m away from stream.
	Green	Green	Orange	Green	Green	Green	Orange				15	

A2: Final Spoil Sites Recommended for Consenting

Spoil Site ID	Visual Assessment	Terrestrial Assessment	Aquatic Assessment	Highly Productive Soils Assessment	Archaeology and Heritage Assessment	Stormwater Assessment	MTA Assessment	Ngati Raukawa 1 Assessment	Ngati Raukawa 2 Assessment	Ngati Raukawa 3 Assessment	Score	Stantec comment 3/12/2021 and 6/04/2021 (GIS Map action)
01	Contouring opportunity to soften roundabout. No landscape constraints.	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date					keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
02	Contouring opportunities to soften roundabout. No landscape constraints.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date					keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
03	Contouring opportunities to soften roundabout. No landscape constraints.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date					keep - shape modified to match new road design - connected with #5 and #6
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
04	Contouring opportunity to soften roundabout. No landscape constraints,	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Highly modified farming to date				0	keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
06	No landscape constraints.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Highly modified farming to date					keep - shape modified to match new road design - connected with #5
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
07	Would be out of place: would compromise cropping paddock and disrupt landscape pattern.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.						Keep - no change
	Orange	Green	Green	Not Completed	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	

09	Anchored against fill embankment.	ETF4 (Low)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - cannot be extended - no change
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
10	Anchored against fill embankment.	ETF4 (Low)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Proximity to significant rivers, streams, springs, wetlands and lakes; need to tread carefully				0	Keep - geometry refined to match new road design - proximity to waterways to be addressed in design
	Green	Green	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15	
	Green	Orange	Orange	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	9	
12	Care required but could be integrated with natural character mitigation proposed in this area between stormwater pond and restored gully wetland.	Within 10 metres of IWSe1-SPG (Moderate)			There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Proximity to wetland and waterways. Need to tread carefully.					keep - shape modified to match new road design - environmental and stormwater issues to be addressed in design
	Orange	Orange	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	9	
13	In wetland gully that highway was aligned to avoid. Would be better on terrace immediately to north adjacent to highway.	May contain EWH9d (Low)	This one does come close to what looks like a wetland, so effects on that wetland will need to be considered.		There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This would involve channel diversion of small, existing, streams that are draining paddocks with zero vegetation shade and low ecological health compared to a stream set back from a working, cropping, farming operation. Mounds could be shaped to avoid concentrated flow paths, and a full perimeter bund to trap sediments in the vegetation establishment phase.	Amber-Red - Site visit needed to better assess Wetlands - site would disturb the natural drainage and soakage capacity of the soil Ngā wai ora: healthy waterways					previously proposed #13 deleted. Now moved at the north side of the highway and combined with #12.
	Red	Orange	Green	Orange	Green	Orange	Red	Not Completed	Not Completed	Not Completed	8	
16	On terrace, against highway low fill batter. No landscape constraints.				There is potential for archaeological sites to be found of edge of terraces overlooking gullies. Similar environment to where geophysical survey identified probable archaeological sites at Pukehou.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Sitting on the highpoint					keep - modify to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
18	Flat land adjacent to highway. However, may be better aligned parallel to highway where it would provide some screening and reduce encroachment into pattern of paddocks.	EHG (Negligible)			Low level potential, but overlooks Waikarito stream	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Farmland to date					keep - reshaped to match new road design and be within designation
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	

19	Anchored against highway fill batter. Unobtrusive		Southern end just clips stream channel. This one could be green if tweaked slightly to clear stream channel.		Low level potential, crosses probably path linking Horowhenua to northern regions.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - reassess southern end - extended slightly to the north
	Green	Green	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
20	Flat land adjacent to highway. Opportunity to provide contoured mound to screen existing house.		Southeast edge within 20 m of stream channel. Could be green if boundary tweaked to further away from stream.		Low level risk, approaches edge of Waitaiki stream	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.	Farmland to date					keep - southern edge modified to be away of stream channel - extended slightly to the north and connected to highway embankment
	Green	Green	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
21	Contouring opportunities to soften roundabout	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - modified to match new road design and connected with #24
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
22	Contouring opportunities to soften roundabout, and separate roundabout from realigned McDonald Road.	EHG (Negligible)				Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow flow paths to be formally diverted and managed.	Farmland to date					keep - modified to match new road design and connected with #25
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
23	Contouring opportunities to soften roundabout.		Southern tip just touches stream channel. Could be green with slight boundary tweak.		Low level risk, approaches edge of Waitaiki stream	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - southern tip modified to be away from stream - geometry modified to follow new road design - connected with #26
	Green	Green	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
24	Opportunity for contouring between SUP and roundabout					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - geometry modified to match new road design - connected to #21
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
25	Would be integrated with adjacent spoil disposal site 22.	EHG (Negligible)				This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Farmland to date					keep - previous #25 was integrated with #22. New #25 is at the south side of the roundabout, connected to road embankment.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	

26	Opportunity to contour between SUP and roundabout.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - geometry modified to match new road design - connected to #23
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
27	Unobtrusive location and could be integrated with naturalisation of stormwater detention area. (But could impede reconfiguring area for agriculture)	EHG (Negligible)			Probably Green, but land court records indicate low level possibility that there may be a cultivation ground/clearing in this area.	Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow existing flow paths to continue or be formally diverted.						keep - although weird shape, must have been left over from previously location of pond. Further examine if more of this section of land can be used if more volume is required.
	Green	Green	Green	Orange	Orange	Green	Green	Not Completed	Not Completed	Not Completed	15	
27b	Is over Koputaroa Stream (would have significant adverse effects)	EHG (Negligible)	Much of this area overlies main stem of Koputaroa Stream.		Sources indicates shell midden and ovens are found along the banks of this stream. Small possibility of cultivation ground/clearing in this area too.	Inappropriate placement over established riparian margin and important stream path. Natural floodplain filled in, raising flood levels in surrounding areas including highway in a flood event.	Going over a significant waterway Te Awa A Te Tau o Koputaroa stream					Previous 27b deleted. New location of 27b, drawn ton the west side of the road, within the same land section as 27.
	Red	Green	Red	Orange	Orange	Red	Red	Not Completed	Not Completed	Not Completed	7	
	Orange	Green	Orange	Orange	Orange	Green	Green	Not Completed	Not Completed	Not Completed	9	
28	Unobtrusive location parallel with highway. Could provide some screening.	EWH5 (Low)	Area is very close to stream channel.		Close proximity to small creek, low level potential for sites.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Adjacent to overland run off - streams					keep - shape and location modified to follow new road design - now further away from stream channel.
	Green	Orange	Orange	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	9	
29	Unobtrusive location parallel with highway. Could provide some screening.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Adjacent to degraded stream					keep - shape and location modified to follow new road design - now further away from stream channel.
	Green	Green	Green	Orange	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15	
30	Unobtrusive location parallel with highway. Could provide some screening. Shortening southern end might better enable agricultural land use and landscape pattern.				Close proximity to small creek, low level potential for sites.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.	Farmland to date					keep - shape modified to match new road design
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
31	Contouring opportunity to soften intersection.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
32	Contouring opportunity to soften intersection.	EHG (Negligible)										original #32 deleted - now coincides with stormwater pond. New #32 at the east side of motorway, contouring roundabout embankment.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	

33	Contouring opportunity to soften intersection.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.					0	Original #33 deleted and modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
34	Contouring opportunity to soften intersection.											Original #34 deleted and modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
35	Contouring opportunity to soften intersection.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Original #35 deleted and modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
36	Contouring opportunity to soften intersection. (opportunity for large spoil disposal site opposite between the south-bound on-ramp and new local link road?)					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Original #36 deleted and modified to match new road design, and based on landscape comments.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
37	Unobtrusive location but would disrupt agricultural land use and landscape pattern.					This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Keep - geometry modified to match new road design and be within designation
	Orange	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
38	Unobtrusive location. Would help separate highway from local road.		Covers wetland.			This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						Keep - geometry modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
41	Parallel with highway. Anchored against fill batter. Potential screening opportunity.	ETF4 (Low)				Diversion channel could go around eastern side of fill site. This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
42	Parallel with highway. Anchored against fill batter. Potential screening opportunity.	ETF4 (Low)			Low level risk of late 1880s house in this area, but I suspect it is situated outside of the designation.	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design and be within designation.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	

43	Parallel with highway. Anchored against fill batter. Potential screening opportunity.				Low level risk of late 1880s house in this area, but I suspect it is situated outside of the designation.	This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape modified to match new road design and be within designation.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
44	Unobtrusive location in angle between highway and over bridge. Minor fill site. Anchored against fill batters.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design and be within designation.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
45	Unobtrusive location in angle between highway and over bridge. Anchored against fill batters. Opportunity to soften over bridge.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design and be within designation. Slightly extended.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
46	Unobtrusive location in angle between highway and over bridge. Anchored against fill batters. Opportunity to soften over bridge.					Pipeline extension to accommodate new footprint over. This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design. New 46a at the east side of ramp.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
47	Unobtrusive location in angle between highway and over bridge. Anchored against fill batters. Opportunity to soften over bridge.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
48	Unobtrusive. Parallel with highway. Anchored against fill batter. Planting spoil disposal site would tie in with storm water wetland.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
49	Parallel with highway. Anchored against fill batter. Unobtrusive. Opportunity for screening from house to NW.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design. Extended to make up for #50.
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
51	Unobtrusive. Parallel with highway. Anchored against fill batter. But interrupts potential agricultural land use and landscape pattern. Better to integrate with Site 53.					Diversion channel could go around western side of fill site. This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - extended to the south to integrate with #53.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
52	Unobtrusive. Parallel with highway. Anchored against fill batter. Fills in left over land between highway and hill.					Mounding site is acceptable assuming high point in the centre spine, with fairly uniform slope shapes to prevent concentrated flow paths. Bund at base perimeter until vegetation is established to capture silts that are caught in the runoff. Footprint to allow flow paths to be formally diverted and managed.	Regenerating indigenous vegetation					keep - moved closer to new alignment and now further away from vegetated area.
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16	

53	Unobtrusive. Parallel with highway. Anchored against fill batter.	EWH9 (Low)	Southern tip of area may overlay ephemeral flow path. Could be green if boundary tweaked to avoid flow path.			Diversion channel could go around western side of fill site. This could be a vegetated surface with sheet flow filtering potential. At base, a drainage swale or wetland swale could be placed allowing ephemeral ponding and a wetland, with soakage and ponding disposal with a bund on perimeter to trap sediments. Specialised planting at base.						keep - shape was modified to be out of stream and pond and integrated with #51.
	Green	Orange	Orange	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	12	
55	OK. On terrace. But separate from highway.	ITS1d (Moderate) Wetland habitat likely to be present based on desktop assessment.			Potential for archaeological sites on terrace over looking Kuku Stream	Out of primary river terrace. Better if further back from terrace.	Indigenous scrub - avoid vegetation Adjacent to stream					keep - geometry modified to be further away from terrace and occupy smaller area.
	Green	Orange	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	
56	Unobtrusive. Potential for replanted site to be integrated with storm water wetland.				Probably Green, but Lindsay indicated possible battle passing through this area where victims were left where they fell (at the time he wasn't 100% certain if the Kuku was the right location, but that was the information he had at the time). Low level risk of finding human remains in this area?	Out of floodplain. Out of primary river terrace.						keep - modifies to be closer to alignment and follow new road embankment.
	Green	Green	Green	Red	Orange	Green	Green	Not Completed	Not Completed	Not Completed	16	
58	Unobtrusive. In angle between highway and over bridge. Opportunity to soften over bridge.	EHG (Negligible)			Probably Green, but Lindsay indicated possible battle passing through this area where victims were left where they fell (at the time he wasn't 100% certain if the Kuku was the right location, but that was the information he had at the time). Low level risk of finding human remains in this area?	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modify to match new highway embankment.
	Green	Green	Green	Red	Orange	Green	Green	Not Completed	Not Completed	Not Completed	16	
59	Unobtrusive. In angle between highway and over bridge. Opportunity to soften over bridge.				Low level risk, close to unnamed stream/creek	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - could be extended to the south?
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
61	Unobtrusive. Parallel with highway. Anchored against fill batter. Potential for screening and softening of highway formation.		Southern end overlays existing stream. Could be green with tweak to boundary to avoid stream.			This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Make sure to bund off around stream					keep - southern end modified not to interfere with stream - extended to the north.
	Green	Green	Red	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	17	
63	unobtrusive. Parallel with highway. But would be bund separated from highway formation by local access. May be better to integrate fill with spoil site 61 on opposite side of highway.	Wetland habitat likely to be present based on desktop assessment.	Area comes within 20 m of existing stream. Could be green if boundary tweaked away from stream.		Low level risk, adjacent to unnamed stream/creek	This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.	Adjacent to stream north part of Spoil site would be ok, not south					Original #63 deleted. New location further to the south and modified to be away from stream.
	Green	Orange	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	10	
64	Unobtrusive. Parallel with highway. Anchored against fill batter. Potential for screening and softening of highway formation. Integrate with spoil site 61 to the north.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
66	Unobtrusive. Parallel with highway. Potential for screening and softening of highway formation.	Within 10 metres of MWG1d (Moderate)				This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - volume increased. Merged with previous #68
	Green	Orange	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	15	
69	Unobtrusive. Parallel with highway. Anchored against low fill batter. Potential for screening and softening of highway formation.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design - integrated with #70 and #71
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	

70	Unobtrusive. In angle between highway and local access track. But will be a separate mound separated by swale.											keep - shape modified to match new road design - integrated with #69 and #71
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
71	Unobtrusive. Parallel with highway. Anchored against low fill batter. Potential for screening and softening of highway formation. Integrate with spoil site 69 to north.					This could be a vegetated surface with sheet flow filtering potential. With a bund on lower perimeter to trap sediments.						keep - shape modified to match new road design - integrated with #69 and #70
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
72	Unobtrusive location alongside highway. But would be a mound separate from highway. It would interrupt agricultural land use and landscape patterns. Priority should be given to sites against the highway.				Low level risk, adjacent to Waikokopu stream							keep - shape slightly modified
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
75	Unobtrusive location anchored against over-bridge ramp. Opportunity to soften ramp.											keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
76	Unobtrusive location anchored against over-bridge ramp. Opportunity to soften ramp.											keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
77	Unobtrusive location anchored against over-bridge ramp. Opportunity to soften ramp.				Former Whiley house could be in this location (suspect much less likely than in Red spoil site) as this was also part of the parcel formerly owned by Whiley.							keep - shape modified to match new road design.
	Green	Green	Green	Orange	Orange	Green	Green	Not Completed	Not Completed	Not Completed	15	
78	Good location. Unobtrusive. Anchored against fill batter. Opportunity to contour to soften highway.				Probably low risk, but approaches edge of Mangahuia Stream.							keep - shape modified to match new road design.
	Green	Green	Green	Orange	Green	Green	Green	Not Completed	Not Completed	Not Completed	18	
81	Unobtrusive location. Anchored against low fill batter. (May be better for visual mitigation to assign volume to an expanded spoil site 79 on opposite side of highway).		Southern tip comes close to permanently flowing stream. Site could be made green with tweak of boundary to move away from stream.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to streams					keep - shape modified to be away of streams.
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	
83	Anchored against fill batter. Opportunity to tie in with naturalisation of Mangahuia Stream diversion.	Within 10 metres of EWG8 (Low) EHG (Negligible)			Probably low risk, but proximity to Mangahuia Stream and spring?		Adjacent to wetland to the south					keep - modified to be away from streams
	Green	Orange	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	
84	Anchored against low fill batter. Opportunity to soften highway.		Southern tip of spoil area comes close to permanently flowing stream. Could be green with tweak of boundary to move away from stream.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to wetland and Manakau stream (each end of the spoil site - possibility to implement 10-20 m buffers?)					keep - shape modified to match new road design and increase capacity. Southern tip modified to be away from stream.
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	
87	Good location. Separates local road from highway. Opportunity to soften views from house to east. Could be merged with spoil site 89 to south.				Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to stream					keep - modified to match new road design.
	Green	Green	Green	Not Completed	Green	Green	Orange	Not Completed	Not Completed	Not Completed	15	
88	OK. Adjacent to highway and over-bridge. Could be contoured to soften Project.		Northern tip of spoil area comes close to permanently flowing stream. Could be green with tweak of boundary to move away from stream.		Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to stream					keep - modified to match new road design. Proximity to stream can be addressed in design.
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	

89	Good location. Separates local road from highway. Opportunity to soften views from houses to east. Could be merged with spoil site 87 to north. Could be featured into over-bridge ramp to south.				Probably low risk, but approaches edge of Mangahuia Stream.		Adjacent to stream					keep - modified to match new road design. Proximity to stream can be addressed in design.
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16	
90	Unobtrusive location. Anchored against fill batter opposite over-bridge. Opportunity to soften views from houses to east.										0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
91	In front of house. Potential to form contoured bund around house to screen highway.	EHG (Negligible)	Southern tip of spoil area comes close to permanently flowing stream. Could be green with tweak of boundary to move away from stream.		Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel		Adjacent to waterway				0	keep - southern end has been shortened slightly to be away from the stream
	Green	Green	Orange	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	13	
92	Unobtrusive location in angle between highway and over-bridge. Anchored against over bridge fill batter. Opportunity to feather earthworks.				Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel		Adjacent to stream				0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	16	
93	OK. Adjacent to highway and over-bridge. Could be contoured to soften Project.				Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel						0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
94	Unobtrusive location in angle between highway and over-bridge. Anchored against over bridge fill batter. Opportunity to feather earthworks.				Probably low level risk, but is on edge of named hill (Puketawhiwhi, also known as Te Tahawhakarungamangahuia) and over looking stream channel						0	keep - geometry modified to match new road design
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
95	Would be on terrace in front of house. Potential to form in contoured bund around house to screen highway.	Open water and wetland habitat appear to be present based on desktop assessment.	Spoil area encroaches on fenced "spring-head"/wetland and comes close to constructed outlet channel of this wet area. Could be made green by tweaking boundary away from these features.		No known sites in this area, but cannot be entirely ruled out.						0	keep - geometry modified to match new road design and location of pond - southern end has been shortened slightly to be away from the stream
	Green	Orange	Orange	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	13	
96	Unobtrusive location. Anchored against fill batter. Southern end should be trimmed to avoid water course. Note that spoil sites on opposite side of highway are higher priority for potential mitigation.		Northern tip of spoil area comes close to permanently flowing stream and southern tip overlies permanent stream. Could be green with tweak of boundaries to move away from stream.		No known sites in this area, but cannot be entirely ruled out.		Adjacent to waterway protect existing stream and enhance				0	keep - geometry modified to match new road design and location of pond - northern end has been shortened slightly to be away from the stream
	Green	Green	Red	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	14	
97	Good location. Anchored against hill fill batters. Opportunity to contribute to softening of highway. This should be priority location of spoil to mitigate adverse visual effects. Widening footprint to designation boundary would be beneficial.	ITT02 (Moderate) - Within construction buffer so assumed to be lost any way. EHG (Negligible)	Northern tip of spoil area overlies permanently flowing stream. Could be green with tweak of boundary to move away from stream.		No known sites in this area, but cannot be entirely ruled out.		Adjacent to waterway protect existing stream and enhance				0	keep - geometry modified to match new road design - northern end has been shortened to be away from the stream
	Green	Green	Red	Red	Green	Green	Orange	Not Completed	Not Completed	Not Completed	14	
98	Unobtrusive location. Anchored against fill batter. Southern end should be trimmed to avoid water course. Note that spoil sites on opposite side of highway are higher priority for potential mitigation.				No known sites in this area, but cannot be entirely ruled out.						0	keep - geometry modified to match new road design, a new #98a has been added between side road and main alignment
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	

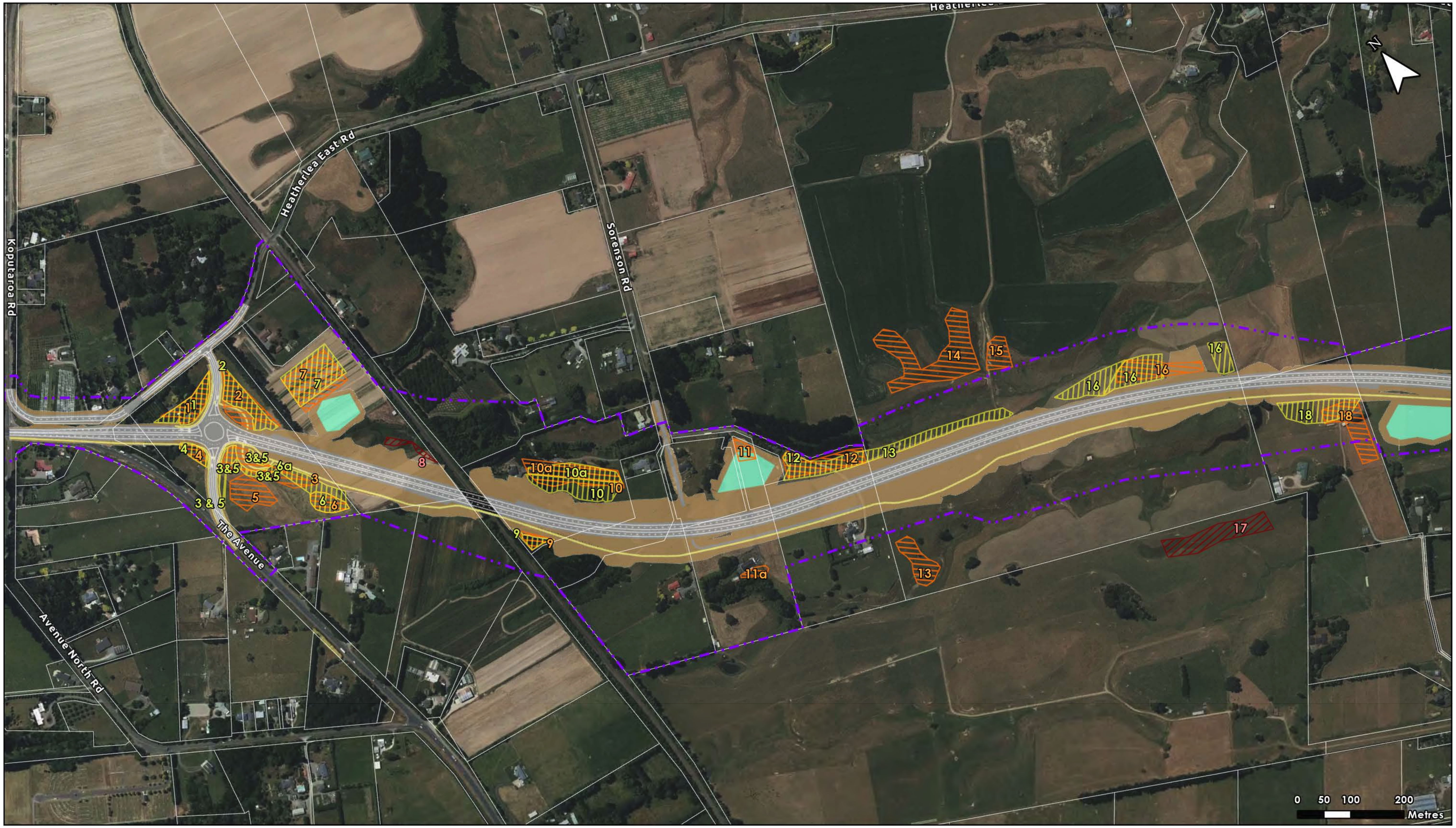
99	Unobtrusive location. Anchored against fill batter. Opportunity to contribute to screening from properties to west. Opportunity to merge with spoil site 98 to north.	ITT04 (Low)			No known sites in this area, but cannot be entirely ruled out.						0	keep - increased to make up for deletion of #101 and #100
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
102	Anchored against approximately 6m high fill batter. Opportunity to create knoll on higher land immediately south-west (CH30660-30800) that would accentuate existing landforms and help embed highway in landscape.				Proximity to named stream (Waiaute/Waiauti) which indicates potential archaeological significance. May be Green, ideally would conduct geophysical survey in this area		Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - geometry modified to match current alignment and designation
	Green	Green	Green	Red	Orange	Green	Orange	Not Completed	Not Completed	Not Completed	13	
106	Unobtrusive location. Anchored against fill batter. Opportunity to feather batter.				Low level potential for archaeological sites to be found on terraces over looking gullies.		Wetlands				0	no change at this stage - wetlands seem to be further away from spoil site, as spoil site is suggested on the terrace
	Green	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	17	
106a	On terrace. Potential to accentuate terrace to help embed highway. Integrate with naturalising of watercourse between terrace and batter. Take care to maintain sightlines to SUP.	EWG4 (Low)	Northern tip looks to overlie wetland. Potential could be green if boundary tweaked away from this area (check with Wildlands).		Could also be Amber, low level potential for archaeological sites to be found on edge of terraces overlooking gully		Wetlands				0	no change at this stage - will need modification in detailed design to tie well with landscape and avoid the mentioned potential constraints
	Green	Orange	Orange	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	11	
107	Unobtrusive location. On sloping terrace. Anchored against fill batter.				Low level potential for archaeological sites, but higher concentrations of charcoal were observed here during geotech test pitting. This area was beyond Pukehou geophysical survey.		Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - no modification at this stage
	Green	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	17	
112	While the site is a small drainage course, it is part of a terrace spur. The landscape has a pattern of terraces and gullies around the toe of Pukehou. Potential to extend this terrace landform (CH32650-32750) while retaining the gully watercourses. Could incorporate spoil sites 108, 109 and 110. This would mimic landform pattern and help embed highway in landscape.				Previously covered by geophysical survey. No obvious archaeological signs, but some patterns in geophysical results that were unexplained.		Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - geometry modified to be moved away waterway and mimic existing terrain - geometry likely needed to modified further in detailed design to tie well with earthworks and landscape
	Green	Green	Green	Red	Green	Green	Red	Not Completed	Not Completed	Not Completed	17	
116	On low terrace spur. Anchored against low fill batter. Opportunity to extend spoil site further east on terrace spur and incorporate volume from spoil sites 117, 118, and 119.				Small possibility for archaeological material in this area, most likely to be found on edge of terraces overlooking gully.	Encroaches into a flow path and floodplain. Ok if upstream fills not placed. Not so ok if upstream fills not placed as well.	Wetlands and Gully's Adjacent to Pukehou - high spiritual significance, spiritual pathway				0	keep - geometry modified to be moved away from terrace and waterway and be closer to the road and tie in with road embankment - geometry likely needed to modified further in detailed design to tie well with earthworks and landscape
	Green	Green	Green	Red	Green	Orange	Red	Not Completed	Not Completed	Not Completed	14	
121	Unobtrusive location. In angle between highway and ramps. Anchored against low fill batter.				Low risk, parts previously covered by geophysical survey. Some iron fragments, expected to be modern farming waste.						0	keep - no modification needed
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
122	Unobtrusive location. In angle between local road and highway. Opportunity to soften highway and interchange.				Low risk, parts previously covered by geophysical survey. Some iron fragments, expected to be modern farming waste.						0	keep - no modification needed
	Green	Green	Green	Red	Green	Green	Green	Not Completed	Not Completed	Not Completed	19	
123	Pasture. Flat. Opportunity to contour (overfill) against new local road. Adjacent to house 82 SH1 (Stantec # 7). Owned by Waka Kotahi. Opportunity to contour as bund buffer.	Site occurs on flat pasture with no indigenous habitats.	Site well away from any waterways.		Low potential for archaeological sites, geophysical survey of paddocks to the north did not detect anything of interest.	Minimal stormwater issues						Keep
	Green	Green	Green	Green	Green	Green	Green				21	

124	Pasture. Flat terrace. Opportunity to contour (overfill) against new local road. Adjacent to house 114 SH1 (Stantec #27). Ō2NL would already have 'high' adverse visual effects for house. Opportunity to contour spoil as bund to help buffer effects.	Site occurs on flat pasture with no indigenous habitats. Will require removal of some exotic tree land, which provides marginal habitat for bird species.	Cuts across Stream 0 (permanently flowing) and zone of proposed riparian planting directly upstream of culvert. This would require culvert extension, which is not desirable and would need to be offset elsewhere. This could be reduced to "Green" if site were to split in two to avoid stream and provide minimum 20 m buffer between edge of spoil and stream channel.		Low potential for archaeological sites, geophysical survey of paddocks to the north did not detect anything of interest.	Spoil crosses over a small meandering watercourse. Environmental offset likely, culvert placement required, potential upstream flooding. May need a gap in the spoil mound for the waterway.	Requires buffer from the stream					keep - Site 124 split in two parts to be 20 m away from stream
	Green	Green	Red	Green	Green	Orange	Green				16	
125	Pasture. Relatively flat terrace above Ō2NL and between Ō2NL and Pukehou. Reasonably elevated. Opportunity to mimic terrace surface and tie in to small scarp at back of site (designation boundary could be shifted to SE to increase the area of this site). Adjacent to a house 170 SH1 (Stantec #19). Ō2NL would already have 'high' adverse visual effects for house. Opportunity to contour spoil as bund to help buffer effects.	Site occurs on flat pasture with no indigenous habitats.	Site away from waterway but would need strict erosion and sediment controls due to adjacent steep-sided gully with Stream 3 at the bottom.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues						Keep
	Orange	Green	Green	Green	Green	Green	Green				18	
126	Pasture. Terrace spur above incised gully and above Ō2NL. Reasonably elevated. Close to Pukehou (between Ō2NL and Pukehou).s Limited opportunities to contour into landform.	Site occurs on flat pasture with no indigenous habitats.	Site away from waterway but would need strict erosion and sediment controls due to adjacent steep-sided gully with the ephemeral Stream 5 at the bottom. This stream is directly linked to wetland downstream of existing SH1, hence we want to avoid elevated sediment runoff.		Probably Green, but there are some unusual geophysical signals here that could be archaeological. If archaeological, impact would likely be Orange.	Minimal stormwater issues	S& E control looks too tight, environmental effects risk is elevated. Avoid if possible.					Keep
	Red	Green	Green	Green	Green	Green	Orange				16	
127	Pasture. Flat gully floor. Adjacent to watercourse identified for natural character and ecological restoration and upstream of culvert under existing SH1. Care would be needed to avoid encroaching on stream and rehabilitation area. However, good opportunity to contour spoil against toe slope immediately to SE or against spur to SW.	Site occurs on flat pasture/cropping field with no indigenous habitats. Borders strip of mahoe-karamu scrub which may be vulnerable to draw down of groundwater during excavation. Potential to disturb indigenous birds roosting or foraging in the vegetation.	Site comes very close (~5 m) of Stream 10 (permanently flowing) and encroaches on proposed riparian planting. There is also other drainage channels near northern and southern edges of site. This could be reduced to "Green" if site were reshaped to provide minimum 20 m buffer for Stream 10 and other adjacent channels. This stream is directly linked to wetland downstream of existing SH1, hence we want to avoid elevated sediment runoff. Strict erosion and sediment controls would be required.		No comment	Minimal stormwater issues	Close to waterways, requires stream planting around site to compensate for effects.					Keep - Spoil site footprint modified to be away from Stream 10. All other issues raised will be addressed in detailed design of the spoil site.
	Orange	Orange	Orange	Green	Green	Green	Orange				9	
128	Pasture. Middle of site is a flat-topped spur, and northern part is a shallow head of a gully above a fill embankment. Suitable for contoured spoil, although care should be taken to avoid spilling into head of gully in south part of the site.	Site largely occurs on flat pasture. At least three exotic trees will need to be removed, although the level of effect will be very low.	Site is over top of the ephemeral Stream 12. This is directly linked to the Waiauti Stream. Careful drainage design and strict erosion and sediment controls required here to avoid elevated fine sediment inputs into Waiauti Stream. Could require extension of Andrew Craig's Culvert 12.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues	Filling in paleochannels, requires planting compensation.					Keep - Extension of culvert 12 may be required.
	Green	Green	Orange	Green	Green	Green	Orange				15	

129	Pasture. Relatively flat terrace. Not adjacent to Pukehou or streams. Potential to contour spoil to fit terrace and to soften top of cut.	Site occurs on flat pasture with no indigenous habitats.	Site away from waterway but would need strict erosion and sediment controls due to proximity to Waiauti Stream.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues	Filling in paleochannels, requires planting compensation.					Keep
	Green	Green	Green	Green	Green	Green	Orange				18	
130	Pasture. Sloping terrain – side and head of small gully. Potential for spoil to be contoured along top of cut and against works at head of gully.	Site occurs on flat pasture with no indigenous habitats.	Site comes close to ephemeral channel that links directly to Waiauti Stream. This could be reduced to "Green" if site were reshaped to provide minimum 20 m buffer with ephemeral channel and use of strict erosion and sediment controls.		Small areas of Orange where the spoil site approaches the edges of gullies. Geophysical survey detected probably archaeological remains on the edge of gullies at Pukehou.	Minimal stormwater issues	Filling in paleochannels, requires planting compensation.					Keep - Reshaped to be ~20 m away from stream.
	Green	Green	Orange	Green	Green	Green	Orange				15	

Appendix 4.4.2 Plans

B1: Long List of Spoil Sites Assessed in MCA Process



Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 10000 - 12400

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

- O2NL Spoil Sites for Consideration (Dec21-Mar22)
- O2NL Spoil Sites for Consideration (July21-Dec21)
- O2NL Spoil Sites for Consideration (Initial Long List pre-July21)
- O2NL Proposed Designation
- Property Parcels

O2NL Draft Design DF4 20220419

- Road User Markings
- Road Surface
- Shared Use Path
- Bridges
- Earthworks
- Ponds

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 12400 - 14000

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
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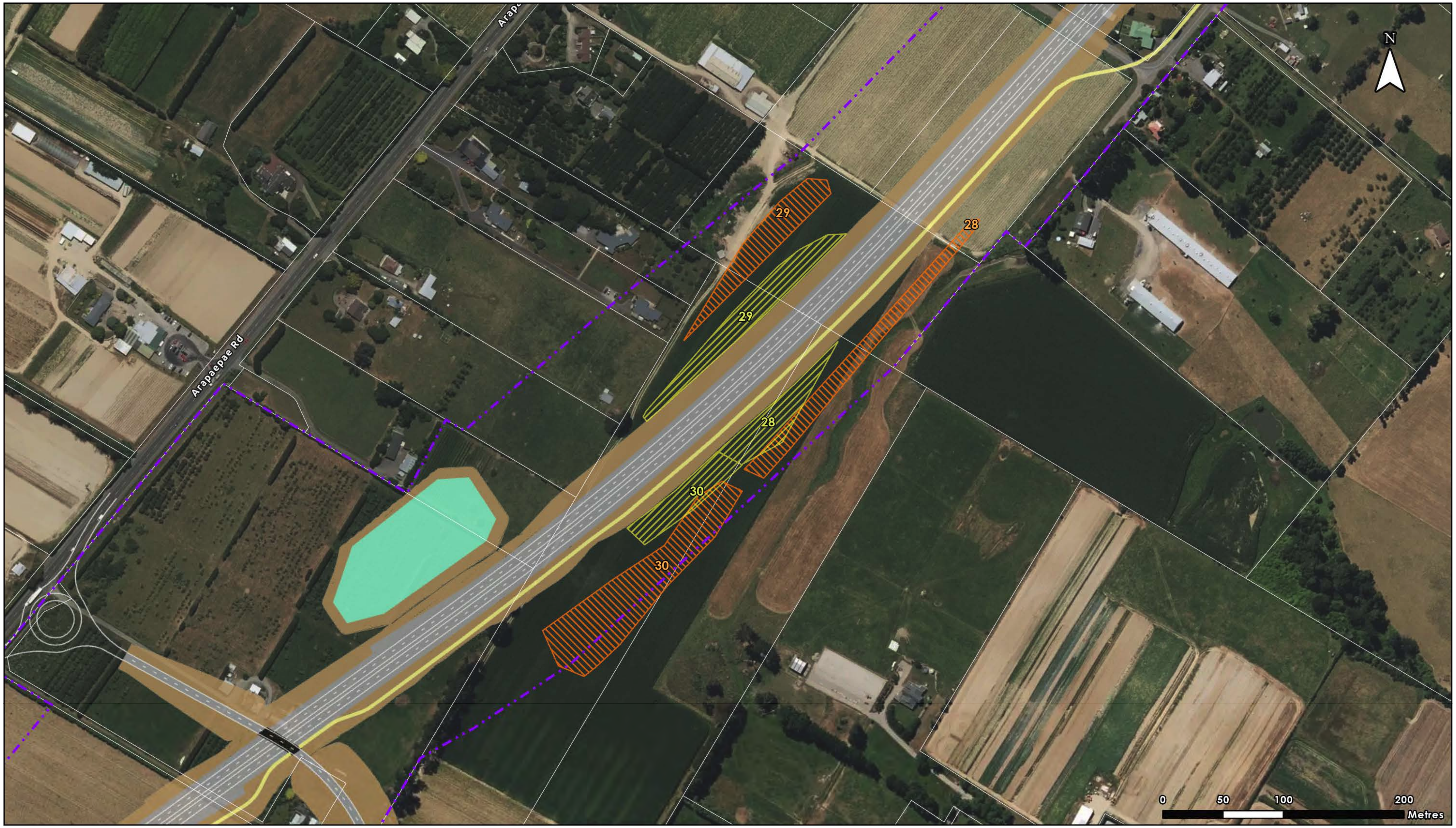

Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 14800 - 15600

WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

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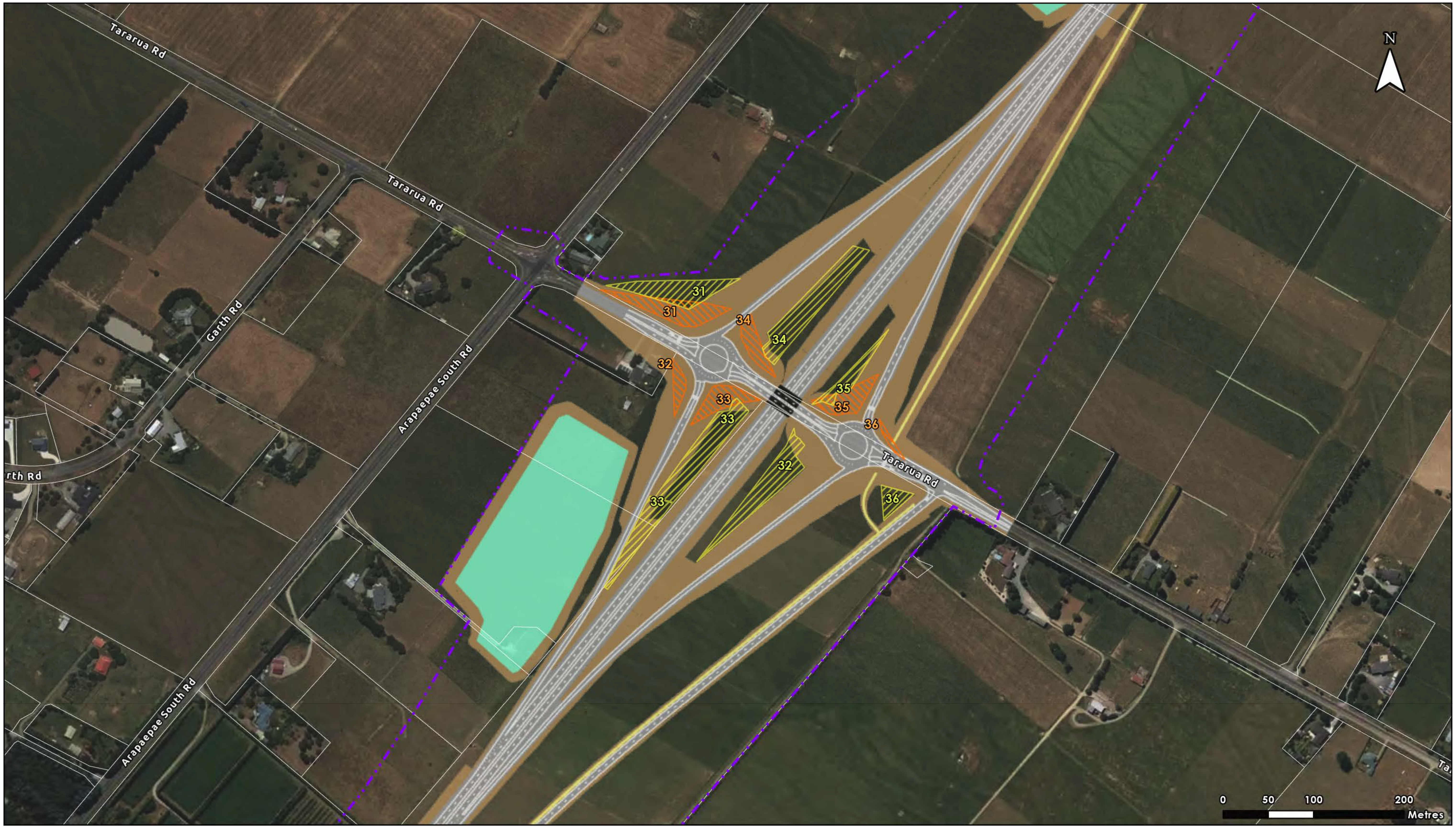

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 17800 - 18800

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

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- O2NL Spoil Sites for Consideration (Initial Long List pre-July21)
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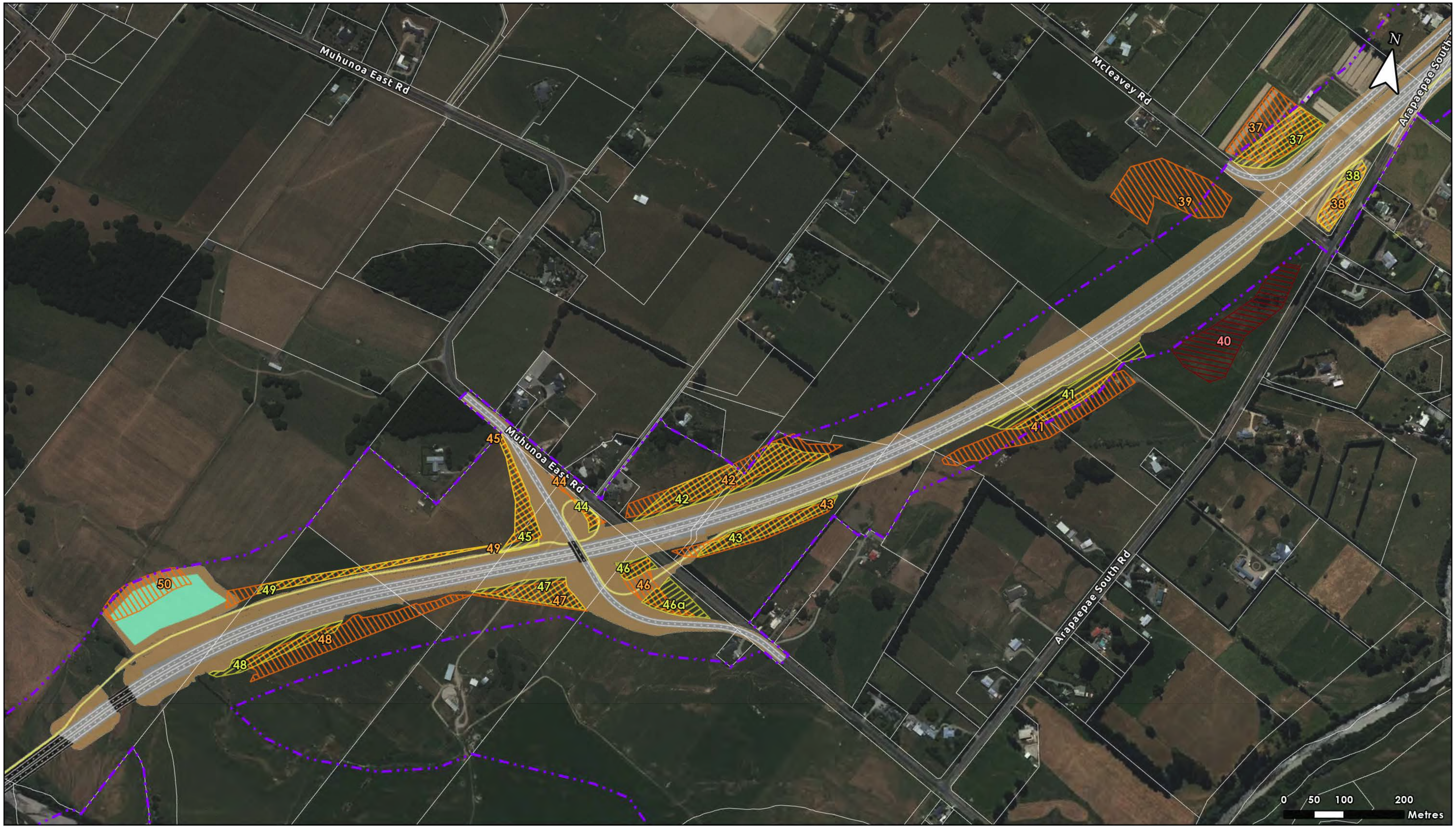
- Property Parcels

O2NL Draft Design DF4 20220419

- Road User Markings
- Road Surface
- Shared Use Path
- Bridges
- Earthworks
- Ponds



Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 20200 - 22600

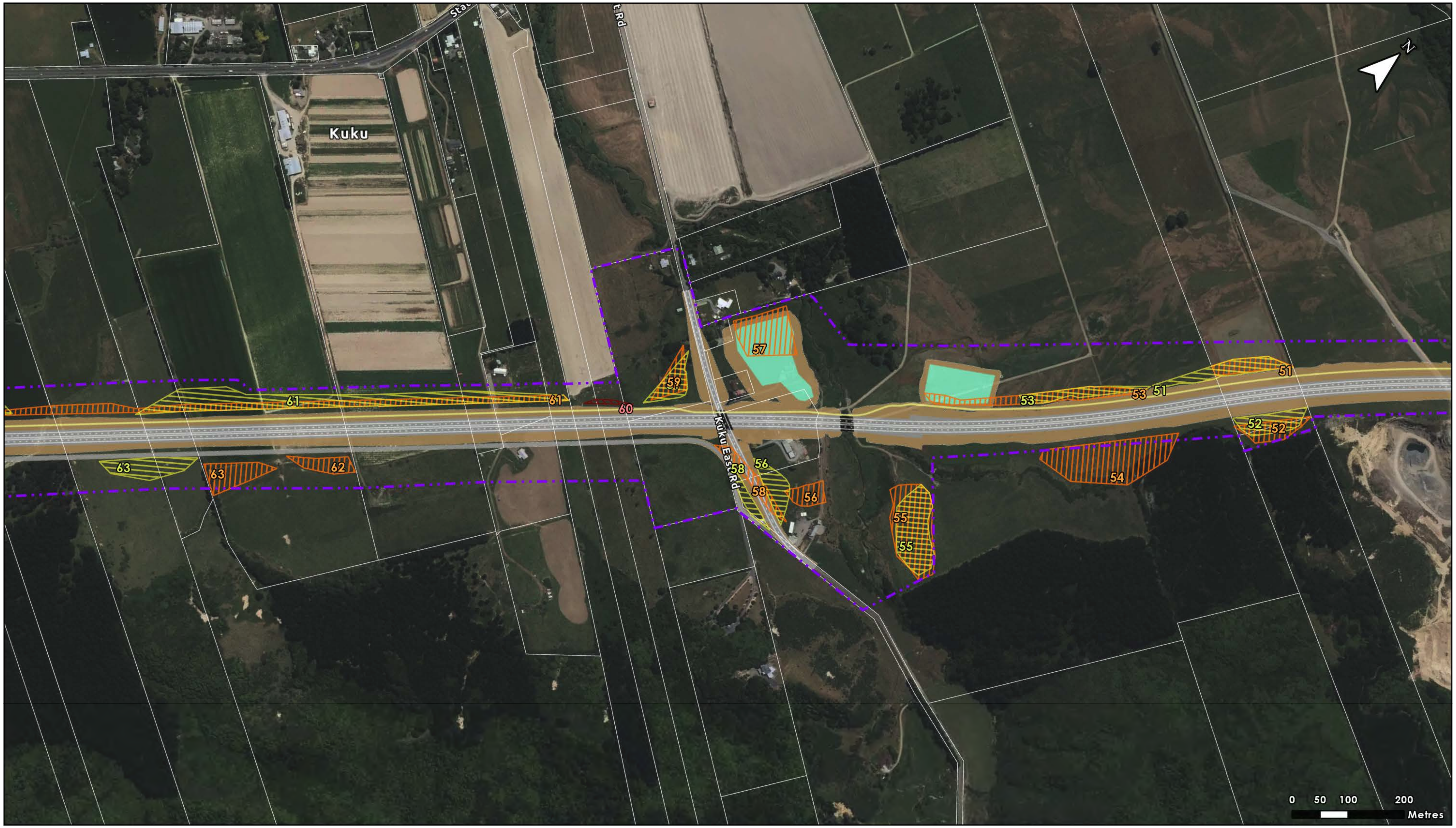
WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

O2NL Spoil Sites for Consideration (Dec21-Mar22)
O2NL Spoil Sites for Consideration (July21-Dec21)
O2NL Spoil Sites for Consideration (Initial Long List pre-July21)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design DF4 20220419
Road User Markings
Road Surface
Shared Use Path
Bridges
Earthworks
Ponds



Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 22800 - 25100

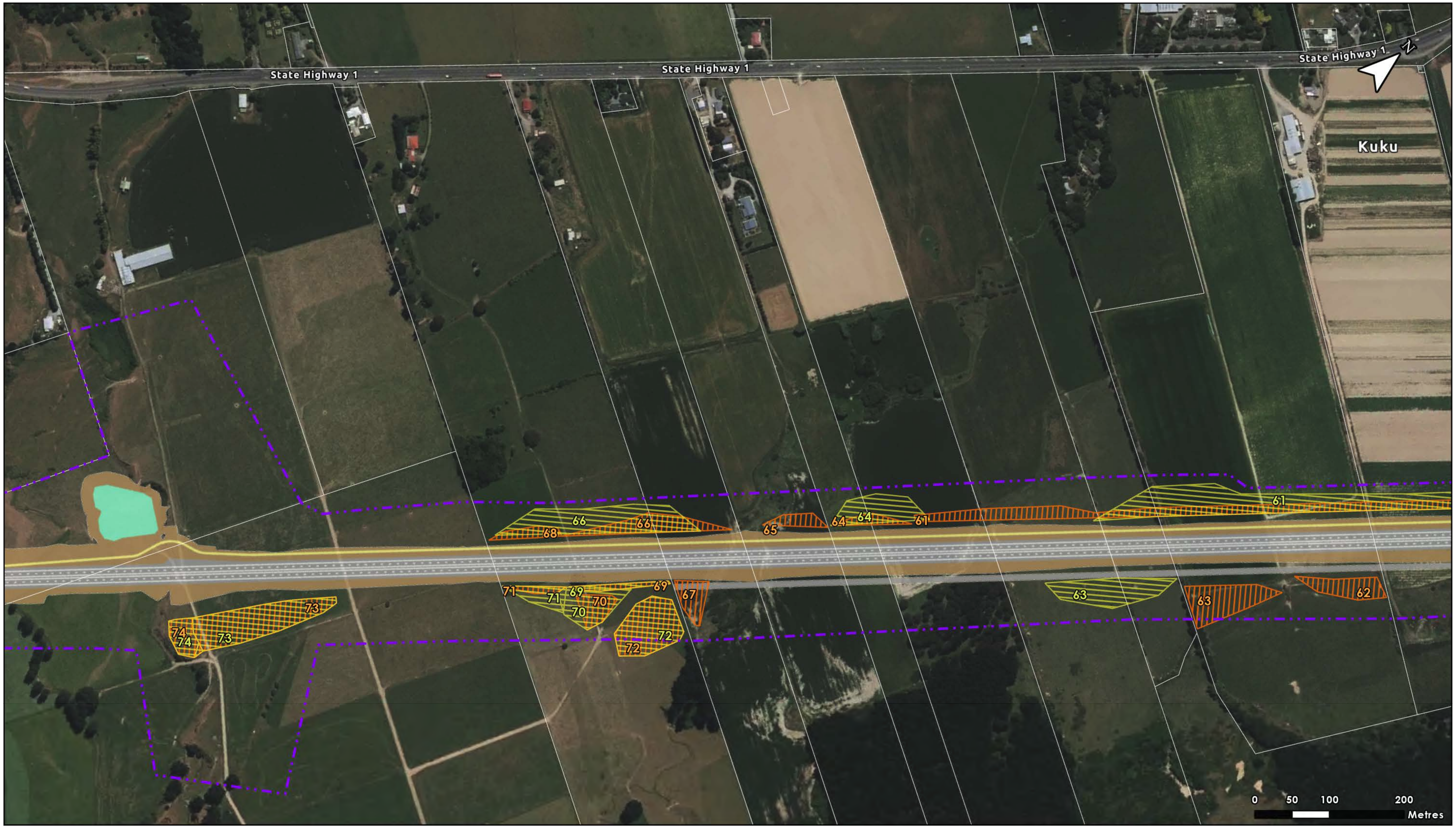
WAKA KOTAHI NZ TRANSPORT AGENCY

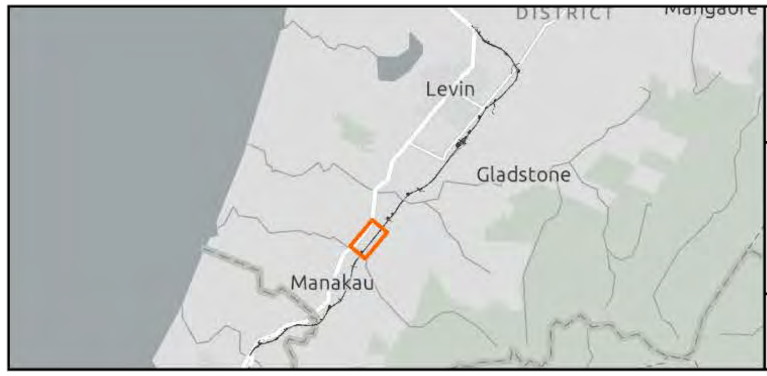
O2NL Spoil Sites for Consideration (Dec21-Mar22)
O2NL Spoil Sites for Consideration (July21-Dec21)
O2NL Spoil Sites for Consideration (Initial Long List pre-July21)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design DF4 20220419
Road User Markings
Road Surface
Shared Use Path
Bridges
Earthworks
Ponds

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022





Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 24600 - 26200

WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
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Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
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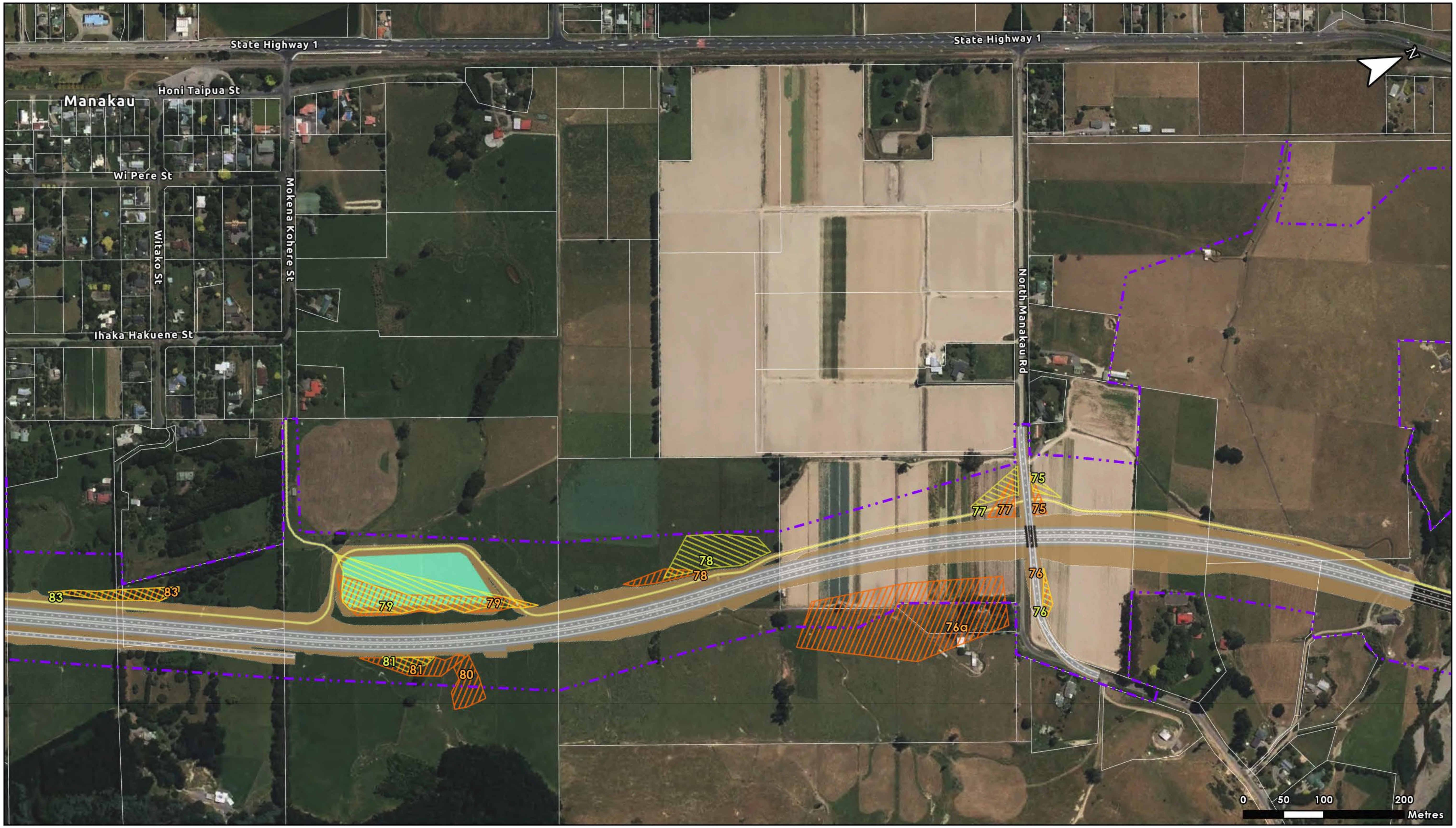

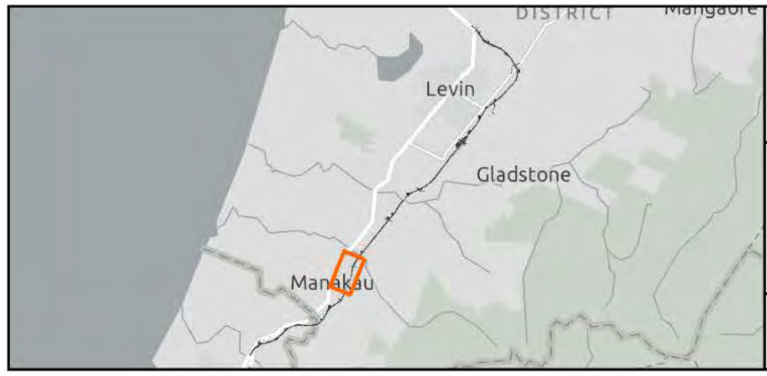

Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 26600 - 28500

WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
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Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
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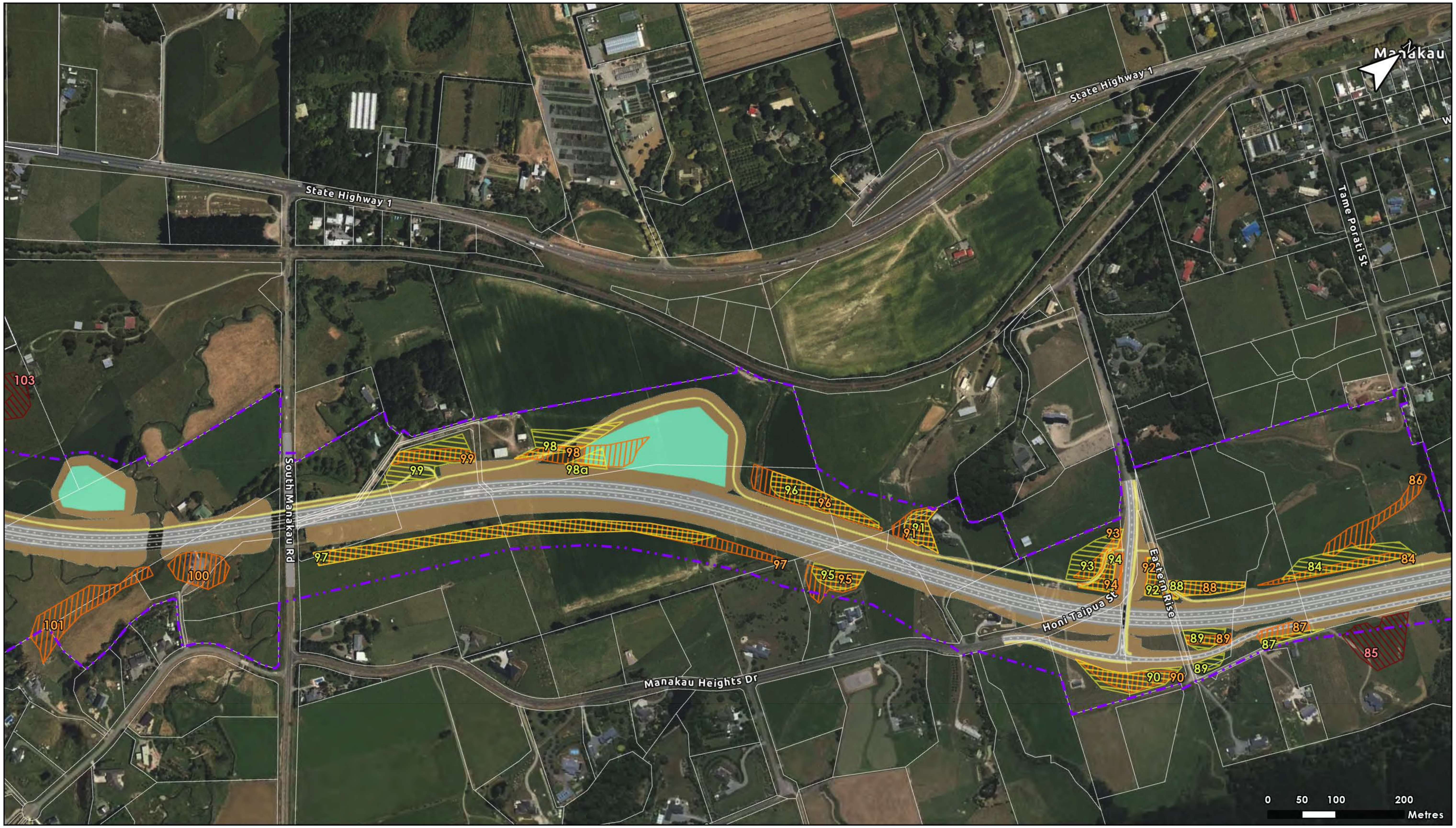

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 28500 - 30500

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

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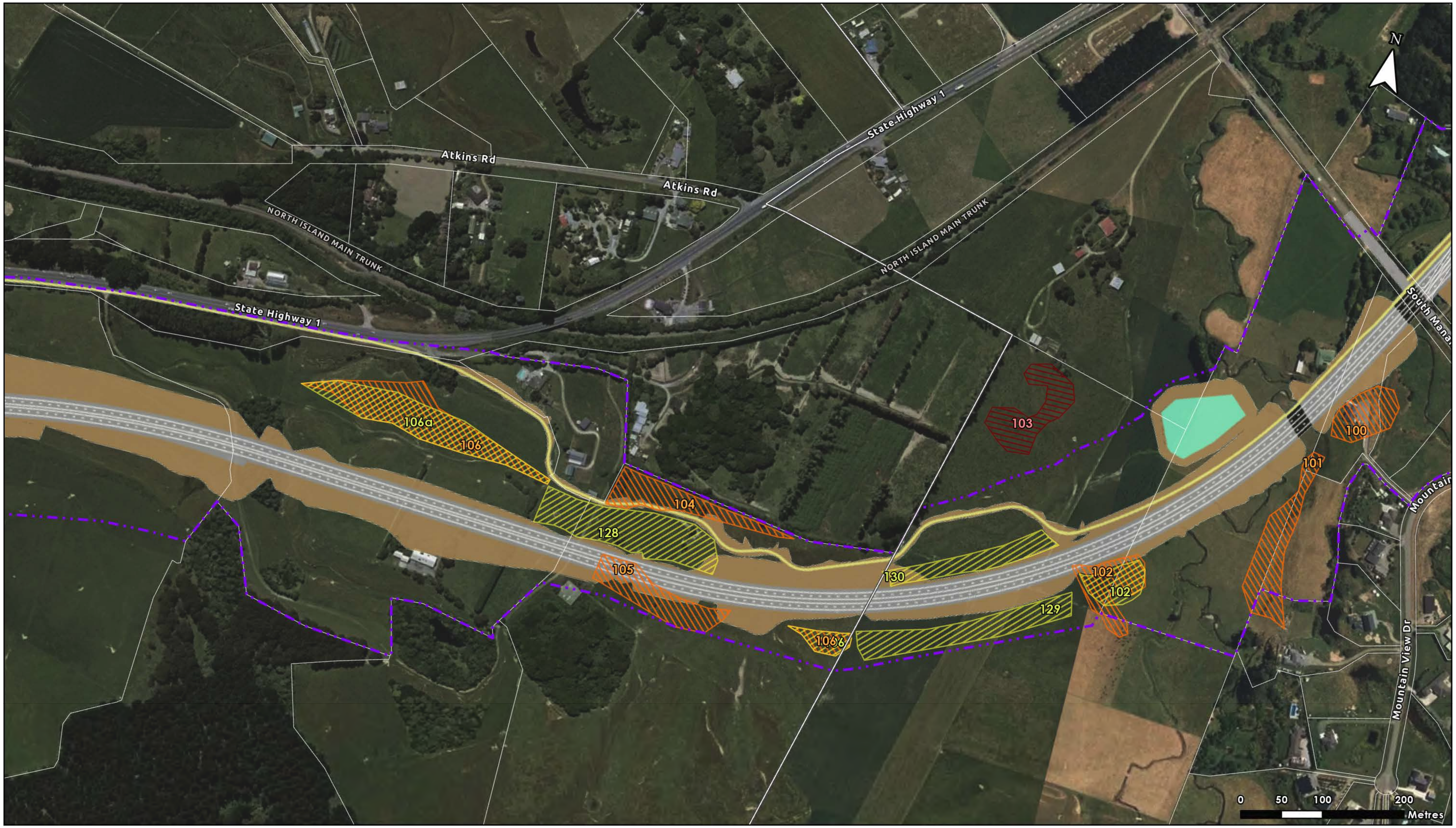

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 30200 - 31800

Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
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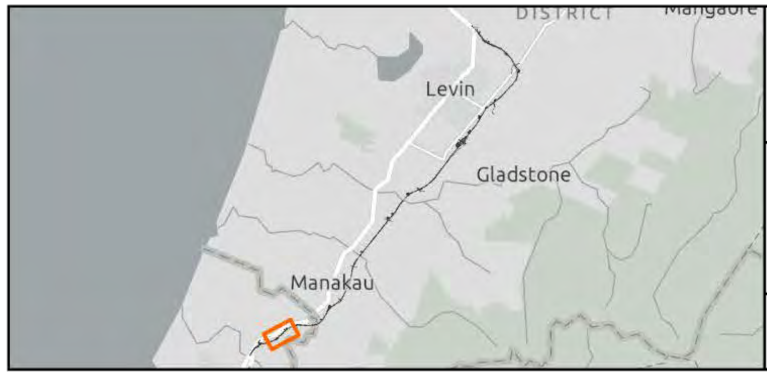

Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 32100 - 33600

WAKA KOTAHI NZ TRANSPORT AGENCY

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Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
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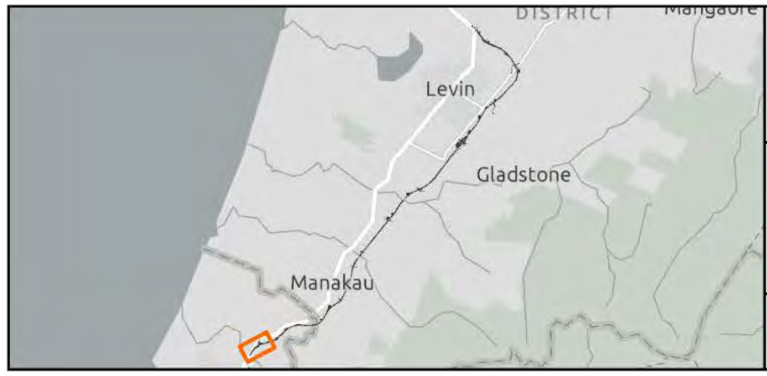

Stantec

Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 33600 - 35000

WAKA KOTAHI NZ TRANSPORT AGENCY

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