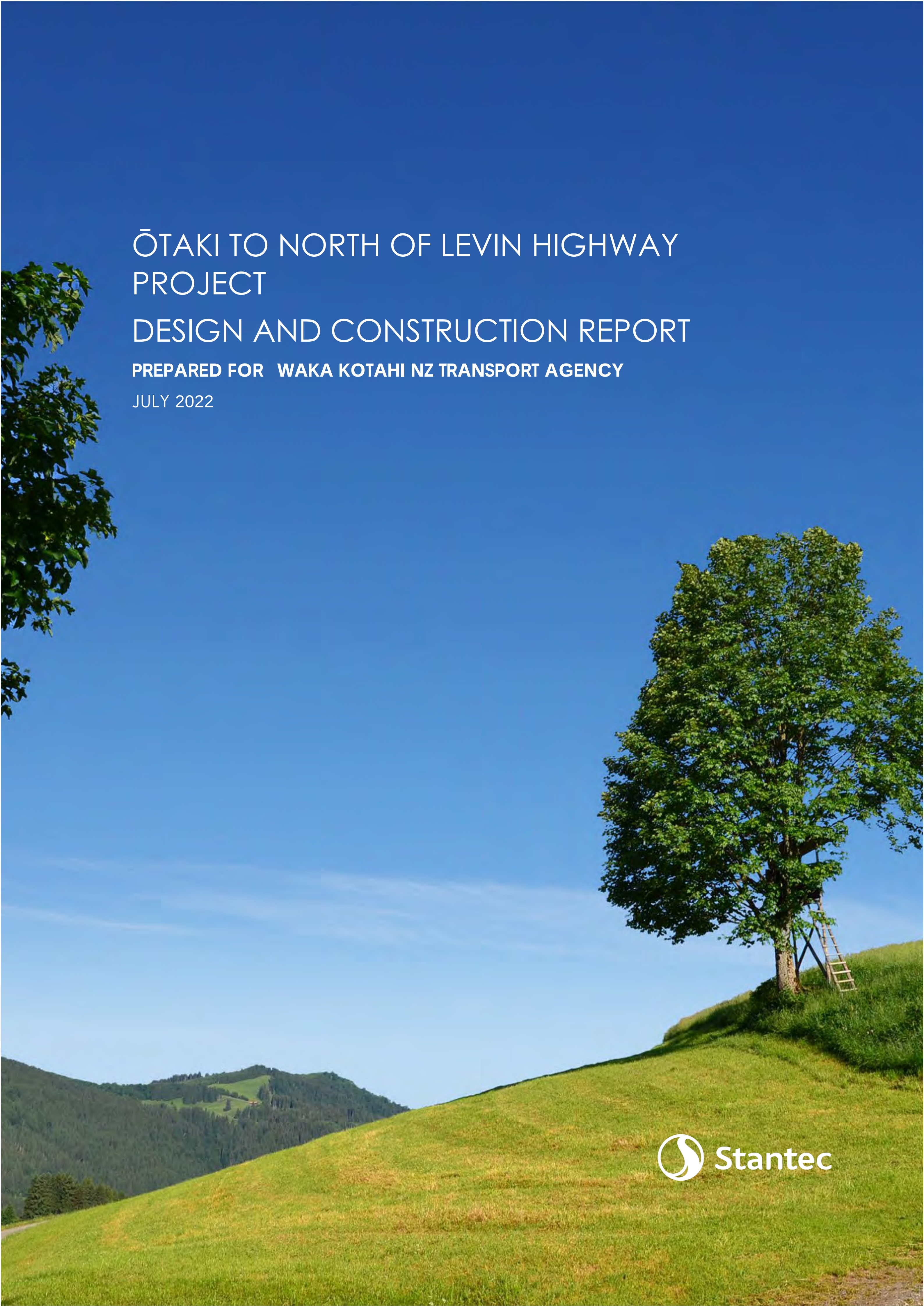
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

DESIGN AND CONSTRUCTION REPORT

PREPARED FOR WAKA KOTAHI NZ TRANSPORT AGENCY

JULY 2022



Stantec

The conclusions in the Report are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion.

QUALITY STATEMENT

PROJECT MANAGER	DESIGN MANAGER
Jon England	Jamie Povall

APPROVED FOR ISSUE BY
Phil Peet

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
0	09/07/21	Draft for Comment	Jamie Povall, Andy Wright			
0.1,0.2,0.3	08/10/21-10/06/22	Update from Review	Jamie Povall	Phil Peet	G. Lee / T. Ryan	
0.4	27/07/22	Update 4	Jamie Povall, Andy Wright	Sarah Heappey	Greg Lee	
0.5	03/08/22	Update 5	Jamie Povall / Greg Lee			
0.6	13/09/22	Update 6	Jamie Povall	Phil Peet	Greg Lee	J. England
0.7	5/10/22	Update 7	Jamie Povall	Greg Lee	Phil Peet	J. England
0.8	13/10/22	Update 8	Jamie Povall	E. Bennett	T..Ryan	J. England
0.9	28/10/22	Update 9	Jamie Povall	L. Dalzell	T..Ryan	J. England

WELLINGTON
Level 15, 10 Brandon Street, Wellington 6011
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 4 381 6700

Waka Kotahi NZ Transport Agency

ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

DESIGN AND CONSTRUCTION REPORT

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

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.

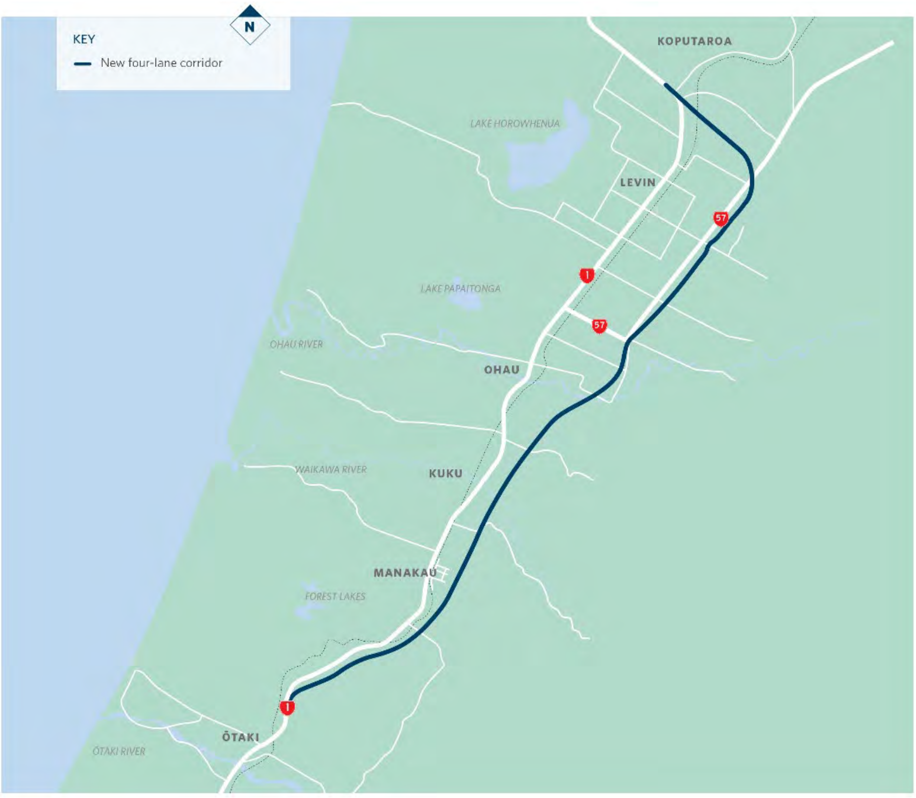


Figure 1: Schematic of the new Ō2NL Highway

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.

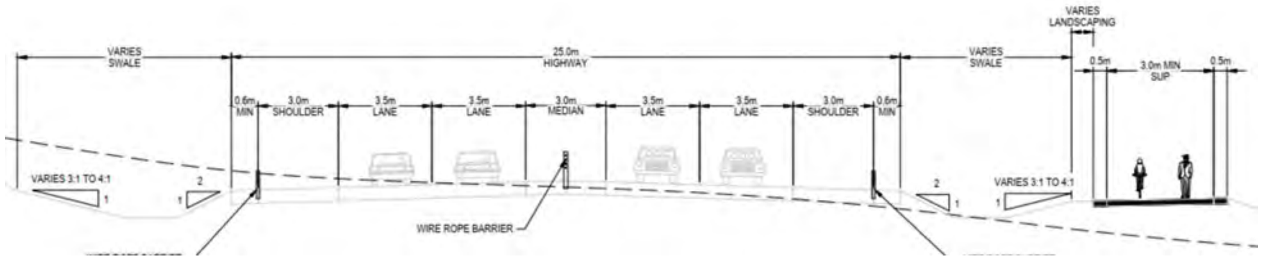


Figure 2: Typical cross section of new highway

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.

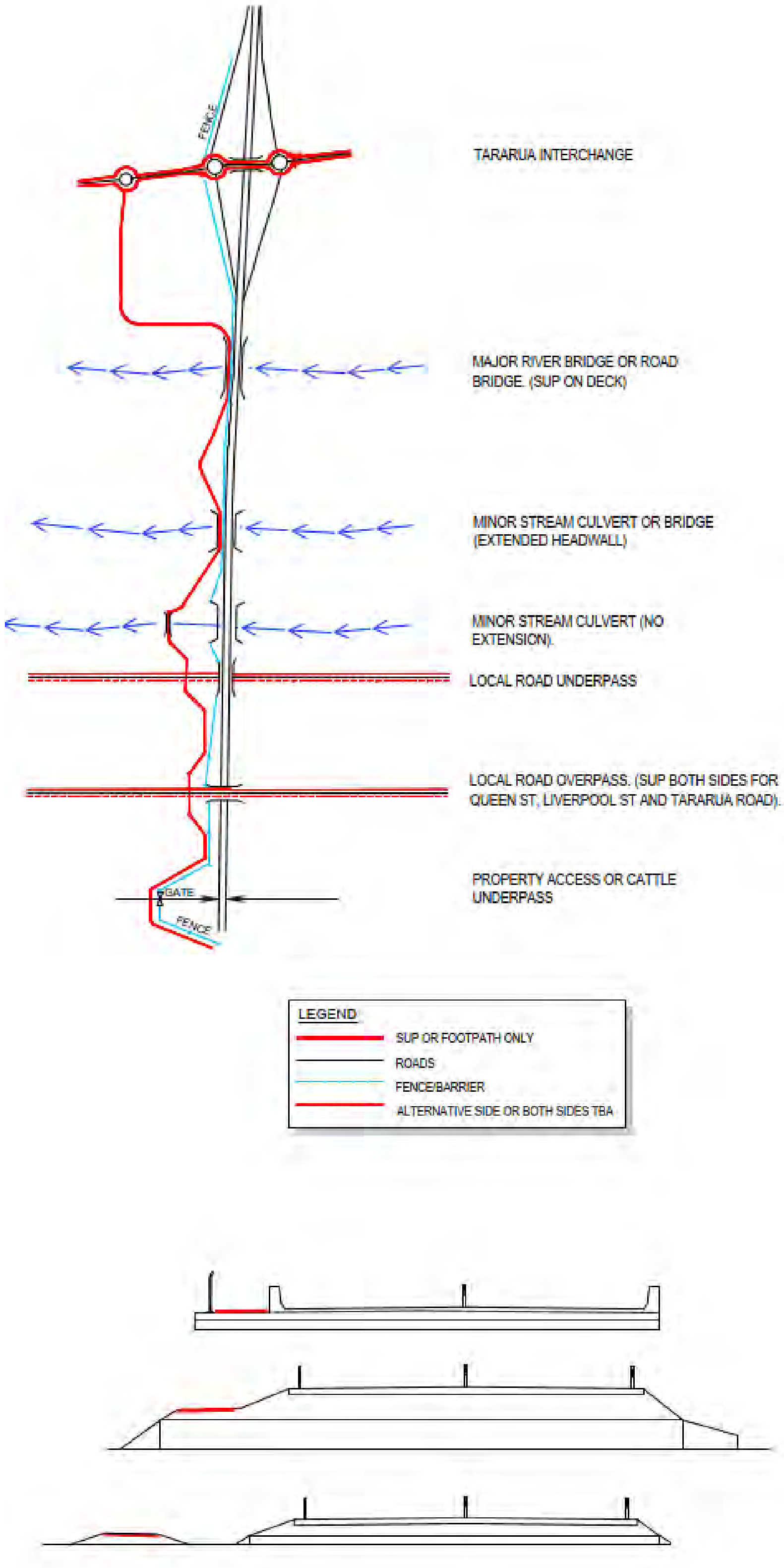


Figure 3: Integration of the SUP and structures (schematic – not north-south representation)

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.

[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:

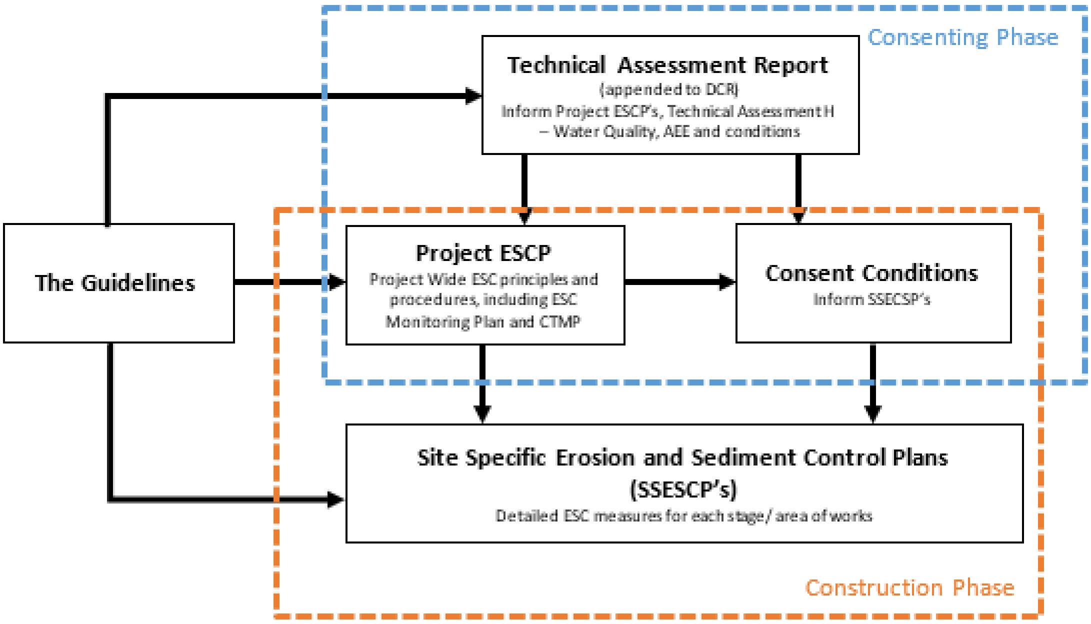


Figure 5: Erosion and Sediment Control design approach

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 m³
Borrow to structural fill (material supply sites)	0.5–1.5M m³
Cut to waste (including undercut and unsuitable)	0.5-1.5M m³

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	150,000-200,000m^3

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

<u>Table Note:</u> 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

Quality Statement

The conclusions in the Report are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion.

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Jon England	Jamie Povall

PREPARED BY Ken Clapcott	[signature]	27 / 07 / 2022
CHECKED BY Jayden Gesche	[signature]	27 / 07 / 2022
REVIEWED BY Jamie Povall	[signature]	27 / 07 / 2022
APPROVED FOR ISSUE BY Jamie Povall	[signature]	27 / 07 / 2022

WELLINGTON
Level 15, 10 Brandon Street, Wellington 6011
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 4 381 6700

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).

Contents

List of Appendices

List of Tables

List of Figures

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.

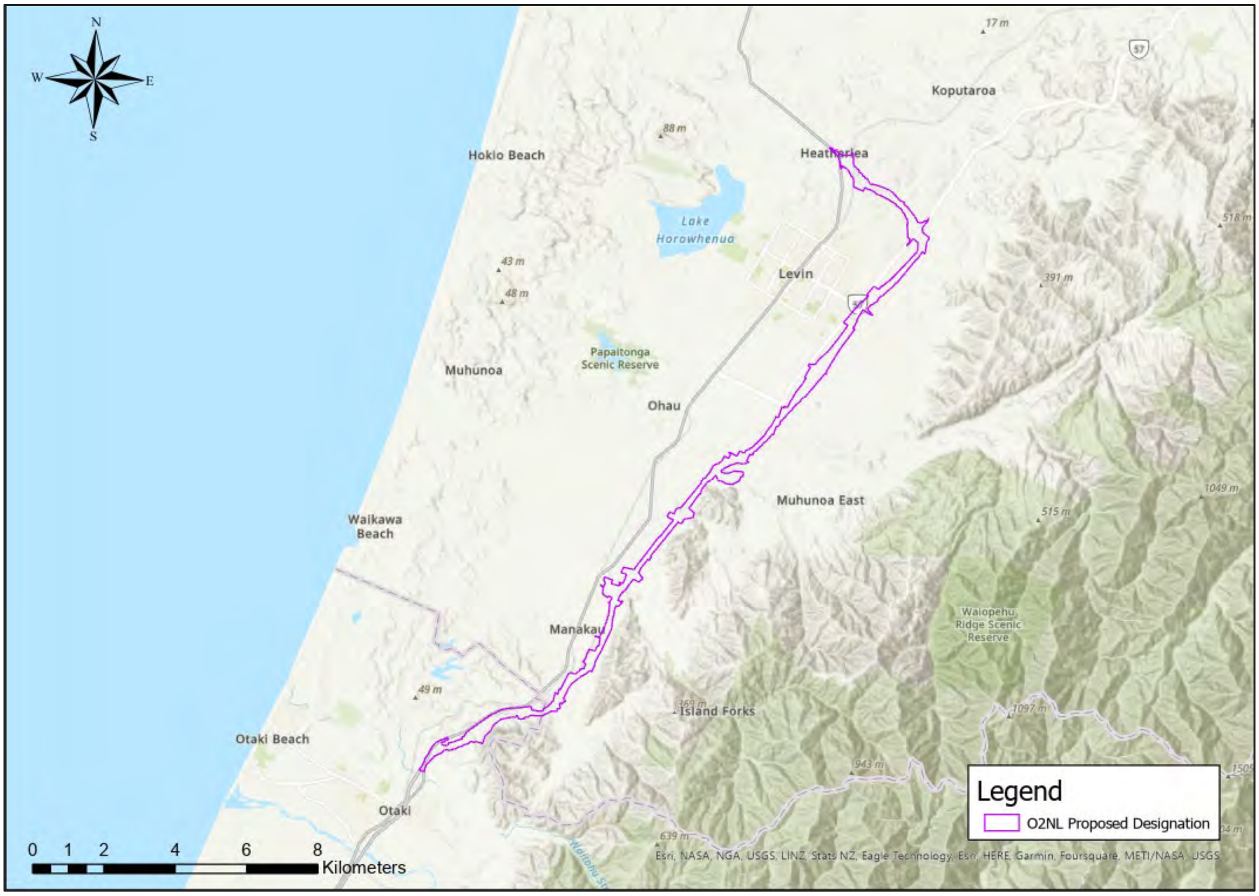


Figure 4.1.1: Site overview

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.

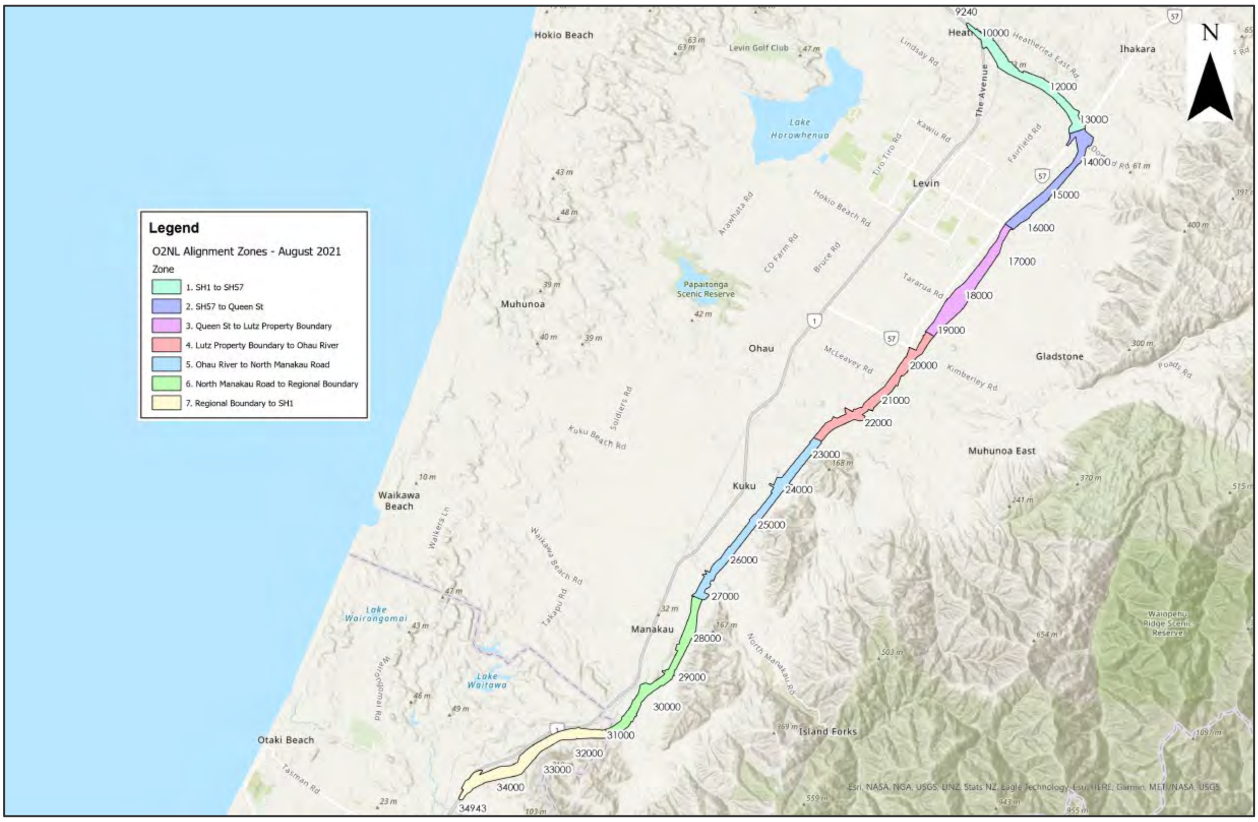


Figure 4.1.2: Alignment by zone

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.

---

[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

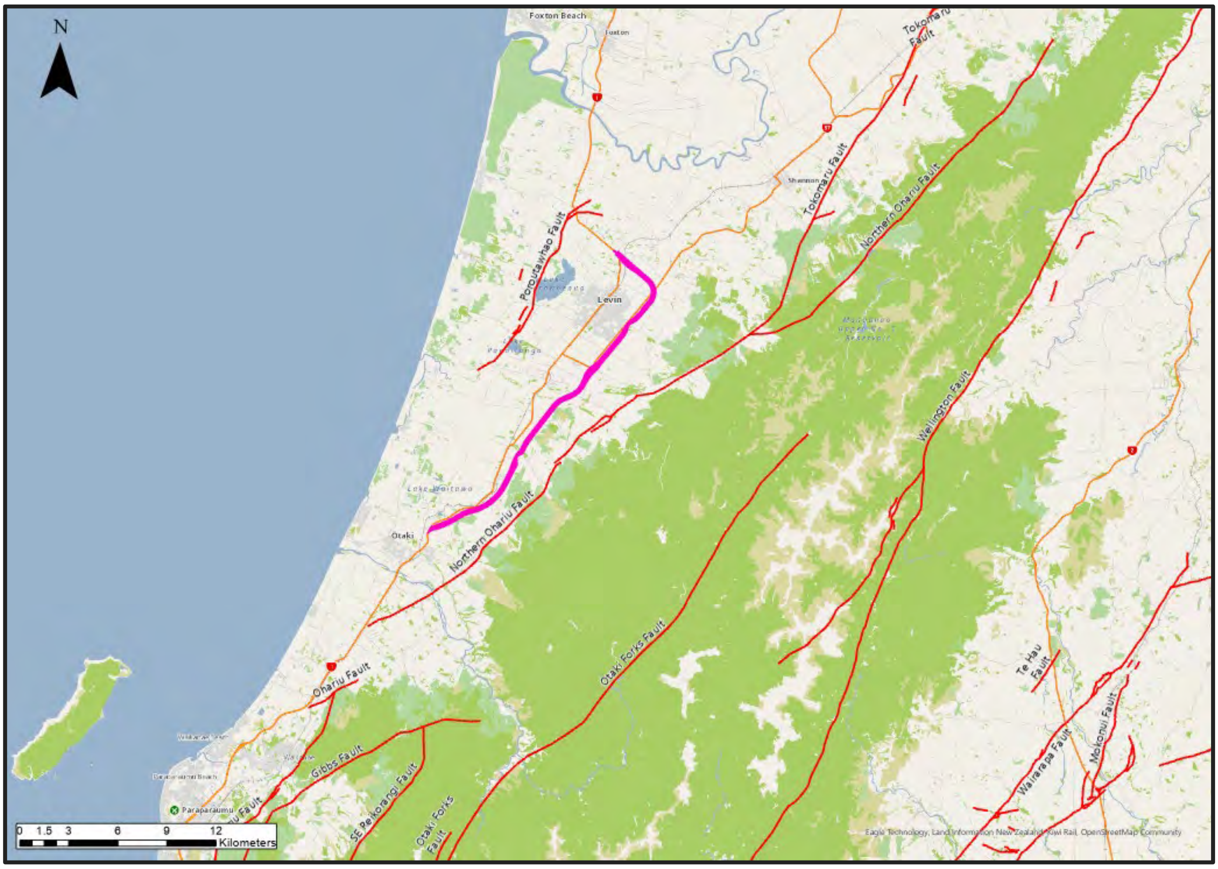


Figure 4.1.3: Active Fault Map

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.

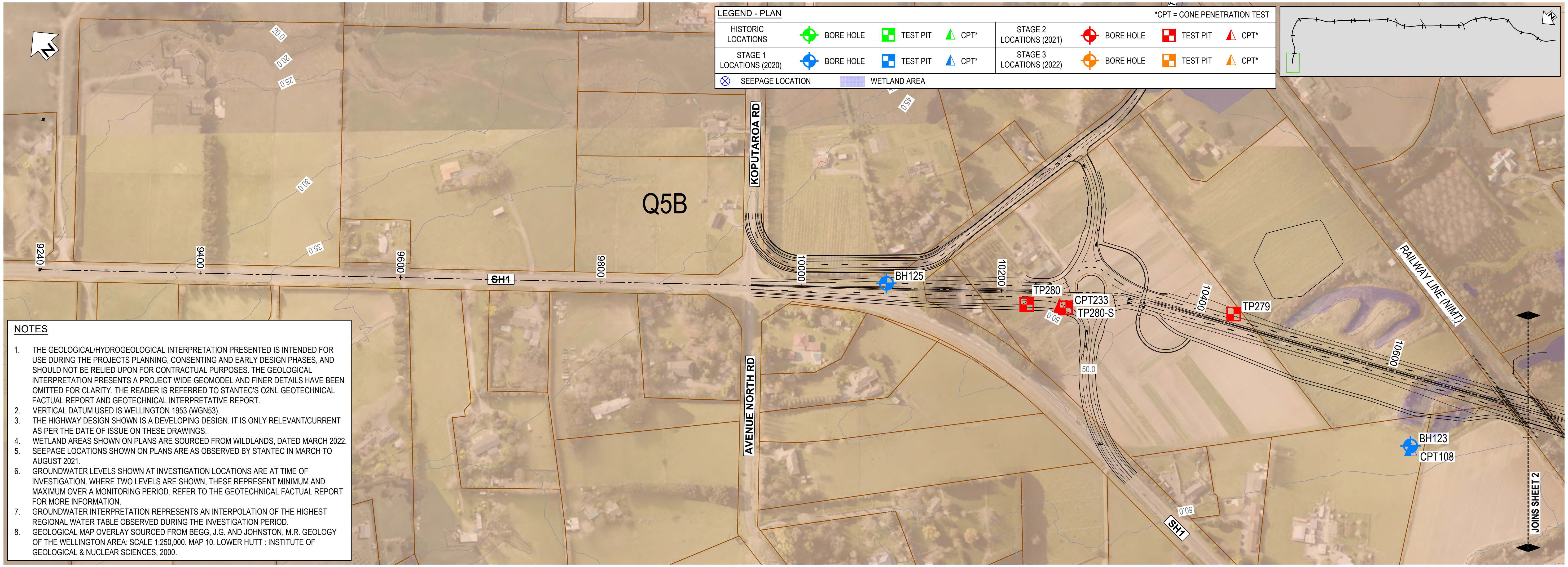
Table 4.1.15: Significant Structures Preliminary Foundation Solutions and Ground Improvements Recommendations

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

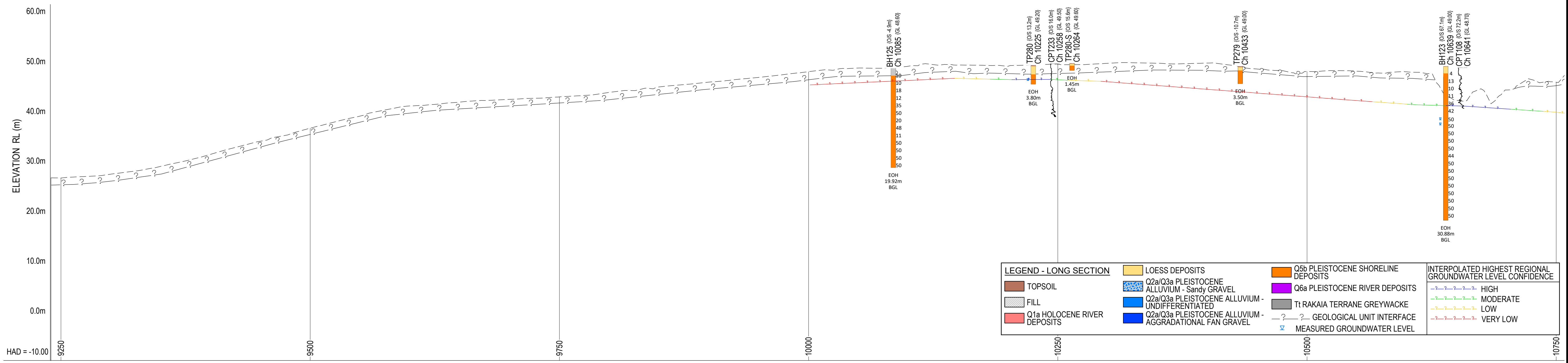


NOTES

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.

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		
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 1

Status Stamp: **WORKING PLOT**

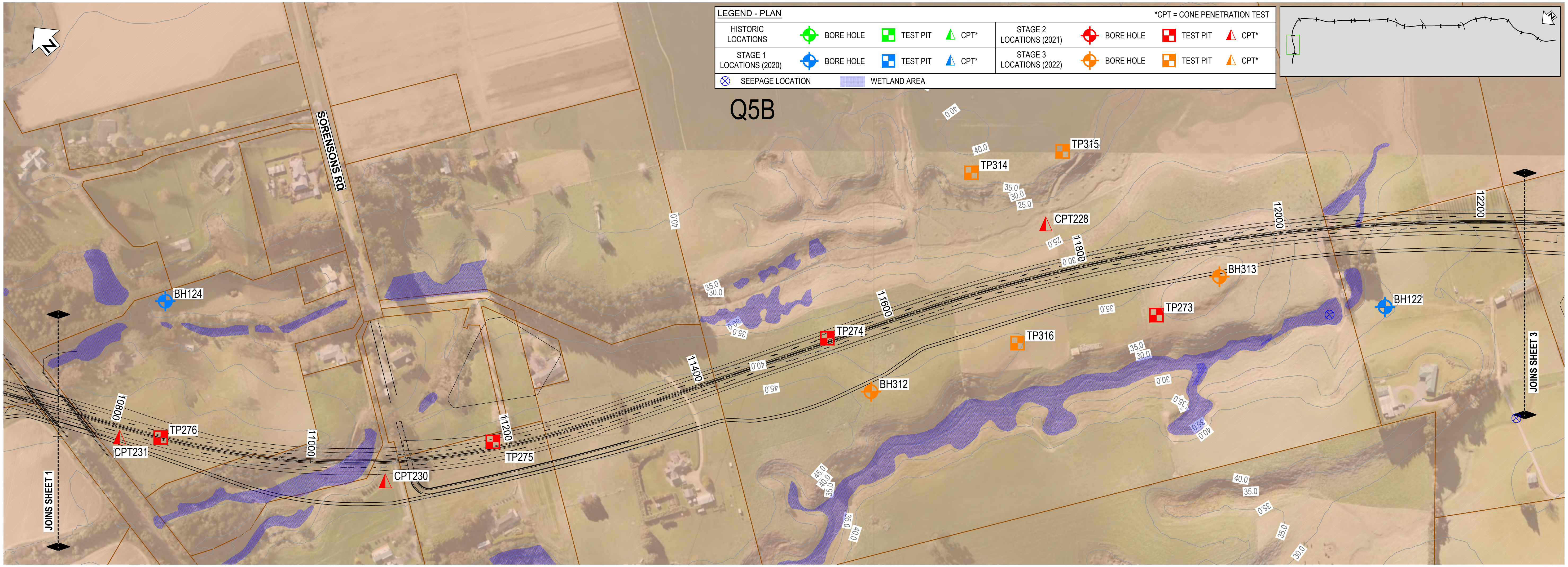
Date Stamp: **16.08.21**

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1000

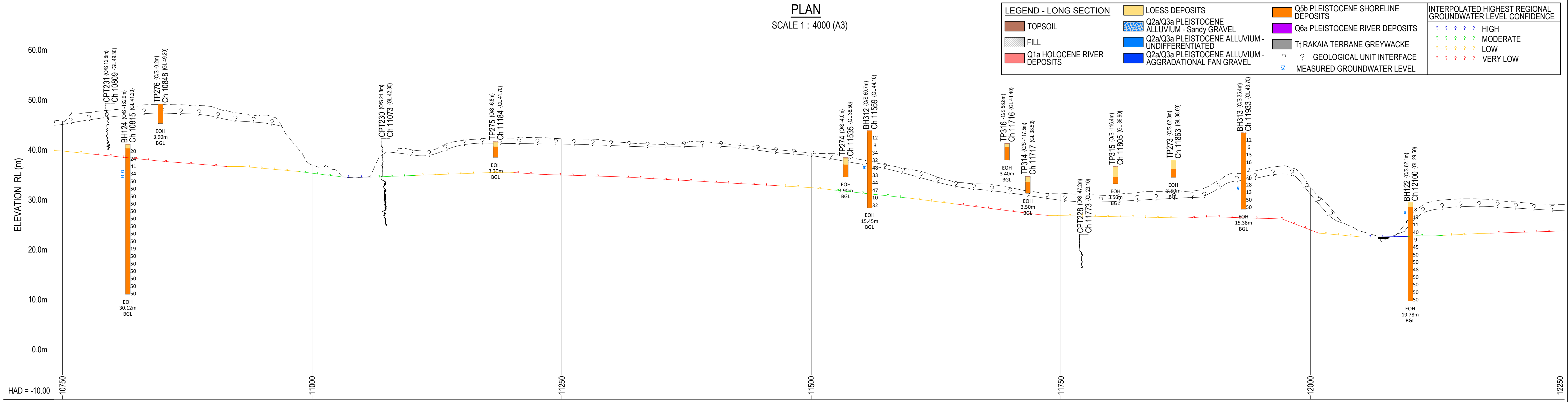
Rev.: D

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-C1000



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
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

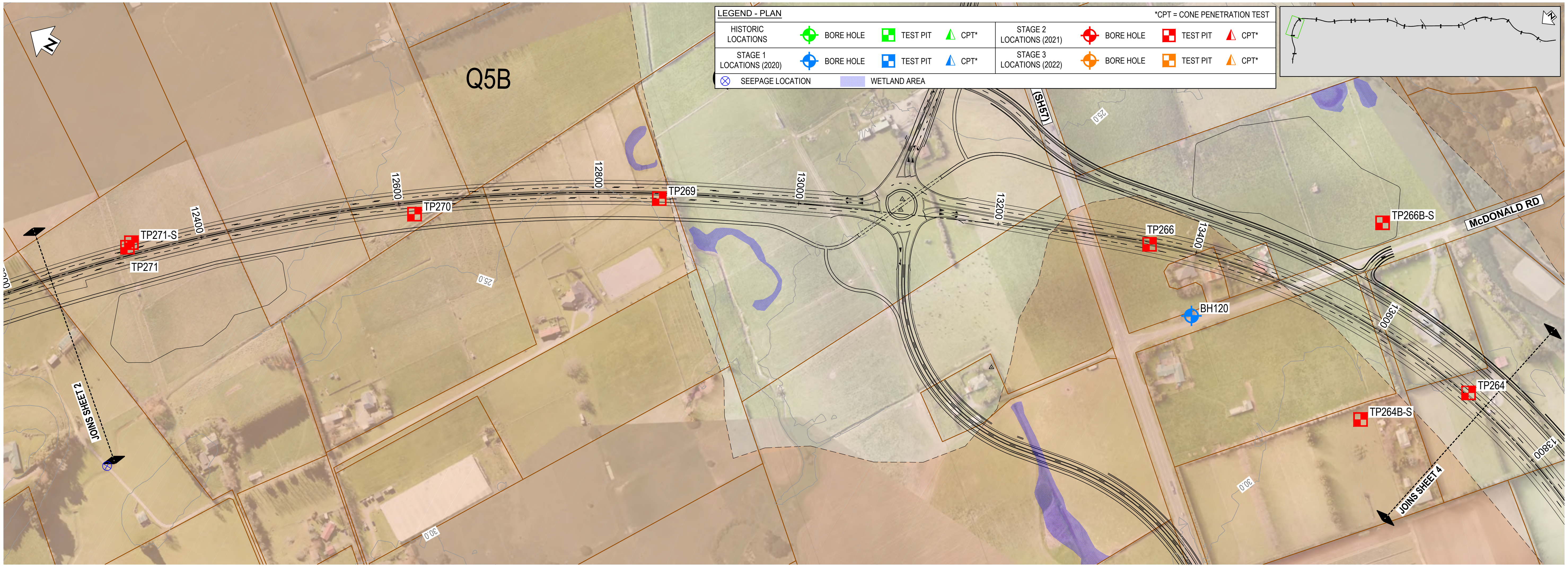
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 2

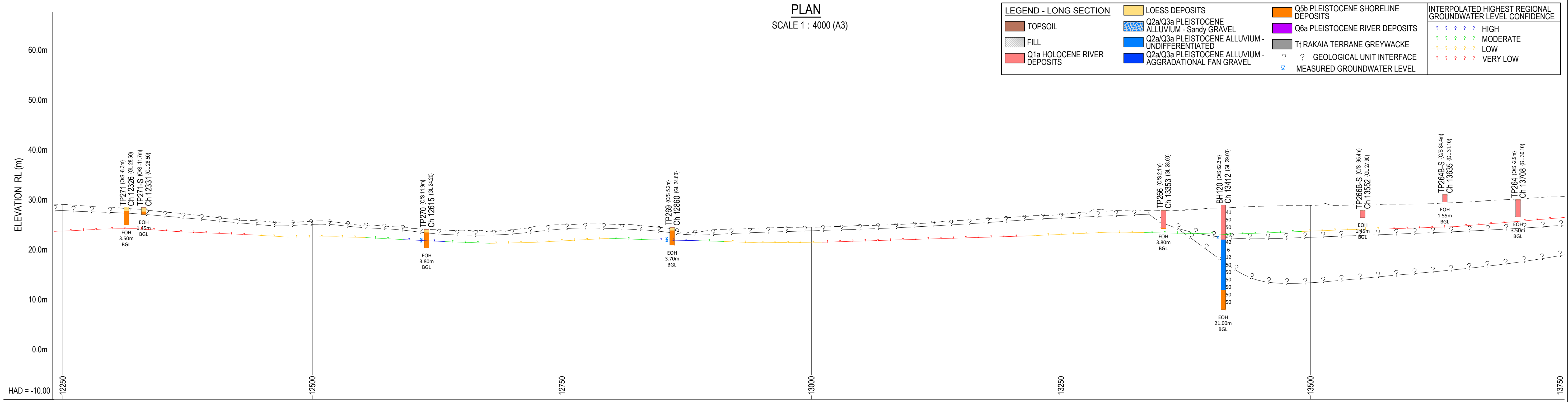
Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1001
Rev.: D

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-C1001



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 3

Status Stamp: WORKING PLOT

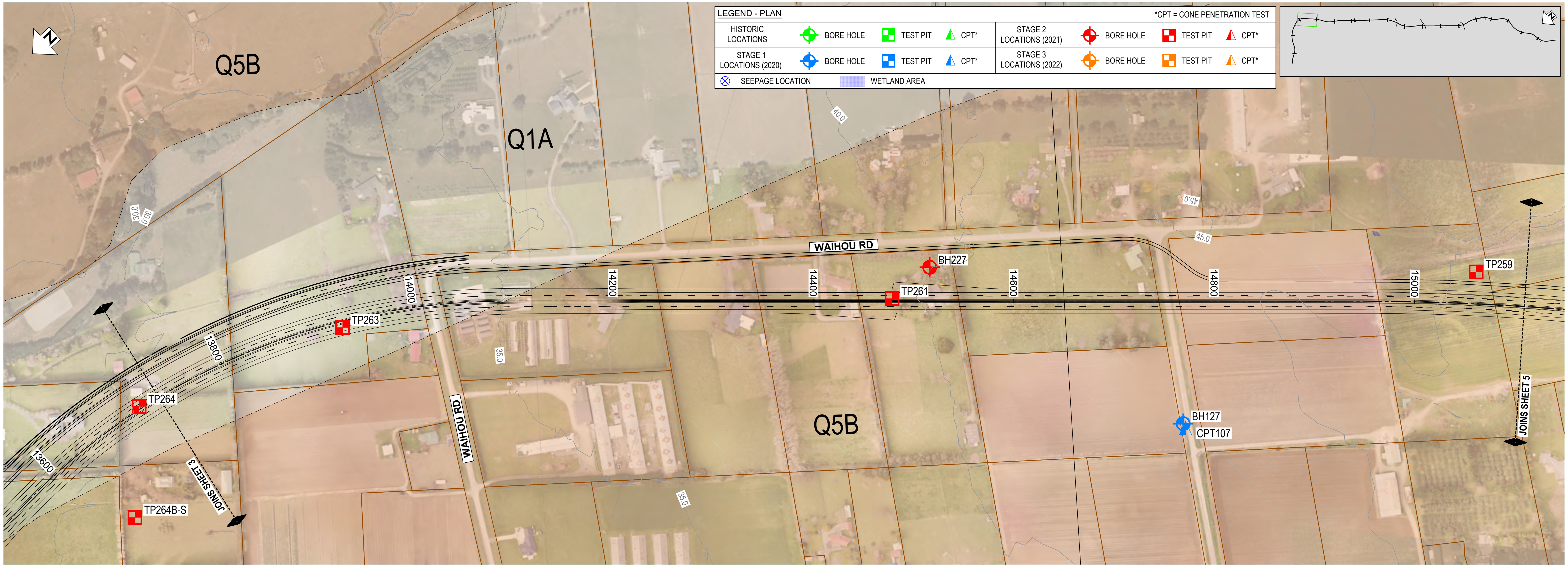
Date Stamp: 16.08.21

Scales: AS SHOWN

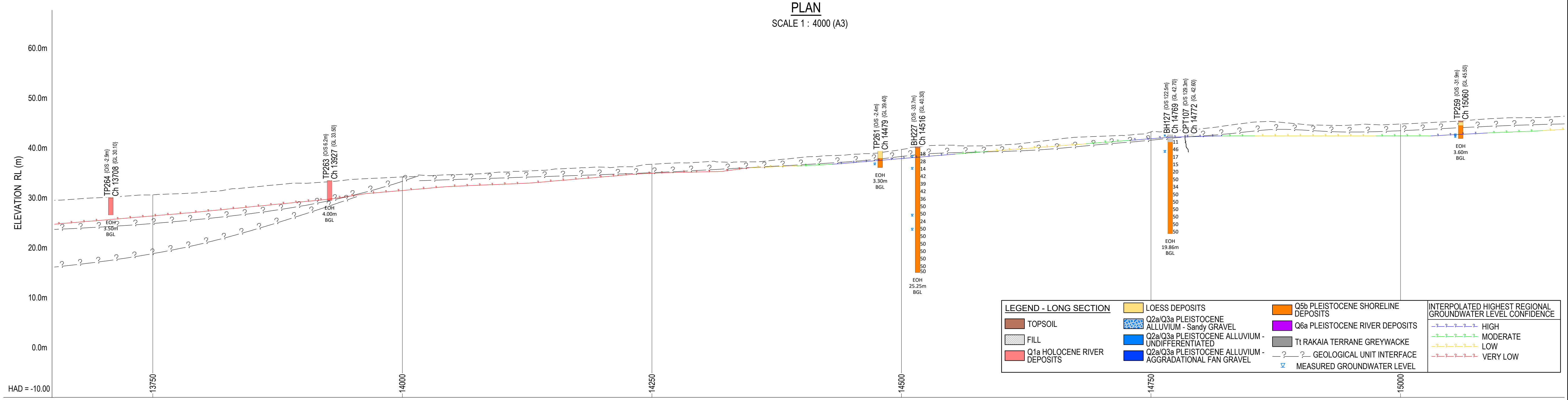
Drawing No. 310203848-01-200-C1002

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-C1002



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		
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

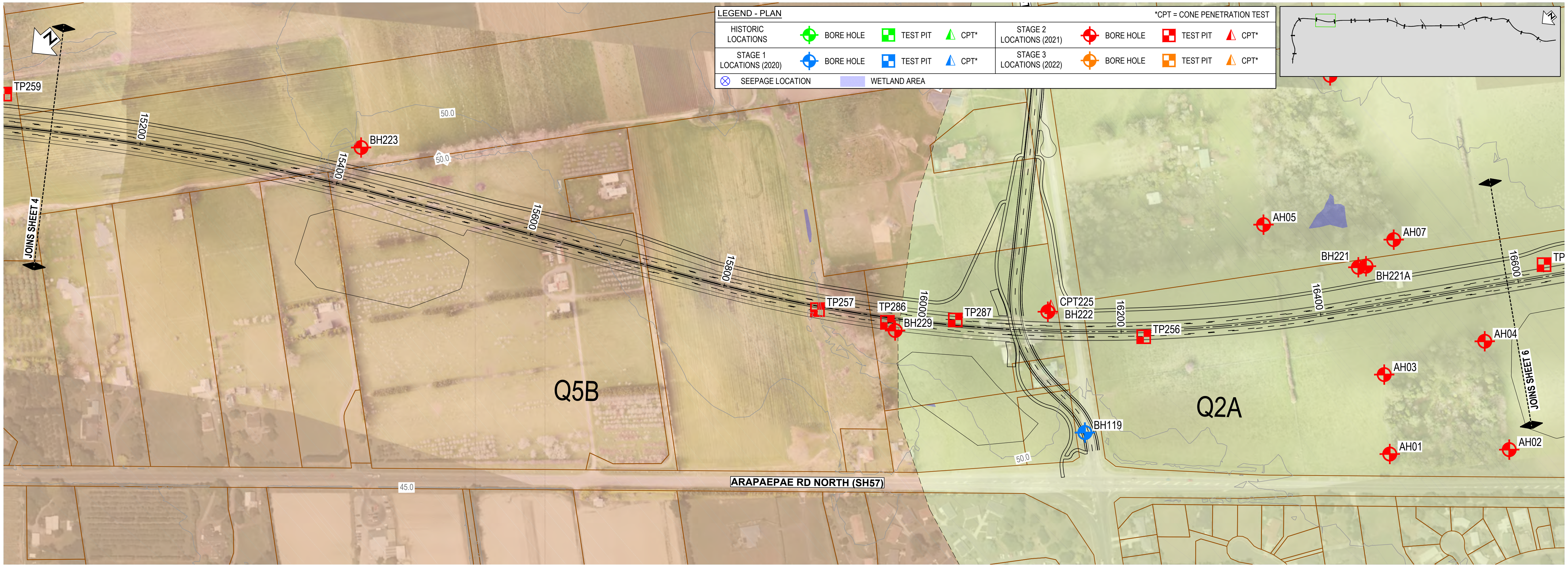
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

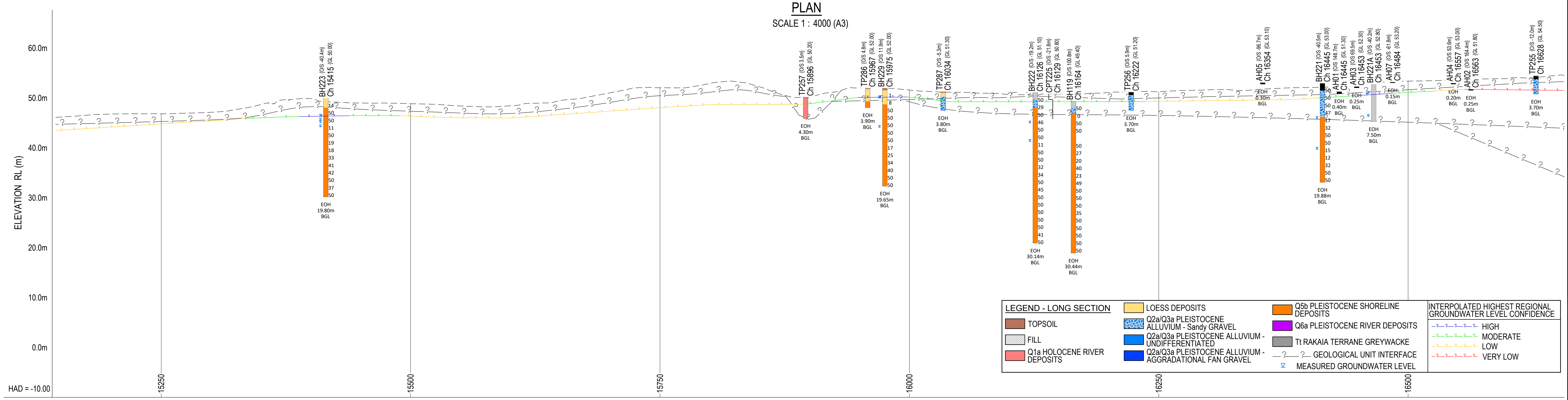
GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 4

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1003
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-C1003



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

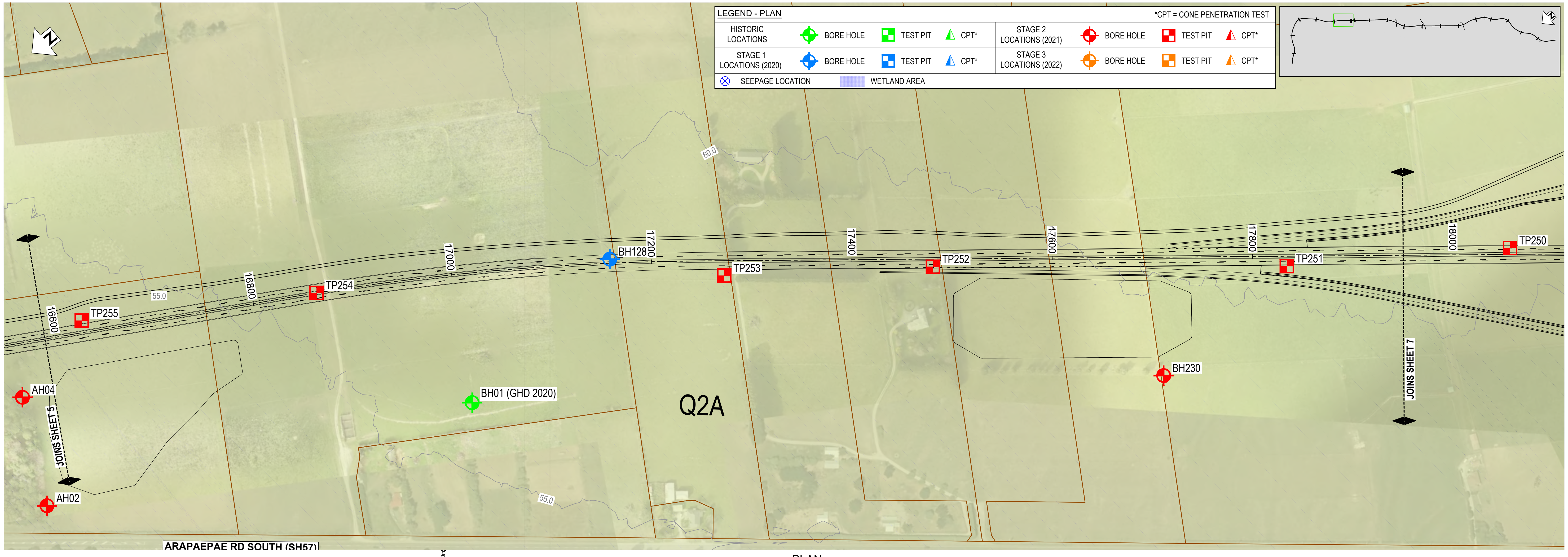
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

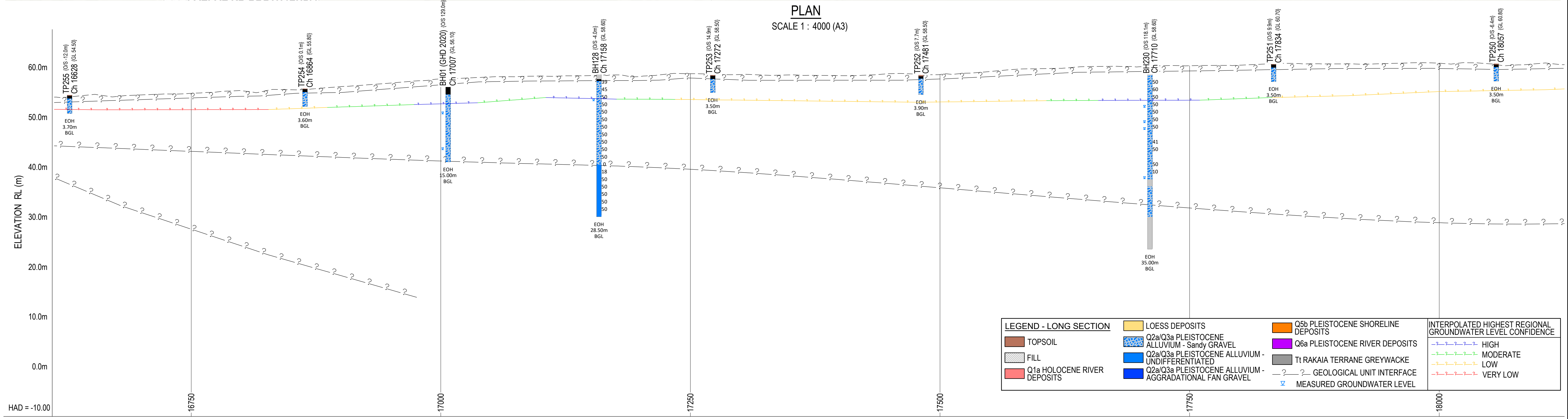
GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 5

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

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-C1004



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		
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

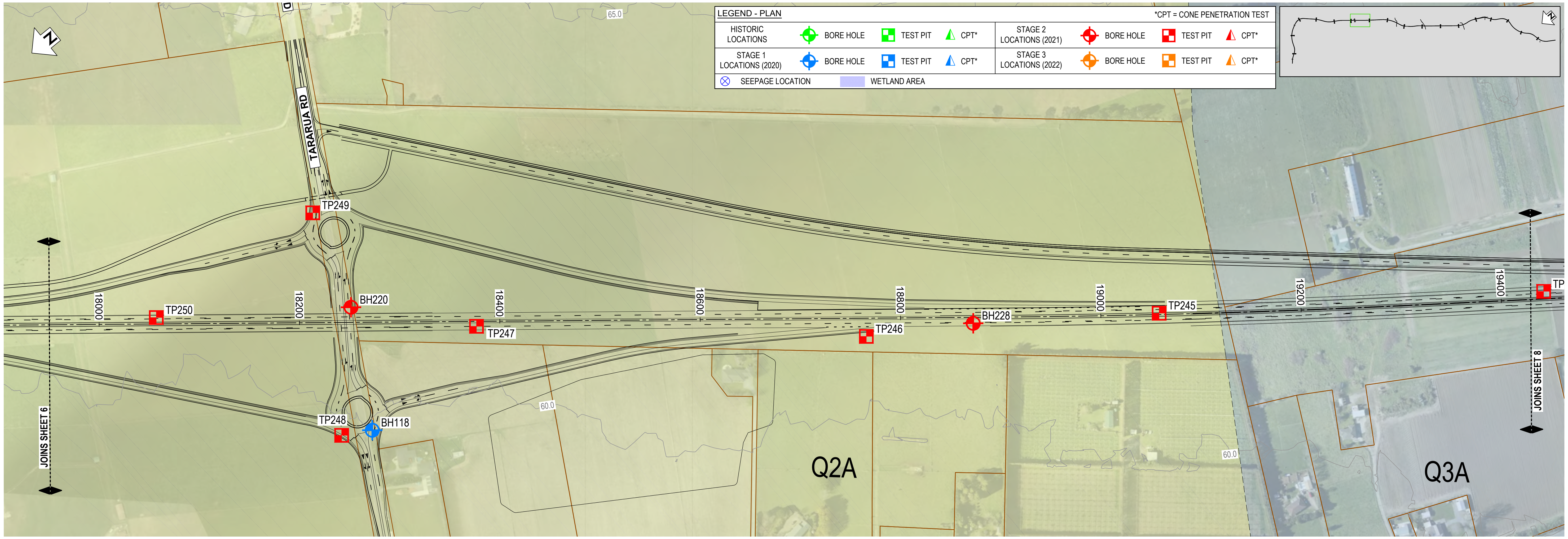
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 6

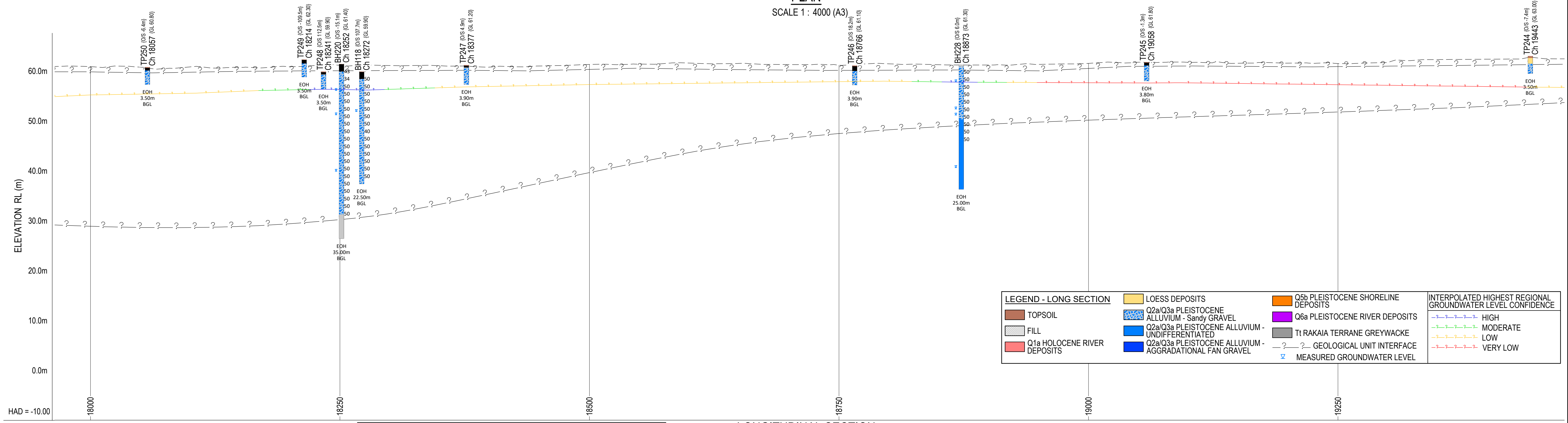
Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1005
Rev.: D

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-C1005



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

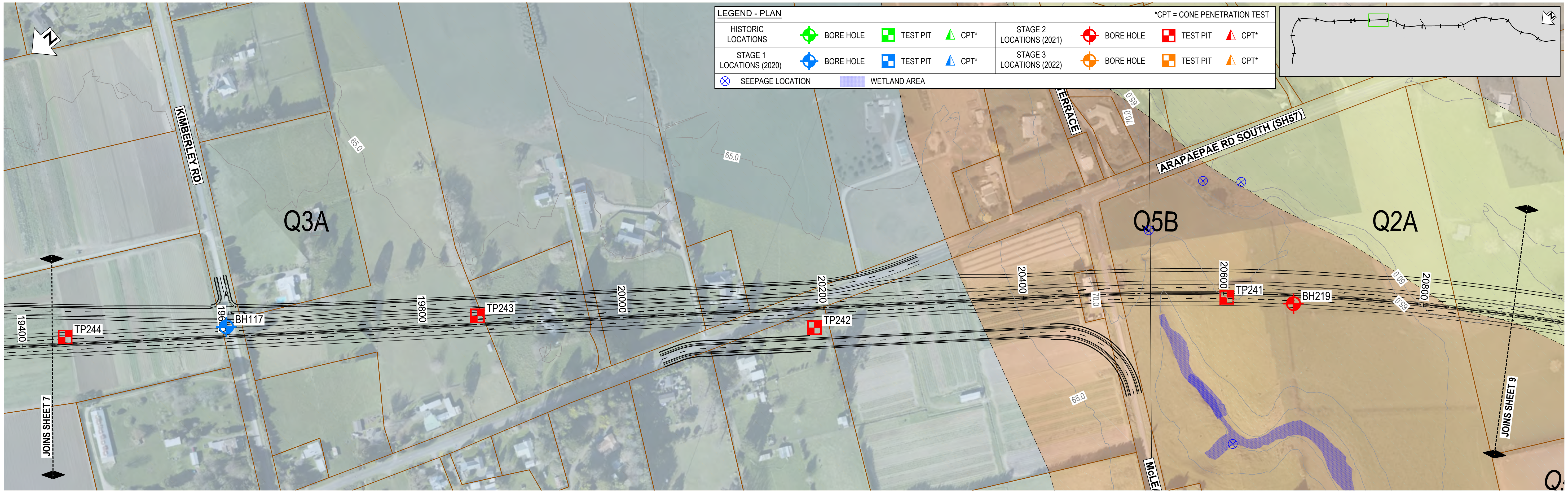
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 7

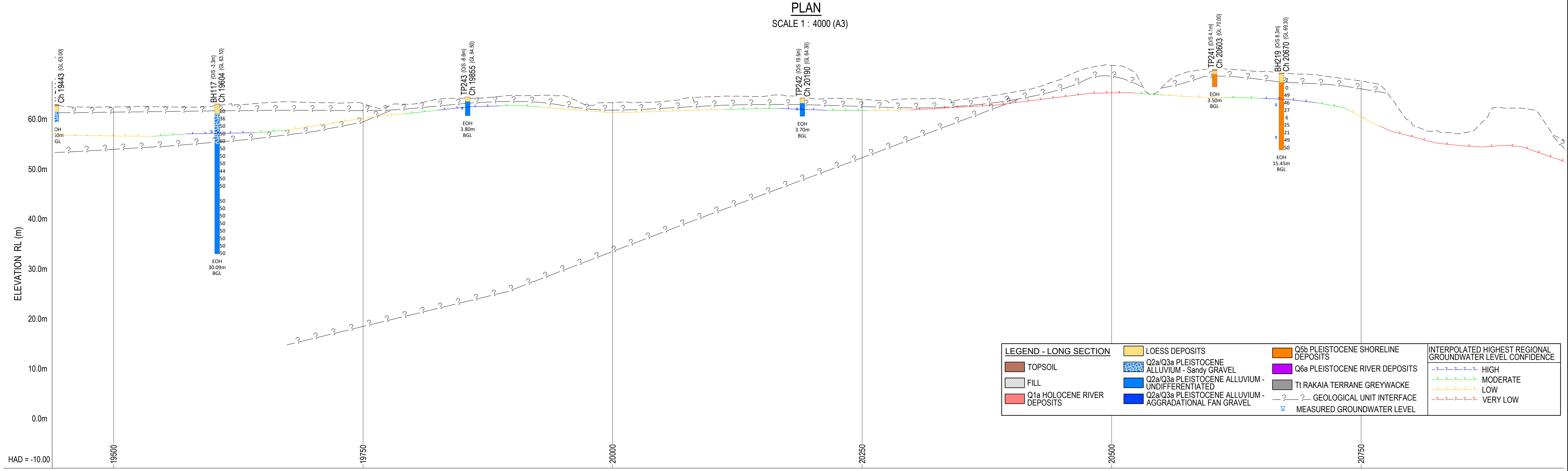
Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1006
Rev.: D

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) — 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		
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

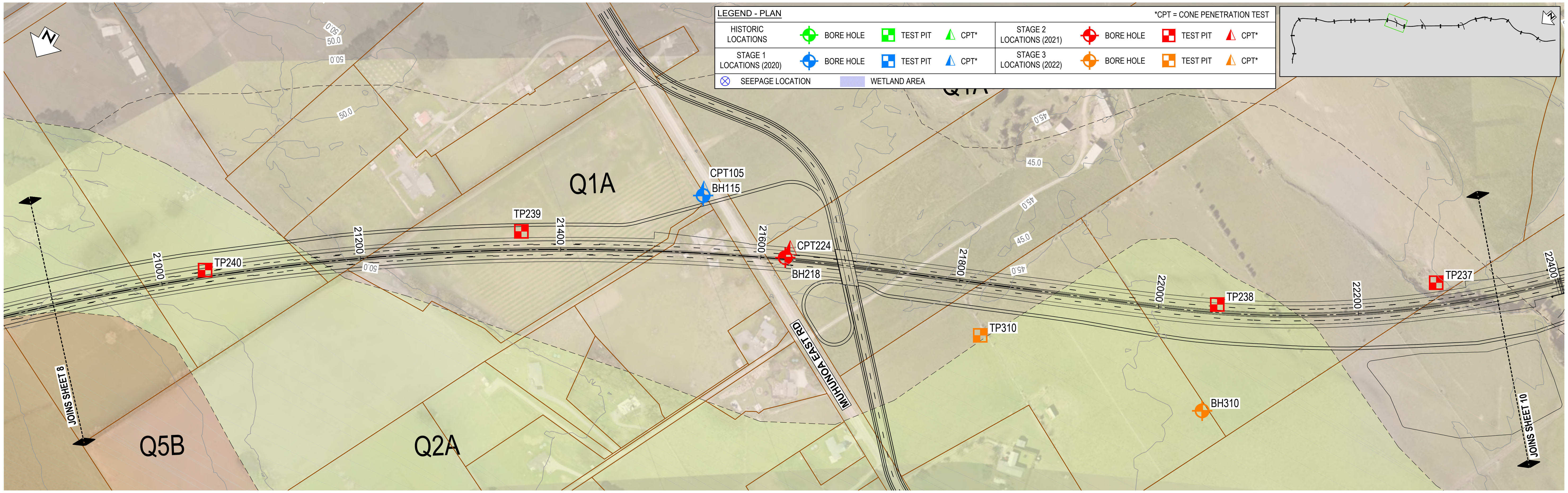
Date Stamp: 16.08.21

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1007

Rev.: D

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-C1007



PLAN

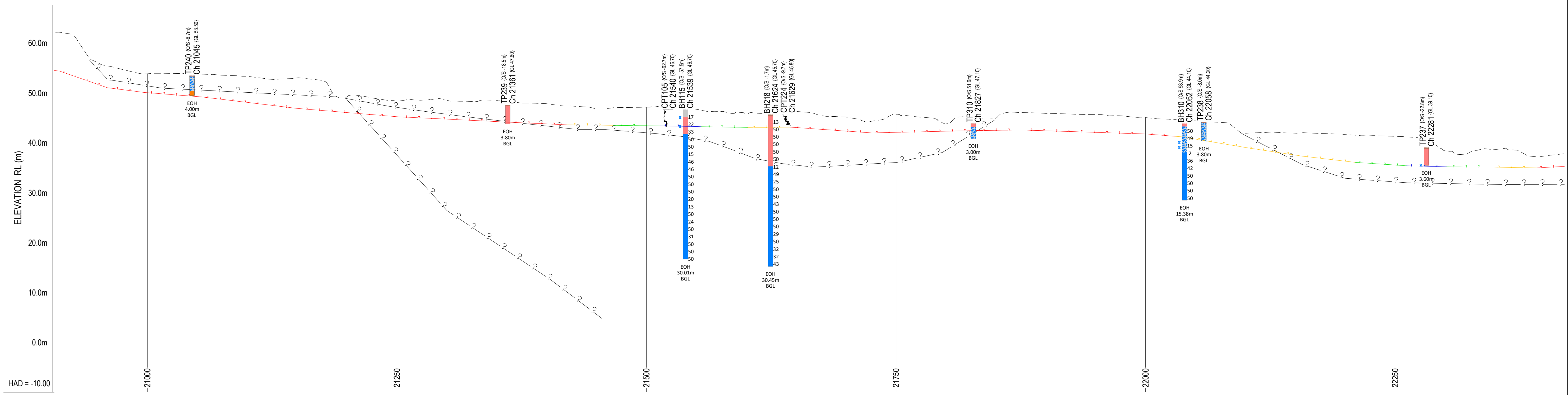
SCALE 1 : 4000 (A3)

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
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 9

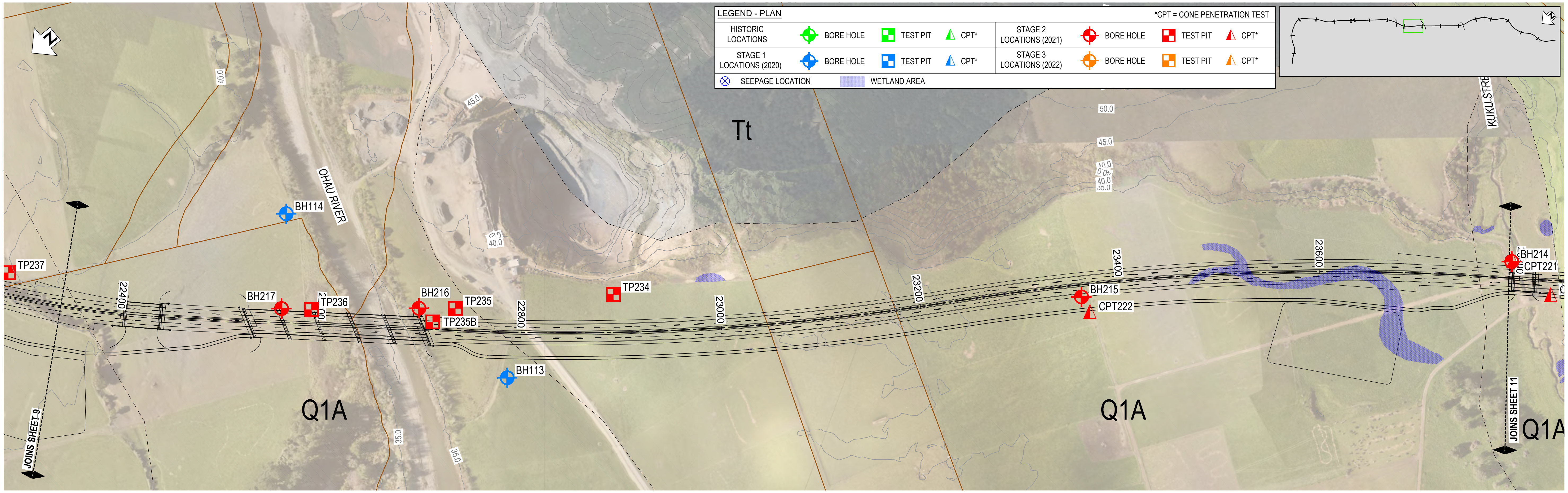
Status Stamp: **WORKING PLOT**

Date Stamp: **16.08.21**

Scales: AS SHOWN

Drawing No.: 310203848-01-200-C1008

Rev.: D



PLAN

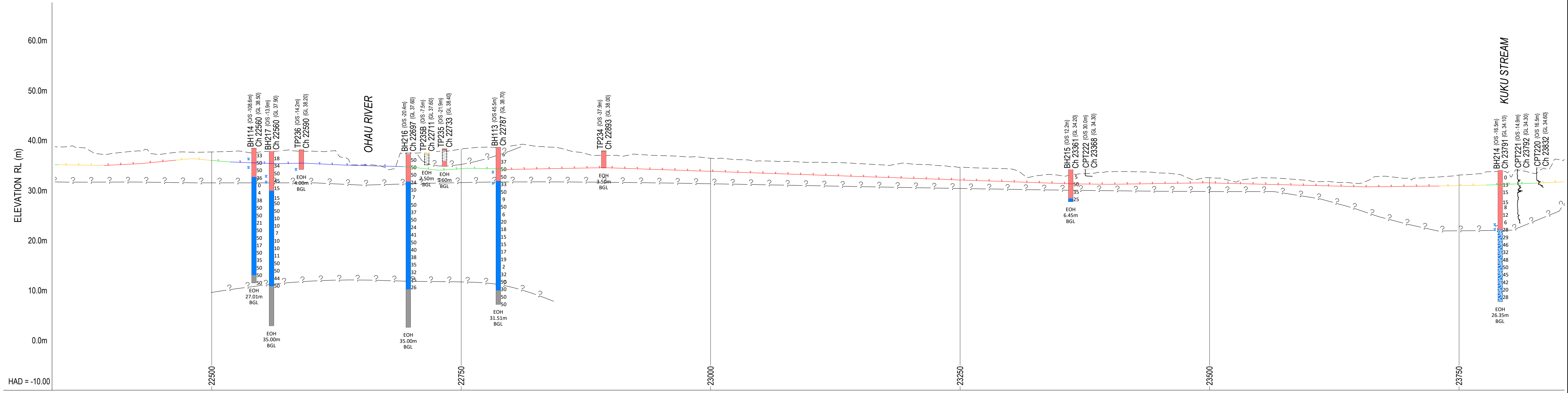
SCALE 1 : 4000 (A3)

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
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 10

Status Stamp: **WORKING PLOT**

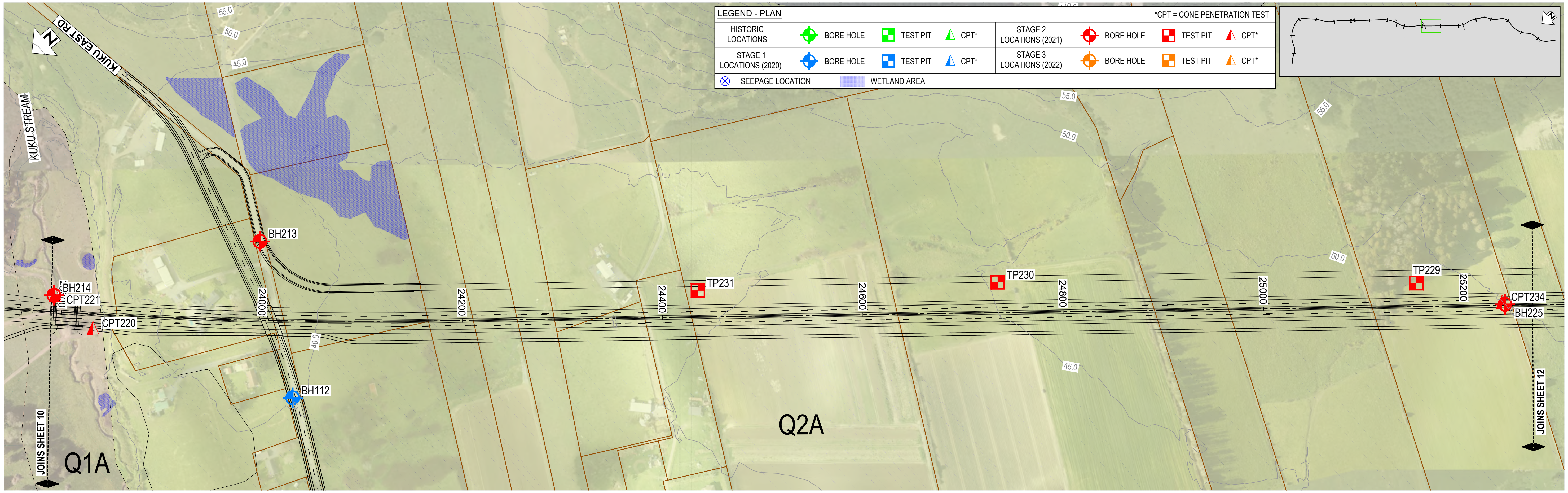
Date Stamp: **16.08.21**

Scales: AS SHOWN

Drawing No. 310203848-01-200-C1009

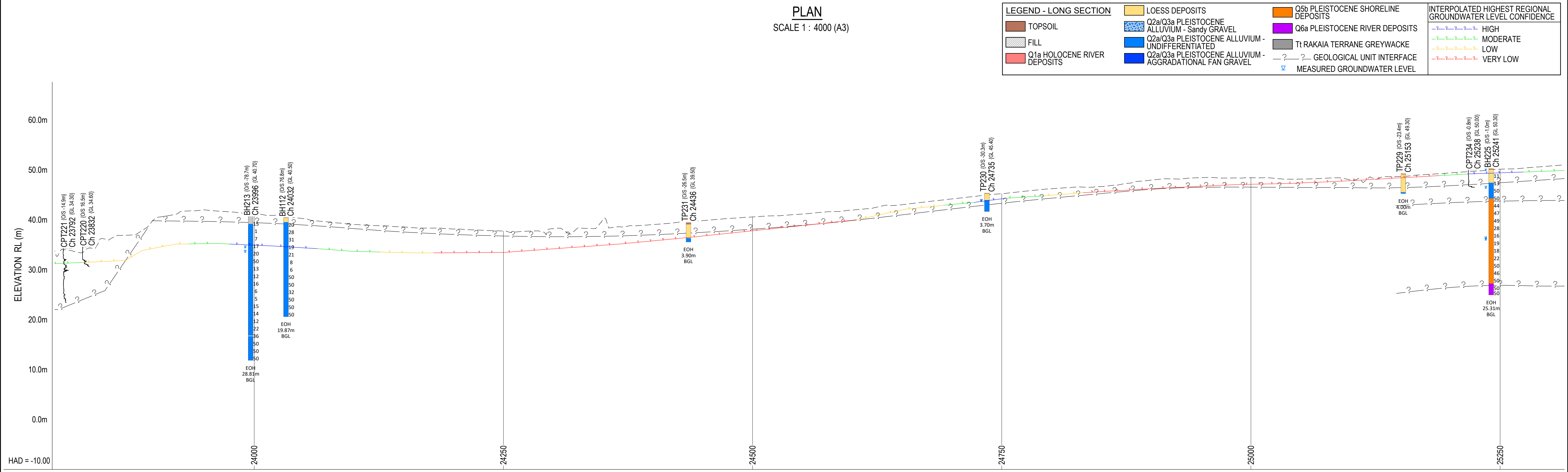
Rev. D

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-C1009



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

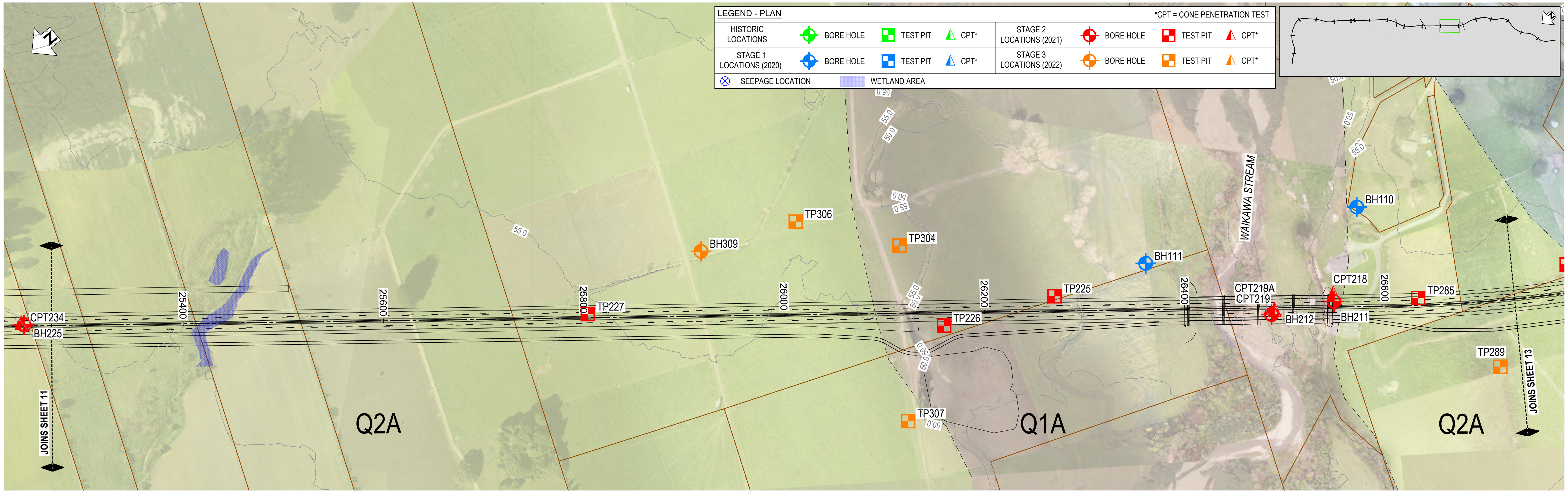
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 11

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



PLAN

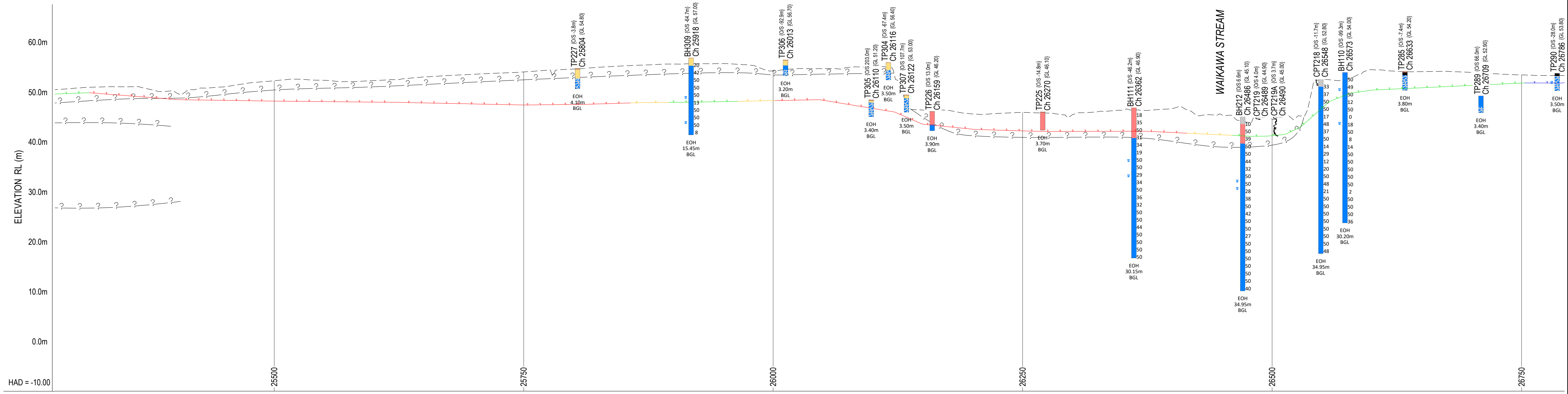
SCALE 1 : 4000 (A3)

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
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

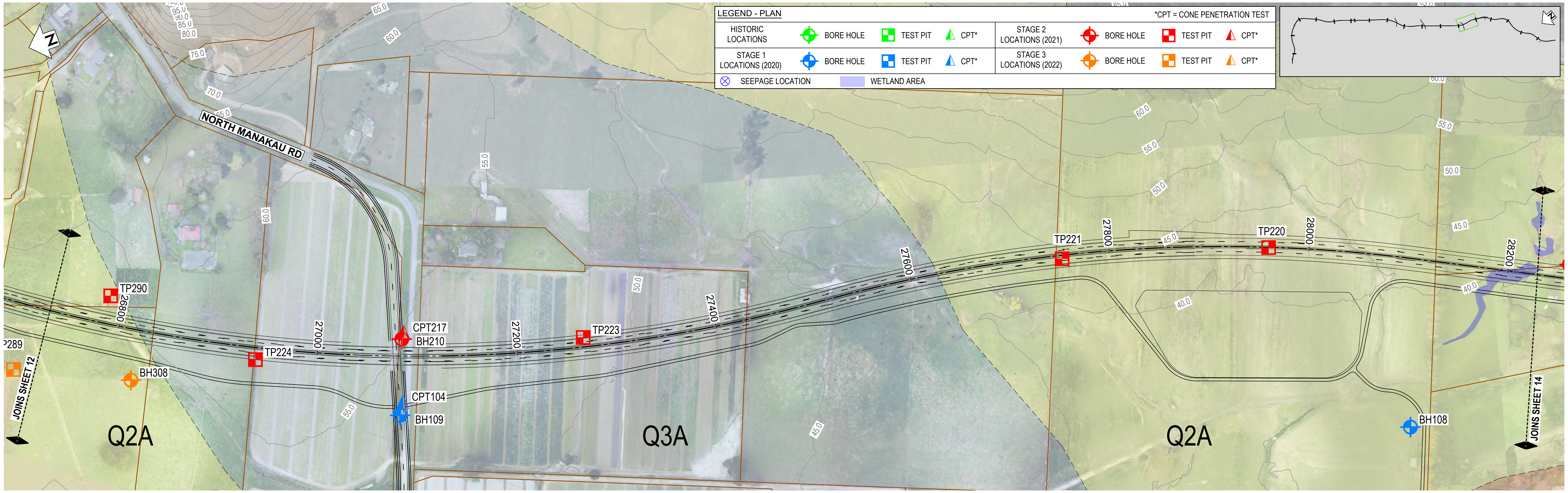
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 12

Status Stamp: **WORKING PLOT**
Date Stamp: **16.08.21**
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1011
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-C1011



PLAN

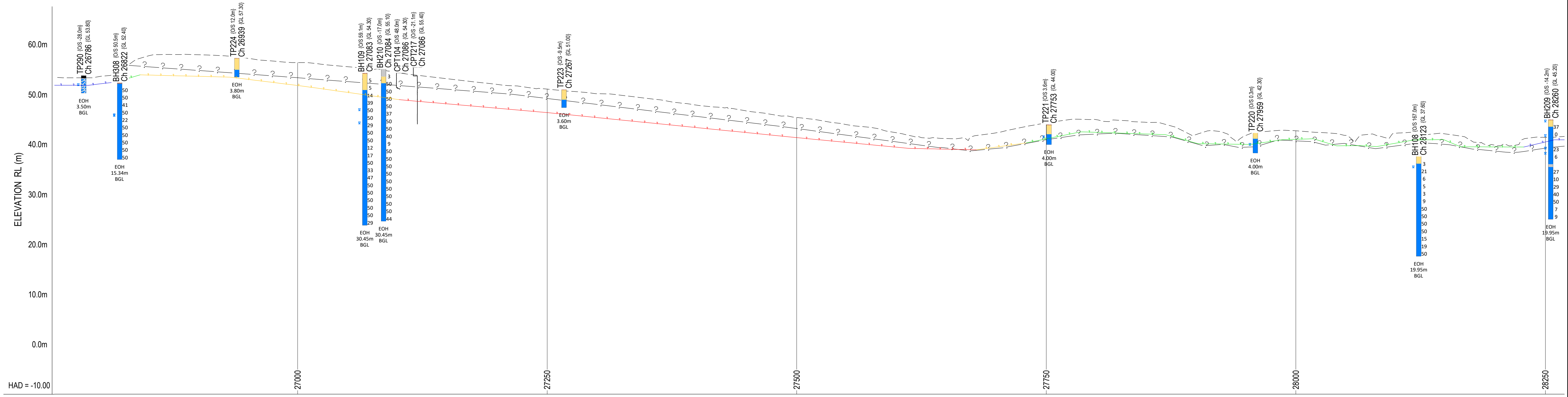
SCALE 1 : 4000 (A3)

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
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:		

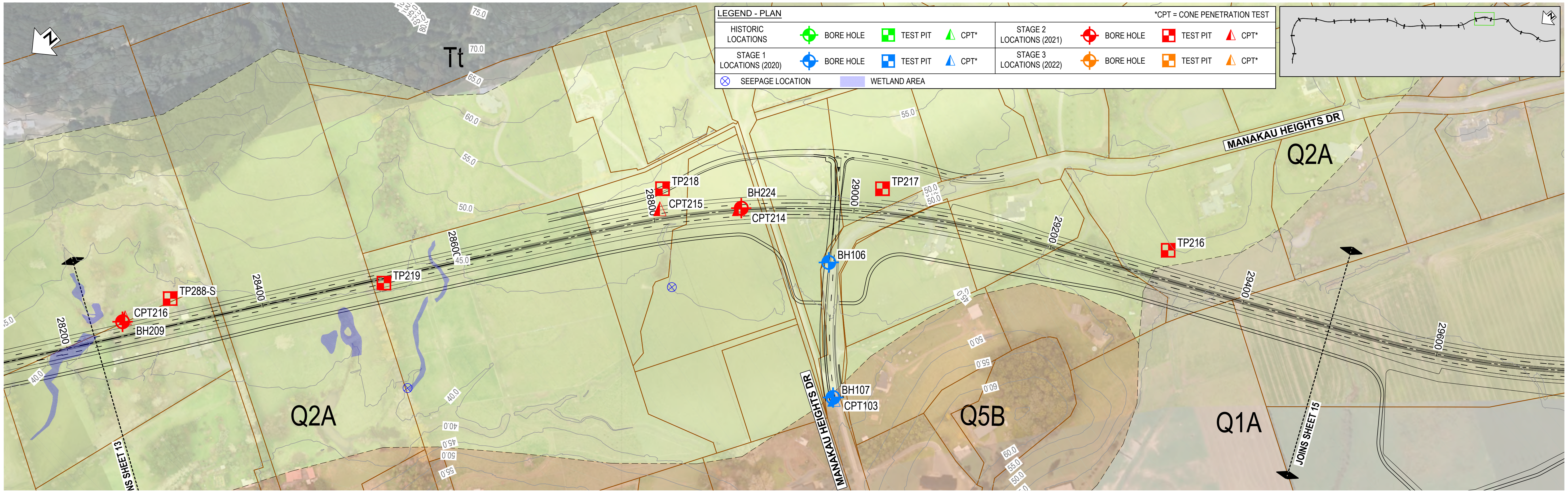
Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 13

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



PLAN

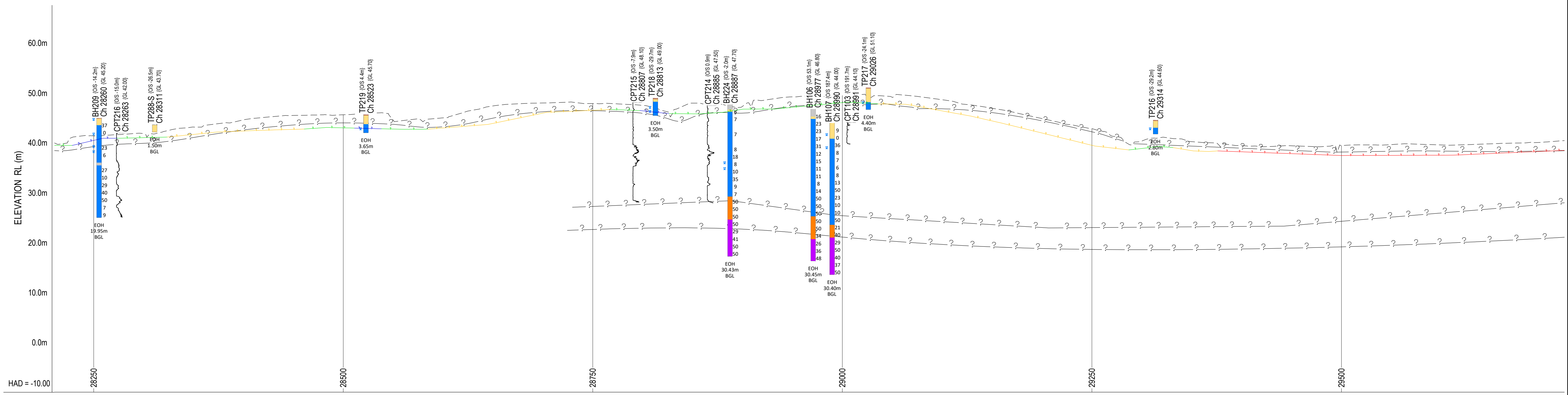
SCALE 1 : 4000 (A3)

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
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:		

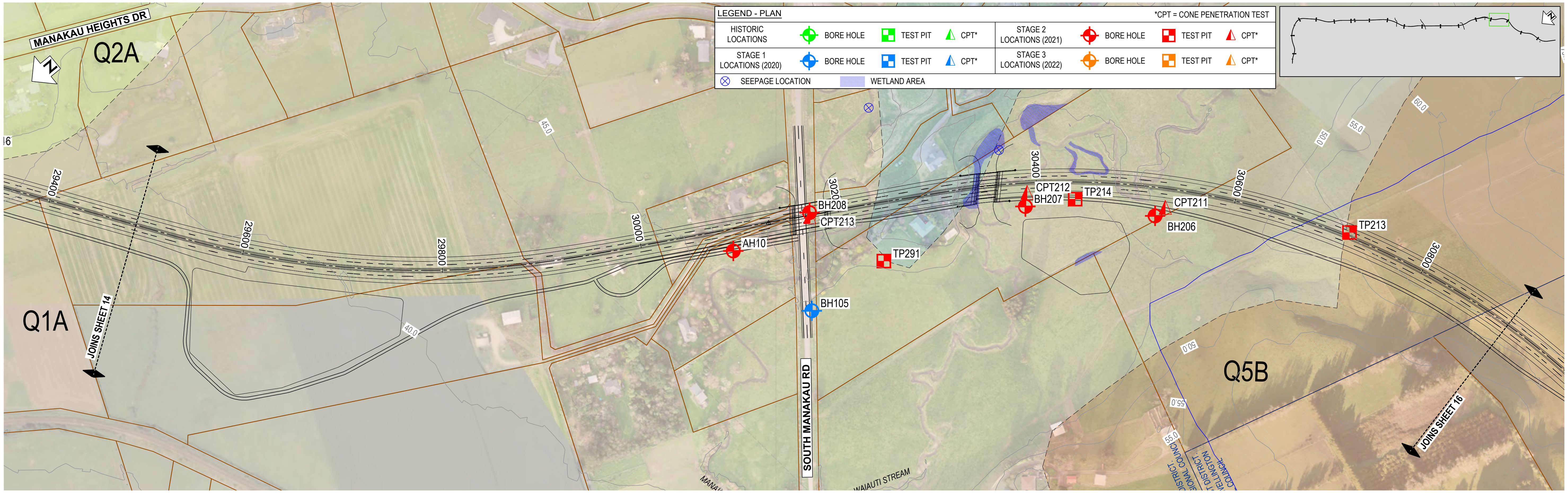
Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

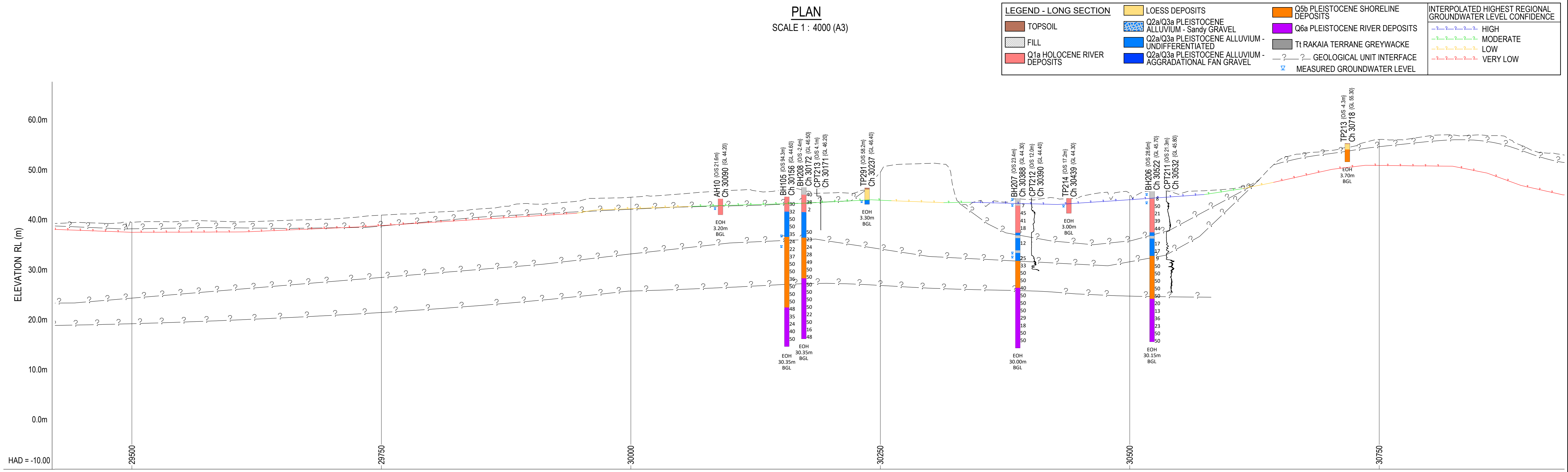
GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 14

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1013
Rev.: D



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

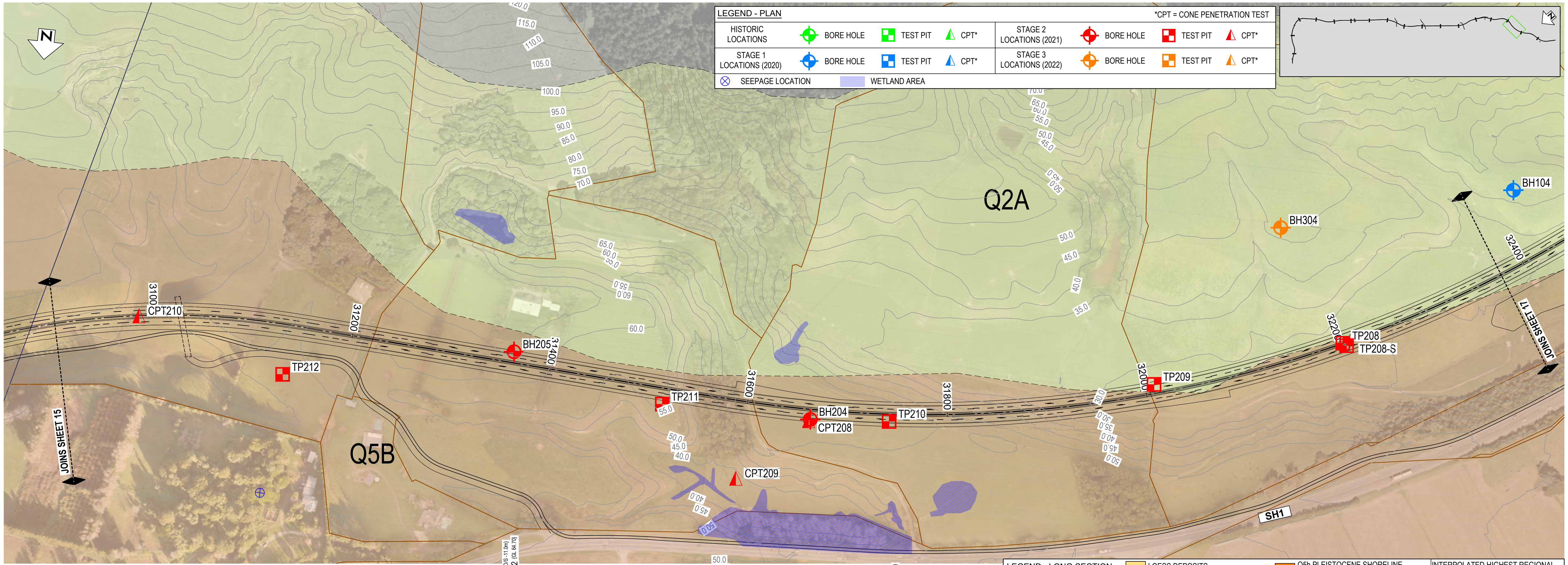
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

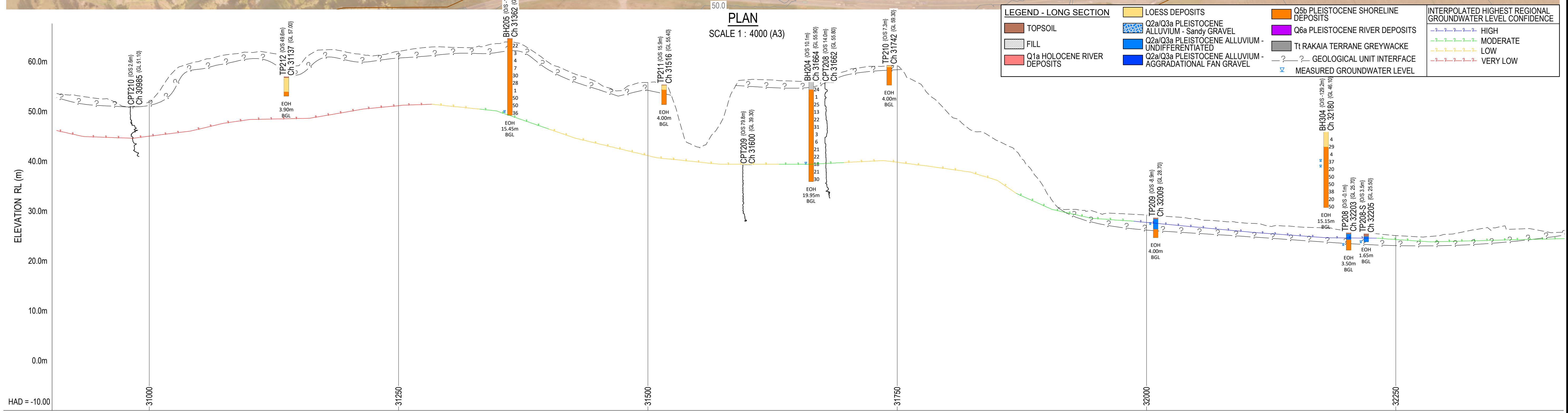
GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 15

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1014
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-C1014



PLAN
SCALE 1 : 4000 (A3)



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

10 0 10 20m
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

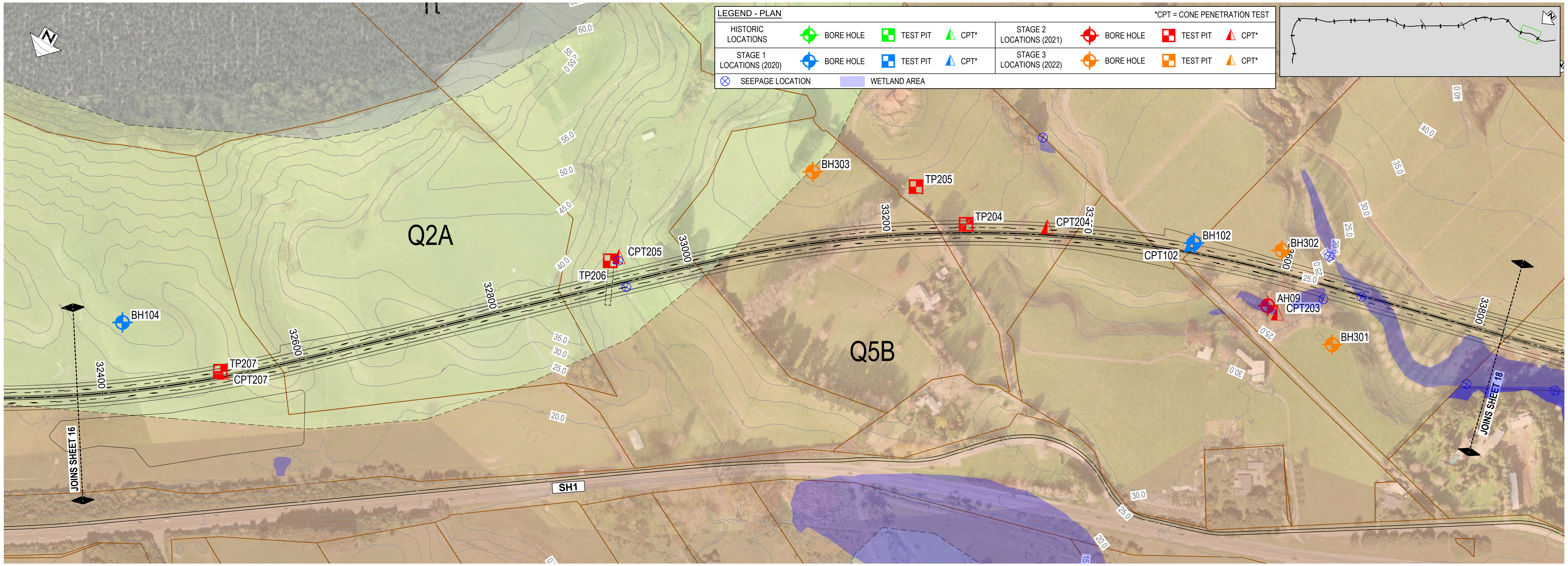
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

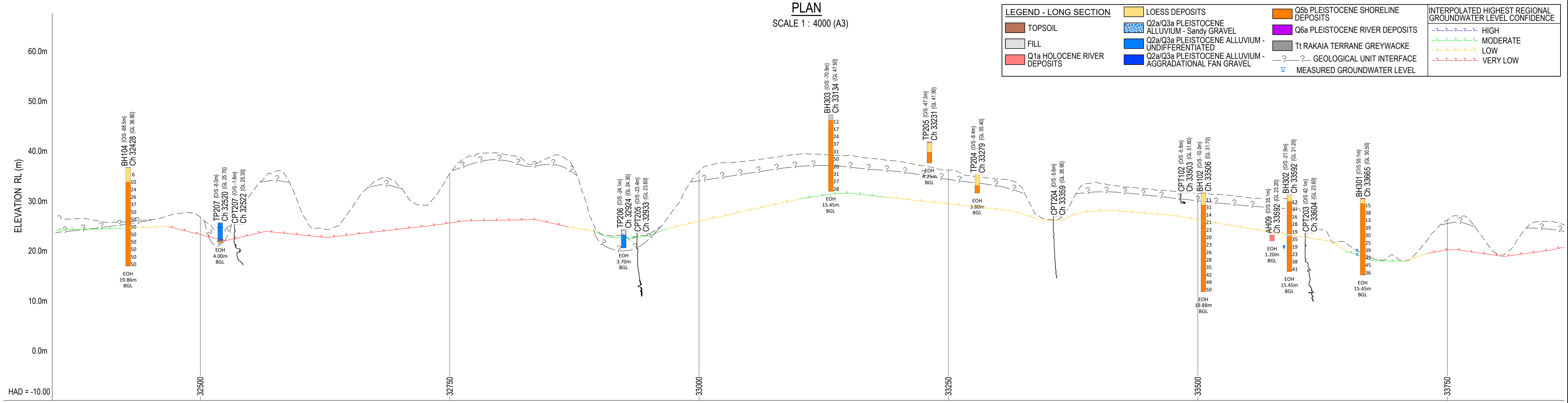
GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 16

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No. 310203848-01-200-C1015
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-C1015



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		
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

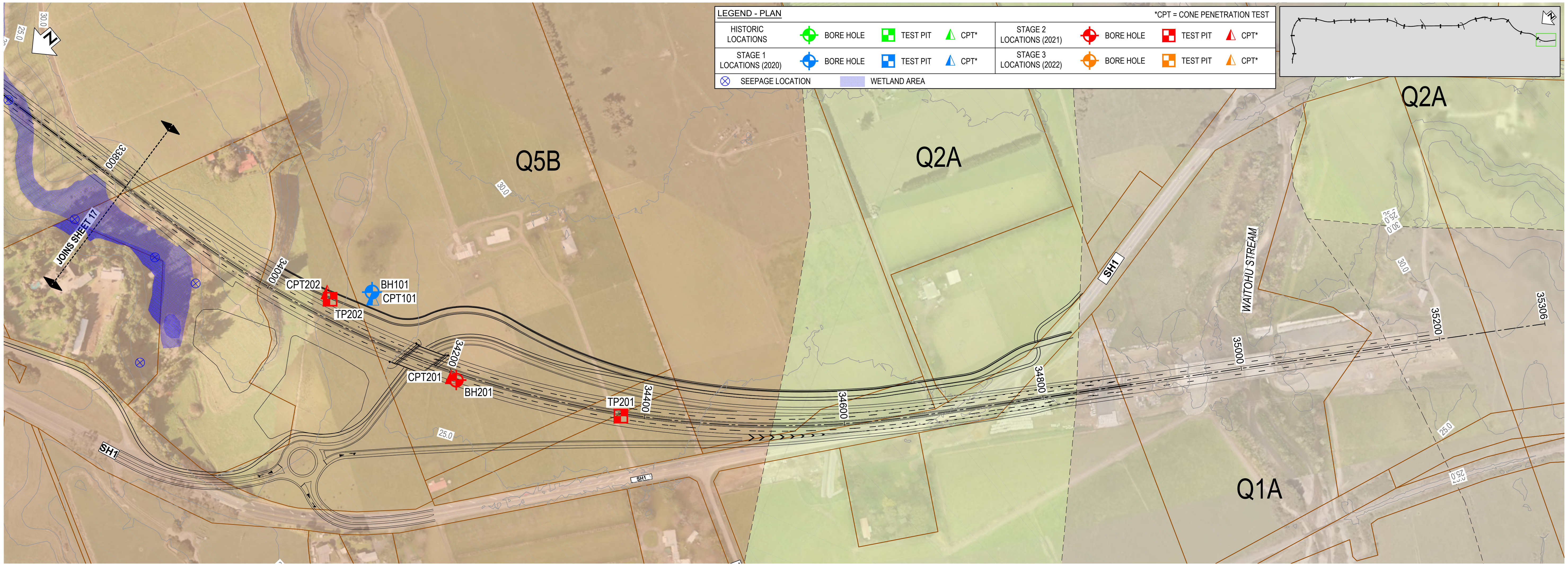
Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
OTAKI TO NORTH OF LEVIN PROJECT

GEOLOGICAL MODEL PLAN AND LONG SECTION
SHEET 17

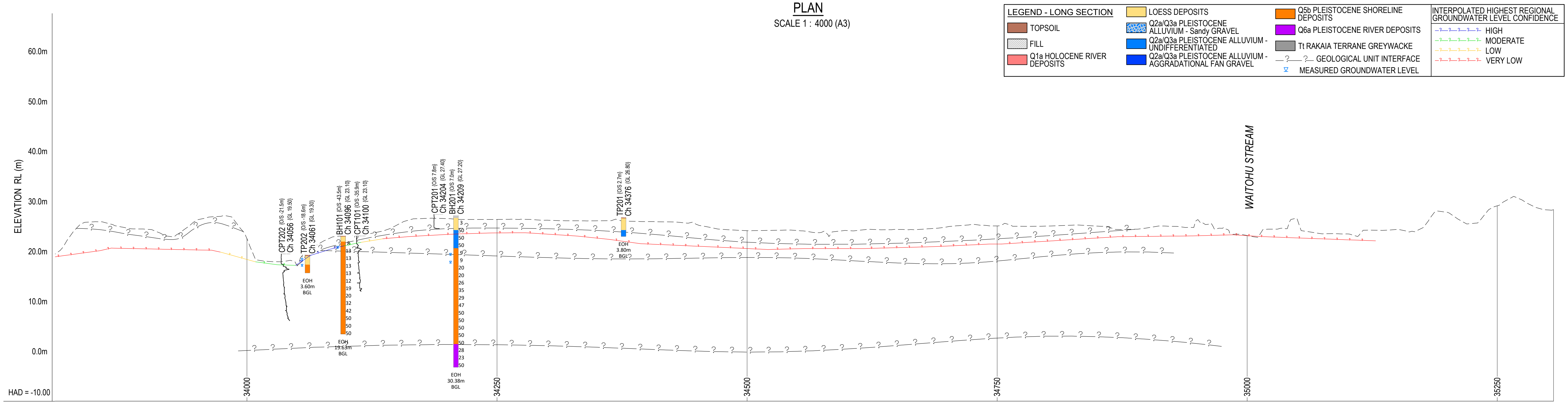
Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No.: 310203848-01-200-C1016
Rev.: D

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-C1016



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
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
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 18

Status Stamp: WORKING PLOT
Date Stamp: 16.08.21
Scales: AS SHOWN
Drawing No. 310203848-01-200-C1017
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-C1017

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.

New Zealand offices:
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;

---

[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

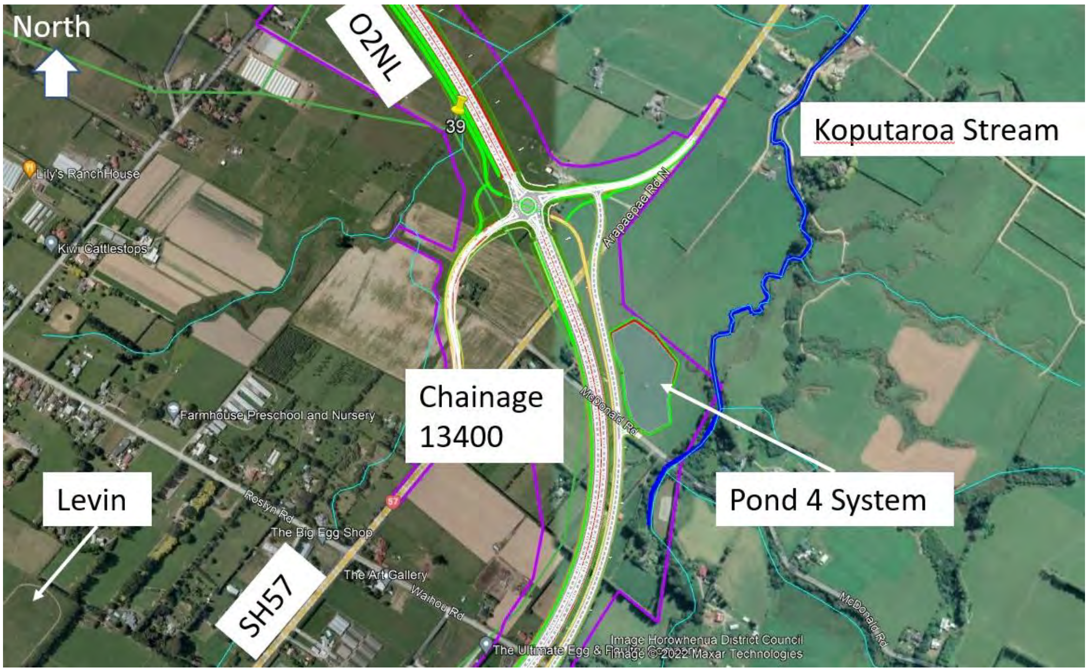


Figure 1: Pond 4 Location Plan

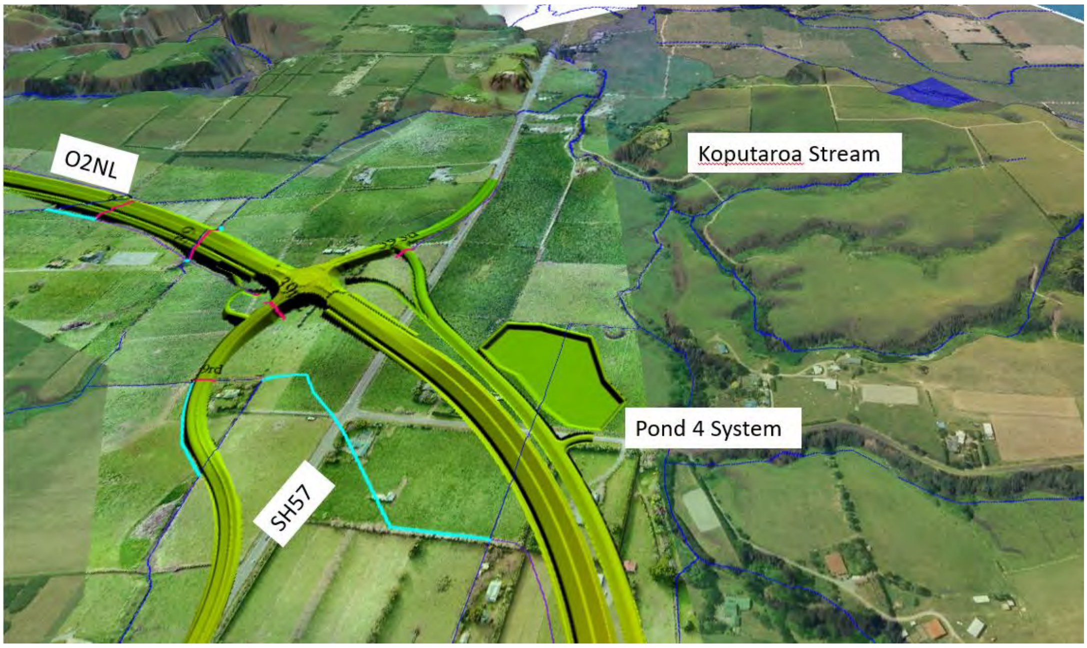


Figure 2: Perspective View of the Pond 4 location and proposed highway (vertical exaggeration applied)

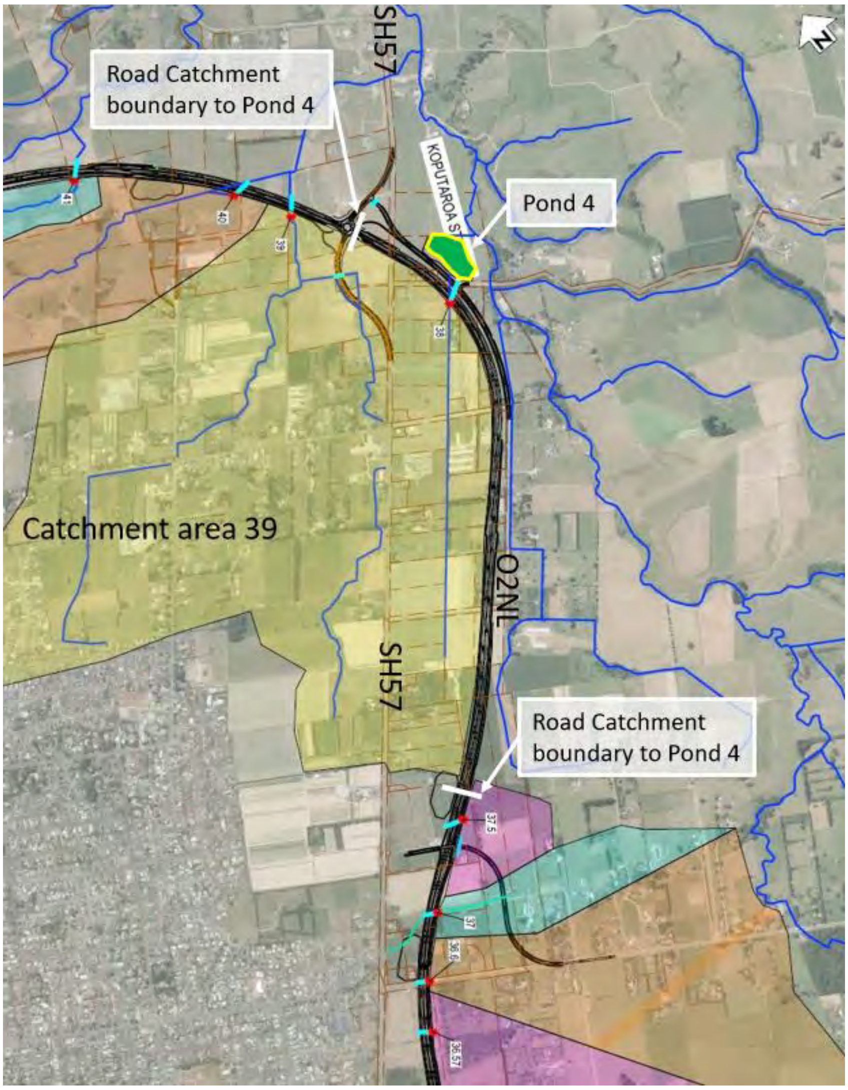


Figure 3: Catchment Areas near Pond 4 –indicating the length of road corridor that drains into Pond 4

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

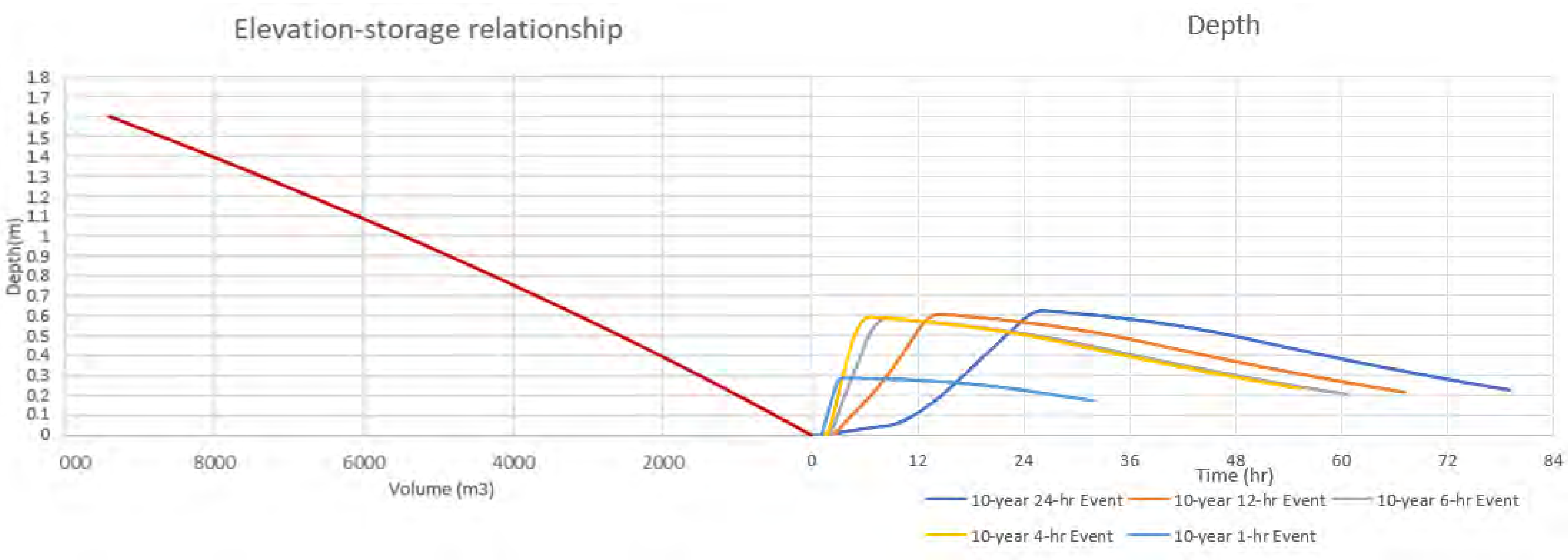


Figure 5: Pond 4: Depth, storage, time relationships

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.

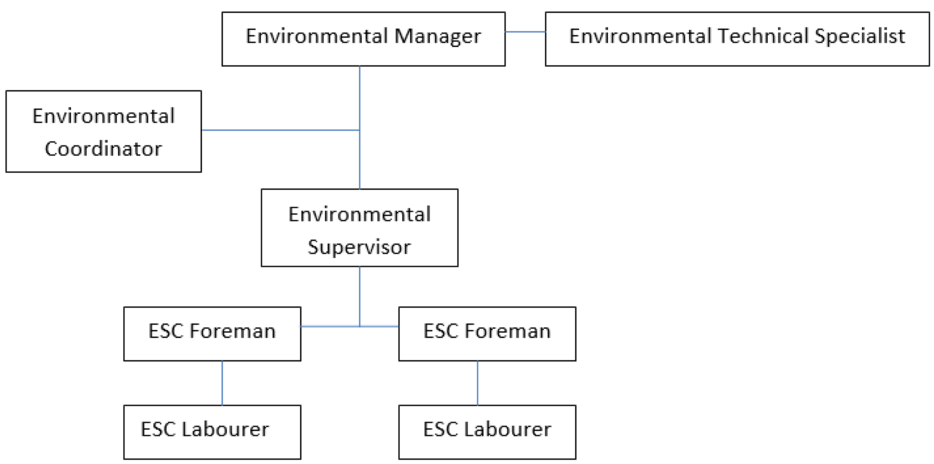


Figure 4.3.2: Indicative Project Environmental Management Team structure (Constructor may split roles and titles differently).

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.

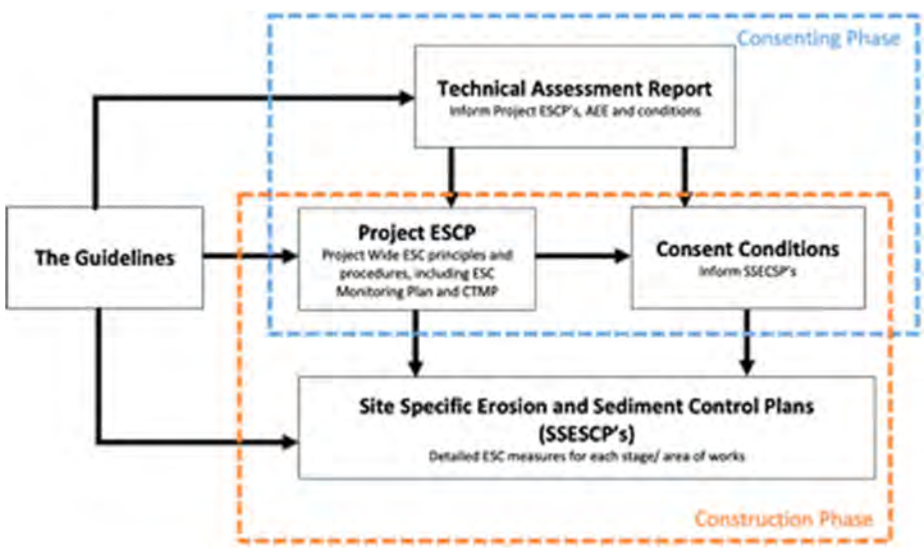


Figure 4.3.3: ESC management document structure

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.
   - o 50% clay, 45% silt, and 5% sand.
   - o 20% clay, 10% silt, and 70% sand
   - o 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**

Management Response Audit

Used in the event of a failure to meet performance targets for treatment efficiency and clarity.

*Required

1. Auditor *

Mark only one oval.

- Reuben Fergusson
- Rory Byrne
- Thomas Josephson
- Oriwa Curtis
- Gregor McLean
- Other: ______________________

2. Zone *

Mark only one oval.

- Zone 1 *Skip to question 3*
- Zone 2 - Wester Access & Eco *Skip to question 4*
- Zone 2 - Meridian *Skip to question 5*
- Zone 3 *Skip to question 6*
- Zone 4 *Skip to question 7*

Zone 1

3. ESC Device Reference

Mark only one oval.

- SRP 1
- SRP 2
- SRP 3
- Other: ____________________

Skip to question 8

Zone 2 - Western Access

4. ESC Device Reference

Mark only one oval.

- DEB 1
- DEB 2
- DEB 3
- DEB 4
- DEB 5
- DEB Eco 1
- DEB-CH4280
- DEB-CH4301
- SRP-CH4460
- SRP-CH4700
- SRP-CH5060
- DEB-CH5550
- DEB-CH5580
- DEB-CH5600
- SRP-CH5650

Skip to question 8

Zone 2 - Meridian

5. Z2 ESC Device *

Choose the correct ESC Device to be inspected

Mark only one oval.

- DEB-CH5900 (FARMERS POND)
- SRP-CH6060 (TAP 03)
- DEB-CH6200 (Cut 13 - Bottom Pond)
- DEB-MAT-CH400 (CUT 13 - Top Pond)
- DEB-MAT-CH440 (CUT 13 - Middle Pond)
- DEB MR01 (Opposite Cut 13 - Behind Farmers Fence)
- SRP-CH6450 (Heading to Tap 05)
- DEB-6500 (Near Smoko Shed Fill 11)
- DEB-6550(Fill 11 Access Track)
- DEB-6600 (TAP 06 Down, Fill 11)
- DEB-6700 (Fill 11 bottom pond)
- SRP-CH6800 (Spoil Site 25)
- SRP-CH6950 (TAP 09)
- SRP 7050 (MAT2)
- DEB 100 (MAT2 - Top of track by TAP 08)
- DEB 200 (MAT2 - Downstream)
- DEB-CH7100 (TAP 09)
- DEB TAP 05
- DEB 460 (Devil's Gut - Top Pond)
- DEB 360 (Devil's Gut - Middle Pond)
- DEB 300 (Devil's Gut - Bottom Pond)
- DEB Haul Road (TAP 10 by Main Gate)
- DEB TAP 08 (Across Haul Road from TAP 08)
- Other: ____________________

Skip to question 8

Zone 3

6. Z3 ESC Device *

Choose the correct ESC Device to be inspected

Mark only one oval.

- SRP-CH7700
- SRP-CH7850
- SRP-CH8000 (Cook Road Compound)
- DEB-CH8100 (Cook Road Compound)
- SRP-CH8360 (Left of Cook Road Access to Compound)
- DEB-CH8700 (Cook Road - Haul Road)
- DEB-CH8740 (Cook Road - Haul Road)
- SRP-CH8800 (Cook Road - Haul Road)
- SRP-CH9000 (Spoil Site 28)
- Spoil Site DEB North (Spoil Site 28)
- Spoil Site DEB South (Spoil Site 28 - Closest to Smoko Shed)
- SRP-CH9550 (BR10)
- Other: ____________________

Skip to question 8

Zone 4

7. Z4 ESC Devices *

Choose the correct ESC Device to be inspected

Mark only one oval.

- SRP-CH11900 (Fill 20)
- SRP-CH12100 (Spoil Site 31)
- SRP-CH12550 (Brad's Hole)
- SRP-CH12800 (Middle of Haul Road near culvert)
- SRP-CH12850 (Auto-Flocker - Left Paddock)
- SRP-CH12900 (Waste Pile - Right Paddock)
- DEB-HR04 (Top of Fill 20 Access Track)
- DEB-HR01 (AgResearch, half way up the hill)
- DEB-HR02 (AgResearch, top of the hill)
- DEB-HR03
- DEB-Skidsite
- SRP-CH12000
- Other: ____________________

Skip to question 8

Catchment

8. Are all clean water diversion shown on the SSESCP installed?

Mark only one oval.

- Yes
- No
- Other: ____________________

9. Are clean water diversions installed in the correct place as per the SSESCP?

Mark only one oval.

- Yes
- No
- Other: _______________

10. Are all dirty water diversions shown on the SSESCP installed?

Mark only one oval.

- Yes
- No
- Other: _______________

11. Are dirty water diversions installed in the correct place as per the SSESCP?

Mark only one oval.

- Yes
- No
- Other: _______________

12. Is the pond receiving the correct catchment as per the SSESCP?

Mark only one oval.

- Yes
- No
- Other: _______________

13. Catchment related recommended actions (complete EARs for all actions)

14. Catchment related photos

Files submitted:

Erosion control

15. Is there erosion occurring in diversions?

Mark only one oval.

- Yes
- No
- Other: ______

16. Are velocity controls installed and maintained in diversions?

Mark only one oval.

- Yes
- No
- Other: ______

17. Is there excessive erosion occurring on cut and fill batters?

Mark only one oval.

- Yes
- No
- Other: ____________________

18. Are there completed sections of earthworks in the catchment that could be stabilised?

Mark only one oval.

- Yes
- No
- Other: ____________________

19. Can additional diversions be installed to direct water away from erosion prone cut and fill batters?

Mark only one oval.

- Yes
- No
- Other: ____________________

20. Is erosion in the inlet channel occurring?

Mark only one oval.

- Yes
- No
- Other: ____________________

21. Are adequate controls installed and maintained in the inlet channel to protect against erosion? i.e. geotextiles, velocity controls, pre-treatment sumps, pipe-drops/nova-coils/flumes etc.

Mark only one oval.

- Yes
- No
- Other: ____________________

22. Is erosion of the pond walls occurring?

Mark only one oval.

- Yes
- No
- Other: ____________________

23. Erosion related recommended actions (complete EARs for all actions)

____
____
____
____
____

24. Erosion control related photos

Files submitted:

Floc

25. Are the diversion channels installed to direct water to a single inlet channel for floc dosing?

Mark only one oval.

- Yes
- No

26. Is the floc dosing point/hose positioned correctly above the main inlet channel?

Mark only one oval.

- Yes
- No
- Other: ______________________

27. Is a reset required?

Mark only one oval.

- Yes
- No
- Other: ______________________

28. Is the floc dosing system setup level?

Mark only one oval.

- Yes
- No
- Other: ______________________

29. Is the rain catch tray setup so that water is directed to the header tank?

Mark only one oval.

- Yes
- No
- Other: ______________

30. Is the rain catch tray setup for the correct dose rate and catchment size?

Mark only one oval.

- Yes
- No
- Other: ______________

31. Are the header tank holes blocked?

Mark only one oval.

- Yes
- No
- Other: ______________

32. Are the header tank holes the correct size?

Mark only one oval.

- Yes
- No
- Other: ______________

33. Are the header tank holes drilled at the correct heights?

Mark only one oval.

- Yes
- No
- Other: ______________________

34. Is sediment-laden run-off continuing to enter the pond after the floc system has stopped dosing?

Mark only one oval.

- Yes
- No
- Other: ______________________

35. Floc related recommended actions (complete EARs for all actions)

____
____
____
____
____

36. Floc related photos

Files submitted:

SRP/DEB

37. Is there water short-circuiting the forebay/DEB? i.e. water entering the main pond of an SRP without going into the forebay or entering the decant end of the pond?

Mark only one oval.

- Yes
- No
- Other: ______________________

38. Does the forebay require a muck-out (more than 50% full)?

Mark only one oval.

- Yes
- No
- Other: ______________________

39. Does the main pond require a muck-out (more than 20% full)?

Mark only one oval.

- Yes
- No
- Other: ______________________

40. Is the level spreader level, installed correctly and maintained?

Mark only one oval.

- Yes
- No
- Other: ______________________

41. Are the decants installed correctly and maintained?

Mark only one oval.

- Yes
- No
- Other: ______________________

42. SRP/DEB related recommended actions (complete EARs for all actions)

43. SRP/DEB Photos

Files submitted:

Other

44. Are any other additional controls (not already identified in the audit) recommended?

45. Is a change to the construction methodology or sequencing of works recommended?

46. Are any changes to the maintenance or inspection of controls recommended?

This content is neither created nor endorsed by Google.

Google Forms

APPENDIX 4.3.B - USLE

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%

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 develo *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	K (USLE Parameters)	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	K (USLE Parameters)	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	K (USLE Parameters)	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	K (USLE Parameters)	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	K (USLE Parameters)	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	K (USLE Parameters)	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	K (USLE Parameters)	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

Ōtaki to North of Levin Highway Project

Appendix 4.3.3: Erosion and Sediment Control Plan

Table of Contents

Appendices

1 Introduction

This Erosion and Sediment Control Plan (ESCP) provides proposed overarching erosion and sediment control (ESC) principles and procedures for the construction of Ōtaki to North of Levin Highway Project (Ō2NL Project or the Project).

This plan is prepared on the basis of the future (yet to be appointed) constructor who will adopt this document and its appendices as a starting point for managing erosion and sediment control. The scope of roles and the titles for those roles specified in this document will likely vary from those listed below.

It is to be read in conjunction with the following appended procedures and is to be updated on receipt of resource consents for the Project to ensure consistency with consent conditions:

- Appendix 4.3.3.1 – Chemical Treatment Management Plan (CTMP)
- Appendix 4.3.3.2 – Erosion and Sediment Control Monitoring Plan (ESCMP)
- Appendix 4.3.3.3 – Dewatering Management Procedure
- Appendix 4.3.3.4 – Emergency Spill Response Procedure
- Appendix 4.3.3.5 – Stream Works procedures
- Appendix 4.3.3.6 – Hazardous Substances Procedure
- Appendix 4.3.3.7 – Minor Changes to Management Plan Register

1.1 Project Description

The Ō2NL Project comprises approximately 24km four-lane (two lanes in each direction), median divided Expressway between Taylors Road north of Ōtaki, linking with the Peka Peka to Ōtaki (PP2Ō) Expressway, and ending just north of Levin, where it connects back into the existing SH1 and to SH57 towards Palmerston North.

The Ō2NL Project will generate approximately 4-4.5M m^3 of excavated (cut) material (excluding topsoil). Approximately 3-3.5M m^3 of this cut material will be placed as structural fill for embankments along the proposed route. The remainder of the excess cut material will likely be disposed of within the designation boundaries or in spoil disposal sites.

2 Erosion and Sediment Management Team

Following section includes titles and descriptions of role of personnel which will likely differ from those of the ultimate constructor.

The earthworks operations will be likely split into four management zones.

Each Zone will have a Zone Manager, Project Engineer, Site Engineer and Site Supervisor. 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.

The Environmental Management Team structure is provided in Figure 4.3.3.1 below, comprising the Environmental Manager, supported by an Environmental Technical Specialist, Environmental Coordinator, Environmental Supervisor, ESC Foremen and ESC Labourers. The ESC measures will be supervised by the Environmental Manager together with the Earthworks Manager.

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.

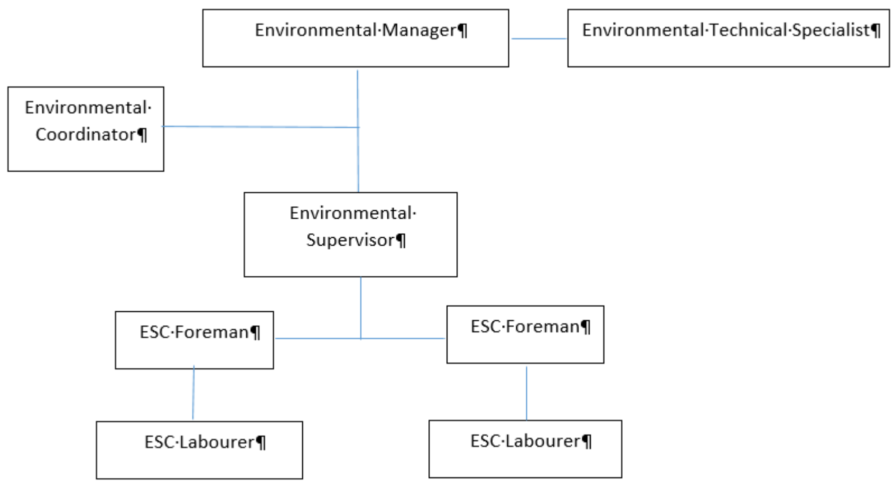


Figure 4.3.3.1: 1Erosion and Sediment Control Team Structure

The Earthworks Manager will have overall responsibility of ensuring that the Site Specific Erosion and Sediment Control Plans (SSESCPs) are complied with in terms of site operations, but with installation and management of the devices being undertaken by the ESC Foremen and Labourers, under the direction of the Environmental Supervisor and management of the Environmental Manager.

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.

The Environmental Technical Specialist will prepare SSESCPs and provide all technical specialist input into ESC management.

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.

2.1 Key Environmental Management Roles

2.1.1 Environmental Manager

The Environmental Manager will have overall management responsibility for all environmental management aspects of the Project.

2.1.2 Environmental Technical Specialist

The Environmental Technical Specialist will be the lead advisor in all ESC design, construction, maintenance and monitoring.

2.1.3 Enviromental Coordinator

The Environmental Cordinator will have the responsibilty of liaising and working closely with the ecologists and Iwi Partners onsite so as to ensure that there is compliance with the relevant conditions of resource consents and compliance with any ecological management plans. They will also need to liaise and work closely with the Department of Conservation in relation to wildlife permits, and iwi and kaitiaki onsite throughout the entire duration of the Project's construction.

The Environmental Coordinator, along with the kaitiaki, will work alongside the Environmental Supervisor to ensure all ecological process and protocols are closely followed.

It is envisaged that this person will also be a qualified ecologist.

2.1.4 Environmental Supervisor

The Environmental Supervisor will have a very strong background in onsite ESC, and will have held a similar position on other sites. It is imperative that this person can communicate well with the earthworks teams as they need to work very closely together to achieve the best outcome. This person will also be responsible for the teams looking after the every day on-site monitoring and maintenance activities. The Environmental Supervisor will be responsible for the operation and maintainance of the chemical treatment systems across the site.

2.1.5 ESC Foremen

TBC

2.1.6 ESC Labourers

TBC

2.2 Contact Details

The key contacts for the Environmental Management Team are as follows:

Role	Person	Details
Environmental Manager	TBC	
Environmental Techncial Specialist	TBC	
Environmental Coordinator	TBC	
Environmental Supervisor	TBC	
ESC Foremen	TBC	

3 Erosion and Sediment Control Principles

3.1 Erosion and Sediment Control Design Standard

All ESC measures implemented through the extent and duration of the Project will be designed, constructed and maintained in accordance 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).

In the unusual circumstance where some variation to the Guideline approach is identified as the best option for a specific area or activity, that variation will be subject to the approval of Greater Wellington Regional Council and Horizons Regional Council (Council's) through the relevant SSESCP.

3.2 Sediment Retention Device Sizing

Sizing of sediment retention devices (Decanting Earth Bunds and Sediment Retention Ponds) will be undertaken using two methods.

3.2.1 GD05:

On earthwork sites with slopes <18° and < 200m in length, design SRP's with a minimum volume of 2% of the contributing catchment area (200m^3 for each ha of contributing catchment).

On earthwork sites with slopes >18° or > 200m in length, design SRP's with a minimum volume of 23 of the contributing catchment area (300m^3 for each ha of contributing catchment).

3.2.2 Waka Kotahi ESC Guidelines - Chapter 6 Hydrological Design Criteria

Where the predominant soils are gravels, the following approach will be used.

Hydrological design is based on the following parameters:

- Soil,
- Slope,
- Rainfall,
- Ground cover, and
- Risk associated with the design.

Steps

1. Determine site location and from that determine latitude and longitude
2. Determine project duration.
3. Using HIRDS or local data select the 1-hour storm using the appropriate frequency storm event risk factor for the receiving environments. (2-year, 5-year, 10-year, 20-year or 100-year from Table 6-4)
4. Determine site soils and slope to select the C Factor.
5. Determine the site area that would drain to a storage practice
6. Use the Rational Formula to calculate the peak discharge for the storm selected in step 1.
7. Multiply the peak discharge by 3,600 seconds to get the volume of the sediment storage practice.

Rational Method

for catchment less than 500ha

$$Q = \frac{0.00278 * C\ I\ A}{360}$$

where

Q = run-off in cubic metres per second, m^3/s

C = run-off co-efficient (see Table 5)

I = rainfall intensity in mm/hr

A = area of catchment above the point being considered in hectares.

Example Calculation

1. Determine project duration **> 6 months**
2. Using HIRDS or local data select the 1-hour storm using the appropriate frequency storm event risk factor for the receiving environments. (2-year, 5-year, 10-year, **20-year** or 100-year from Table 6-4)
3. Determine site soils and slope to select the C Factor – **Flat gravel 0.15 (<10%), sloping gravel 0.25 (>10%).**
4. Determine the site area that would drain to a storage practice - **1ha**

	C	**I**	**A**	**Volume**
Manukau/Ohau	0.15	29.7	1	$44.59m^3$
	0.25	29.7	1	$74.31m^3$

3.3 Erosion and Sediment Control Design Philosophy

The Project will adopt and implement the following ESC design principles:

- Emphasis will be given to erosion control and the most effective means of minimising potential sediment generation and sediment discharge from the Project.
- Sediment controls will be diligently managed to maximise their efficiency at all times.
- A “treatment train” approach will be adopted, whereby the suite of erosion control and sediment control measures, including staging and stabilisation, will be implemented to maximise sediment treatment efficiency and minimise sediment yield.
- Clean water will be diverted away from works sites via stable channels or bunds.
- Disturbance of soil will be staged and limited wherever possible to reduce the risk of sediment generation.
- Areas of disturbed soil will be stabilised either temporarily or permanently as soon as practicable to limit sediment generation through erosion.
- Design long approaches to sediment treatment devices greatly improves their performance.
- Chemical treatment will be used on sediment retention ponds (SRPs) and decanting earth bunds (DEBs) in accordance with the Project CTMP.

- Large particle drop-out pits will be utilised prior to dirty water being delivered into SRPs and DEBs.
- All weather machinery access will be provided for maintenance of all SRPs and DEBs.

3.4 Management & Design Objectives

The management and design objectives of the ESCP are:

- To operate in full compliance with the designation and resource consent conditions and demonstrate this through reporting procedures and third-party compliance monitoring.
- To operate in full compliance with the Resource Management Act 1991.
- To liaise closely with Councils and their agents during construction over matters of ESC.
- To provide the methods that will be employed to avoid, remedy or mitigate adverse effects of sediment on the environment due to construction activities.
- To provide a safe and healthy working environment for all staff on, or near the site.
- To facilitate the very best environmental outcome through innovative, practical, and pragmatic means.

3.5 Staging and Sequencing of Works

The high-level construction programme has indicated that earthworks will be required over four years. The areas to be worked in each year will vary based on construction programming, and progressive and permanent stabilisation.

The key construction stages associated with a large infrastructure project comprise:

a) Preparatory Works – Initial works to enable Establishment Works and Construction Works such as site surveys and investigations, monitoring set-up and some land disturbance.
b) Establishment Works – Progressively opening up the site including, for example, constructing and/or widening access tracks to provide access for construction of sediment controls; followed by vegetation clearance, stream diversions, and construction yards.
c) Construction Phase: Main Works -.

From an ESC perspective, the proposed construction methodology and sequence is a practical approach to achieving the bulk earthworks required for the Project. This incorporates consideration of water management methodologies and includes erosion and sediment control implementation.

4 Erosion and Sediment Control Implementation

4.1 Overall Approach

The ESC design approach is illustrated in Figure 4.3.3.2. This ESCP provides the overarching principles of the ESC implementation, and the various procedures that will be implemented, including the ESCMP. The ESCP and appendices have been informed by the ESC Assessment report (provided as Appendix 4.3 to the Design and Construction Report (Appendix Four to Volume II) and the Guidelines. In conjunction with the ESC Assessment and the Guidelines, this ESCP informs the development of resource consent conditions and will be updated after resource consents are granted to reflect any amendments required by the final conditions.

SSESCPs will be prepared for each works area, based on the Guidelines and any additional requirements imposed through the finalised resource consent conditions. The SSESCPs will be focussed technical documents including drawings that will detail the ESC measures of that area. They will be consistent with this ESCP but will not repeat the general contents of this ESCP.

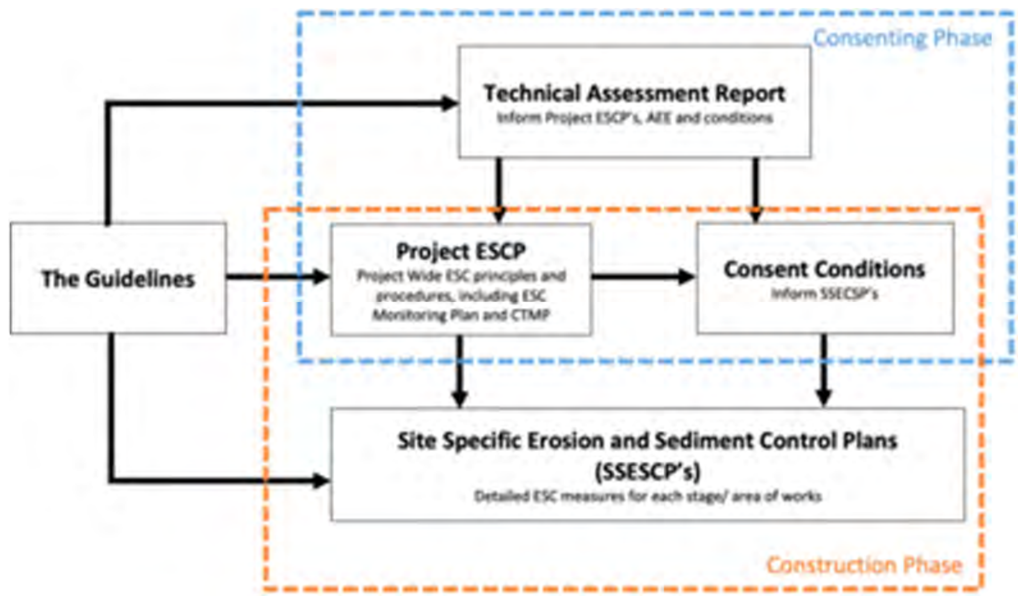


Figure 4.3.3.2 ESC design structure

4.2 Design and Implementation of SSESCPs

The construction of all erosion and sediment controls will be managed as follows:

- The Environmental Technical Specialist will prepare a SSESCP in conjunction with the relevant construction Zone Manager or Engineer and the Environmental Supervisor;
- The SSESCP will be approved by the Environmental Manager and then submitted to the relevant council(s) for certification against the Guidelines.
- Once certified, the Environmental Manager will issue an approved SSESCP to the earthworks Site Supervisors responsible for the implementation.
- A pre-construction meeting will be held by the Environmental Management Team where the sediment controls to be built will be discussed and specific direction given on construction.

- The location of the controls and requirements of the relevant SSESCP will be confirmed on site with the construction team and the Environmental Management Team.
- The construction of the controls will be overseen by the Zone Site Supervisors and members of the Environmental Management Team.
- Hold points for construction will be established for each control whereby the Environmental Management Team will inspect the work completed, for example the installation of anti-seep collars or the installation of primary outlet.
- Each control will be 'as built' certified by a suitably experienced ESC practitioner from the Environmental Management Team to confirm compliance with the SSESCP prior to bulk earthworks commencing in the catchment of the device(s).
- Copies of the 'as-built' certifications will be submitted to Councils.
- All DEBs and SRPs will be labelled clearly with their identification number to aid identification of controls and effective communication both with Project and Council's personnel.

4.3 Changes to ESC Measures

At the commencement of the Project, the Environmental Manager, Environmental Technical Specialist and Environmental Coordinator will agree with Councils a range of minor amendments that can be made to ESC measures on site that can occur without Council's approval. Such amendments may include:

- Minor relocation of a silt fence;
- Installation of additional control measures i.e. drop out pits and cut off drains.

All other changes to ESC measures will be discussed with the Council inspector and submitted with supporting information to Councils for approval prior to being implemented.

4.4 Decommissioning ESC Measures

No ESC measures will be decommissioned without the written approval of the Councils. The Environmental Manager will be responsible for liaising with the Councils regarding the SSESCPs and will provide all decommissioning requests and plan amendment requests in writing. Copies of all Council sediment control decommissioning approvals and plan amendment approvals will be kept on site.

The process of decommissioning a sediment control device will be as follows:

1. Written approval to decommission will have been received from Councils.
2. The weather conditions will be dry or no more than light showers.
3. The contributing catchment of the device to be decommissioned will be stabilised or diverted to another appropriate ESC device prior to decommissioning.
4. The water contained within the control will be of a quality that can be discharged. Where it is not it will need to be treated prior to discharge.
5. The control will be dewatered subject to approval (permit to pump, refer to Appendix 4.3.3.3 to this ESCP - Dewatering Management Procedure) by the Environmental Manager.
6. The "pipe work" and emergency spillway fabrications will be dismantled.
7. The pond or storage area will be filled in and the surface landscaped.
8. The surface will be grassed and stabilised with mulch.
9. A decommissioning notification will be given to the Councils by the Environmental Manager confirming the control has been removed.

5 Plant and Machinery

The Earthworks Manager and Project Engineers will be responsible for ensuring that plant and machinery is available at all times for the ongoing and responsive maintenance of ESC measures throughout the Project.

The Project will adopt the principles and practices of the guideline "*Keep It Clean – Machinery hygiene guidelines and logbook to prevent the spread of pests and weeds"* issued by the National Pest Control Agencies (NPCA) in collaboration with the Local Government Biosecurity Managers Group, Rural Contractors New Zealand, Federated Farmers, and Ministry for Primary Industries, Published June 2013. The management of biosecurity risks will be undertaken in accordance with a Pest Plant Procedure (note yet to be prepared).

6 Materials

The Environmental Manager in conjunction with the ESC Team will establish and maintain an on-site supply of ESC related materials such as geotextile fabrics, wire, piping, decant kits, safety fences, waratahs, and ground staples to ensure that all necessary construction and maintenance of devices can be undertaken in a timely and responsive manner for the duration of the Project.

7 Training

The objectives of this ESCP will only be met successfully when all those responsible for its implementation and review are thoroughly conversant with its content, interpretation and performance measurement.

Project staff need to be trained and up-skilled to be aware of the potential impact their role can have on environmental performance and compliance of the Project. This is fundamental to achieving good compliance and environmental outcomes. The Environmental Manager will be responsible for ensuring that training is provided.

Training content will be targeted at the most relevant information for various staff roles. All training will include awareness of the activities and associated effects that earthworks can have on the local receiving environments, including an overview of the values of those environments. Training will also ensure that all staff understand what ESC measures are, the function of those measures, and the importance of diligently complying with SSESCPs. Training will ensure that staff understand the ESC management structure, and how to report on any maintenance requirements they identify during their work. It will also address the legal responsibilities of all personnel and legal consequences of non-compliance.

More specific training will be provided to staff that will be involved in the day to day implementation of ESC measures. This will include on-the-ground practical training on the construction, maintenance and decommissioning of devices.

Induction training will also make contractors aware of resource consent conditions, designation conditions, environmental control procedures and the requirements of the ESCP. Specific individuals with environmental responsibilities may require the following training:

- Emergency response training;
- Spill kit training;
- Environmental auditing;
- Sampling and monitoring.

A record will be kept of people who have undertaken induction training. The Environmental Manager will have responsibility for maintaining and updating these records.

Staff involved in environmental monitoring required by any resource consent conditions and by the requirements identified within this ESCP will be trained and competent in the operation, calibration and maintenance of the equipment. Relevant staff will also be trained and competent in sample collection, handling, storage and transport methodologies and techniques. Records of staff training will be kept and made available for inspection upon request.

8 Monitoring and Responses

8.1 ESC Monitoring

Monitoring of the ESC measures and outcomes will be undertaken in accordance with the appended Erosion and Sediment Control Monitoring Plan (ESCMP, Appendix 4.3.3.2 to this ESCP). The ESCMP details all monitoring to be undertaken during the construction phases of the Project, including weather forecasting and monitoring, business-as-usual management of the site, rainfall trigger event monitoring, response and reporting.

8.2 Environmental non-compliance and corrective actions

Corrective actions are required when a non-compliance is identified. Corrective actions are needed for any incidents, such as failures or non-performance of ESC measures and legal non-compliance, and under the following circumstances:

- When inspection of environmental protection measures on site reveals that the measures have not been correctly installed or maintained;
- When site inspections or monitoring is undertaken that indicate expected ESC performance levels are not being achieved (refer to the ESCMP);
- When negative environmental outcomes are investigated;
- After analysing circumstances leading to an incident, emergency or "near miss".

Preventative action involves identifying any potential problems before they occur in order to minimise the potential of an occurrence.

If a non-compliance involving a discharge occurs, an 'Opportunity for Improvement' form shall be completed detailing the environmental incident, and corrective actions shall be identified and implemented.

The Opportunity for Improvement will contain the corrective actions required to be completed by the on-site personnel to:

- eliminate;
- isolate;
- minimise;
- improve;
- remove; or any combination of the above.

A timeframe will be given for completion. Upon completion of the corrective action, the relevant personnel shall notify the Environmental Manager of the action taken, at which time the Environmental Incident will be updated and closed out if appropriate.

9 Changes and Updates to the ESCP and Supporting Documents

The ESCP and supporting documents will be reviewed on receipt of the finalised resource consent conditions and updated as may be necessary to be consistent with those conditions. Once construction of the Project has commenced, the ESCP and supporting documents will be reviewed annually, in the month of August, throughout the construction period.

The annual review of the ESCP and supporting documents will be undertaken by the Environmental Manager in consultation with the Construction Team to ensure that all compliance requirements are being met as set out. This review may be a one off or additional reviews may be undertaken to ensure the documents are current and relevant to all activities been undertaken.

Any relevant or required significant revisions to the ESCP and supporting documents will be submitted to the Council's for review and certification at least 10 working days before becoming operational.

As part of continuous improvement, changes to the ESCP and supporting documents may be appropriate during the course of the Project. These changes may be a result of:

- Any significant changes to construction activities or methods;
- Site personnel comments;
- Audit findings and recommendations;
- Environmental monitoring records;
- Environmental complaints, incidents and emergencies;
- Details of corrective and preventative actions;
- Environmental non-compliances;
- Changes to organisational structure;
- On-going compliance with objectives, conditions and targets; and
- Possible changes in legislation and standards.

Any reasons for making changes to the ESCP and supporting documents will be documented. A copy of the original ESCP and supporting documents and subsequent versions will be kept for the Project records and maintained on site, and all documents superseded marked as obsolete. Each new / updated version of the documentation will be issued with a version number and dated to eliminate obsolete versions being inadvertently used.

10 Supporting Documents

10.1 Chemical Treatment Management Plan

Refer to the CTMP in **Appendix 4.3.3.1.**

10.2 Erosion and Sediment Control Monitoring Plan

Refer to the ESCMP in **Appendix 4.3.3.2**.

10.3 Dewatering Management Procedure

Refer to the Dewatering Procedures in **Appendix 4.3.3.3**.

10.4 Emergency Spill Response Procedure

The Emergency Spill Response Procedures contains the procedures to be followed in the event of a spill of any kind of contaminant including flocculant and is attached in **Appendix 4.3.3.4.**

10.5 Stream Works Procedure

Refer to the Stream Works Procedures for construction processes and procedures for undertaking works in and around streams (attached in **Appendix 4.3.3.5**).

10.6 Hazardous Substances Procedure

The Hazardous Substances Procedure attached in **Appendix 4.3.3.6** contains the procedures to be followed in order to appropriately manage the use of hazardous substances on site.

10.7 Minor Changes to Management Plan Register

Refer to an example of a Minor Changes to Management Plan Register in **Appendix 4.3.3.7**.

Appendix 4.3.3.1 – Chemical Treatment Management Plan

Ōtaki to North of Levin (Ō2NL) Project

Appendix 4.3.3.1: Chemical Treatment Management Plan

Table of Contents

Appendices

1 Introduction

1.1 Purpose and Scope

This Chemical Treatment Management Plan (CTMP) applies to the construction of Ōtaki to North of Levin (Ō2NL) Project.

The CTMP sets out the methodology for determining the effectiveness and dosing rates for chemical treatment to enhance the sediment retention efficiency of sediment retention ponds (SRPs), decanting earth bunds (DEBs) and other water impoundment devices such as treatment tanks that will be used throughout the Project.

The CTMP shall be implemented for the duration of the construction of the Project. It will support the overall erosion and sediment control (ESC) principles and methods described in the Erosion and Sediment Control Plan (ESCP) and will inform the development of site-specific erosion and sediment control plans (SSESCPs).

1.2 Implementation and Operation

Table 4.3.3.1.1 details the roles and responsibilities that will apply to the implementation and management of the chemical treatment systems across the Project.

Table 4.3.3.1.1 CTMP - roles and responsibilities

Name	Role	Contact details	Responsibility
	Project Construction Manager		Overall project responsibility
	Civil Construction Manager		Includes responsibility for earthworks
	Structures Manager		Responsible for structures
	Earthworks Manager		
	Production Manager		
	Environmental Manager		Overall responsibility for Environmental Management and Performance
	Environmental Technical Specialist		Suitable qualified and experienced erosion and sediment control specialist who prepares the erosion and sediment control plans and audits their implementation
	Environmental Supervisor		

2 Methodology

In accordance with industry best practice, it is proposed to chemically dose the SRPs, DEBs and impoundment containers in accordance with the CTMP to maximise sediment retention.

Soil sampling and bench testing (laboratory testing of chemical responses), and the management of the chemical treatment systems will be undertaken in accordance with Appendix F1 and Section F2.0 of Erosion and Sediment Control Guide for Land Disturbing Activities in the Wellington Region (The Guidelines).

Ongoing sampling will also be required as the earthworks progress. In this regard protocols have been established and are set out in Section 5.

Any sampling and bench testing of sub-soils (below topsoil) that is necessary will be taken from the contributing catchment of sediment controls devices to determine the optimum chemical response and dosing rate, balanced within an acceptable pH range.

Ongoing sampling will also be required as the earthworks progress.

Bench tests of soil samples will be undertaken using:

1. Poly Aluminium Chloride (PAC).
2. Superfloc. Superfloc is a blend of PAC and PolyDADMAC.

The recommended chemical and dose rate will be that which achieves the best settlement rate within the acceptable pH range of 5.5 to 8.5 and will not change the baseline pH beyond +/-1.

3 Implementation

A SSESCP will be prepared for each works area. Those SSESCPs will identify and provide the sizing calculations and drawings for all ESC measures to be implemented in the corresponding area. Once a SSESCP has been certified by Greater Wellington Regional Council and Horizons Regional Council (the Councils), the ESC measures will be constructed in that works area.

Confirmation of the recommended chemical, dose rates, roof tray sizes and header tank outlet spacings for each device will be submitted to the Councils with the as-built certification of the devices and Appendix 4.3.3.1.C of this CTMP will be updated with the recommended dose rates for that SSESCP area.

4 Flocculation System

4.1 Rainfall Activated Dosing System

The rainfall activated dosing system has been developed specifically for earthworks sites. The system uses a rainfall catchment tray to capture rainfall with the size of the tray being determined by the required chemical dose and the land catchment size.

Rainwater caught by the catchment tray is piped into a header tank, and then into a displacement tank which floats in a larger tank containing the flocculant filled to the level of an outlet pipe leading to the sediment laden diversion about 10m upstream of the inlet of the sediment control device. The greater the rate of rainwater flow into the displacement tank the greater the flow of flocculant into the sediment laden runoff channel. The header tank is designed to provide for no dosing during the initial rainfall of up to 12mm of rain under dry conditions to reflect the lag time between the onset of rainfall and the arrival of runoff at the device. The dual outlet of the header tank outlet also attenuates chemical flow during the initial stages of a storm and after rain has ceased at the end of a storm.

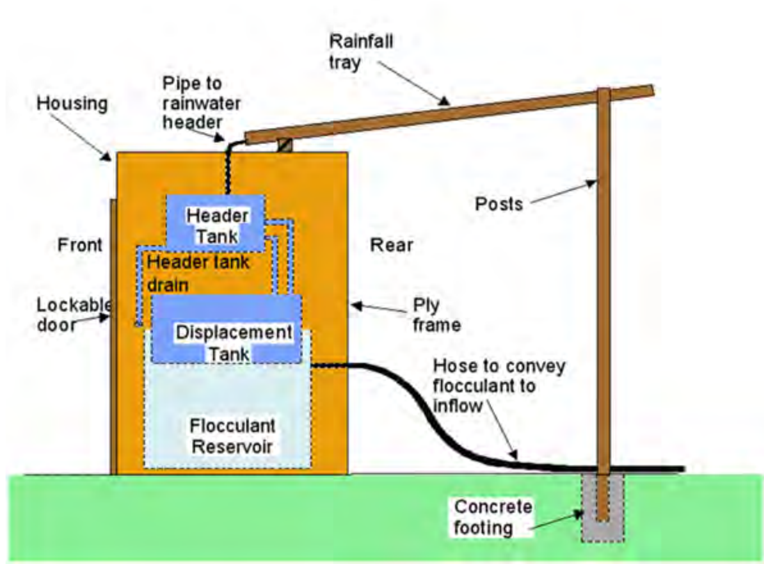


Figure 4.3.3.1.1: Traditional floc shed schematic.

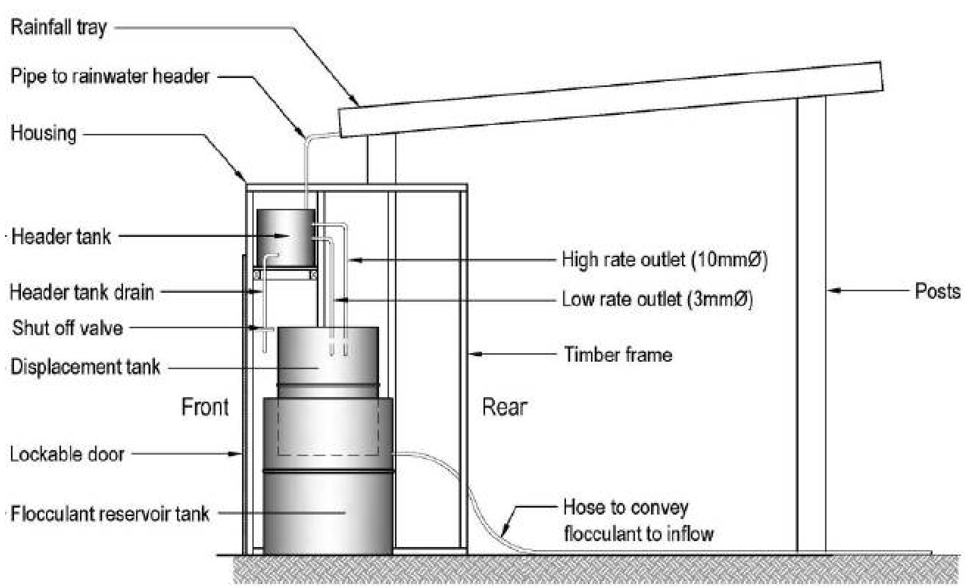


Figure 4.3.3.1.2: Components of the floc shed.

A mini Floc Shed (Figure 4.3.3.1.3) or Floc Box (Figure 4.3.3.1.4) are well suited for DEBs with catchment areas less than 3,000m^2 and are set up in a similar way to the traditional floc shed outlined above.

Figure 4.3.3.1.3 : Mini floc shed

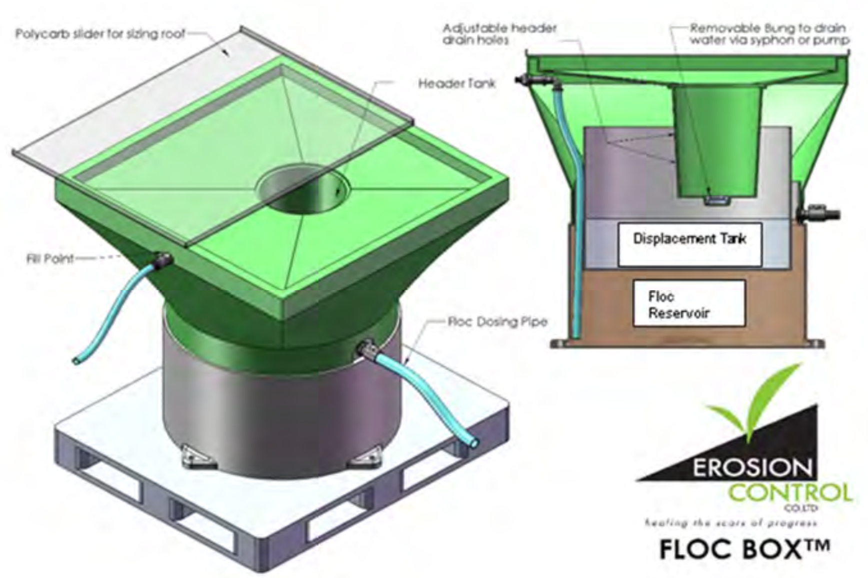


Figure 4.3.3.1.4: Floc box

4.1.1 Area of rainwater catchment tray required for rainfall activated system

The area of the rainwater catchment tray is determined by the dose required, and the area of the earthwork catchment draining to the sediment control device.

The rainwater catchment tray size is determined by the total land catchment area draining to the sediment control device including both the ‘open’ area and stable areas. If the catchment area is changed, then the catchment tray size should also be changed in proportion. Reduction of the tray size is easily achieved by placing a piece of plywood on top of the upstand over the lower end of the tray, thereby allowing the rain which falls on the plywood to run to waste. Floc boxes include a sliding lid that adjusts the catchment tray size in a similar way.

The required tray size will be calculated and submitted with the as-built certifications associated with each SSESCP and included in Appendix 4.3.3.1.C to this CTMP.

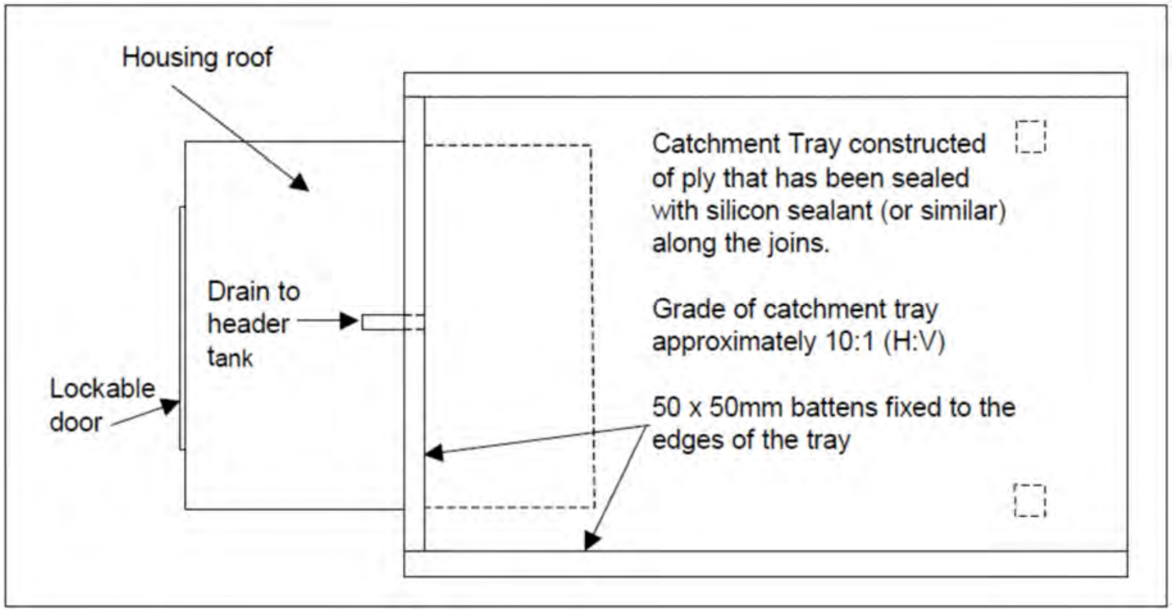


Figure 4.3.3.1.5 Roof tray design.

4.1.2 Header Tank Outlet Spacing

Rainfall from the catchment tray is drained into a header tank which has two outlets offset vertically. This provides a storage capacity that avoids dosing during initial rainfall following a dry period and to attenuate dosing at the beginning and end of a rainstorm event.

The volume between the drain (lowest) header tank outlet and the first dosing outlet is equal to the volume of 12mm of rain on the catchment tray and the volume between the first and second dosing outlets is the same.

The required header tank outlet spacing details will be calculated and submitted with the as-built certifications associated with each SSESCPs and included in Appendix 4.3.3.1.C to this CTMP.

Header Tank Management in summer months will be as per the Guidelines, which requires:

- After 3 days without rain – reduce volume by 50%.
- After 6 days without rain – empty completely.

4.1.3 Sediment Laden Runoff Channel and Dosing Point for Rainfall Activated System

The chosen chemical needs to be added to the sediment laden runoff channel to provide mixing with the sediment laden runoff before it reaches the area of ponded water in the forebay or the sediment control device itself.

All sediment laden runoff from the catchment should be combined into a single channel if possible before it reaches the chemical dosing point. To maximise mixing, the dosing point should be located at least 10 metres prior to the point where the runoff reaches the inlet of the device (in the case of a SRP, the inlet of the forebay).

The dosing point should be at a location where the chemical will fall into the sediment laden flow during periods of low flow. The end of the dosing tube should be only a few centimetres above the diversion channel to ensure that the chemical falls into the sediment laden runoff and is not blown away during periods of strong wind.

4.2 Batch Dose Treatment

Batch dosing is largely undertaken as a reactive measure to treat impounded runoff that has not been treated to the correct standard. Batch dosing is achieved by adding liquid reagent to the surface of impounded runoff to increase the rate of settlement to achieve the required standard of discharge.

Batch dosing may be undertaken as a contingency measure in devices that have been treated by a rainfall activated system. Batch dosing can be utilised during dewatering / pumping processes (refer to the Dewatering Management Procedure for specific details, Appendix 4.3.3.3 of the ESCP).

The criterion to establish the need for batch dosing is the clarity of the sediment laden runoff. Clarity will be measured by either of the following two techniques:

- Secchi Disc
  - A 50-80mm diameter disc is attached to a 1m long stick with a centimetre scale starting at the disc is lowered vertically into the water to be tested until it disappears, and then is raised until it just reappears. The depth of reappearance is recorded as the clarity of the water.
- Clarity Tube
  - A clarity tube containing a magnetic back disc will be filled with water from the device. The tube will be laid horizontal and the disc will be moved down the tube until it disappears, when viewed from the end of the tube and the distance is recorded. The disc is then moved back until it reappears, and the distance is recorded.
  - Readings should be taken in diffuse sunlight or shade. If it is impossible to avoid bright sunlight, work with the tube perpendicular to the sun's plane.
  - Readings will not be taken in very low light conditions (insufficient for colour perception).

Water with a clarity of 100mm or greater is considered to be acceptable for discharge. Water with a depth of clarity of less than 60mm should be batch dosed. If the sediment laden runoff has clarity between 60-100mm after rainfall has ceased, it should be left for 48 hours to settle. If the clarity has not reached 100mm after 48 hours, or if sediment laden runoff has to be discharged within 48 hours because the pond is full, the sediment laden runoff should be batch treated.

The batch dose rate will be based on the specific bench testing for that area and calculated against the volume of the device to be treated. The batch dose rates will be provided in Appendix 4.3.31.C of this CTMP.

4.2.1 Application Procedure for Batch Dosing

The chemical dose should be applied evenly over the surface of the sediment control device as quickly as practicable. It is best to apply the dose in one application, rather than going over the surface of the water two or more times.

The total dose may be applied in one of two ways.

a) Spray
The chemical can be applied to the surface of the pond using a sprayer that produces large drops.

b) Bucket
Place no more than 1 litre of chemical in a 10-litre bucket and throw the chemical onto the pond surface so that the chemical divides into drops before hitting the surface.

Settlement generally requires 1-2 hours.

4.2.2 Timing

As impounded water often develops marked temperature gradients during the day, which can inhibit mixing of the chemical that is added to the surface of the impounded water and the settlement of coagulated solids, batch treatment should be carried out in the early morning to optimise mixing of the chemical with the sediment laden runoff and the subsequent settlement of coagulated solids.

5 Determination of Dose Rate

Bench testing will be undertaken to determine the preferred chemical treatment system and optimum dose for suspended solids removal. The bench testing will also consider the effects on pH of the treated water for the sediment retention devices.

Bench testing will be undertaken as an ongoing and continual process throughout the life of the Project (refer to Section 3 of this CTMP "Implementation"). Ongoing monitoring will also be undertaken of the site's sediment retention devices as outlined in Appendix 4.3.3.1.B to this CTMP. If the monitoring highlights any deficiencies further bench testing will be undertaken. All bench testing results will be recorded in the Bench Testing Result Sheets in Appendix 4.3.3.1.C to this CTMP.

6 Monitoring and Maintenance Requirements

6.1 Routine Management and Maintenance

Instructions for routine management and maintenance of the chemical treatment system are provided in Appendix 4.3.3.1.A to this CTMP. A copy of this table will be kept onsite and will be available for review.

All monitoring records and maintenance checks and actions will be recorded on the monthly record sheet provided in Appendix 4.3.3.1.B to this CTMP. The systems will be checked after each rainfall event, and during dry periods the systems will be checked weekly.

It is also noted that chemical treatment increases the sediment removal efficiency of the sediment controls. The sediment controls will need to be regularly desilted to ensure that the maximum volume is re-established after rain events.

6.2 Contingency Management

Contingencies could include poor performance of the treatment system, or effects of other influences on sediment laden runoff quality, such as reduced pH, that might make the use of chemicals inappropriate.

If the treated water in the sediment control device is consistently very clear it could indicate overdosing, and the possibility of lowered pH which can present a risk to receiving waters as a result of elevated free aluminium concentration in the discharge. If the treated water is consistently clear the pH of the water in the sediment control device will be tested.

Contingencies such as poor treatment performance or consistently very clear treated water should be dealt with as part of the day to day environmental management of the site. Refer to the ESCMP (Appendix 4.3.3.2) for additional monitoring and maintenance procedures that are to be implemented across the Project.

A treatment chemical spill contingency procedure is provided in Section 6.6 below.

6.3 Record Keeping and Reporting

A copy of the maintenance record for the chemical treatment system will be kept on site (Appendix 4.3.3.1.B to this CTMP).

A copy of the maintenance record for the chemical treatment system will be provided to Horizons on request.

6.4 Procedure for Chemical Transportation

The use of flocculants will be in accordance with the "Construction Health and Safety Plan" and Hazardous Substances Procedure.[1]

PAC and Superfloc will be delivered to the site by commercial carriers in accordance with current Hazardous Substances and New Organisms Act 1996, and Ministry of Transport, Transporting Dangerous Goods Safety, An Industry Guide.[2] These chemicals can be requested from the supplier generally in 20 litre containers, 200 litre drums and/or 1,000 litre IBCs. PAC and Superfloc all weigh about 250kg and are most easily moved within the site in a loader bucket. Transport around the site will be via suitable vehicles or machinery and containers will be sealed and secured such that the containers cannot topple over.

6.5 Storage of Chemicals on Site

Chemicals will be stored in accordance with the Hazardous Substances Procedure (Appendix 4.3.3.6 to the ESCP). Bulk PAC and Superfloc supplies will be held in secure storage. 200L polyethylene drums or IBCs of PAC and Superfloc will be held beside each chemical treatment shed / floc box, on level ground and secured so that the container cannot topple over. Those drums will be under the overall security and control of the site as a secure workplace. Drums of chemical will always be stored on end with the screw caps uppermost. Topping up of flocculant chemical will be made weekly as part of the regular inspection regime.

6.6 Chemical Spill Contingency Procedure

Spills will be manged in accordance with the Emergency Spill Response Procedure (Appendix 4.3.3.4 to the ESCP).

If there is a spill of PAC or Superfloc onto the ground it should be immediately contained using earth bunds to prevent it entering water. The spilt chemical should be recovered if possible and placed in polyethylene containers. If the spilt chemical cannot be recovered, it should be mixed with a volume of soil equal to at least ten times the volume of spilt chemical. This will effectively neutralize the chemical.

---

[1] For further information, refer to the Hazardous Substances Procedure, Appendix 4.3.3.6 to the ESCP

[2] For further information, refer to Hazardous Substances and New Organisms Act 1996 (reprinted 2017), and https://www.transport.govt.nz/assets/Import/Documents/ca67c03328/Transporting20Dangerous20Goods.pdf

The soil with which the chemical has been mixed should be buried in the ground a minimum of 0.5 metres below the surface.

If there is a spill of chemical into ponded water, discharge from the pond to natural water should be prevented.

If there is any spill into flowing water:

1. The Council's should be advised immediately.
2. The volume of the spill should be recorded.
3. If possible, the water and spilt chemical should be pumped into a bund or sediment control device until all the spilt chemical has been removed from the watercourse.
4. If the chemical cannot be removed from the watercourse any downstream users should be identified and advised.

6.7 Chain of Responsibility for Monitoring and Maintenance

The Environmental Manager and the Environmental Technical Specialist will have overall responsibility for chemical treatment systems.

The ESC Foremen and ESC Labourer(s) will check the effect of PAC and Superfloc dosing on the pH of the treated water once the pond has filled for the first time and monitor pH and overall performance throughout the duration of works.

6.8 Training of Person Responsible for Maintenance and Monitoring

If a person with experience in the monitoring and maintenance of the chemical treatment system is not available, the Environmental Manager will train a person nominated by the Project team to carry out the routine monitoring and maintenance of the chemical treatment system, and to keep the required records. This person's contact details will be provided to Horizons.

6.9 Procedure Modification

It is expected that as the Project progresses, performance checks of the chemical treatment systems may be required due to changing soil types etc. This will be undertaken following additional sampling and testing and approval from the Environmental Manager.

Appendix 4.3.3.1.A - Instructions for Maintenance of Rainfall Activated Treatment Systems

Reducing the Header Tank Water Volume

The header tank is used to avoid dosing during the initial stages of rainfall when site conditions are dry, and no runoff is to be expected.

The volume in the header tank is lowered using the lowest of the three outlet tubes.

- After 3 days without rain - reduce volume to 50%.
- After 6 days without rain - reduce volume to empty (level at lowest outlet).

Refilling the Chemical Reservoir

The chemical reservoir tank should be refilled when the white displacement tank is half full, or sooner if heavy rain is predicted. This is done by first emptying the white tank (baling with a bucket is efficient), and then refilling the black reservoir tank until the PAC or Superfloc level is at the lower edge of the outlet.

Observation of Water Quality in Sediment Control Device

The pond water quality will be observed at least weekly, and the clarity determined using a black disc and recorded on the monitoring sheet. pH shall be recorded once the pond has filled up to ensure that chemical dosing does not have an unacceptable effect.

Periodic System Checks

Check that the rainfall catchment tray is not leaking – especially along the lower edge of the tray. This should be done after rainfall has ceased.

Check the lower hose with the small tube outlet, from the header tank to the displacement tank, is not blocked.

Monitoring Records

A separate sheet is provided for monitoring records for each month (see Appendix 4.3.3.1.C to this CTMP). The information to be recorded is as follows:

Visual check - Check the tray for leaks, the plumbing, and the hoses from the header tank. Record 'ok' or if maintenance is required write 'M' and note requirement in Notes column.

How full is the header tank (%)? This is the volume between the lowest and middle outlets. After rain this should be either 100% after 12mm or more rain, or between 0-100% after less than 12mm rain. In summer: 50% when lowered after 3 dry days; 0% when emptied after 6 dry days.

Depth in Displacement Tank (%) - Measure depth of water in cm. Reduces to 0 when emptied.

Chemical volume added - Record the PAC or Superfloc volume added. 1 drum = 200L, 9cm in the 200L drum = 20L. The volume can also be calculated from change in water level in displacement tank where 1cm change = 4 litres of chemical.

Water Clarity - Record using black disc near device outlet. (Refer above).

Appendix 4.3.3.1.B – Chemical Treatment Monitoring and Maintenance Record

Site:

Sediment Control Device Name: Month: Maintenance Person:

Date	Visual Check	% Header Tank Full	Water depth in Displacement Tank (cm)	Chemical Volume Added	Water Clarity (cm)	pH	Notes on maintenance required or additional information	Rainfall (mm)	Initial
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									

Appendix 4.3.3.1.C – Bench Testing Results Sheets

1 Introduction

Soil samples were taken from the contributing catchments of (insert description of devices and catchment).

These two chemicals were tested: (delete any chemical that was not tested)

1. **Poly Aluminium Chloride (PAC)**
2. **Superfloc**

Superfloc is a blend of PAC and PolyDADMAC.

Bench test flocculation trials were undertaken to determine soil reactivity to chemical treatment in accordance with the Erosion and Sediment Control Guide for Land Disturbing Activities in the Wellington Region.

2 Bench Test Trials

2.1 Results of PAC Bench Test

Initially, bench tests using PAC. The results of the bench tests are as follows.

Sample 1, Catchment 1 Initial pH = Initial Turbidity =

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0					
2					
4					
6					
8					
10					

Sample 2, Catchment 1 Initial pH = Initial Turbidity =

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0					
2					
4					
6					
8					
10					

2.2 Results of Superfloc Bench Tests

Bench tests were also undertaken using Superfloc. The results of the bench tests are as follows.

Sample 1, Catchment 1 Initial pH = Initial Turbidity =

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0					
1.6					
3.2					
4.8					
6.4					

Sample 2, Catchment 1 Initial pH = Initial Turbidity =

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0					
1.6					
3.2					
4.8					
6.4					

3 Discussion

Insert discussion and conclusion based on the bench testing results.

Include recommendation / chemical to be used and dose rate

3.1 Batch Dose Rate

Insert batch dose rate and requirements

3.2 Rainfall Activated Dosing System Details

Floc Shed Tray Size

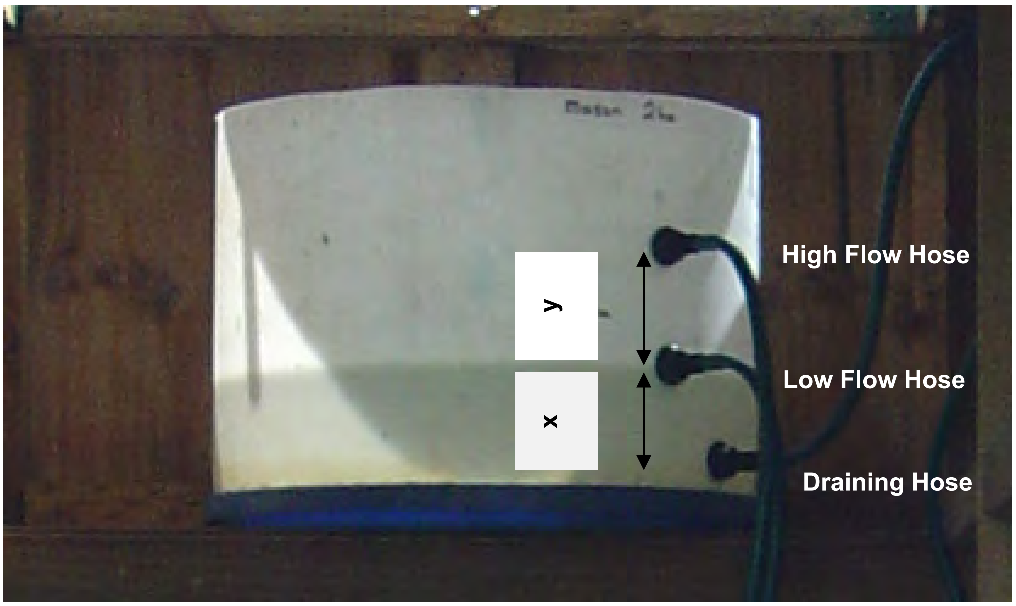
Based on the bench test results displayed in Section 2 undertaken on [insert date of testing] the required tray size is XXX square metres per hectare of exposed land catchment draining to the sediment control device. This is the area inside the upstand around the edge of the tray.

Sediment Retention Device	Catchment area (ha)	Tray Size (m^2)
XX	X	X
XX	X	X

Header Tank Outlet Spacing

The distance between the drain and first dosing outlet, and between the two dosing outlets, for a standard header tank made from a 200-litre drum with an internal diameter of 55 cm would be:

Sediment Retention Device	Catchment Area (ha)	Distance (x) (cm)	Distance (y) (cm)
XX	XX	X	X
XX	XX	X	X



Appendix 4.3.3.2 – Erosion and Sediment Control Monitoring Plan

Ōtaki to North of Levin (Ō2NL) Project

Appendix 4.3.3.2: Erosion and Sediment Control Monitoring Plan

Table of Contents

1 Introduction

The purpose of this Erosion and Sediment Control Monitoring Plan (ESCMP) is to detail the erosion and sediment control (ESC) management and monitoring system that will be implemented for the duration of the earthworks period of Ōtaki to North of Levin (the Project). The ESCMP includes details of process and procedures that will be followed and confirms how the ESC management and monitoring will be undertaken and the methods used in the context of the Project to ensure that effects and performances are managed appropriately.

This ESCMP has been written to detail how we propose to manage and monitor ESC measures during construction, to ensure management of performance of the Project's ESC measures and to provide rapid and real time information and control to the Project team.

The ongoing monitoring and reporting that is proposed in this ESCMP, creates a continuous feedback loop of the performance of the Project's ESC site and device management. This ESCMP provides the approaches to be followed in regard to ESC maintenance, monitoring and reporting and will be reviewed on receipt of the finalised consent conditions and updated as may be necessary to be consistent with those conditions.

This document will be reviewed on an annual basis.

The ESCMP covers:

- Site management structures, practices and procedures.
- Weather Monitoring.
    - Prior to commencement of construction works two automated weather stations will be installed onsite.
- Erosion and Sediment Control Monitoring
    - Scheduled site visits, pre and post rain event monitoring and water sampling.
    - Chemical treatment will be monitored in accordance with the Project's Chemical Treatment Management Plan (Appendix 4.3.3.1 to the Erosion and Sediment Control Plan (ESCP)).
- Reporting
    - Rainfall trigger event summary following a rainfall trigger event
    - Recommendations of changes that need to be implemented on site and modifications to any ESC devices or practices will also be included.
- Annual Reporting
    - A Monitoring and Maintenance annual report will be completed and issued to Greater Wellington Regional Council and Horizons Regional Council (Councils) and iwi partners by the end of June after the completion of each earthworks season. This report will contain all the monitoring results and interpretation of the fluctuations and observations recorded over the previous year, as well as any changes or modifications that are proposed to this ESCMP.

1.1 Site Specific Erosion and Sediment Control Implementation

The construction of all erosion and sediment controls will be managed as follows:

- The Environmental Technical Specialist will prepare a Site-Specific Erosion and Sediment Control Plan (SSESCP) in conjunction with the relevant construction zone Project Engineer, Site Engineer and the Environmental and Site Supervisor's.
- The SSESCP will be approved by the Environmental Manager and then submitted to Councils for certification against the Guidelines and the consent conditions.
- Once certified, the Environmental Manager will issue an approved SSESCP to the appropriate earthworks zone Site Supervisor responsible for implementation.
- A pre-construction meeting will be held by the Environmental Management Team where the sediment controls to be built will be discussed and specific direction given on construction.
- The location of the controls and requirements of the relevant SSESCP will be confirmed on site with the construction team and the Environmental Management Team.
- The construction of the controls will be overseen by the Site Supervisors and members of the Environmental Management Team.
- Hold points for construction will be established for each control whereby the Environmental Management Team will inspect the work completed, for example the installation of anti-seep collars or the installation of primary outlet.
- Each control will be 'as built' certified by the Environmental Management Team to confirm compliance with the SSESCP prior to bulk earthworks commencing in the catchment of the device(s).
- Copies of the 'as-built' certifications will be submitted to Council's.

1.2 Erosion and Sediment Control Inspections

The Environmental Manager and / or Environmental Supervisor will conduct routine (minimum weekly) inspections of the site. These inspections will take place with adequate time allocated and will be thorough and systematic. Members of the construction team including the relevant zone's Project Engineer and/or Site Engineer and/or /Site Supervisor, will accompany the Environmental Manager or Environmental Supervisor on these inspections so that the Environmental Manager or Environmental Supervisor can better understand the work occurring at that time and that programmed to take place. It is also useful for the Project Engineers to be reminded of their ESC obligations and for both parties to recognise good performance and outcomes, and where performance has not been to the standard expected or required by consents and the Guidelines. This is particularly relevant in identifying how communication between personnel can be improved to avoid a recurrence of an issue.

Communication is critical to the successful implementation of SSESCPs. Internal inspections will cover all areas of the Project, even those that may have been dormant for some time, to ensure that the controls are still operating properly. These internal inspections will be captured in writing and will include actions and timeframes for close out.

1.3 Weather Monitoring

1.3.1 Rain Forecast

Rain forecasts relevant to the site will be checked daily using the MetService / MetVuw online forecasting systems. Close monitoring of the rain forecast will be necessary to ensure the appropriate site works can be implemented prior to rainfall trigger events.

The daily weather forecast checks will be forwarded to all Project Engineers, Site Engineers and Site Supervisors every morning and will be recorded in the daily prestart job sheets.

If the forecasts show more than 20mm of rainfall over a 24-hour period, then this will trigger the pre-rain event environmental team inspections as outlined in section 3.2 of this ESCMP (pre-rain event with forecast >20mm over 24 hours). This is in addition to the routine pre-rain event inspections undertaken by Site Engineers and Site Supervisors as detailed in section 3.1 of this ESCMP below. Note the pre-rain forecast trigger of >20mm over 24 hours is less than the rainfall trigger monitoring.

1.3.2 Rain Gauges

A minimum of two telemetered rainfall monitoring stations will be installed on site to provide real-time continuous rainfall intensity and volume data which will be able to be observed online by Project personnel. Email and/or text notifications will be programmed to ensure relevant staff, including the Environmental Management Team, are alerted when rainfall trigger events occur onsite.

1.4 Erosion and Sediment Control Device Monitoring

1.4.1 Site inspections

Routine inspections are undertaken during and post instalment of ESC devices. During construction certain stages are identified for inspection, such as during the installation of anti-seep collars, level spreaders, and T-bars.

Construction monitoring is undertaken once a sediment retention ponds ("**SRP**") or decanting earth bunds ("**DEB**") is operational, and the rainfall activated chemical treatment system is operational for the first time. Monitoring will take place as soon as practicable following the first rainfall event that generates a discharge. This is to assess the performance of the device and chemical treatment system and the resulting quality of treated water being discharged from the site.

The site will be inspected weekly as a minimum by the Environmental Manager and/or Environmental Supervisor and/or Environmental (ESC) Technical Specialist during the course of the works. These inspections will ensure that all ESC devices are installed correctly and then operate effectively throughout the duration of the works. This inspection programme will provide certainty to all parties that appropriate measures are being undertaken to ensure compliance with conditions of consent and the SSESCPs. The inspection regime will keep ESC management at the forefront of works on site. Any potential problems will be identified immediately, and remedial works will be promptly carried out.

The inspection programme shall consist of:

- **Weekly** site walkovers involving the Environmental Management Team to inspect all ESC measures, identify any maintenance or corrective actions necessary, assign timeframes for completion, and identify any devices that are not performing as anticipated through the SSESCP.
- **Pre-rain event:** Prior to all forecast rainfall events, additional inspections will be made of ESC devices, including chemical treatment systems and automated monitoring devices, to ensure that they are fully functioning in preparation for the forecast event. These will be undertaken by the Site Engineers and Site Supervisors.
- **Pre-rain event with forecast > 20mm over 24 hours:** Prior to forecast rainfall "trigger" events the site will be inspected by the Environmental Management Team (in addition to the business as usual pre-rain inspections undertaken by the Site Engineers and Site Supervisors). The aim of the inspection will be targeted at any additional ESC measures that are required to be installed to ensure that the site's ESC management system performs effectively during an expected larger event.
- **Rainfall Trigger Inspections**: In addition to the general post rainfall event monitoring, during or immediately after rainfall trigger events (subject to health and safety restrictions) inspections will be made of the SRPs and DEBs with catchments prioritised as per Section 1.4.2. Clarity of the water within the device adjacent to the decant outlet will be measured using either a clarity tube or secchi disc indicator. Manual pH testing of the outlet flows undertaken along with

a general inspection of the sediment control devices. The purpose of these inspections is to confirm the performance of devices under the stress of heavy rainfall.

The rainfall trigger alerts will be generated via the on-site rainfall gauge and will be linked to the mobile phones of the Environmental Management and Construction Teams.

The key rainfall event triggers driving specific device monitoring are as follows:

- >50mm rainfall over any 24-hour period
- >15mm rainfall within an hour

1.4.2 Risk Based Monitoring During Rainfall Triggers

Rainfall triggered monitoring will be prioritised in the following catchments.

- Catchment B (Waitohu),
- Catchment C (Waitohu),
- Catchment I (Mangahuia).
- Catchment M (Ohau River),
- Catchment J (Waikawa),
- Catchment L (Kuku Stream)
- Catchment F (Manakau)

1.4.3 Clarity Monitoring

Manual clarity checks will be made at each SRP and DEB, using the following procedure:

Secchi disc

- A 50-80mm diameter disc is attached to a 1m long stick with a centimetre scale starting at the disc is lowered vertically into the water to be tested until it disappears, and then is raised until it just reappears. The depth of reappearance is recorded as the clarity of the water.

Clarity Tube

- A clarity tube including a magnetic back disc will be filled with water from the device. The tube will be laid horizontal and disc is moved down the tube until it disappears, and the distance is recorded. The disc is then moved back until it reappears, and the distance is recorded.
- Readings should be taken in diffuse sunlight or shade. If it is impossible to avoid bright sunlight, work with the tube perpendicular to the sun's plane.
- Readings will not be taken in very low light conditions (insufficient for colour perception)

1.4.4 pH Monitoring

pH will be recorded at each device receiving chemical treatment, using the following procedure:

1. Ensure that the pH meter has been calibrated and that the calibration has not expired.
2. Use the pond water (or water that is to be discharged) to rinse out a small container then half fill with water from the same source.
3. Immerse the pH meter in the water and leave for up to 1 minute or until the reading stabilises and doesn't change. Place the container in a shaded place (out of direct sunlight) while it stabilises.
4. Record the pH reading given on the meter along with the date, time, and source of the water (e.g. SRP 4).

1.4.5 Threshold Triggers

Where the clarity of a device is less than 100mm, the following actions shall be undertaken.

- Within 24hrs of a threshold exceedance, a full audit of the condition of the control device and its contributing catchment will be carried out and recorded in writing.
- 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).

In consultation with Councils, implement alterations to erosion and sediment control measures and methodologies.

2 Management Responses

In addition to the threshold trigger exceedance responses detailed above, if one of the following cases occur, additional management responses will be triggered as outlined below. In some instances, responses may need to be discussed and agreed with Council's to ensure the most appropriate outcomes are achieved.

i. A failure of a perimeter control that has resulted in visible discharge of sediment to a stream.
ii. A failure of a SRP or DEB that has resulted in a visible discharge of sediment to a stream.
iii. Slumping / mass movement or erosion associated with the works, but which is outside the catchment of a sediment control device or has resulted in a device being over-topped by sediment, where that sediment has discharged to a stream.

- Remedy the failure or event to prevent further uncontrolled discharges.
- Implement the Event Based ecology and water quality monitoring

3 Reporting

3.1 Site Auditing

Daily inspections will be undertaken by the ESC Foremen.

An internal audit will be undertaken by the Environmental Manager and / or Environmental (ESC) Technical Specialist weekly at a minimum. Any maintenance actions will be undertaken that day where practical.

Actions will be loaded into the Environmental Management system and Work Instructions with details and timeframes will be issued by the Environmental Supervisor to the relevant ESC Foreman, with specific actions and closeout timeframes. The ESC Foreman will report completion of those actions and the Environmental Supervisor will inspect the works and close-out the items in the management system.

For programmed Council inspections, a member of the Environmental Management Team will accompany the Council inspector in all audits. Usually a member of the Construction Team will also be present.

As for internal audits, all ESC maintenance actions identified by the Council inspector will be recorded into the Project Environmental Management system. Work Instructions, with details and timeframes, will be issued to the ESC Foreman by the Environmental Supervisor, based on the Council's instructions. The ESC Foreman will report back the completion of those actions to the Environmental Supervisor who will inspect the works and confirm that those actions have been completed. Confirmation will be emailed to the Council inspector.

3.2 Rainfall Trigger Event Reporting

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. The summary will include:

- Rainfall (total and intensity)
- A summary of the manual monitoring undertaken;
- Identification if a threshold exceedance occurred. This will outline what exceedance occurred, the extent of the exceedance, any actions taken to mitigate the effects of the event and a proposed management response if required.
- A record of any other matters which may have compromised the overall ESC performance during the rain event and the identified mitigation, maintenance and management response.

3.3 Annual Report

An annual report containing monitoring results and an assessment of discharge compliance will be provided to Councils within the month of August of each year. This report will contain the following details.

- A summary of the results of all monitoring within that period.
- A summary of any threshold exceedances that occurred and the response actioned.
- Any proposed changes or updates to the ESCMP are to be discussed with Councils. Written certification from Councils must be provided if any significant changes to the ESCMP are made.

Appendix 4.3.3.3 - Dewatering Management Procedure

Project Name:	**Ōtaki to North of Levin**
Procedure:	Appendix 4.3.3.3: Dewatering Management Procedure

1 Application

This Dewatering Management Procedure forms a part of the Erosion and Sediment Control Plan (ESCP) for Ōtaki to North of Levin (the Project). The proposed construction works on the Project will include piling, earthworks and streamworks operations that require dewatering by pumping.

The purpose of this Procedure is to ensure that the required level of sediment treatment on site is achieved during these operations.

2 Scope of works

The construction activities of the Project include the following:

- Ground improvements;
- Excavations;
- Bridge construction and culvert installations (inside & outside highly sensitive ecological areas);
- Upgrading of existing road network.

3 Potential Environmental Effects

The key potential environmental aspects and impacts relating to dewatering are:

Aspects	Impacts
Very high sediment loads from construction water.	Overloading of sediment control devices, causing sediment to discharge direct to water.
Incorrect machinery being used.	Incorrect processes being followed onsite, causing sediment discharge to land where it may enter water, or direct to water, which may then cause damage to aquatic life and environment.

4 General Procedure

Sediment retention ponds (SRPs) and decanting earth bunds (DEBs) are to be constructed in accordance with Auckland Council Guideline Document No 5 *Erosion and Sediment Control Guide 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). The control devices will be chemically dosed with Polyaluminium Chloride (PAC) to improve the efficiency of the devices when receiving pumped water from dewatering operations.

There will be two procedures for dewatering excavations from the site. Each of these procedures has a specific methodology for ensuring that the sediment treatment achieved by the procedure is in accordance with the Guidelines requirements and industry best practice.

The two procedures are:

- Pumping directly from the excavation or stream diversion works to the receiving environment without any treatment.
- Pumping to a sediment control device where the flows will be stored, batch dosed with PAC, and then discharged to the receiving environment.

Any pumping will require a “permit to pump” to be signed by the Environmental Manager, prior to any works commencing (refer Appendix 4.3.3.3.A to this Procedure). This allows for a thorough and robust assessment of the activity and the risks associated.

All dewatering and pumping activities will be overseen by the Environmental Supervisor / an ESC Foreman.

4.1 Direct Pumping

This option is the least likely to be utilised in practice and relies on impounded water within an excavation having a greater clarity than 100mm at all times and the ability of the pump to be able to remove the impounded water without disturbing any sediment. This method is not to be used for dewatering depths of less than 500mm.

NOTE: when pumping from stream diversion works, while the stream is being de-fished, the pump must have a mesh screen of not more than 3mm to protect against fish from being sucked into the pump. The velocity at the screen must be less than $0.3m^3$/second.

The procedure for pumping directly to the receiving environment will be as follows:

- Dewatering and Pumping Record Sheet (Appendix 4.3.3.3.A to this Procedure) is to be completed and signed off.
- Prior to pumping the clarity of the impounded water is to be confirmed as being greater than 100mm and a pH within the range of 5.5-8.5.
- The inlet to the pump is to be supported no less than 500mm above the base of the excavation in a location and manner where the inlet will not disturb settled sediments within the excavation. Where possible a floatation device shall be installed on the pump inlet to ensure pumping down from the cleanest water.
- The outlet of the pump is to be located on a stabilised surface/area to prevent erosion. It is preferable to discharge the pump to a piped stormwater system.
- During pumping the clarity of the impounded water is to be checked and recorded every 15 minutes. If the clarity drops below 100mm pumping is to stop and an alternative pumping procedure used.

4.2 Batch Dosing

In this method impounded water shall be pumped to a SRP or DEB to be stored and batch dosed, with PAC. When the depth of clarity has increased to greater than 100mm and the pH has been checked and confirmed to be within the range of 5.5 – 8.5 then the stored water will be discharged via the decant of the DEB or SRP. Batch dosing will only be undertaken by a member of the erosion and sediment control team as described in Figure 4.3.3.2 of the ESCP.

The procedure for batch dosing is as follows:

- Dewatering and Pumping Record Sheet (Appendix 4.3.3.3.A to this Procedure) is to be completed and signed off.
- Pumping to a DEB or SRP that already has a contributing catchment should only occur if there is a minimum 24hrs of fine weather forecast.
- The outlet or dewatering device of the SRP or DEB to receive the pumped flows is to be capped or raised to prevent a discharge while water is being pumped to the device.

- The pumped water shall be discharged in a manner that minimises disturbance within the SRP or DEB and must be to the forebay or inlet of the device.
- Pumping may continue until complete or until the SRP or DEB has filled to the level of the primary spillway. Pumping is not to continue once this level has been reached.
- Once pumping is complete, the water clarity and pH is to be checked. If water clarity is greater than 100mm and pH is within the range 5.5-8.5, then the DEB can be allowed to discharge. If not, the volume of stored water is to be noted and the correct volume of Polyaluminium Chloride (PAC) added.
- The dose rate is determined by the Chemical Treatment Management Plan (Appendix 4.3.3.1 to the ESCP).
- The PAC is to be added to the surface of the SRP or DEB by spraying with a backpack sprayer with a 'stream' outlet rather than a 'mist'. PAC is to be sprayed evenly over the surface of the SRP or DEB. Ponded water can develop marked temperature gradients during the day through its depth which can inhibit mixing of PAC. It is therefore recommended that batch treatment be carried out, whenever possible, in the early morning. Refer to Section 4.2 of the CTMP for the batch dosing methodology.
- PAC is to be mixed into the surface as well as practical using a pole or similar without disturbing the sediment at the base of the device.
- The SRP or DEB is then to be left for a minimum of 2 hours to allow settlement to occur.
- Following 2 hours the clarity and pH is to be checked and recorded.
- In the event that the clarity of the SRP or DEB is still less than 100mm, specialist advice is to be sought from the ESC Team.
- In the event that once the clarity of the DEB is greater than 100mm, however the pH is outside the limits of 5.5 – 8.5 then specialist advice is to be sought regarding correction of the pH level.
- Once the clarity of the SRP or DEB is greater than 100mm and the pH is within the range of 5.5 – 8.5, the water can be discharged by removing the cap or lowering the dewatering device (t-bar). The time of this discharge and the pH and clarity are to be recorded on the Dewatering and Pumping Record Sheet (Appendix 4.3.3.3.A to this Procedure).

5 Procedure Modification

It is expected that as the Project progresses, modification of the dosage rates may be required due to changing soil types etc. This will be undertaken following additional sampling and testing and approval from the Environmental Manager in accordance with the CTMP.

Appendix 4.3.3.3.A

Dewatering and Pumping Record Sheet – Permit to Pump

Date:			Time:		
Location of water to be pumped					
Estimated volume of water to be pumped					
Weather forecast for following 24hrs (Note a 48hr period may need to be considered if intending to hold the water for a longer period)					
Proposed dewatering method (Circle):			Signed		
Direct pumping					
Batch dosing			Device pumping to (i.e. DEB 12):		
Direct pumping			Sign as confirmation		
Is clarity of impounded water greater than 100mm?			Yes / No		
Is pump inlet supported a minimum of 500mm above the base of the excavation?			Yes / No		
Is the outlet of the pump stabilised to prevent erosion?			Yes / No		
Confirm clarity of water at pump inlet every 15 minutes during pumping					
Time					
Clarity					
Signed					
Pumping to an impoundment device				Sign as Confirmation	
Impoundment device to be used:			E.g. DEB 12		
Is the outlet capped prior to pumping or dewatering device (t-bar) raised above primary spillway?			Yes / No		
Volume pumped (stored within impoundment device) Time pumping stopped			m^3 am/pm		
If, clarity is greater than 100mm and pH is between 5.5-8.5 – OK to discharge. Record details			mm pH		
Or, if not, batch dosing to occur. Confirm volume of impounded water Confirm batch dose rate Volume of chemical to be added:			 m^3 ml/m^3 L		
Clarity is greater than 100mm prior to discharge (record clarity)			mm		
Measured pH is between 5.5-8.5 prior to discharge. Note: if pH is outside this range refer to Environmental Manager / Project Manager for corrective actions			pH		
Time of discharge			am/pm		

Appendix 4.3.3.4 - Emergency Spill Response Procedure

	PROCEDURE	
Project Name:	**Ōtaki to North of Levin**		
Procedure:	Appendix 4.3.3.4: Emergency Spill Response		

1 Application

This Procedure forms a part of the Erosion and Sediment Control Plan (ESCP) for Ōtaki to North of Levin (the Project). The purpose of this Procedure is to have the procedures in place to manage spills that occur, and to reduce environmental impact of these incidents.

2 Scope of works

The construction activities of the Project include the following:

- Ground improvements;
- Excavations;
- Bridge construction and culvert works (inside & outside highly sensitive ecological areas);
- Upgrading of existing road network.

3 Potential Environmental Impacts of Activities.

The key potential emergency situations and the environmental impacts of these are:

Aspects	Impacts
Accidental spills and leaks of oils and chemicals to water bodies. Failure of slopes, stockpiles or environmental controls leading to severe sedimentation and contamination of watercourses. Fire and explosion leading to noxious air emissions and damage to habitats and wildlife.	Acute and chronic harm to aquatic ecosystems and riparian habitats. Suffocation of benthic life and harm to other aquatic life. Decrease in water quality. Impacts on local air quality, nuisance/danger and harm to local residents and wildlife.

4 Key Responsibilities

Responsibilities.

The ***H&S Manager*** is responsible for:

- Ensuring controls to prevent emergency situations are in place; and
- Ensuring controls to manage emergency situations are in place.

The ***Earthworks Manager/Project Engineers are*** responsible for:

- Ensuring the implementation of this Procedure;
- Communicating requirements to relevant site personnel; and
- Ensuring personnel have received appropriate training to competently address emergency procedures.

The ***Environmental Manager*** is responsible for:

- Ensuring adequate spill response materials are available for all activities;
- Ensuring that all spill kits are in stock; and
- Ensuring all site personnel have received appropriate instruction and training in avoiding and dealing with emergency situations.

All ***Site Personnel*** are responsible for:

- Following the requirements of this Procedure; and
- Reporting any defects, incidents or accidents to the Earthworks Manager or Environmental Manger.

5 Oil and Chemical Spills

5.1 Prevention

- All oils and chemicals on site must be stored securely within a site approved Hazardous Substances structure in accordance with the Hazardous Substances Procedure.
- All refuelling and plant or equipment maintenance activities will be undertaken in accordance with the Hazardous Substances Procedure (Appendix 4.3.3.6 to the ESCP).
- Spill kits will be kept at identified locations throughout the construction zone, but also at the following key locations:
  - All hazardous substances storage facilities;
  - Areas designated for the handling and use of hazardous substances;
  - Vehicles carrying hazardous substances (e.g. refuelling vehicles);
  - In the vicinity of, and readily available for all work areas;

- Spill kits will comprise, as a minimum, the following:
  - Sawdust (or equivalent absorbent material);
  - An absorbent boom;
  - Absorbent matting;
  - Disposable overalls, gloves and boot covers; and
  - A designated container for the disposal of contaminated equipment and soils.

All spill kits will be regularly inspected to ensure that they are fully stocked at all times.

5.2 Response to Spills

In the event of an oil or chemical spill **to the ground**:

- The supervisor of the works will:
  - Identify the source and nature of the spill and prevent further release;
  - Immediately contain the spill and prevent it from spreading, using the spill kit or other available material;
  - Advise the Environmental Manager / Project Engineer immediately;
  - Clean up and dispose of any contaminated material in designated contaminated waste containers, no chemical dispersants are to be used in this process; and
  - Notify the Environmental Management Team and Project Engineer of the actions taken to clean up;
- The Environmental Manger will assess any wider impacts resulting from the spill; and

In the event of an oil or chemical spill **to watercourses or treatment ponds:**

- The site personnel involved will:
  - Immediately contain the spill and prevent it from spreading using the absorbent boom or matting if appropriate;
  - Identify the source and nature of the spill and prevent further release;
  - Notify the Environmental Manager & Project Engineer and agree further actions; and
  - Where possible clean up spilt material from the water course using absorbent matting or other suitable material from the spill kit, no chemical dispersants are to be used in this process;
  - The Environmental Manger will assess the nature of the spill and potential wider impacts; and

If any spills exceeding 20L on the ground, or 5L over water occur, the Environmental Manager will immediately advise the Councils, with a full detailed report being completed and submitted to these parties within 48 hours.

6 Failure of stockpiles, embankments and environmental controls (e.g. sediment ponds)

Procedures to address the failure of stockpiles, embankments and environmental controls are set out in the ESCP (Section 9 - Monitoring and Responses, and in particular section 9.2 Environmental non-compliance and corrective actions).

The monitoring and maintenance of control devices is covered by the ESCP and the ESCMP.

7 Fires and Explosion

7.1 Prevention

- Smoking is not permitted in the vicinity of Hazchem depots or vulnerable vegetation.
- Open fires are not permitted on site for any reason.

7.2 Response

All hazardous substances containers / structures will be stocked with an appropriate fire extinguisher, sand bucket and other fire fighting equipment. Site vehicles will carry fire extinguishers.

In the event of a minor fire site personnel are permitted to utilise available equipment to extinguish it, if adequately trained with the use of the fire extinguisher. Water should **not** be used to extinguish a chemical or oil-based fire and more serious fires should only be tackled by professional fire fighters.

On identification of a fire or explosion Fire & Emergency NZ is to be contacted **immediately**, followed by the Construction Manager and Environmental Manager.

All personnel should be evacuated from the area of a serious fire or explosion, or where an explosion risk (e.g. near Hazardous Substances storage structures) may exist.

Measures should be taken to minimise the spread of a fire where possible and protect surrounding habitats.

Measures should be taken to minimise the spread of fire water and prevent release into water courses, using available spill kits and containment ponds where appropriate.

Following a fire or explosion the Health & Safety Manager will carry out a thorough investigation of the cause and will raise a report detailing the actions taken to prevent a reoccurrence.

8 Training

In order to prevent the occurrence of spills it is essential that site personnel have received appropriate training. Spill response training will be undertaken for all staff, including the use of spill response kits and emergency prevention and response. It is the responsibility of each Project Engineer to ensure their personnel have received the appropriate emergency training.

9 External Emergency Contacts

Emergency services, Fire, Police Ambulance	Dial 111

10 Project Emergency Contacts

Environmental Manager	TBC
Health and Safety Manager	TBC

Appendix 4.3.3.5 - Stream Works Procedure

Document Status

This Procedure forms part of the Erosion and Sediment Control Plan (ESCP) for the Ōtaki to North of Levin (the Project). The proposed construction works for the Project will include works being undertaken to divert flowing watercourses and install culverts.

The purpose of this Procedure is to ensure that the required level of environmental protection is achieved during these operations.

1 Scope of works

The proposed construction works on the the Project will include the following:

- Ground improvements;
- Excavations;
- Bridge and culvert construction (inside & outside highly sensitive ecological areas);
- Upgrading of existing road network.

2 Potential Environmental Impacts of Activities.

The key potential environmental aspects and impacts relating to stream works are:

Aspects	Impacts
Sedimentation from in stream works. Long-term erosion.	Dirty water discharge from culvert works, causing sedimentation downstream, infilling of stony bottom watercourse, damage to aquatic life and ecosystems. Erosion caused by works changing water velocity and alignments.

For all instream works, Site Specific Erosion and Sediment Control Plans (SSESCPs) will be prepared and certified by the Councils, and relevant Work Instructions will establish the controls to be applied. During the development of Work Instructions, the following issues will be considered.

3 Design

All permanent culverts have been modelled and designed to pass a 1:100 year flood event. Erosion control has been designed to ensure that there is no additional scouring that occurs at the inlet and outlet of the culverts during normal flow conditions.

All permanent stream diversions have been modelled and designed to convey a 1:100 year flood event. Stream diversions have been designed on a like for like basis, that is, any replacement stream will mirror the same type of stream that was there prior to the works commencing.

Any temporary culverts and stream diversions are designed to convey a 1:20 year rainfall event as far as practicable or otherwise certified through the relevant SSESCP by the Councils. Flows in excess of a 20-year event will be accommodated in part by the diversion and within the works area, by providing temporary non-erodible flow paths.

There are a large number of stream works locations along the length of the alignment associated with culvert installation and stream diversions.

4 Methodology for stream diversion

All stream works and culvert works will be undertaken in accordance with a SSESCP. Wherever practicable, construction works will take place "in the dry" and "offline" i.e. with flows diverted around the works site. Where this approach is not practicable the SSESCP will detail the approach to be undertaken to manage the interface between the existing freshwater environment and the construction process. This may include temporary damming and over pumping.

Diversions will be installed, stabilised and made live prior to streamworks commencing. The site of the diversion will be treated by appropriate controls, such as silt fencing, following which the diversion will be constructed and stabilised with geotextile lining pinned at 500mm centres, or similar. Once constructed, flows from the original channel will be diverted using sheet steel or sandbag dams and the channel will be isolated upstream and downstream.

Once the diversions are installed, a Project ecologist will de-fish the off-line section of stream, following which the stream can be dewatered to a sediment control device (refer to Dewatering Procedure Appendix 4.3.3.3). The channel will be mucked out and material disposed elsewhere within a control area. Any temporary stockpiles will be located away from the floodplain of the stream.

Once the works are complete and the new flow channel has been stabilised, the stream can be redirected into its new flow path. A sheet steel or sandbag dam will be installed across the upstream end of the diversion to divert stream flows into the new channel / pipe. The diversion will be allowed to drain by gravity. Following this, a sediment control measure will be installed at the downstream end and the diversion will be filled.

5 Fish Passage

Culverts will be designed to provide for fish passage.

Appendix 4.3.3.6 – Hazardous Substances Procedure

	PROCEDURE		
Project Name:	**Ōtaki to North of Levin**		
Procedure:	Appendix 4.3.3.6: Hazardous Substances Procedure		

1 Application

This Procedure forms a part of the Erosion and Sediment Control Plan (ESCP) for the for the Ōtaki to North of Levin (the Project). The purpose of this Procedure is to outline the hazardous substances that may be required onsite in relation to erosion and sediment control.

A full Hazardous Substances Management Plan will be part of the site Health and Safety Management Plan.

2 Scope of works

The construction activities of the Project include the following:

- Ground improvements;
- Excavations;
- Bridge construction.

3 Objectives

The objectives of this Hazardous Substances Procedure are:

- To aid compliance with the HSE and HSNO legislation and regulations (refer Health & Safety Management Plan).
- To operate in full compliance with the Resource Consent condition requirements.
- To eliminate wherever practically possible the harmful effects of hazardous substances on people and the environment.

4 Potential Environmental Impacts of Activities.

The key potential environmental aspects and impacts relating to hazardous substances are:

Aspects	Impacts
The discharge of hazardous chemicals into the environment from incorrect storage and use of materials. Fuels and oils not stored / used causing spills to land and water. Chemicals used onsite causing spills to land and water.	Spills causing harm to aquatic environments causing harm to ecosystems.

5 Key Responsibilities

Responsibilities.

The ***H&S Manager*** is responsible for:

- Leading and advising upon the overall management of hazardous substances.
- The development of a schedule for the completion of hazardous substance audits across the Project.
- Production of a bi-annual audit schedule for hazardous substances permanent and semi-permanent (more than 3 months) storage facilities.
- Completion of audits outlined in the audit schedule.
- The review of audit and inspections results of hazardous substances facilities and processes.
- The monthly reporting of any hazardous substance management near misses and incidents.
- Communicating with local enforcement agencies such as Worksafe NZ or the Regional/District Councils.
- Completing audits of hazardous substances facilities and processes.
- Audit and inspection results, including actions and close outs.
- Site plans.
- Safety data sheets.
- Emergency response plans.

The ***Earthworks Manager/Project Engineers are*** responsible for:

- Ensuring that a staff member, who has successfully completed the "Managing Hazardous Substances" training program, is nominated as the "Person in Charge" and is made available for all work areas where hazardous substances are used or stored.
- Supporting the "Person in Charge" (described below) to achieve full compliance with hazardous substances management requirements.
- Ensuring that inspections are carried out of hazardous substance storage facilities.
- Ensuring that the hazardous substances inward goods process is adhered to within the Project.

The ***"Person in Charge"*** is responsible for:

- Ensuring the necessary test certificates are obtained for their location.
- Ensuring the necessary approved handler's certificates are obtained.
- Maintaining site plans.
- Overseeing the deployment of suitable PPE and equipment to staff.
- Provision of information and documents regarding effective disposal of hazardous substances.
- Maintaining an up to date register of hazardous substances under their control.
- Ensuring that an up to date safety data sheet is obtained and made available for all hazardous substances under their control.
- Ensuring the correct signage is used for the hazardous substances under their control.
- Ensuring the correct labelling is used for the hazardous substances under their control.
- Providing to the Environmental Manager up to date copies of register, site plans and SDS.

The ***Environmental Advisor*** is responsible for:

- Supporting the overall management of hazardous substances.
- Arranging the delivery of a hazardous substance training program for all staff, including the "Person in Charge".

All ***Site Personnel*** are responsible for:

- Following the requirements of this Procedure.
- Reporting any incidents or accidents to the Health and Safety Manager.

6 Hazardous Substances Registers

A register of the Hazardous Substances stored and used on site shall be maintained and updated on at least a monthly basis. A copy of the register will be kept near the various storage locations along with a copy held at the main site office.

7 Safety Data Sheets

A Safety Data Sheet (SDS) shall be held for every Hazardous Substance stored and used on site. The SDS shall not be more than 5 years of age. Copies of the SDS will be kept near the various storage locations.

8 Diesel Storage

As part of this Project, diesel will be delivered by mobile mini tankers to the machines. 40,000L double skinned fuel tanks may be established on site at key locations. While diesel is not a particularly flammable substance, it is an environmental hazard, with considerable clean-up costs if it should leak into a drain, watercourse or the soil. When using or storing diesel, the following safety measures will be adhered to:

- Containers will be positioned away from any source of direct heat.
- Drums will be located in an area where the risk of collision with vehicles, such as forklift trucks, is minimised as far as practicable.
- Leaks and spills will be confined to the vicinity of the drum with the source of the spill stopped immediately (i.e. drum up-righted or plugged), contained and cleaned-up quickly.

9 Refuelling Procedures

The following procedure will be followed when refuelling construction vehicles on site.

- The location of the refuelling will not be any closer than 50m from a watercourse.
- Both the vehicle being refuelled and the vehicle dispensing the fuel will be turned off.
- The refuelling will only take place when a spill kit is immediately available.
- Refuelling will take place away from any “hot works” or heat sources.
- The refuelling process will be constantly monitored by the staff responsible for dispensing the fuel and will not be left unattended at any time.

This process will be explained to all personnel during the induction to site, special guidance will be given to mobile refuelling staff to reinforce the above procedure.

10 PAC Storage

As part of this Project, Polyaluminium Chloride (PAC) will be used as a flocculent for the treatment of sediment laden water. Large quantities of flocculent will only be stored at the main compounds in a hazardous goods shed. Small quantities of the flocculants will be stored adjacent to the floc box rain activated dosing sheds out in the field.

Appendix 4.3.3.7 – Minor Changes to Management Plan Register

Register of Minor Changes to Management Plan **Management Plan:** Erosion and Sediment Control Management Plan

Change Number	Date of Change	Description of Change	Authorised by Environmental Manager	Management Plan Revision into which the change was formalised
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				

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

The conclusions in the Report are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion.

Quality statement

Project manager	Project technical lead
Jon England	Jamie Povall

PREPARED BY

Eleni Gkeli — 29 / 07 / 2022

CHECKED BY

Ken Clapcott — 29 / 07/ 2022

REVIEWED BY

Phil Peet — 02 / 08 / 2022

APPROVED FOR ISSUE BY

Jamie Povall — 11 / 08 /2022

WELLINGTON, New Zealand
Level 15, 10 Brandon Street Wellington 6011
P.O Box 13-052, Armagh, Christchurch 8141
Tel 64 4 381 6700
STATUS ISSUE 2 | Project No 310203848

Contents

List of appendices

List of tables

List of figures

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.

[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

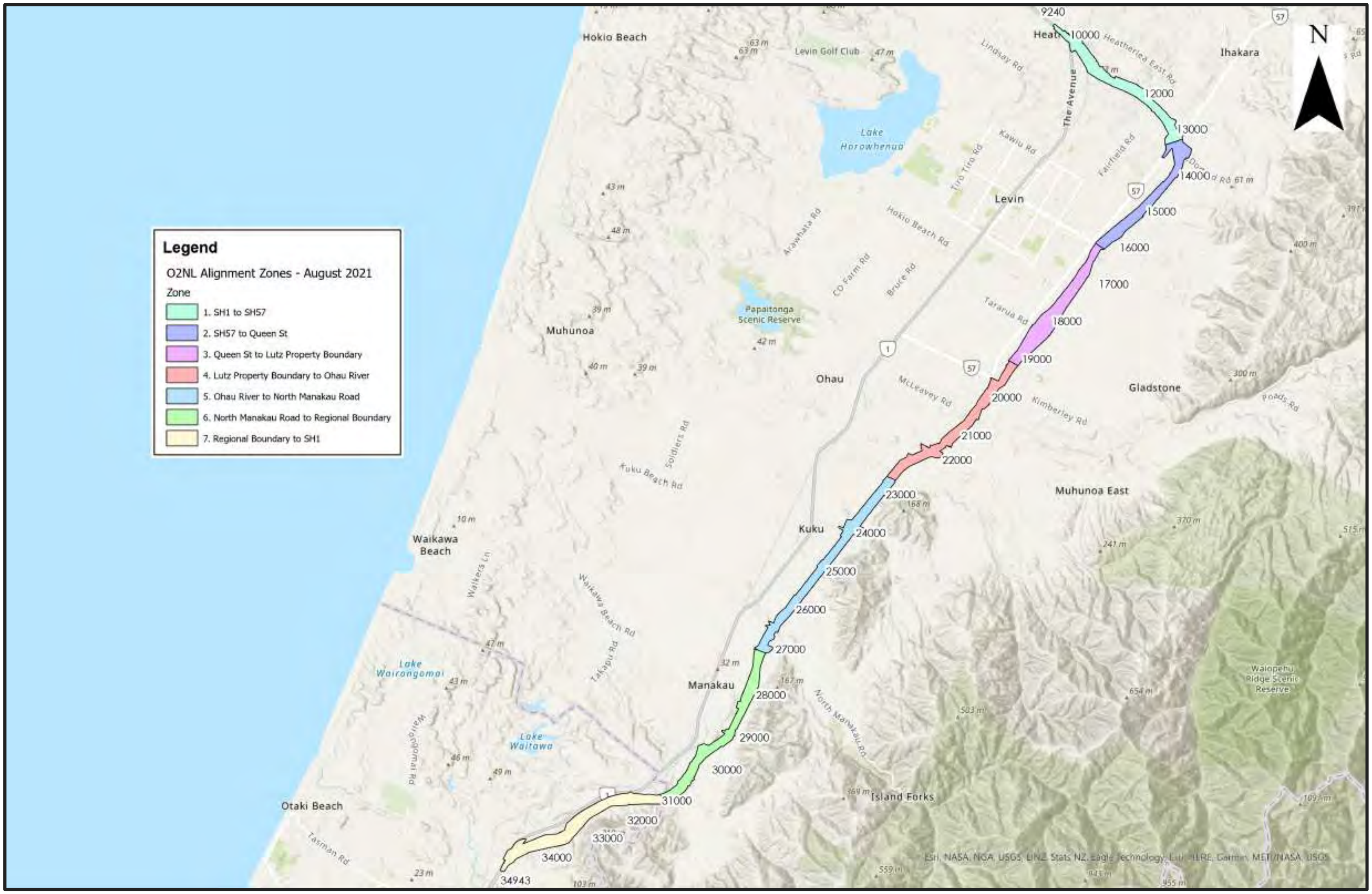


Figure:4.4.1 Overview of the alignment by Zone

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.

---

[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

We design with community in mind

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.	EWHS (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	

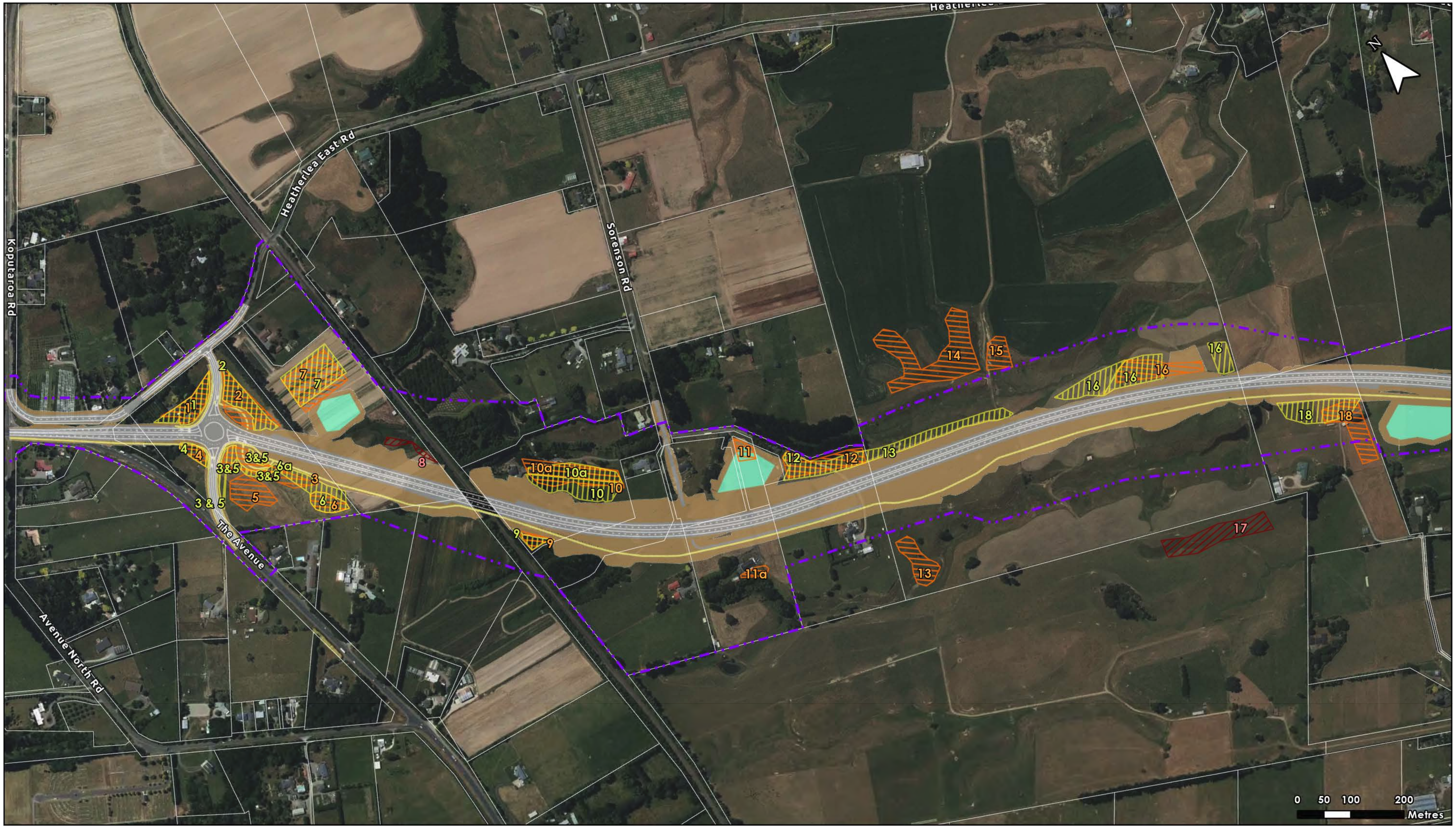
99	Unobtrusive location. Anchored against fill batter. Opportunity to contribute to screening from properties to west. Opportunity to merge with spoil site 98 to north.	ITT04 (Low)			No known sites in this area, but cannot be entirely ruled out.						0	keep - increased to make up for deletion of #101 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

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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.

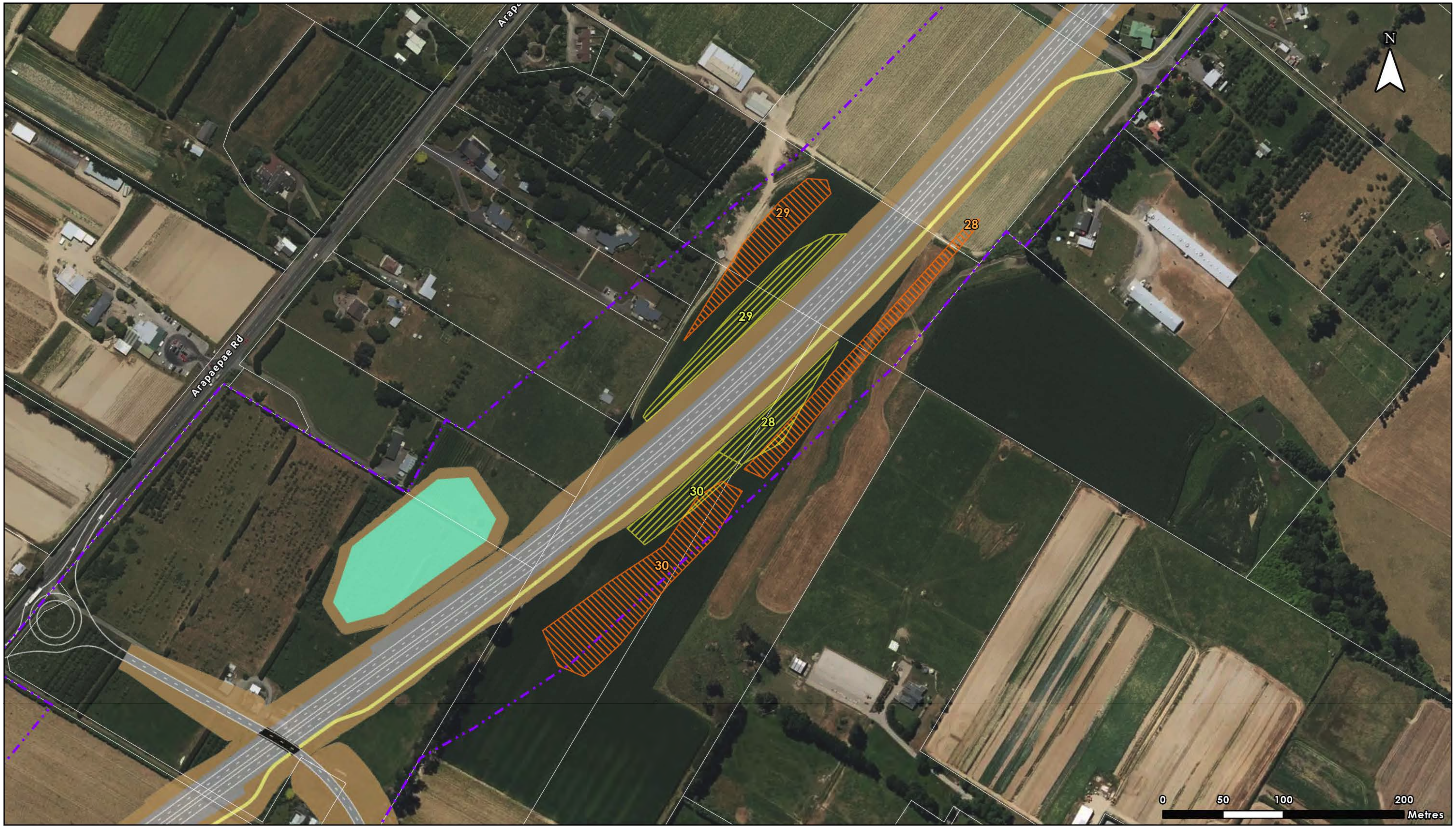
Author: rmcpherson, Stantec (2022)
Reviewed by: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 14800 - 15600

WAKA KOTAHI NZ TRANSPORT AGENCY

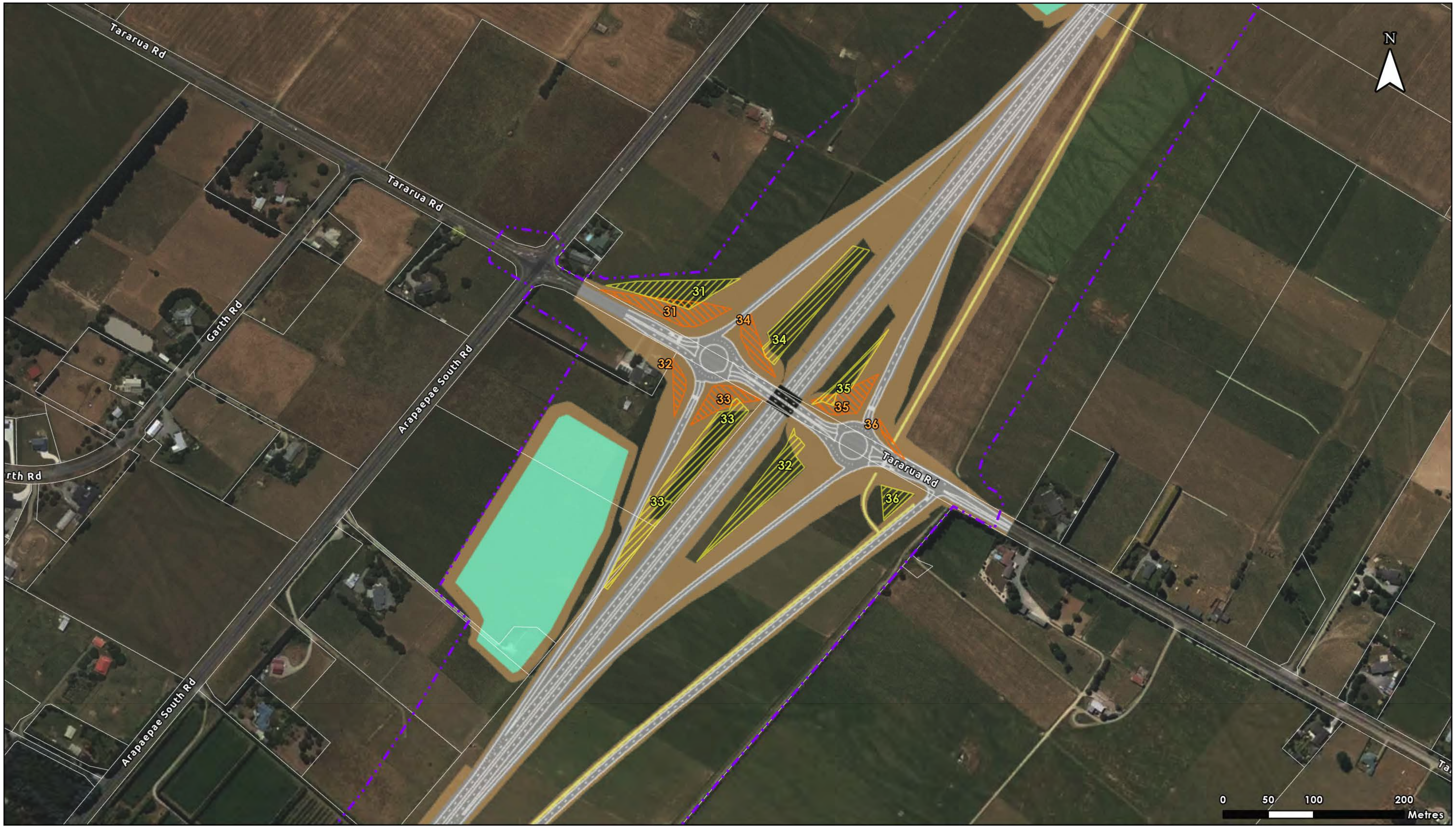
Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

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 17800 - 18800

WAKA KOTAHI NZ TRANSPORT AGENCY

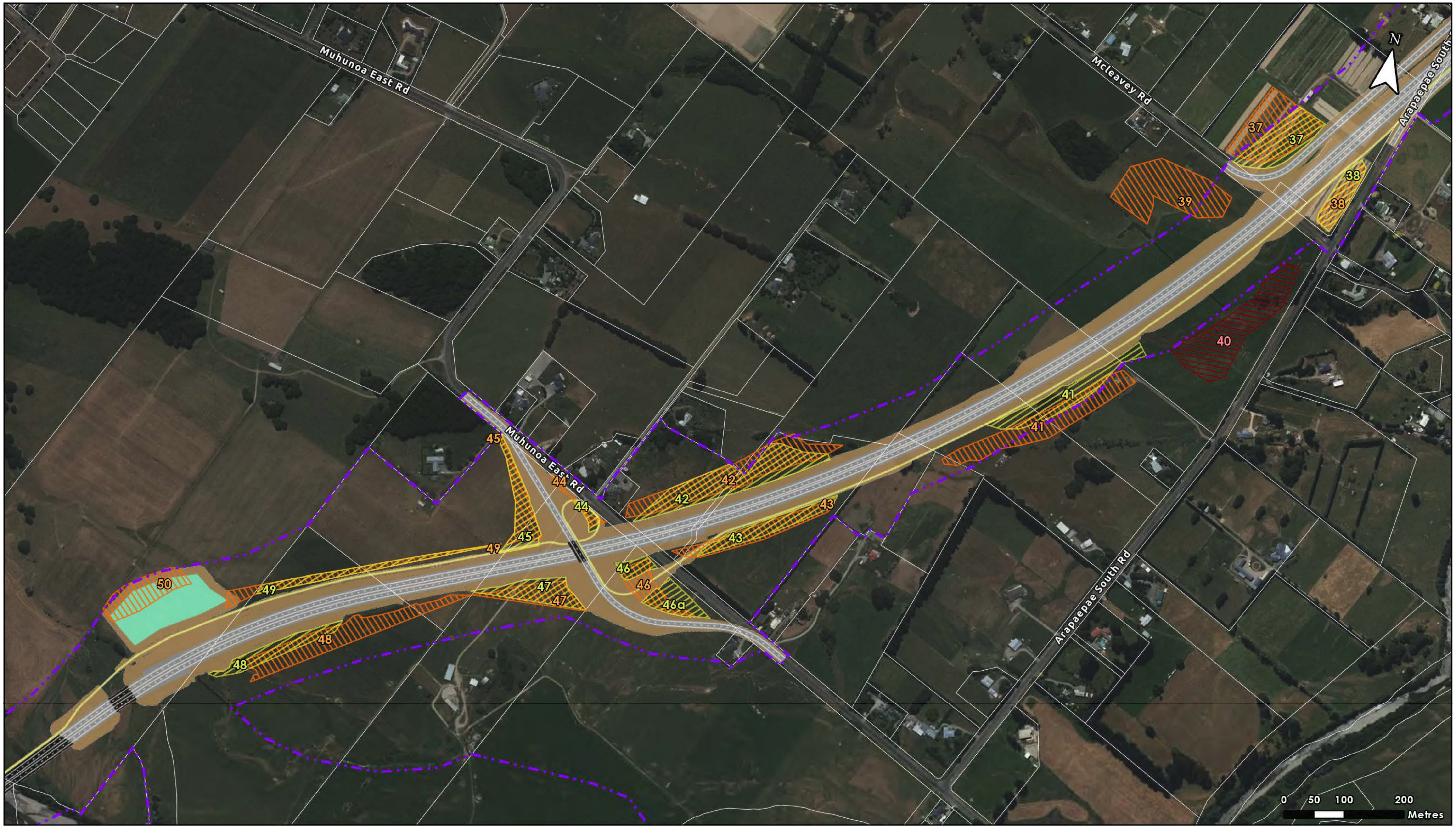
Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 20200 - 22600

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

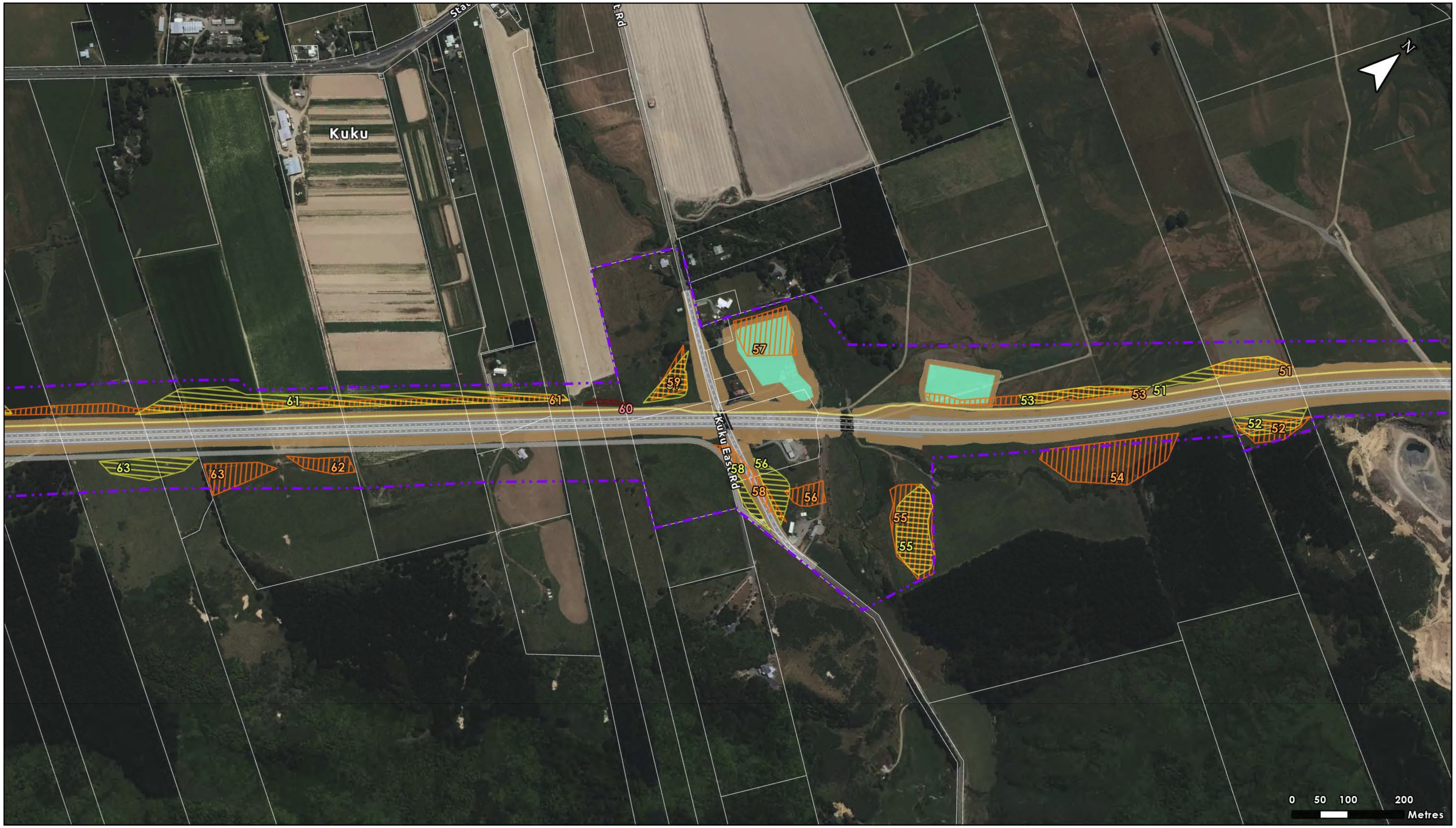
Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

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 22800 - 25100

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

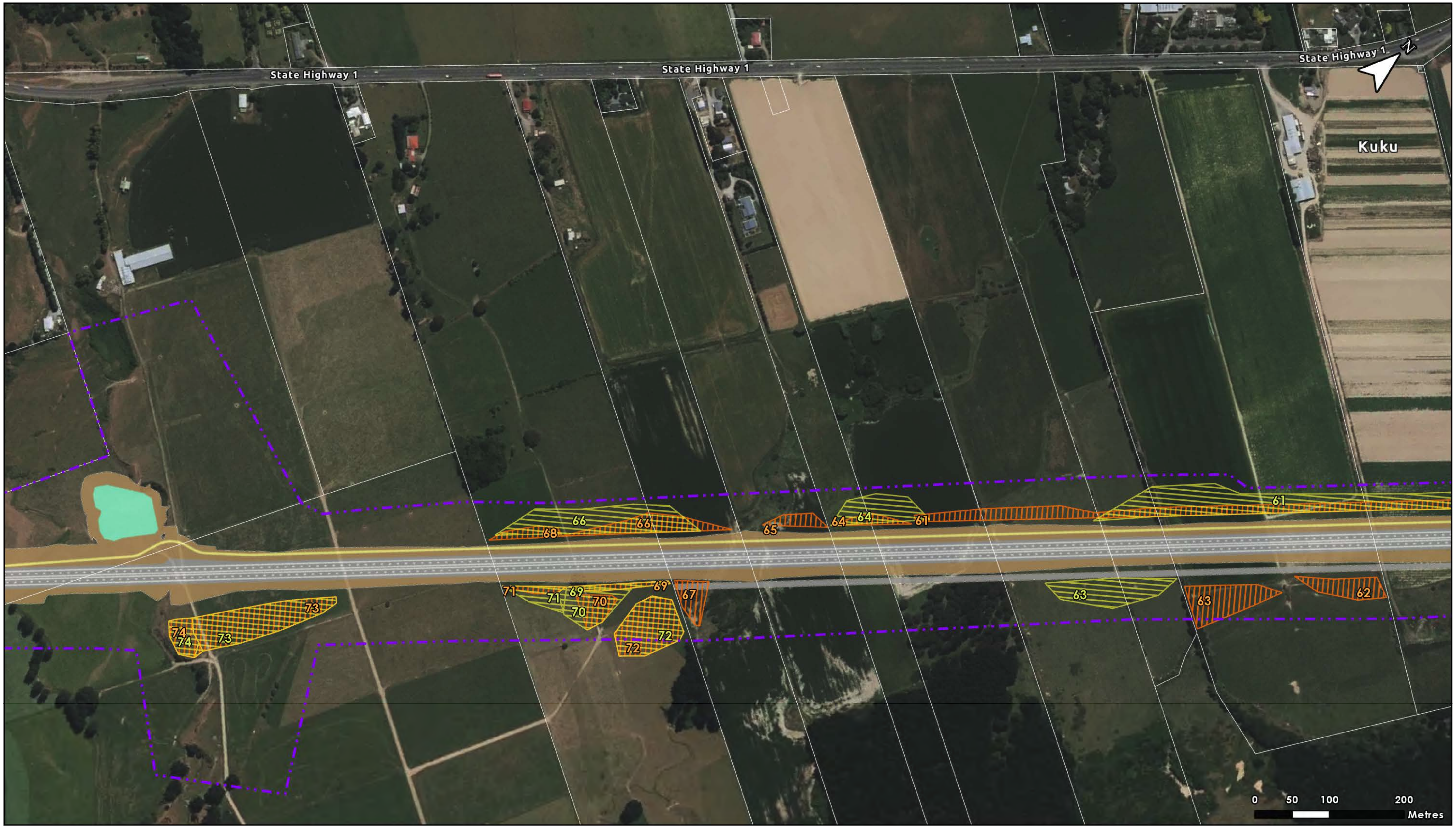
O2NL Spoil Sites for Consideration (Dec21-Mar22)
O2NL Spoil Sites for Consideration (July21-Dec21)
O2NL Spoil Sites for Consideration (Initial Long List pre-July21)
O2NL Proposed Designation
Property Parcels

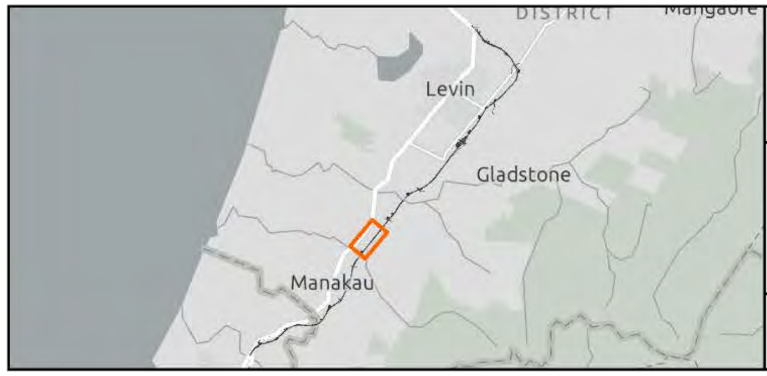
O2NL Draft Design DF4 20220419
Road User Markings
Road Surface
Shared Use Path
Bridges
Earthworks
Ponds

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

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





Long List of Spoil Sites - Spoil Sites Assessed in MCA Process

Chainage 24600 - 26200

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.

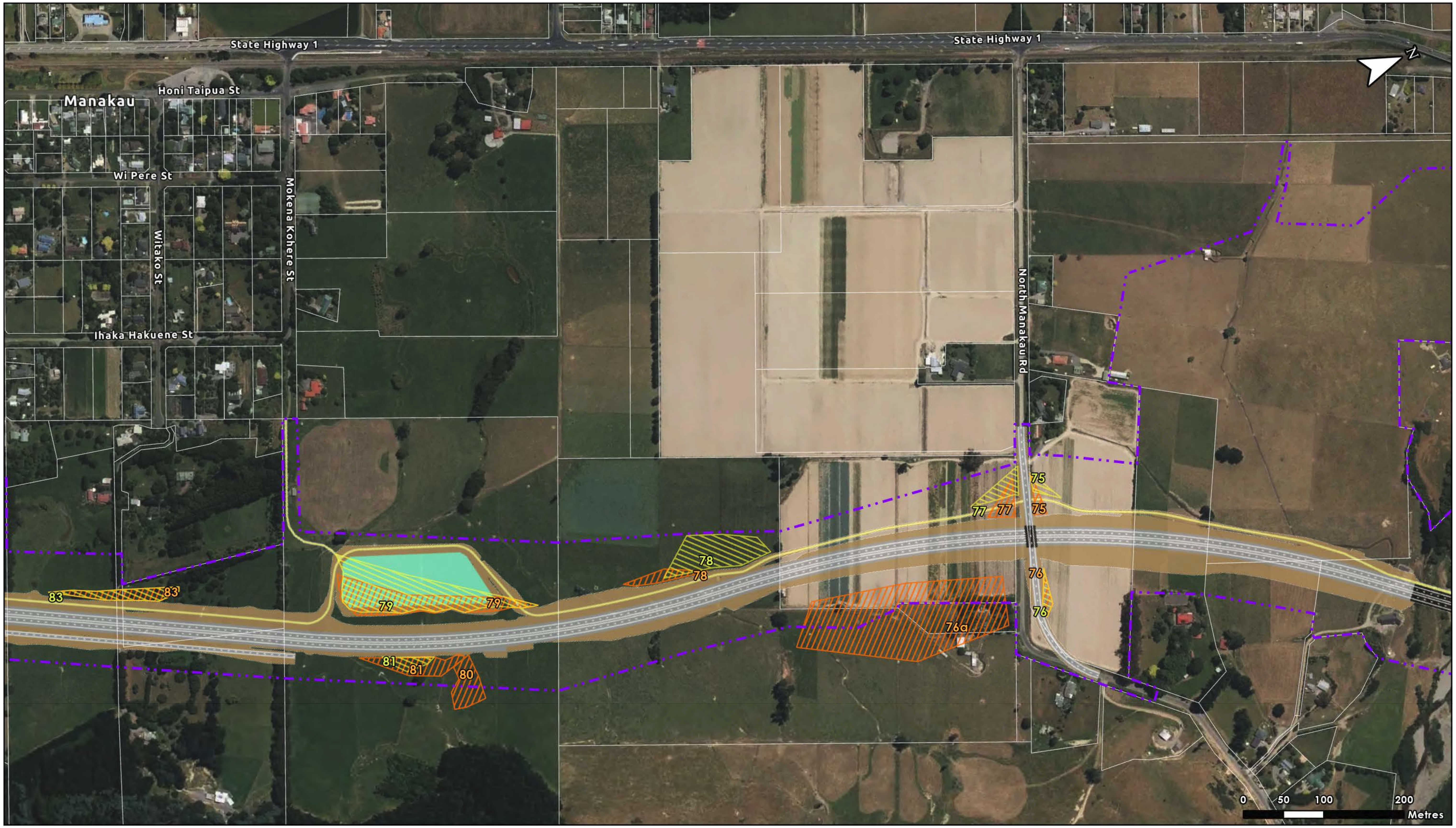
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

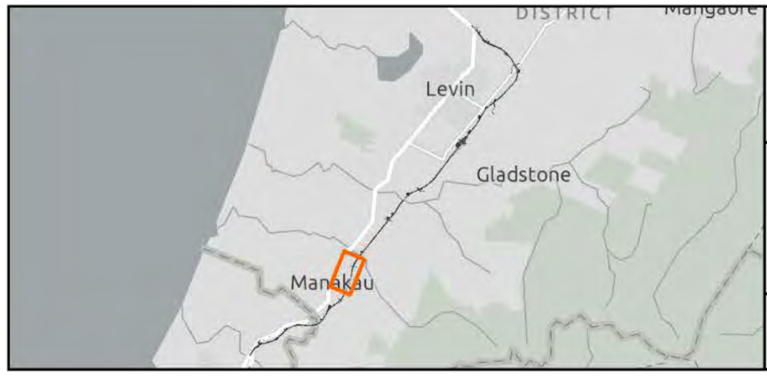
This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 26600 - 28500

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.

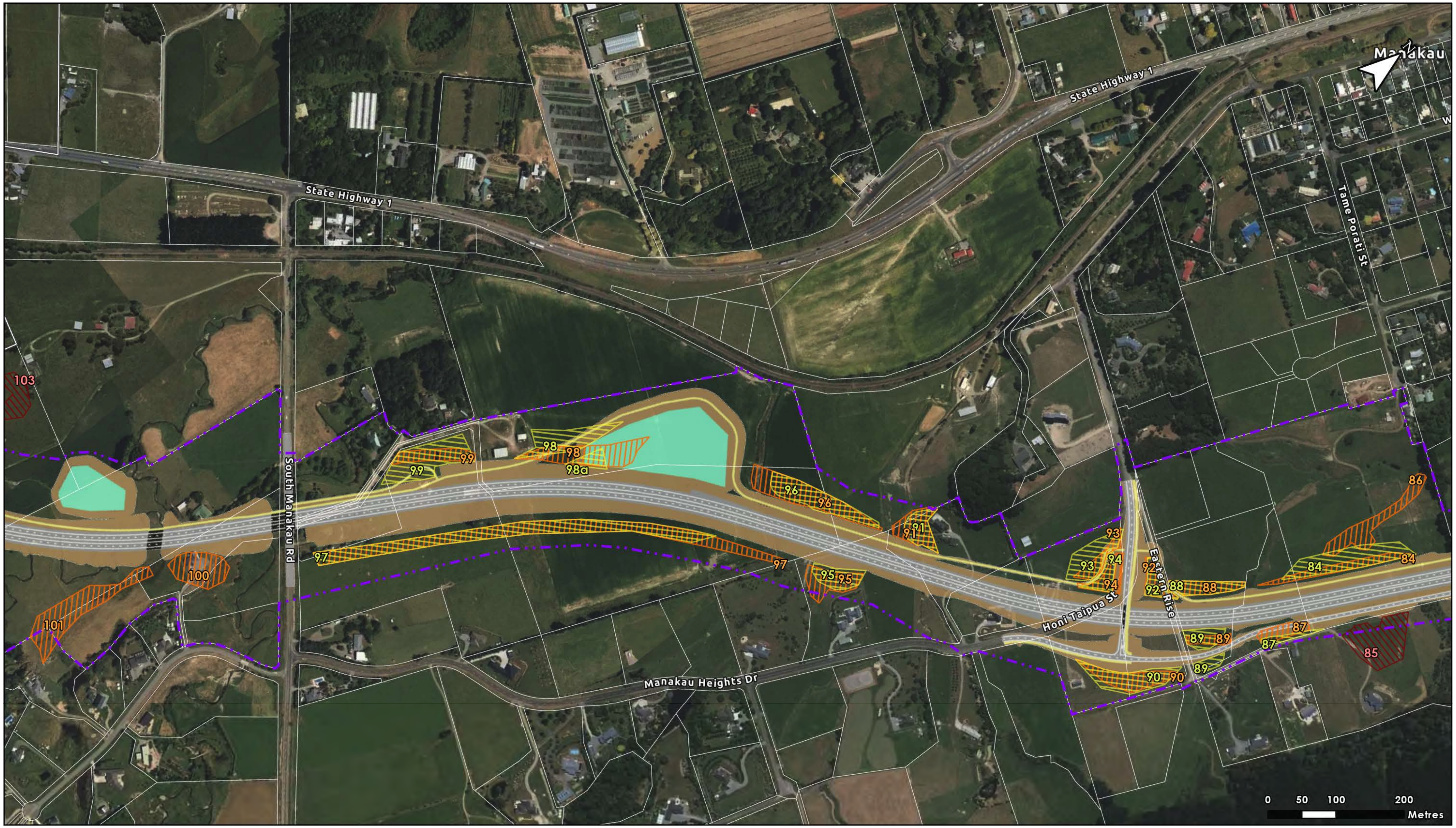
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 28500 - 30500

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.

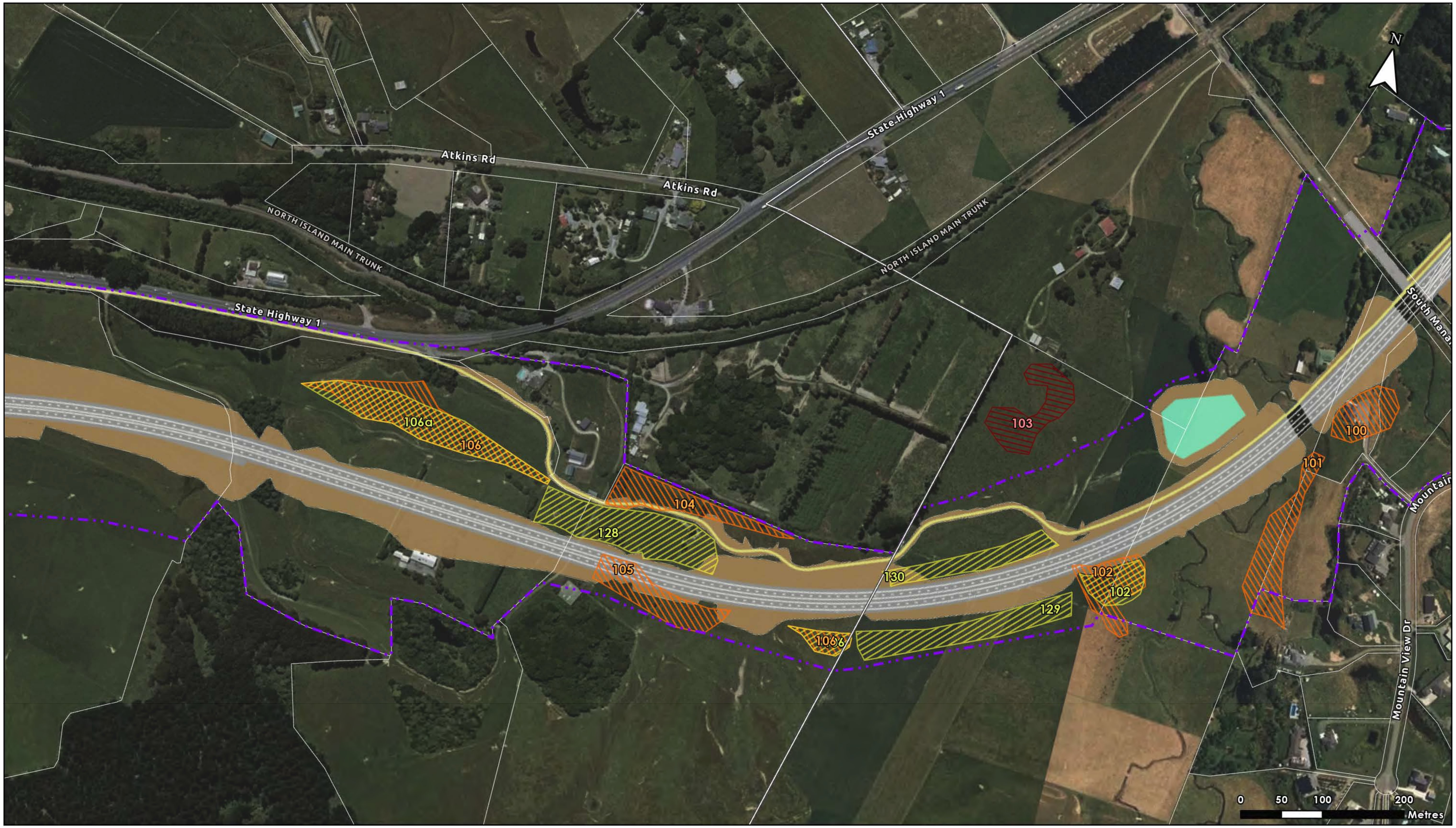
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 30200 - 31800

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.

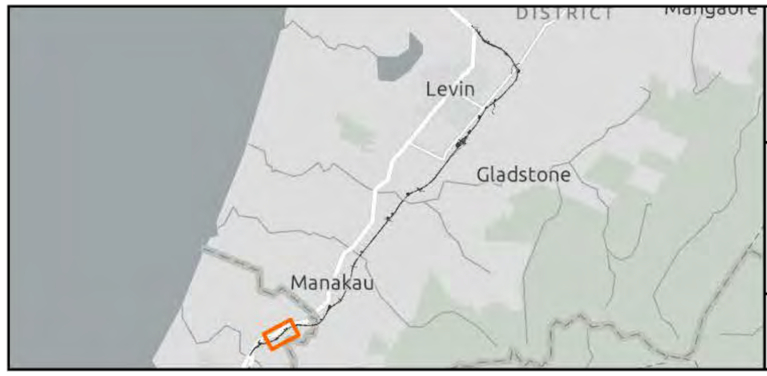
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 32100 - 33600

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.

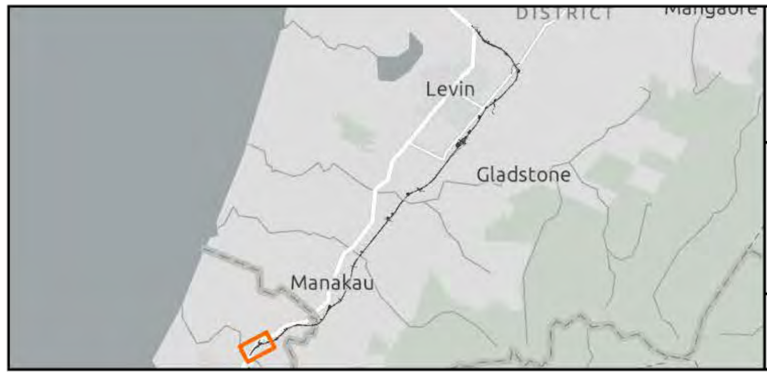
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- 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 33600 - 35000

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.

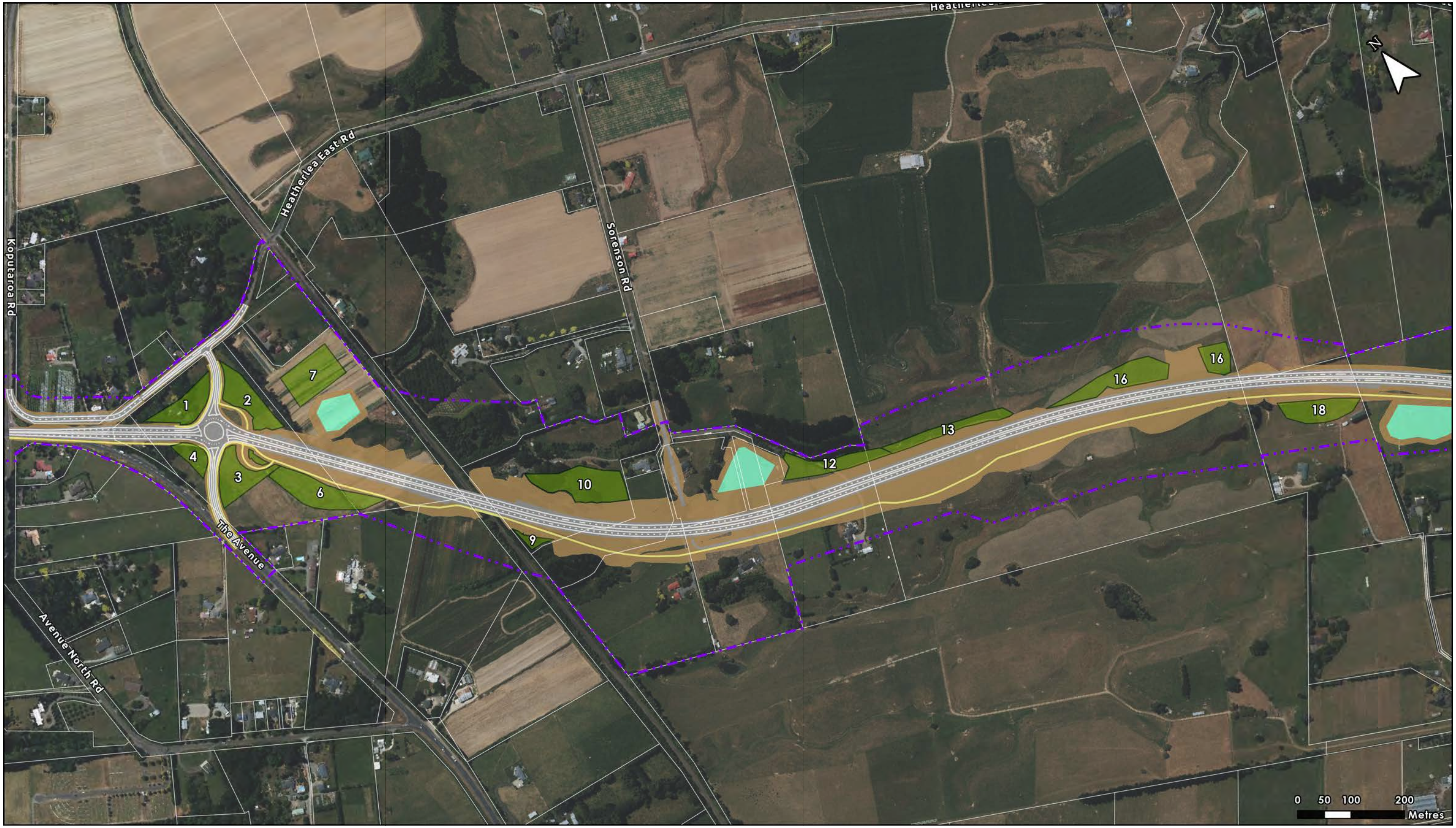
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 09/6/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

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

B2: Long List of Spoil Sites Assessed in MCA Process



Stantec

Final Spoil Sites Recommended for Consenting

Chainage 10000 - 12400

WAKA KOTAHI NZ TRANSPORT AGENCY

- O2NL Spoil Sites Recommended for Consideration (July 2022)
- O2NL Proposed Designation
- Property Parcels

O2NL Draft Design (DF5 20220714)

- 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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Stantec

Final Spoil Sites Recommended for Consenting

Chainage 12400 - 14000

WAKA KOTAHI NZ TRANSPORT AGENCY

O2NL Spoil Sites Recommended for Consideration (July 2022)

O2NL Proposed Designation

Property Parcels

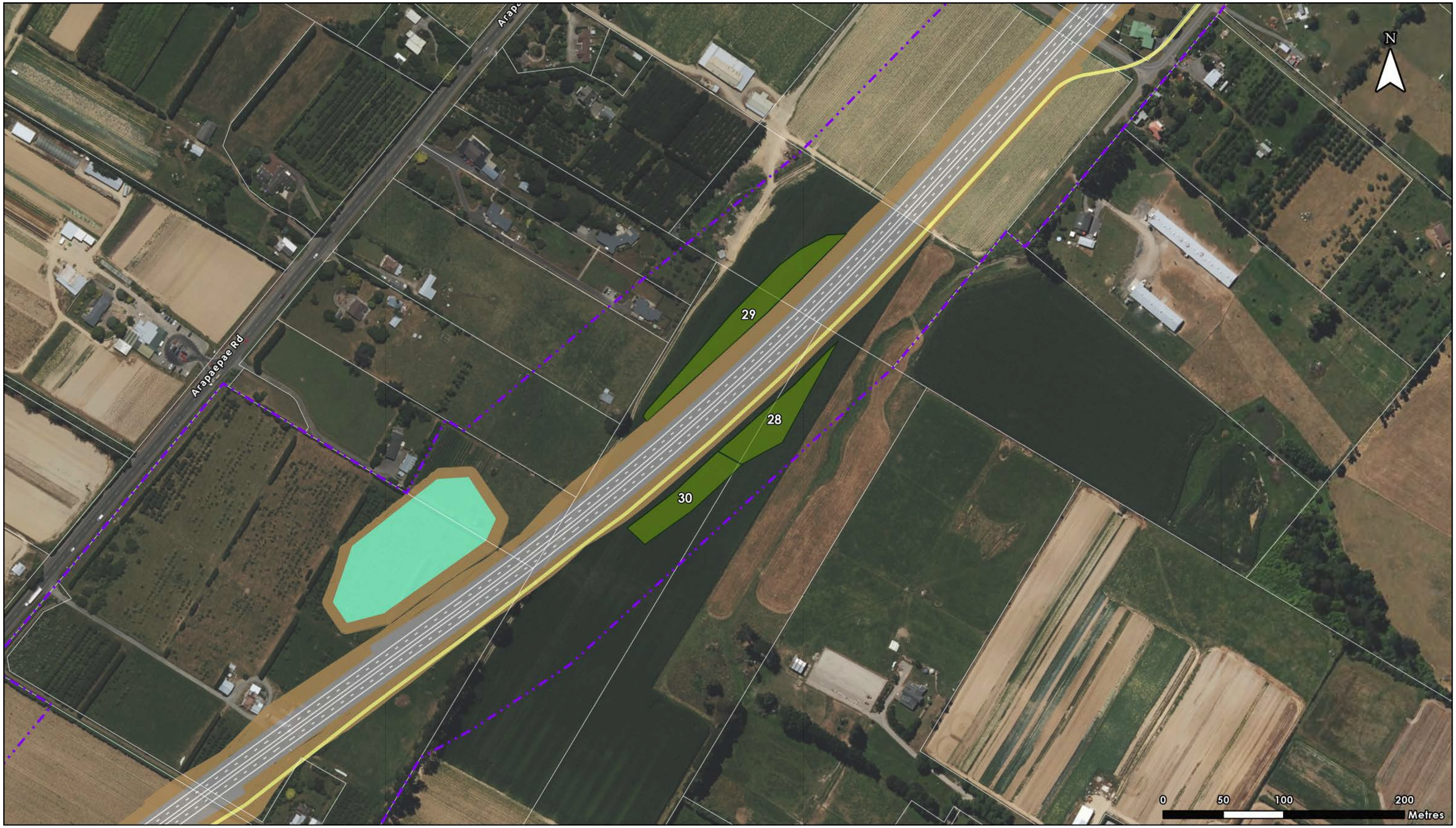
O2NL Draft Design (DF5 20220714)

- 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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

Final Spoil Sites Recommended for Consenting

Chainage 14800 - 15600

WAKA KOTAHI NZ TRANSPORT AGENCY

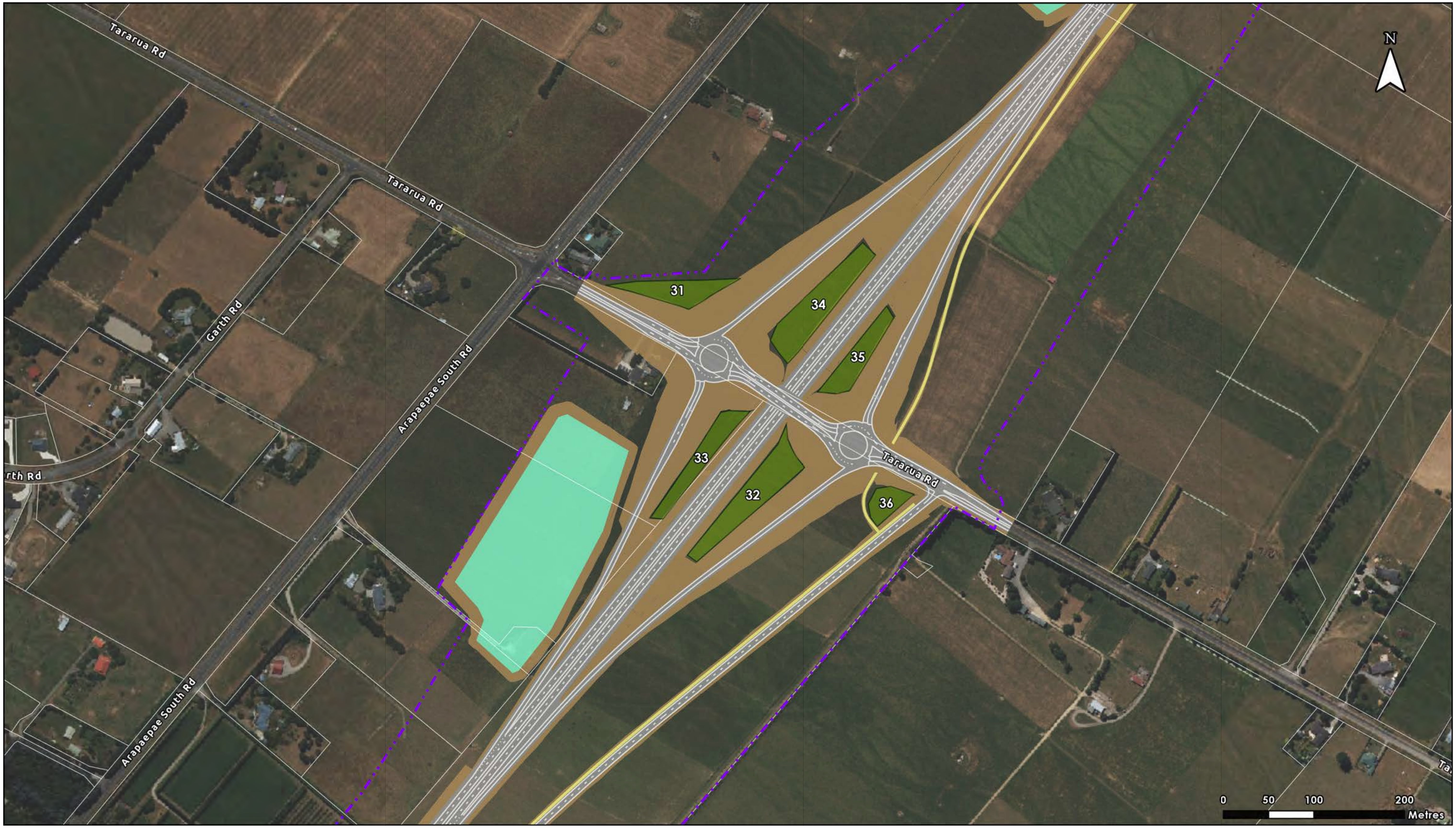
O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design (DF5 20220714)
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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

Final Spoil Sites Recommended for Consenting

Chainage 17800 - 18800

WAKA KOTAHI NZ TRANSPORT AGENCY

O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design (DF5 20220714)
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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Stantec

Final Spoil Sites Recommended for Consenting

Chainage 20200 - 22600

WAKA KOTAHI NZ TRANSPORT AGENCY

O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design (DF5 20220714)
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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Stantec

Final Spoil Sites Recommended for Consenting

Chainage 22800 - 25100

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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design (DF5 20220714)
- Road User Markings
- Road Surface
- Shared Use Path
- Bridges
- Earthworks
- Ponds

Stantec

Final Spoil Sites Recommended for Consenting

Chainage 24600 - 26200

WAKA KOTAHI NZ TRANSPORT AGENCY

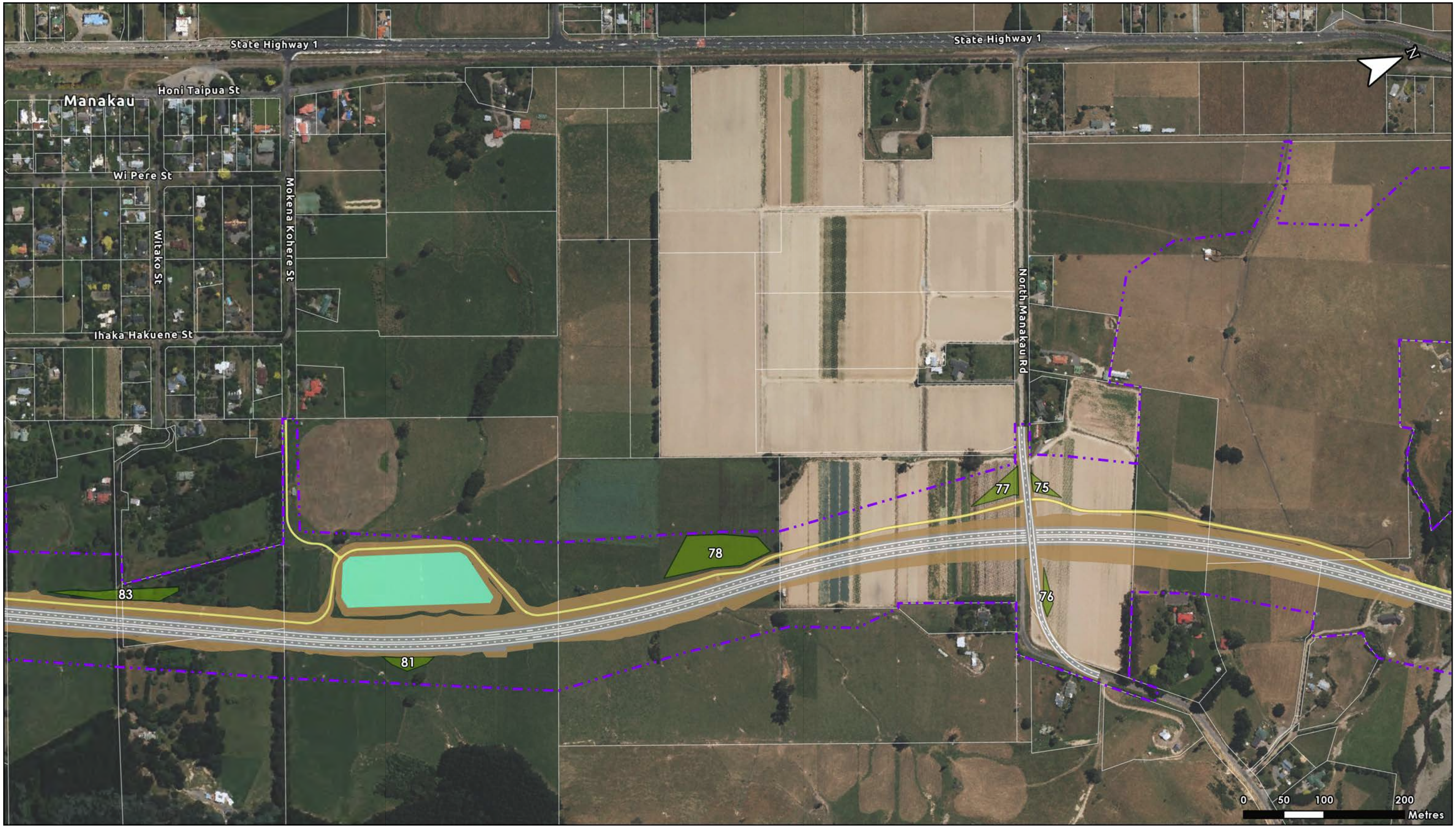
Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

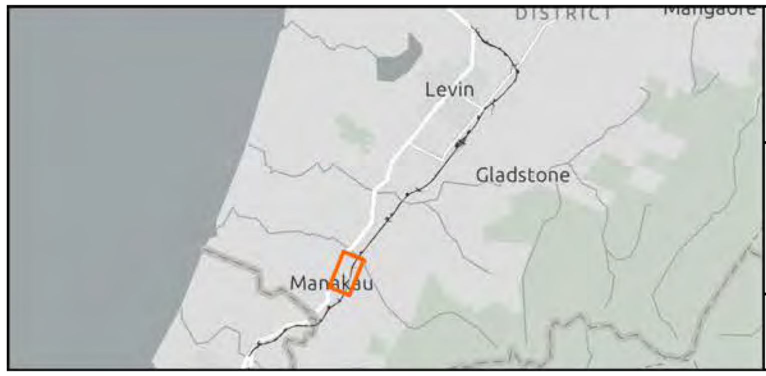
Author: rmcpherson, Stantec (2022)
Reviewed by: egkell, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design (DF5 20220714)
Road User Markings
Road Surface
Shared Use Path
Bridges
Earthworks
Ponds





Stantec

Final Spoil Sites Recommended for Consenting

Chainage 26600 - 28500

WAKA KOTAHI NZ TRANSPORT AGENCY

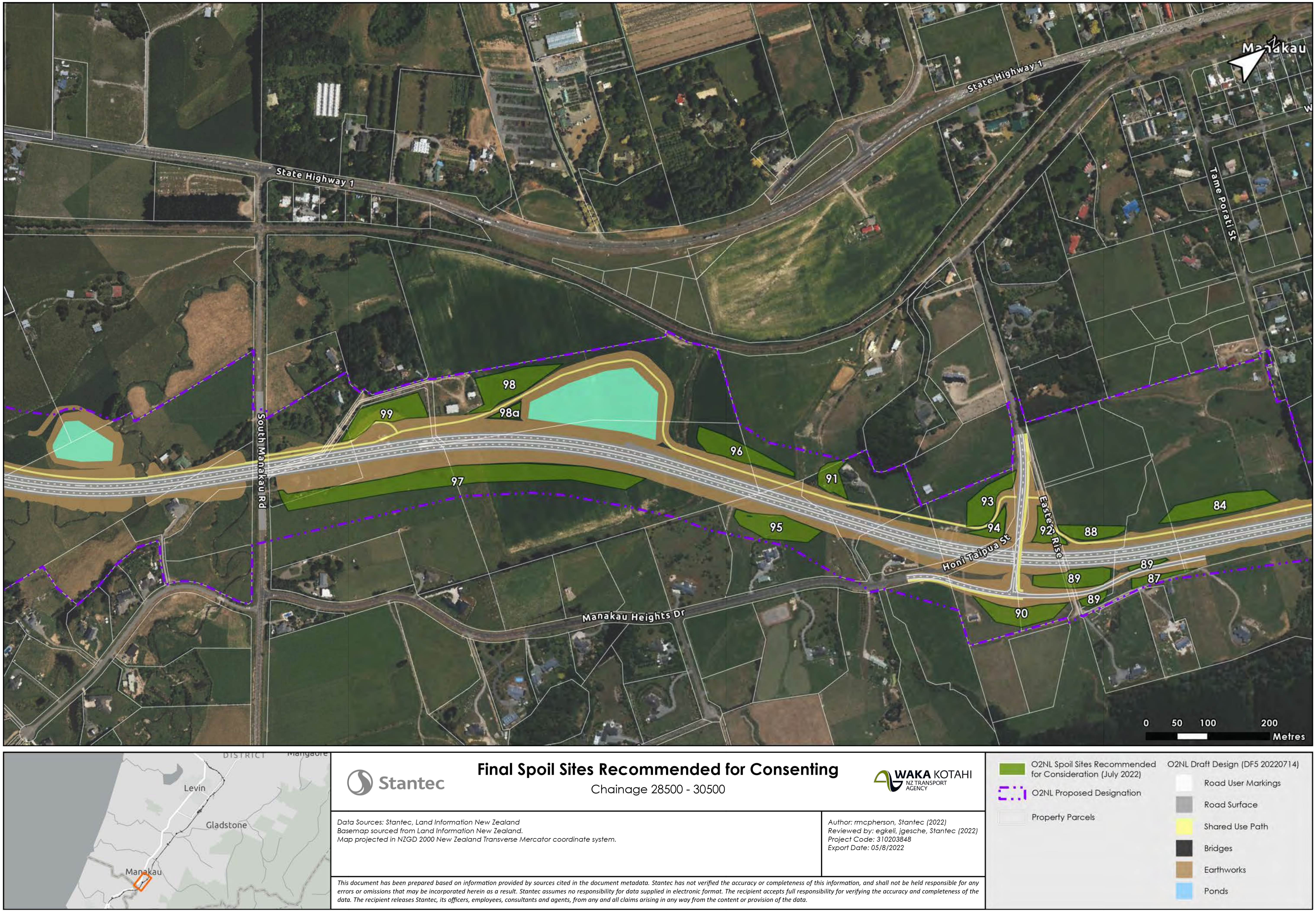
Data Sources: Stantec, Land Information New Zealand
Basemap sourced from Land Information New Zealand.
Map projected in NZGD 2000 New Zealand Transverse Mercator coordinate system.

Author: rmcpherson, Stantec (2022)
Reviewed by: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

O2NL Draft Design (DF5 20220714)
Road User Markings
Road Surface
Shared Use Path
Bridges
Earthworks
Ponds



Final Spoil Sites Recommended for Consenting

Chainage 28500 - 30500

Stantec

WAKA KOTAHI NZ TRANSPORT AGENCY

O2NL Spoil Sites Recommended for Consideration (July 2022)

O2NL Proposed Designation

Property Parcels

O2NL Draft Design (DF5 20220714)

Road User Markings

Road Surface

Shared Use Path

Bridges

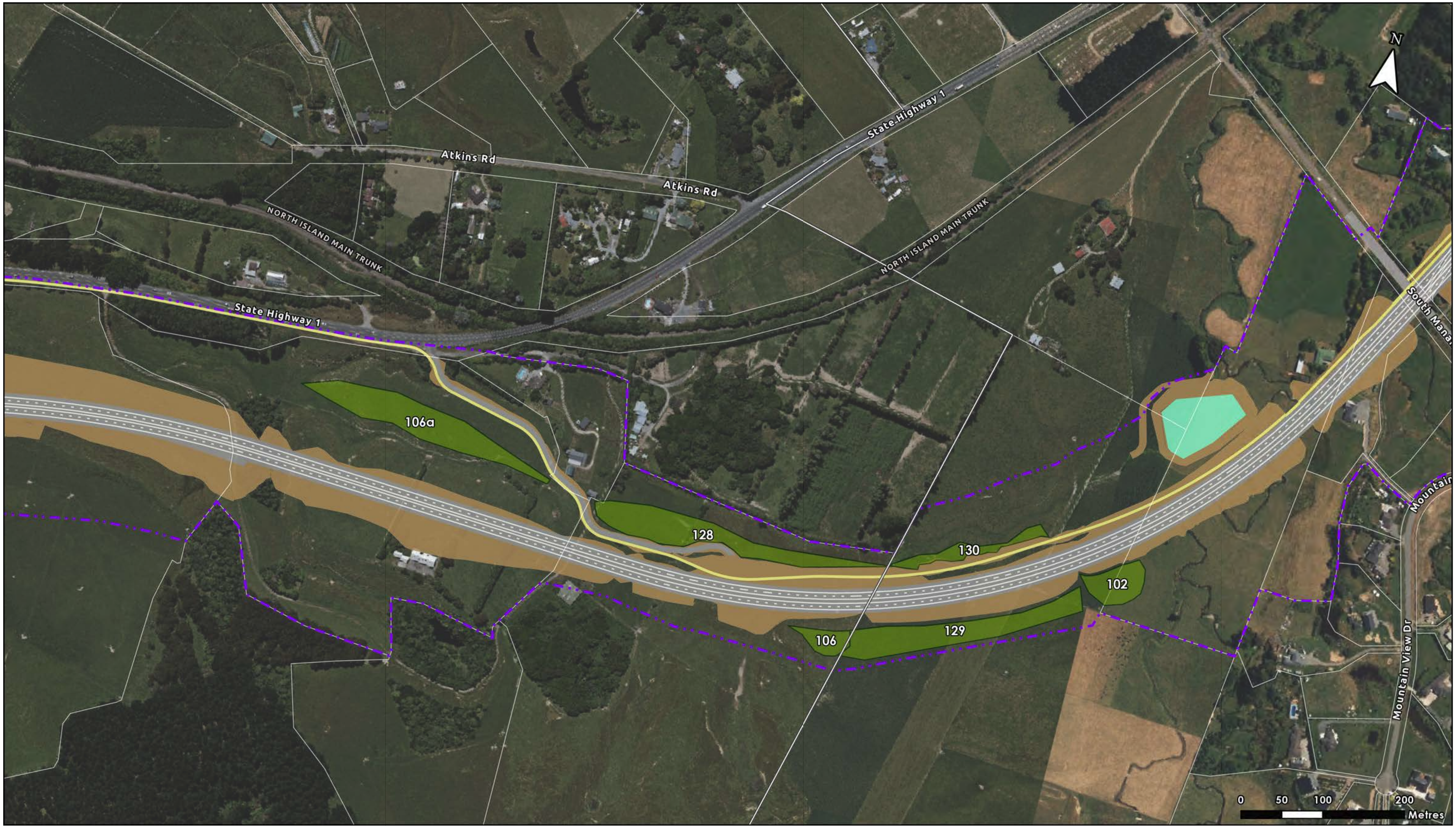
Earthworks

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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

Final Spoil Sites Recommended for Consenting

Chainage 30200 - 31800

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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- O2NL Spoil Sites Recommended for Consideration (July 2022)
- O2NL Proposed Designation
- Property Parcels

O2NL Draft Design (DF5 20220714)

- Road User Markings
- Road Surface
- Shared Use Path
- Bridges
- Earthworks
- Ponds

Stantec

Final Spoil Sites Recommended for Consenting

Chainage 32100 - 33600

WAKA KOTAHI NZ TRANSPORT AGENCY

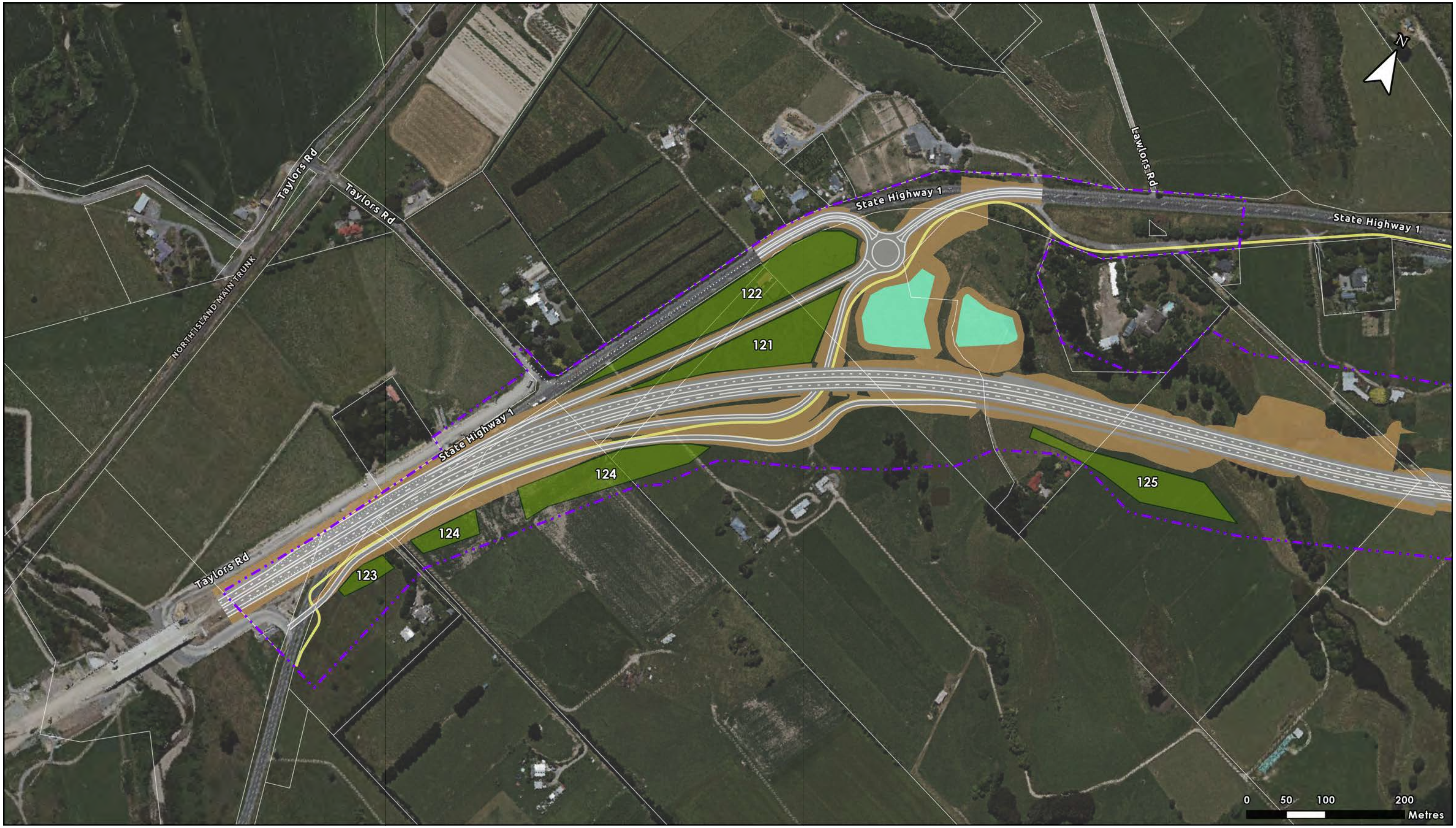
O2NL Spoil Sites Recommended for Consideration (July 2022)
O2NL Proposed Designation
Property Parcels

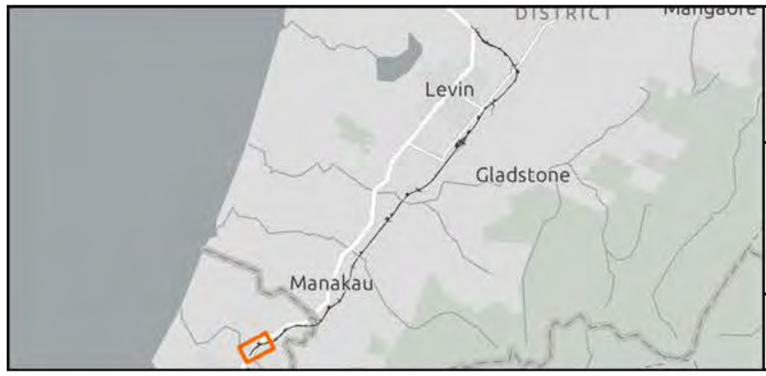
O2NL Draft Design (DF5 20220714)
Road User Markings
Road Surface
Shared Use Path
Bridges
Earthworks
Ponds

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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.





Final Spoil Sites Recommended for Consenting

Chainage 33600 - 35000

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: egkeli, jgesche, Stantec (2022)
Project Code: 310203848
Export Date: 05/8/2022

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

- O2NL Spoil Sites Recommended for Consideration (July 2022)
- O2NL Proposed Designation
- Property Parcels

O2NL Draft Design (DF5 20220714)

- Road User Markings
- Road Surface
- Shared Use Path
- Bridges
- Earthworks
- Ponds

DESIGN WITH COMMUNITY IN MIND

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of place and 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. This allows us to assess what's needed and connect our expertise, to appreciate nuances and envision what's never been considered, to bring together diverse perspectives so we can collaborate toward a shared success.

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.

Stantec trades on the TSX and the NYSE under the symbol STN.
Visit us at stantec.com or find us on social media.

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

Appendix 4.5 Material Supply Sites Summary Report

Ōtaki to north of Levin Highway Project

Appendix 4.5: Material Supply Study 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**
1	15.03.2022	First Draft	Ken Clapcott			
2	22.06.2022	Draft for Comment	Ken Clapcott / Chris Hansen		Jamie Povall	
3	31.07.2022	Final	Ken Clapcott / Chris Hansen	Phil Peet	Jamie Povall	Jon England

The conclusions in the Report are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion.

Quality statement

Project manager	Project technical lead
Jon England	Jamie Povall

PREPARED BY Ken Clapcott / Chris Hansen	[signature]	31 / 07 / 2022
CHECKED BY Phil Peet	[signature]	31 / 07 / 2022
REVIEWED BY Jamie Povall	[signature]	31 / 07 / 2022
APPROVED FOR ISSUE BY Jon England	[signature]	31 / 07 / 2022

WELLINGTON
Level 15, 10 Brandon Street, Wellington 6011
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 4 381 6700

Contents

List of appendices

List of tables

List of figures

Abbreviations

Enter Abbreviation	Enter Full Name
DBC	Detailed Business Case
DCR	Design & Construction Report
Ō2NL Project	Ōtaki to north of Levin Highway Project
CEDF	Cultural & Environmental Design Framework
RMA	Resource Management Act 1991

1 Introduction

1.1 Overview of Ō2NL Project

Waka Kotahi NZ Transport Agency (Waka Kotahi) is preparing Resource Management Act 1991 (RMA) approvals (designation and resource consents) to construct, operate and maintain the Ōtaki to north of Levin Highway Project (Ō2NL 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 to Ōtaki (PP2Ō) highway, currently under construction. The Ō2NL Project is included in the NZ Upgrade Programme to 'improve safety and access, support economic growth, provide greater route resilience, and better access to walking and cycling facilities'.

1.2 The Purpose of the Material Supply Study

Through the preparation of the Detailed Business Case (DBC) it was identified that the current earthworks design of the Ō2NL Project relies on a significant amount of fill, exceeding the amount of material that is anticipated to be won through earthwork cut activities. The current design (Revision DF5.0 – dated May 2022) is based on a shortfall of 800,000 to 1,500,000+ m^3 of earth material being found (or imported) for structural embankment fill. Design constraints, notably grade separating local roads from the highway, topography and geological conditions, cause this unfavourable cut/fill material balance.

In order to resolve this issue, a process has been developed to investigate locations that can be used to supply bulk fill earth material to the Ō2NL Project and the resource consents required.

The Material Supply Sites Study objectives are to:

- Identify material supply source options.
- Confirm sites are technically viable.
- Secure access to resources.
- If required, obtain approvals for the Material Supply Sites needed.

A key focus of the study has been to identify sites that can leave a legacy and create a positive environment for future generations, as informed by the Cultural and Environmental Design Framework (CEDF). This can be achieved by removing the material in a way that extends the landscape and leaves it in a form that the excavations are not obvious. Stantec's acknowledges the project's iwi partners who provided the inspiration for this positive legacy approach to the study.

Stantec also acknowledges Chris Hansen (from Chris Hansen Consultants Ltd) for his involvement into the study and contribution into this report.

1.3 Options to Address Shortfall in Bulk Material

A number of options have been identified to address this shortfall in bulk material for the Ō2NL Project. These include:

1. Commercial Suppliers
2. Materials within the proposed Ō2NL Designation
3. Materials outside the proposed Ō2NL Designation

Option 1 involves obtaining further knowledge and information from existing supplies and the industry. The known commercial sources within the region are shown in Figure 4.5 1.

Supplier Name	Total Kilometers
Blackleys	70
Bryfords Oringi	104
Bryfords Scarborough Road	89
Byfords Toetoe	137
Fulton Hogan Carterton	153
Fulton Hogan Featherston	119
G Bagrie - Waitohu Quarry	16
Higgins Gladstone Rd	15
Higgins Waingawa	170
HiRock - Linton	49
HiRock - Prenters Pahiatua	86
HiRock - Te Matai	66
Horokiwi	84
Hoults	63
Kiwi Point Quarry (H.G. Leach)	81
Longburn Shingle	51
PJ Warren Diversion Rd	123
PJ Warren Underhill Road	119
Pratts Quarry	68
Rangitikei Aggregates	74
Ruahine Aggregates	151
Tokomaru Quarry	40
Webb's Quarry	1
Willowbank Farm Quarry	71
Winstone Belmont	78
Winstone Bulls	64
Winstone Kapiti	35
Winstone Otaki	14
Winstone Waikanae	30

Figure 4.5 1: Known commercial sources within the region

The Ō2NL Project team will continue to investigate this option, with tasks including:

- A survey of existing quarry suppliers within the region to determine the availability of materials for the project.
- Close liaison with councils and the quarry industry to determine if any new quarry operations within the region are planned.

Sourcing material solely from commercial suppliers would likely result in significant additional costs which may impact the Ō2NL Project's economic feasibility. Transporting material from commercial sources would also generate significant additional truck movements on the existing roading network resulting in considerable environmental and traffic impacts.

Options 2 and 3 include undertaking a Material Supply Study that goes through a process of identifying numerous options, and then undertaking an assessment to ascertain a shortlist and ultimately the selection of the preferred Material Supply Sites. This process is documented within this report.

2 Key Principles and Values

Through Waka Kotahi's partnership with Mana Whenua, 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 core principles and values bring a focus on the Ō2NL Project development and design response for positive, measurable outcomes. These core principles and values have shaped the Material Supply Sites approach and findings, with the process described further in section 5.

3 Estimation of Bulk Fill Materials Required

The alignment has been broken into zones based on the project design, geology, topography and a potential construction zoning system. This system allows earthwork volumes to be quantified per zone and establish where there are material supply deficits. The zones are summarised in Table 4.5.1.

Table 4.5.1: Alignment Zone Breakdown

No.	Zone Start	Zone Finish	Ch Start (Approx.)	Ch Finish (Approx.)	Length (m) (approx.)
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

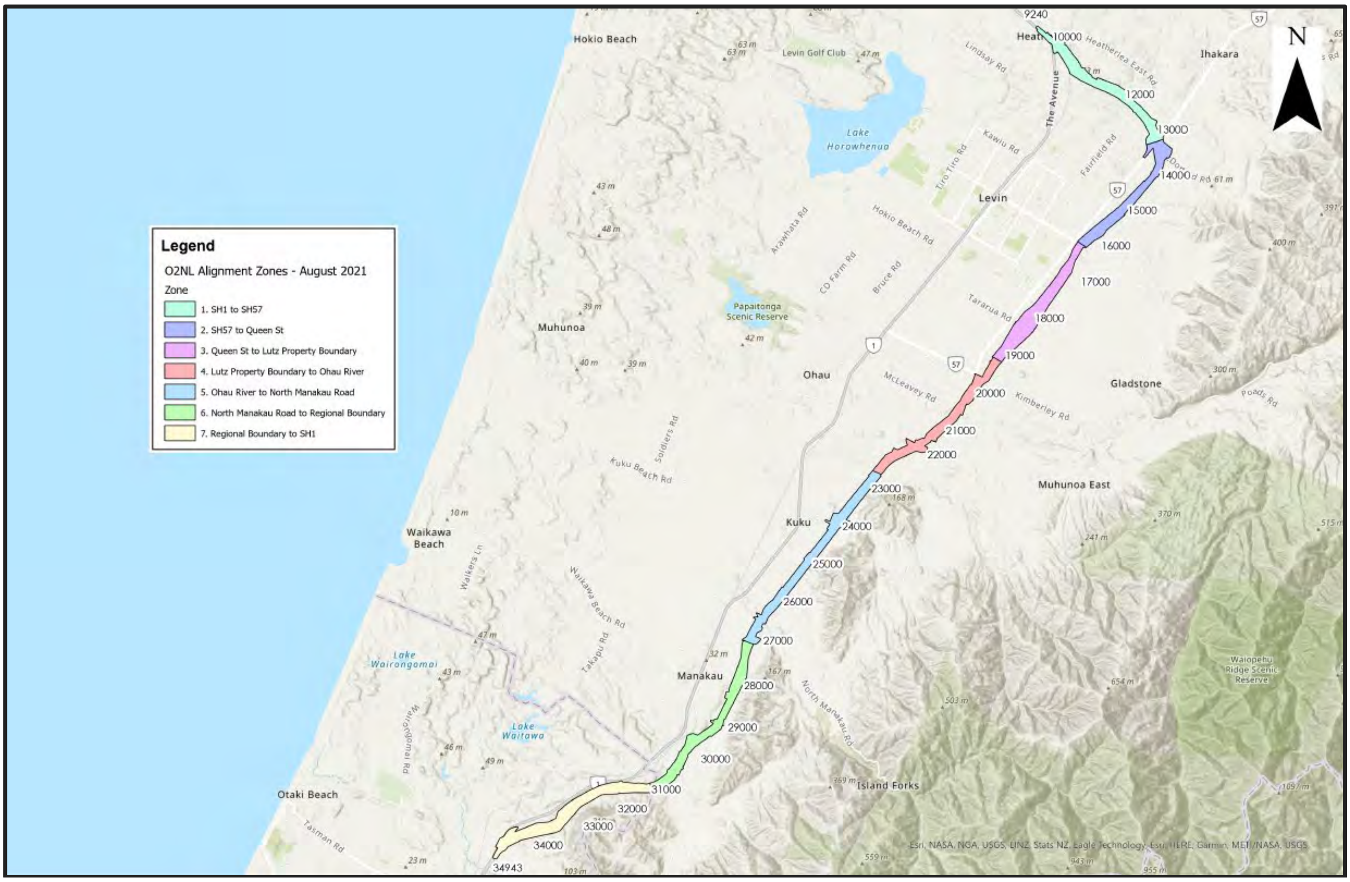


Figure 4,5.2: Alignment by Zone

Based on the concept design, anticipated fill requirements are presented in Table 4.5.2. Anticipated fill requirements are calculated volumes over and beyond what's available/reusable from the project cuttings. A percentage of the total cut material will need to be "spoiled or disposed" as it is deemed unsuited for earthwork construction of state highways.

Table 4.5.2: Ō2NL Project Fill Demand

Zone	Modelled Fill Volume Demand	Anticipated Extra Fill Demand* (Approx.)
1	378,000	68,000
2	148,000	77,000
3	285,000	130,000
4	231,000	45,000
5	447,000	230,000
6	512,000	423,000
7	411,000	0

**Additional fill material that cannot be sourced within zone based on expected material re-use*

4 Site Selection Considerations

4.1 Embankment Design Constraints / Opportunities

To achieve project goals (economic, carbon, core principle/values etc), a key objective of the Material Supply Site study was to identify supply sites within close proximity to where the fill is required.

Design constraints conditions currently cause an unfavourable cut/fill material balance due to:

- Flood levels which dictate the minimum road level of the highway (i.e., the required cover (fills) over culverts, bridge levels)
- Fills required for grade-separation (going over/under existing roads)
- Achieving horizontal/vertical geometric alignment
- Avoiding groundwater level interception at East of Levin

4.2 Geology and Geomorphology

A summary of the geological setting, published geology and the project's geological model (including a 18 page drawing set of the Projects' geological model) is provided within Stantec's Geotechnical Consenting Design Report[1]. Figure 4.5.3 summarises the published geology along the alignment.

Material source options considered for material supply of bulk road embankment fill include:

- Rock (Tt Rakaia Terrane Greywacke)
- Alluvial Deposits (Q1a/Q2a/Q3a Gravels)
- Shoreline Deposits (Q5b Sands)

This study categorised the Material Supply Sites into these three source options.

[1] SH1 Ōtaki To North Levin Highway Project, Appendix 4.1 - Geotechnical Consenting Design Report, July 2022

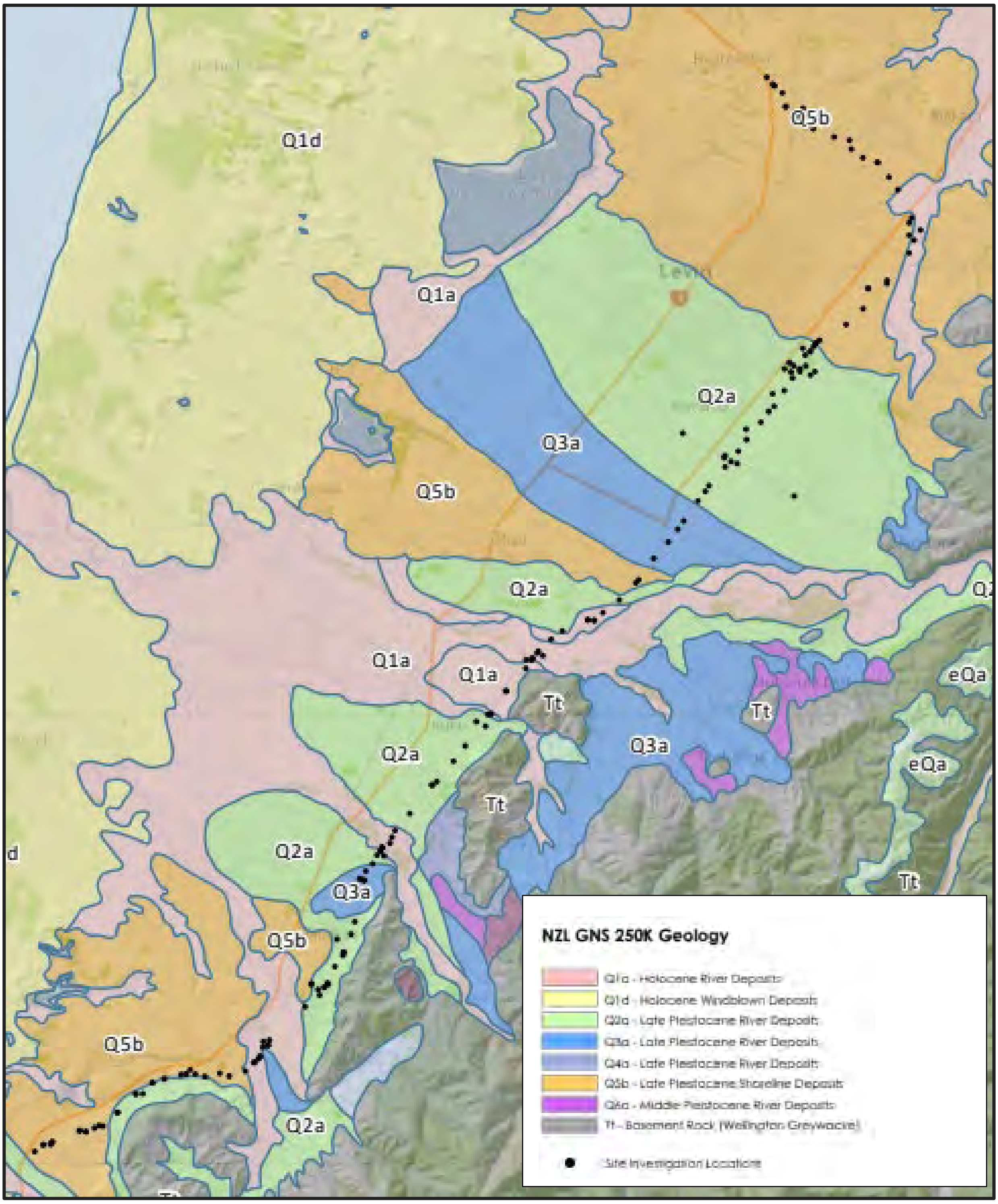


Figure 4.5.3: Published Geology along the alignment

In addition to the Stantec Geotechnical Interpretative Report, two technical memorandums have been compiled focusing on collating factual information and interpretation specifically relevant to the Material Supply Study. These include memorandums on Alluvial Deposits (Q1a/Q2a/Q3a Gravels) and Shoreline Deposits (Q5b Sands) and are attached within **Appendix 4.5.4**.

For completeness, an additional technical memorandum is also attached within **Appendix 4.5.4**. This was focused on exploring the quarry viability of the Q2a Gravels located East of Levin. This site was subsequently discarded in the long to short site selection process.

The Loess (surficial material) has been assessed (within the Geotechnical Interpretative report) to be challenging for reuse and therefore has not been targeted for material supply.

5 Material Supply Sites Selection Methodology

5.1 Long to Short List of Material Supply Sites

Through the DBC, it has been identified that there is a shortfall of material for structural road embankment fill, as outlined above. In order to address this matter, a process to identify locations and to develop a ‘legacy and outcome’ approach to selecting and then designing Material Supply Sites has been closely worked through with iwi partners using an assessment matrix aligned with the core principles and values, as outlined in Section 2 above. The agreed focus was on selecting sites that can ultimately result in a positive legacy outcome.

The first step in the Material Supply Site selection process was to identify a long list of potential site locations for evaluation. A long list of potential Material Supply Site locations was initially identified by the Stantec Geotechnical Team using the geotechnical information available, supported by a whanau consultation process, including a series of public events, undertaken by our iwi partners. This exercise resulted in 38 potential Material Supply Site locations being identified. Refer **Appendix 4.5.1** for figures illustrating site locations.

To ensure the Ō2NL Project’s core principles and values are brought into the selection process, the following assessment matrix was developed with iwi partners:

Table 4.5.3: Assessment Matrix - Tread lightly, with Whenua

	Evaluation Criteria (higher score the better, no-go if fatally flawed)			
	1	2	3	Fatal Flaw?
Minimise earthworks	Final form of the site will fit the existing landscape	Offers a good yield, allowing other sites to be avoided	Avoids important sites (including nearby) and has a low ‘discovery’ profile	
Select sites close to where the material is required as fill	Less than 1km from where the material will be needed	Within the designation/or more straightforward property arrangements	The only site in this area so will contribute to a good ‘spread’	
Minimise impact on waterways	Offset from active waterways	Avoids floodplain	No excavation below groundwater is needed to get a good yield	
Minimise impact on whakapapa	Avoids named natural features	Avoids areas of known settlement, events, stories, trade, travel, mahinga kai	Avoids other identified sites including wahi tapu	
Minimise impact on ecology	Avoids indigenous vegetation	Existing hydrological patterns can be retained	Avoids disruption of existing habitats including ecological pathways	
Minimise impact on community (note close sites will reduce disruption and improve safety)	There is a logical and short transport route that will avoid public roads	The site is located away from public areas or is to be screened using bunds/planting	There are very few houses with a view of the site (existing or proposed)	

Table 4.5.4: Assessment Matrix - Create an Enduring Legacy

	1	2	3	Fatal flaw?
Rehabilitation and restoration	The site can be easily revegetated (take no more than 10-15 years to achieve good cover?); rock sites take longer	The site is able to be linked with other rehabilitation and restoration planting for the project	Rehabilitation of the site will make a positive contribution to ecological pathways and/or threatened habitat types	
Hazard management	The site could improve flood management			
Community benefits	The site has potential as a quarry post project	The site provided business/property opportunities for mana whenua	Final form & rehabilitation provides opportunity for SUP designation and/or highway stopping place, including appropriate access to streams/other features	

The matrix assessment approach led to the identification of the following criteria used to identify the long list of sites:

- Proximity to the future highway designation
- Good spread of sites along the highway alignment and especially at the areas where Material Supply Sites are expected to be mostly needed.
- Opportunities for landscaping interventions without impact on the natural environment
- Opportunities provided by geomorphological features (e.g. natural terraces) to level off or provide more usable land to farms or adjacent properties, and
- No effect on environmental, archaeological, cultural or other constraints based on the Project Design Team's existing knowledge (at the time).

A table summarising the iwi partners matrix assessment of the long list is provided in **Appendix 4.5.1**.

In parallel with iwi partners assessment, the long list was also evaluated at an 'initial level' by technical specialist assessors using a "traffic light signal assessment" process. A table summarising the full traffic light signal assessment of the long list is provided in **Appendix 4.5.1**.

The technical specialist assessors (i.e. organisations) who contributed to the long list evaluation process are set out in Table 4.5.5 below.

Table 4.5.5: Technical Specialist Assessors

Evaluation Topic	Technical Specialist Assessor (Organisation)	Technical Specialist Assessor
Landscape / Visual	Isthmus	Gavin Lister/Lisa Rimmer
Terrestrial Ecology	Wildland Consultants Ltd	Nick Goldwater
Aquatic Ecology	EOS Ecology	Alex James
Archaeology and Heritage	Insite Archaeology	Daniel Parker
Built Heritage	Ian Bowman	Ian Bowman
Flooding and Stormwater	Stantec	Andrew Craig
Groundwater	SLR	Jack McConchie
Water Quality	Stantec	Keith Hamill/Kristy Harrison
Transport	Stantec	Phil Peet
Noise & Vibration	Altissimo	Michael Smith
Social	Beca	Jo Healy
Air Quality	Pattle Delamore Partners	Andrew Curtis
Highly Productive Land Values	Land Vision	Lachie Grant
Contaminated Land	Stantec	Kathryn Halder

Following selection of the technical specialist assessors, each were given access to Google Earth KMZ files that include polygons for each site and indicative access, and an Excel spreadsheet to record their traffic light signal evaluations for each long listed Material Supply Site location. This evaluation system enabled each technical specialist assessor to record whether they had low, medium or high-level concerns with any of the sites as follows:

- Green (or 1) 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 3) if an option is likely to have serious or significant negative impacts or issues.

The purpose of this initial assessment was to identify any 'fatal flaws' with the long list of sites from an environmental perspective that would mean the site is not taken to the next level of investigation. This assessment also provided environmental opportunities to be identified which resulted in the identification of important indigenous vegetation being located on site #25 that needed to be retained, and the identification of an alternative new site #36 just north of site #25 for further assessment. The outcomes of the traffic light signal assessment were provided to iwi partners.

At the same time, a collection of sites were visited by iwi partners, CEDF and archaeology experts and based on that site visit, further sites were excluded on the basis that proposed use of the site would cause significant disturbance and would not be able to developed in a manner that delivered positive legacy outcomes.

5.2 Final Short List of Material Supply Sites

The next step in the process was to determine a short list of Material Supply Sites based on the outcomes of the long list process. The final short list of Material Supply Sites and the reason they were selected is set out in Table 4.5.6. A total of fourteen sites were discarded as they were fatally flawed as part of the "Tread lightly, with Whenua" assessment criteria. The majority of the potential rock source sites were included in these discarded sites.

Table 4.5.6: Final Short List of Material Supply Sites Progressed Further

Material Supply Site ID	Location (Approx. Chainage)	Traffic Light Signal Evaluation	Key Reasons for Progressing Material Supply Site
#15 (South of Waikawa Stream)	26500 - 27100	Green – Orange	There are no 'red' traffic light signals for this site. There are a six 'orange' signals relating to: air quality; archaeology; transport; contaminated land; social and high class soils. Archaeology would turn 'green' if testing determines no site present/destroyed or bounds of site identified and avoided.
#19 North of Waikawa Stream)	25700 - 26100	Green – Orange	There are no 'red' traffic light signals for this site. There are six 'orange' signals relating to: freshwater ecology; terrestrial ecology; transport; contaminated land; social and high class soils. Freshwater ecology would turn 'green' if a 20m setback from stream and transport if an alternative access considered. The remainder of the signals are 'green'.
#36 North of Ohau River	22000	Green	There are no 'red' traffic light signals for this site. All signals are 'green' apart from two 'orange'' signals (air quality & social) primarily due to possible air quality effects on nearby crops and impacts on a large area of farmland and one house.
#34a	12000	Green	There are no 'red' traffic light signals for this site. All signals are 'green' apart from three 'orange' signals relating to: landscape, social & water quality.

The next step of the process involved undertaking geotechnical investigations of the short-listed sites (where land access was available) to confirm geotechnical assumptions to provide a higher level of confidence regarding material available. The outcomes of these geotechnical investigations are summarised in Section 6 below, with further technical information contained within the memorandums within **Appendix 4.5.4**.

At the same time iwi partners undertook a review of the process so far and, in discussions with ecologists, hydrogeologists, hydrologists and water quality experts, confirmed that short listed sites were appropriate.

During this review, iwi identified an opportunity for a wetland or lake to be created at site #36 that would meet the legacy outcome focus of the Project. This opportunity was investigated further to determine whether creating a wetland or open water area is feasible from a hydrology and flood management perspective, and whether there would be any adverse environmental effects on groundwater conditions, and in particular Lake Papaitonga and Punahau/Lake Horowhenua. Creating an open water area also provides an off-setting opportunity for the loss of open water from the Project. A workshop was held with relevant experts to consider at a high-level whether it was feasible for the site to be developed as a wetland or open water area, with no adverse environmental effects on Lake Papaitonga or Punahau/Lake Horowhenua. The hui concluded a wetland on the site was feasible from a hydrological perspective.

Conceptual designs on the short-listed sites were prepared showing a possible extent of excavations, contours, access etc, along with initial, high level, indicative concepts, to illustrate rehabilitation options and to test the opportunities to preserve, restore, enhance and create positive outcomes at each of the sites. These draft designs are shown in the initial concept drawings included in **Appendix 4.5.2**.

The initial concept drawings of the short listed sites were then provided to the technical specialist assessors to undertake a more detail assessment to determine if there were any environmental effects relevant to their area of discipline. **Appendix 4.5.3** collates the responses from the experts in a table format, with a summary of the assessments provided in Section 6 below.

In response to a number of matters raised in the detail assessment of concept drawings provided by experts, the perimeter extent of each of the short-listed Material Supply Sites were reviewed and refined.

6 Preferred Material Supply Sites

6.1 General description

The resultant short list of Material Supply Sites (identified in Table 4.5.3 above) have been chosen as they provide opportunity to develop an end form landscape that has similar characteristics to the current environment.

For the 3 alluvial sites (site #15, #19 and #36), the work can be designed so that the position of existing terraces are moved horizontally in manner that retains /mimics existing riverine sinuosity. These sites are all carefully located to avoid direct effects on water courses and no adverse effects on groundwater are anticipated (to be confirmed by proposed geotechnical investigations and future assessment during detailed design).

For the Qb5 sand site (site #34a), the existing wetland can be enhanced and restored. There will be no additional effects on groundwater, water, native bush / trees (the area impacted is in grass) and wetlands.

Sites were also selected on the basis that they could provide a positive legacy outcome. For example, as discussed above, there is an opportunity to develop a wetland on site #36 as a legacy outcome for the Ō2NL Project with no adverse effects on groundwater conditions.

The final short-listed sites are all located within the Horizons RC and Horowhenua DC areas of jurisdiction.

The following sections provide a description of the final short-listed sites, a summary of the geotechnical investigation that were undertaken, and the required actions that were identified from Technical Specialist assessment.

6.2 Site #15 – South of Waikawa Steam

6.2.1 Geotechnical Assessments

6.2.1.1 Topography / Slope Landform / Surface Conditions

This site lies on the floodplain, slightly elevated from the contemporary bed of the Waikawa Stream. Topography at the site is flat to very gently sloping towards the terraced slopes above the Waikawa river.

Two drainage channels cut through the site, in a north-south and a south-west to north-east orientation. The channels are typically 1m across and up to 1m deep. The site is currently used as grazing farmland.

Figure 4.5.4 shows the borrow site area (enclosed within the dashed blue line) in the context of the published geological map (Begg & Johnston, 2000) and the nearby site investigations

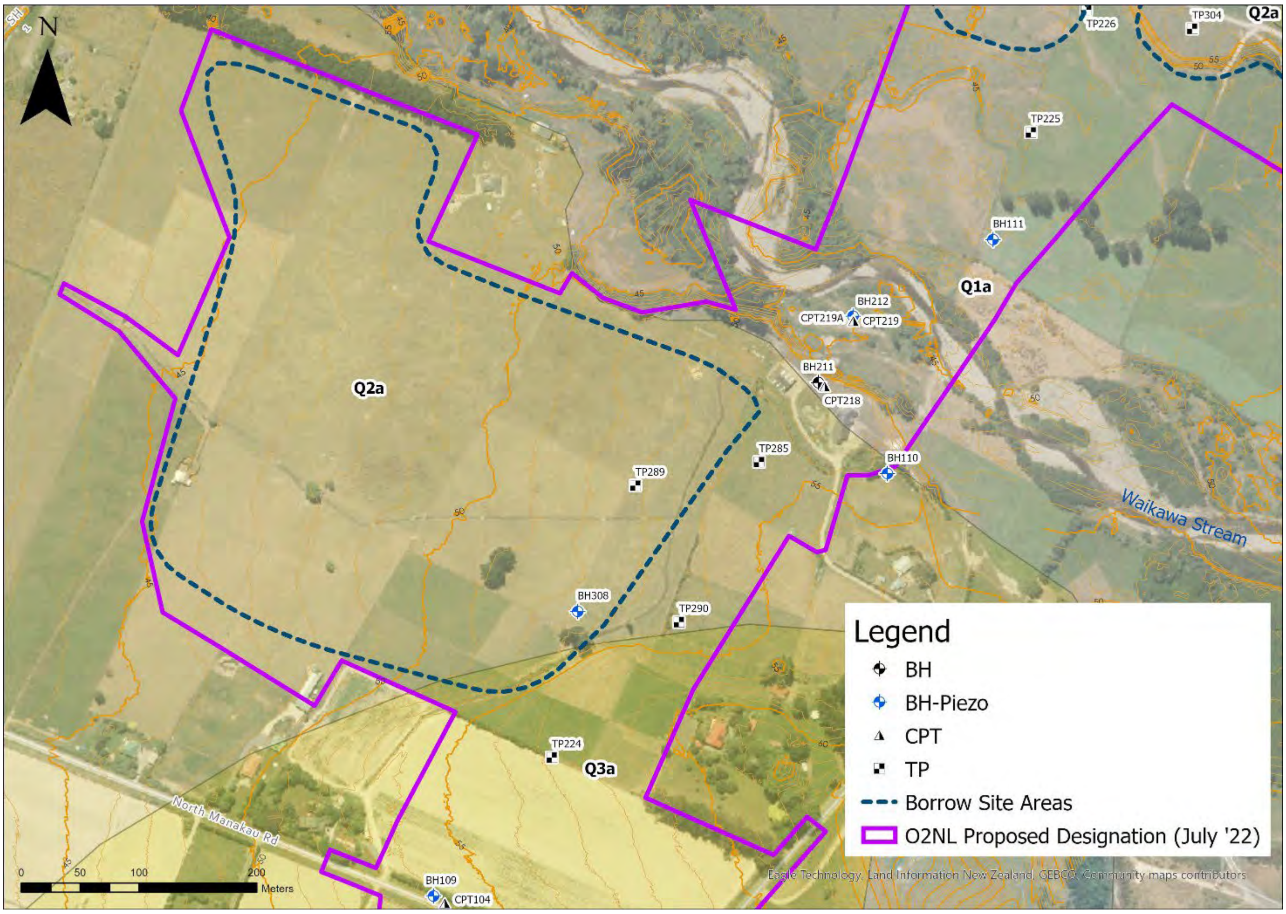


Figure 4.5.4: Site plan - South of Waikawa Stream

6.2.1.2 Subsurface Conditions and Geologic Interpretations

The Waikawa Stream South Site is shown on the GNS 1:250,000 Geology map of New Zealand to be situated in the Q2a Pleistocene alluvium geological unit. Table 4.5.7 presents the available investigation data for the site.

Table 4.5.7: Summary of Site Investigations – South of Waikawa Stream

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m BGL)	Depth where Gravels of Interest Encountered (m BGL)
		Easting	Northing				
BH109	Borehole	1788177	5491389	54.2	27094	30.45	3.45 – 30.45
BH210	Borehole	1788248	5491362	55.1	27095	30.45	2.90 – 30.45
BH211	Borehole	1788504	5491825	52.6	26559	34.95	1.50 – 34.95
BH308	Borehole	1788300	5491630	52.5	26822	15.35	1.50 – 15.35
TP224	Test pit	1788278	5491507	57.3	26950	3.80	2.40 – 3.80
TP223*	Test pit	1788190	5491191	51.0	27277	3.60	2.10 – 3.60
TP285	Test pit	1788454	5491758	54.2	26644	3.80	0.30 – 3.80
TP289	Test pit	1788349	5491738	52.9	26709	3.40	0.10 – 3.40
TP290	Test pit	1788386	5491622	53.8	26796	3.50	0.05 – 3.50
CPT104	CPT	1788187	5491383	54.3	27096	3.24	Refusal on gravels?
CPT217	CPT	1788251	5491359	55.4	27097	11.34	Refusal on gravels?
CPT218	CPT	1788509	5491822	52.8	26559	1.53	Refusal on gravels?

The expected ground conditions at the area of interest based on the forementioned investigations is summarised in Table 4.5.8 below.

Table 4.5.8: Waikawa Stream South Site Expected Ground Conditions

Unit Name	Description	Typical Depth to the Top of Layer (m bgl)	Typical Thickness Range (m)	SPT 'N' Range (average)
Q2a/Qa3 Pleistocene Alluvium – Undifferentiated	Medium dense to very dense, silty GRAVEL with minor clay and sand layers	0 - 6	13 - 15	0 – 50 (16)

BH308 has the only piezometer within the proposed area. Groundwater levels have varied from 4.9 to 6.9m BGL, with measurements undertaken towards the end of summer when the water table is likely to be depressed. The ground water level may be higher during winter months.

Ponded water was observed within surface depressions during site visits in October 2021, but these were perceived as perched.

6.2.2 Actions resulting from Technical Specialist assessment

The detail assessment of Site #15 confirmed there were no significant environmental effects on flooding and hydrology; freshwater ecology; terrestrial ecology; archaeology; noise and vibration; landscape & visual; heritage; water quality; groundwater; and erosion and sediment control.

Actions resulting from Technical Specialist assessment include:

- Air Quality – perimeter extent of Site #15 has been changed to exclude the residential property from within the site; any dust effects would be managed through a Construction Management Plan; alternative water supplies can be made available if required.
- Transport - traffic effects will be managed through a Construction Traffic Management Plan, site controls and timeframes for material extraction.

- Contaminated Land – the perimeter extent of Site #15 has been modified to avoid a potential dump, but this will need be confirmed through further investigations.
- Social - perimeter extent of Site #15 has been changed to exclude the residential property from within the site; the changed perimeter extent goes further west; the rehabilitation of the site would see approximately 1/3 of the site (to the west) be restored to pasture; the remainder of the site will include landscape and visual planting, restoration wetlands and future access to Waikawa Stream and a recreation reserve via the Shared Use Path has positive community benefits.
- High Class Soils – while there will be a loss of high class soils, it is proposed to reinstate approximately 1/3 of the site (to the west) into pasture.

These actions have been taken or are included as planned management regimes within the Assessment of Environmental Effects.

6.3 Site #19 – North of Waikawa Stream

6.3.1 Geotechnical Assessments

6.3.1.1 Topography / Slope Landform / Surface Conditions

The topography of the site is flat to very gently sloping towards the Waikawa Stream to the south. The southern-most extent of the site is bounded by an alluvial terrace approximately 7m higher in elevation. A small drainage channel spanning 1m across and 1m deep passes from north-west to south-east through the site and connects to a tributary of the Waikawa Stream approximately 300m south of the site. The site is currently used as grazing farmland and crop paddocks.

Figure 4.5.5 shows the borrow site areas (enclosed within the blue dashed lines) in the context of the published geological map (Begg & Johnston, 2000).

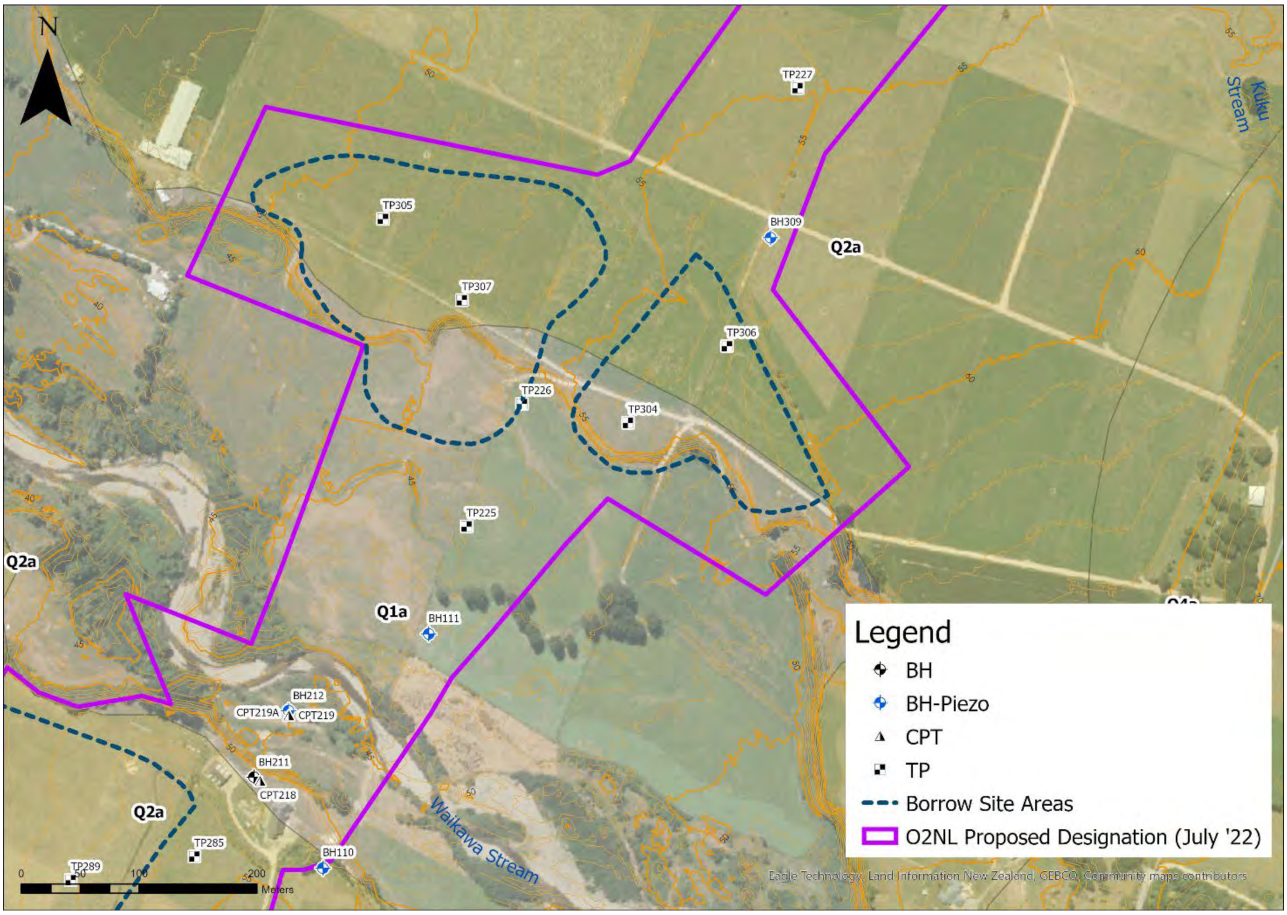


Figure 4.5.5: Site plan - North of Waikawa Stream

6.3.1.2 Subsurface Conditions and Geologic Interpretations

The Waikawa Stream North Site is shown on the GNS 1:250,000 Geology map of New Zealand to be situated in the Q2a Pleistocene alluvium geological unit. Table 4.5.9 presents the available investigation data for the site.

Table 4.5.9: Summary of Site Investigations - North of Waikawa Stream

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination depth (m BHL)	Depth where Gravels of Interest Encountered (m BGL)
		Easting	Northing				
BH309	Borehole	1788943	5492283	56.9	25918	15.45	1.65 – 15.45
TP304	Test Pit	1788822	5492126	56.4	26116	3.5	1.6 – 3.5
TP305	Test Pit	1788614	5492299	51.9	26110	3.4	0.6 – 3.4
TP306	Test Pit	1788906	5492191	56.5	26013	3.2	1.2 – 3.2
TP307	Test Pit	1788681	5492230	53.0	26122	3.5	0.8 – 3.5
TP226	Test Pit	1788732	5492142	46.2	26159	3.9	0.6 – 2.7
TP227	Test Pit	1788966	5492410	54.8	25804	4.1	2.1 – 4.1

The expected ground conditions at the area of interest based on the forementioned investigations is summarised in Table 4.5.10 below.

Table 4.5.10: Waikawa Stream North Site Expected Ground Conditions

Unit Name	Description	Typical Depth to the Top of Layer (m bgl)	Typical Thickness Range (m)	SPT 'N' Range (average)
Loess	Stiff, clayey SILT, moderate to high plasticity.	0	0.5 – 1.5	-
Q2a/Q3a Pleistocene Alluvium	Medium dense to very dense, silty GRAVEL with minor clay and sand layers.	0 - 6	13 - 15	0 – 50

Groundwater levels have been measured in the piezometer within BH309.

Groundwater levels varied from 10.3 to 13.0m BGL, with groundwater measurement undertaken towards the end of summer when the water table is likely to be depressed. The ground water level may be higher during winter months. The nearby BH111 has also recorded groundwater level depth >10m BGL.

6.3.2 Actions resulting from Technical Specialist assessment

The detail assessment of Site #19 confirmed there were no significant environmental effects on flooding and hydrology; air quality; archaeology; noise & vibration; landscape & visual; heritage; water quality; groundwater; high class soils; and erosion and sediment control.

Actions resulting from Technical Specialist assessment include:

- Freshwater Ecology – southern boundaries have been adjusted to provide a buffer to Stream 27.1; ESC Plan manages sediment on eastern boundary close to Stream 28
- Terrestrial Ecology – western boundary amended to avoid small area of vegetation, trees on eastern side to be identified.
- Transport - traffic effects will be managed through Construction Traffic Management Plan; an alternative new accessway onto SH1 from Kuku East Rd should be investigated as part of this plan.

- Contaminated Land – further investigation of the low point of the site to be undertaken.
- Social – planting included to manage potential visual effects on two houses.

These actions have been taken or are included as planned management regimes within the Assessment of Environmental Effects.

6.4 Site #36 – North East of Ohau River

6.4.1 Geotechnical Assessments

6.4.1.1 Topography / Slope Landform / Surface Conditions

The site is relatively flat with small hummocks representing historical river or stream banks. The southernmost extent of the site is bounded by a series of small alluvial terraces that extend to the active river channel. The site is currently used as grazing farmland and crop paddocks.

Figure 4.5.6 shows the borrow site area (enclosed within the blue dashed line) in the context of the published geological map (Begg & Johnston, 2000).

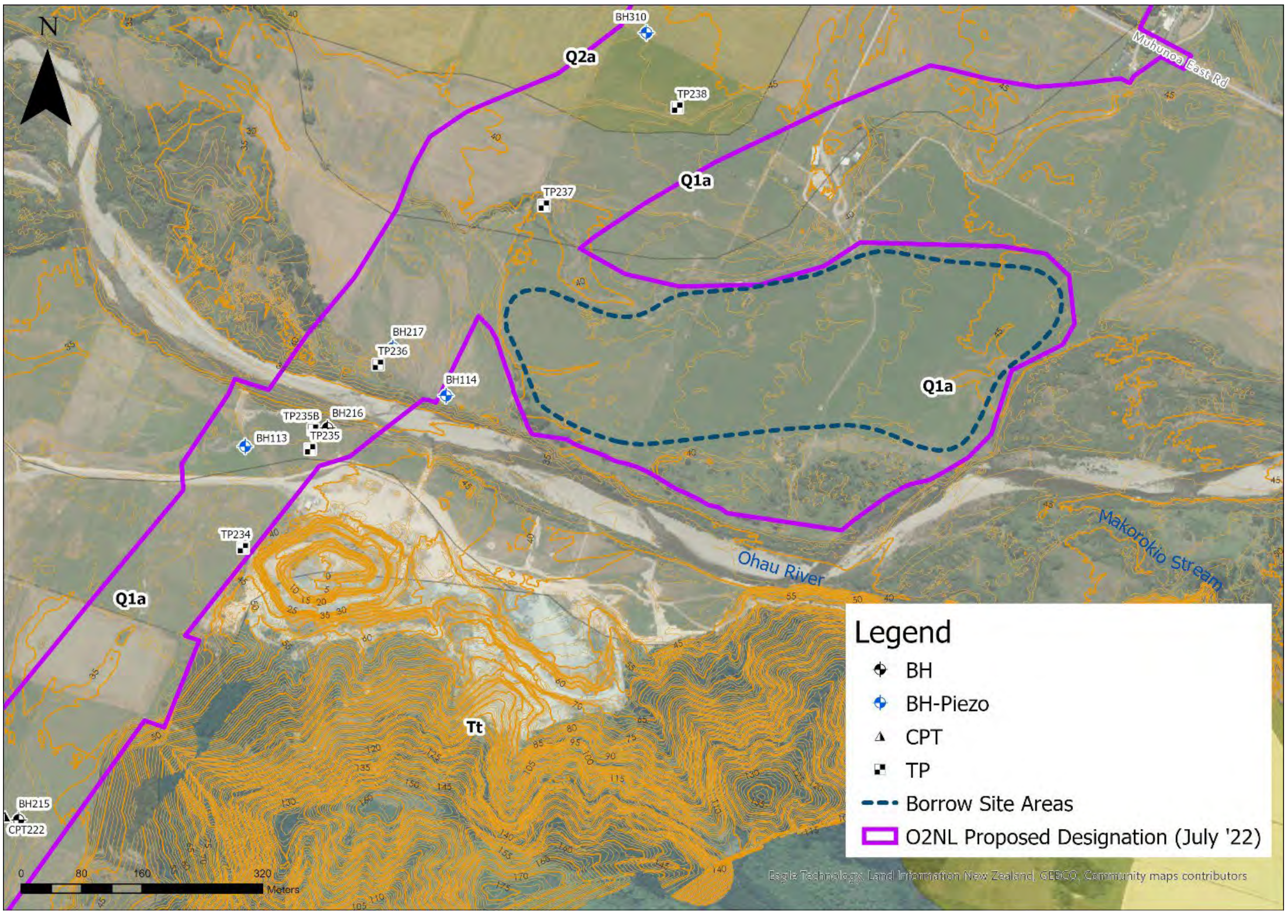


Figure 4.5.6: Site plan - Northeast of Ōhau River

6.4.1.2 Subsurface Conditions and Geologic Interpretations

The Ohau River North east Site is shown on the GNS 1:250,000 Geology map of New Zealand to be situated within the Q1a Holocene alluvium geological unit.

This area was not targeted during the 2022 Stage 3 investigations due to late identification of this Material Supply Site. We have interpreted the nearby investigations which are generally within the designation corridor, north of the Ohau River. The actual ground conditions at the site may be different than described and this site has increased risk of unknown geological and groundwater conditions.

Table 4.5.11 presents a summary of the relevant intrusive investigations completed near the area of interest.

Table 4.5.11: Summary of nearby site investigations - Northeast of Ohau River

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m BGL)	Depth where Gravels of Interest Encountered (m BGL)
		Easting	Northing				
BH114	Borehole	1791048	5494886	38.5	22560	27.0	0.2 – 25.5
BH217	Borehole	1790977	5494949	37.9	22560	35.0	1.5 – 27.0
TP236	Test Pit	1790958	5494927	38.2	22590	4.0	0.2– 4.0
TP237	Test Pit	1791178	5495138	39.1	22281	3.6	1.3 – 3.6
TP238	Test Pit	1791355	5495268	44.2	22058	3.8	0.3 – 3.8
TP310	Test Pit	1791543	5495415	47.1	21827	3.0	0.1 – 3.0

The expected ground conditions at the area of interest based on the forementioned investigations is summarised in Table 4.5.12 below.

Table 4.5.12: Ohau River North East Site Expected Ground Conditions

Unit Name	Description	Typical Depth to the Top of Layer (m bgl)	Typical Thickness Range (m)	SPT 'N' Range (average)	Qc Range
Q1a Holocene Alluvium	Silty sandy GRAVEL, with cobbles, loose to very dense.	0	5 - 12	10 - 50+	Q1a Holocene Alluvium

6.4.2 Actions resulting from Technical Specialist assessment

The detail assessment of Site #36 confirmed there were no significant environmental effects on flooding and hydrology; freshwater ecology; terrestrial ecology; air quality; archaeology; transport; noise & vibration; contaminated land; landscape & visual; heritage; water quality; groundwater; and erosion and sediment control.

Actions resulting from Technical Specialist assessment include:

- Social – any dust and noise effects on house will be managed through a Construction Management Plan; rehabilitation planting included with ecology and natural character mitigation.

6.5 Site #34a – Koputaroa

6.5.1 Geotechnical Assessments

6.5.1.1 Topography / Slope Landform / Surface Conditions

The site is positioned on the northern edge of a gully, which has incised from the adjacent terrace. The terrace is undulating with moderately sloping hills. A farm dam is located at the western extent of the gully as forms a small pond.

Figure 4.5.7 shows the borrow site area (enclosed within the blue dashed line) in the context of the published geological map (Begg & Johnston, 2000).

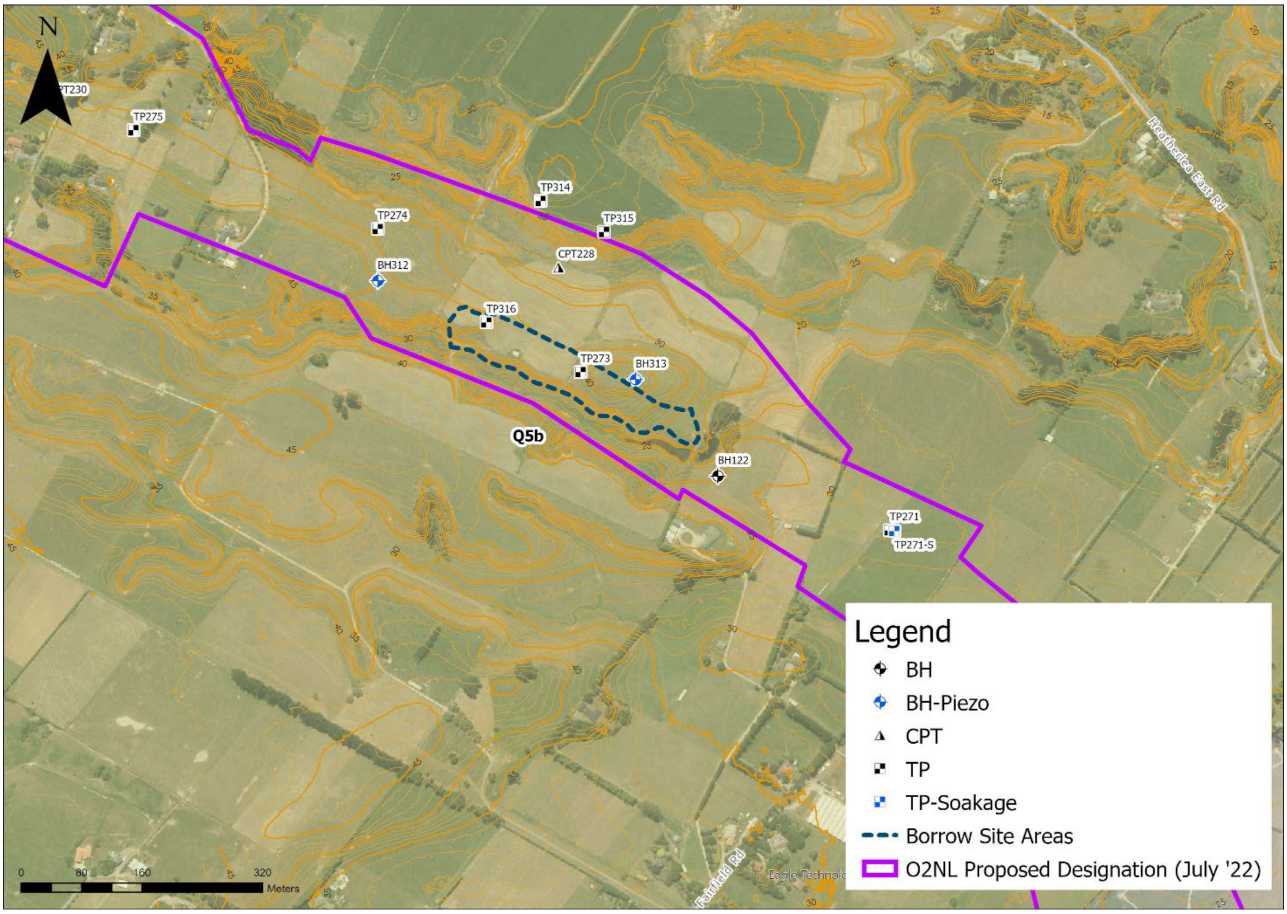


Figure 4.5.7: Site plan - Koputaroa

6.5.1.2 Subsurface Conditions and Geologic Interpretations

The Koputaroa Site is shown on the GNS 1:250,000 Geology map of New Zealand to be situated within the Q5b Shoreline Deposits geological unit.

Table 4.5.13 presents a summary of the relevant intrusive investigations completed near the area of interest.

Table 4.5.13: Summary of Nearby Site Investigations – Koputaroa Site

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m bgl)
		Easting	Northing			
BH122	Borehole	1796056	5502678	29.5	12150	19.78
BH312	Borehole	1795605.0	5502937.0	45.5	11559	15.45
BH313	Borehole	1795947.0	5502806.0	44.1	11933	15.38
TP273	Test Pit	1795874	5502816	38.0	11850	3.50
TP274	Test Pit	1795605	5503006	38.5	11550	3.90
TP275	Test Pit	1795281	5503137	41.7	11200	3.20
TP276	Test Pit	1795027	5503350	49.2	10850	3.90
TP314	Test Pit	1795821	5503043	38.2	11717	3.50
TP315	Test Pit	1795905	5503002	36.7	11805	3.50
TP316	Test Pit	1795749	5502882	41.2	11716	3.40

The expected ground conditions at the area of interest based on the forementioned investigations is summarised in Table 4.5.14 below.

Table 4.5.14: Koputora Site Expected Ground Conditions

Unit Name	Description	Typical Depth to the Top of Layer (m bgl)	Typical Thickness Range (m)	SPT 'N' Range (average)
Loess	Silty CLAY, firm to very stiff, moist, low to moderate plasticity.	0	1 - 3	-
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+*

Groundwater levels have been measured in the piezometer within BH312 and BH313. Groundwater levels have varied from 7.3 to 11.3m BGL. It is perceived that this represents a perched groundwater within the terrace.

6.5.2 Actions resulting from Technical Specialist assessment

The detail assessment of Site #34a confirmed there were no significant environmental effects on flooding and hydrology; freshwater ecology; terrestrial ecology; air quality; archaeology; transport; noise & vibration; contaminated land; heritage; groundwater; high class soils; and erosion and sediment control. It was noted that while there were no significant archaeology, potentially this site has a likely archaeological site in the vicinity.

Actions resulting from Technical Specialist assessment include:

- Landscape - mitigated through planting batter below highway and the restoration planting suggested;
- Social – overall landscape mitigation proposed for corridor manage effects on nearby house(s);
- Water Quality - potential sediment discharges will be managed through standard erosion and sediment control included in the ESC Plan; potential impacts on water temperature will be addressed by stream and wetland revegetation already proposed as part of the Project.

These actions have been taken or are included as planned management regimes within the Assessment of Environmental Effects.

7 Recommendations for Future Works

7.1 Geotechnical Investigations

Additional geotechnical investigations are recommended at each of the preferred sites to; confirm groundwater levels, ascertain spatial variability of the subsurface material, and ensure the excavated material will be fit for purpose. The information obtained will also be used to confirm the temporary and permanent design of the sites.

7.2 Design

7.2.1 Temporary works

Temporary design will need to incorporate:

- Erosion and Sediment Control measures
- Final Construction Methodology, including
  - Any staged excavations
  - Areas in which spoiled material is used for recontouring

7.2.2 Permanent

Permanent design will need to incorporate:

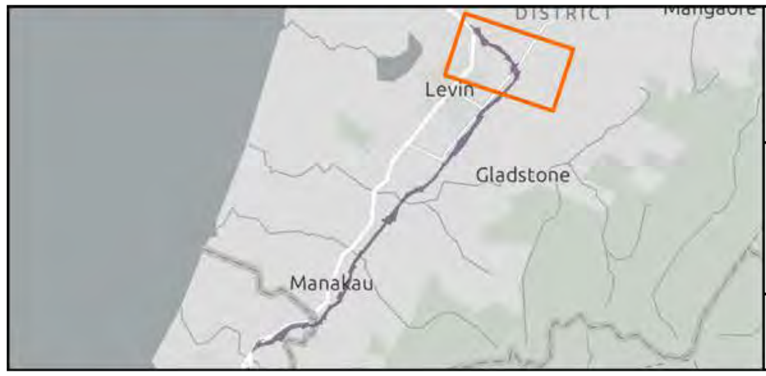
- Final volume demands required from the Project
- The principles developed during this study and included in the CEDF
- Drainage considerations

Appendices

We design with community in mind

Appendix 4.5.1 Summary of the Long List Assessment

Figures Illustrating “Long List” Locations



Stantec

O2NL Material Supply - Long List

Zone 1: SH1 to SH57

WAKA KOTAHI NZ TRANSPORT AGENCY

O2NL Proposed Designation 20210729
O2NL Potential Material Supply Sites
O2NL Potential Material Supply Sites Access Routes
10m Contours
River / Stream
Property Parcels
Roads

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: rmcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Stantec

O2NL Material Supply - Long List

Zone 2: SH57 to Queen St

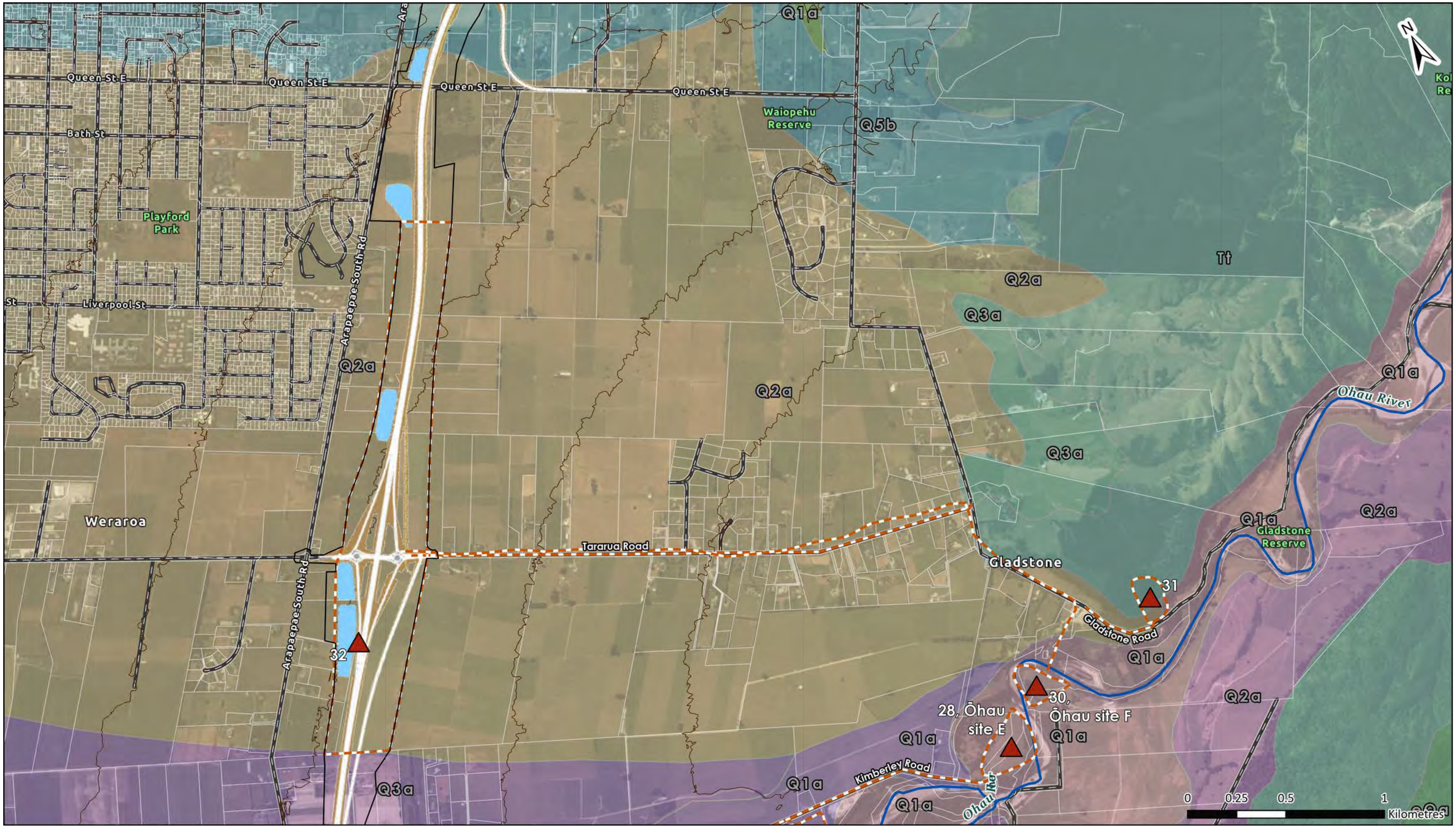
WAKA KOTAHI NZ TRANSPORT AGENCY

- O2NL Proposed Designation 20210729
- O2NL Potential Material Supply Sites
- O2NL Potential Material Supply Sites Access Routes
- 10m Contours
- River / Stream
- Property Parcels
- Roads

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: rmcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

O2NL Material Supply - Long List

Zone 3: Queen St to Lutz Property Boundary

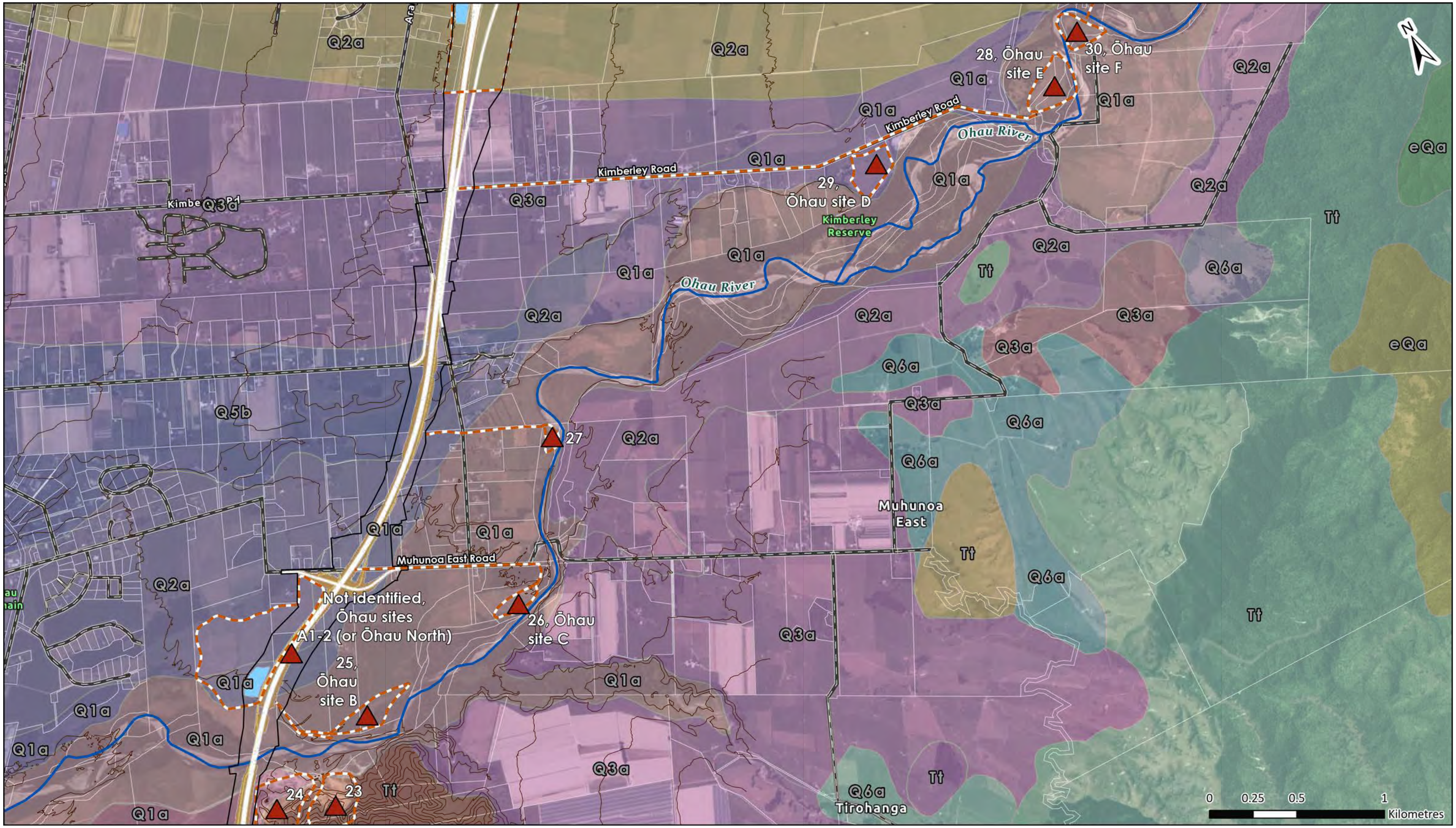
WAKA KOTAHI NZ TRANSPORT AGENCY

- O2NL Proposed Designation 20210729
- O2NL Potential Material Supply Sites
- O2NL Potential Material Supply Sites Access Routes
- 10m Contours
- River / Stream
- Property Parcels
- Roads

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: rmcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

O2NL Material Supply - Long List

Zone 4: Lutz Property Boundary to Ohau River

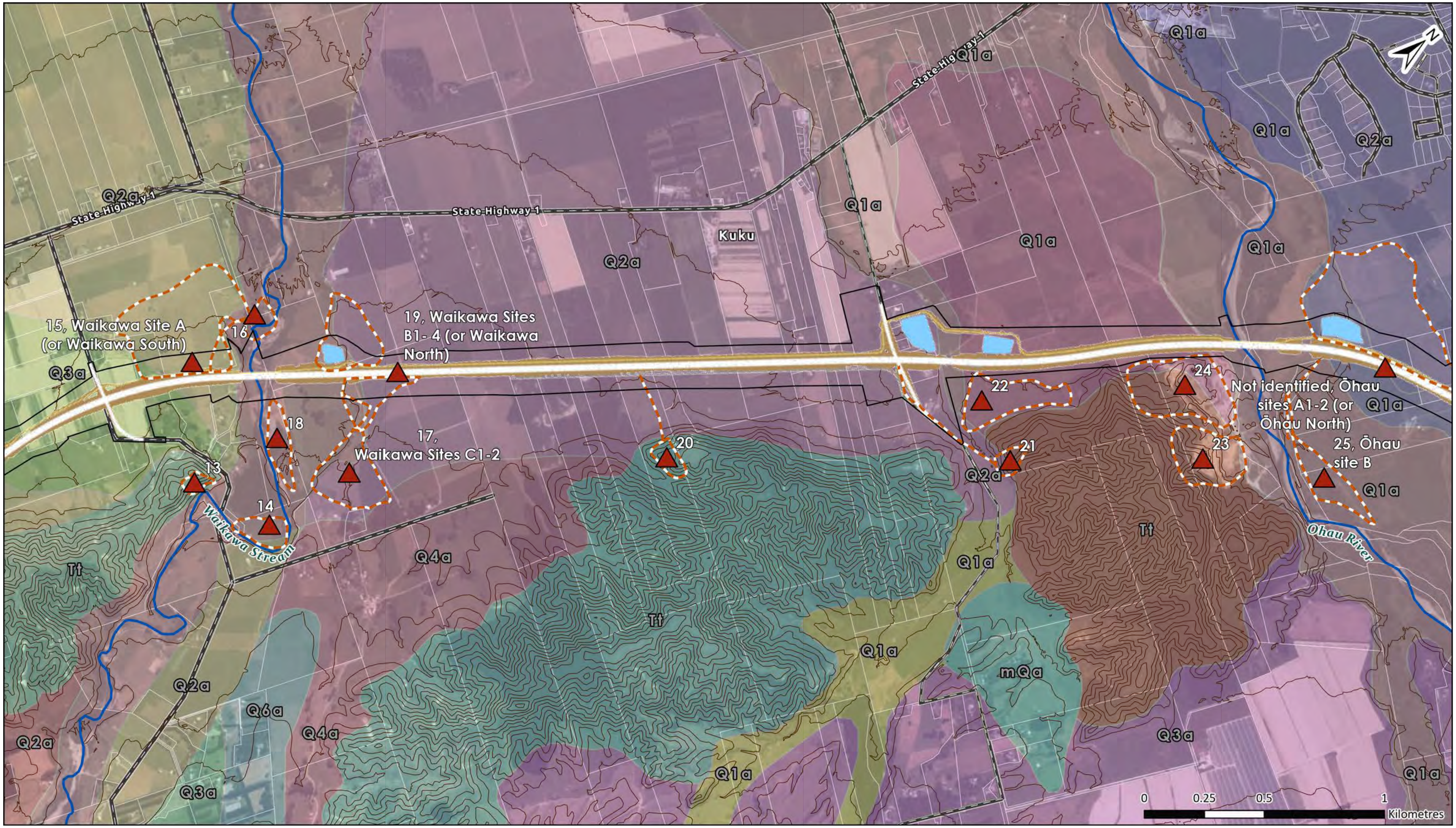
WAKA KOTAHI NZ TRANSPORT AGENCY

- O2NL Proposed Designation 20210729
- O2NL Potential Material Supply Sites
- O2NL Potential Material Supply Sites Access Routes
- 10m Contours
- River / Stream
- Property Parcels
- Roads

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: rmcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

O2NL Material Supply - Long List

Zone 5: Ohau River to North Manukau Road

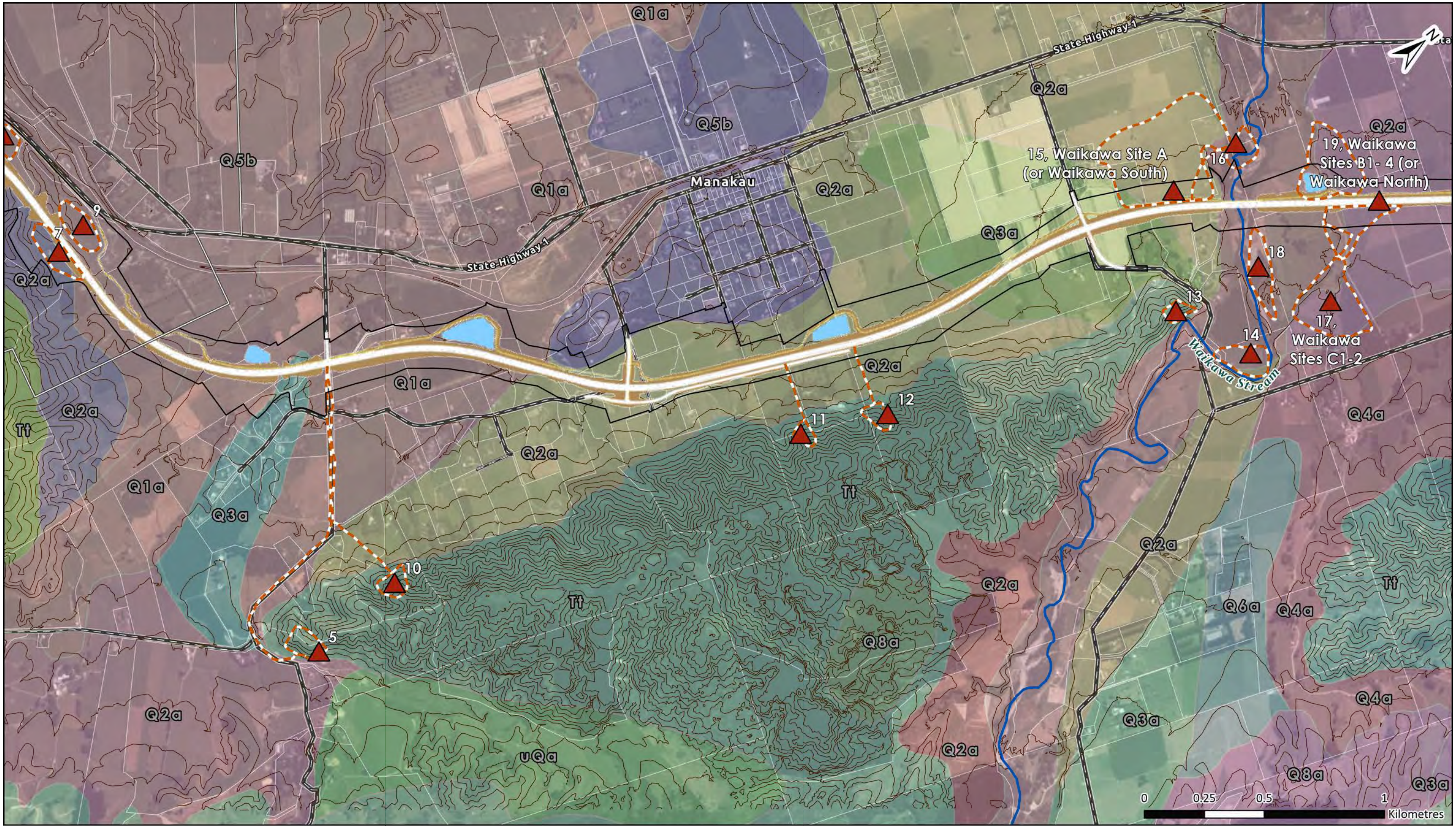
WAKA KOTAHI NZ TRANSPORT AGENCY

- O2NL Proposed Designation 20210729
- O2NL Potential Material Supply Sites
- O2NL Potential Material Supply Sites Access Routes
- 10m Contours
- River / Stream
- Property Parcels
- Roads

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: mcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

O2NL Material Supply - Long List

Zone 6: North Manukau Road to Regional Boundary

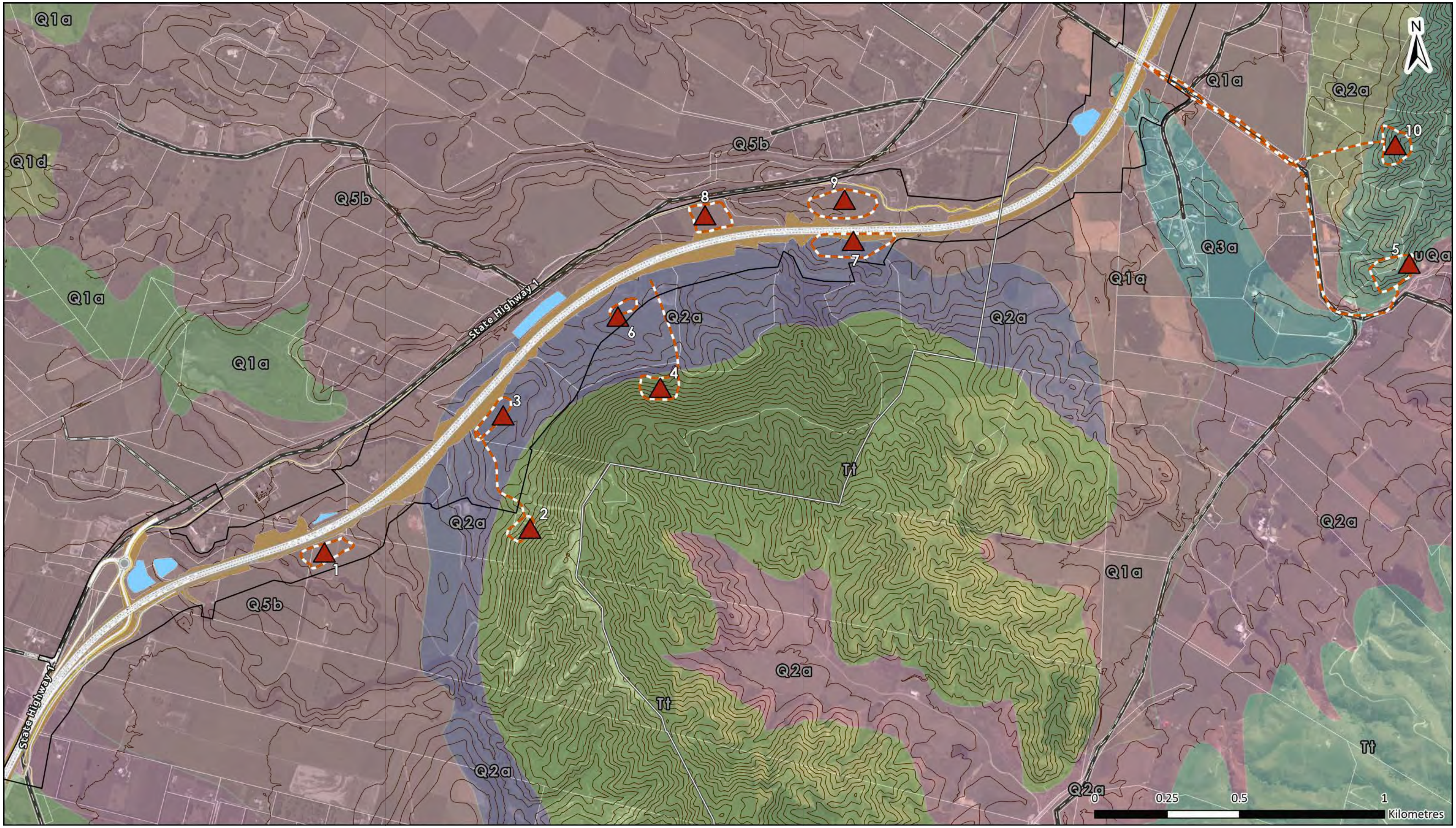
WAKA KOTAHI NZ TRANSPORT AGENCY

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: rmcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

- O2NL Proposed Designation 20210729
- O2NL Potential Material Supply Sites
- O2NL Potential Material Supply Sites Access Routes
- 10m Contours
- River / Stream
- Property Parcels
- Roads

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.



Stantec

O2NL Material Supply - Long List

Zone 7: Regional Boundary to SH1

WAKA KOTAHI NZ TRANSPORT AGENCY

- O2NL Proposed Designation 20210729
- O2NL Potential Material Supply Sites
- O2NL Potential Material Supply Sites Access Routes
- 10m Contours
- River / Stream
- Property Parcels
- Roads

Data Sources: Stantec, Land Information New Zealand
Basemap Service Credits: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., LINZ, Stats NZ, Eagle Technology, Esri, HERE, Garmin, FAO, METI/NASA, USGS
Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Author: rmcpherson, Stantec (2022)
Project Code: 310203848
Export Date: 2022-01-19 1:35 PM

This document has been prepared based on information provided by sources cited in the document metadata. Stantec has not verified the accuracy or completeness of this information, and shall not be held responsible for any errors or omissions that may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

IWI Partners Matrix Assessment

Site ID (Long List Aug'21)	New Site ID (Nov'21)	Geology	Location	Tread Lightly, with the whenua (18)						Enduring Legacy (7)			Total (25)	Notes
				Earthworks (3)	Proximity (3)	Waterways (3)	Historical (3)	Ecology (3)	Disruption (3)	Revegetation (3)	Hazard management (1)	Community benefits (3)		
														Refer to Material Supply Whānau pack Draft D 22nd Feb 2022 for explanation of criteria noting summary titles e.g.
Sand sites - refer to Material Supply- Q5b Shoreline deposits, powerpoint update 9th March 2022														Minimise impact on the Community = 'Disrptuion in this table
~~1~~	~~Pukehou~~	~~Sand sources~~		~~2~~	~~3~~	~~1~~	~~tbc~~	~~2~~	~~2~~	~~2~~	~~NA~~	~~0~~	~~12~~	NO LONGER REQUIRED. No hīkoi, concern re impact on wetlands below, no SUP proximity.
~~3~~	~~Pukehou~~	~~Sand sources~~		~~2~~	~~3~~	~~1~~	~~tbc~~	~~2~~	~~2~~	~~2~~	~~NA~~	~~0~~	~~12~~	NO LONGER REQUIRED. No hīkoi, concern re impact on wetlands below, no SUP proximity
~~6~~	~~Pukehou~~	~~Sand sources~~		~~2~~	~~3~~	~~1~~	~~tbc~~	~~2~~	~~2~~	~~2~~	~~NA~~	~~0~~	~~12~~	NO LONGER REQUIRED. no hīkoi, concern re impact on wetlands below, no SUP proximity
~~7~~	~~Pukehou~~	~~Sand sources~~		~~2~~	~~3~~	~~1~~	~~tbc~~	~~1~~	~~1~~	~~2~~	~~NA~~	~~0~~	~~10~~	NO LONGER REQUIRED concerns re impacts on bush remnants, house removed, no SUP proximity
~~8~~	~~Pukehou-below~~	~~Sand sources~~		~~2~~	~~3~~	~~1~~	~~tbc~~	~~1~~	~~2~~	~~2~~	~~NA~~	~~1~~	~~12~~	NO LONGER REQUIRED no hīkoi, concerns re impacts on bush remnants
~~9~~	~~Pukehou- below~~	~~Sand sources~~		~~2~~	~~3~~	~~1~~	~~tbc~~	~~1~~	~~2~~	~~2~~	~~NA~~	~~1~~	~~12~~	NO LONGER REQUIRED no hīkoi, concerns re impacts on bush remnants, building removal?
34	Koputoroa	Sand sources		2	3	1	tbc	1	2	1	NA	1	11	no hīkoi, limited legacy outcomes
34a	Koputoroa	Sand sources		2	3	1	tbc	2	2	3	NA	2	15	no hīkoi, this would extend an existing wetland, ecologists comment is that this would be positive-restore/create habitat and potential access to wider mahinga kai area, whakapapa assessment required to complete the evaluation
35	Koputoroa	Sand sources		2	3	1	tbc	2	2	2	NA	0	12	no SUP proximity
Alluvial and Rock sources- refer to Material Supply Whānau pack Draft D 22nd Feb 2022														
2		Rock Sources	Pukehou				fatal flaw						0	fatal flaw notes tbc with partners
4		Rock Sources	Pukehou				fatal flaw						0	fatal flaw notes tbc with partners
5		Rock Sources	Hanawera Ridge				fatal flaw						0	fatal flaw notes tbc with partners
10		Rock Sources	Hanawera Ridge				fatal flaw						0	fatal flaw notes tbc with partners
11		Rock Sources	Hanawera Ridge				fatal flaw						0	fatal flaw notes tbc with partners
12		Rock Sources	Hanawera Ridge				fatal flaw						0	fatal flaw notes tbc with partners
13		Rock Sources	Hanawera Ridge				fatal flaw						0	fatal flaw notes tbc with partners
14		Alluvial Sources	Waikawa	2	0	1	*tbc*	2	1	3	0	0	9	no hīkoi, information on important sites, whakapapa required to complete assessment
18		Alluvial Sources	Waikawa	2	1	1	*tbc*	1	3	3	0	0	11	no hīkoi, information on important sites, whakapapa required to complete assessment
15	Waikawa Site A (or Waikawa South)	Alluvial Sources	Waikawa	2	2	2	*tbc*	3	3	3	0	1	16	information on important sites, whakapapa required to complete assessment
17	Waikawa Sites C1-2	Alluvial Sources	Kuku tributary	2	0	1	*tbc*	2	1	3	0	0	9	no hīkoi, information on important sites, whakapapa required to complete assessment
19	Waikawa Sites B1- 4 (or Waikawa North)	Alluvial Sources	Waikawa	2	2	2	*tbc*	3	3	3	0	1	16	information on important sites, whakapapa required to complete assessment
20		Rock Sources	Poroporo				fatal flaw							fatal flaw notes tbc with partners
21		Rock Sources	Ōtararere				fatal flaw							fatal flaw notes tbc with partners
22		Alluvial Sources					fatal flaw							fatal flaw notes tbc with partners
24		Rock Sources	Ōtararere				fatal flaw							fatal flaw notes tbc with partners
23		Rock Sources	Ōtararere				fatal flaw							fatal flaw notes tbc with partners
n/a	Ōhau sites A1-2 (or Ōhau North)	Alluvial Sources	Ōhau River				*fatal flaw*							fatal flaw notes tbc with partners
25	Ōhau site B	Alluvial Sources	Ōhau River	2	2	1	*tbc*	0	3	2	0	0	10	no hīkoi, information on important sites, whakapapa required to complete assessment
26	Ōhau site C	Alluvial Sources	Ōhau River	2	2	1	*tbc*	3	1	3	0	0	12	information on important sites, whakapapa required to complete assessment
27		Alluvial Sources	Ōhau River	2	2	1	*tbc*	0	3	2	0	0	10	no hīkoi, information on important sites, whakapapa required to complete assessment
~~29~~	~~Ōhau site D~~	~~Alluvial Sources~~	~~Ōhau River~~	~~2~~	~~1~~	~~3~~	~~*tbc*~~	~~3~~	~~3~~	~~2~~	~~0~~	~~0~~	~~14~~	UNAVAILABLE information on important sites, whakapapa required to complete assessment
~~28~~	~~Ōhau site E~~	~~Alluvial Sources~~	~~Ōhau River~~	~~2~~	~~1~~	~~1~~	~~*tbc*~~	~~0~~	~~3~~	~~3~~	~~0~~	~~0~~	~~10~~	UNAVAILABLE no hīkoi, information on important sites, whakapapa required to complete assessment
~~30~~	~~Ōhau site F~~	~~Alluvial Sources~~	~~Ōhau River~~	~~2~~	~~0~~	~~1~~	~~*tbc*~~	~~0~~	~~3~~	~~3~~	~~0~~	~~0~~	~~9~~	UNAVAILABLE no hīkoi, information on important sites, whakapapa required to complete assessment
31		Rock Sources	Gladstone Rd	1	0	3	*tbc*	1	0	0	0	0	5	information on important sites, whakapapa required to complete assessment
32		Alluvial Sources	East of Levin				fatal flaw							fatal flaw notes tbc with partners
33		Rock Sources	MacDonald Rd	1	1	3	*tbc*	3	2	1	0	1	12	benefits relate to future quarry, information on important sites, whakapapa required to complete assessment
36	NEW SITE	Alluvial sources	Ōhau River	3	2	1	*tbc*	3	2	3	0	2	16	no hīkoi. Repo/Roto options to be investigated during detailed design. Ecologists comment is that this would be positive-restore/create habitat including large scale open water. Legacy outcomes including access from the SUP progressed through hydrology and geotech screen. Community benefits include possible rongoa, mahinga kai source. Whakapapa assessment required to complete the evaluation

Technical Expert Traffic Light Assessment

O2NL MATERIAL SUPPLY SITES STUDY

Technical Expert Traffic Light Assessment (Long List)

Site ID (long List Aug '21)	Flooding	Freshwater Ecology	Terrestrial Ecology	Air Quality	Archaeology	Transport	Noise & Vibration	Contaminated Land	Landscape	Social	Heritage	Water Quality	Groundwater	HC Soils	Key Comments on Red ranking	Key comments on amber ranking - priority sites only
1	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	**Groundwater** - No hydrological effects or interaction with surface water bodies. Any groundwater is likely to be at depth. However, this site is on a marine terrace and the interfluve between two of the better formed and preserved 'box valleys' that have been eroded into the Otaki Sandstone (Q5b). This makes the site distinctive and geomorphically significant.	
2	Green	Amber	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green	**Landscape** - Excavation into side of Pukehou, a significant landmark.	
3	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Amber	Green		
4	Green	Amber	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green	**Landscape** - Excavation into side of Pukehou, a significant landmark.	
6	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Amber	Green		
7	Green	Green	Amber	Red	Green	Green	Green	Green	Green	Green	Green	Green	Amber	Green	**Air Quality** - close proximity to a number of receptors.	
8	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Amber	Green		
9	Green	Amber	Amber	Amber	Green	Green	Green	Green	Green	Green	Green	Green	Amber	Green		
5	Green	Red	Red	Red	Green	Green	Amber	Green	Amber	Amber	Green	Amber	Green	Green	**Freshwater Ecology** - Close proximity to Manakau Stream and current extent encroaches on tributary stream. Looks to require removal of riparian vegetation. Access would require temporary crossings to be installed in Manakau Stream. Could be reduced to an orange light if area tweaked to avoid stream channel; **Terrestrial Ecology** - Would require removal of indigenous vegetation on steep hillslope. Potential for indigenous fauna to be harmed or killed during vegetation removal; **Air Quality** - Christmas tree farm next door	
10	Green	Amber	Red	Red	Green	Green	Amber	Green	Red	Amber	Green	Green	Green	Green	**Terrestrial Ecology** - Would require removal of what appears to be intact indigenous vegetation on steep hillslope. Potential for indigenous fauna to be harmed or killed during vegetation removal.; **Air Quality** - Farmstay less than 200 m away; **Landscape** - Would quarry into side spur of Hanawera hill behind Manakau Heights. Visual effects on Manakau Heights valley, would extend and exacerbate adverse visual effects in an area already significantly adversely affected.	
11	Green	Amber	Amber	Amber	Green	Amber	Green	Green	Red	Amber	Green	Green	Green	Green	**Landscape** - Would quarry into spur of Hanawera hill behind Manakau. Elevated location on side of hill. Visual effects on eastern end of Manakau village and valley.	
12	Green	Amber	Amber	Green	Green	Amber	Green	Green	Red	Amber	Green	Green	Green	Green	**Landscape** - Would quarry into spur of Hanawera hill behind Manakau. Elevated location on side of hill. Visual effects on eastern end of Manakau village, valley, and neighbour.	
13	Green	Amber	Red	Red	Amber	Amber	Amber	Green	Red	Amber	Green	Amber	Green	Green	**Terrestrial Ecology** - Likely to involve removal of native riparian vegetation on steep slopes. Very little riparian vegetation remains in this part of the catchment; **Air Quality** - Road passes a number of sensitive receptors; **Landscape** - Would quarry into (and disfigure) the knoll at northern end of Hanawera hill. Elevated in a reasonably visible location. Visual effects from North Manakau Road and properties in vicinity. Natural character effects on Waikawa Stream.	
14	Red	Red	Green	Red	Amber	Amber	Amber	Green	Amber	Amber	Green	Amber	Green	Green	**Flooding** - active meandering floodplain, could recover some material and allow to re-fill naturally, but risky long term requiring active management for small recovery; **Freshwater Ecology** - Close proximity to Waikawa Stream and parts may look to be in channel. Looks to require removal of riparian vegetation. Could be green if area tweaked to avoid Waikawa Stream channel and riparian vegetation. Could site remediation include creation of floodplain wetland habitat and perhaps even open water habitats? With the neighbouring river and forest remnant, it could be great opportunity to create mosaic of linked habitats; **Air Quality** - Road passes a number of sensitive receptors.	

O2NL MATERIAL SUPPLY SITES STUDY

Technical Expert Traffic Light Assessment (Long List)

Site ID (long List Aug '21)	Flooding	Freshwater Ecology	Terrestrial Ecology	Air Quality	Archaeology	Transport	Noise & Vibration	Contaminated Land	Landscape	Social	Heritage	Water Quality	Groundwater	HC Soils	Key Comments on Red ranking	Key comments on amber ranking - priority sites only
15*																**Air Quality** - Large Area, encompasses a residential property; **Archaeology** - Section of this site includes the site of the Parikawau Shag hunting location (also crossed by Climies track, but physical traces not expected). Would be green if testing determines no site present/destroyed or bounds of site identified and avoided. Can be avoided by removing Lot1 DP 362812 portions; **Transport** - Access SH1 via North Manakau Road. Issues with short stacking. Also a lot of material sites in this proximity could result in very high volumes of turning trucks; **Contaminated Land** - Further investigation of historical photos (Retrolens.nz) suggests that the potential landfill site 700692 is closer to the borrow site than indicated at the northern boundary of this borrow site. The extent of this borrow site could be reduced to avoid this area. Further investigation would be required. Site 700060 is located across the river from this borrow site; **Social -** Though partially within the designation this is a large area that will extend disturbance further west and take up a much larger (nearly half) area of farmland that is anticipated to impact functionality. One house directly backs onto the site however it is assumed that this will already be acquired by the project. (The polygon indicating the area cuts through an existing farm shed but it is assumed this is an approximate representation only and that this can be adjusted to avoid this if property not acquired). Assumption made that post use site will be part of overall landscaping mitigation for corridor and or used as part of road, SUP or stormwater. The area outside the designation will need to be restored to be in fitting with the landscape and use; **HC Soils** - Significant area of highly productive 3s2 land.
16															**Flooding** - active meandering floodplain, could recover some material and allow to re-fill naturally, but risky long term requiring active management for small recovery; **Freshwater Ecology** - Close proximity to Waikawa Stream and parts may be within floodplain. As recently as June 2016 main river channel was within the proposed extraction area. Concerns that river may change course and be flowing within the area between now and extraction period. Looks to require removal of riparian vegetation; **Terrestrial Ecology** - Would require removal of riparian vegetation. Very little riparian vegetation remains in this part of the catchment; **Contaminated Land** - Further investigation of historical photos (Retrolens.nz) suggests that the potential landfill site 700692 is closer to the borrow site than indicated. Historical disturbed land and trucks observed within the footprint of this borrow site it is unclear if this was to extract gravel or to dispose of material further investigation would be required. Site 700060 is located across the river from this borrow site.	
18															**Flooding** - active meandering floodplain, could recover some material and allow to re-fill naturally, but risky long term requiring active management for small recovery; **Freshwater Ecology** - Close proximity to Waikawa Stream and parts may be within floodplain. As recently as Feb 2015 main river channel was within the proposed extraction area. Concerns that river may change course and be flowing within the area between now and extraction period. Looks to require removal of riparian vegetation; **Terrestrial Ecology** - Would require removal of locally important remnant of riparian vegetation which has been proposed as a potential terrestrial offset site. Very little riparian vegetation remains in this part of the catchment;	
17															**Freshwater Ecology** - Looks to directly impact Stream 27.1, a moderate ecological value tributary of Waikawa Stream. Alluvium extraction here would likely require stream diversion and potential offsetting. Is there potential to split area in two and avoid disturbing stream?	

O2NL MATERIAL SUPPLY SITES STUDY

Technical Expert Traffic Light Assessment (Long List)

Site ID (long List Aug '21)	Flooding	Freshwater Ecology	Terrestrial Ecology	Air Quality	Archaeology	Transport	Noise & Vibration	Contaminated Land	Landscape	Social	Heritage	Water Quality	Groundwater	HC Soils	Key Comments on Red ranking	Key comments on amber ranking - priority sites only
19*																**Freshwater Ecology** - Comes close to Stream 27.1 at two locations. Would be green if area tweaked to be minimum 20 m away from this stream; **Terrestrial Ecology** - Small area of mahoe-mamaku-blackberry-barberry scrub will be affected in western site. Potential for indigenous fauna to be harmed or killed during vegetation removal; **Transport** - As with 15, but sites north of the river use one lane bridge on N Manakau Road. A better alternative may be a new accessway onto SH1 near Tatum Park; **Contaminated Land -** Further investigation of historical photos (Retrolens.nz) suggests that the potential landfill (Site 700060) is located closer to the borrow site than indicated at the western boundary of this borrow site. Historical disturbed land observed close to the farm buildings and shows an area filled in over time. It is unclear what this fill consisted of and further investigation would be required. The extent of this borrow site could be reduced to avoid this area; **Social** - Partially within the designation although will extend construction works further towards 2 houses which are located less than 100m from the proposed borrow site. There would be a reduction in farmland although a fairly large area of a functional shape remains. Assumption made that post use site will be part of overall landscaping mitigation for corridor and or used as part of road, SUP or stormwater. The area outside the designation would need to be restored to be in keeping with the surrounding landscape and use; **HC Soils** - Significant area of highly versatile land which is outside the corridor.
20															**Terrestrial Ecology** - Would require removal of what appears to be intact indigenous vegetation on steep hillslope. Potential for indigenous fauna to be harmed or killed during vegetation removal.	
22																
21																
24															**Landscape** - It would use an existing quarry. It consent already exists then those effects would be assumed as part of the existing environment. If not (assumed situation for red traffic light), it would compound the existing adverse effects of the quarry in a cumulative manner. It is a sensitive and prominent location at the north end of Ōterere overlooking the Ōhau River. It would be very visible from the highway and plains. Although set back from the Ōhau River, there would be some adverse natural character effects. (There may be options to extend the existing quarry to a more modest extent as part of a strategy to close and rehabilitate it).	
23																
n/a*																**Social** - Partially within designation but also covers a large area of farmland outside of this that was not previously impacted. Remaining farmland in this block may no longer be viable due to large reduction in size and awkward shape (which was not the case before). Two houses within 50 and 75m away. Assumption made that post use site will be part of overall landscaping mitigation for corridor and or used as part of road, SUP or stormwater. The area outside the designation will need to be restored in keeping with the surround landscape and use requirements; **HC Soils** - Very large area of highly productive land (3s2).
25															**Terrestrial Ecology** - Would require removal of indigenous riparian vegetation which has been proposed as a potential terrestrial offset site. Potential for indigenous fauna to be harmed or killed during vegetation removal.	
36*																**Air Quality -** Looks like crops are nearby and could get effected / Source assumed to be the same as 25**; Social** - Outside of designation, close to house and impacts a large area of farmland.
26																
27															**Air Quality** - Close to residential properties and no access road so will need to be built	

O2NL MATERIAL SUPPLY SITES STUDY

Technical Expert Traffic Light Assessment (Long List)

Site ID (long List Aug '21)	Flooding	Freshwater Ecology	Terrestrial Ecology	Air Quality	Archaeology	Transport	Noise & Vibration	Contaminated Land	Landscape	Social	Heritage	Water Quality	Groundwater	HC Soils	Key Comments on Red ranking	Key comments on amber ranking - priority sites only
29															**Air Quality** - Close to residential property; **Noise & Vibration** - Longer haul road that passes close to many properties; **Landscape** - Would cut into high terrace at edge of plain. However, the configuration limits ability to mimic natural landform (it would resemble a quarry pit) and is sensitive location at entrance to Kimberley Reserve.	
28															**Freshwater Ecology** - Close proximity to Ōhau River and parts may be within floodplain. As recently as June 2020 part of flowing river channel was within the proposed extraction area. Looks to require removal of riparian vegetation. Could be green if area tweaked to avoid Ōhau River channel and riparian vegetation. Is there potential for remediation of site to create floodplain wetland habitat?; **Terrestrial Ecology** - Currently impacts exotic and indigenous riparian vegetation and potential wetland habitat to the west. Could be green if boundary amended to avoid riparian vegetation and wetland. Some potential for remediation of site to create floodplain wetland habitat that links with existing riparian habitats;**Noise & Vibration** - Longer haul road that passes close to many properties.	
30															**Freshwater ecology** - Close proximity to Ōhau River and parts may be within floodplain. Looks to require removal of riparian vegetation. Could be orange if area tweaked to avoid Ōhau River channel and riparian vegetation. Also need to consider access as may require temporary fording of Ōhau River to link to Gladstone Road. Is there potential for remediation of site to create floodplain wetland habitat?; **Terrestrial Ecology** - Currently impacts exotic and indigenous riparian vegetation and potential wetland habitat to the west. Could be green if boundary amended to avoid riparian vegetation and wetland. Some potential for remediation of site to create floodplain wetland habitat that links with existing riparian habitats;**Air Quality** - Access road goes over water and through a house... then travels long distance; **Noise & Vibration** - Longer haul road that passes close to many properties; **Landscape** - Would cut into low terrace within Ohau River flood plain. Moderate adverse effects on natural character of Ōhau River. Cut could be contoured to resemble a natural scarp, and the peninsula rehabilitated to mitigate adverse natural character effects. Would need to be designed to maintain the existing river meander. Appears to be closer to neighbouring properties than site 28. Additional adverse effects on natural character from access across river required.	
31															**Noise & Vibration** - Longer haul road that passes close to many properties; **Landscape** - Would cut into low terrace within Ohau River flood plain. Moderate adverse effects on natural character of Ōhau River. Cut could be contoured to resemble a natural scarp, and the peninsula rehabilitated to mitigate adverse natural character effects. Would need to be designed to maintain the existing river meander. Appears to be closer to neighbouring properties than site 28. Additional adverse effects on natural character from access across river required.	
32																
33															**Noise & Vibration** - Longer haul road that passes close to many properties. Lesser effects closer to SH57.	
34																

O2NL MATERIAL SUPPLY SITES STUDY

Technical Expert Traffic Light Assessment (Long List)

Site ID (long List Aug '21)	Flooding	Freshwater Ecology	Terrestrial Ecology	Air Quality	Archaeology	Transport	Noise & Vibration	Contaminated Land	Landscape	Social	Heritage	Water Quality	Groundwater	HC Soils	Key Comments on Red ranking	Key comments on amber ranking - priority sites only
34a																**Landscape** - While 34 entailed widening a cut into the terrace on uphill side of highway, 34a would entail removing a section of terrace altogether between the highway and a gully that is earmarked for restoration for ecology and natural reasons. The removal of the terrace will have some adverse effects on natural character and also provide opportunities for naturalisation. On the one hand it will alter the gully's natural landform and increase the highway's visible presence from the gully. On the other hand it will provide opportunity to construct a larger naturalised wetland which would be visible from the highway and have a naturalised appearance. The orange score indicates that there are some adverse effects compared to 34, and that opportunities for enhancement depend on how the work is carried out: **Social** - House within 200m (need to confirm if this will be acquired as part of project), site on land already indicated for disturbance (within designation). May result in increased disturbance. Assumption made that post use site will be part of overall landscaping mitigation for corridor and or used as part of road, SUP or stormwater where it is within the corridor; **Archaeology** - while a 'green' rating given, potentially this site could be 'orange' as likely archaeological site in the vicinity; **Water Quality** - Koputaroa Stream catchment - located directly adjacent to an unnamed first order tributary of the Koputaroa Stream (stream ID 41) which includes an online farm dam. Potential for runoff to enter the watercourse. Easy access immediately adjacent to O2NL corridor.
35																

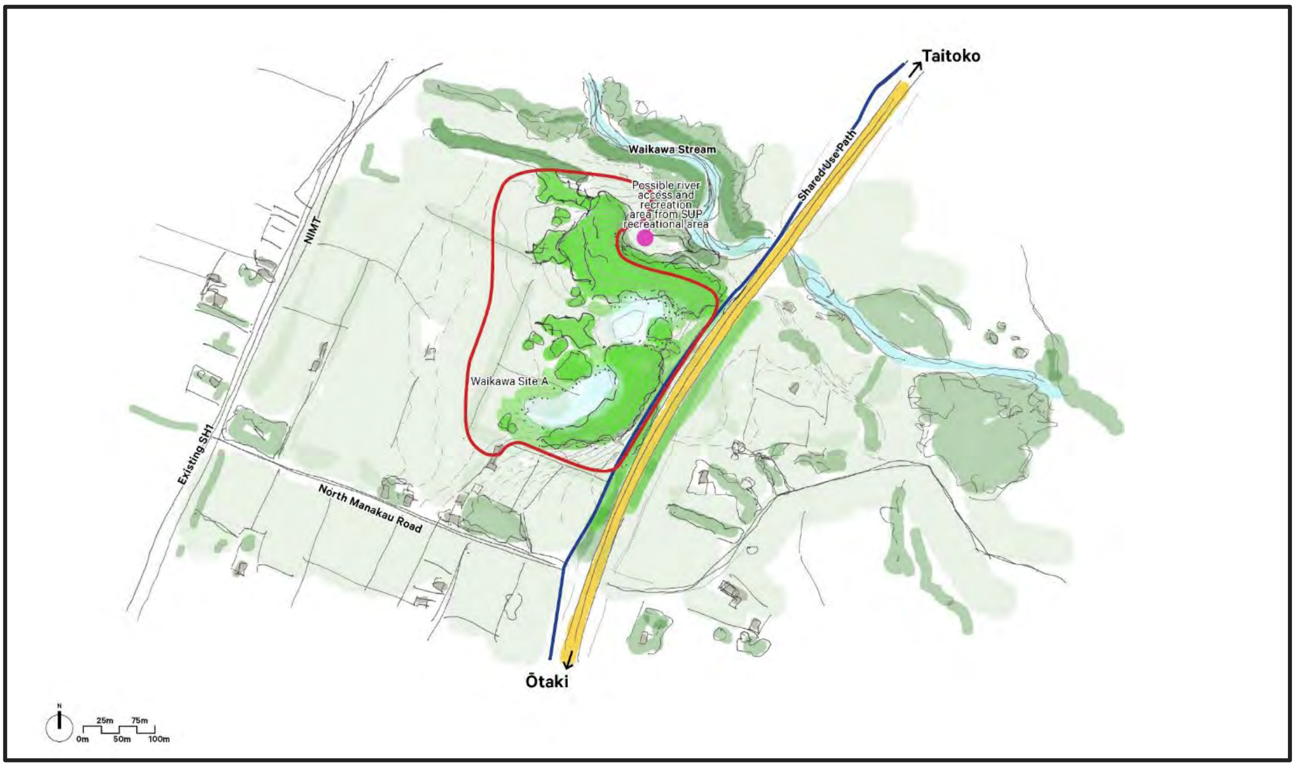
* Preferred sites

Appendix 4.5.2 Material Supply Sites Drawings

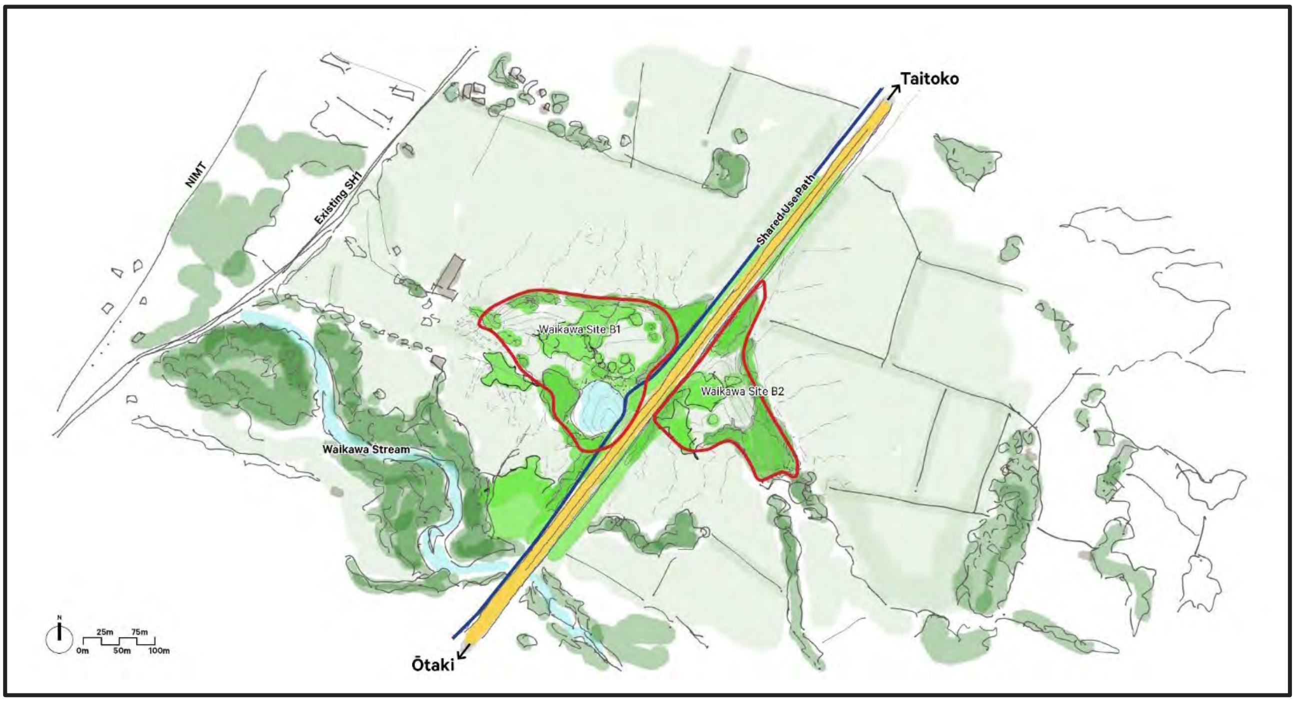
Concept Drawings of Preferred Sites

The following are the concept drawings proposed to experts to undertake an initial detail assessment of the preferred 4 Material Supply Sites:

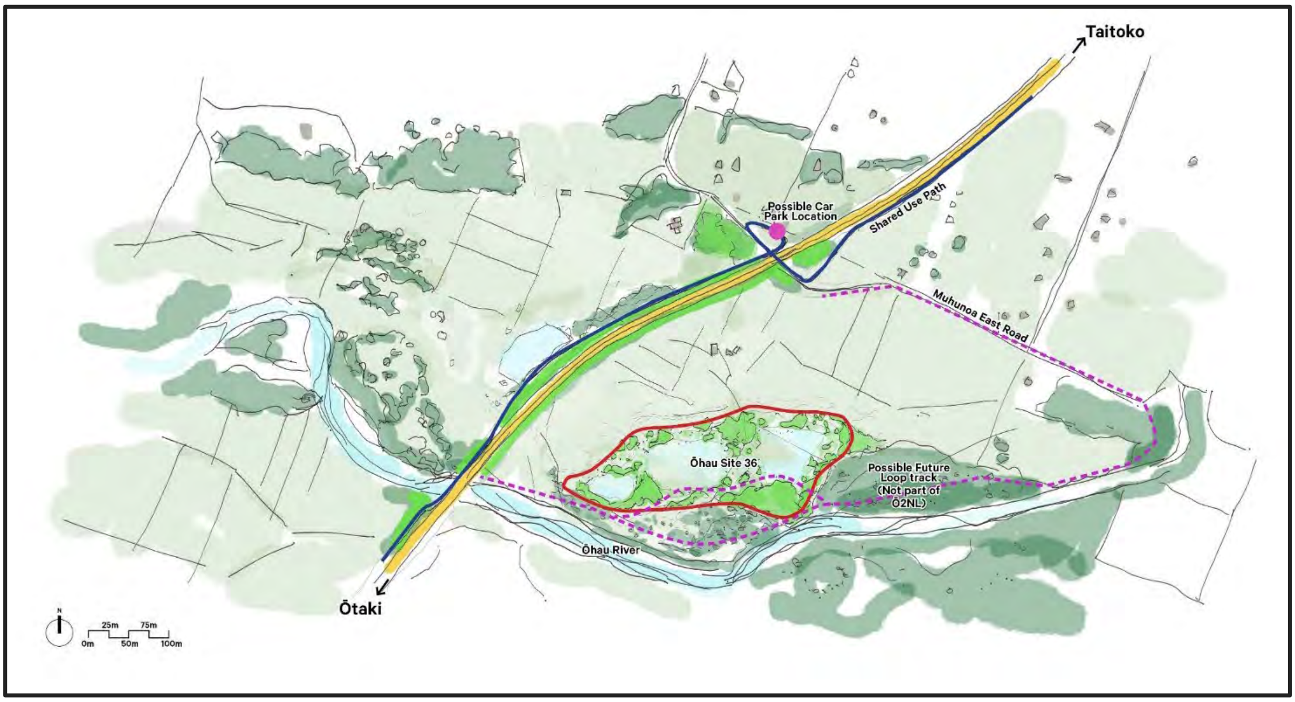
Site #15 – South of Waikawa Stream



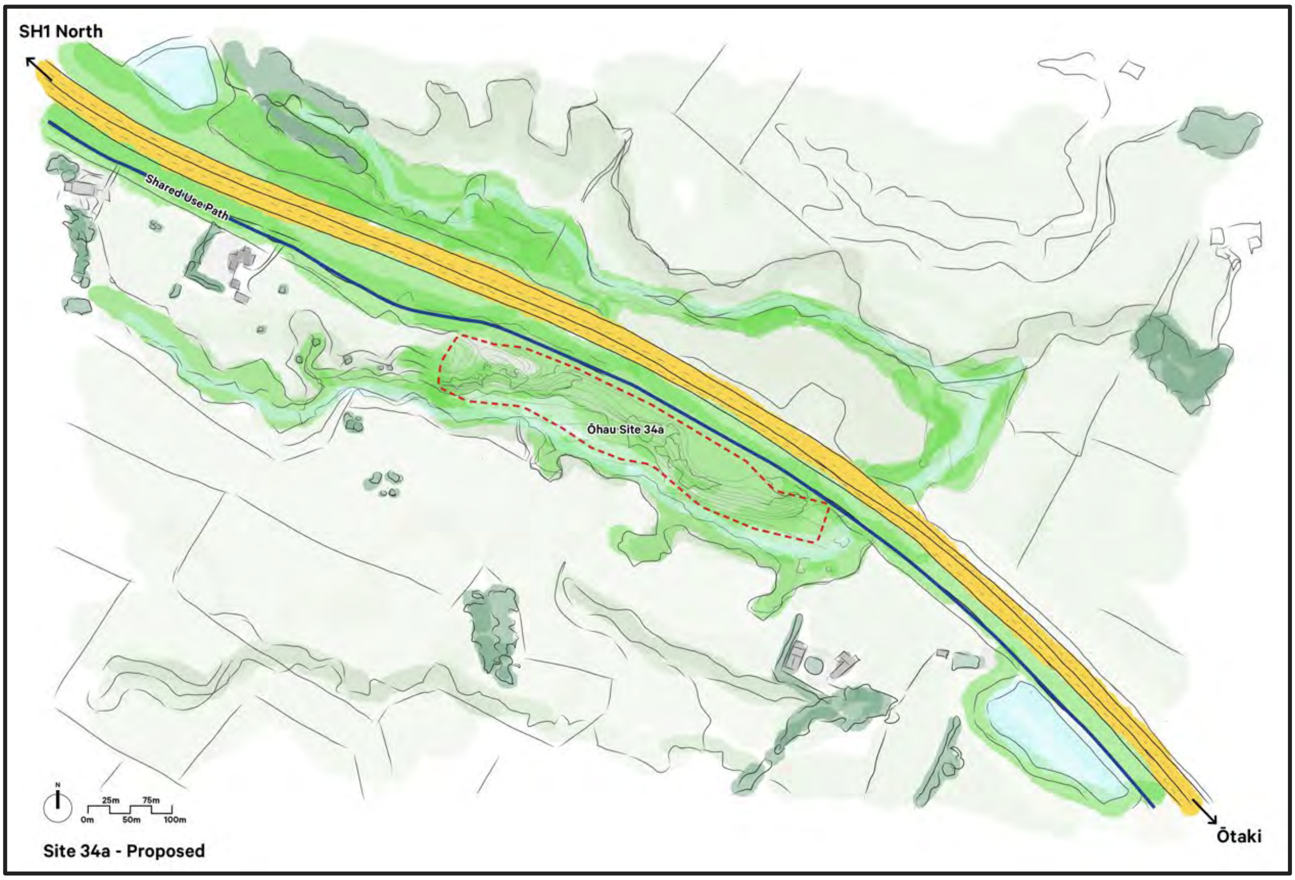
Site #19 – North of Waikawa Stream



Site #36 – North-east of Ohau River



Site #34a – Koputaroa



General Arrangement Drawings

G	ISSUED FOR RMA CONSENT	SS			
F	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	08.04.22
E	ISSUED FOR INFORMATION	SS	KC	JP	04.03.22
D	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	09.12.21
C	ISSUED FOR CONSENTING - RE-ISSUE DRAFT REVIEW	SS	KW	JP	09.09.21
B	ISSUED FOR CONSENTING - DRAFT REVIEW	SS	KW	JP	30.08.21
A	ISSUED FOR DBC	SS	KW	JP	18.06.21
REV	REVISIONS	DRN	CHK	APP	DATE

SURVEYED		
DESIGNED	Steve Muller	18.06.21
DRAWN	Steve Sutton	18.06.21
CAD REVIEW	Steve Sutton	18.06.21
DESIGN CHECK	Jamie Povall	08.04.22
DESIGN REVIEW	Keith Weale	08.04.22
APPROVED		
PROF REGISTRATION:		

NOT APPROVED

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

GENERAL ARRANGEMENT PLAN - INDICATIVE
SHEET 2

Status Stamp: FOR CONSENT

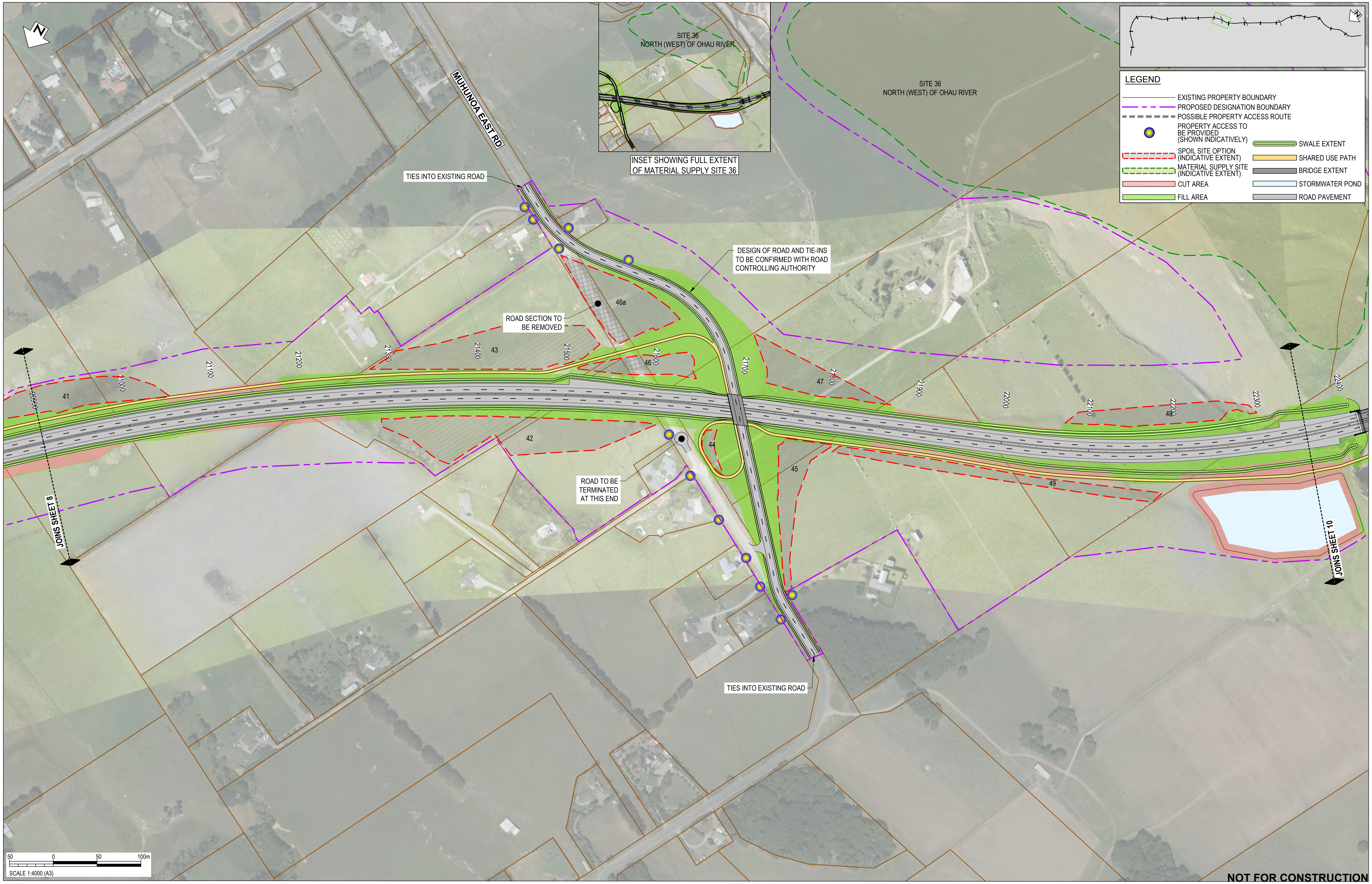
Date Stamp

Scales: 1 : 4000 (A3)

Drawing No.: 310203848-01-100-C1001

Rev.: G

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\100 - Geometric Design\310203848-01-100-C1001



NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE
G	ISSUED FOR RMA CONSENT	SS			
F	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	08.04.22
E	ISSUED FOR INFORMATION	SS	KC	JP	04.03.22
D	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	09.12.21
C	ISSUED FOR CONSENTING - RE-ISSUE DRAFT REVIEW	SS	KW	JP	09.09.21
B	ISSUED FOR CONSENTING - DRAFT REVIEW	SS	KW	JP	30.08.21
A	ISSUED FOR DBC	SS	KW	JP	18.06.21

SURVEYED		
DESIGNED	Steve Muller	18.06.21
DRAWN	Steve Sutton	18.06.21
CAD REVIEW	Steve Sutton	18.06.21
DESIGN CHECK	Jamie Povall	08.04.22
DESIGN REVIEW	Keith Weale	08.04.22
APPROVED	NOT APPROVED	
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

GENERAL ARRANGEMENT PLAN - INDICATIVE
SHEET 9

Status Stamp: FOR CONSENT

Date Stamp

Scales: 1 : 4000 (A3)

Drawing No.: 310203848-01-100-C1008

Rev.: G

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\100 - Geometric Design\310203848-01-100-C1008

NOT FOR CONSTRUCTION

REV	REVISIONS	DRN	CHK	APP	DATE
G	ISSUED FOR RMA CONSENT	SS			
F	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	08.04.22
E	ISSUED FOR INFORMATION	SS	KC	JP	04.03.22
D	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	09.12.21
C	ISSUED FOR CONSENTING - RE-ISSUE DRAFT REVIEW	SS	KW	JP	09.09.21
B	ISSUED FOR CONSENTING - DRAFT REVIEW	SS	KW	JP	30.08.21
A	ISSUED FOR DBC	SS	KW	JP	18.06.21

SURVEYED		
DESIGNED	Steve Muller	18.06.21
DRAWN	Steve Sutton	18.06.21
CAD REVIEW	Steve Sutton	18.06.21
DESIGN CHECK	Jamie Povall	08.04.22
DESIGN REVIEW	Keith We[illegible]	08.04.22
APPROVED		
PROF REGISTRATION:		

NOT APPROVED

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

GENERAL ARRANGEMENT PLAN - INDICATIVE
SHEET 10

Status Stamp: FOR CONSENT

Date Stamp

Scales: 1 : 4000 (A3)

Drawing No.: 310203848-01-100-C1009

Rev.: G

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\100 - Geometric Design\310203848-01-100-C1009

REV	REVISIONS	DRN	CHK	APP	DATE
G	ISSUED FOR RMA CONSENT	SS			
F	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	08.04.22
E	ISSUED FOR INFORMATION	SS	KC	JP	04.03.22
D	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	09.12.21
C	ISSUED FOR CONSENTING - RE-ISSUE DRAFT REVIEW	SS	KW	JP	09.09.21
B	ISSUED FOR CONSENTING - DRAFT REVIEW	SS	KW	JP	30.08.21
A	ISSUED FOR DBC	SS	KW	JP	18.06.21

SURVEYED		
DESIGNED	Steve Muller	18.06.21
DRAWN	Steve Sutton	18.06.21
CAD REVIEW	Steve Sutton	18.06.21
DESIGN CHECK	Jamie Povall	08.04.22
DESIGN REVIEW	Keith Weale	08.04.22
APPROVED	NOT APPROVED	
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

GENERAL ARRANGEMENT PLAN - INDICATIVE
SHEET 12

Status Stamp: FOR CONSENT

Date Stamp

Scales: 1 : 4000 (A3)

Drawing No.: 310203848-01-100-C1011 | Rev.: G

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\100 - Geometric Design\310203848-01-100-C1011

REV	REVISIONS	DRN	CHK	APP	DATE
G	ISSUED FOR RMA CONSENT	SS			
F	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	08.04.22
E	ISSUED FOR INFORMATION	SS	KC	JP	04.03.22
D	ISSUED FOR CONSENT - DRAFT	SS	KW	JP	09.12.21
C	ISSUED FOR CONSENTING - RE-ISSUE DRAFT REVIEW	SS	KW	JP	09.09.21
B	ISSUED FOR CONSENTING - DRAFT REVIEW	SS	KW	JP	30.08.21
A	ISSUED FOR DBC	SS	KW	JP	18.06.21

SURVEYED		
DESIGNED	Steve Muller	18.06.21
DRAWN	Steve Sutton	18.06.21
CAD REVIEW	Steve Sutton	18.06.21
DESIGN CHECK	Jamie Povall	08.04.22
DESIGN REVIEW	Keith Weale	08.04.22
APPROVED	NOT APPROVED	
PROF REGISTRATION:		

Stantec

Client: WAKA KOTAHI NZ TRANSPORT AGENCY

WAKA KOTAHI
ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

GENERAL ARRANGEMENT PLAN - INDICATIVE
SHEET 13

Status Stamp: FOR CONSENT
Date Stamp:
Scales: 1 : 4000 (A3)
Drawing No. 310203848-01-100-C1012
Rev. G

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\100 - Geometric Design\310203848-01-100-C1012

Appendix 4.5.3 Summary of Detailed Assessments of Preferred Sites

O2NL MATERIAL SUPPLY SITE STUDY
SUMMARY OF DETAILS EFFECTS ASSESSMENT – ALLUVIAL MATERIAL SUPPLY SITES #15, 19, 36 & Q5b SAND MATERIAL SITE #34a

31 May 2022

Site #15 – South of Waikawa Stream

Technical Expert	Assessment
Transport	This site would be accessed via North Manakau Road. This intersection has some safety concerns due to the short stacking length between the state highway and the railway line which would need to be managed. If material is moving south, there is potential for internal haul routes to be used to move material to reduce the number of trucks exiting on North Manakau Road. Access onto North Manakau Road from SH1 is good from both directions. This can be mitigated by prohibiting right turns from North Manakau Road. Further comment on final Site #15 perimeter extent: This site was originally given amber due to the short stacking and likely number of trucks required for haulage. It has increased in size approximately 20%. This would remain an amber and would likely still be able to be mitigated to green depending on the improvements, site controls and timeframes for material extraction.
Freshwater Ecology	This site does not include any permanently flowing stream channels. However, it does include former water race channels (Stream 26 in technical report). These are now defunct, however may still have some drainage function during heavy rain events (i.e., are ephemeral channels), which is something to be aware of during the extraction period in terms of ESC. Once constructed, any such inputs could be advantageous at maintaining any constructed wetland habitats. The boundary of this site comes within ~70 m of the active Waikawa Stream channel. This stream has a very mobile channel and it is possible that at some stage in the future it may move to be within the Site 15 area. This is a natural process, and not any issue from a freshwater ecology perspective, but something to be aware of when rehabilitating the site.
Terrestrial Ecology	No indigenous vegetation or wetlands have been identified/mapped within footprint of borrow site. Four small patches of what appears to be exotic treeland are present in the footprint, although these will need to be confirmed with a site visit. The footprint also encroached on a small area of exotic riparian vegetation. Entire area appears to be grazed, therefore no potential habitat for indigenous lizards and snails. Will impact some degraded farm streams (will need offsetting).
Noise & Vibration	This site abuts the main Ō2NL alignment between North Manakau Road and Waikawa Stream. There are 5 dwellings within 200m of the supply site, however each of these dwellings is also affected by noise from earthworks from the highway itself. Therefore the effects of the material supply site will mainly be due to increased duration / frequency of activities. Any truck movements on North Manakau Road will be consistent with other construction traffic and subject to the Construction Traffic Management Plan (CTMP). There are no dwellings within 50m of the supply site. Mitigation in the form of screening may be appropriate to the dwellings south of the site. **Figure 1** below shows buffers from the material supply site, as well as the main construction footprint and buffers (in thinner lines).

Technical Expert	Assessment
Flooding & Hydrology	There would be no detrimental effects on flooding upstream or downstream as a result of material extraction. The site could provide a slight benefit in terms of flood risk, by capture and attenuation of overland flow that heads toward existing SH1 west of the site. There is a small discontinued water race across the site. The material supply site will serve to capture and route a similar catchment size to the outlet. The route of the historical water race will still be used as an overland flow path to pass excess runoff in exceedance events, with attenuation included by design so that the future peak discharge would be less than existing. I have recently provided a proposed westward extension to the designation as shown below (refer to **Figure 2**), to allow the drainage / water race invert to be lowered slightly allowing greater material extraction (same footprint, but slightly deeper along the western boundary). The site outline currently shows a small extension onto the Waikawa floodplain near the proposed O2NL bridge – details is not provided but it is understood that this may be intended as a potential construction corridor rather than forming part of material supply or legacy outcomes. Care should be taken in detailed design to protect the river bank in this location, to avoid increasing potential risk of lateral scour from the Waikawa Stream which is highly mobile. The site also extends beyond the (current) draft proposed designation – so either the designation should be extended or the material supply area constrained to within the designation. (Updated 240522)
Groundwater	No effect on surface water features or water balance. The nearest bore to the site (BH308 located outside of material supply site #15) indicates that the groundwater may get within 5m of the ground surface and therefore material could likely be excavated at this site to 5m before the ground surface before interacting with the water table or groundwater. Likely above the contemporary floodplain and therefore no effect on any existing hazard. It is recommended that, should this site be considered further, at least one piezometer and water level recorder be installed in immediate vicinity of the proposed borrow pit. Additional comment 230522: Further investigation using piezometers is required to confirm the surface water/groundwater interactions so that these can subsequently be enhanced and promoted. This information is essential to the final design and therefore function of the proposed environment.
Water Quality	Site 15 contains alluvial materials. It is located south of Waikawa Stream and immediately west of the proposed highway. It is approximately 160,000 m2 in area and 150,000-320,000m3 in volume. As the site is located immediately adjacent to the proposed highway, it is easily accessible and no new roads are required. The site is mainly agricultural land, but also includes the floodplain of the Waikawa Stream, and a farmhouse. The site extends up to the edge of the Waikawa Stream[1] (stream ID 25) and crosses 620 metres of an unnamed first order tributary (ID 26) and is immediately adjacent to another watercourse. Of the four short-listed sites, this is the only one that extends up to a major stream and that will excavate one, possibly two watercourses. From aerial photography it cannot be determined if the smaller watercourses are permanent or intermittent, but both have defined channels. If excavation extends up to the Waikawa Stream, this will result in bank instability and potential direct discharges of sediment to the stream. It is recommended that this is avoided by enforcing a setback (ideally 50 metres) from Waikawa Stream. Excavations of one or both small watercourses should be avoided, where possible. Where this is not possible, erosion and sediment measures should be employed to minimise water quality impacts, with mitigation applied for any loss of stream length. north-eastern extent of this site to avoid direct impacts on the Waikawa Stream. Any loss in stream length should be mitigated by the restoration or recreation of stream(s) in other parts of the Project.

[1] The current extent of material supply site #15 is mapped up to the edge of Waikawa Stream. According to Chris Hansen (27/05/22 pers. comm.), no excavation is occurring in this area, and it has only been included in the footprint of the site to enable legacy outcomes to be fulfilled (i.e. providing public access to the Waikawa Stream).

Technical Expert	Assessment
	Standard erosion and sediment control should also be implemented. (Updated 270522)
Landscape & Visual	There will be some adverse landscape effects during excavation, and from modifying the natural landform. Such effects will be remedied through construction of what would be a reasonably naturalistic landform, and rehabilitation of the site with indigenous habitat and vegetation. This would compare with the current farmland. The net outcome is potentially positive. There will be some adverse effects on perceptions of natural character during construction, although the site will be buffered from the Waikawa Stream - the excavation will occur behind an island of terrace, and because the excavation will occur in the context of construction works along the highway corridor. The rehabilitated site will have a naturalistic appearance and will merge with the natural character enhancement proposed along the Waikawa Stream. It will increase the amount of natural vegetation and habitat along the corridor. It will contribute to some extent to both biophysical and perceptual aspects of natural character. The net outcome is potentially positive.
Heritage	There are no heritage sites identified near this site so therefore there are no adverse effects.
Archaeology	The main factor of consideration is the close proximity to the Waikawa Stream. There are no specific archaeological sites recorded in the area, but there is a possibility that archaeological sites could be found in this area (without detailed survey it is difficult to assess due to the complex history of the area, movements of the stream, have flood deposits destroyed or protected sites etc).
Air Quality	Medium risk of effects - Site 15 is an alluvial source and is located close to sensitive receptors and the close proximity of works means that nuisance dust issues could arise. In order to decrease the overall ranking to green, PDP consider that the residences (13 and 12A North Manakau Rd) bordering the soil site would not be occupied during the works and appropriate mitigation measures adopted to minimise impacts on homeowners. This could include for example offering alternate water supplies if they current use roof collected water or property cleaning. This assessment outcome remains unchanged. (Updated 250522)
Social/Community	Though partially within the existing Project designation this is a large area that will extend disturbance and land requirements further west and take up a much larger area of existing farmland. It is noted that this impact is on a property level rather than a community level. It the house is not part of the required area but will be close to the supply site.. It will be located adjacent to the Shared Use Path (SUP) and in proximity to Ngati Wehi Wehi Marae. It is indicated that this will form a natural area in the future in keeping with the surrounding area. Opportunities indicated in the supporting documentation include possible river access and recreation area (reserve adjacent to river) from the SUP indicating it could become an area for recreation, mahinga kai and rongoā. On this basis any existing use of the river would be enhanced and it would provide additional community assets and align with the values the communities identify with regards to their local rivers as important natural and recreational assets. The improved planting may provide improvement the quality of the local living environment. Without the development of a community asset the site may have negligible impact once rehabilitated, provided it could be used as previously (such as farmland)) and there are not residual visual impacts. If the option to establish a community asset is realised this could have low to moderate positive community impacts on community character, community services, way of life and health and wellbeing. (Updated 240522)
Contaminated Land	It is acknowledged that the material supply site located to south of the Waikawa Stream will be defined to avoid a potential dump site however the current extents provided in the drawings still covers ground that is likely to have been part of the dump site as indicated by historical photos.

Technical Expert	Assessment
HC Soils	Loss of highly productive land with no mitigation options available. Site 15 was "orange" in initial TLA so this reclassification would no doubt make no difference to the overall classification particularly when there are no core values or principles related to productive land so the TLA with respect to productive land appears meaningless.
ESC	From an Erosion and Sediment Control perspective, there is nothing remarkable about Site #15, other than the proximity to the Waikawa Stream. It is noted that the final contours tie into the upper terrace, above the 100 year flood plain, and therefore it appears the site has the protection of the 100 year flood during extraction. It is considered that erosion and sediment control devices that comply with the GWRC ESC Guideline could be installed to provide control for this site.
Iwi/CEDF	Iwi partners aware of preferred site and seem fine with it; the change to the boundary to avoid house and old rubbish pit has also been discussed with iwi partners. Iwi partners are preparing Cultural Impact Assessments (CIA) and the CEDF audit process and these two mechanisms allow detailed issues to be identified as relevant. (Updated 310522)

Site #19 – North of Waikawa Stream

Technical Expert	Assessment
Transport	As with Site 15, this site would be accessed via North Manakau Road but with additional local road haulage including a 1-way bridge. The same concerns relating to North Manakau Road exist here. As this site is north of Waikawa Stream, the opportunity exists to use local haul roads to access Kuku East Road in a limited fashion to manage truck volumes at North Manakau Road. Other mitigation would also be to prohibiting right turns from North Manakau Road. Further comment on final Site #15 perimeter extent: This site has remained approximately the same size with one portion becoming marginally larger and one marginally smaller. No change to the assessment.
Freshwater Ecology	1. West of Ō2NL - This site does not include any permanently flowing stream channels. The southern tip of the site does however, come too close to Stream 27.1 (a permanently flowing stream of "moderate" ecological value). The boundary of the site needs to be adjusted to be at least 20 m away from the stream channel. It would be great if any rehabilitation of this site via planting could be integrated with proposed revegetation of this stream within the designation. 2. East of Ō2NL - This site does not include any permanently flowing stream channels. The southern tip of the site does however, come too close to Stream 27.1 (a permanently flowing stream of "moderate" ecological value). The boundary of the site needs to be adjusted to be at least 20 m away from the stream channel. Eastern boundary does come close to Stream 28 which is a constructed ephemeral channel, which is something to consider from ESC perspective.

Technical Expert	Assessment
Terrestrial Ecology	Western site intersects with a small area of māhoe-mamaku-blackberry-barberry scrub, although this vegetation has already been accounted for in the terrestrial offsets model given that is occurs within the alignment footprint and is therefore assumed to be impacted. Western extent overlaps a small area of vegetation that could support indigenous species and also wetland habitat. The boundary should be amended to avoid these areas (see **Figure 3** below). Eastern site likely to have negligible impacts, although the identity of the two trees should be confirmed. No wetlands or indigenous vegetation has been identified in the footprint. Most of the sites are grazed or used for cropping so are unlikely to support indigenous lizards and snails.
Noise & Vibration	This site also accesses the alignment directly. There is only 1 dwelling within 200m of the supply site. This dwelling will observe increased noise from the supply site compared to general construction works. While compliance with construction noise criteria could be achieved with no specific mitigation, bunding should be considered as part of the supply site design. **Figure 4** below shows the buffers around the site.
Flooding & Hydrology	[Site #19 East & West) There would be no detrimental effects on flooding upstream or downstream as a result of material extraction. The site has the potential to offer a very slight flood benefit if allowed to flood in major events (for example >1:10 AEP) by offering additional floodplain storage potential. Integration of the stormwater pond into the western side will be an important design consideration to maximise material recovery and legacy outcomes. Resilient integration with the main river floodplain will be important in terms of levels, ecological legacy and scour resistance. (Updated 240522)
Groundwater	No effect on surface water features or water balance. The water table may be relatively deep given the distance from and elevation above the stream. Likely above the contemporary floodplain and therefore no effect on any existing hazard. It is recommended that, should this site be considered further, at least one piezometer be installed in immediate vicinity of the proposed borrow pit. Additional comment 230522: Further investigation using piezometers is required to confirm the surface water/groundwater interactions so that these can subsequently be enhanced and promoted. This information is essential to the final design and therefore function of the proposed environment.
Water Quality	Site 19 contains alluvial materials. It is located north of Waikawa Stream and is divided by the Ō2NL corridor, meaning that it is partly located east, and partly west, of the proposed highway. It is approximately 75,000 m2 in area and 200,000-320,000m3 in volume. As the site is located either side of the proposed highway, it is easily accessible and no new roads are required. The site is agricultural land, located approximately 170 m north of the Waikawa Stream on the upper and lower river terrace and escarpment. It is immediately north of an unnamed third order tributary of the Waikawa Stream (stream ID 27.1) and immediately west of a first order tributary of Kuku Stream (ID 28). These watercourses are immediately adjacent to, but outside, of the zone of work. Aerial photographs indicate that some small areas of ponding (wetlands?) may to be present at the base of the escarpment within the site. The main impacts on water quality will be potential erosion and sediment discharges to the two streams. This will be insignificant compared to the activities already being undertaken along the proposed highway. No additional mitigation required. Potential sediment discharges can be managed through standard erosion and sediment control. (Updated 270522)

Technical Expert	Assessment
Landscape & Visual	There will be some adverse landscape effects during excavation, and from modifying the natural landform. Such effects will be remedied through construction of a naturalistic landform, and rehabilitation of the site with indigenous habitat and vegetation – replacing the existing farmland. The net outcome is potentially positive. There will be minimal adverse effects on perceptions of natural character during construction, because of the distance of the works from the Waikawa Stream (typically 150m – 250m), and because the excavation will occur in the context of construction works along the highway corridor. The rehabilitated site will merge with the natural character enhancement proposed along the Waikawa Stream, and with planting around the stormwater wetland. It will increase the amount of natural vegetation and habitat along the corridor. It will contribute to both biophysical and perceptual aspects of natural character. The net outcome is potentially positive.
Heritage	There are no heritage sites identified near this site so therefore there are no adverse effects.
Archaeology	In addition to the general potential for sites in the vicinity of the Waikawa, there is a shag (kawau) hunting site called Parikawau (see **Figure 5** below). It unclear if the site is within the bounds of option 15 (possibly 16), if it has survived etc, but it is something to take into account. Further field investigation may be helpful here and I expect there is ample opportunity for minor changes to avoid/minimise adverse effects if direct evidence of archaeological material is discovered. However, the presence of a possible site at this stage would not rise to the level of a fatal flaw or suggest the need for radical changes at this stage (speaking as an archaeologist, but iwi may approach that differently). I think the presence of the site also creates opportunities for integrating cultural elements into the restoration/revegetation process at the conclusion of the material extraction.
Air Quality	Low risk of effects - However as the area is away from sensitive receptors and is within or in close proximity to the designation boundary it is unlikely to cause any adverse effects in terms of air quality.
Social/Community	Though partially within the existing Project designation this is a large area of farmland that will extend disturbance and land requirements further west and take up a much larger area of existing farmland. It is noted that this impact is on a property level rather than a community level. Two homes are within 100m from the proposed borrow site. Once operation it has the opportunity to provide a visual buffer to the new Corridor. However it is noted that the ground level is lowered either side of the new corridor making the new corridor potentially more prominent in the landscape. It will also be dependent on how surrounding land use is integrated into current functions. It will be located adjacent to the Shared Use Path and it is noted the planting scheme will provide an enhanced experience for the shared use path users. On this basis (the mitigation is carried out) it is considered that it would have once established have a negligible impact for the sub-local community (new planting may provide improvement to the quality of the sub-local local living environment). For SUP users it may have a low positive impact. (Updated 240522)
Contaminated Land	There is a low point at the North eastern side of this site that may encounter unnatural fill material and should be avoided.
HC Soils	Western side approximately .5 ha - .25ha Class 1 and .25ha Class IVs1 land; Eastern side majority Class 1. Loss of highly productive land with no mitigation options available. Site 19 was “orange” in initial TLA so this reclassification would no doubt make no difference to the overall classification particularly when there are no core values or principles related to productive land so the TLA with respect to productive land appears meaningless. (Updated 300522)

Technical Expert	Assessment
ESC	From an Erosion and Sediment Control perspective, there is nothing remarkable about Site #19, other than the proximity to the Waikawa Stream. It is considered that erosion and sediment control devices that comply with the GWRC ESC Guideline could be installed to provide control for this site.
Iwi/CEDF	Iwi partners aware of preferred site and seem fine with it. Iwi partners are preparing Cultural Impact Assessments (CIA) and the CEDF audit process and these two mechanisms allow detailed issues to be identified as relevant. (Updated 310522)

Site #36 – North of Ōhau River

Technical Expert	Assessment
Transport	Different routes will be used from this site depending on the destination of the carted material. Access to southern zones is likely via Bishops Road and northern sites through Arapaepae Road. There are no issues in terms of access to the north, but access to and from the south is problematic as Muhunoa East Road has a size constraint with the rail overbridge and McLeavey and Bishops Roads have short stacking and other rail safety issues. Further comment on final Site #15 perimeter extent: This site has become slightly larger, equivalent to an additional 10%. This would remain an amber and would likely still be able to be mitigated to green depending on the improvements, site controls and timeframes for material extraction.
Freshwater Ecology	This site does not include any permanently flowing stream channels. The boundary does come within ~30 m of the active Ohau River channel, which may be advantageous if it is possible to provide some kind of connection to the river. There is potential to create permanent open water habitat at this site that can provide habitat for numerous indigenous species. A periodic surface water connection to the Ohau River would allow fish species to colonise, such as shortfin tuna/eels.
Terrestrial Ecology	The site would require the removal of some indigenous vegetation along the northern river terrace. This vegetation would to be identified and quantified so that appropriate offsetting can be carried out. Fauna mitigation is likely to be required. No wetlands or streams are present in the footprint. Excellent restoration potential in terms of creating wetland habitat that links to riparian forest. It is intended to use the areas of open water created at this site to offset the cumulative loss of open water (i.e., ponds) within the alignment footprint.
Noise & Vibration	This site is located between Ohau River and Muhunoa Road East. Again, access to the alignment will minimise haulage via the local road network. There are no dwellings within 200m of the proposed supply sites. **Figure 6** below shows the buffers around the site.

Technical Expert	Assessment
Flooding & Hydrology	There would be no detrimental effects on flooding upstream or downstream as a result of material extraction. The site represents a very slight advantage in terms of flood risk, due to additional storage of flood water on a wider floodplain in some events. The proposed outline currently shows a small clash with an overland flow path on the north-western side of the site (O2NL chainage 22250), which could be easily addressed by either modifying the proposed outline or by re-alignment of the overland flow path within the proposed designation extent. The terrace does have some overland flow in major events (larger than approximately 1:10 AEP current climate), so the scour resistance and long term morphological stability of the river and embankments around the site will need to be considered during detail design. Similarly, sustainability and minimising maintenance requirements will be important for the outlet at the western / downstream end. Resilient integration with the main river floodplain will be important in terms of levels, ecological legacy and scour resistance. Whilst the river is relatively stable currently, there remains the possibility that future injections of gravel from earthquakes or severe storms can increase the risk of aggradation, lateral erosion and avulsion. (Updated 240522)
Groundwater	No effect on surface water features or water balance. The water table may be relatively deep given the distance from and elevation above the stream. Likely well above the contemporary floodplain and a significant distance from the Ohau River. Therefore, no effect on any existing hazard. Will need to avoid any interaction with potential paleochannels and overland flow paths. Should an extreme event occur could provide some additional flood storage. It is recommended that, should this site be considered further, at least one piezometer be installed in immediate vicinity of the proposed borrow pit. Additional comment 230522: Further investigation using piezometers is required to confirm the surface water/groundwater interactions so that these can subsequently be enhanced and promoted. This information is essential to the final design and therefore function of the proposed environment. Need to explore the option of providing a 'formal' surface hydraulic connection to the river during higher flows to provide some flushing and improved dynamics of any open water. This would be facilitated by the upstream of the 'pit' being on the outside of a meander and the downstream end being on a straight reach.
Water Quality	Site 36 contains alluvial materials. It is located between the Ō2NL corridor and the Ohau River (stream ID number 33). It is approximately 136,000 m^2 in area and between 180,000-400,000m^3 in volume. As the site is located in close proximity to the proposed highway, it is easily accessible for construction machinery and no new roads are required. The site is located on the Ohau River terrace and is separated from the river by a width of between 40-180 metres. This area is grazed with sparse trees and shrubs. A narrow band of fenced vegetation occurs adjacent to the river. Two small watercourses are mapped immediately to the north and east of the proposed site (stream ID 34 and N/A). These appear to be historic or ephemeral watercourses that would only flow during heavy rainfall. During extreme flood events, the proposed aggregate supply site would become inundated with water from the Ohau River. Up to a 1 in 10-year Annual Exceedance Probability (AEP) event the area receives rainfall and minimal surface water flows from surrounding farmland. In a 1:100 AEP, the area would become inundated by the Ohau River. The main impacts on water quality will be potential erosion and sediment discharges, particularly caused by scour during extreme flood events. Due to the low frequency of such events (>1:10 AEP) mitigation is not considered appropriate. This is because actions such as bunding against extreme events would be prohibitive, and could potentially increase flooding downstream. No additional mitigation required. Potential sediment discharges can be managed through standard erosion and sediment control. (Updated 270522)

Technical Expert	Assessment
Landscape & Visual	There will be some adverse landscape effects during excavation, and from modifying the natural landform. Such effects will be remedied through construction of a naturalistic landform, and rehabilitation of the site with indigenous habitat and vegetation – replacing the existing farmland. The net outcome is potentially positive. There will be some adverse effects on perceptions of natural character during construction, although the site is buffered by the Ohau River by the ecological and natural character works proposed as part of Ō2NL, and the excavation will occur in the context of construction works along the highway corridor. The rehabilitated site will merge with the natural character enhancement proposed along the river margins. It will increase the amount of natural vegetation and habitat along the corridor. The net outcome is potentially positive.
Heritage	There are no heritage sites identified near this site so therefore there are no adverse effects
Archaeology	The main factor for consideration is the close proximity to the Ohau River. There are no specific archaeological sites recorded in the area, but there is a possibility that archaeological sites could be found in this area (without detailed survey it is difficult to assess due to the complex history of the area, movements of the river, have flood deposits destroyed or protected sites etc). In addition, the team should be aware that there was a homestead complex belonging to an early settler's family just outside the boundary of the proposed extent (see **Figure 7** below, John Davies house and buildings). There is currently a milkshed and other farm buildings in the area and it won't be affected by the current plans, but it is something to be aware of if there is a possibility this location needs to be crossed to enable vehicle access or the farming facilities are dismantled (if the current farm setup is determined to be impractical).
Air Quality	Low risk of effects - The alluvial resources at this location have the potential to be high in silt and therefore have a high dust potential. The length of the haul road has decreased and therefore the potential for dust generation has also reduced. Based on this, and the site being away from sensitive receptors, the assessment rating has decreased from medium to low as it is unlikely to cause any adverse effects in terms of air quality. (Updated 250522)
Social/Community	This site is outside the current proposed designation footprint impacting a large area of farmland and is in close proximity to an existing dwelling. It provides opportunities in the future to consider a possible future loop trail on northern bank of Ohau -Muhunoa East Road (to be developed by others). It provides an improved river environment that is a valued and used recreational asset for the local community. Assuming this is in keeping with the surrounding environment. On that basis once established, it is considered to have a negligible impact for the sub-local community (improved planting may provide improvement the quality of the sub-local local living environment).
Contaminated Land	There has been no HAIL activity identified on this site. The site has been farmland since prior to 1961. As with any farmland there is a possibility historical farm dumps could be encountered and historic buildings if they exist within the footprint of the borrow site may have other contaminants (Lead, asbestos etc) associated with them. The likelihood of this at site #36 is unknown. It is understood that someone has looked at historic farm and early settlers dump sites but this information has not been seen to date.

Technical Expert	Assessment
HC Soils	Loss of highly productive land with no mitigation options available. Site 36 is above Site 26 and was classified as “green” under the initial assessment under the assumption it was mostly LUC unit 4s1 where in fact it is LUC unit 2s1. The traffic light assessment should have been “orange” for site 36.
ESC	From an Erosion and Sediment Control perspective, there is nothing remarkable about Site #36, other than the proximity to the Ohau River. It is noted that the final contours tie into the upper terrace, above the 100 year flood plain, and therefore it appears the site has the protection of the 100 year flood during extraction. I am of the opinion that erosion and sediment control devices that comply with the GWRC ESC Guideline could be installed to provide control for this site.
Iwi/CEDF	Iwi partners support open water option – at hui 2303 have agreed to design further open water option. Iwi partners are preparing Cultural Impact Assessments (CIA) and the CEDF audit process and these two mechanisms allow detailed issues to be identified as relevant. (Updated 310522)

<u>Site #34a – Q5b Sand Site at Koputaroa</u>

Technical Expert	Assessment
Transport	This was originally given a green site due to the reduction in required transport from the zone 4 sites. While it appears to have gotten smaller, the same points remain valid. Remains green.
Freshwater Ecology	As per the TLA, this site does not include any permanently flowing stream channels. While the original proposal included a proposed enlargement of the pond which was supported as it would address some of the loss of open water in upper Koputaroa catchment, it is understood the pond extension idea was not really viable. However this site still has ecological benefits resulting in permanent removal of cattle from an area of the catchment and creation of a wetland environment. Therefore, the original “green” assessment of the site stands, with the proviso that works are carefully managed to minimise adverse effects (e.g., sedimentation) on the adjacent ponds and wetland.
Terrestrial Ecology	Entirely within pasture and does not intersect with any seepage wetlands. Unlikely to have any adverse ecological effects as long as wetland hydrology/groundwater is not impacted and robust sediment controls are implemented.
Noise & Vibration	There is only one PPF (Protected Premises and Facilities) within 200m of the site – site is ‘green’ from a noise and vibration perspective.
Flooding & Hydrology	There would be no detrimental effects on flooding either upstream or downstream as a result of material extraction. The boundary provided is set back from the (ephemeral) stream floodplain, although it is understood that the proposed site will be integrated into an online wetland (i.e. not separated from the stream). The site represents a very slight advantage in terms of flood risk (due to additional storage of flood water on a wider floodplain).

Technical Expert	Assessment
Groundwater	There are no 'red flags' and the proposal is generally supported. Notwithstanding this, the final design must extend and connect to the existing box valley i.e., extend the extent of the flat valley floor. Careful design and construction will be required to ensure the enhancement and extension of existing hydrological/wetland processes and not the replacement of the existing wetland environment. Further investigation using piezometers is required to confirm the surface water/groundwater interactions so that these can subsequently be enhanced and promoted.
Water Quality	Site 34a contains Qb5 sands. It is located between the Ō2NL corridor and an unnamed first order tributary of the Koputaroa Stream (stream ID number 41). It is approximately 17,900 m^2 in area and between 40,000 – 80,000m^3 in volume. As the site is located adjacent to the proposed highway, it is easily accessible for construction machinery and no new roads are required. The site is located on agricultural land that slopes towards the unnamed tributary to the south. A small farm dam is located to the south-east of the proposed aggregate supply site. From topography, the tributary appears to be an intermittent steam, with permanent water behind the dam. The watercourse itself is outside of but immediately adjacent the zone of work. The main impacts on water quality will be potential erosion and sediment discharges, and possible increases in water temperature through removal of shading from the northern bank. This will be insignificant compared to the activities already being undertaken along the proposed highway. No additional mitigation required. Potential sediment discharges can be managed through standard erosion and sediment control. Potential impacts on water temperature will be addressed by stream and wetland revegetation already proposed as part of the Project.
Landscape & Visual	It appears the terrace will be removed to a level a little higher than the gully so as not to disrupt hydrology of the wetland. The lowered ground could be planted with wet forest. While it would not increase the extent of the wetland, it would provide a deeper margin around the gully. This is consistent with the intent to restore the gully for natural character purposes. The only adverse effects would be increased visibility of the highway from the nearest houses to the SE and S (161 and 157 Fairfield Road). This would be mitigated through planting batter below highway and the restoration planting mentioned above. Overall, the revisions would not change previous ratings for this site.
Heritage	There are no heritage sites identified near this site so therefore there are no adverse effects
Archaeology	An assessment of the revised site #34a confirms it is of lesser extent than the previous design freeze, so the probability of encountering an archaeological site also reduced – as per the TLA, this site could possibly be Orange as there is the potential for archaeological sites to be found in the area (archaeological site located further up gully, beyond extraction site).
Air Quality	Site 34a is located within the designation footprint and therefore unlikely to cause any adverse effects in terms of air quality.
Social/Community	House within 200m (need to confirm if this will be acquired as part of Project) of site on land already indicated for disturbance (within designation). May result in increased disturbance. Assumption made that post use site will be part of overall landscaping mitigation for corridor and or used as part of road, SUP or stormwater where it is within the corridor. Site remains orange as per TLA.
Contaminated Land	There has been no HAIL activity identified on this site from Council records. Farmland observed since prior to 1939. No historical development of farm buildings seen on this site although there is a possibility for unexpected discovery of an old farm dump in areas next to the river.

Technical Expert	Assessment
HC Soils	Approximately half of the site is Class 6, with the rest Class 2. The location of the proposed corridor compromises the remaining piece of highly productive land – this could have been avoided if the proposed road was against the edge of the site (designation) to minimise the effect/loss of highly productive land. Overall the site is 'green'.
ESC	Essentially from an Erosion and Sediment Control perspective there is nothing remarkable about the site, other than the proximity to the watercourse. The site is characterised by gentle contours and should be quite simple and straight forward from an ESC perspective. I am of the opinion that erosion and sediment control devices that comply with the GWRC ESC Guideline could be installed to provide control for these sites.
Iwi/CEDF	Iwi partners aware of preferred site and seem fine with it. Iwi partners are preparing Cultural Impact Assessments (CIA) and the CEDF audit process and these two mechanisms allow detailed issues to be identified as relevant.

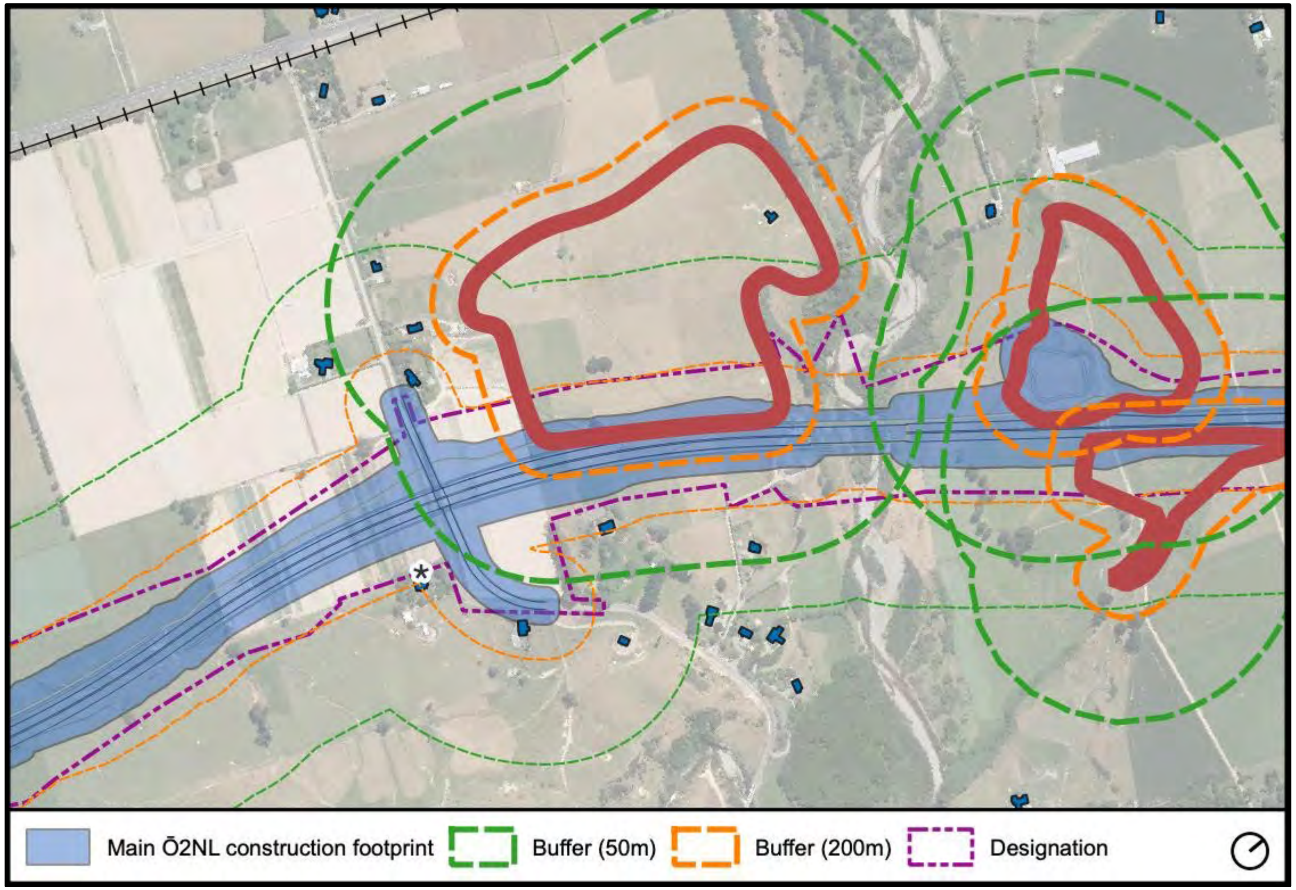


Figure 1 – Noise & Vibration buffers around site #15

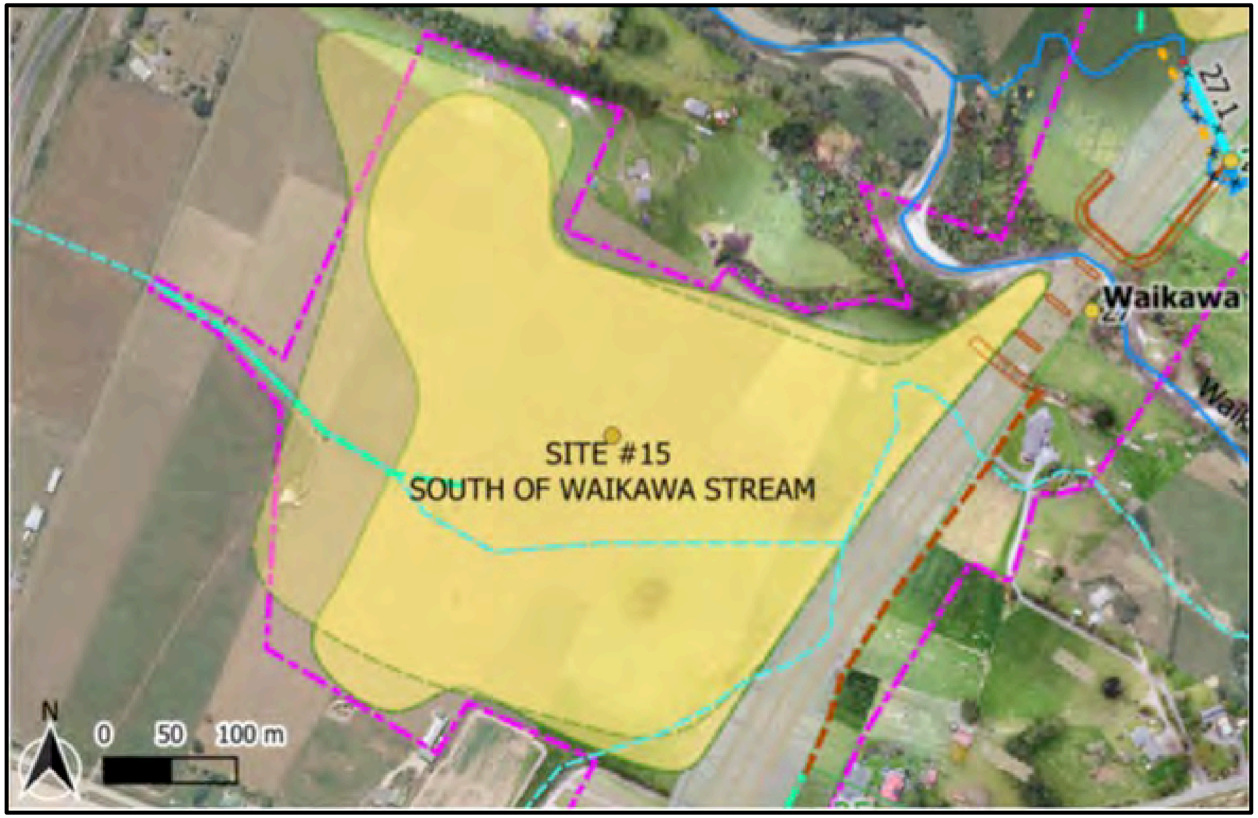


Figure 2 – Proposed westward extension to the designation recommended by Andrew Craig

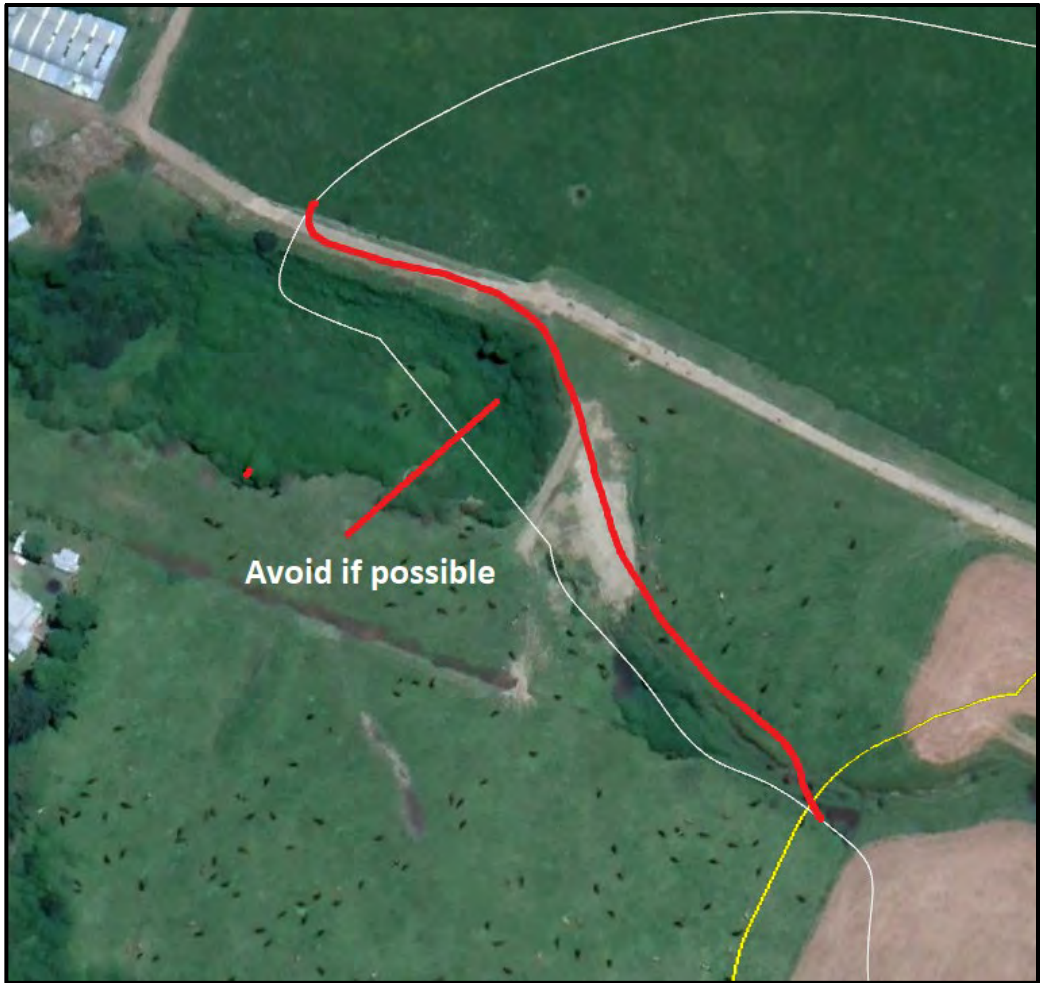


Figure 3 - Western extent of Site 19 showing potential overlap with indigenous vegetation and potential wetland

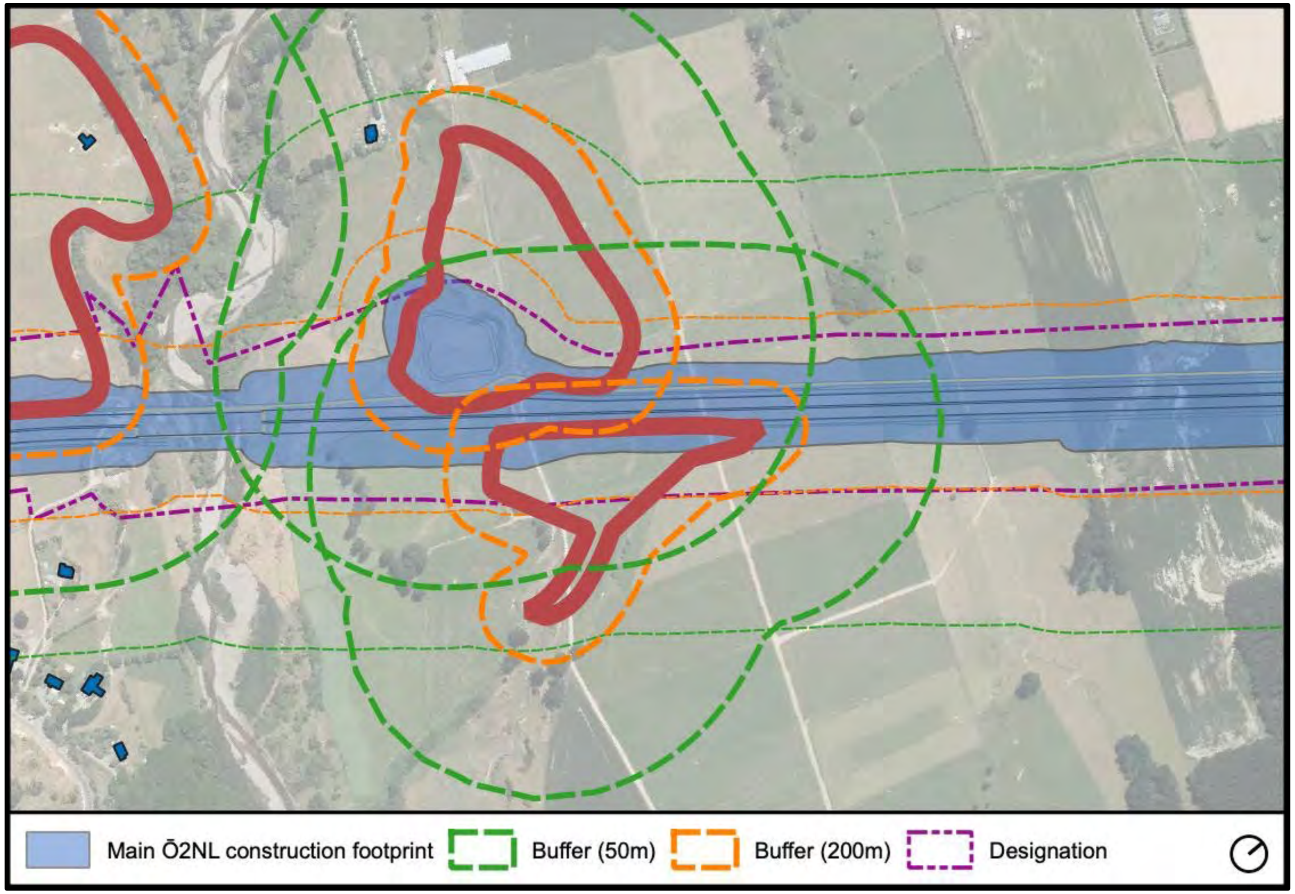


Figure 4 - Noise & Vibration buffers around site #19

Figure 5 - Hunting site called Parikawau

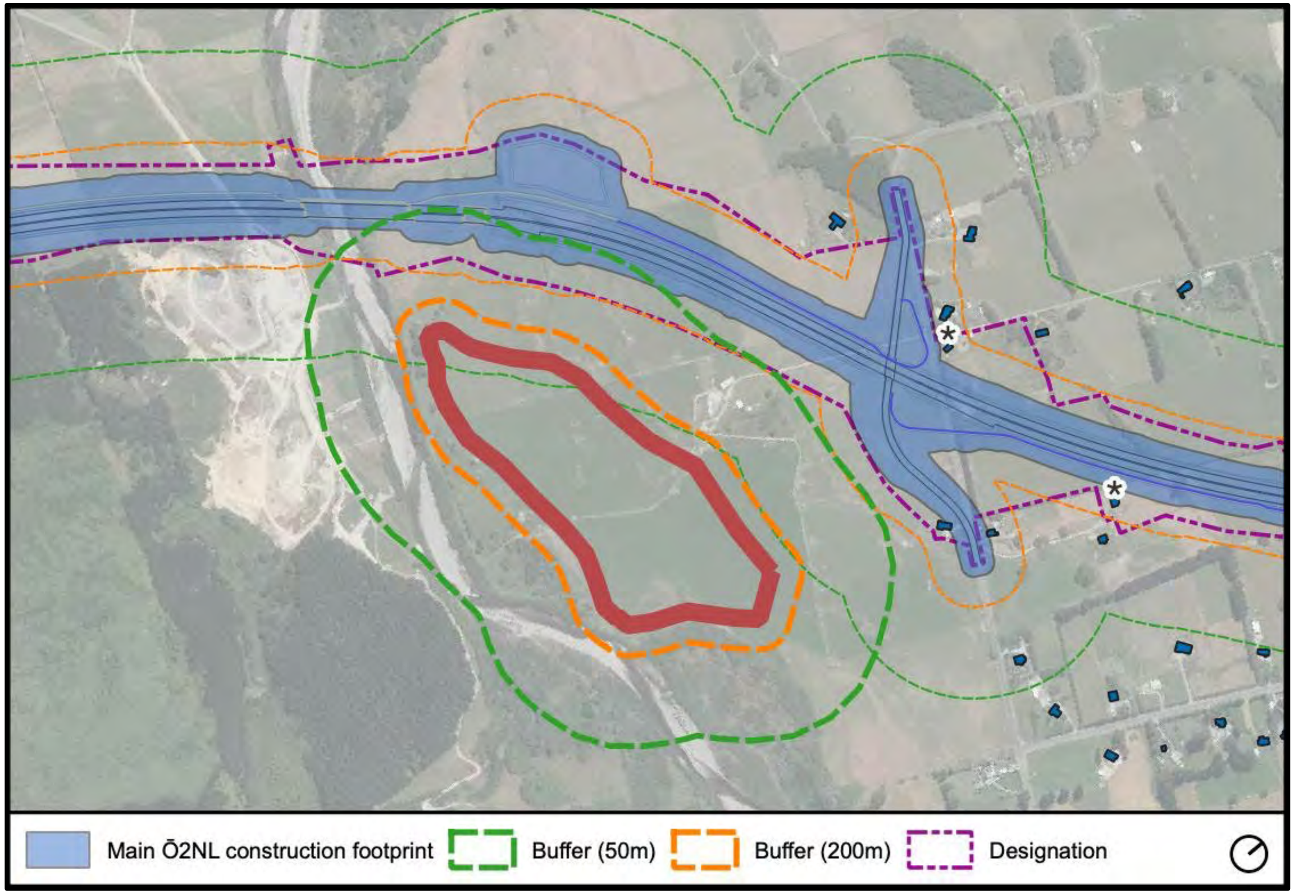


Figure 6 - Noise & Vibration buffers around site #36

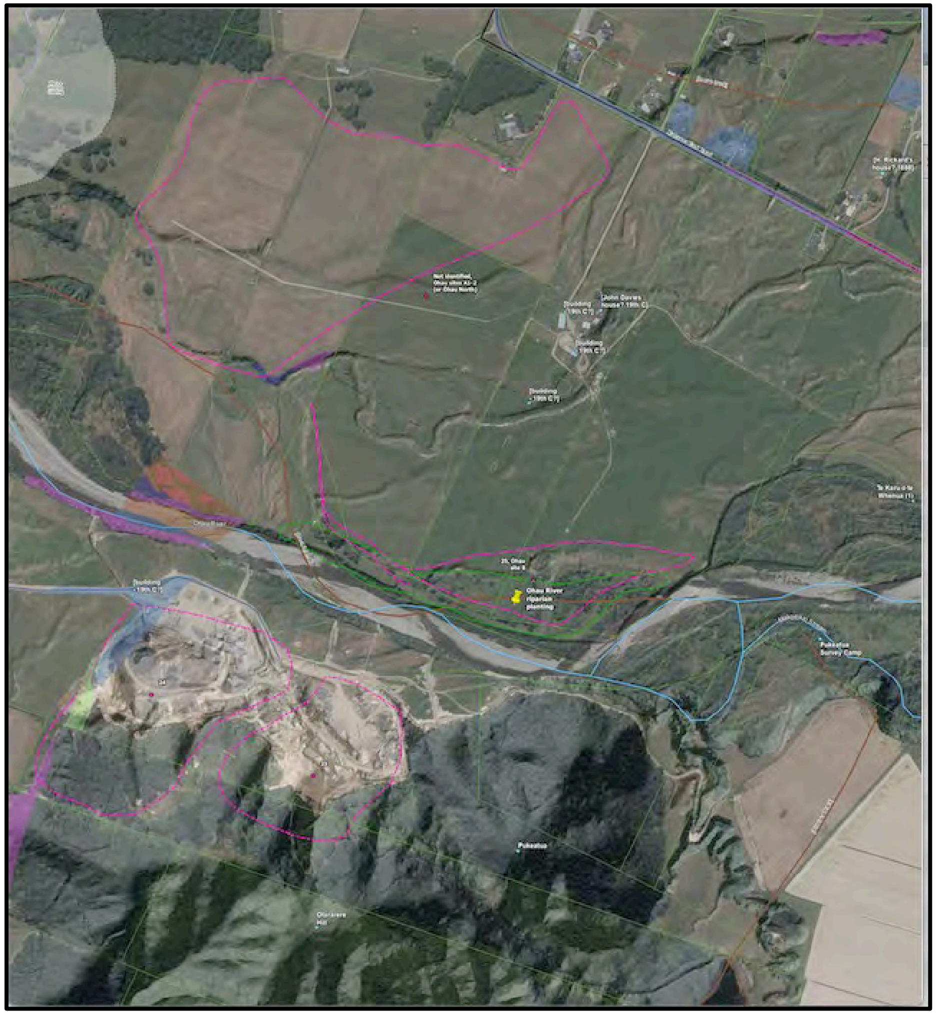


Figure 7 – John Davies house and buildings

Appendix 4.5.4 Geotechnical Memorandums

Geotechnical Assessment Memorandum for Q5b Shoreline Deposits, May 2022

Stantec

Otaki to North Levin (O2NL) Geotechnical Assessment Memorandum for Q5b Shoreline Deposits (Sands)

The conclusions in the Report are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from the Client and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion

Rev. no	Date	Description	Prepared by	Checked by	Reviewed by	Approved by
1	03-08-2021	Expediated factual information compilation and re-use interpretation of Q5b sand material	KC/RC	EG	IA	JP
2	30-05-2022	Q5b Sand material interpretation	KC/RC	JG	EG	JP

1 Introduction

Stantec has been engaged by Waka Kotahi to undertake geotechnical investigations and reporting for the Otaki to North Levin (O2NL) project. The first stage of the geotechnical investigation was completed in 2020, the second stage in 2021 and the third stage in 2022. The investigation results are presented within Stantec's Geotechnical Factual Report[1].

The purpose of this memorandum is to summarise factual results and provide geotechnical interpretation of the re-useability of the Q5b shoreline material (referred to Q5b Sands).

The Q5b sand material represents a geological formation as shown on published geological maps[2]. The proposed O2NL alignment crosses significant lengths of Q5b material between SH1 (Ch. 10,000) to SH57 (Ch. 13,000) north of Levin and between Ch. 30,700 to Ch 34,000 north of the Otaki River. Refer to Figures 2.1 and 2.2 respectively.

This Q5b sands are currently targeted for use as a bulk/general embankment fill, either as an efficient cut-to-fill process, or an efficient borrow-to-fill process. This assumption has been flagged as considerable project risk, with significant consequential effects.

An initial version of this memorandum recommended to avoid the re-use of this material if possible. However, on completion of a subsequent Material Supply (Borrow) Study[3], alternatives were not readily and efficiently available, and this has resulted in the need to rely on Q5b sand material for embankment construction. Assuming the material was going to be re-used, initial recommendations included:

- *Desktop review of historical documentation relating to the construction of SH57 between Shannon and Linton.*
- *Additional geotechnical investigation / testing targeting Q5b sand material source sites.*
- *Discussion with local Contractors regarding workability.*
- *Feasibility desktop assessment on using potential mixing (i.e., gravels) or additives (i.e., lime or fly ash).*
- *Constructability / compaction trial (material in natural state).*
- *Constructability / compaction trial (potential mixing (i.e., gravels) or additives (i.e., lime or fly ash).*

Excluding the field trials, these tasks have been completed and documented within this revised document.

The overall objective of this memorandum is to provide a compilation of the relevant geotechnical information, present a discussion on re-use interpretation of the Q5b sands, and provide recommendations going forward. The intent is that it will be appended to Stantec Geotechnical Interpretative Report[4].

[1] Geotechnical Factual Report for SH1 Ōtaki to North Levin, Rev C, Stantec, May 2022
[2] 1:250,000 Institute of Geological and Nuclear Sciences (IGNS) Geology of the Wellington Area, Map 10
[3] Ōtaki to North Levin (Ō2NL) Material Supply Study Report, Stantec, May 2022 (pending)
[4] Preliminary Geotechnical Interpretative Report for SH1 Ōtaki to North Levin, Rev D Stantec, May 2022

2 Location Plans

2.1 Northern Extent - Ch. 10,000 to Ch. 13,000

Figure 2.1, below, shows the investigation locations within the Q5b sands, at the northern extent of the alignment.

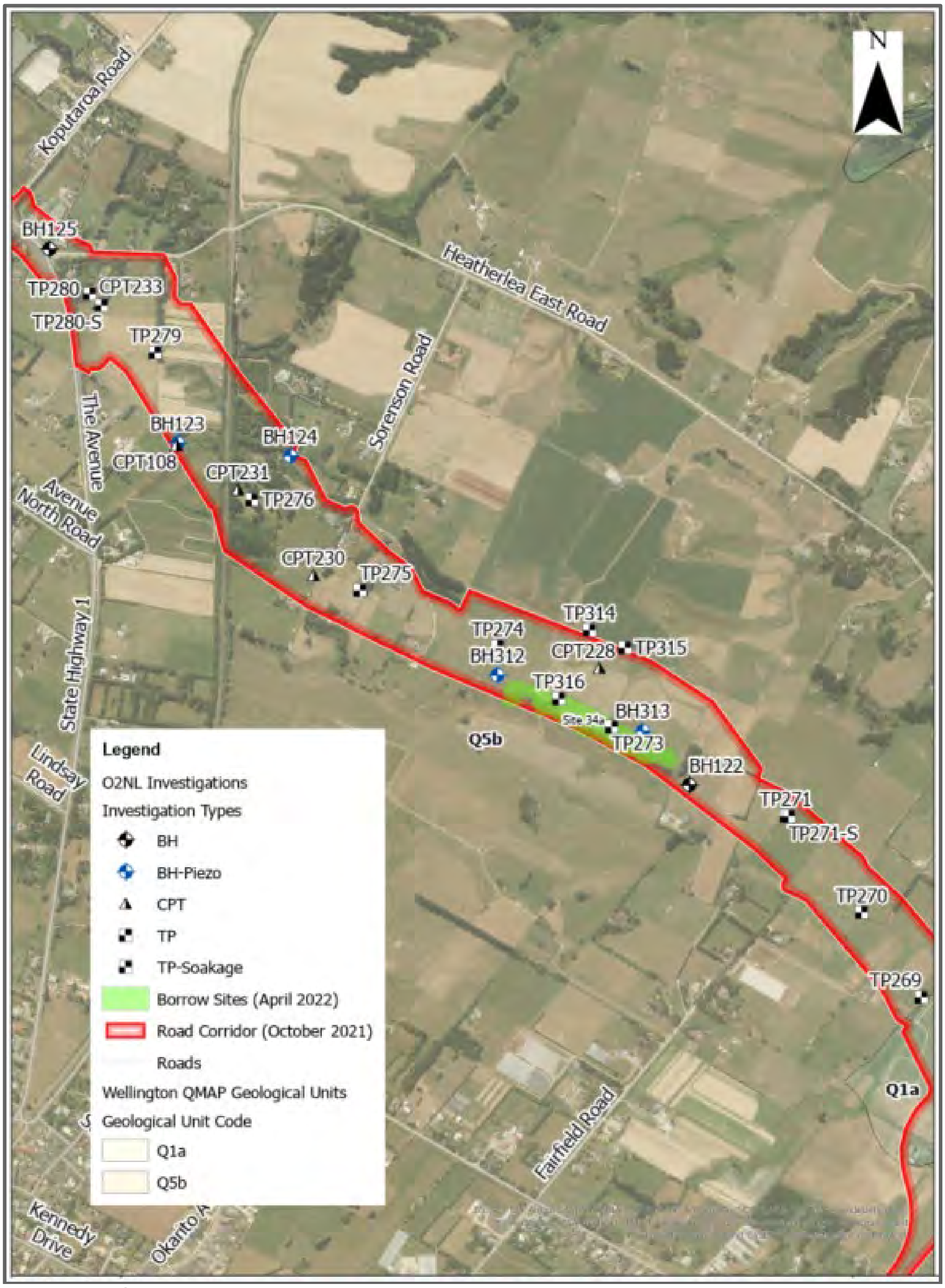


Figure 2.1: O2NL Northern Extent

2.2 Southern Extent - Ch. 30,700 to Ch. 34,000

Figure 2.2, below, shows the investigation locations within the Q5b sands, at the southern extent of the alignment.

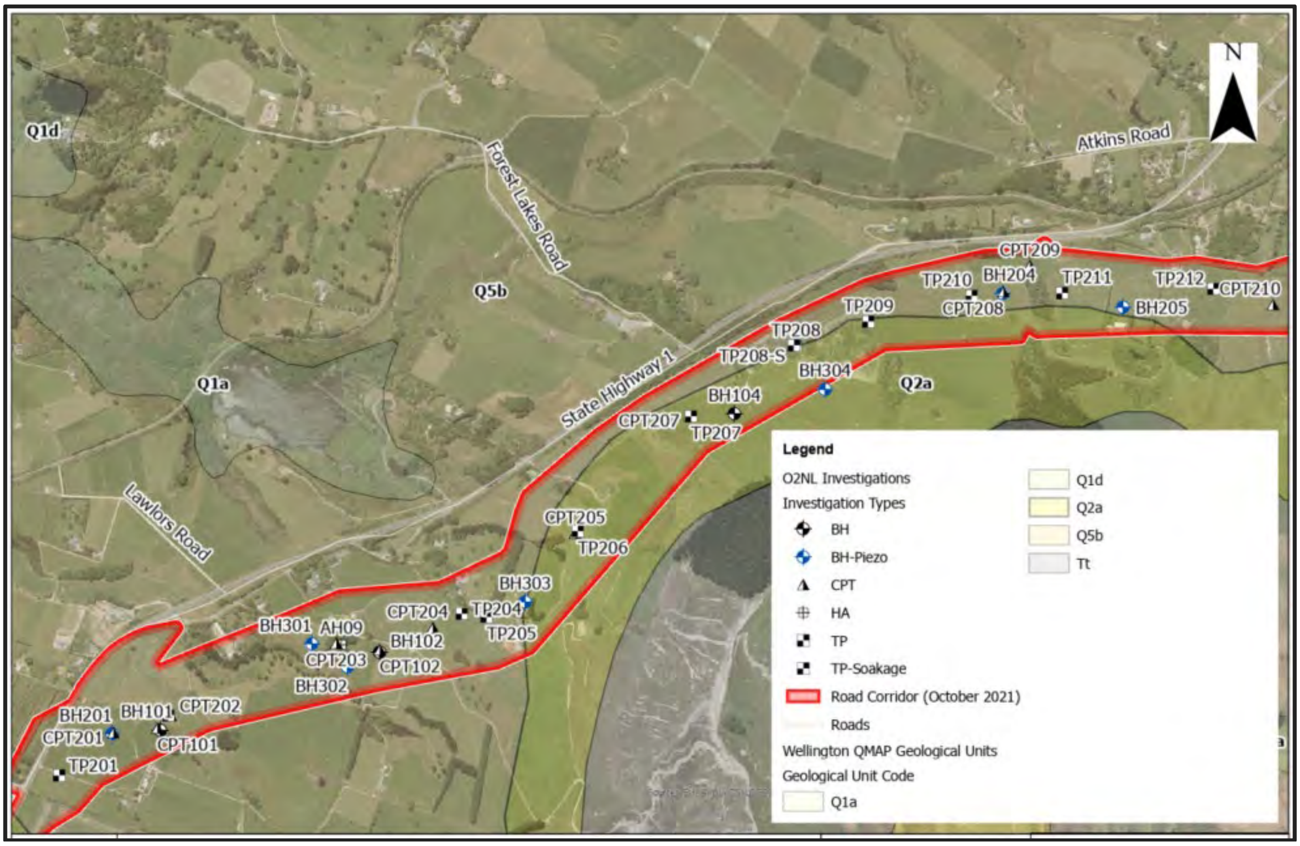


Figure 2.2: O2NL Southern Extent

Note that Q5b sand material was encountered elsewhere along the route, but this study focused on the northern and southern extents where of the alignment is primarily expected to be underlain by this material.

3 Knowledge of Q5b Sand Material

3.1 Published Geological Knowledge

The Q5b formation, as mapped and defined on 1:250,000 geological map of the Institute of Geological and Nuclear Sciences (IGNS) [5], is described as late Pleistocene age shoreline (ocean and beach) deposits, consisting of sand and marine gravel with sand commonly being overlaid by loess and fan deposits.

The Q5b formation of the IGNS geological map is inferred to include the following stratigraphy, described in the literature pertinent to the project area:

- The Otaki formation, consisting of two units, the Otaki Beach sand and Otaki Dune sand.
- Cover-beds of loess that generally overlie the Otaki and other geological formations in the wider area of the project. Loess consists of a sequence of up to four units of a total thickness of 4 m (Palmer et al. 1988[6]). The upper loess contains the Aokautere Ash. Loess sheets are typically discontinuous in the area and a complete sequence is rare. Generally, one or two loess units are missing, sometimes replaced by sands.
- The Koputaroa sands, which overlie the Otaki formation at the areas west and north of Levin, and possibly in the Otaki - Te Horo areas (Hawke and McConchie, 2005[7]).

The Otaki formation is underlain by the Pukehou formation. This is believed to correspond to the formation denoted as Q6 in the IGNS geological map, described as middle Pleistocene poorly graded to moderately sorted river gravel underlying loess-covered, commonly eroded aggradational surfaces. The formation wedges out against gravels about 2km west of State Highway 1. In the boreholes carried out for the Otaki to North Levin alignment, the Pukehou formation was inferred to have been encountered at depths greater than 20 – 25 m from the ground level in boreholes at the south part of the alignment. The formation is described as blue clay, blue fine sand, blue peaty sand, grey clayey silt, or fine grey sand (Sewell, 1991[8]). Occasional thin gravel lenses (0.2- 0.3 m) are also present. Almost without exception, peat, wood or carbonaceous matter are noted within it.

The Otaki formation and the Koputaroa sands are discussed in more detail in the following sections, as they are encountered near the ground surface and will influence aspects of the design and construction of the Otaki to North Levin motorway, as described in Section 1 of this memo.

3.1.1 Otaki formation

The Otaki formation is a predominantly shallow-water marine deposit, as described by Oliver (1948)[9]. In comparing the texture and composition of the Otaki Formation with the present-day coastal deposits to the west, Oliver made the following observations:

1. Sand in the Otaki Formation is generally more rounded than present-day beach and dune sand; and
2. Otaki Formation has a higher ferromagnesian content than present-day beach and dune sand.

Oliver considered the formation to be a predominantly shallow-water marine deposit with dune sands laid above coalescing alluvial fans.

The two units consisting of the Otaki formation are described in more detail below, from the older to the youngest stratigraphical member of the sequence (based on Sewell, 1991).

Otaki Beach Sand:
The lower stratigraphically unit of the Otaki formation is a light olive-grey, fine- to medium-grained gravelly sand with occasional sharply defined interbeds and lenses of yellow-grey to very pale orange, silty sand. The sand is generally moderately hard and maintains a stable vertical face at existing cuttings. However, outcrops of moderately soft sand are not uncommon and seem to have resulted from slight weathering. The unit is described as sandstone in the geological references, as the sandy soils have been cemented, to variable degrees.

The unit is referenced in the literature to have a thickness ranging from 13 m to 20 m. In the boreholes carried out along the Otaki to North Levin alignment, it was found with typical thicknesses ranging between 10 m and 14 m.

---

[5] Begg, J.G.; Johnston, M.R. (compilers) 2000: Geology of the Wellington area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences 1:250,000 geological map 10. 64 p. + 1 folded map.

[6] Palmer A, Barnett R, Pillans B, Wilde R 1988. Loess, river aggradation terraces and marine benches at Otaki, southern North Island, New Zealand. In: Eden D, Furkert R ed. Loess: its distribution, geology and soils. Proceedings of an International Symposium on Loess, New Zealand, 14-21 February 1987. Balkema. Pp 163-174.

7 Hawke R. M & McConchie J. A. (2005) The source, age, and stabilisation of the Koputaroa dunes, Otaki-Te Horo, New Zealand.

[8] Sewell, A. H., (1991) Paleoenvironmental Analysis of Quaternary starta in the Levin area, Thesis, Massey University.

[9] Oliver, R. L., 1948, The Otaki Sandstone and its geological history: N.Z. D.S.I.R. Geological Memoirs, v. 7, p. 49 p.

Silty beds and organic layers, well stratified or with crossbedding are described within the formation. The silty beds are interpreted in the literature to reflect periodic heavy influxes of fine sediment into an otherwise sand-dominated environment. The interbedding and nature of the Otaki Beach sand layers indicate a foreshore sub-environment of a wave-dominated shoreline (Elliot 1986)[10]. The silty beds are possibly the result of infrequent flood episodes of adjacent rivers into an open beach environment.

Otaki beach sand grades up into Otaki dune sand, which is described below.

Otaki Dune Sand:
The Otaki Dune sand consists of orange brownish grey, fine to coarse graded sands and silty sands. The unit is characterised by intense crossbedding, consisting of alternating thin (2 – 3 mm) silty laminae containing carbonaceous matter.

3.1.2 Koputaroa Sands

Cowie (1963)[11] distinguished the much younger Koputaroa phase dune-sands (18,000 to 35,000 years old) from what Oliver had previously included as part of the Otaki Formation in the Levin area. He noted a strongly weathered clay separated the two units which indicated a period of intense and prolonged weathering.

Cowie considered the Koputaroa dune-sands to be of fluvial origin primarily because they accumulated during the Last Glaciation when sea level was considerably lower. Based on Hawke and McConchie (2005)[12], the Koputaroa dune sand is almost identical to the Holocene dune sand, but it is distinctly different to that derived from local rivers.

3.2 Stantec's Investigation Field Descriptions

The Q5b stratigraphy described in Section 3.1, have been encountered in the boreholes carried out along the Otaki to North Levin alignment. The different units are generally described as follows in the boreholes along the alignment:

- **Loess:** described as silty CLAY, to clayey SILT, often interlayered with sand and gravel, brown, to light yellowish-brown with orange mottles. The layer is often encountered directly on the ground surface, below the topsoil, and has a thickness from 0.5 m and up to 4 m, but it was also absent from some boreholes and test pits.
- **Koputaroa Sand:** encountered as SAND with some silt to silty SAND, brown, medium dense to dense. The layer has been interpreted to be up to 7 – 10 m thick, it overlies the Otaki formation and is found either directly on the ground surface or below a layer of loess.
- **Otaki Dune Sand:** This unit of the Otaki formation is described as fine to medium silty SAND to SAND with silt and clay, brown. The unit is generally medium dense but could also be dense to very dense. Interlayers of reddish-brown silty clay layers and organics have been observed. Often these layers denote the transition from the dune sands to the underlying Otaki beach sands unit. The thickness of the dune sand unit is of the order of 10 to 15 m.
- **Otaki Beach Sand:** This unit of the Otaki formation is described as fine to medium SAND with some silt, silty SAND, brown to grey-brown. The layer is generally very dense and often retrieved partially cemented. The thickness of the layer in the boreholes was found to be up to 10 – 15 m.

It is generally difficult to distinguish the Otaki dune sands from the Otaki beach sands in the boreholes, especially when the latter are not cemented. Distinguishing between the two layers in the ground model developed for the project was primarily based on the N_{SPT} values and the degree of cementation, with the higher values, believed to correspond to the Otaki beach sands.

3.3 Geotechnical or Construction Knowledge

Stantec are not aware of any previous geotechnical testing results or assessment of the Q5b sand material.

Stantec understands (via discussion with WSP) that the Q5b sand material was not encountered in the nearby Pekapeka to Otaki project.

It is acknowledged that SH57 passes through mapped Q5b areas between Shannon and Linton. Waka Kotahi (Sarah Heappy) undertook a drive-by and confirmed fill slopes are present but couldn't confirm if they were constructed using Q5b sand material. Stantec understands (via discussion with WSP) silty sand material was utilised for construction (job overseen by Opus) of these fills, but contractors had to condition (dry) the material and it was only suitable for summer construction.

[10] Elliot, T., 1986, Siliclastic Shorelines, in ch. 7 of Reading, H. G., ed., Sedimentary Environments and Facies [2nd ed.): London, Blackwell Scientific Publications, p. 155-188.
[11] Cowie, J. D., 1963, Dune-building phases in the Manawatu District, New Zealand: New Zealand Journal of Geology and Geophysics, v. 6, p. 268-280.
[12] Hawke R.M. & McConchie J.A. (2005) The source, age, and stabilisation of the Koputaroa dunes, Otaki-Te Horo, New Zealand, New Zealand Journal of Geology and Geophysics, 48:3, 517-522

Waka Kotahi (Sarah Heappy) discussed the potentially workability of the Q5b sands with local Contractor Stan Goodman. Mr Goodman believed the Q5b sand material was workable, noting that a high level of earthworks management would be required. The conversation derived the following suggestions for earthworks planning:

- 70% of the cut Q5b sand material should be efficient to use as “cut to fill”.
- Drying of 4-5% moisture content can be typically achieved via discing (over 2 days if conditions allow) prior to compaction. Drying >5% becomes more challenging to achieve.
- Lime conditioning may be advantageous to extend the earthwork season.
- Pneumatic tyre roller compaction is likely the most suitable type for construction.

4 Investigations Completed

Investigations within the mapped Q5b area (southern and northern extents) and the O2NL road corridor have been completed by Stantec between June 2020 to March 2022. Stantec has completed ten boreholes within these areas during the O2NL Stage 1 and 2 investigations. All boreholes were completed by Griffiths Drilling with a PQ sized core barrel using a sonic drilling methodology per NZS 4411:2001 Environmental Standard for drilling of Soil and Rock.

Stantec has completed fifteen test pits within the Q5b area (southern and northern extents) as part of the Stage 2 and Stage 3 investigations. Test pits were excavated by Goodmans Contracting and Rocka Excavation between April 2021 – March 2022 using a 14t wheeled excavator.

Stantec has completed fourteen cone penetration tests (CPT) within the Q5b area over the Stage 1 and Stage 2 investigations. Stage 1 investigations were completed by Griffiths Drilling in 2020 and Stage 2 investigations by Ground Investigations Ltd in 2021.

Logging and sampling of the boreholes and test pits were completed by Stantec geologists. Samples have been stored at secure Waka Kotahi containers before testing.

4.1 Northern Extent - Ch. 10,000 to Ch. 13,000

Table 4.1 presents a summary of the relevant intrusive investigations completed with the Q5b material located within the northern extent of the project.

Table 4.1: Summary of Investigations Completed with the Q5b Material (northern extent)

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m bgl)	Depth where Q5b Encountered (m bgl)	Q5b Sands Subunits
		Easting	Northing					
BH119	Borehole	1795114	5499693	49.4	16150	30.44	3.85 - >30.44	3.85 – 9.00 Koputaroa Sand 9.00 – 12.00 Otaki Dune Sand 12.00 – 30.44 Otaki Beach Sand
BH122	Borehole	1796056	5502678	29.5	12150	19.78	3.00 >19.78	3.00 – 8.00 Koputaroa Sand 8.00 – 19.78 Otaki Dune Sand
BH123	Borehole	1794852.3	5503483.3	48.5	10650	30.88	2.00 >30.88	2.00 – 8.00 Koputaroa Sand 8.00 – 17.30 Otaki Dune Sand 17.30 – 30.88 Otaki Beach Sand
BH124	Borehole	1795116.8	5503452.7	40.95	10800	30.12	3.00 >30.12	3.00 – 7.30 Otaki Dune Sand 7.30 – 30.12 Otaki Beach Sand
BH125	Borehole	1794550	5503940	48.6	10100	19.92	1.75 - >19.92	1.75 – 5.35 Koputaroa Sand 5.35 – 7.50 Otaki Dune Sand 7.50 – 19.92 Otaki Beach Sand
BH127	Borehole	1796143.6	5500632.1	42.7	14780	19.86	1.70 – 19.86	1.70 – 9.00 Otaki Dune Sand 9.00 – 19.86 Otaki Beach Sand
BH227	Borehole	1796429.7	5500713.2	40.3	14527	25.25	0.80 – 25.25	0.80 – 5.90 Koputaroa Sand 5.90 – 14.00 Otaki Dune Sand 16.5 – 25.25 Otaki Beach Sand
BH223	Borehole	1795791.6	5500072.3	50	15425	19.8	2.00 – 19.80	2.00 – 5.20 Koputaroa Sand 5.20 – 8.90 Otaki Dune Sand 8.90 – 19.80 Otaki Beach Sand
BH229	Borehole	1795312.8	5499775.2	52	15986	19.65	3.30 – 19.65	3.30 – 12.60 Koputaroa Sand 12.60 – 15.40 Otaki Dune Sand 15.40 – 19.65 Otaki Beach Sand
BH222	Borehole	1795230.9	5499645.3	51.1	16137	30.14	3.00 – 30.14	3.00 – 22.00 Otaki Dune Sand 22.00 -30.14 Otaki Beach Sand
BH221	Borehole	1795069.2	5499377.2	53	16456	19.88	8.80 – 19.88	8.80 – 19.88 Otaki Dune Sand
BH312	Borehole	1795605.0	5502937.0	45.5	11559	15.45	0.40 – 15.45	0.40 – 3.40 Koputaroa Sand 3.40 – 15.45 Otaki Dune Sand
BH313	Borehole	1795947.0	5502806.0	44.1	11933	15.38	0.20 – 15.38	0.20 – 9.00 Koputaroa Sand

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m bgl)	Depth where Q5b Encountered (m bgl)	Q5b Sands Subunits
		Easting	Northing					
								9.00 – 13.15 Otaki Dune Sand 13.15 – 15.38 Otaki Beach Sand
TP259	Test Pit	1796058	5500314	45.5	15071	3.60	1.00 – 3.60	1.00 – 3.60 Koputaroa Sand
TP261	Test Pit	1796432	5500762	39.4	14489	3.30	1.50 – 3.30	1.50 – 3.30 Koputaroa Sand
TP269	Test Pit	1796603	5502179	24.6	12861	3.70	0.80 – 3.70	0.80 – 3.70 Otaki Dune Sand
TP270	Test Pit	1796462	5502379	24.2	12600	3.80	0.80 - >3.80	0.80 – 2.10 Otaki Dune Sand 2.10 – 3.80 Otaki Dune Sand OR Otaki Beach Sand
TP271	Test Pit	1796284	5502606	28.5	12300	3.50	0.80 - >3.50	0.80 – 3.5 Otaki Dune Sand
TP273	Test Pit	1795874	5502816	38.0	11850	3.50	1.90 - >3.50	1.90 – 3.50 Otaki Dune Sand
TP274	Test Pit	1795605	5503006	38.5	11550	3.90	1.50 - >3.90	1.50 – 3.90 Otaki Dune Sand
TP275	Test Pit	1795281	5503137	41.7	11200	3.20	1.10 - >3.20	1.10 – 3.20 Otaki Dune Sand
TP276	Test Pit	1795027	5503350	49.2	10850	3.90	0.10 - >3.90	0.10 – 0.55 Koputaroa Sand 0.55 – 3.90 Otaki Dune Sand
TP279	Test Pit	1794799	5503697	49.0	10450	3.50	0.90 - >3.50	0.90 – 3.50 Otaki Dune Sand
TP280	Test Pit	1794645	5503835	49.2	10200	3.80	1.90 - >3.80	1.90 – 3.80 Koputaroa Sand
TP314	Test Pit	1795821	5503043	38.2	11717	3.50	1.20 - >3.50	1.20 – 3.50 Otaki Dune Sand
TP315	Test Pit	1795905	5503002	36.7	11805	3.50	0.80 - > 3.40	0.80 – 3.40 Otaki Dune Sand
TP316	Test Pit	1795749	5502882	41.2	11716	3.40	0.80 - >3.40	0.80 – 3.40 Otaki Dune Sand
CPT108	CPT	1794849	5503479	48.7	10650	8.22	1.60 - >8.22	1.60 – 8.22 Koputaroa Sand
CPT228	CPT	1795844.6	5502954.6	23.1	11800	6.78	2.50 - >6.78	2.50 – 6.78 Otaki Dune Sand
CPT230	CPT	1795171.6	5503172.8	42.3	11050	17.45	1.5 - >17.45	1.50 – 7.50 Otaki Dune Sand 7.50 – 17.45 Otaki Beach Sand
CPT231	CPT	1794993.9	5503374.4	49.3	10800	9.23	2.70 - >9.23	2.70 – 6.90 Otaki Dune Sand 6.90 – 9.00 Otaki Beach Sand
CPT233	CPT	1794668.3	5503811.4	49.5	10250	10.66	0.90 - >10.66	0.90 – 4.70 Koputaroa Sand 4.70 – 7.40 Otaki Dune Sand 7.40 – 10.66 Otaki Beach Sand

4.2 Southern Extent - Ch. 30,700 to Ch. 34,000

Table 4.2 presents a summary of the relevant intrusive investigations completed with the Q5b material located within the southern extent of the project.

It is noted that the depths where Q5b material have been encountered shown in the last column of both Tables 4.1 and 4.2 are based on the ground model we have interpreted based on the geotechnical data available at this stage of design. Some of the depths shown in the Tables may be slightly modified in the next stages of design of the alignment, as more information becomes available.

Stantec

Table 4.2: Summary of investigations completed with the Q5b material (southern extent)

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, Wel 1953)	Approx Chainage	Termination Depth (m bgl)	Depth where Q5b Unencountered (m bgl)	Q5b Subunits
		Easting	Northing					
BH101	Borehole	1783347	5487230	23.1	34100	19.63	1.20 - >19.63	1.20 – 13.5 Otaki Dune Sand 13.5 – 19.63 Otaki Beach Sand
BH102	Borehole	1783897	5487426	31.7	33500	19.88	2.50 - >19.88	2.5 – 16.5 Otaki Dune Sand 16.5 – 19.88 Otaki Beach Sand
BH104	Borehole	1784788	5488023	36.8	32400	19.86	3.00 - >19.86	3.00 – 8.00 Otaki Dune Sand 8.00 – 19.86 Otaki Beach Sand
BH201	Borehole	1783225.8	5487220.5	27.2	34200	30.38	6.36 - >30.38	6.36 – 19.50 Otaki Dune Sand (6.36 to 9.0 potentially Loess) 19.50 – 30.38 Otaki Beach Sand
BH204	Borehole	1785461.5	5488325.4	55.8	31650	19.95	4.50 - >19.95	4.50 – 19.95 Otaki Dune Sand
BH205	Borehole	1785762.7	5488289.9	64.7	31354	15.45	0.25 – 15.45	0.25 – 10.90 Otaki Dune Sand 10.90 – 15.45 Otaki Beach Sand
BH301	Borehole	1783727	5487446	30.4	33665	15.45	1.10 – 15.45	1.10 – 15.45 Otaki Dune Sand
BH302	Borehole	1783817	5487389	31.1	33592	15.45	1.35 – 15.45	1.35 – 15.45 Otaki Dune Sand
BH303	Borehole	1784263	5487552	52.1		15.45	1.20 – 15.45	1.20 – 15.45 Otaki Dune Sand
BH304	Borehole	1785015	5488085	45.6	32180	15.15	3.00 – 15.15	3.00 – 8.70 Otaki Dune Sand 8.70 – 15.15 Otaki Beach Sand
TP202	Test Pit	1783368	5487267	19.3	34050	3.6	2.00 - >3.60	2.00 – 3.60 Otaki Dune Sand
TP204	Test Pit	1784104	5487522	35.4	33300	3.8	2.30 - >3.80	2.30 – 3.80 Otaki Dune Sand
TP205	Test Pit	1784166	5487514	41.9	33218	4.25	2.10 - >4.25	2.10 – 4.25 Otaki Dune Sand
TP206	Test Pit	1784395	5487729	24.3	32904	3.7	2.80 - >3.70	2.80 – 3.70 Otaki Dune Sand
TP207	Test Pit	1784679	5488017	25.7	32500	4.0	3.70 – >4.00	3.70 – 4.00 Otaki Dune Sand
TP208	Test Pit	1784941	5488193	25.7	32200	3.5	1.40 - >3.50	1.40 – 3.50 Otaki Dune Sand
TP209	Test Pit	1785124	5488254	28.7	32000	4.0	2.30 - >4.00	2.30 – 4.00 Otaki Dune Sand
TP210	Test Pit	1785383	5488319	59.3	31750	4.0	0.45 - >4.00	0.45 – 4.00 Otaki Dune Sand
TP211	Test Pit	1785610	5488326	55.4	31510	4.0	1.10 – >4.00	1.10 – 4.00 Otaki Dune Sand
TP212	Test Pit	1785990	5488337	57.0	31100	3.9	3.10 - >3.90	3.10 – 3.90 Otaki Dune Sand

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, Wel 1953)	Approx Chainage	Termination Depth (m bgl)	Depth where Q5b Unencountered (m bgl)	Q5b Subunits
		Easting	Northing					
TP213	Test Pit	1786393	5488375	55.3	30723	3.70	1.30 - >3.70	1.30 – 3.70 Otaki Dune Sand
CPT101	CPT	1783340	5487235	23.1	34100	11.5	1.60 - >11.50	1.60 – 11.50 Otaki Dune Sand
CPT102	CPT	1783898	5487431	31.6	34050	2.13	1.70 - >2.13	1.70- 2.13 Otaki Dune Sand
CPT201	CPT	1783229.5	5487223.7	27.4	34200	2.88	Not encountered	--
CPT202	CPT	1783373.5	5487266.3	19.5	34050	13.41	2.10 - >13.41	2.10 – 13.41 Otaki Dune Sand
CPT204	CPT	1784031.0	5487486.5	26.9	33350	12.38	3.30 - >12.38	3.30 – 12.38 Otaki Dune Sand
CPT205	CPT	1784388.1	5487723.4	23.6	32900	12.73	3.20 - >12.73	3.20 – 12.73 Otaki Dune Sand
CPT207	CPT	1784674.6	5488018.8	25.3	32500	8.12	3.90 - >8.12	3.90 – 8.12 Otaki Dune Sand
CPT208	CPT	1785462.8	5488329.4	55.8	31650	23.22	4.90 - >23.22	4.90 – 20.00 Otaki Dune Sand 20.00 – 23.22 Otaki Beach Sand
CPT210	CPT	1786138.5	5488296.7	51.1	31000	10.15	1.70 - >10.15	1.70 – 10.15 Otaki Dune Sand (1.7 – 3.8 potentially interbedded Loess)

5 Laboratory Testing

5.1 Testing Standards

Testing was undertaken by Geocivil laboratory, in accordance with the following standards:

- Particle Size Distribution (wet sieve) tested in accordance with ASTM D6913-17
- Particle Size Distribution (hydrometer) tested in accordance with NZS 4402:1986 Test 2.8.1, 2.8.4
- Natural Water Content tested in accordance with Test 2.1, NZS4402:1986
- Density of Soil tested in accordance with Test 5.1.4 & 5.1.5, NZS4402:1986
- Atterberg Limits tested in accordance with ASTM D4318 - 00
- NZ Compaction Test via the Standard Compaction Test in accordance with NZS 4402:1986 Test 4.1.1
- California Bearing Ratio tested in accordance with NZS 4407: 2015, Test 3.15.

It should be noted that ASTM D6913-17 defines fine sands as the material between 0.075mm – 0.475mm whilst NZ geological guidelines (used for field descriptions) defines fine sands as the material between 0.075mm – 0.2mm. The ASTM D6913-17 standard has been used to facilitate the derivation of material properties from industry-accepted empirical relationships, including the liquefaction triggering assessments.

5.2 Testing Summary

5.2.1 Northern Extent - Ch. 10,000 to Ch. 13,000

Table 5.2a presents a summary of the relevant laboratory testing that was undertaken (within Q5b material, northern extent).

Table 5.2a: Laboratory Testing Summary (within Q5b material, northern extent)

Sample ID	Particle Size Distribution (Wet Sieve)	Particle Size Distribution (Hydrometer)	Natural Water Content	Atterberg Limits	NZ Compaction Test	California Bearing Ratio
BH119	4	-	4	-	-	-
BH122	1	-	1	-	-	-
BH123	3	-	3	-	-	-
BH124	1	-	1	-	-	-
BH125	1	-	1	-	-	-
BH221	2	-	3	1	-	-
BH222	3	-	3	-	-	-
BH223	2	-	2	-	-	-
BH227	2	-	4	-	-	-
BH229	3	-	-	1	-	-
BH312	10	-	10	-	-	-
BH313	9	-	9	-	-	-
TP259	1	-	1	-	-	1
TP261	1	-	1	1	-	-
TP269	1	-	1	-	-	-
TP270	1	-	1	-	-	-
TP271	1	-	1	-	-	-
TP273	1	-	1	-	1	1
TP274	1	-	1	1	1	1
TP276	1	-	1	-	-	-
TP279	1	-	1	-	-	-
TP280	1	-	1	-	-	-
TP314	1	-	1	-	1	-
TP315	1	-	1	-	1	-
TP316	1	1	2	1	1	-

5.2.2 Southern Extent - Ch. 30,700 to Ch. 34,000

Table 5.2b presents a summary of the relevant laboratory testing that was undertaken (within Q5b material, southern extent).

Table 5.2b: Laboratory Testing Summary (within Q5b material, southern extent)

Sample ID	Particle Size Distribution (Wet Sieve)	Particle Size Distribution (Hydrometer)	Natural Water Content	Atterberg Limits	NZ Compaction Test	California Bearing Ratio
BH101	2	-	2	-	-	-
BH102	3	1	3	-	1	2
BH104	2	-	2	-	-	-
BH201	1	-	1	1	-	-
BH204	7	-	7	1	-	-
BH205	-	-	4	2	-	-
BH301	10	-	10	-	-	-
BH302	10	-	10	-	-	-
BH303	10	-	10	-	-	-
BH304	9	-	10	3	-	-
TP202	-	-	-	-	1	1
TP204	1	-	1	-	1	1
TP208	2	-	2	-	2	-
TP209	1	-	1	1	1	1
TP210	1	1	1	-	1	1
TP212	2	-	2	1	1	-

6 Laboratory Testing Summarisation

6.1 Laboratory Results Summary

6.1.1 Northern Extent - Ch. 10,000 to Ch. 13,000

Table 6.1a presents a summary of relevant laboratory testing results (within Q5b material, northern extent).

Stantec

Table 6.1a: Laboratory Testing Results (within Q5b material, northern extent).

Sample ID	Depth (m bgl)	Particle Size Distribution (Wet Sieve) % Gravel					Provisional Classification According to USCS	Natural Water Content (%)	GWL (m bgl) Observations (at Time of Sampling)	Terrain (at Sampling Location)	Q5b Subunits
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt /Clay					
		>4.75 mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075m m					
BH119	4.5 - 4.9	0.2	0.3	3.1	73.5	22.9	SM/SC	35.9	Undetermined	Flat	Koputaroa Sand
BH119	6.0 - 6.4	0	0.2	1.4	89.2	9.2	SP-SM/SC	20.9	Undetermined	Flat	Koputaroa Sand
BH119	10.5 - 10.95	0.2	0.1	1.8	81.1	16.8	SM/SC	27.4	Undetermined	Flat	Otaki Dune Sand
BH119	15.0 - 15.5	0	0.2	4.8	80.5	14.5	SM/SC	26.2	Undetermined	Flat	Otaki Beach Sand
BH122	4.0 – 4.5	0	0.6	1.7	84.5	13.2	SM/SC	16.6	Undetermined	Flat	Koputaroa Sand
BH122	9.0 – 9.45	0	0	0.9	84.9	14.2	SM/SC	23.4	Undetermined	Flat	Otaki Dune Sand
BH123	4.0 - 4.2	0	0	1	86.5	12.5	SM/SC	24.2	10.45	Top of terrace	Koputaroa Sand
BH123	5.75 - 6.0	0	0.1	0.8	85.4	13.7	SM/SC	23.3	10.45	Top of terrace	Koputaroa Sand
BH123	9.0 - 9.45	0	0	0.7	75.7	23.6	SM/SC	21.7	10.45	Top of terrace	Otaki Dune Sand
BH124	5.0 - 5.25	0	0.7	2.1	82.3	14.9	SM/SC	19.3	5.9	Top of terrace	Otaki Dune Sand
BH125	3.8 – 4.0	0	0	0.3	25.6	74.1	MH/ML/CL/CH	71.8	Undetermined	Top of terrace	Koputaroa Sand
BH125	6.0 – 6.6	0	0	1.5	87.1	11.4	SP SM/SC	24.8	Undetermined	Flat	Otaki Dune Sand
BH221	9.0 – 9.45	0	0	0.9	88.6	10.5	SP	29.7	2.85	Flat	Otaki Dune Sand
BH221	15.0 – 15.45	0	0	2.1	84.4	13.4	SM/SC	24.8	2.85	Flat	Otaki Dune Sand
BH222	4.50 – 4.84	0	0	1.0	89.5	9.6	SP	26.5	7.1	Flat	Otaki Dune Sand
BH222	9.0 - 9.45	0	0	0.8	87.8	11.4	SP	22.1	7.1	Flat	Otaki Dune Sand
BH222	15.0 - 15.45	0	0	1.2	87.8	11.0	SP	30.9	7.1	Flat	Otaki Dune Sand
BH223	5.5 – 6.45	1.6	0.2	1.1	21	76.1	MH/ML/CL/CH	40	Undetermined	Flat	Otaki Dune Sand
BH223	13 – 13.95	0	0	1.2	22.5	76.3	MH/ML/CL/CH	25.8	Undetermined	Flat	Otaki Beach Sand
BH227	16.0 – 18.0	23	6.5	9.4	16.5	44.6	MH/ML/CL/CH	7.4	Undetermined	Flat	Otaki Beach Sand
BH227	20.0 - 21.0	20.8	5.8	11.4	17.2	44.8	MH/ML/CL/CH	9.8	Undetermined	Flat	Otaki Beach Sand
BH229	5.5 – 6.0	0	0	0.3	11.4	88.3	MH/ML/CL/CH	26.5	3.43	Flat	Koputaroa Sand
BH229	6.0 – 7.0	0	0	0.3	84.9	14.7	SM/SC	22.9	3.43	Flat	Koputaroa Sand
BH229	15.0 – 16.0	0	0	0.1	11.8	88	MH/ML/CL/CH	22.1	3.43	Flat	Otaki Dune Sand/ Otaki Beach Sand
BH312	1.5 – 1.95	0	0	2	79	19	SM/SC	20.6	7.34	Top of terrace	Koputaroa Sand
BH312	3.0 – 3.45	0	0	2	44	54	MH/ML/CL/CH	49.1	7.34	Top of terrace	Koputaroa Sand
BH312	4.5 – 4.95	0	0	1	93	6	SP	17.8	7.34	Top of terrace	Otaki Dune Sand
BH312	6.0 – 6.45	0	0	1	89	10	SP	19.8	7.34	Top of terrace	Otaki Dune Sand
BH312	7.5 – 7.95	0	0	1	88	11	SP	19.1	7.34	Top of terrace	Otaki Dune Sand
BH312	9.0 – 9.45	0	0	0	91	9	SP	15.1	7.34	Top of terrace	Otaki Dune Sand
BH312	10.5 – 10.95	0	0	1	85	14	SM/SC	21.3	7.34	Top of terrace	Otaki Dune Sand
BH312	12.0 – 12.45	0	0	0	89	11	SP	20.4	7.34	Top of terrace	Otaki Dune Sand
BH312	13.5 – 13.95	0	0	1	85	14	SM/SC	22.9	7.34	Top of terrace	Otaki Dune Sand
BH312	15.0 -15.45	0	0	0	90	10	SP	22.7	7.34	Top of terrace	Otaki Dune Sand

Sample ID	Depth (m bgl)	Particle Size Distribution (Wet Sieve)					Provisional Classification According to USCS	Natural Water Content (%)	GWL (m bgl) Observations (at Time of Sampling)	Terrain (at Sampling Location)	Q5b Subunits
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt /Clay					
		>4.75 mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075m m					
BH313	1.5 – 1.95	0	0	1	89	10	SP	19.2	11.15	Top of terrace	Koputaroa Sand
BH313	3.0 – 3.45	0	0	0	75	25	SM/SC	20.1	11.15	Top of terrace	Koputaroa Sand
BH313	4.5 – 4.95	0	0	0	84	16	SM/SC	16.2	11.15	Top of terrace	Koputaroa Sand
BH313	6.0 – 6.45	0	0	1	87	12	SM/SC	15.7	11.15	Top of terrace	Koputaroa Sand
BH313	7.5 – 7.95	0	0	1	26	73	MH/ML/CL/CH	51.5	11.15	Top of terrace	Koputaroa Sand
BH313	9.0 – 9.45	0	0	1	87	12	SP SM/SC	19.0	11.15	Top of terrace	Otaki Dune Sand
BH313	10.5 – 10.95	0	0	0	89	11	SP	22.9	11.15	Top of terrace	Otaki Dune Sand
BH313	13.5 – 13.80	0	0	0	81	19	SM/SC	17.3	11.15	Top of terrace	Otaki Beach Sand
BH313	15.0 -15.38	0	0	1	82	17	SM/SC	12.2	11.15	Top of terrace	Otaki Beach Sand
TP259	2.3 – 2.5	21.3	1.5	5.4	67.9	3.9	SP	22.9	2.9 (seepage), 3.2 (strong flow)	Flat	Koputaroa Sand
TP261	2.0 – 2.5	0	0.3	4.4	88.7	6.5	SP	25.0	2.6 (strong flow)	Flat	Koputaroa Sand
TP269	2.3 – 2.5	0	0.5	10.7	76.7	12	SP SM/SC	37.4	2.3 (seepage), 2.8 (strong flow)	Flat	Otaki Dune Sand
TP270	2.2 – 2.5	0	0	1	92	7	SP	25.2	2.1 (seepage), 2.5 (strong flow)	Flat	Otaki Dune Sand
TP271	2.5 – 3.0	0	0	4	72	24	SM/SC	21.4	Not encountered	Top of terrace	Otaki Dune Sand
TP273	2.0 – 2.3	0	0	2	95	3	SP	9.5	Not encountered	Top of terrace	Otaki Dune Sand
TP274*	2.2 – 3.5	0	0	0	48	52	ML	9.9	Not encountered	Top of terrace	Otaki Dune Sand (potentially captured bottom of Loess)
TP279	1.6 – 1.9	0	0	4	59	38	SM/SC	15.5	Not encountered	Flat	Otaki Dune Sand
TP280	2.0 – 2.3	0	0	2	66	32	SM/SC	23.6	2.9 (seepage)	Flat	Koputaroa Sand
TP314	3.3 – 3.5	0	0	0	91	9	SP	16.4	Not encountered	Top of terrace	Otaki Dune Sand
TP315	2.4 – 2.6	0	0	1	91	9	SP	10.1	Not encountered	Top of terrace	Otaki Dune Sand
TP316	3.2 – 3.4	0	0	0	37	63	MH/ML/CL/CH	29.8	Not encountered	Top of terrace	Otaki Dune Sand
Non-plastic											

6.1.2 Southern Extent - Ch. 30,700 to Ch. 34,000

Table 6.1b presents a summary of relevant laboratory testing results (within Q5b material, southern extent).

Table 6.1b: Laboratory Testing Results (within Q5b material, southern extent).

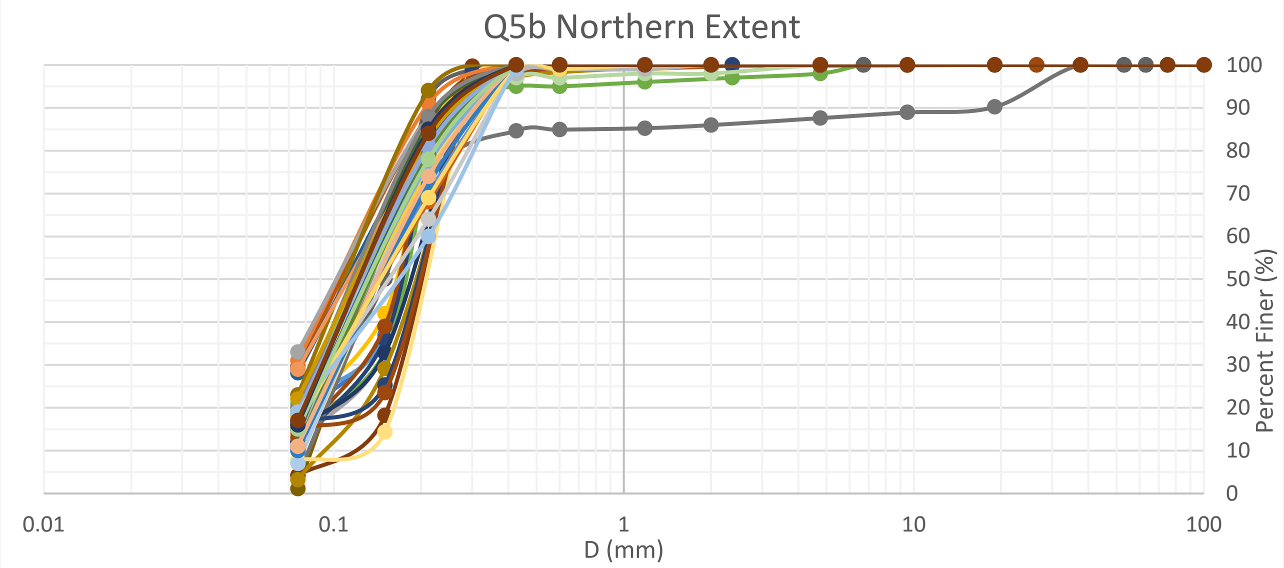
Sample ID	Depth (m bgl)	Particle Size Distribution (Wet Sieve)					Provisional Classification According to USCS	Natural Water Content (%)	GW Observations (at Time of Sampling)	Terrain (at Sampling Location)	Q5b Subunits
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt /Clay					
		>4.75 mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075mm					
BH101	3.0 – 3.45	0	0	0.5	85.5	14	SM/SC	25.2	Undetermined	Flat	Otaki Dune Sand
BH101	6.5 – 6.95	0	0	0.6	87.6	11.8	SP SM/SC	27.4	Undetermined	Flat	Otaki Dune Sand
BH102	4.5 – 4.95	0	0	0.6	78.7	20.7	SM/SC	28.1	Undetermined	Flat	Otaki Dune Sand
BH102	7.5 – 7.95	2.2	1	2.3	79.6	14.9	SM/SC	27.0	Undetermined	Top of terrace	Otaki Dune Sand
BH102	10.5–10.95	0	0.2	1.2	81	17.6	SM/SC	25.8	Undetermined	Top of terrace	Otaki Dune Sand
BH104	7.5 – 7.95	0	0	0.3	87.1	12.6	SM/SC	18.5	Undetermined	Top of terrace	Otaki Dune Sand
BH104	9.0 – 9.4	0	0	0.1	84.7	15.2	SM/SC	23.5	Undetermined	Top of terrace	Otaki Beach Sand
BH201	10.5 – 11.8	0	0	0.2	92.1	7.7	SP	25.7	Undetermined	Flat	Otaki Dune Sand
BH204*	4.5 – 4.95	0	0	0	85	15	SM/SC	13.6	19.09/16.33 Max	Top of terrace	Otaki Dune Sand
BH204	9.0 – 9.45	0	0	0	96	4	SP	10.7	19.09/16.33 Max	Top of terrace	Otaki Dune Sand
BH204	7.5 – 7.95	0	0	0	77	23	SM/SC	18.1	19.09/16.33 Max	Top of terrace	Otaki Dune Sand
BH204	10.5 – 10.95	0	0	1	70	29	SM/SC	38.4	19.09/16.33 Max	Top of terrace	Otaki Dune Sand
BH204	13.5 – 13.95	0	0	0	85	15	SM/SC	24.1	19.09/16.33 Max	Top of terrace	Otaki Dune Sand
BH204	15.0 -15.45	0	0	1	83	16	SM/SC	25.3	19.09/16.33 Max	Top of terrace	Otaki Dune Sand
BH301	1.5 – 1.95	0	0	1	70	29	SM/SC	30.5	10.50	Top of terrace	Otaki Dune Sand
BH301	3.0 – 3.45	0	0	2	88	10	SM/SC	18.1	10.50	Top of terrace	Otaki Dune Sand
BH301	4.5 – 4.95	0	0	1	81	18	SM/SC	25.0	10.50	Top of terrace	Otaki Dune Sand
BH301	6.0 – 6.45	0	0	1	83	16	SM/SC	19.0	10.50	Top of terrace	Otaki Dune Sand
BH301	7.5 – 7.95	0	0	0	79	21	SM/SC	18.1	10.50	Top of terrace	Otaki Dune Sand
BH301	9.0 – 9.45	0	0	0	85	15	SM/SC	63.7	10.50	Top of terrace	Otaki Dune Sand
BH301	10.5 – 10.95	0	0	0	81	19	SM/SC	24.1	10.50	Top of terrace	Otaki Dune Sand
BH301	12.0 – 12.45	0	0	0	80	20	SM/SC	22.6	10.50	Top of terrace	Otaki Dune Sand
BH301	13.5 – 13.95	0	0	0	78	22	SM/SC	19.5	10.50	Top of terrace	Otaki Dune Sand
BH301	15.0 -15.45	0	0	0	76	24	SM/SC	20.8	10.50	Top of terrace	Otaki Dune Sand
BH302	1.5 – 1.95	0	0	1	89	10	SP	24.0	10.42	Top of terrace	Otaki Dune Sand
BH302	3.0 – 3.45	0	0	0	89	11	SP	19.7	10.42	Top of terrace	Otaki Dune Sand
BH302	4.5 – 4.95	0	0	0	81	19	SM/SC	20.5	10.42	Top of terrace	Otaki Dune Sand
BH302	6.0 – 6.45	0	0	0	89	11	SP	19.7	10.42	Top of terrace	Otaki Dune Sand
BH302	7.5 – 7.95	0	0	1	80	19	SM/SC	18.5	10.42	Top of terrace	Otaki Dune Sand
BH302	9.0 – 9.45	0	0	1	83	16	SM/SC	17.3	10.42	Top of terrace	Otaki Dune Sand
BH302	10.5 – 10.95	0	0	1	80	19	SM/SC	20.7	10.42	Top of terrace	Otaki Dune Sand
BH302	12.0 – 12.45	0	0	0	85	15	SM/SC	27.0	10.42	Top of terrace	Otaki Dune Sand
BH302	13.5 – 13.95	0	0	0	84	16	SM/SC	21.3	10.42	Top of terrace	Otaki Dune Sand

Sample ID	Depth (m bgl)	Particle Size Distribution (Wet Sieve)					Provisional Classification According to USCS	Natural Water Content (%)	GW Observations (at Time of Sampling)	Terrain (at Sampling Location)	Q5b Subunits
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt /Clay					
		>4.75 mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075mm					
BH302	15.0 -15.45	0	0	0	83	17	SM/SC	19.8	10.42	Top of terrace	Otaki Dune Sand
BH303	1.5 – 1.95	0	0	1	88	11	SP	16.7	Not encountered	Top of terrace	Otaki Dune Sand
BH303	3.0 – 3.45	0	0	1	88	11	SP	14.8	Not encountered	Top of terrace	Otaki Dune Sand
BH303	4.5 – 4.95	0	0	0	81	19	SM/SC	19.8	Not encountered	Top of terrace	Otaki Dune Sand
BH303	6.0 – 6.45	0	0	1	88	11	SP	16.5	Not encountered	Top of terrace	Otaki Dune Sand
BH303	7.5 – 7.95	0	0	0	93	7	SP	17.8	Not encountered	Top of terrace	Otaki Dune Sand
BH303	9.0 – 9.45	0	0	0	93	7	SP	15.7	Not encountered	Top of terrace	Otaki Dune Sand
BH303	10.5 – 10.95	0	2	1	80	17	SM/SC	18.9	Not encountered	Top of terrace	Otaki Dune Sand
BH303	12.0 – 12.45	0	0	1	82	17	SM/SC	17.5	Not encountered	Top of terrace	Otaki Dune Sand
BH303	13.5 – 13.95	0	0	0	69	31	SM/SC	17.4	Not encountered	Top of terrace	Otaki Dune Sand
BH303	15.0 -15.45	0	0	0	67	33	SM/SC	16.0	Not encountered	Top of terrace	Otaki Dune Sand
BH304	3.0 – 3.45	0	0	0	19	81	MH/ML/CL/CH	19.0	5.74 Manual	Top of terrace	Otaki Dune Sand
BH304	4.5 – 4.95	0	0	0	39	61	MH/ML/CL/CH	30.8	5.74	Top of terrace	Otaki Dune Sand
BH304	6.0 – 6.45	0	0	1	72	27	SM/SC	21.1	5.74	Top of terrace	Otaki Dune Sand
BH304	7.5 – 7.95	1	1	7	20	71	MH/ML/CL/CH	62.0	5.74	Top of terrace	Otaki Dune Sand
BH304	9.0 – 9.45	0	0	5	87	8	SP	21.5	5.74	Top of terrace	Otaki Beach Sand
BH304	10.5 – 10.95	0	0	1	76	23	SM/SC	14.1	5.74	Top of terrace	Otaki Beach Sand
BH304	12.0 – 12.45	0	0	0	86	14	SM/SC	16.5	5.74	Top of terrace	Otaki Beach Sand
BH304	13.5 – 13.95	0	0	1	83	16	SM/SC	17.8	5.74	Top of terrace	Otaki Beach Sand
BH304	15.0 -15.45	0	0	1	72	27	SM/SC	8.1	5.74	Top of terrace	Otaki Beach Sand
TP204	3.0 - 3.5	0	0	3	94	3	SP	9.8	Not encountered	Top of terrace	Otaki Dune Sand
TP208	2.2 – 2.4	0	0	3	68	30	SM/SC	32.7	2.4 (strong flow)	Valley	Otaki Dune Sand
TP208	2.8 – 3.4	12	2	1	80	4	SP	25.2	2.4 (strong flow)	Valley	Otaki Dune Sand
TP209*	2.5 – 3.4	0	0	1	71	28	SM/SC	21.8	1.2 (Very localised seepage)	Valley	Otaki Dune Sand
TP210	3.6 – 4.0	0	0	1	98	1	SP	9.7	Not encountered	Top of terrace	Otaki Dune Sand
TP212	3.2 – 3.6	0	0	0	83	17	SM/SC	17.4	Not encountered	Valley	Otaki Dune Sand
TP212*	3.6 – 3.9	0	0	2	83	15	SM/SC	17.1	Not encountered	Valley	Otaki Dune Sand
** Non-plastic*											

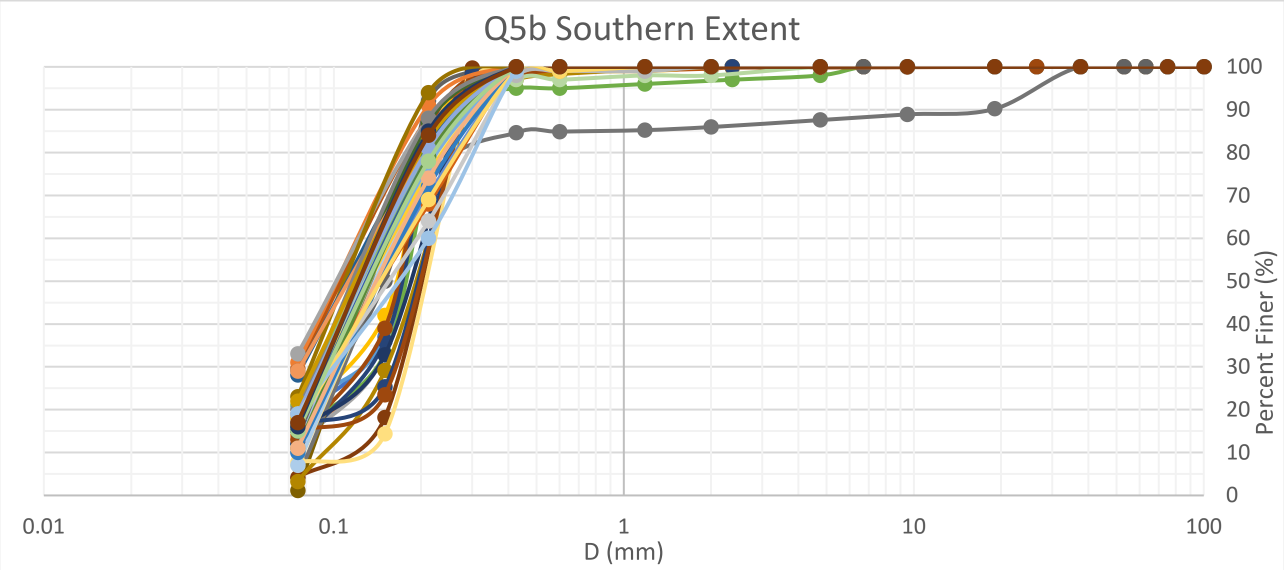
Stantec

6.2 Particle Size Distribution Plots

Figures 6.2a to 6.2b presents Particle Size Distribution plots for the Q5b Material. The curves limit is 0.075mm as per ASTM D6913-17.



6.2a: Particle Size Distribution for Q5b Materials – Northern Extent



6.2b: Particle Size Distribution for Q5b Materials – Southern Extent

6.3 NZ Compaction Test

Table 6.3 presents the results from the NZ standard compaction test with plots presented in Figure 6.2a to 6.2m.

Table 6.3: Results from the NZ standard Compaction Test

Sample ID	Depth (m bgl)	Natural Moisture Content, w_n (%)	Optimum Moisture (Water) Content, w_o (%)	Max Dry Density, $\rho_{d,max}$ (t/m³)	Terrain (at Sampling Location)	Q5b Subunits
BH102	5.0 – 15.0	27.0	14.00	1.76	Top of terrace	Otaki Dune Sand
TP202	2.5 – 3.6	24.6	19.03	1.61	Valley	Otaki Dune Sand
TP204	3.0 – 3.5	9.8	17.66	1.63	Top of terrace	Otaki Dune Sand
TP208	2.2 – 2.4	32.7	17.41	1.74	Valley	Otaki Dune Sand
TP208	2.8 – 3.2	25.2	15.39	1.69	Valley	Otaki Dune Sand
TP209	2.5 – 3.4	21.8	15.14	1.80	Valley	Otaki Dune Sand
TP210	3.6 – 4.0	9.7	16.16	1.68	Top of terrace	Otaki Dune Sand
TP212	3.2 – 3.6	17.4	20.20	1.63	Valley	Otaki Dune Sand
TP273	2.0 – 2.3	9.5	15.36	1.64	Top of terrace	Otaki Dune Sand
TP274	2.2 – 3.5	9.9	14.59	1.72	Top of terrace	Otaki Dune Sand
TP314	3.3 – 3.5	17.0	17.10	1.73	Top of terrace	Otaki Dune Sand
TP315	2.4 – 2.6	9.0	12.20	1.69	Top of terrace	Otaki Dune Sand
TP316	3.2 – 3.4	30.0	22.30	1.57	Top of terrace	Otaki Dune Sand

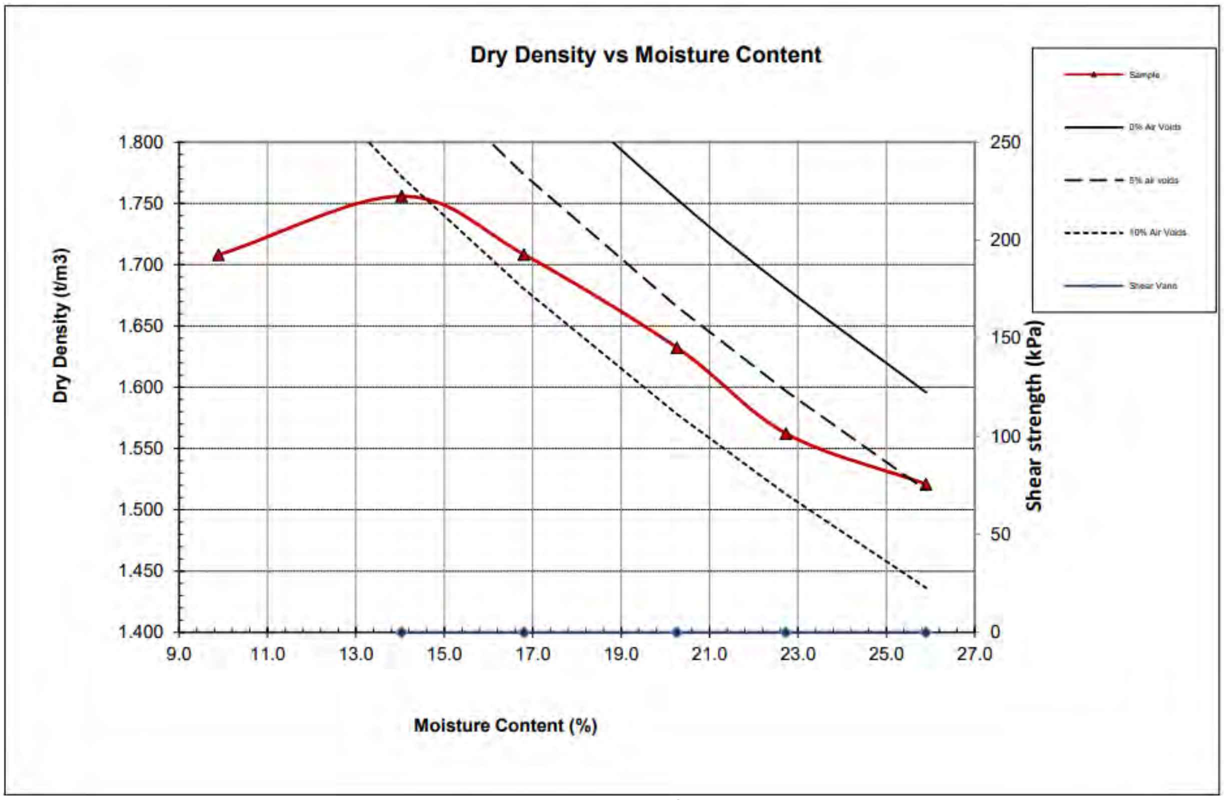


Figure 6.3a: BH102 5.0 – 15.0 m - Dry Density vs. Moisture Content Plot

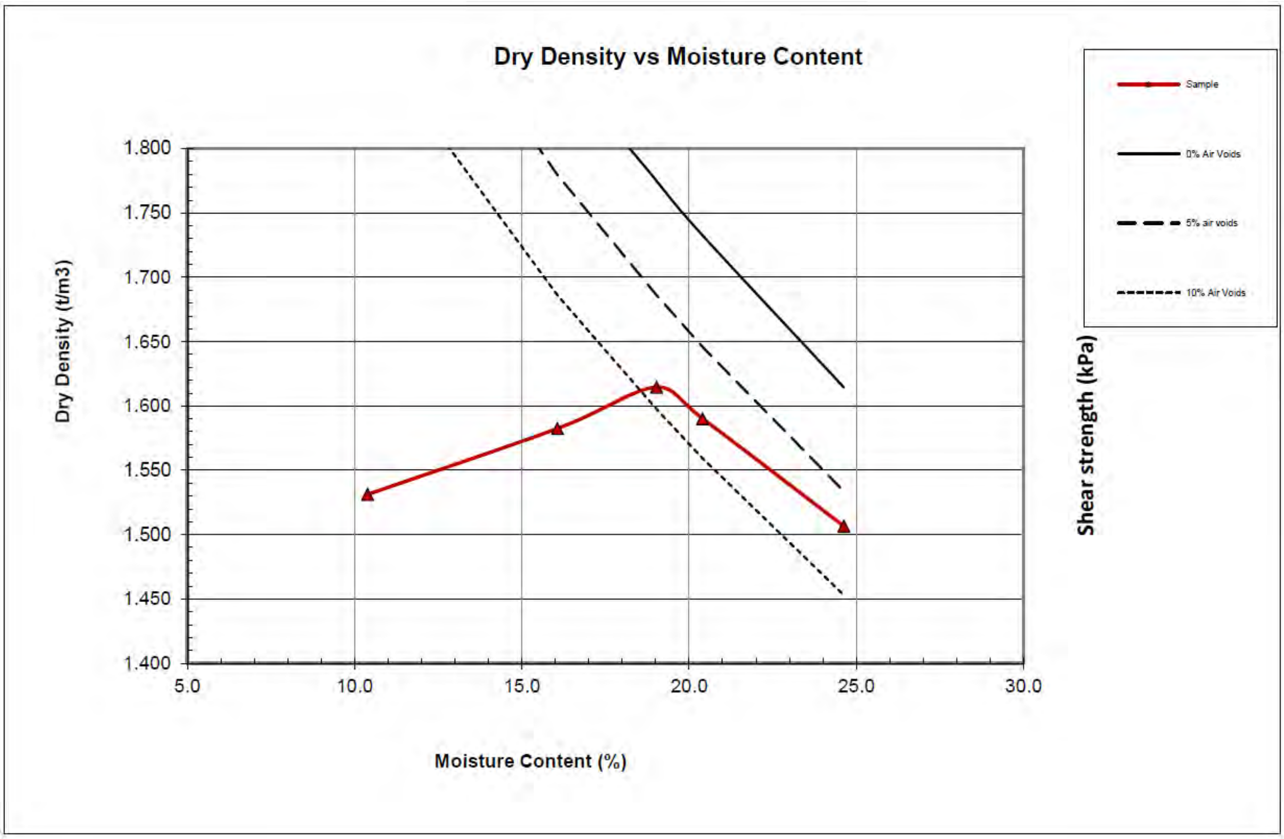


Figure 6.3b: TP202 2.5 – 3.6 m - Dry Density vs. Moisture Content Plot

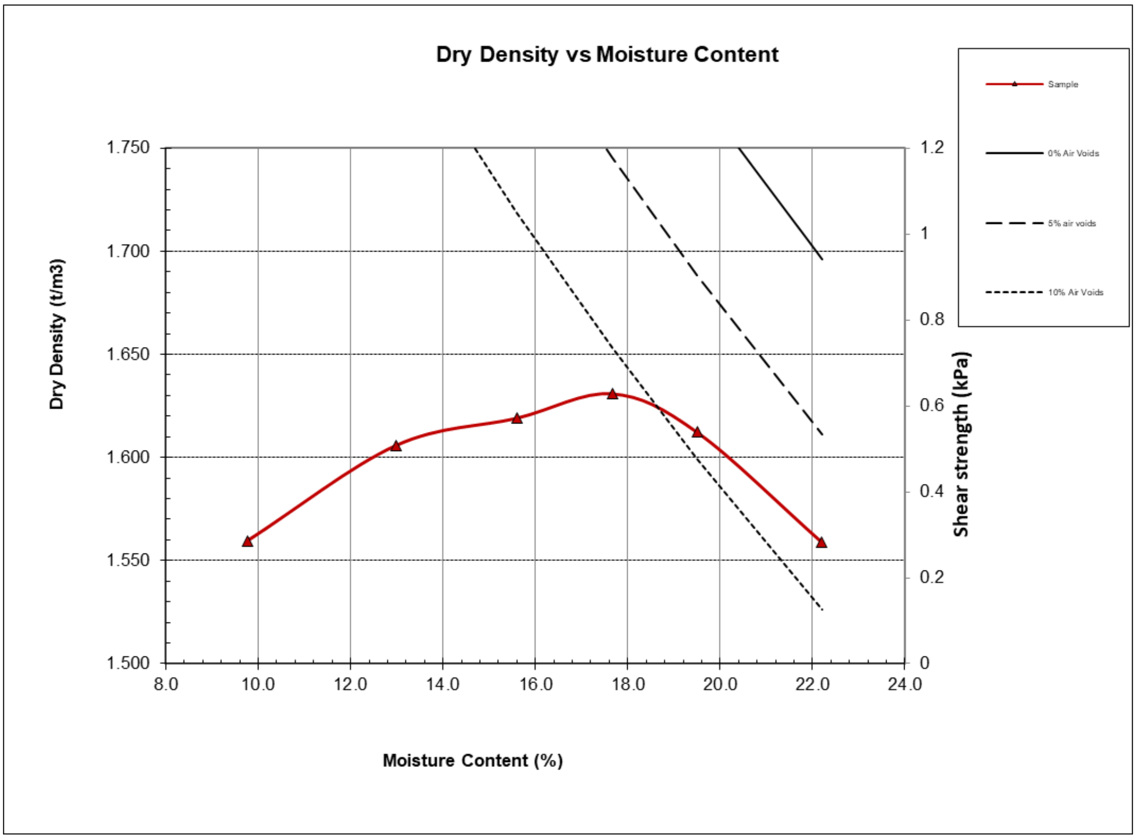


Figure 6.3c: TP204 3.0 – 3.5 m - Dry Density vs. Moisture Content Plot

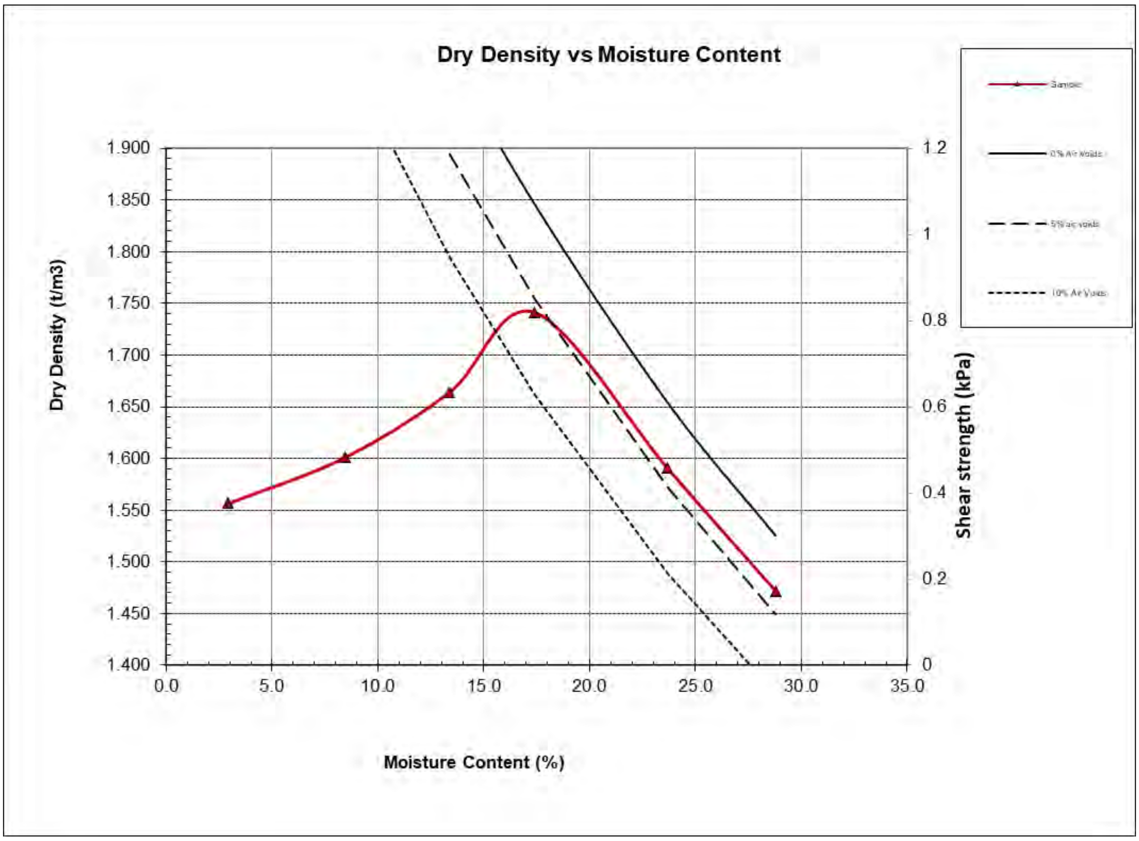


Figure 6.3d: TP208 2.2 – 2.4 m - Dry Density vs. Moisture Content Plot

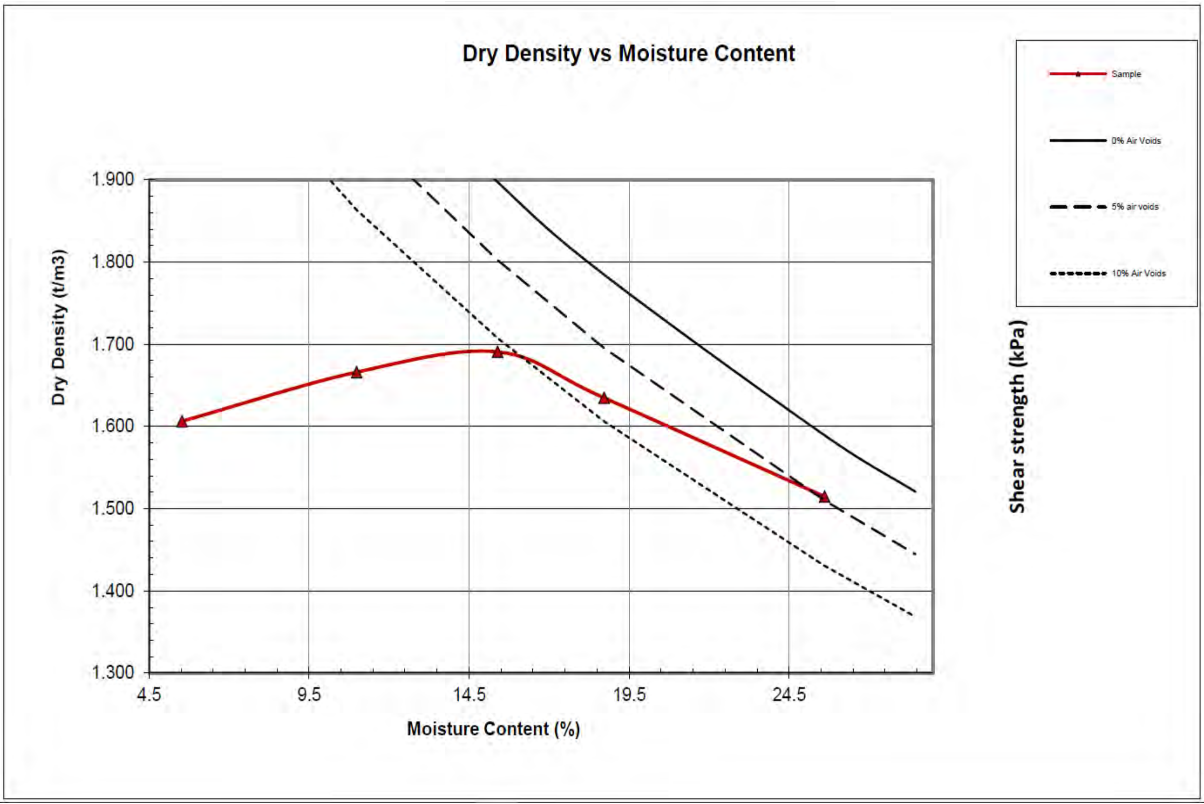


Figure 6.3e: TP208 2.8 – 3.2 m - Dry Density vs. Moisture Content Plot

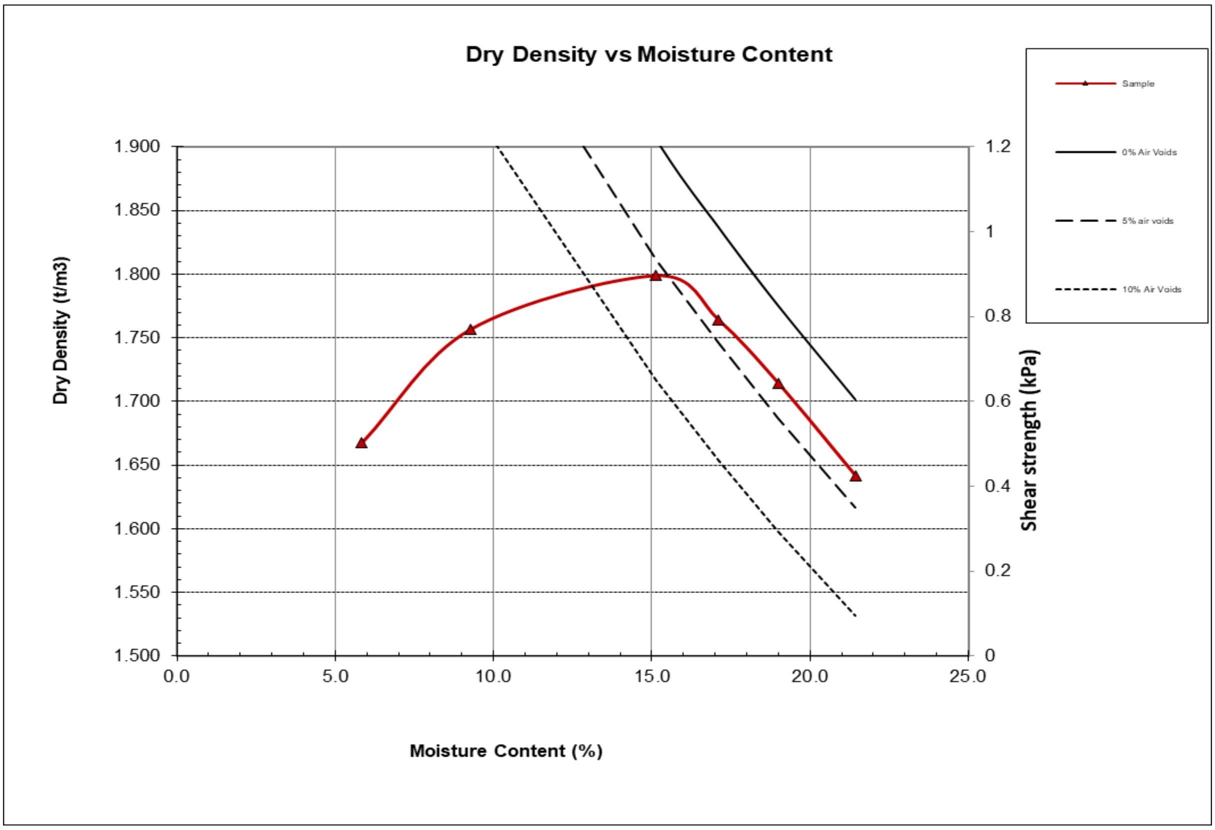


Figure 6.3f: TP209 2.5 – 3.4 m - Dry Density vs. Moisture Content Plot

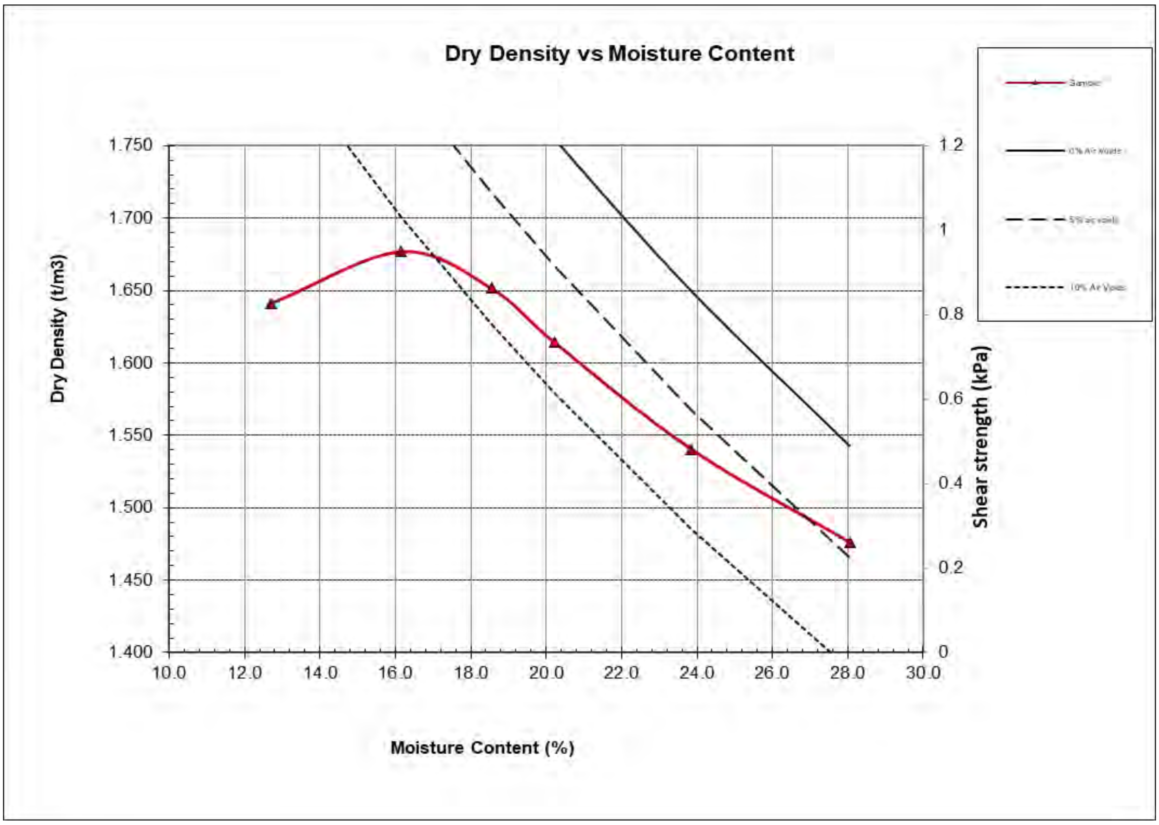


Figure 6.3g: TP210 3.6 – 4.0 m - Dry Density vs. Moisture Content Plot

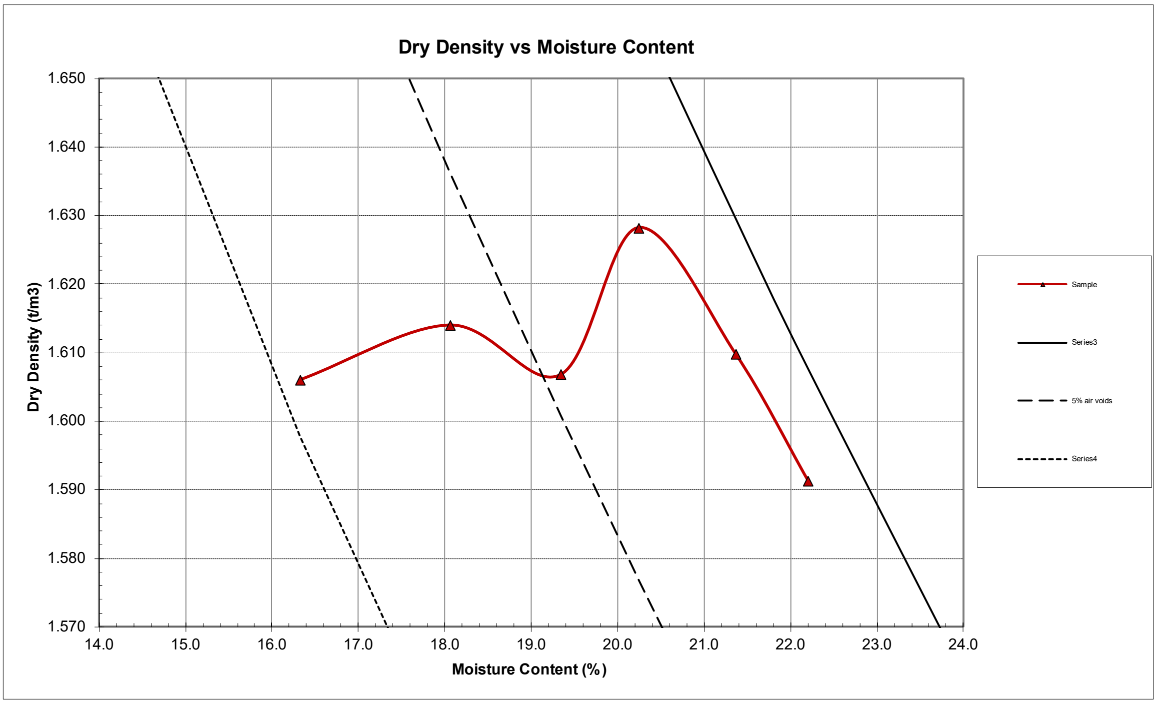


Figure 6.3h: TP212 3.3 – 3.6 m - Dry Density vs. Moisture Content Plot

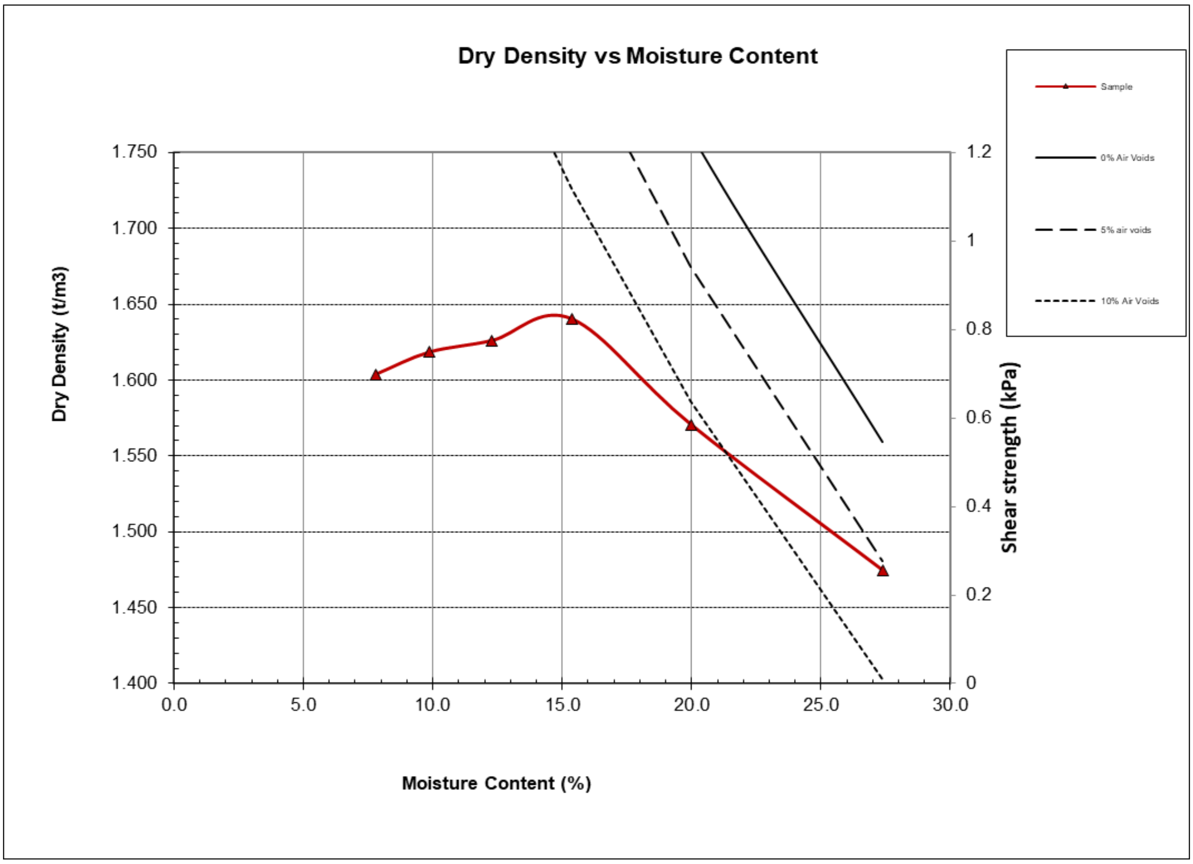


Figure 6.3i: TP273 2.0 – 2.3 m - Dry Density vs. Moisture Content Plot

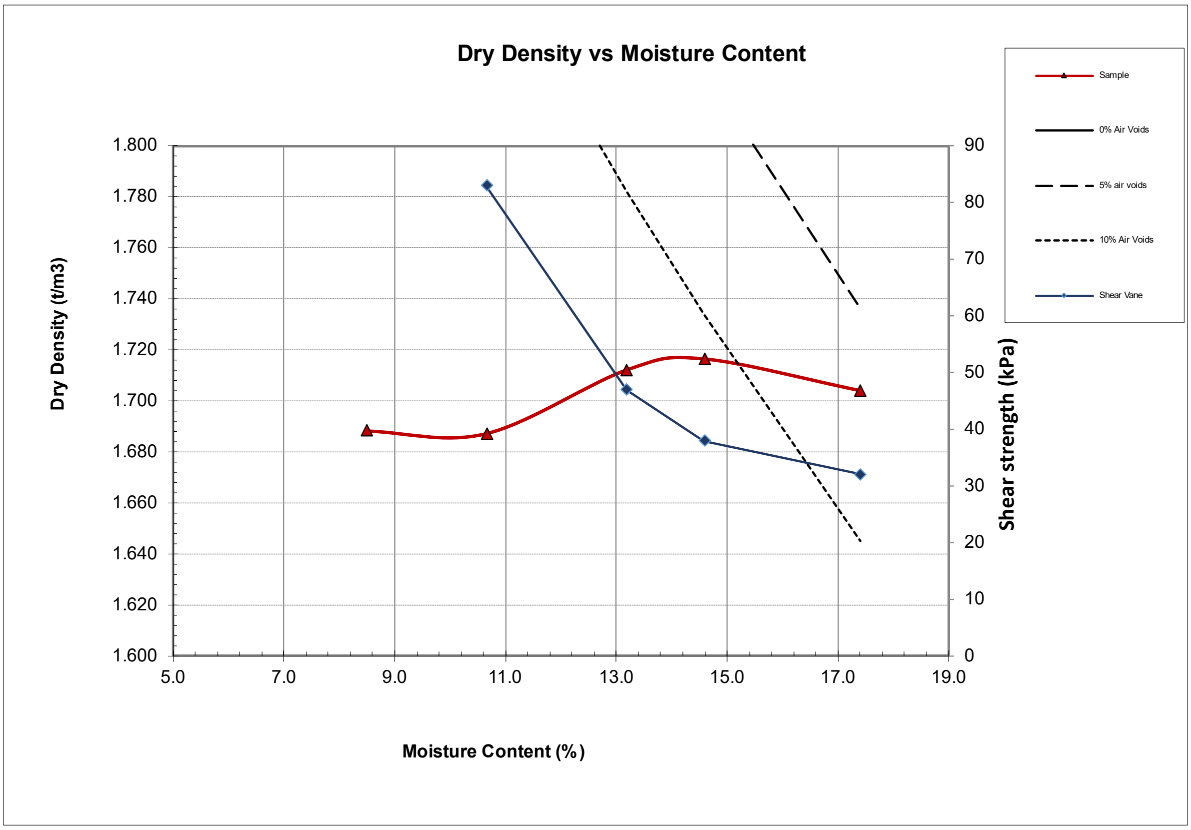


Figure 6.3j: TP274 2.2 – 3.5 m - Dry Density vs. Moisture Content Plot

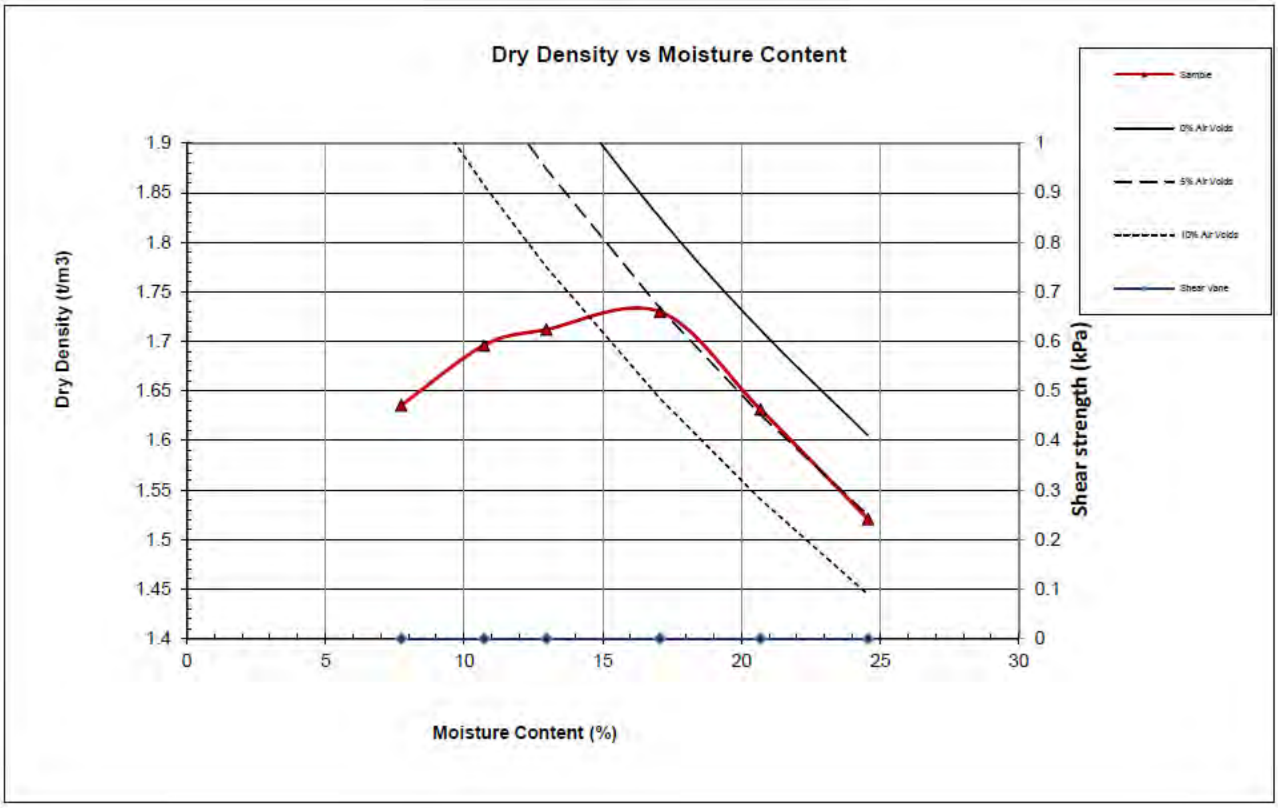


Figure 6.3k: TP314 3.3 – 3.5 m - Dry Density vs. Moisture Content Plot

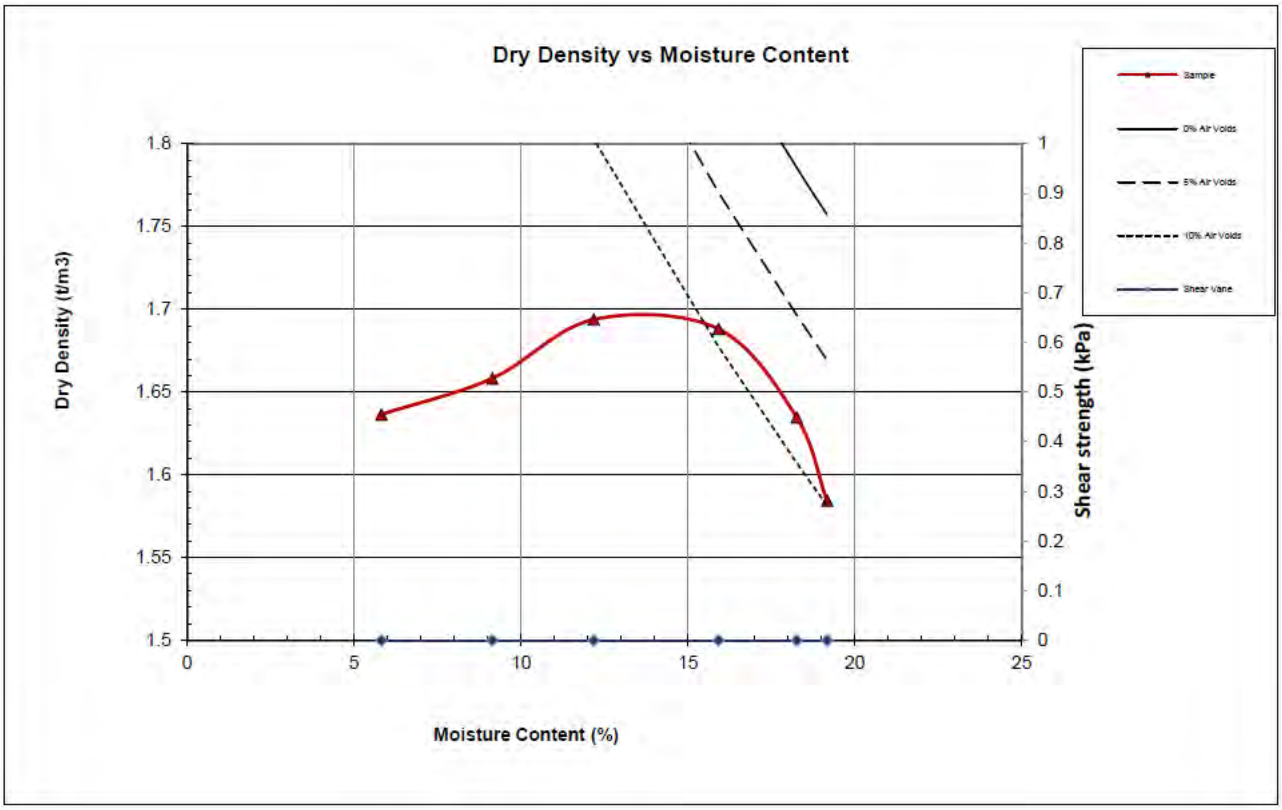


Figure 6.3l: TP315 2.4 – 2.6 m - Dry Density vs. Moisture Content Plot

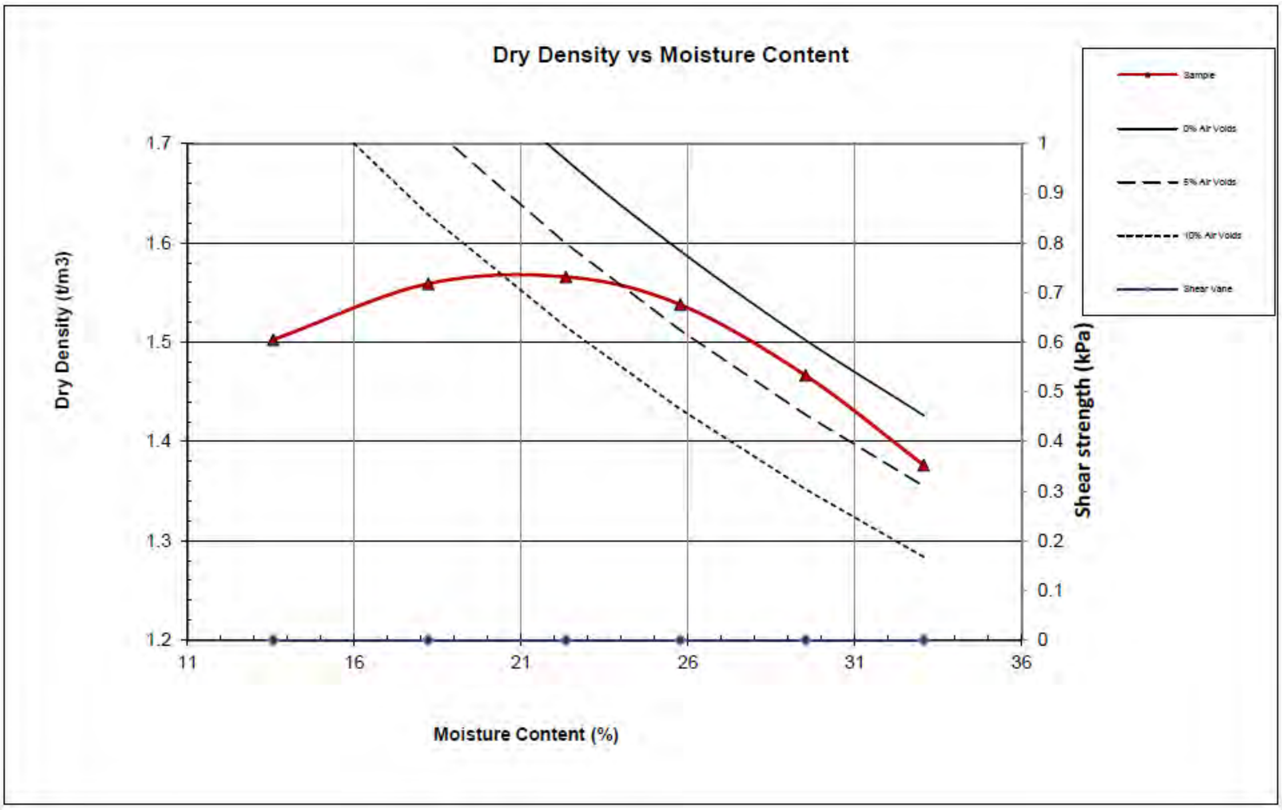


Figure 6.3m: TP316 3.2 – 3.4 m - Dry Density vs. Moisture Content Plot

6.4 California Bearing Ratio

Table 6.4 presents Q5b Material California Bearing Ratio (CBR) results. Testing comments are also provided.

Table 6.4: Q5b Material California Bearing Ratio Results

Sample ID	Depth (m bgl)	Bulk Density (t/m3)	Dry Density (t/m3)	CBR (%)	Comments
BH102	5.0 - 15.0	1.96	1.62	1.5	Soaked CBR @ natural water content
BH102	5.0 - 15.0	1.95	1.62	1.5	Unsoaked @ natural water content
TP204	3.0 - 3.5	1.92	1.63	30.0	Soaked CBR @ Optimum water content
TP209	2.5 - 3.4	2.06	1.75	9.0	Tested at Optimum Water Content - 6% water, by mass removed from the sample.
TP210	3.6 - 4.0	1.96	1.69	25.0	Soaked CBR @ Optimum water content
TP210	3.6 - 4.0	1.95	1.68	30.0	Unsoaked @ Optimum water Content
TP259	2.3 -2.5	2.03	1.64	110	Soaked CBR
TP273	2.0 - 2.3	1.79	1.58	14.0	3% water added, by mass, Standard compactive effort.
TP274	2.2 – 3.5	1.86	1.69	17.0	Tested at Optimum Water Content. No water content adjustment is required.

6.5 Natural Moisture Content

Figures 6.5a and 6.5b presents Q5b Sand Material Natural Moisture Content (NMC) versus depth. Samples obtained from terraces have been separately shown as “Top of terrace” whilst the remaining samples were retrieved from “flat terrain”. Outliers >50% have not been presented.

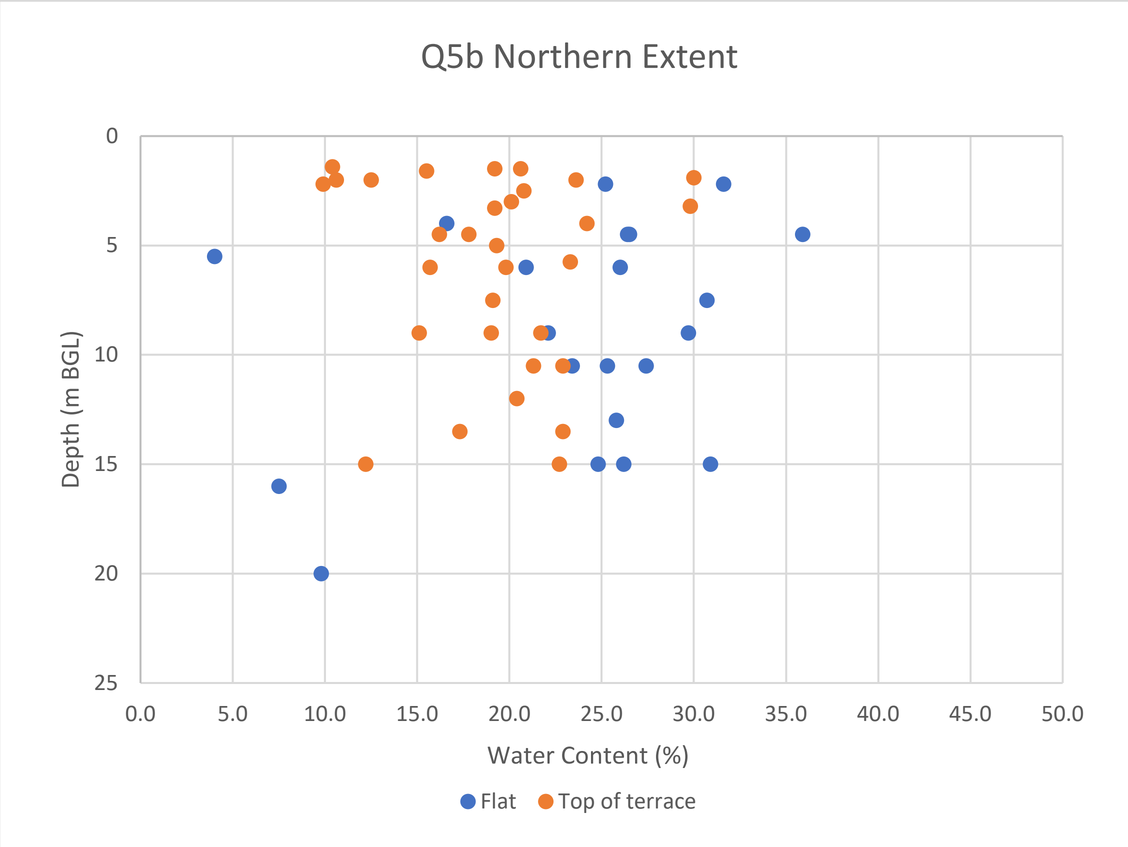


Figure 6.5a: Q5b Material NWC versus Depth Northern Extent – All samples

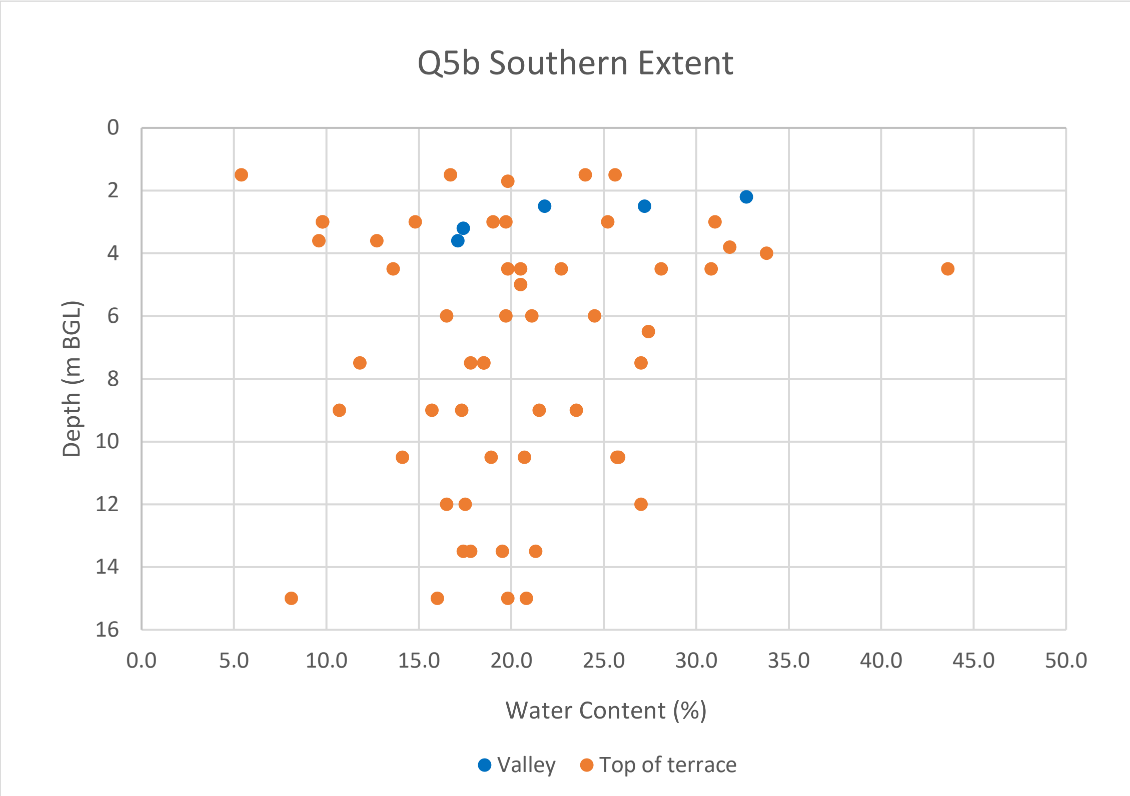


Figure 6.5b: Q5b Material NWC versus Depth Southern Extent – All samples

6.6 Hydrometer Plots

Figures 6.6 presents Q5b Material Hydrometer Plots.

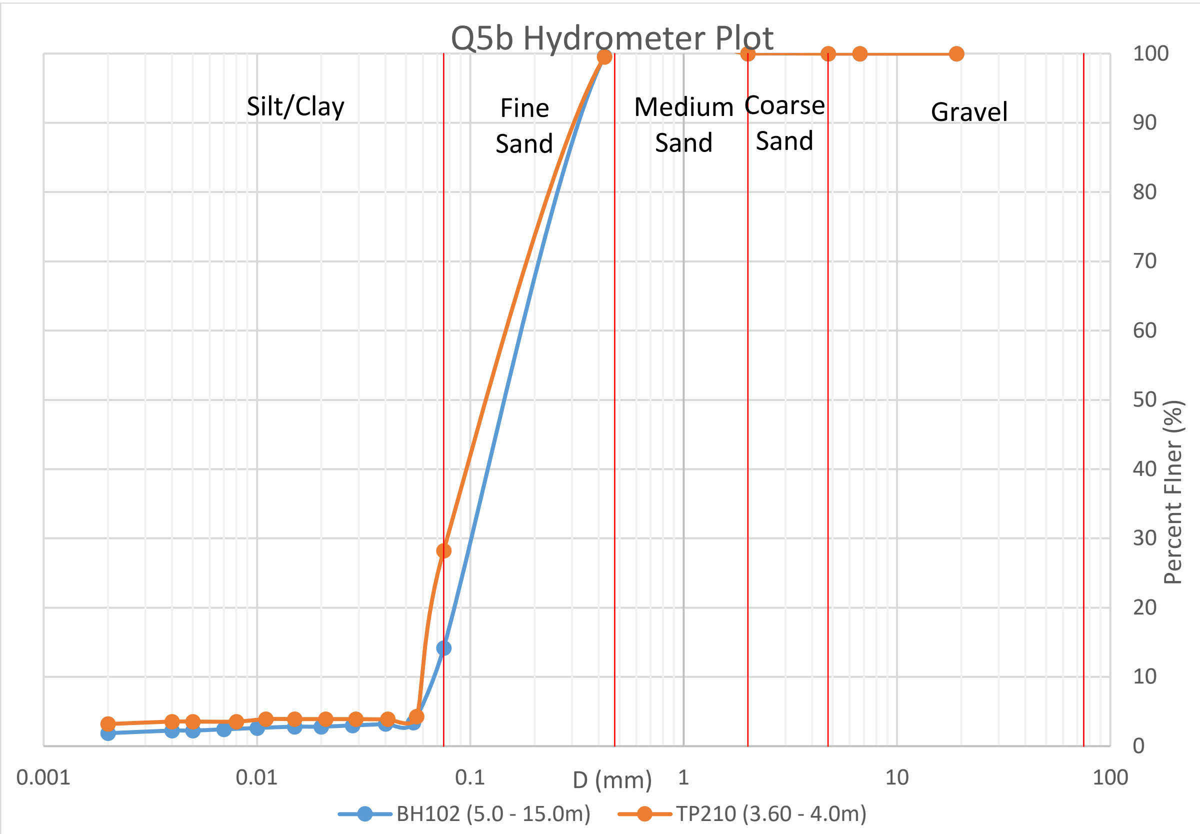


Figure 6.6: Q5b Material - Particle Size Distribution (Hydrometer) Plot

7 Q5b Material Re-usability

7.1 Observations / Conclusions

The following observations have been made:

- General observations:
    - The material classified in the Q5b formation is generally described as fine silty sand to sand, with minor clay in places. The presence of fines, predominantly silts, was notable.
    - The material was generally described as moist, but in many cases as wet or saturated.
    - The material liquefied when wetted and shaken.

- Results from classification testing:
    - Q5b sand material fines content was typically between 15% - 20% but ranged from 1% to 38% There was a number of outliers, but these were discounted (as deemed the sample captured lens/pockets consisting of a finer material).
    - Moisture content testing of "all" in-situ samples generally showed high values. Ignoring outliers (>50%), this averaged at 21.1% (with a median of 20.6%), with a range between 4.0% – 49.1%.
    - Moisture content testing of "Top of Terrace" samples showed slightly lower values. Ignoring outliers (>50%), this averaged at 20.6% (with a median of 19.8%), with a range between 5.4% – 49.0%. This suggests the Q5b sand material located within the terraces is dryer than the material from the valley floors.
    - The fine-grained material is non-plastic to low plasticity (limited testing performed).
    - Laboratory results did not conclude notable trends to differentiate between northern and southern Q5b sand material.
    - Laboratory results did not conclude notable trends to differentiate between Q5b sand material encountered at different depths. Albeit there is a wider range of natural moisture contents near the surface, than at depth. This potentially suggests that materials near the surface are more prone to fluctuating moisture contents (with infiltration from rainfall events likely being the primary source of moisture).

- Results from the compaction testing:
    - Optimum Water Content ranged from 14.0% to 22.3%, averaging 16.6%. It appears the range is associated with varying levels of fines content in the tested samples.
    - Material with the higher fines content (28% – 52%) achieved an average MDD of 1.75 t/m^3, whilst material with a lower fines content (1% – 9%) achieved an average MDD of 1.68 t/m^3.
    - The material with the higher fines content tended to have curves trending between the 0.0% - 5.0% air void lines.
    - Curve peaks were relatively steep, with curves dropping relatively steeply after optimal conditions were achieved.

Based on the above observations, Stantec concludes:

- Q5b sand material in its native state will likely prove challenging to compact. Vibratory compaction has the potential to liquefy the material. Pneumatic tyre roller compacting is expected to be the most suitable methodology; however, the high fines and water contents are expected to create challenges that will need to be managed.

- Natural Moisture Contents are generally above Optimum Moisture Content. This is demonstrated with Figure 7.1 where a distribution of tests results are plotted against Natural Moisture Content (for two data sets). The graph shows the percentage of tests results greater than the NMC listed on the horizontal axis. The average OMC is shown as a red vertical line for comparative purposes. The samples obtained from sites located on the top of the terraces (orange line) are considered the best representation of the material that will be utilised for fill. This illustrates approximately 77% of samples tested had a NMC greater than the average OMC. Assuming that the Q5b sand material can be dried up to 5%, and the average OMC is 16.6%, a good indicator for reuse is to observe the percentage of results at a NMC = 21.6% (ie 16.6 + 5 = 21.6%). This is shown as a green vertical line.

  Observations show:
    - ~40% (77% – 37%) of the material should be able to be dried efficiently via discing.
    - ~37% of the material is likely to be too wet to efficiently dry.

Acknowledging that some of this wetter material could be mixed with the dryer proportion (NMC <16.5%), the resulting assumption of 70% reuse proposed by Stan Goodman appears reasonable.

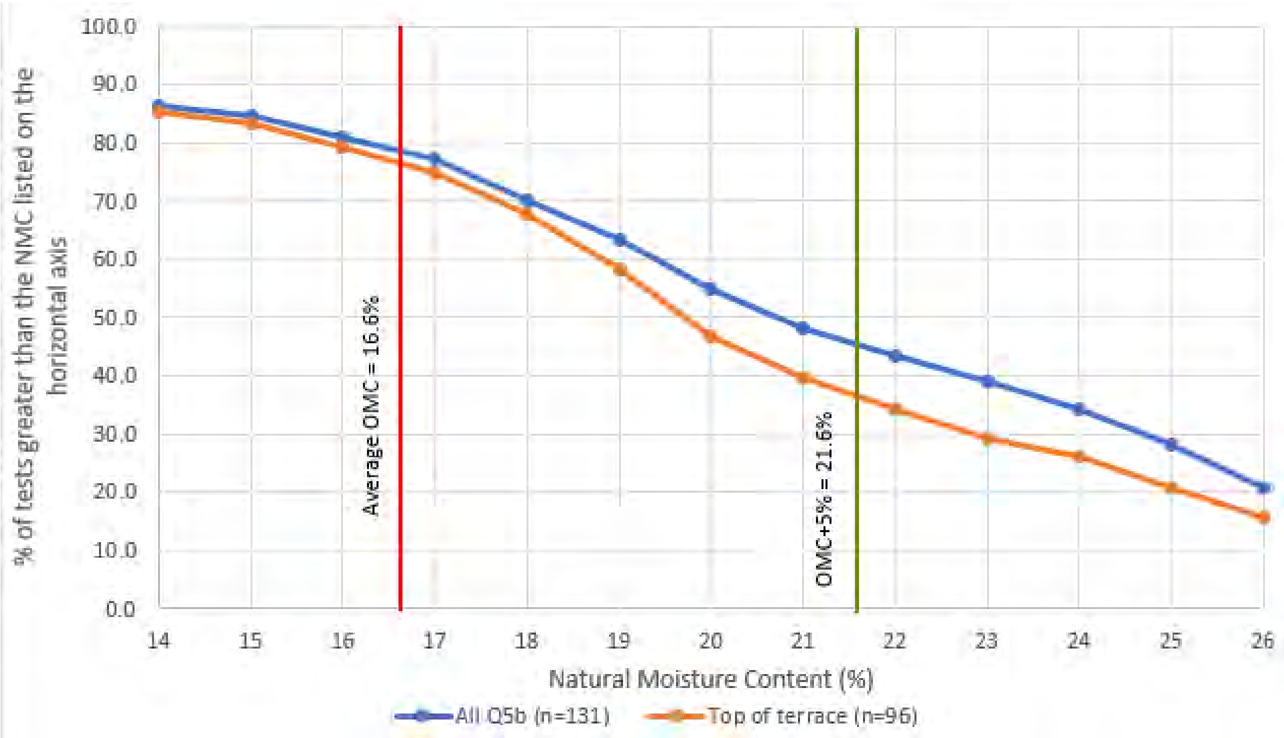


Figure 7.1: Q5b Sand Material Natural Moisture Content (NMC) Distribution of Test results

- A large proportion (~40%) of freshly cut Q5b sand material is likely going to need to be dried out before reuse. Re-using the material at greater than optimum conditions (without drying) will result in poor compaction that will lead to a reduction of densities/strengths being achieved. This will need careful consideration when developing the earthworks quality control specification and evaluating the seismic performance of fill embankments.

- Any drying of the Q5b sand material will create project construction risk, as the process is weather and time dependent. Due to the large cut to fill volumes required, the drying process creates programming and logistical challenges. These need to be considered during project planning and earthworks management.

- Figure 7.3 presents Table1.4 from the Earth Manual[13] which suggests a material of Q5b's composition is "fair" in terms of workability. It is commonly accepted within the geotechnical profession that as fines content increase over 10 to 15%, the workability of the material becomes more challenging. A higher fines content can also change how the compacted material performs under loading. Design and seismic assessment of embankment constructed of Q5b fill material is yet to be completed.

[13] Earth Manual, Part 1, 3rd Edition, US Department of the Interior, Bureau of Reclamation

Table 1-4.—Engineering use chart for compacted soils

Engineering Properties of Compacted Soil[1]						Relative Desirability for Various Uses (No. 1 is considered the best)							
						Rolled earth dams			Canal sections		Foundations and fills		
Soil group name	Group symbol	Permeability[2]	Shear strength (saturated)	Compressibility (saturated)	Workability as a construction material	Homogeneous embankment	Core	Shell	Erosion-resistant blanket or belt	Compacted earth lining	Impervious	Pervious	Resistance to frost heave
Well-graded gravel	GW	Pervious	Excellent	Negligible	Excellent	—	—	1	1	—	—	1	1
Poorly graded gravel	GP	Pervious	Good	Negligible	Good	—	—	2	2	—	—	3	2
Silty gravel	GM	Semipervious to impervious	Good	Negligible	Good	2	4	—	4	4	1	4	6
Clayey gravel	GC	Impervious	Good to fair	Very low	Good	1	1	—	3	1	2	6	5
Well-graded sands	SW	Pervious	Excellent	Negligible	Excellent	—	—	3 if gravelly	6	—	—	2	3
Poorly graded sands	SP	Pervious	Good	Very low	Fair	—	—	4 if gravelly	7 if gravelly	—	—	5	4
Silty sands	SM	Semipervious to impervious	Good	Low	Fair	4	5	—	8 if gravelly	5 erosion critical	3	7	12
Clayey sands	SC	Impervious	Good to fair	Low to medium	Good	3	2	—	5	2	4	8	7
Silt	ML	Semipervious to impervious	Fair	Medium	Fair	6	6	—	—	6 erosion critical	6	9	11
Lean clay	CL	Impervious	Fair	Medium	Good to fair	5	3	—	9	3	5	10	9
Organic silt and organic clay	OL	Semipervious to impervious	Poor	Medium to high	Fair	8	8	—	—	—	7	11	—
Elastic silt	MH	Semipervious to impervious	Fair to poor	High	Poor	9	9	—	—	—	8	12	10
Fat clay	CH	Impervious	Poor	High	Poor	7	7	—	10	—	9	13	8
Organic silt and organic clay	OH	Impervious	Poor	High	Poor	10	10	—	—	—	10	14	—
Peat and other highly organic soils	PT	—	—	—	—	—	—	—	—	—	—	—	—

[1] Compacted to at least 95 percent of laboratory maximum dry density or to at least 70 percent relative density.
[2] Impervious: < 1 ft/yr (1 x 10^{-6} cm/s)
Semipervious: 1 to 100 ft/yr (1 x 10^{-6} cm/s to 1 x 10^{-4} cm/s).
Pervious: > 100 ft/yr (1 x 10^{-4} cm/s).

Figure 7.3: Table1.4 from the Earth Manual

7.2 Recommendations

- Proceed with planning/consenting O2NL with the assumption that Q5b sand material will be challenging to re-use. This includes advancing with the following assumptions:

    - During earthwork planning and cost estimating, assume:
        - 70% of the cut Q5b sand material will be efficient to use as “cut to fill”.
        - 30% will need to be spoiled with a bulking factor of 1.2
        - that a large majority (40 to 80%) of the material will need to be dried via discing (or alternative process) prior to compaction
        - that 2% lime conditioning may be advantageous to extend the earthwork season, and lime use should therefore be allowed for.
        - allow program contingency for adverse weather.

- Undertake a constructability / compaction trial (material in natural state) to validate the assumptions above. Consider constructability / compaction trials that involve additives (i.e., lime).

- Undertake a detailed seismic stability assessment to ascertain how the Q5b sand material performs (and deforms) when utilised as an embankment fill.

- During the planning phase, allow for the inclusion of a gravel base layer and the use of geogrid (ground improvements) for the higher embankments. Requirement of the use of a gravel layer and geogrid to be determined during the detailed design.

- Consider undertaking additional investigations at proposed Q5b sand material supply (borrow) sites.

Geotechnical Assessment Memorandum for Q2a/Q3a Gravels in Proximity to Ohau River and Waiakawa Stream, May 2022

Otaki to North Levin (O2NL)
Geotechnical Assessment Memorandum for Material Supply (Borrow) Sites located at the South/North of Waikawa Stream and the Northeast of Ōhau River.

This report has been prepared for the benefit of Waka Kotahi. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to Waka Kotahi and other persons for an application for permission or approval or to fulfil a legal requirement.

The information contained in this memorandum is accurate to the best of our knowledge at the time of issue. The interpretations as to the likely subsurface conditions contained in this report are based on the site observations and field investigations made at discrete locations as described in this report. The type, spacing and frequency of the investigations, sampling, and testing of materials were selected to meet the technical, financial and time requirements agreed by the client. Stantec NZ accepts no liability for any unknown or adverse ground conditions that would have been identified had further investigations, sampling, and testing been undertaken. This report does not purport to describe all the site characteristics and properties.

Quality statement

Rev. no	Date	Description	Prepared by	Checked by	Reviewed by	Approved by
1	30-05-2022		KC/RC	JG	EG	JP

1 Introduction

1.1 Brief

Stantec has been engaged by Waka Kotahi to undertake geotechnical investigations and reporting for the Otaki to North Levin (O2NL) project. The first stage of the geotechnical investigation was completed in 2020, the second stage in 2021 and the third stage in 2022. The investigation results are presented within Stantec's Geotechnical Factual Report[1].

The purpose of this memorandum is to summarise factual results and provide a geotechnical interpretation for the re-useability of the proposed alluvial gravel material supply (borrow) sites. These proposed sites are:

- South of Waikawa Stream (Site 15)
- North of the Waikawa Stream (Site 19)
- Northeast of Ōhau River (Site 36).

This alluvial material is currently targeted for use as a bulk/general embankment fill.

The objectives of this memorandum are to provide a compilation of the relevant geotechnical information for each site, present a discussion on re-use interpretation, and provide recommendations.

The memorandum is intended to supplement the Material Supply (Borrow) Study[2] and Geotechnical Interpretative Report[3]

1.2 Background

The ongoing geotechnical assessments have identified the Q2a and Q3a Late Pleistocene River deposit geological units (as mapped by (Begg & Johnston, 2000)4) as being potentially suitable material for re-use. Certain materials in the Q1a Holocene River deposits have also been identified as such.

The target material is generally described as sandy gravels, acknowledging that some portion of finer grain materials may be present.

Based on the geological interpretation along the proposed highway designation, locations of potential borrow sites, where significant areas of this material may be encountered, have been identified. These have been refined to the three sites discussed in this memorandum.

For the purpose of our assessments these geological units have been denoted as "Q1a Holocene Alluvium (Q1a)" and "Q2a/Q3a Pleistocene Alluvium (Q2a/Q3a)". Further classification is detailed in the Interpretive Report.

[1] Geotechnical Factual Report for SH1 Ōtaki to North Levin, Rev C, Stantec, 2022
[2] Material Supply (Borrow) Study for SH1 Ōtaki to North Levin, Rev A, Stantec, 2022
[3] Geotechnical Interpretive Report for SH1 Ōtaki to North Levin, Rev D, Stantec, 2022
[4] Geology of the Wellington area: scale 1:250,000. Map 10. Institute of Geological & Nuclear Sciences. Begg & Johnston, 2000

2 South of Waikawa Stream (Borrow Site #15)

2.1 Site Description

Figure 2-1 shows the borrow site area (enclosed within the dashed green line) in the context of the published geological map (Begg & Johnston, 2000) and the nearby site investigations. The proposed O2NL alignment crosses Q2a/Q3a material from Waikawa Stream (Ch. 26,500) to North Manukau Road (Ch. 27,100).

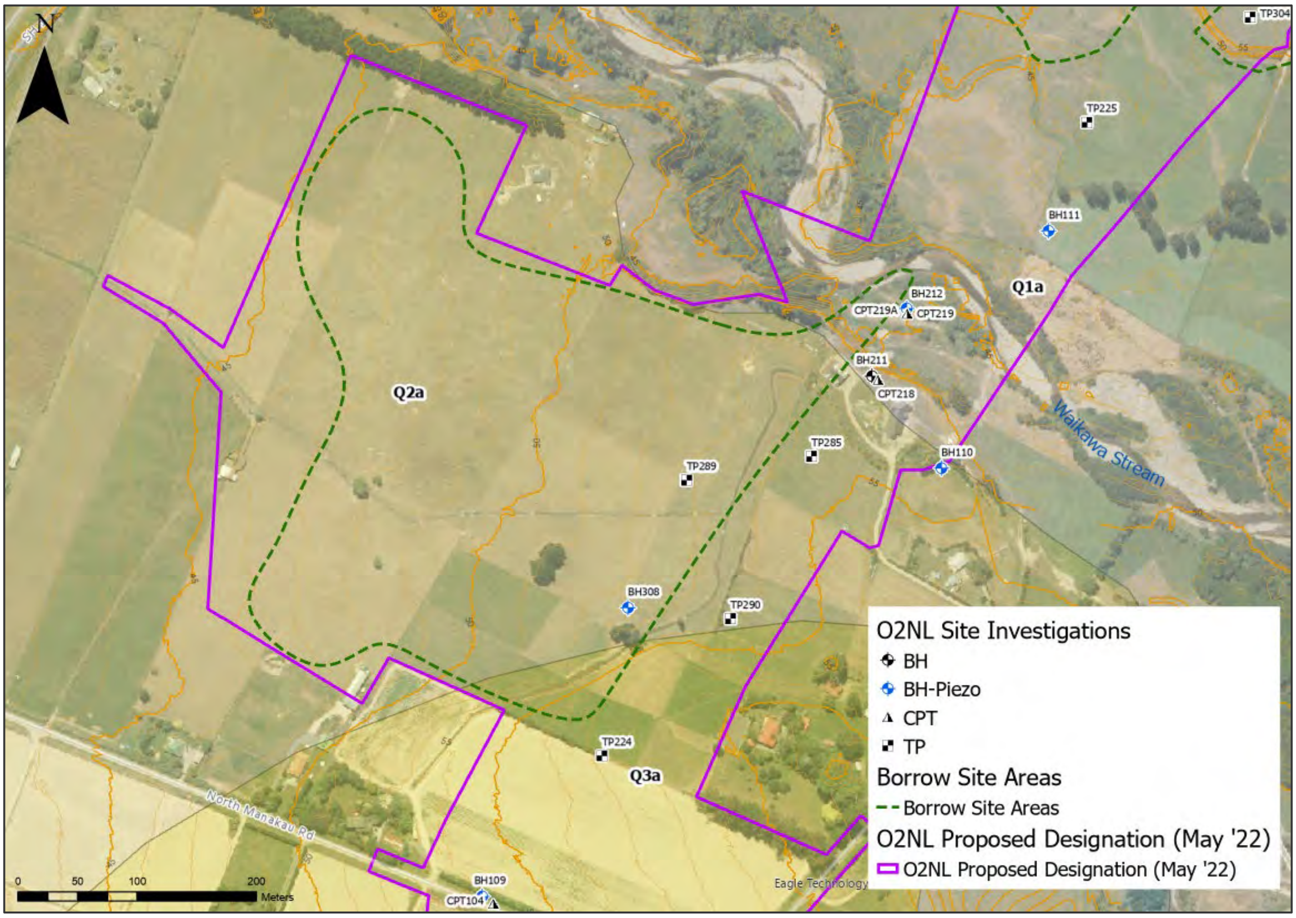


Figure 2-1: Site plan - South of Waikawa Stream

2.2 Topography / Slope Landform / Surface Conditions

This site lies on the floodplain, slightly elevated from the contemporary bed of the Waikawa Stream. Topography at the site is flat to very gently sloping towards the terraced slopes above the Waikawa river (Figure 2-2).

Two drainage channels cut through the site, in a north-south and a south-west to north-east orientation. The channels are typically 1m across and up to 1m deep. The site is currently used as grazing farmland.

Figure 2-2: Terrace found at 121A North Manakau Road. The terrace is located between BH211 and BH212, on the southern bank of the Waikawa River.

2.3 Investigations Completed

The following site investigations were completed within or near the area of interest by Stantec between June 2020 and March 2022:

- Four (4) sonic boreholes.
- Four (4) test pits.
- Three (3) cone penetration tests (CPT).
- One (1) groundwater monitoring piezometer.
- One (1) geophysical survey.

The location information is summarised in Table 2-1 below and the investigation logs, results and interpretation are presented in the Factual and Interpretive Reports.

Table 2-1: Summary of Site Investigations – South of Waikawa Stream

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination depth (m BGL#)	Depth where gravels of interest encountered (m BGL)
		Easting	Northing				
BH109	Borehole	1788177	5491389	54.2	27094	30.45	3.45 – 30.45
BH210	Borehole	1788248	5491362	55.1	27095	30.45	2.90 – 30.45
BH211	Borehole	1788504	5491825	52.6	26559	34.95	1.50 – 34.95
BH308	Borehole	1788300	5491630	52.5	26822	15.35	1.50 – 15.35
TP224	Test pit	1788278	5491507	57.3	26950	3.80	2.40 – 3.80
TP223*	Test pit	1788190	5491191	51.0	27277	3.60	2.10 – 3.60

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination depth (m BGL#)	Depth where gravels of interest encountered (m BGL)
		Easting	Northing				
TP285	Test pit	1788454	5491758	54.2	26644	3.80	0.30 – 3.80
TP289	Test pit	1788349	5491738	52.9	26709	3.40	0.10 – 3.40
TP290	Test pit	1788386	5491622	53.8	26796	3.50	0.05 – 3.50
CPT104	CPT	1788187	5491383	54.3	27096	3.24	Refusal on gravels?
CPT217	CPT	1788251	5491359	55.4	27097	11.34	Refusal on gravels?
CPT218	CPT	1788509	5491822	52.8	26559	1.53	Refusal on gravels?

BGL = Below Ground Level
*Out of site area, but included as considered relevant

2.4 Subsurface Conditions and Geological Interpretation

A geological interpretation of the entire highway alignment has been undertaken as part of the Interpretative Reporting.

The expected ground conditions at the area of interest based on the forementioned investigations are summarised in Table 2-2 below.

Table 2-2: Expected Ground Conditions – South of Waikawa Stream

Unit Name	Generalised Material Description	Typical Depth to the Top of Layer (m BGL)	Typical Thickness Range (m)	SPT 'N' Range (average)
Q2a/Q3a Pleistocene Alluvium	Medium dense to very dense, silty GRAVEL and COBBLES, with minor clay and sand layers.	0 - 6	13 - 15	0 – 50 (16)

2.5 Groundwater

BH308 has the only piezometer within the proposed area. Groundwater levels have varied from 4.9 to 6.9m BGL, with measurements undertaken towards the end of summer when the water table is likely to be depressed. The ground water level may be higher during winter months.

Ponded water was observed within surface depressions during site visits in October 2021, but these were perceived as perched.

2.6 Laboratory Testing

2.6.1 Testing Standards

Testing was undertaken by Geocivil laboratory, in accordance with the following standards:

- Particle Size Distribution (wet sieve) tested in accordance with ASTM D6913-17.
- Natural Water Content tested in accordance with Test 2.1, NZS4402:1986.
- Density of Soil tested in accordance with Test 5.1.4 & 5.1.5, NZS4402:1986.
- Atterberg Limits tested in accordance with ASTM D4318 – 00.
- NZ Standard Compaction Test in accordance with NZS 4402:1986 Test 4.1.1.
- California Bearing Ratio tested in accordance with NZS 4407: 2015, Test 3.15.

It should be noted that ASTM D6913-17 defines fine sands as the material between 0.075mm – 0.475mm whilst NZ geological guidelines (used for field descriptions) defines fine sands as the material between 0.075mm – 0.2mm. The ASTM D6913-17 standard has been used to facilitate the derivation of material properties from industry-accepted empirical relationships, including the liquefaction triggering assessments.

2.6.2 Testing Summary

Geotechnical laboratory testing was targeted at representative material targeted for re-use (ie gravely material). The quantities of tests undertaken are summarised below.

Table 2-3: Lab Testing Quantity Summary - South of Waikawa Stream

Sample ID	Particle Size Distribution	Natural Water Content	Atterberg Limits	NZ Compaction Test	California Bearing Ratio
TP224	1	-	-	-	1
TP285	1	1	-	-	-
TP289	2	2	-	1	-
TP290	2	2	1	1	-
TP223	1	2	-	1	2

2.7 Laboratory Test Results

2.7.1 Summary

The laboratory test results are summarised below.

Table 2-4: Laboratory Testing Results Summary - South of Waikawa Stream

Sample ID	Depth (m BGL)	Particle Size Distribution (Wet Sieve)					USCS Classification	Water Content (%)
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt/Clay		
		>4.75 mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075mm		
TP224	2.50 – 3.80	73.1	7.5	0.9	1.4	17.1	GM	7.6
TP285	1.40 – 2.40	72.0	10.4	7.3	3.2	7.1	GP	6.4
TP289	1.00 - 1.20	52.0	6.0	6.0	3.0	33.0	GM	5.2
TP289	2.60 – 2.80	77.0	8.0	9.0	3.0	3.0	GP	4.4
TP290	0.50	61.2	12.7	13.1	6.8	6.2	GM	17.1
TP290	1.65 – 1.85	66.8	14.2	11.5	2.2	5.3	GW	9.0
TP223	3.30 – 3.60	69.1	13.0	11.8	4.6	1.5	GW	6.9

2.7.2 Particle Size Distribution Plots

Figure 2-3 presents Particle Size Distribution plots for the alluvial gravels south of Waikawa Stream.

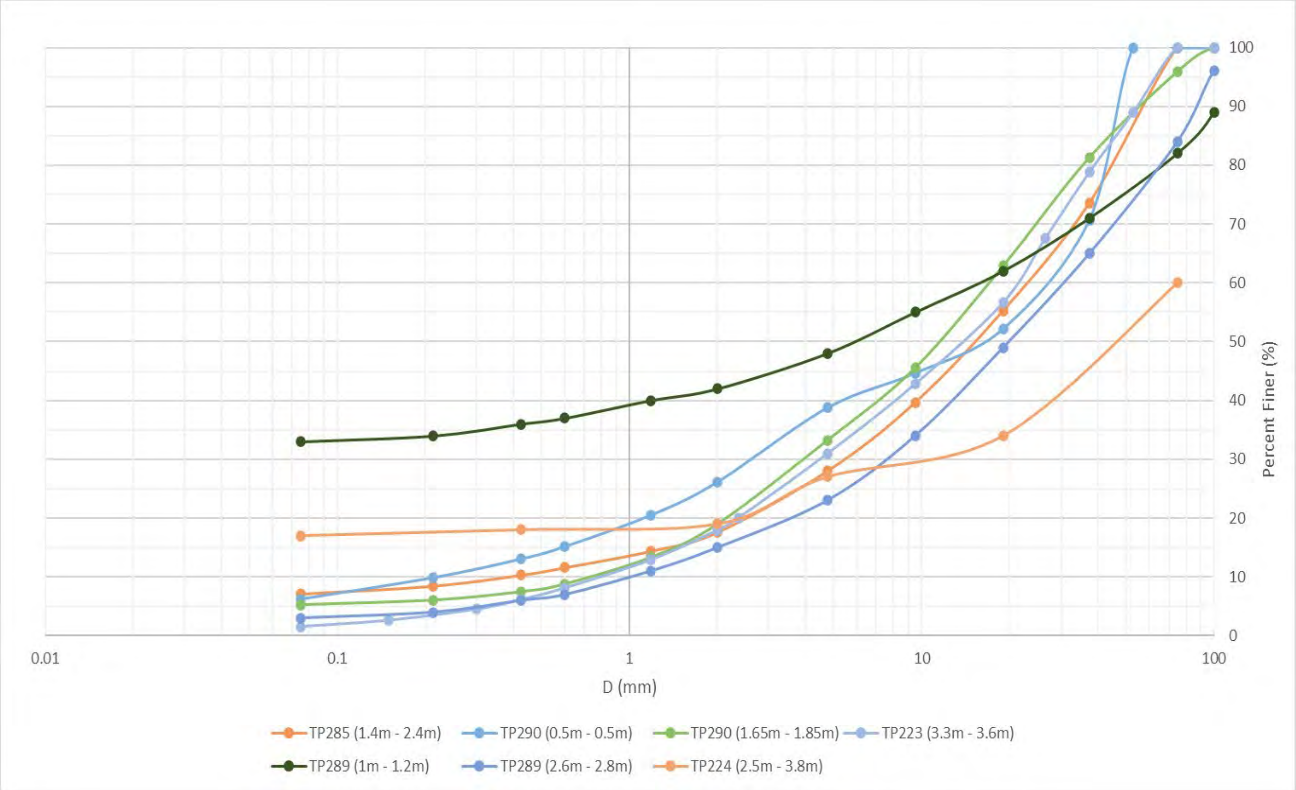


Figure 2-3: Particle Size Distribution (Wet sieve) Plot - South of Waikawa Stream Alluvial Gravel Material

2.7.3 Coefficients of Uniformity and Curvature

Coefficients of Uniformity, C_u, and Curvature, C_c, were calculated for locations where a "D_{10}" was available from the grading results. Table 2-5 present the results.

Table 2-5: Coefficients of Uniformity and Curvature – South of Waikawa Stream

Sample ID	Depth (m BGL)	D_{60}	D_{30}	D_{10}	C_u	C_c
TP285	1.40 – 2.40	23.80	5.60	0.40	60.60	3.30
TP224	2.50 – 3.80	19.00	5.60	0.04	448.90	38.5
TP223	3.30 – 3.60	21.30	4.50	0.80	25.60	1.20
TP290	0.50	26.80	2.80	0.20	120.80	1.40
TP290	1.65 – 1.85	17.40	4.10	0.80	23.10	1.30
TP289	2.60 – 2.80	31.72	7.77	1.04	30.65	1.84

2.7.4 Atterberg Limits

The materials encountered at the site were generally granular and non-cohesive, therefore extensive Atterberg Limit (plasticity) testing was not undertaken. A single test was completed on a sample from a pocket of fine-grained material and is included to illustrate the variability of the material. Results are shown in Table 2-6 below. This material was not targeted for testing as it is assumed that selective "borrowing" would occur with pockets of cohesive material being discarded. Additional intrusive testing is recommended to better understand the variability of the material.

Table 2-6: Atterberg Limits Test Results - South of Waikawa Stream

Sample ID	Depth (m BGL)	Moisture Content, w_n (%)	Liquid Limit (LL, %)	Plastic Limit (%)	Plasticity Index (%)
TP290	0.50	17.1	87	58	29

2.7.5 NZ Compaction Test

Table 2-7 presents the results from the NZ Standard Compaction test with plots presented in Figure 2-4 to Figure 2-6.

Table 2-7: NZ Standard Compaction Test Results – South of Waikawa Stream

Sample ID	Depth (m BGL)	Natural Moisture Content, w_n (%)	Optimum Moisture (Water) Content, w_o (%)	Max Dry Density, $\rho_{d, max}$ (t/m³)
TP290	1.65 – 1.85	9.0	9.0	2.08
TP223	3.30 – 3.60	11.5	12.2	2.01
TP289	2.60 – 2.80	6.1	9.0	2.14

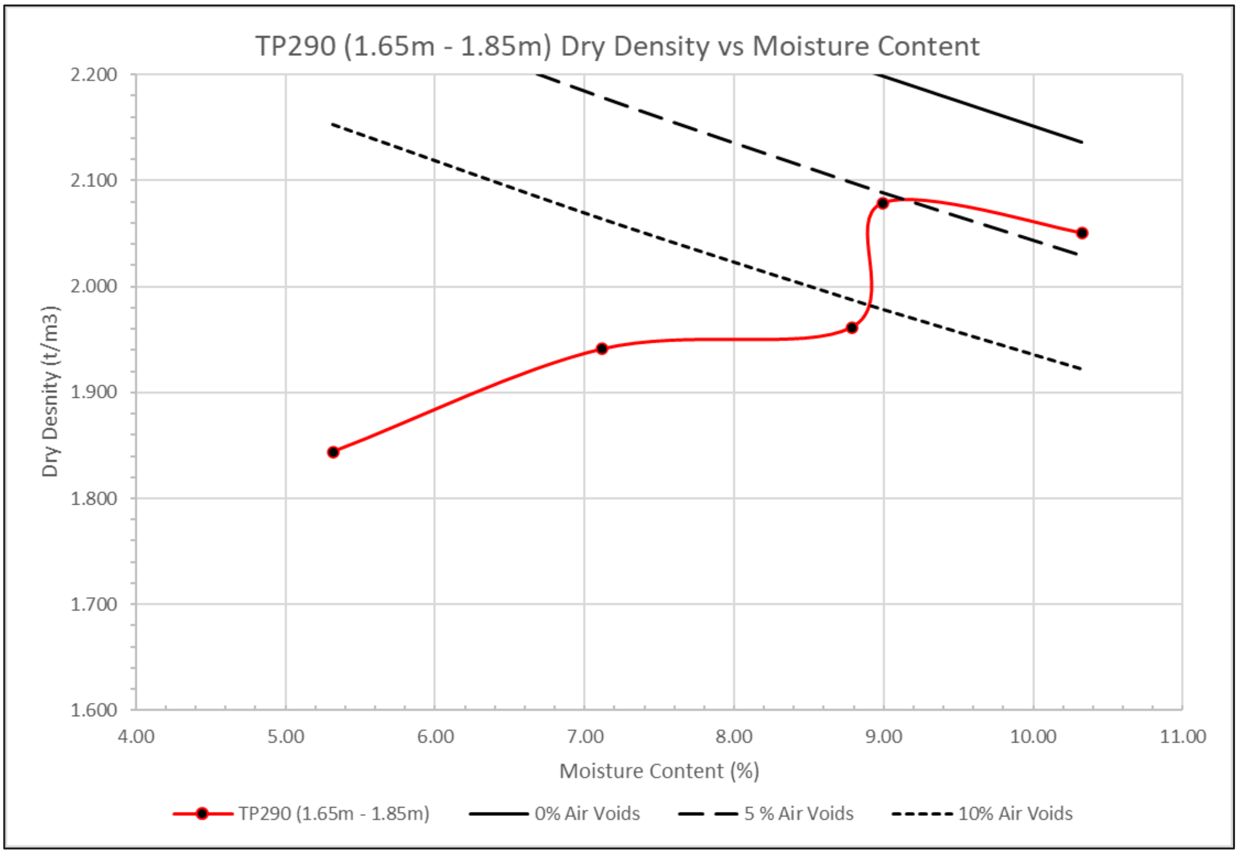


Figure 2-4: TP290 (1.65 – 1.85m) Dry Density vs. Moisture Content Plot

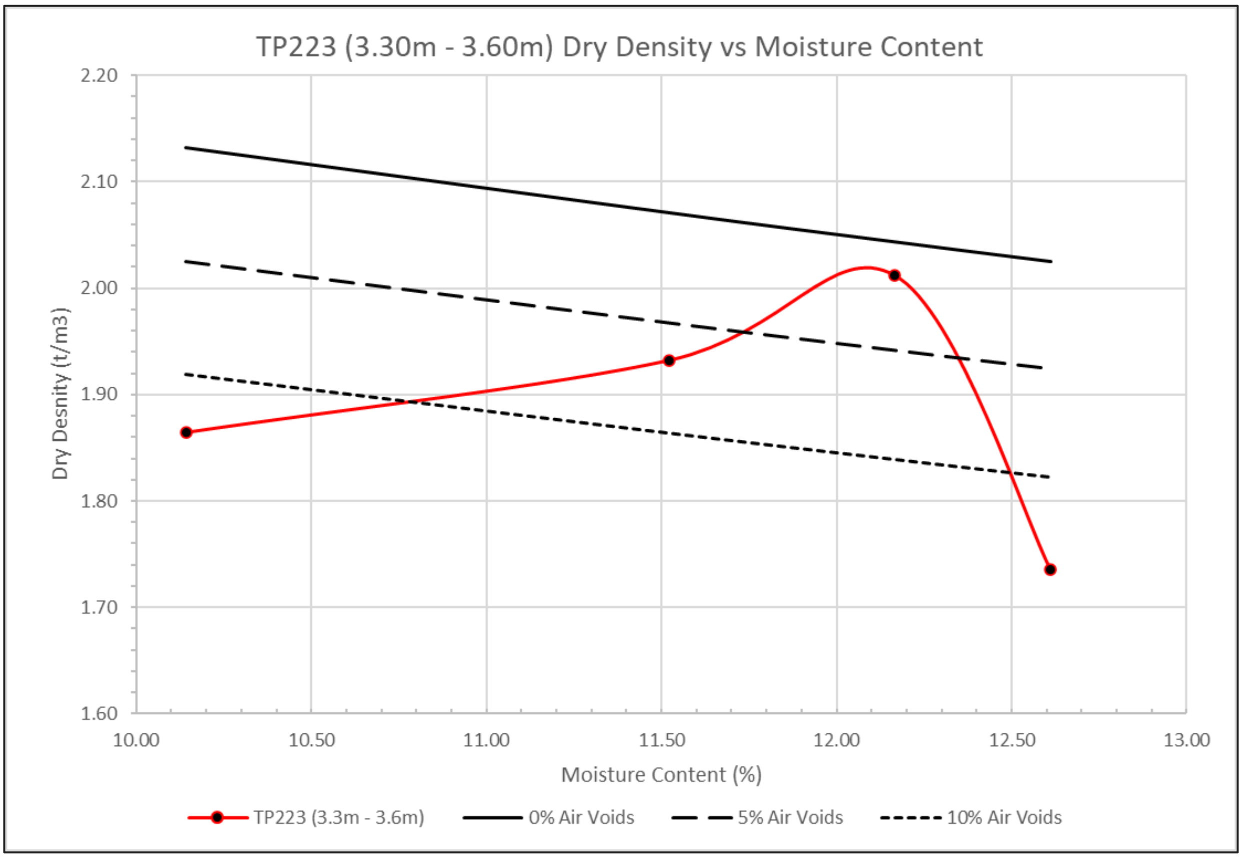


Figure 2-5: TP223 (3.30 - 3.60m) Dry Density vs. Moisture Content Plot

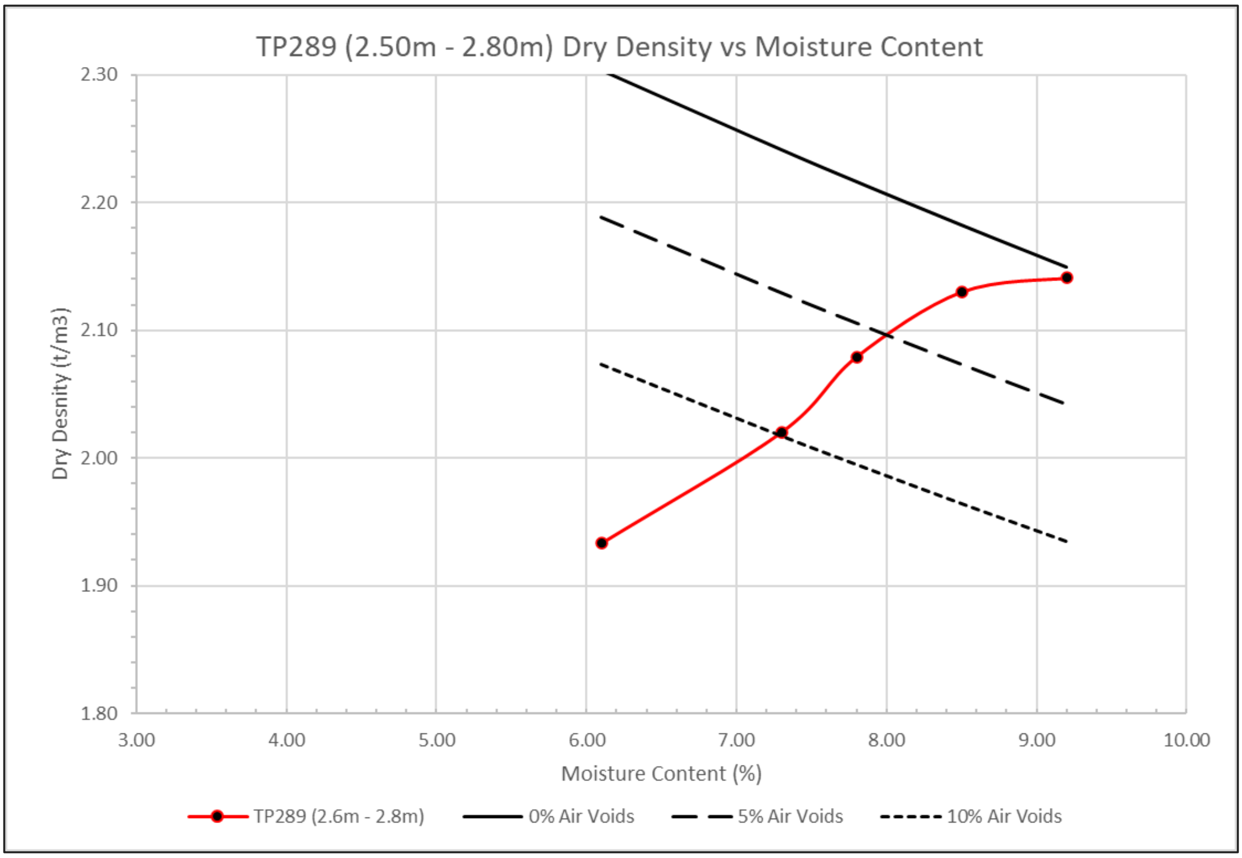


Figure 2-6: TP289 (2.50 – 2.80) Dry Density vs. Moisture Content Plot

2.7.6 California Bearing Ratio (CBR)

California Bearing Ratio (CBR) test results are presented in Table 2-8 below.

Table 2-8: CBR Results - South of Waikawa Stream

Sample ID	Depth (m BGL)	Bulk Density (t/m3)	Dry Density (t/m3)	CBR (%)	Comments
TP224	2.5 – 3.8	1.98	1.77	16	Soaked @ optimum water content
TP223	3.3 – 3.6	2.14	1.93	40	Soaked @ natural water content
TP223	3.3 – 3.6	2.15	1.93	50	Unsoaked @ natural water content

3 North of Waikawa Stream

3.1 Site Description

Figure 3-1 shows the borrow site areas (enclosed within the dashed green lines) in the context of the published geological map (Begg & Johnston, 2000) and the nearby site investigations. Q2a/Q3a material is expected north of the Waikawa Stream alluvial terrace.

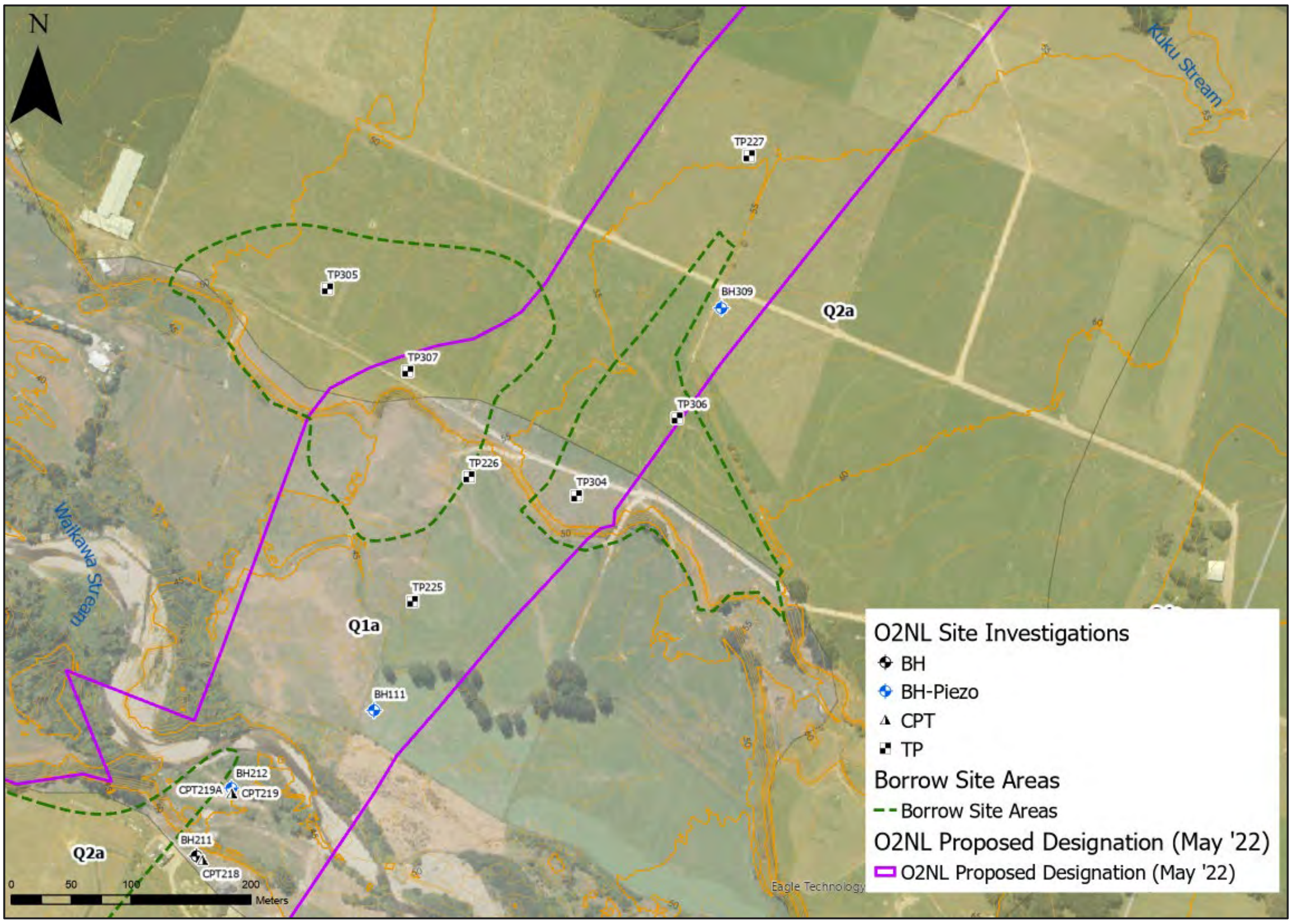


Figure 3-1: Site plan - North of Waikawa Stream

3.2 Topography / Slope Landform / Surface Conditions

The topography of the site is flat to very gently sloping towards the Waikawa Stream to the south. The southern-most extent of the site is bounded by an alluvial terrace approximately 7m higher in elevation. A small drainage channel spanning 1m across and 1m deep passes from north-west to south-east through the site and connects to a tributary of the Waikawa Stream approximately 300m south of the site. The site is currently used as grazing farmland and crop paddocks.

3.3 Investigations Completed

The following site investigations were completed within or near the area of interest by Stantec between June 2020 and March 2022:

- Six (6) test pits.
- One (1) borehole.
- One (1) groundwater monitoring piezometer.

The location information is summarised in Table 3-1 below and the investigation logs, results and interpretation are presented in the Factual and Interpretive Reports.

Table 3-1: Summary of Site Investigations - North of Waikawa Stream

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m BHL)	Depth where Gravels of Interest Encountered (m BGL)
		Easting	Northing				
BH309	Borehole	1788943	5492283	56.9	25918	15.45	1.65 – 15.45
TP304	Test Pit	1788822	5492126	56.4	26116	3.5	1.6 – 3.5
TP305	Test Pit	1788614	5492299	51.9	26110	3.4	0.6 – 3.4
TP306	Test Pit	1788906	5492191	56.5	26013	3.2	1.2 – 3.2
TP307	Test Pit	1788681	5492230	53.0	26122	3.5	0.8 – 3.5
TP226	Test Pit	1788732	5492142	46.2	26159	3.9	0.6 – 2.7
TP227	Test Pit	1788966	5492410	54.8	25804	4.1	2.1 – 4.1

3.4 Subsurface Conditions and Geological Interpretation

A geological interpretation of the entire highway alignment has been undertaken as part of the Interpretative Reporting.

The expected ground conditions at the area of interest based on the forementioned investigations are summarised in Table 3-2 below.

Table 3-2: Expected Ground Conditions - North of Waikawa Stream

Unit Name	Description	Typical Depth to the Top of Layer (m BGL)	Typical Thickness Range (m)	SPT 'N' Range (average)
Loess	Stiff, clayey SILT, moderate to high plasticity.	0	0.5 – 1.5	-
Q2a/Q3a Pleistocene Alluvium	Medium dense to very dense, silty GRAVEL with minor clay and sand layers.	0 - 6	13 - 15	0 – 50 (16)

3.5 Groundwater

Groundwater levels have been measured in the piezometer within BH309.

Groundwater levels varied from 10.3 to 13.0m BGL, with groundwater measurement undertaken towards the end of summer when the water table is likely to be depressed. The ground water level may be higher during winter months. The nearby BH111 has also recorded groundwater level depth >10m BGL.

3.6 Laboratory Testing

3.6.1 Testing Summary

Geotechnical laboratory testing was targeted at representative material targeted for re-use (ie gravely material). The quantities of tests undertaken are summarised below.

Table 3-3: Lab Testing Quantity Summary - North of Waikawa Stream

Sample ID	Particle Size Distribution (Wet Sieve)	Natural Water Content	Atterberg Limits	NZ Compaction Test	California Bearing Ratio
BH309	-	-	1	-	-
TP226	1	1	1	-	-
TP227	1	1	1	-	-
TP304	1	1	-	-	-
TP305	1	1	-	1	1
TP306	1	1	-	-	1
TP307	1	1	-	1	1

3.7 Laboratory Test Results Presentation

3.7.1 Summary

The laboratory test results are summarised below.

Table 3-4: Laboratory Testing Results Summary - North of Waikawa Stream

Sample ID	Depth (m BGL)	Particle Size Distribution (Wet Sieve)					Classification according to USCS	Natural Water Content (%)
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt /Clay		
		>4.75mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075mm		
TP226	2.00 – 2.40	79	6	9	4	1	GP	-
TP227	3.80 – 4.10	69	10	10	5	5	GW	-
TP304	1.90 – 2.10	75	8	9	3	5	GW	6.4
TP305	2.60 – 2.80	76	9	9	3	3	GW	7
TP306	3.00 – 3.20	68	10	9	7	6	GP	9.0
TP307	1.60 – 1.80	72	9	11	4	4	GW	8.1

3.7.2 Particle Size Distribution Plots

Figure 3-2 presents Particle Size Distribution plots for the alluvial gravels north of the Waikawa Stream.

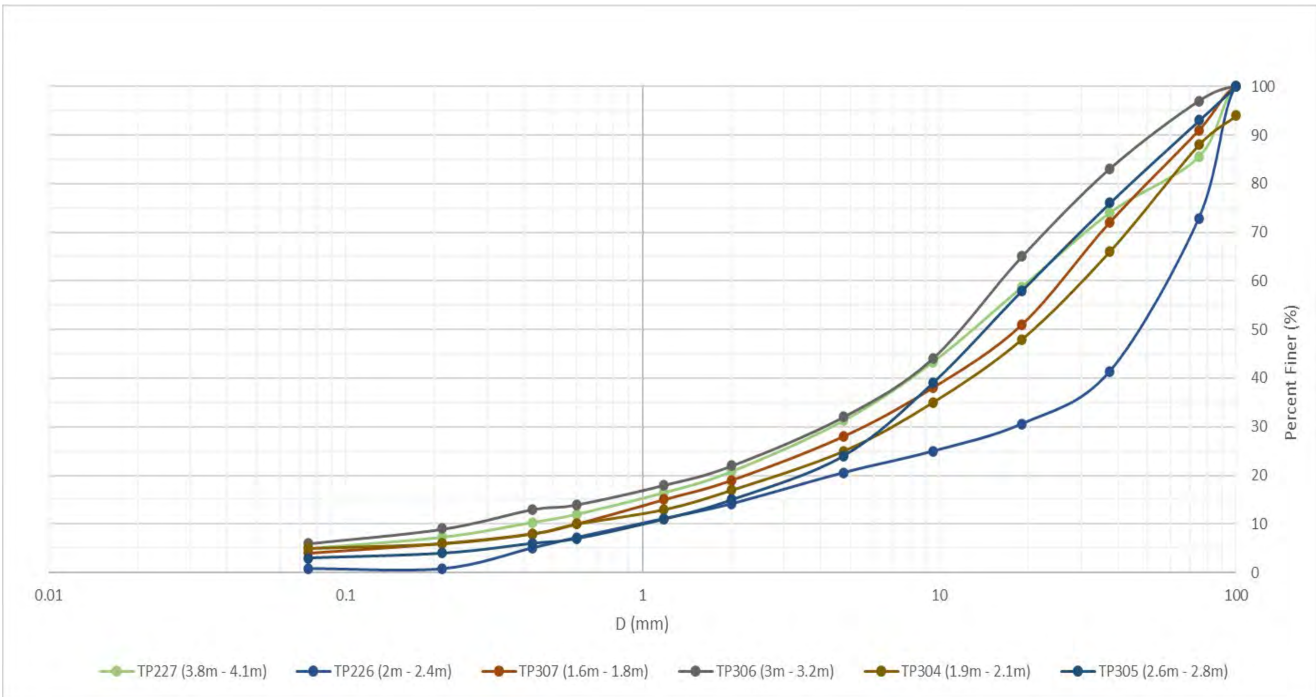


Figure 3-2: Particle Size Distribution (Wet Sieve) Plot - North of Waikawa Stream

3.7.3 Coefficients of Uniformity and Curvature

Coefficients of Uniformity, C_u, and Curvature, C_c, were calculated for locations where a “D_{10}” was available from the grading results. Table 3-5 present the results.

Table 3-5: Coefficients of Uniformity and Curvature - North of Waikawa

Sample ID	Depth (m BGL)	D_{60}	D_{30}	D_{10}	C_u	C_c
TP226	2.00 – 2.40	59.76	17.42	1.04	57.7	4.9
TP227	3.80 – 4.10	20.23	4.48	0.425	47.6	2.3
TP304	1.90 – 2.10	31.33	7.13	0.60	52.22	2.7
TP305	2.60 – 2.80	21.06	6.65	1.04	20.34	2.03
TP306	3.00 – 3.20	16.74	4.20	0.27	63.1	4.0
TP307	1.60 – 1.80	26.93	5.70	0.60	44.9	2.0

3.7.4 Atterberg Limits

Table 3-6 presents the results from the Atterberg Limits test completed in the south of Waikawa gravels.

Table 3-6: Atterberg Limit Test results – North of Waikawa Stream

Sample ID	Depth (m BGL)	Natural Moisture Content, w_n (%)	Liquid Limit (LL, %)	Plastic Limit (%)	Plasticity Index (%)
TP226	2.7 – 3.0	24.9	31	19	12

3.7.5 NZ Compaction Test

Table 3-7 presents the results from the NZ standard compaction test with plots presented in Figure 3-3 to Figure 3-4.

Table 3-7: NZ Standard Compaction Test Results – North of Waikawa Stream

Sample ID	Depth (m BGL)	Natural Moisture Content, w_n (%)	Optimum Moisture (Water) Content, w_o (%)	Max Dry Density, $\rho_{d, max}$ (t/m³)
TP305	2.60 – 2.80	7.0	12.0	2.00
TP307	1.60 – 1.80	9.0	11.2	2.05

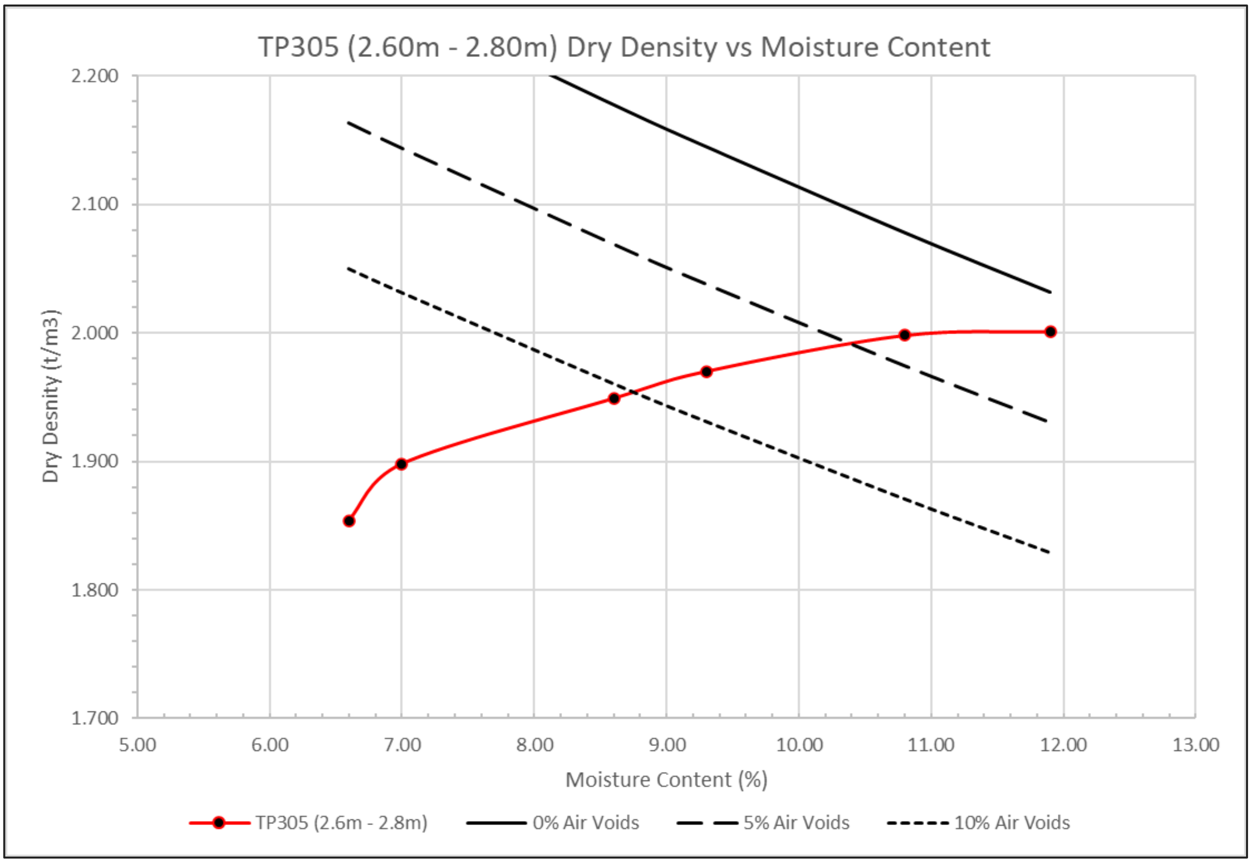


Figure 3-3: TP305 (2.60 - 2.80m) Dry Density vs. Moisture Content Plot

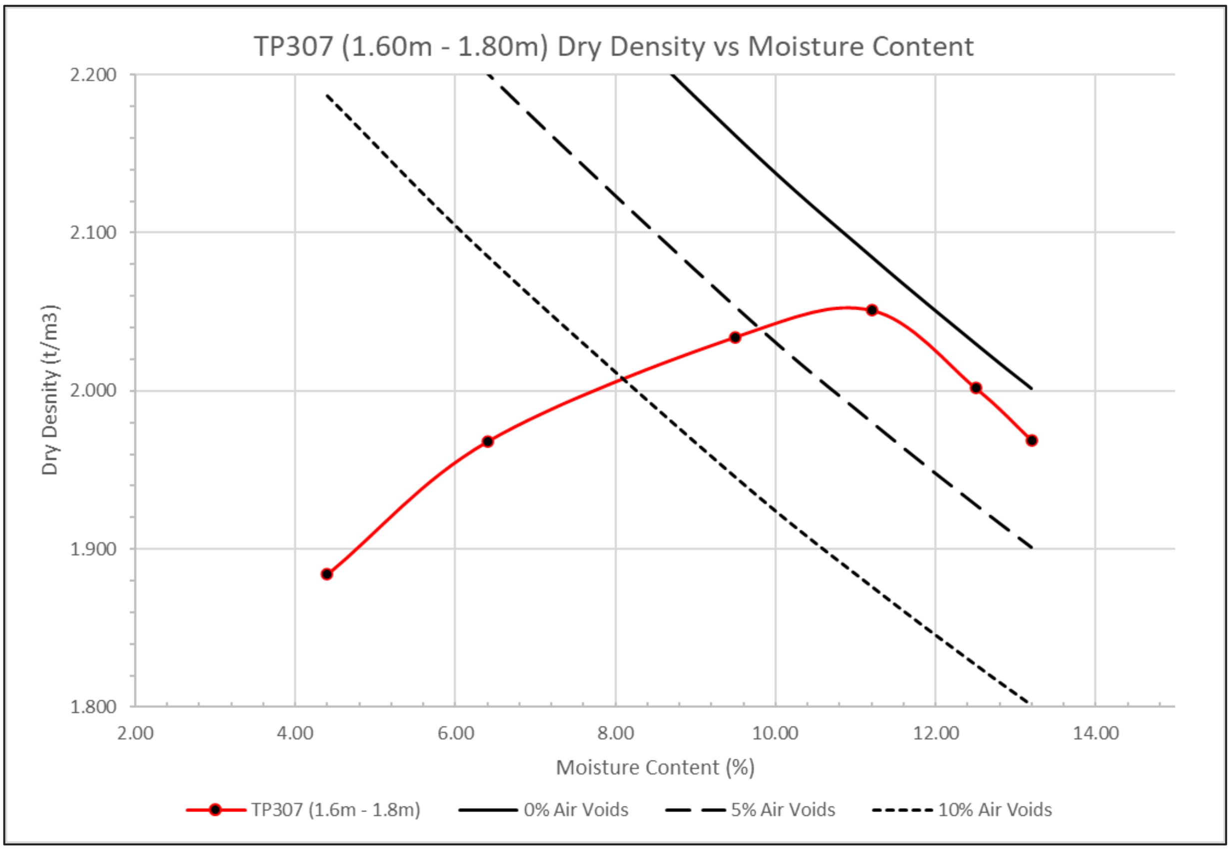


Figure 3-4: TP307 (1.60 – 1.80m) Dry Density vs. Moisture Content Plot

3.7.6 California Bearing Ratio (CBR)

California Bearing Ratio (CBR) lab test results are presented in Table 3-8 below.

Table 3-8: CBR Results - North of Waikawa Stream

Sample ID	Depth (m BGL)	Bulk Density (t/m3)	Dry Density (t/m3)	CBR (%)	Comments
TP305	2.60 - 2.80	2.23	2.02	40	Tested at natural water content
TP306	1.40 – 1.60	2.13	1.87	25	Tested at natural water content
TP307	1.60 – 1.80	2.16	1.99	55	Tested at natural water content

4 Northeast of Ōhau River

4.1 Site Description

Figure 4-1 shows the borrow site area (enclosed within the green dashed line) in the context of the published geological map (Begg & Johnston, 2000) and the nearby site investigations. The proposed O2NL alignment is within the Q1a Holocene Alluvium in this area.

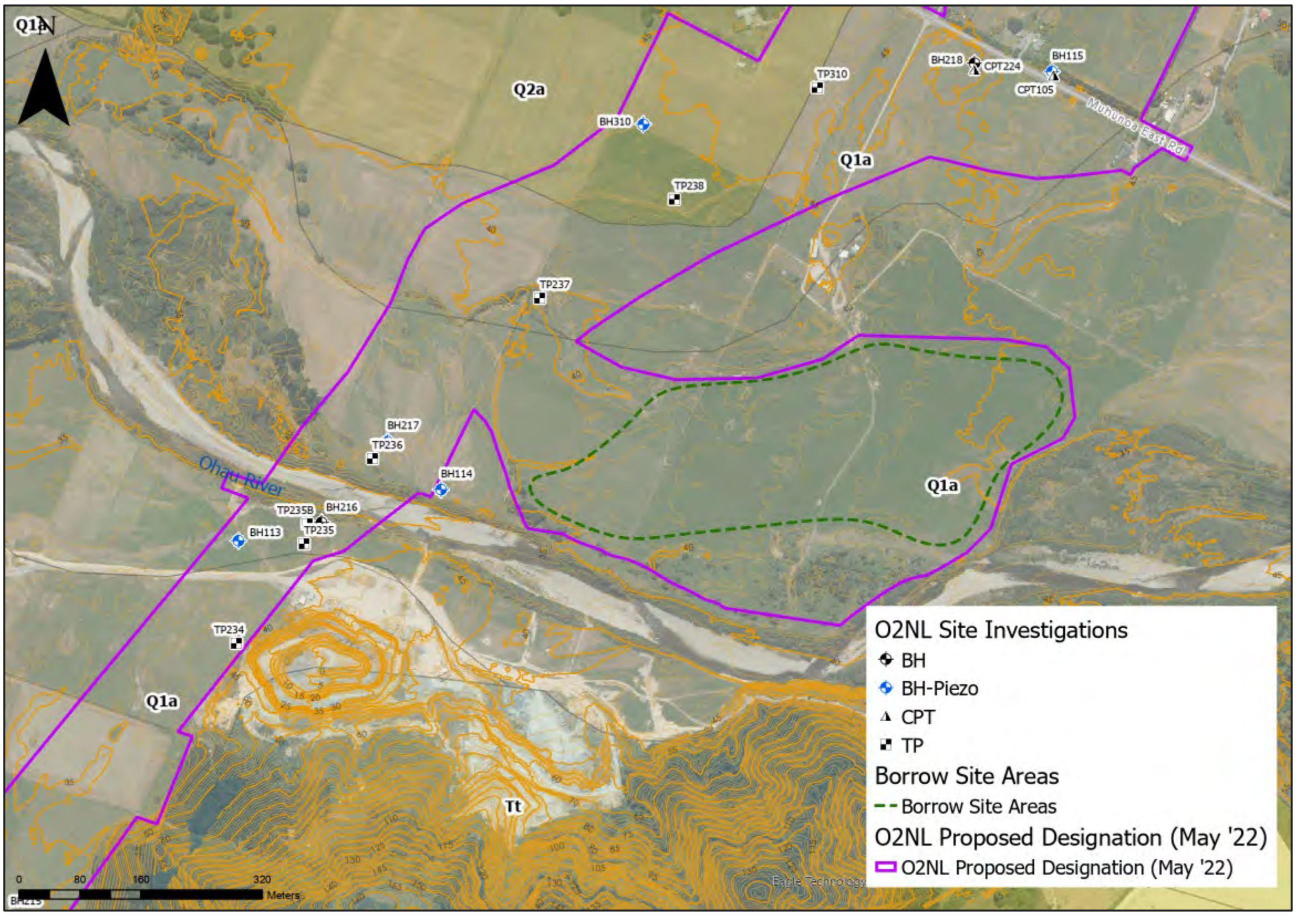


Figure 4-1: Site plan - Northeast of Ōhau River

4.2 Topography / Slope Landform / Surface Conditions

The site is relatively flat with small hummocks representing historical river or stream banks. The southernmost extent of the site is bounded by a series of small alluvial terraces that extend to the active river channel. The site is currently used as grazing farmland and crop paddocks.

4.3 Investigations Completed

This area was not targeted during the 2022 Stage 3 investigations due to late identification of this material supply site. We have interpreted the nearby investigations which are generally within the designation corridor, north of the Ōhau River. The actual ground conditions at the site may be different than described.

Table 4-1 presents a summary of the relevant intrusive investigations completed near the area of interest.

Table 4-1: Summary of Nearby Site Investigations - Northeast of Ōhau River

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approx. Chainage	Termination Depth (m BGL)	Depth where Gravels of Interest Encountered (m BGL)
		Easting	Northing				
BH114	Borehole	1791048	5494886	38.5	22560	27.0	0.2 – 25.5
BH217	Borehole	1790977	5494949	37.9	22560	35.0	1.5 – 27.0
TP236	Test Pit	1790958	5494927	38.2	22590	4.0	0.2– 4.0
TP237	Test Pit	1791178	5495138	39.1	22281	3.6	1.3 – 3.6
TP238	Test Pit	1791355	5495268	44.2	22058	3.8	0.3 – 3.8
TP310	Test Pit	1791543	5495415	47.1	21827	3.0	0.1 – 3.0

4.4 Subsurface Conditions and Geological Interpretation

A geological interpretation of the entire highway alignment has been undertaken as part of the Interpretative Reporting.

The expected ground conditions at the area of interest as inferred from the investigations carried out near the area are summarised in Table 4-2 below.

Table 4-2: Inferred Ground Conditions - Northeast of Ōhau River

Unit Name	Description	Typical Depth to the Top of Layer (m BGL)	Typical Thickness Range (m)	SPT 'N' Range (average)
Q1a Holocene Alluvium	Silty sandy GRAVEL, with cobbles, loose to very dense.	0	5 - 12	10 - 50+

4.5 Groundwater

The closest piezometer to the borrow area (BH114) has recorded (based on >12months of monitoring) groundwater level fluctuations between 2.2 and 3.9m BGL.

4.6 Laboratory Testing

4.6.1 Testing Summary

Geotechnical laboratory testing was targeted at representative material targeted for re-use (ie gravely material). The quantities of tests undertaken are summarised below.

Table 4-3: Laboratory Testing Summary - Northeast of Ōhau River

Sample ID	Particle Size Distribution (Wet Sieve)	Natural Water Content	Atterberg Limits	NZ Compaction Test	California Bearing Ratio
BH114	2	2	2	-	-
BH217	2	2	2	-	-
TP236	1	1	-	-	-
TP237	1	1	1	-	-
TP238	1	1	-	-	-
TP310	1	1	-	1	1

4.7 Laboratory Test Results

4.7.1 Summary

The laboratory test results are summarised below.

Table 4-4: Laboratory Testing Results Summary - Northeast of Ōhau River

Sample ID	Depth (m BGL)	Particle Size Distribution (Wet Sieve)						Classification according to USCS	Natural Water Content (%)
		% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt /Clay			
		>4.75mm	4.75 – 2mm	2 – 0.475mm	0.475 – 0.075mm	<0.075mm			
BH114	1.95 – 2.50	65	6	10	8	11		GM/GC/GP/GW	3.6
BH114	7.50 – 7.95	0	0	0	40	51	9	GM/GC/GP/GW	21.0
BH217	7.00 – 7.80	33	7	16	17	25		SM/SC	14.4
BH217	12.0 – 13.0	45	9	14	14	18		GM/GC	8.4
TP236	2.00 – 2.50	69	7	15	7	2		GW	3.6
TP237	1.50 – 1.80	58	12	20	5	4		GP	5.0
TP238	2.40 – 2.70	79	8	9	2	3		GW	5.2
TP310	2.60 - 2.80	75	11	10	3	1		GW	-

4.7.2 Particle Size Distribution Plots

Figure 4-2 presents Particle Size Distribution plots for the alluvial gravel material northeast of the Ōhau River.

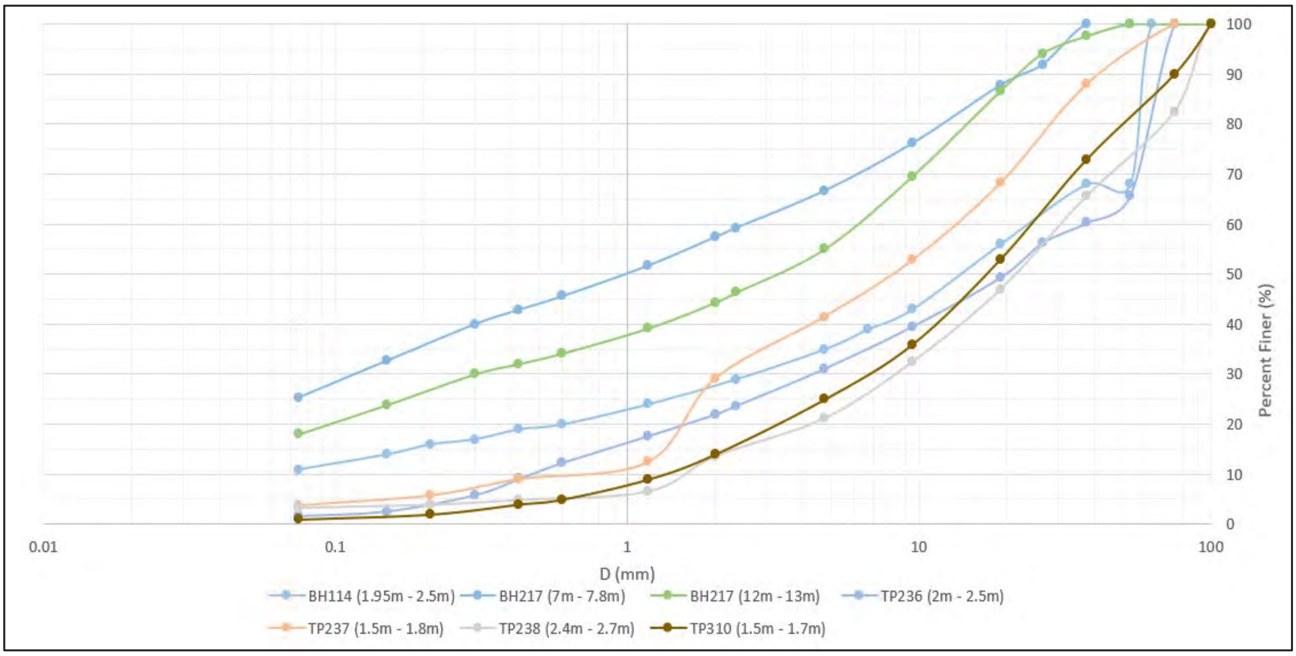


Figure 4-2: Particle Size Distribution (Wet sieve) Plot – Northeast of Ōhau River

4.7.3 Coefficients of Uniformity and Curvature

Coefficients of Uniformity, C_u, and Curvature, C_c, were calculated for locations where a "D_{10}" was available from the grading results. Table 4-5 present the results.

Table 4-5: Coefficients of Uniformity and Curvature – Northeast of Ōhau River

Sample ID	Depth (m BGL)	D_{60}	D_{30}	D_{10}	C_u	C_c
BH114	7.50 – 7.95	0.075	0.040	0.003	28.1	7.8
TP236	2.00 – 2.50	37.5	4.41	0.48	77.6	1.1
TP237	1.50 – 1.80	13.93	2.21	0.68	20.6	0.5
TP238	2.40 – 2.70	31.66	8.63	1.53	20.7	1.5
TP310	1.50 – 1.70	25.48	6.91	1.34	18.95	1.39

4.7.4 Atterberg Limits

Table 4-6 presents the results from the Atterberg Limits test completed on samples from around the Northeast of Ōhau River site. It should be noted the majority of these are at depths greater than the proposed excavations but are included to provide at indication of the properties of the pockets/layers of fine material present.

Table 4-6: Atterberg Limit Test Results - Northeast of Ōhau River

Sample ID	Depth (m BGL)	Natural Moisture Content, w_n (%)	Liquid Limit (LL, %)	Plastic Limit (%)	Plasticity Index (%)	Classification according to USCS
BH114	7.50 – 7.95	21.0	23	17	6	ML-CL
BH114	9.00 – 9.45	38.8	50	23	27	CH
BH217	7.00 – 7.80	14.4	-	-	Non-Plastic	-
BH217	9.45 – 9.90	29.5	-	-	Non-Plastic	-
TP237	0.60 – 0.80	26.0	40	27	13	ML

4.7.5 NZ Compaction Test

Table 4-7 presents the results from the NZ standard compaction test with plots presented in Figure 4-3.

Table 4-7: NZ Standard Compaction Test Results - Northeast of Ōhau River

Sample ID	Depth (m BGL)	Natural Moisture Content, w_n (%)	Optimum Moisture (Water) Content, w_o (%)	Max Dry Density, $\rho_{d,\,max}$ (t/m^3)
TP310	1.50 – 1.70	5.8 - 7.1	8.7	2.07

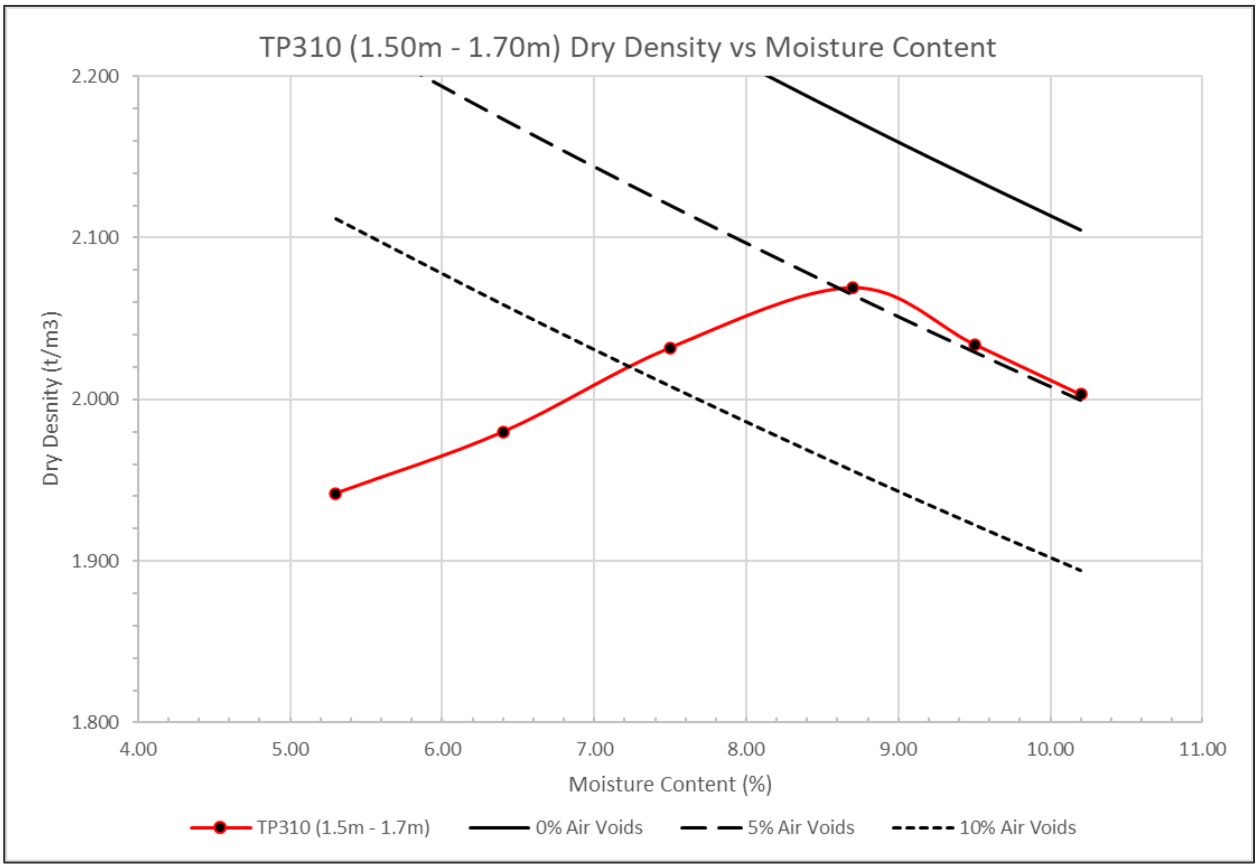


Figure 4-3: TP310 (1.50 – 1.70m) Dry Density vs. Moisture Content Plot

4.7.6 California Bearing Ratio (CBR)

California Bearing Ratio (CBR) lab test results are presented in Table 4-8.

Table 4-8: California Bearing Ratio (CBR) Test Results - Northeast of Ōhau River

Sample ID	Depth (m BGL)	Bulk Density (t/m3)	Dry Density (t/m3)	CBR (%)	Comments
TP310	1.50 – 1.70	2.11	1.97	60.0	Tested at natural water content

5 Material Re-usability

5.1 Observations / Conclusions

The following observations were made:

- Material appears to be relatively consistently graded with a typically high proportion of gravel.
- Fines content typically ranged from 1% – 18%, with an average of 7-8% (excluding outliers >18%). Three samples tested with greater than 18% fines, likely related to pockets of silts and clays which relates to the expected variable depositional history of the area. Select discarding or mixing of this finer grained material will be required during construction.
- The Q2a/Q3a gravelly material at Waikawa Stream appears to be less variable (and contain less fines) then the inferred Q1a gravelly material Northeast of Ōhau River.
- Compaction results appear typical for a material of this nature and suggest it should be suitable for general/bulk fill for embankment construction. It is noted that some graphs show irregular “curve fits” and therefore these have been interpreted using engineering judgement.
- CBR testing results ranged 16% – 60% and suggest material would be suitable for general/bulk fill for embankment construction.
- No investigations have been completed within the Northeast of Ōhau River (#36) Site, with interpretation based on nearby investigations. Therefore, this site has the lowest confidence of interpretation and therefore the presents the highest risk of unknown ground conditions going forward.

Figure 5-1 presents Table 1.4 from the Earth Manual[5] which suggests the Q1 and Q2a/Q3a material (soil type: GW, GP, GM, GC) located between Waikawa Stream to North Manukau Road is considered “good” to “excellent” for workability as a construction material. The lower “number ratings” are considered the best.

Table 1-4.—Engineering use chart for compacted soils

Engineering Properties of Compacted Soil[1]						Relative Desirability for Various Uses (No. 1 is considered the best)							
						Rolled earth dams			Canal sections		Foundations and fills		
Soil group name	Group symbol	Permeability[2]	Shear strength (saturated)	Compressibility (saturated)	Workability as a construction material	Homogeneous embankment	Core	Shell	Erosion-resistant blanket or belt	Compacted earth lining	Impervious	Pervious	Resistance to frost heave
Well-graded gravel	GW	Pervious	Excellent	Negligible	Excellent	—	—	1	1	—	—	1	1
Poorly graded gravel	GP	Pervious	Good	Negligible	Good	—	—	2	2	—	—	3	2
Silty gravel	GM	Semipervious to impervious	Good	Negligible	Good	2	4	—	4	4	1	4	6
Clayey gravel	GC	Impervious	Good to fair	Very low	Good	1	1	—	3	1	2	6	5
Well-graded sands	SW	Pervious	Excellent	Negligible	Excellent	—	—	3 if gravelly	6	—	—	2	3
Poorly graded sands	SP	Pervious	Good	Very low	Fair	—	—	4 if gravelly	7 if gravelly	—	—	5	4
Silty sands	SM	Semipervious to impervious	Good	Low	Fair	4	5	—	8 if gravelly	5 erosion critical	3	7	12
Clayey sands	SC	Impervious	Good to fair	Low to medium	Good	3	2	—	5	2	4	8	7
Silt	ML	Semipervious to impervious	Fair	Medium	Fair	6	6	—	—	6 erosion critical	6	9	11
Lean clay	CL	Impervious	Fair	Medium	Good to fair	5	3	—	9	3	5	10	9
Organic silt and organic clay	OL	Semipervious to impervious	Poor	Medium to high	Fair	8	8	—	—	—	7	11	—
Elastic silt	MH	Semipervious to impervious	Fair to poor	High	Poor	9	9	—	—	—	8	12	10
Fat clay	CH	Impervious	Poor	High	Poor	7	7	—	10	—	9	13	8
Organic silt and organic clay	OH	Impervious	Poor	High	Poor	10	10	—	—	—	10	14	—
Peat and other highly organic soils	PT	—	—	—	—	—	—	—	—	—	—	—	—

[1] Compacted to at least 95 percent of laboratory maximum dry density or to at least 70 percent relative density.
[2] Impervious: < 1 ft/yr (1 x 10^{-6} cm/s)
Semipervious: 1 to 100 ft/yr (1 x 10^{-6} cm/s to 1 x 10^{-4} cm/s).
Pervious: > 100 ft/yr (1 x 10^{-4} cm/s).

Figure 5-1: Table 1.4 from Earth Manual

[5] Earth Manual, Part 1, 3rd Edition. US Department of The Interior. Bureau of Reclamation, 1998.

5.2 Geotechnical Recommendations

Based on investigations completed to date, Stantec believe the three alluvial gravel sites identified are suitable for bulk/general fill for the construction of the road embankments.

Given the depositional history of the material, variation is to be expected and encountering pockets of unsuitable material should be allowed for. This unfavourable material could be spoiled or potentially mixed to enable reuse (or both). Additional geotechnical testing will aid in establishing the degree of variability, and therefore allow more informed project and site-specific planning. If pockets/layers of finer materials are regularly encountered, additional testing should also target these, with the assumption that the that mixing will be undertaken.

The piezometers located within South of Waikawa Stream (Site 15) and North of the Waikawa Stream (Site 19) should be monitored for a minimum of 12 months to establish groundwater level fluctuations. Ideally, there should be two to three piezometers at each site. This is particularly relevant if the restoration/rehabilitation of the site involved the establishments of wetlands or open water (i.e., ponds/lakes).

Based on the above discussion, the following geotechnical additional investigations are recommended in Table 5-1. It is recommended that the investigations are completed as soon as possible.

Table 5-1: Recommended Additional Geotechnical Investigations

Site	Borehole/Piezometer	Test Pit	Lab Testing
South of Waikawa Stream (Site 15)	1	5	Yes
North of the Waikawa Stream (Site 19)	1	3	Yes
Northeast of Ōhau River (Site 36)	3	8	Yes

6 References

Begg, J., & Johnston, M. (2000). *Geology of the Wellington area: scale 1:250,000. Map 10.* Lower Hutt: Institute of Geological & Nuclear Sciences.

Reclamation, B. (1998). *Earth Manual, Part 1, 3rd Edition. Earth Manual, Part 1, 3rd Edition, US Department of The Interior.*

Stantec. (2022). *Geotechnical Factual Report for SH1 Ōtaki to North Levin, Rev C.* Auckland.

Stantec. (2022). *Geotechnical Interpretive Report for SH1 Ōtaki to North Levin, Rev D.*

Stantec. (2022). *Material Supply (Borrow) Study for SH1 Ōtaki to North Levin, Rev A.*

Stantec's Geotechnical Factual Memorandum for Q2a Gravels, Rev 1, 2 August 2021 (East of Levin)

Otaki to North Levin (O2NL)
Geotechnical Factual Memorandum for Q2a Gravels

This report has been prepared for the benefit of Waka Kotahi. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to Waka Kotahi and other persons for an application for permission or approval or to fulfil a legal requirement.

Rev. no	Date	Description	Prepared by	Checked by	Reviewed by	Approved by
1	2 August	Interim factual Q2a gravel memo to inform quarry viability assessment	RC	KC	EG	JP

1 Introduction

Stantec has been engaged by Waka Kotahi to undertake geotechnical investigations and reporting for the Otaki to North Levin (O2NL) project. The first stage of geotechnical investigations was completed in 2020 and the second stage is currently progressing. The 2020 investigation results are presented within Stantec's Geotechnical Factual Report (Rev A – October 2020), and the intent is that the Geotechnical Factual Report (GFR) will be updated to include the 2021 results. This update will be completed after investigations are complete with an expected GFR issue in September 2021

The purpose of this memorandum is to summarise and provide interim factual results in an advance of the GFR issue. Although there are some lab results outstanding, the majority of the investigations and lab testing within the gravelly material east of Levin, which are mapped within the Q2a formation, as shown on 1:250,000 Institute of Geological and Nuclear Sciences (IGNS) Geology of the Wellington Area, Map 10, have been completed. The proposed O2NL alignment crosses the gravels of the Q2a formation between Kimberley Road and Queen St (East of Levin). Refer Figure 2.1.

The current O2NL vertical alignment between Kimberley Street and Queen Street East is within a large cut through the Q2a gravel material. The intent is that the Q2a material becomes available for re-use. An opportunity has been identified that this material could be potentially quarried/processed into a higher-grade aggregate.

The overall objective of this memorandum is that the geotechnical factual information is compiled and presented so a quarrying technical specialist can undertake an assessment of the viability of quarrying/processing the Q2a gravel into higher-grade aggregates.

2 Location Plan

Figure 2.1, below, shows the investigation locations within the Q2a gravel east of Levin. The site investigation plan is also appended in Appendix A.1.

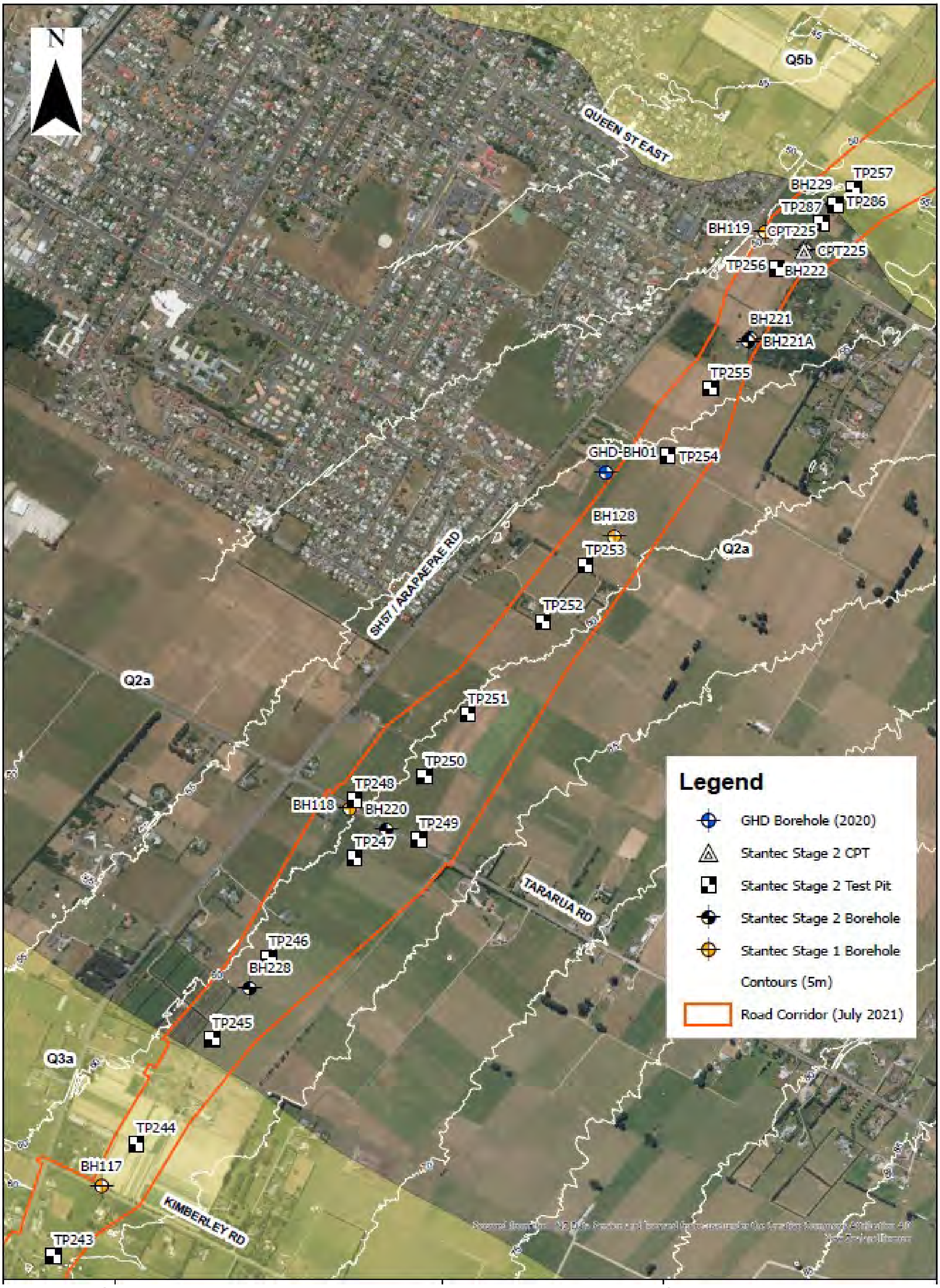


Figure 2.1: **Site Investigation Plan with investigation locations within the Q2a gravel**

3 Material Field Description

The Q2a formation is described on the IGNS map as late Pleistocene river and aggradational terrace deposits, consisting of poorly to moderately sorted gravel with minor sand or silt, underlying terraces. The unit also includes minor fan gravel.

Due to the different deposition processes of the soil materials classified under the Q2a formation, their nature and composition was found to vary along the length of the alignment. The different soils encountered in the investigations along the alignment consist of:

- Silty SAND to SAND with some silt
- CLAY to silty CLAY
- Sandy SILT to SILT
- Silty / clayey GRAVEL
- Sandy GRAVEL
- Sandy / cobbly GRAVEL

The fine-grained materials are predominantly encountered at the wider area of Manakau and south of the Manakau stream.

The coarse-grained materials of the Q2a formation are encountered at the area east of Levin. They are expected to be fairly consistently present in this area, at depths from 0.5 to 4 m below ground level and with thicknesses exceeding 10 m.

Even in this area it should be expected that the composition of the Q2a gravel may vary within close distances, for example in the percentage of fines contents or the percentage and size of cobbles present. A characteristic example is BH128 and TP253 (carried out at a distance of 100m apart) which had a noticeable difference in fines and cobble content between 2.0 and 3.0m bgl.

A layer of finer loess soils has been observed to overlay the Q2a gravel east of Levin. The thickness of the loess soils was typically ~0.5m thick but is expected to vary from 0.2 m to up to 3.0 – 4.0 m locally.

4 Investigations Completed

Investigations within the mapped Q2a area (east of Levin) and O2NL road corridor have been completed by Stantec and GHD between June 2020 to June 2021. Stantec has completed six boreholes during the O2NL Stage 1 and 2 investigations and GHD has completed one borehole within the road corridor in December 2020, as part of the Taraika project.

All boreholes were completed by Griffiths Drilling using a PQ sized core barrel with a sonic drilling methodology in accordance with NZS 4411:2001 Environmental Standard for drilling of Soil and Rock.

Stantec has completed 12 test pits within the Q2a area (east of Levin) as part of the Stage 2 investigations. Test pits were completed by Goodman's Contracting between 8 April - 12 May using a 14tn wheeled excavator.

Logging and sampling of the boreholes and test pits was completed by a Stantec geologist. Samples have been stored at a secure Waka Kotahi container prior to testing.

Table 4.1 presents a summary of the relevant intrusive investigations completed within the Q2a gravel material (East of Levin).

Table 4.1: Summary of Investigations

Investigation ID	Investigation Type	Coordinates (NZTM 2000)		Elevation (m RL, WGN 1953)	Approximate Chainage	Termination depth (m bgl)	Depth Q2a Gravel Encountered
		Easting	Northing				
TP245	Test Pit	1793478	5497304	61.8	19050	3.80	0.2 - >3.8
TP246	Test Pit	1793645	5497545	61.1	18750	3.90	0.2 - >3.9
TP247	Test Pit	1793899	5497840	61.2	18350	3.90	0.2 - >3.9
TP248	Test Pit	1793900	5498013	59.9	18200	3.50	0.6 ->3.5
TP249	Test Pit	1794090	5497895	62.3	18200	3.50	0.5 - >3.5
TP250	Test Pit	1794108	5498082	60.8	18050	3.50	0.7 - >3.5
TP251	Test Pit	1794235	5498266	60.7	17800	3.50	0.7 - >3.5
TP252	Test Pit	1794458	5498540	58.5	17500	3.90	0.3 - >3.9
TP253	Test Pit	1794583	5498707	58.5	17250	3.50	0.8 - >3.5
TP254	Test Pit	1794827	5499033	55.8	16850	3.60	0.45 - >3.6
TP255	Test Pit	1794954	5499232	54.5	16600	3.70	0.7 - >3.7
TP256	Test Pit	1795151	5499587	51.2	16200	3.70	0.6 - >3.7
BH118	Borehole	1793884.6	5497986.1	59.8	18200	22.50	1.5 - >22.5
BH128	Borehole	1794668.0	5498785.0	58.6	17150	28.50	1.3 - 15.2
BH220	Borehole	1793993.0	5497925.0	61.4	18200	30.12	1.5 - >30.1
BH221	Borehole	1795069.2	5499377.2	52.7	16450	19.88	0.15 - 6.7
BH221a	Borehole	1795065.2	5499370.6	52.7	16450	7.50	0.15 - 7.5
BH228	Borehole	1793587.6	5497454.1	65.0	18850	25.0	0.5 - 11
GHD-BH01	Borehole	1794644.0	5498982.0	56.1	17000	15.0	1.5 - >15

The borehole and test pit logs are currently preliminary in status.

5 Laboratory testing

5.1 Testing Standards

Testing was undertaken by Geocivil laboratory, in accordance with the following standards:

- Particle Size Distribution tested in accordance with ASTM D6913-17.
- NZ Compaction Test via the Vibrating Hammer Compaction Test in accordance with NZS 4402: 1986, Test 3.1.3.
- Crushing Resistance tested in accordance with NZS 4407: 2015, Test 3.10.
- Weathering Quality Index tested in accordance with NZS 4407: 2015, Test 3.11.
- California Bearing Ratio tested in accordance with NZS 4407: 2015, Test 3.15.
- (Sample prepped via Vibrating Hammer Compaction at Optimum Water Content).

Performance requirements to TNZ M/4: 2006 SP/SM4:060418 Specification for Basecourse Aggregate (TNZ M/4).

5.2 Testing summary

Table 5.2 presents a summary of the relevant laboratory testing that was undertaken.

Table 5.2: Laboratory Testing Summary

Sample ID	Depth (m bgl)	Particle Size Distribution	NZ Compaction Test	Crushing Resistance	Weathering Quality Index	California Bearing Ratio
TP245	2.5 - 3.5	1	1	1	1	1
TP246	3.2 – 3.5	1	-	1	-	-
TP247	2.7 - 3.9	1	1	1	1	-
TP248	3.0 - 3.4	1	-	-	-	-
TP250	3.0 - 3.5	1	-	-	-	1
TP251	2.6 – 2.6	1	-	-	-	-
TP252	2.9 – 3.2	1	-	-	-	-
TP253	2.9 – 3.2	1	-	-	-	-
TP254	3.4 – 3.6	1	-	-	-	1
TP255	2.8 – 3.1	1	-	-	-	-
BH118	2.0 – 2.8* 6.5 – 7.2*	2	-	-	-	-
BH128	1.7 – 2.3* 5.0 – 5.4	2	-	-	-	-
BH220	6.2 – 6.6	1	-	-	-	-
BH228	6.5 – 8.0	1	-	-	-	-
*	*Potentially interpretated as not a Q2a gravel material, or mixed with an upper layer*					

Ethylene Glycol Accelerated Weathering Testing on samples from TP246 and TP252 are in progress.

The testing results are currently in draft status.

6 Laboratory Testing Summarisation

6.1 Particle Size Distribution

6.1.1 Test Pits

Table 6.1a presents Q2a Gravel Material (East of Levin) Particle Size Distribution Results (from test pit samples), with plots presented Figure 6.1a.

Table 6.1a: Q2a Material Particle Size Distribution Results (Test pit samples)

Sample ID	Depth (m bgl)	% Gravels	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt/Clay
		>4.75mm	4.75 – 2.00	2.00 – 0.475	0.475 – 0.075	<0.075
TP245	2.5 - 3.5	70	9	10	5	6
TP246	3.2 – 3.5	72	11	10	3	3
TP247	2.7 - 3.9	70	12	13	3	3
TP248	3.0 - 3.4	74	9	11	4	2
TP250	3.0 - 3.5	66	12	12	5	5
TP251	2.6 – 2.6	79	9	9	3	1
TP252	2.9 – 3.2	*TBC*	*TBC*	*TBC*	*TBC*	*TBC*
TP253	2.9 – 3.2	65	12	12	5	6
TP254	3.4 – 3.6	74	10	9	3	4
TP255	2.8 – 3.1	77	10	10	2	1

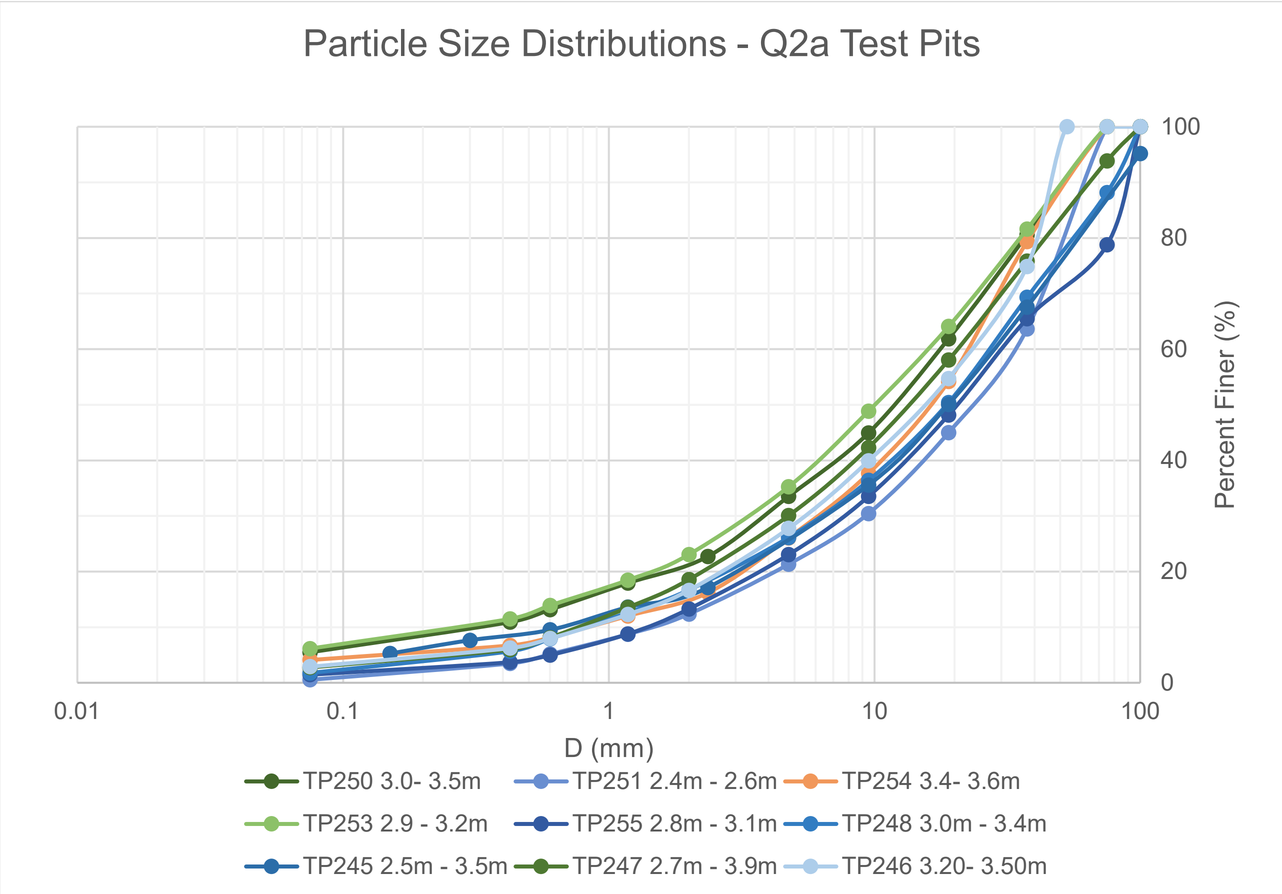


Figure 6.1a: Q2a Material - Particle Size Distribution Plot (Test pit samples)

Gravel clasts >100mm diameter and cobbles were rarely sampled, so typically in-situ material is coarser in nature then depicted by testing results.

6.1.2 Bore Holes

Table 6.1b presents Q2a Gavel Material (East of Levin) Particle Size Distribution Results (from Borehole samples), with plots presented Figure 6.1b

Table 6.1b: Q2a Material Particle Size Distribution Results (Borehole samples)

Sample ID	Depth (m bgl)	% Gravels	% Coarse Sand	% Medium Sand	% Fine Sand	% Silt/Clay
		>4.75mm	4.75 – 2.00	2.00 – 0.475	0.475 – 0.075	<0.075
BH118	2.0 – 2.8	54.5	12.7	16.7	6.9	9.2
BH118	6.5 – 7.2	59.8	8	12	6.9	13.3
BH128	1.7 – 2.3	36.5	11	20.1	12.4	20.0
BH128	5.0 – 5.4	51.8	11.3	15.8	8.5	12.6
BH220	6.2 – 6.6	48	11	10	12	19
BH228	6.5 – 8.0	*TBC*	*TBC*	*TBC*	*TBC*	*TBC*

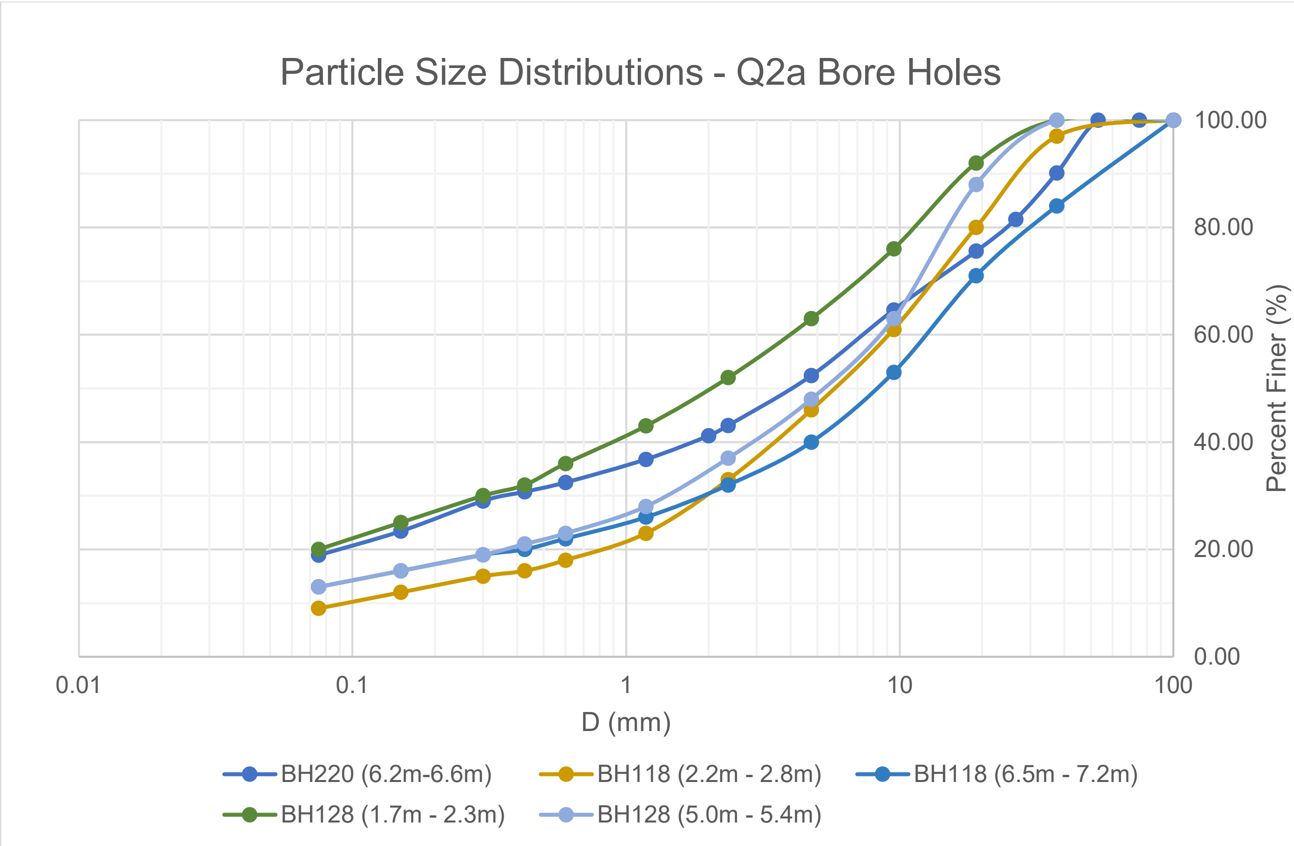


Figure 6.1b: Q2a Material - Particle Size Distribution Plot (Borehole samples)

Clast size limited to core barrel diameter (85mm), which increases the fractions of fines. It is also inferred that sonic drilling through dense gravels creates additional fine material within the sample, so typically in-situ material is coarser in nature then depicted by testing results.

6.2 NZ Compaction Test

Table 6.2 presents the results from the NZ compaction test, with plots presented with Figure 6.2a to 6.2b

Table 6.2: Results from NZ Compaction Test

Sample ID	Depth (m bgl)	Natural Water Content, wn (%)	Optimum Water Content, wo (%)	Max Dry Density, ρd,max (t/m³)2
TP245	2.5 – 3.5	5.63	6.50	2.26
TP247	2.7 – 3.9	5.36	6.50	2.22

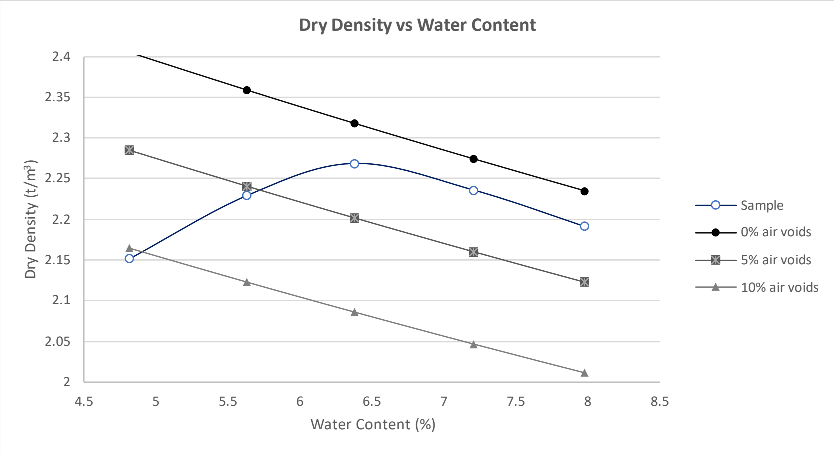


Figure 6.2a: TP245 2.5m to 3.5m - Dry Density Vs Water Content Plot

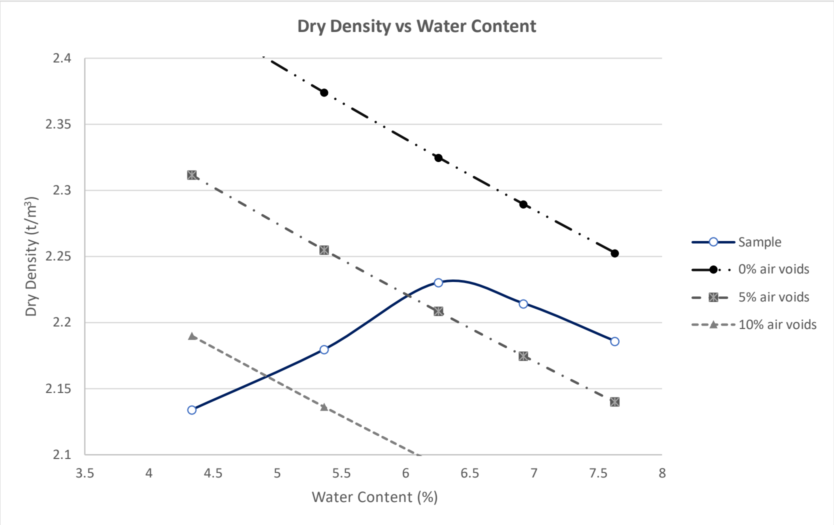


Figure 6.2b: TP247 2.7m to 3.9m - Dry Density Vs Water Content Plot

6.3 Crushing Resistance

Table 6.3 presents the Q2a Material Crushing Resistance results.

Table 6.3: Q2a Material Crushing Resistance Results

Sample ID	Depth (m bgl)	Specified Load (kN)	Greater Than / Lest Than	% Passing 2.36 mm sieve
TP245	2.5 – 3.5	130	Greater Than	2.6
TP246	3.2 – 3.5	130	Greater Than	3.1
TP247	2.7 – 3.9	130	Greater Than	2.4

TNZ M/4: 2006 requires that the Crushing Resistance Test, under a load of 130 kN, must produce less than 10% fines passing 2.36 mm sieve size.

6.4 Weathering Quality Index

Table 6.4 presents the Q2a Material Weathering Quality Index results.

Table 6.4: Q2a Material Weathering Quality Index Results

Sample ID	Depth (m bgl)	% of dry sample retained on 4.75 mm)	Cleanness value of wash water	Weathering quality index
TP245	2.5 – 3.5	97.4	98.0	AA
TP247	2.7 – 3.9	98.4	98.0	AA

TNZ M/4: 2006 requires the aggregate shall have a quality index of AA, AB, AC, BA, BB or CA

6.5 California Bearing Ratio

Table 6.5 presents Q2a Material California Bearing Ratio results.

Table 6.5: Q2a Material California Bearing Ratio Results

Sample ID	Depth (m bgl)	Bulk Density (t/m3)	Dry Density (t/m3)	% Oversize material	CBR (%)	Comments
TP245	2.50 - 3.50	2.36	2.18	53.99	**135.00**	1% water added, by mass
TP250	3.00 - 3.45	2.32	2.14	33.24	**90.00**	Soaked
TP254	3.40 - 3.60	2.29	2.14	45.26	**140.00**	Soaked

TNZ M/4: 2006 requires the soaked CBR of the basecourse aggregate shall not be less than 80%.

7 Flow chart for Basecourse Aggregate Testing

Figure 7.1 presents an extract from TNZ M/4: 2006, which illustrates the testing sequence for basecourse aggregates.

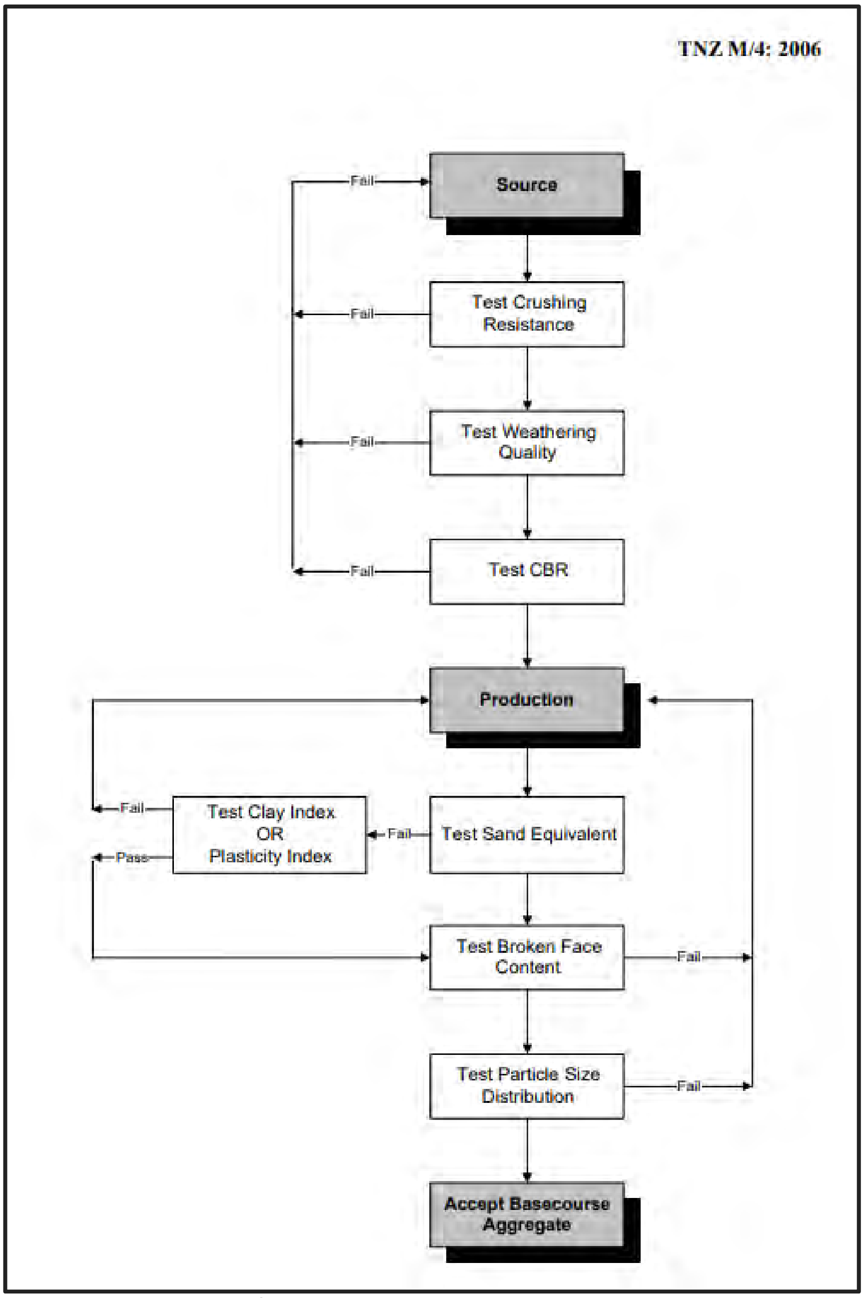


Figure 7.1: Flow chat for Basecourse Aggregate Testing

Appendices

A1 Site Investigation Plan

A2 Borehole Core and Photo Logs

BH118
BH128
BH220
BH221
BH221a
BH228
GHD-BH01

A3 Test Pit Logs

TP245
TP246
TP247
TP248
TP249
TP250
TP251
TP252
TP253
TP254
TP255
TP256

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.

New Zealand offices:
Alexandra, Auckland, Balclutha, Christchurch, Dunedin, Gisborne, Greymouth, Hamilton, Hastings, Nelson, Palmerston North, Queenstown, Tauranga, Wellington, Whangārei

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

Appendix 4.6 Schedule of Design Refinements

Freeze & Date	Geometrics	Structures	Stormwater	Earthworks / geotech
DF2 **30 August 2021**	• Initial Draft DBC Design • New highway in cutting east of Levin	• Baseline design	• Longitudinal swale and grey infrastructure. • Culvert locations and sizing	• Baseline design • Inclusion of cut/fill slope grades based on geo stability assessment
DF2.5 **08 Sept 2021**	• Drawing scale reduced • SUP connection added to Manakau village / school • Individual property access points added • Median and edge barrier extents removed from plans • Added adjacent Speed & Infrastructure Programme (online safety works) schematic layouts into plan sets • Dual SUPs removed from NIMT bridge, new underpass added further north	• Reduced deck width at NIMT crossing as northern SUP no longer required	• Design pond locations and sizes	
DF3 **9 Dec 2021**	• East of Levin, new highway level removed from trench cutting, changed to at-grade (with changes to Queen and Tararua) • Queen Street realigned to north of existing QSE with new roundabout connection to SH57/Arapaepae • SUP taken off Arapaepae Road and onto east side of new highway east of Levin, New location of underpass at new SH1/SH57 roundabout • Changes to horizontal alignment South Manakau (CH30000) to Forest Lakes area (CH32000)	• Extents of ground improvements added • Reinforced earth blocks added • Rock rip-rap scour protection added to watercourse bridges • Queens Street East road bridge relocated and deck cross-section reconfigured • Queens Street East footbridge drawings added • Waikawa Stream flood relief culvert size increased and reconfigured to a triple box	• Refine sizing of swales • Refine sizing and soakage design • First phase rock armour / revetment inclusion at bridge locations • Additional ponds added east of Levin due to change in longitudinal grade / low points • Pond footprint / number reduced at new SH57 roundabout • Pond removed South of S. Manakau Rd and north of Ohau River • Changes to culvert location and sizing in response to geometric changes • Widen bridge spans at Waiauti and Ohau flood relief based on updated hydraulic model results.	• Inclusion of Spoil Sites
DF4 **20 April 2022**	• Change in vertical profile / finished RL (to K=71 value) at rail crossing in north and in area to south of South Manakau Road • Sorenson ROW reviewed due to vertical changes above. • Change in edge treatment cross sectional profile, steeper front slope and reduced offset to edge barrier • SUP at Kuku changed to be at edge of Highway (avoid Treeland) • SUP taken under bridge at Kuku and at grade crossing on Kuku removed • Vertical alignment of SH57 Underpass amended	• Value engineering elements added namely: • Reduce median to 3m across all bridges, bar NIMT and Waiauti bridges • Incorporate 20 degree skew into NIMT and Taylors bridges • Queens St East road bridge span reduced and deck reconfigured • SUP added to Kuku Stream Bridge • Queens St East Footbridge main span increased from 30m to 34m • Increase in Waiauti Stream bridge span	• Refine positions and sizes of culverts, ponds, soakage and swales/pipes with geometrics. • Rock armouring refinement at bridge sites • 450m reduction in stream reclamation from DF3 • 150m reduction in culvert length from DF3 • SW pond at Kuku amended to be clear of bush • Removal of redundant pond at CH33500	• Cut and fills reduced following vertical profile change • Inclusion of Material Supply (Borrow) Sites. • Some refinement of Spoil Site locations / perimeter extents (Changes documented within Spoil Site Report). • Geological model plan/section dwgs created. • Reduced fill requirements in north and south based on revised vertical profile
DF5 **19 August 2022**	• Change to Queen Street reconnection • Inclusion of East West Arterial (Liverpool Street) • Update to accessway / track designs • Refinement of access and SUP at CH31300	• As per geometrics • Amendment of underpass locations and sizing at CH31000 and CH33000	• Refinement on treatment pond at Queen Street • Inclusion of abstraction and storage ponds • Revision of pond layout to reduce impact on existing watercourse at CH32400	• Minor refinement to extents for both Material Supply (Borrow) and Spoil Sites • Geological model plan/section dwgs updated

Appendix 4.7 Potential surface sources of construction water

O2NL CONSTRUCTION WATER

Appendix 4.7: Potential surface sources of construction water

Prepared for: Waka Kotahi (NZ) Transport Agency

SLR Ref: 720.30017.00000-R01
Version No: -v0.1
June 2022

PREPARED BY

SLR Consulting NZ Limited
Company Number 2443058
Tenancy 202 Submarine School, Sub Base Platypus, 120 High Street,
Wellington, 6011 New Zealand

T: +64 37 211 5973
E: sydney@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Waka Kotahi (NZ) Transport Agency (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
720.30017.00000-R01-v0.1	12 October 2022	Oliver Anderson	Deborah Maxwell	Jack McConchie
720.30017.00000-R01-v0.1	30 June 2022	Oliver Anderson	Deborah Maxwell	Jack McConchie

CONTENTS

1 Introduction

As part of the investigations relating to the potential construction of Ōtaki to North Levin Highway Project (Ō2NL Project), options to abstract 'construction water' from the Ohau River and the Waikawa, Manakau, Koputaroa and Waitohu Streams are being explored. Water will likely be pumped to storage ponds, to buffer any mismatch between water supply and demand, and then conveyed to construction zones along the length of the proposed highway. Additional water storage along the route would provide further security of supply.

It is estimated that an average daily abstraction of 2,350m^3 of water, with a maximum daily abstraction of 3,900m^3, will be required to support construction of the Ō2NL Project. These volumes equate to continuous average abstraction rates of 27L/s and 45L/s, respectively. The total abstraction will be taken from a combination of the water available from each of the five rivers and streams. The abstraction from any specific stream is proposed to be consistent with the requirements of the relevant planning policies and rules.

To support consideration of options to provide the water necessary for construction, including the risk of periods of restricted abstraction, low flow analyses for the Ohau River and Waikawa, Manakau, Koputaroa and Waitohu Streams were undertaken. The potential effects of the abstraction on the flow regimes and instream values of these waterways were also considered.

This report therefore assesses the low flow behaviour of these rivers and streams and discusses the impacts of abstraction of 'construction water', at a combined rate of up to 3,900m^3/day, on their flow regimes.

2 Demand Analysis

During construction of the Ō2NL Project, water will be required to support several activities relating to the earthworks and pavements. The demand for water is expected to be considerably smaller at the start of construction and increase as the Project progresses. It is anticipated that water will be required:

- For dust suppression to meet compliance requirements, 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.

Given that that the precise construction methodology has not been specified, there is some uncertainty as to the exact volume of water that might be required, and considerable daily variability is expected. It is noted that only the minimum volume of water required to meet very specific purposes will be abstracted and that water will only be abstracted during the construction seasons over the duration of the Project.

The overall strategy for managing water demand is to firstly minimise requirements and then to utilise water that becomes available to the Project through existing consented takes (from boreholes or takes that are authorised to occur on land that is acquired to allow construction of the Ō2NL Project). Additional opportunities to recycle water collected on site through dewatering and erosion and sediment control devices will also be explored. It is unknown how much water will become available through these sources.

Given the inherent uncertainty of the requirement for construction water, the risk associated with balancing the supply and demand for water, potential periods of restricted abstraction caused by low flows, and the nature of resource consents which specify maximum rates of abstraction, a water permit for the maximum potential volume that may be required is being sought. This will ensure that the Project can be practicably constructed.

3 Existing Constraints

3.1 Hydrological constraints

Given the volume of construction water required, it is likely that the total abstraction will come from a combination of sources. Waitohu Stream is likely the only water source with the potential to meet the total demand, although even on this river abstraction would be restricted during periods of low flow. The Ohau River and Waikawa, Manakau and Koputaroa Streams are associated with several different management units, divided into sub-zones identified within Horizon's One Plan. Waitohu Stream is associated with the Kāpiti Coast Surface Water Management Zone, managed by Greater Wellington Regional Council (GWRC). The relevant sub-zones, including their currently available Core Allocations, are:

- Ohau_1b (Lower Ohau River) – 409m^3/day;
- West_9a (Waikawa) – 4,498m^3/day;
- West_9b (Manakau) – 156m^3/day;
- Mana_13e (Koputaroa) – 351m^3/day; and
- Waitohu Stream – 3,240m^3/day.

It should be noted that these volumes are those currently availability from each sub-zone independent of the others. Consequently, if water is allocated in one sub-zone it may change the volume available in another sub-zone.

Abstraction of water from any of these sources is subject to minimum flow restrictions. For the Ohau River (Ohau at Rongomatane), the minimum flow is 0.820m^3/s. The minimum flow for the Waikawa Stream (at North Manakau Road) is 0.220m^3/s, while the minimum flow for the Manakau Stream (at SH1 Bridge) is 0.040m^3/s. Restrictions in the Koputaroa catchment are based on the minimum flow measured in the Manawatū River at Teachers College i.e., 12.240m^3/s. For the Waitohu Stream (Waitohu at Water Supply Intake) the minimum flow is 0.140m^3/s. The abstraction of construction water from any of these waterways is likely to be extremely difficult to consent below the minimum flows. The nature of the minimum flows and their implications for the Ō2NL Project are discussed in detail later.

Since abstraction will be restricted during periods of low river flow, it is necessary that the frequency, magnitude, and duration of these periods are determined so that the risk to the Ō2NL Project can be quantified. The potential impact of these periods of restricted abstraction on construction activities can be mitigated by a range of measures, including the provision of water storage along the route. This storage will improve the security of water supply and mitigate the effect of restricted abstraction during periods of low flow in the river.

3.2 Planning constraints

Under Horizon's One Plan, the abstraction of water is managed by the Core Allocation from each catchment and the Minimum Flow below which all abstractions must cease. The abstraction of construction water must be consistent with these metrics for it to be a Controlled Activity. Meeting these requirements, however, means that any potential adverse environmental effects of the proposed abstraction have already been considered and are regarded as 'acceptable' under the One Plan. This report therefore focuses on the potential availability of water to support the construction of the Project obtained from the various rivers and streams under this planning framework.

The One Plan and the Proposed Natural Resources Plan, however, also provide for the Supplementary Allocation of water that is outside of the core allocation discussed above. One Plan Policy 5-17 allows for a supplementary allocation from rivers and streams in circumstances where the water is only abstracted when the river flow is greater than the median flow. The total amount of water taken by way of a supplementary allocation must not exceed 10% of the actual flow in the river at the time of abstraction. Similarly, Policy P124 (of the Proposed Natural Resources Plan) allows for a supplementary water take of up to 10% of actual flow in the river when flow in the Waitohu exceeds the median.

Essentially, a Supplementary Allocation allows for 'water harvesting' during higher flows in the river when there are no adverse effects on either the environment, or existing users under the Core Allocation. It is possible therefore that the Ō2NL Project could also make use of a Supplementary Allocation from each river or stream. This would allow water storage along the Project corridor to be filled prior to having to rely solely on the Core Allocation and abstraction above the minimum flow. Use of a Supplementary Allocation, when combined with water storage, therefore has the potential to mitigate the potential risk to the Project of extended periods when the rivers and streams are below their respective minimum flows.

Since the hydrological risks associated with accessing a Supplementary Allocation are small, and any potential adverse hydrological effects negligible, the implications of Supplementary Allocations are not discussed further in this report.

4 Hydrological Setting

The Horowhenua District contains many hydrological features, including Punahau / Lake Horowhenua to the west of Levin, and a network of rivers and streams which drain an area of approximately 395km^2. These waterways generally flow north-west, from headwaters in the Tararua Range to the coast, or the Manawatū River in the case of Koputaroa Stream.

Because of the steep topography of the Tararua Range, the rivers and streams respond rapidly to rainfall; however, they are also prone to extended periods of low flow during times of low rainfall. Consequently, the flows of these rivers and streams exhibit a high degree of variability. This will act as a constraint on any potential abstraction of construction water. The relevant sub-zones and catchments of the various rivers and streams considered from the perspective of construction water are shown in **Figure 1.**

The Ohau River flows from the confluence of the North and the South Ohau Rivers in the Tararua Range. It drains the Ohau_1 sub-zone, initially flowing north before continuing westward, southeast of Levin, and discharging to the Tasman Sea.

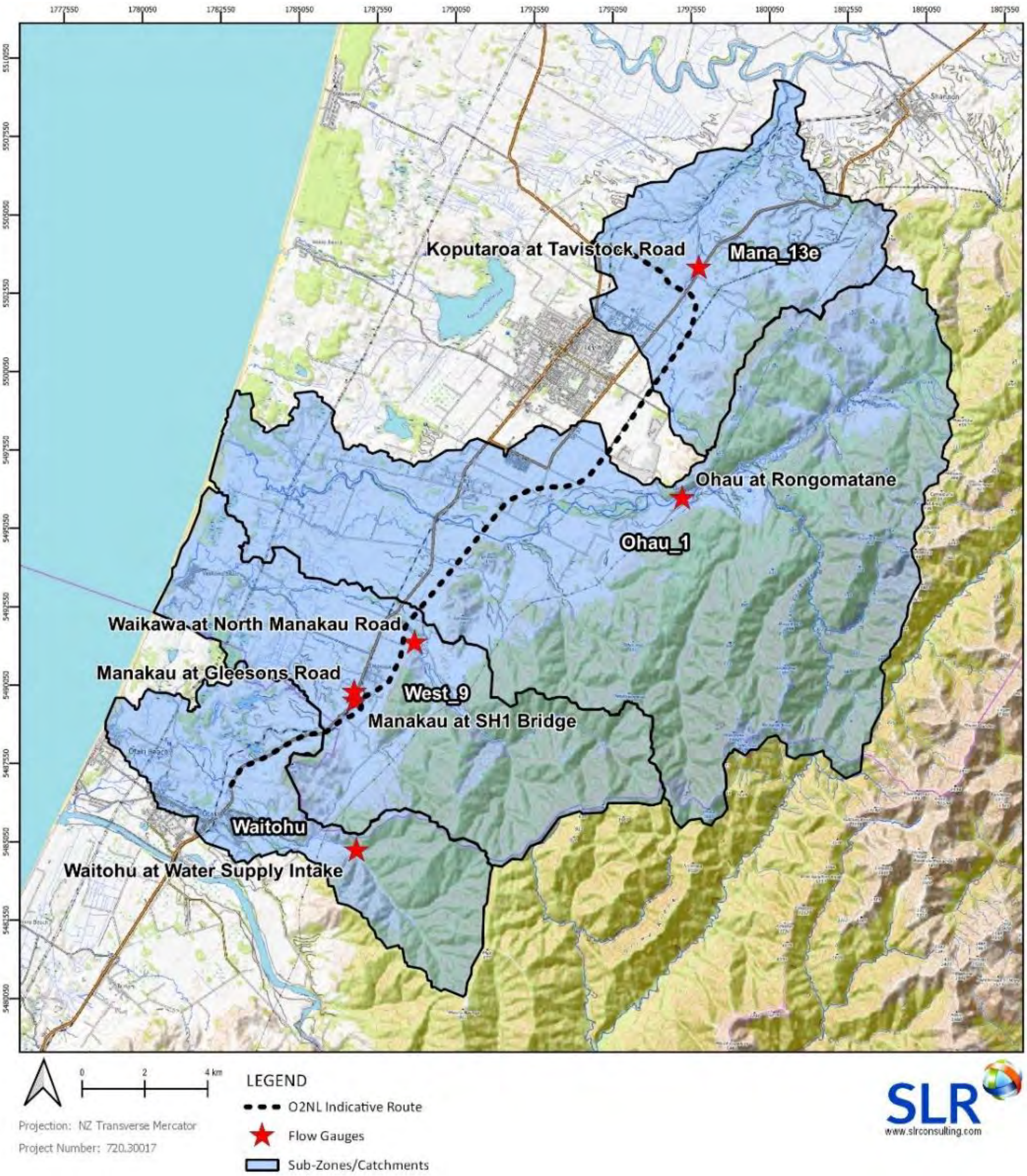


Figure 1: Locations of flow recorders used when assessing the potential effect of abstracting 'construction water' from the Ohau River, and Waikawa, Manakau, Koputaroa and Waitohu Streams.

Draining the West_9 sub-zone, Waikawa Stream flows north/north-west from its headwaters in the Tararua Range. South of Ohau township, Waikawa Stream heads west and flows to the Tasman Sea at Waikawa Beach.

Manakau Stream also drains the West_9 sub-zone, beginning just south of Manakau township and flowing north-west. Approximately 3km east of Waikawa Beach, Manakau Stream joins Waikawa Stream.

The headwaters of Koputaroa Stream are in Kohitere Forest at the foothills of the Tararua Range, east of Levin and north of the Ohau River. The stream flows in a northerly direction before joining the Manawatū River, west of Shannon. Koputaroa Stream drains part of the extensive Mana_13 sub-zone.

Waitohu Stream is part of the Kāpiti Coast Surface Water Zone, which lies in the north-west of the Wellington region on the boundary with Horowhenua District and Horizon's region. Waitohu Stream drains a catchment area of 54km^2, with headwaters in the Tararua foothills to the southeast of Ōtaki. The stream flows northwest, turning westward north of Ōtaki, before discharging into the Tasman Sea at Ōtaki Beach.

The Ohau_1 and West_9 sub-zones can be grouped together as they are both within the Horowhenua Groundwater Management Zone, which covers an area of 395km^2. To the north, the Mana_13 sub-zone lies at the southern end of the Manawatū Groundwater Zone. The major land use in the Horowhenua zone is agriculture, with 16% used for sheep and beef farming. Dairy farming accounts for a further 19%. Native bush covers 35% of the zone, mostly within the conservation area of the Tararua Range. The remaining land is used for forestry (7%), various forms of agriculture, and urban development. Levin is the largest urban area within the catchment, with some smaller communities serving agricultural areas. The land use over the length of Koputaroa Stream through the Manawatū zone is similar. Approximately 40% of the Waitohu catchment is covered in native and exotic forests. The remainder of the catchment includes a variety of land uses, such as pastoral farmed floodplains, small lakes, wetlands, sand dunes, and urban areas.

5 Hydrometric Data

5.1 Flow series

Six flow sites are present in the vicinity of the proposed Ō2NL Highway (**Figure 1**). Two on Manakau Stream, and one on each of the Ohau River and Waikawa, Koputaroa and Waitohu Streams.

The Ohau at Rongomatane flow record is suitable for assessing the potential effects of abstraction from the Ohau River. The gauge is located where the river exits the Tararua Ranges, approximately 3km east (upstream) of the indicative Ō2NL Project corridor. This location is at the transitional point where the river changes from a narrow, confined channel to a wider meandering channel across the piedmont/coastal plain. The gauging station and recorder are maintained by Horizons. Since the flow recorder is a significant distance upstream of the proposed Ō2NL Project, any analysis of the potential effect of the abstraction of construction water will be conservative i.e., the effects will be less than assessed as the actual flows in the Ohau River will be slightly greater at the point of abstraction than assumed.

The Waikawa at North Manakau Road recorder is located approximately 5km south of Ohau township, and 500m east of the indicative Ō2NL Project corridor. At this site, Waikawa Stream is approximately 10m wide, with relatively flat agricultural land on the north bank, and hilly forestry blocks to the south. Downstream, Waikawa Stream meanders across a flat, agricultural floodplain. Because of the proximity of the flow recorder to the Ō2NL Project, the potential reliability and effect of abstraction from Waikawa Stream are likely to be well defined. There may be slight changes in flow caused by the interaction of the river with the adjacent riparian unconfined aquifer. This could lead to variation between flow at the recorder and actual flow at a proposed location of abstraction, however, any effects will be small and likely impossible to quantify. The gauging station and recorder are maintained by Horizons.

Flow has been recorded at two sites on the Manakau Stream. The Manakau at Gleesons Road recorder is located about 500m south of the Manakau township; the Manakau at State Highway 1 (SH1) Bridge recorder is approximately 200m further downstream. The stream channel between these recorders is narrow and meandering, with flat agricultural land on either side. Between the two recorders, there is no diversion of water or any tributaries entering the stream. Consequently, basing the hydrological assessment of Manakau Stream on a combined flow series from both the Gleesons Road and SH1 at Bridge recorders, provides a more accurate and robust analysis of the potential effect of abstraction from the stream because of the longer flow record. The combined flow series and subsequent assessment will be referred to as 'Manakau Combined'. These gauging stations and recorders were or are maintained by Horizons. Again, because of the proximity of these flow recorders to the Ō2NL Project, the potential reliability and effect of abstraction from Manakau Stream are likely to be well defined using these data.

The effects of abstraction from the Koputaroa Stream can be assessed by analysing the flow series from the Koputaroa at Tavistock Road recorder. This recorder is located approximately 5km north-east of Levin, and 6.5km upstream of Koputaroa Stream's confluence with the Manawatū River. This site and flow record were maintained by Horizons from 1974-1996, after which the site was decommissioned. The gauging site and flow recorder have been subsequently reinstated to support the development of the Ō2NL Project, although the recent record is relatively short. The site is now maintained by NIWA on behalf of the Ō2NL Project.

The contributing catchment upstream of Tavistock Road is approximately 16.08km^2. Immediately upstream and downstream of the recorder, the stream has a narrow, confined channel. From approximately 5km upstream of the Tavistock Road recorder, downstream to its confluence with the Manawatū River, Koputaroa Stream meanders through flat agricultural land. All significant tributaries to Koputaroa Stream are a considerable distance either upstream or downstream from the Tavistock Road recorder.

The Project corridor, and therefore any potential abstraction of construction water, is likely to be a significant distance upstream of the flow recorder. For example, the catchment area upstream of McDonald Road, a possible source of abstraction, is only about 40% of that upstream of Tavistock Road. Since flows, particularly low flows, in a river or stream are largely a function of catchment area, flows in Koputaroa Stream near McDonald Road are likely to be only about 40% of those recorded downstream at Tavistock Road. The implications of this for the potential abstraction of construction water is described in more detail later in this report.

The Waitohu at Water Supply Intake recorder is suitable for assessing the impact of any potential abstraction of construction water from this catchment. The gauge is located approximately 4.5km east of Ōtaki, where the Waitohu Stream exits the foothills of the Tararua Ranges. Steep forested land borders the stream to the north of the gauge, with flatter pastoral land to the south. The channel is narrow with little variation immediately upstream and downstream of the flow recorder. The gauging station and recorder are maintained by GWRC.

Since the flow recorder on Waitohu Stream is a significant distance upstream of the proposed Ō2NL Project, any analysis of the potential effect of the abstraction of construction water will be conservative i.e., the effects will be less than assessed as the actual flows in Waitohu Stream will be slightly greater at the point of abstraction than assumed.

No independent quality assurance of the flow records described above has been undertaken. However, the hydrometric sites and flow records have been maintained by either Horizons (all sites except that on Waitohu Stream and until recently the Koputaroa Stream) or GWRC. It is therefore assumed that measurements, gaugings, and ratings have been undertaken in a manner consistent with industry best practice.

The data from Koputaroa Stream, while obtained from Horizons hydrometric archive, are not fully quality assured. Flow record notes state that many of the annual maximum flows, including the largest in the record, occurred during times the recorder was not operating. These peak flows have therefore been derived by taking measurements of debris levels or correlating with local flow records. The conclusion of the rating team was that peak flows should be reasonably accurate. No comments are provided regarding the reliability of the low flow record. As these are the only available data, they have been assumed accurate for the purposes of this analysis.

5.2 Flow Analyses

Given the requirements of Horizon's One Plan and any potential abstraction regime, it is likely that the abstraction of construction water will be managed on the basis of the mean daily flow. Consequently, the quasi-instantaneous flow series (i.e., 15-min flow data) from each river or stream were converted the mean daily flows and the following analyses are based on those data.

The Ohau, Waikawa, Manakau, Koputaroa and Waitohu exhibit a high degree of variability, both within their own flow series and when compared to each other. The Ohau River is the largest of the four waterways (**Table 1)** and recorded flows have ranged from a minimum of 0.585m^3/s (March 1989), to a maximum of over 183m^3/s (January 2008) (**Figure 2**). In comparison, flows recorded in Waikawa Stream have ranged from 0.19m^3/s to 44.5m^3/s (**Table 1**). The minimum flow was recorded in April 2014, while the maximum flow was recorded in January 2008 (**Figure 3**). Waikawa Stream is the second largest of the five waterways, with a mean flow approximately five times higher than those of the Manakau and Koputaroa Streams, although four times smaller than the mean flow of the Ohau River (**Table 1**). The Manakau Stream and Koputaroa Streams have recorded minimum flows of 0.009 m^3/s and 0.012m^3/s, respectively (**Table 1**). The maximum recorded flow in Manakau Stream was 20.7m^3/s in January 2008 (**Figure 4**), while in the Koputaroa the maximum flow of 7.982m^3/s was recorded in December 1976 (**Figure 5**). Flow in the Waitohu Stream has ranged from a minimum of 0.065m^3/s, to a maximum of 34.7m^3/s (**Table 1**). The Waitohu Stream experienced this minimum flow in April 2003, while the maximum flow occurred in January 2008 (**Figure 6**).

The flow regimes of the Ohau River and Waikawa and Waitohu Streams are typical of waterways draining pastoral hill-country at the foothills of the Tararua Range. Flows are generally higher than those of the Manakau and Koputaroa Streams, which are typical of waterways draining low-lying, flat agricultural land.

Table 1: Summary statistics of the mean daily flows at the five sites (m^3/s).

Site	Min	Max	Mean	Std Dev	L.Q.*	Median	U.Q.**
Ohau at Rongomatane	0.585	183.9	6.47	7.83	2.46	4.15	7.45
Waikawa at North Manakau Road	0.191	44.5	1.47	1.72	0.57	0.95	1.72
Manakau Combined	0.009	20.7	0.25	0.43	0.11	0.14	0.23
Koputaroa at Tavistock Road	0.012	8.0	0.24	0.33	0.07	0.15	0.28
Waitohu at Water Supply Intake	0.065	34.7	0.98	1.39	0.30	0.54	1.12

* *L.Q. is the Lower Quartile flow i.e., the flow that is exceeded 75% of the time*
** *U.Q. is the Upper Quartile flow i.e., the flow that is exceeded 25% of the time*

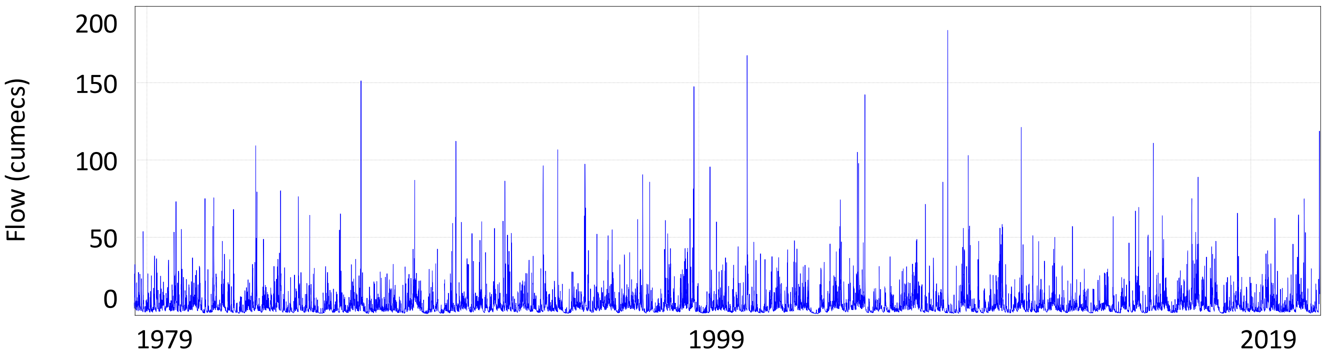


Figure 2: Ohau at Rongomatane mean daily flow series (1978-2021).

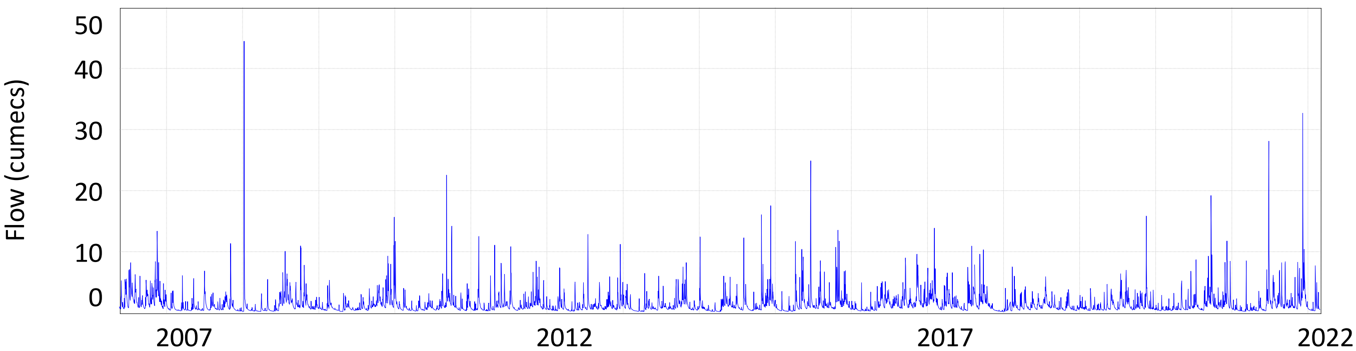


Figure 3: Waikawa at North Manakau Road mean daily flow series (2006-2022).

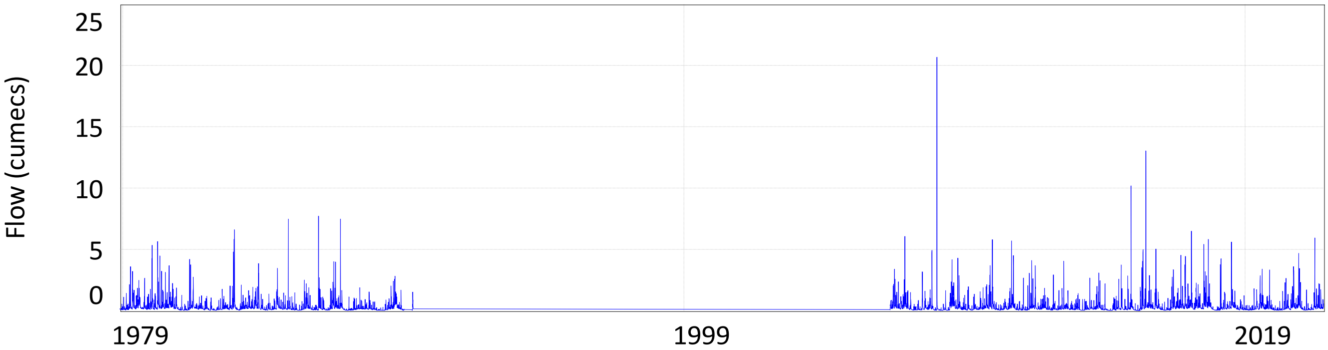


Figure 4: Manakau Combined mean daily flow series (1978-2021). The flat line is when no data exists.

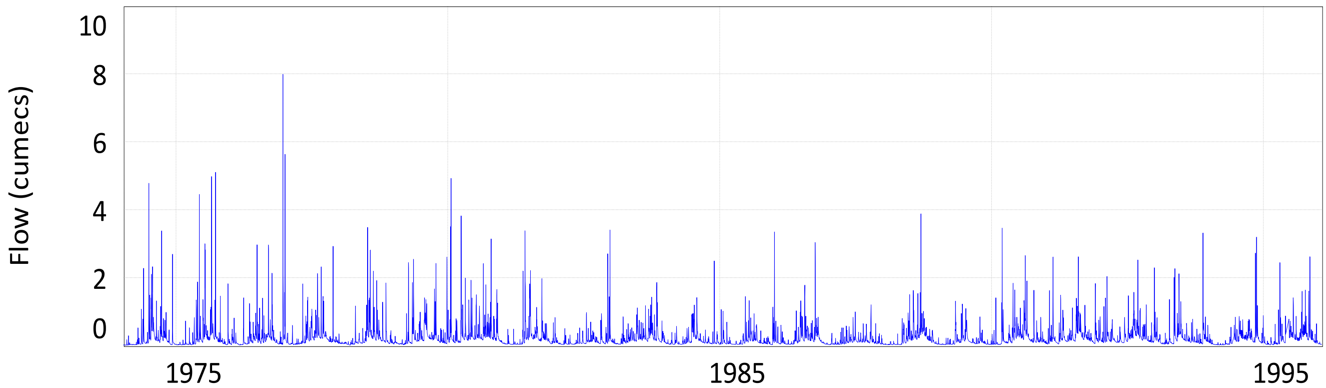


Figure 5: Koputaroa at Tavistock Road mean daily flow series (1974-1996).

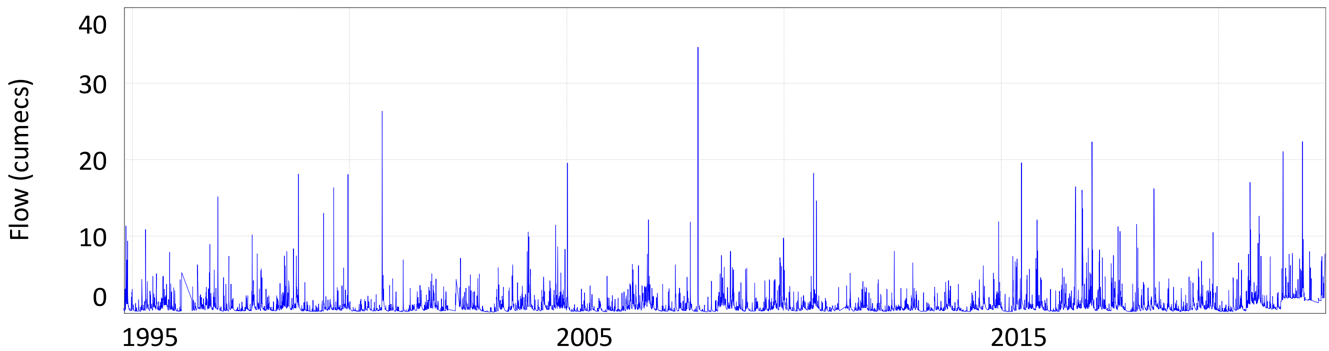


Figure 6: Waitohu at Water Supply Intake mean daily flow series (1994-2022).

Each of these waterways experience sustained periods of moderate to low flow over most of their records. These periods are interspersed with occasional flood and fresh events of varying magnitude (**Figure 2** through **Figure 6**). Typically, flood/fresh events in each of the waterways follow a cyclic pattern. In the Ohau River and Waikawa and Waitohu Streams, larger flows tend to occur every 3-5 years. Larger flows in the Manakau and Koputaroa Streams generally happen every 1-2 years. Higher and moderate-high flows occur most frequently during winter and spring, and lower flows at the end of summer and into autumn. The extreme maximum flows in each waterway appear to occur in either January or December (i.e., summer months) and are typically of short duration. Any sustained periods of moderate-high flow generally occur in winter and spring.

6 Core Allocation

Each sub-zone has a Core Allocation. The estimated maximum combined abstraction of construction water of 3,900m^3/day is greater than the core allocation currently remaining from the Ohau River (409m^3/day), Manakau (156m^3/day), Koputaroa (351m^3/day) and Waitohu (3,240m^3/day). Although the estimated maximum abstraction of construction water is less than the currently available allocation from Waikawa Stream (4,498m^3/day), it represents 86% of the total available allocation. However, when the available allocations from each river or stream are combined, there is a potential allocation of 8,654m^3/day available. The maximum abstraction of 3,900m^3/day represents only 45% of this total available allocation.

Abstraction of construction water will not likely occur during winter and abstraction would be required only during the construction of the Ō2NL Highway i.e., a relatively short duration. It will, however, be necessary to 'share' the maximum required abstraction between the five waterways to avoid exceeding the Core Allocation of any particular sub-zone. The majority of 'construction water' abstracted under the Core Allocation framework will likely need to come from the Waikawa and Waitohu Streams.

7 Minimum Flows

Minimum flows are used to manage the abstraction of water from rivers to maintain in-stream values during periods of low flow. A minimum flow, however, does not prevent the flow in a river or stream decreasing below that threshold, which it does naturally when low rainfall and runoff conditions persist. The minimum flow simply restricts abstraction, and therefore the effects of abstraction.

The setting of a minimum flow is informed by the best available information at the time. In the early 1990's, this often involved the detailed Instream Flow Incremental Methodology (IFIM). Using the IFIM, the minimum flow is set to retain 90% of the instream habitat; with the focus generally on trout rather than native fishes.

Minimum flows will vary at different locations along a river depending on catchment area and the physical characteristics of the channel. Therefore, professional judgement informs the final minimum flow which is adopted.

Because of the limited number of IFIM determinations in the Manawatū when preparing the One Plan, Horizons undertook a study to compare the IFIM data available to the 1-day Mean Annual Low Flow (MALF). It was found that for rivers with a MALF greater than 3.7m^3/s, the IFIM could be correlated to a flow of 80% of the MALF. At the time of the One Plan, using data from 1-July-1923 through 1-July 2008, the MALF of the Manawatū River was 15.3m^3/s (**Figure 7**). Since 80% of the MALF (15.3m^3/s) was 12.24m^3/s, this was adopted as the minimum flow at the Teachers' College hydrometric site.

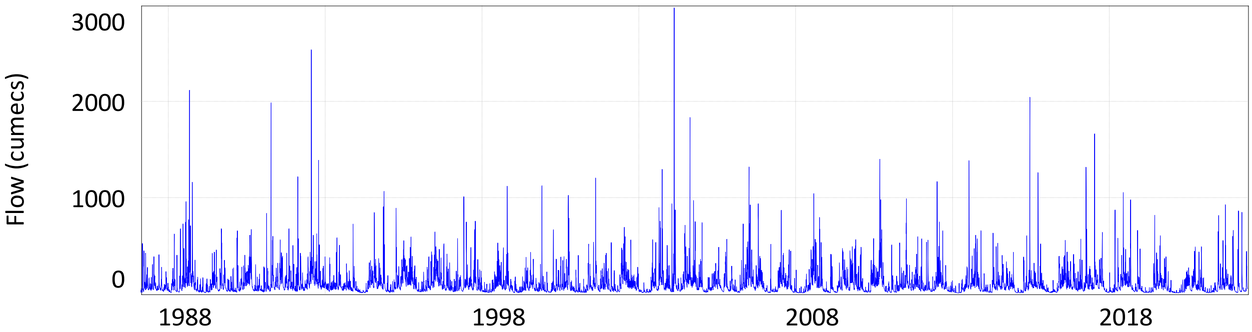


Figure 7: Manawatū at Teachers College mean daily flow series (1974-2021).

The same approach has been used to derive the minimum flows for the following sites:

- Ohau at Rongomatane – 0.820m^3/s;
- Waikawa at North Manakau Road – 0.220m^3/s;
- Manakau at SH1 Bridge – 0.040m^3/s; and
- Waitohu at Water Supply Intake – 0.140m^3/s.

Extending the analysis to include data up until 2022 (**Figure 7**), the MALF at the Manawatū at Teachers College site would be 14.7m^3/s (not 15.3m^3/s) and the minimum flow would be 11.76m^3/s and not 12.24m^3/s. This analysis can also be completed for the other sites to see if there have been any changes in their flow regimes over more recent years that might affect the minimum flows.

Recalculating the MALF for Ohau at Rongomatane gives a value of 1.089m^3/s and a minimum flow of 0.871m^3/s. For Waikawa at North Manakau Road, the MALF increases to 0.286m^3/s which gives a new minimum flow value of 0.228m^3/s. The updated MALF for Manakau Combined gives a value of 0.068m^3/s, which provides a minimum flow of 0.055m^3/s. The minimum flow for the Waitohu Stream is 0.146m^3/s, based on an updated MALF of 0.182m^3/s.

It should be noted that, because of the limited flow data available for Koputaroa Stream, abstraction is managed by the minimum flow in the Manawatū at Teachers College i.e., a flow of 12.24m^3/s at that site. While developing an abstraction regime for construction water from this stream will involve consideration of the actual flows, the trigger for when any abstraction must cease will still be referenced to flow in the Manawatū at Teachers College.

All of the recalculated minimum flows are the same as or slightly higher than those provided by Horizons and GWRC. However, irrespective of the above analysis, it is likely that those minimum flows provided in Horizon's One Plan, and by GWRC, are those that would be adopted in any resource consent process. The magnitude of any potential effects of abstraction, however, will be reduced because of the higher low flow regimes that appear to currently exist within these rivers and streams.

8 Periods of Restricted Abstraction

8.1 Minimum flows

Horizons' One Plan and the GWRC PRNP set minimum flows for the abstraction of water forming part of the Core Allocation in the sub-zones containing the various waterways. **Table 2** displays the minimum flows for each sub-zone, the hydrometric site to which they are related, and waterway they affect.

Table 2: Minimum flow restrictions for relevant sub-zones, set by Horizons' One Plan (Ohau_1b, West_9a, West_9b and Mana_13e) and GWRC's PRNP (Waitohu).

Sub-Zone	Minimum Flow (m^3/s)	Site measured from	Affected waterway
Ohau_1b	0.820	Ohau at Rongomatane	Ohau River
West_9a	0.220	Waikawa at North Manakau Road	Waikawa Stream
West_9b	0.040	Manakau at SH1 Bridge	Manakau Stream
Mana_13e	12.240	Manawatū at Teachers College	Koputaroa Stream
Waitohu	0.140	Waitohu at Water Supply Intake	Waitohu Stream

Flow has fallen below the minimum flow in the Ohau at Rongomatane (**Table 3** & **Figure 8**) and Waikawa at North Manakau Road (**Table 4** & **Figure 9**) for less than 1% of their respective records. At Manakau Combined, flow has fallen below the minimum flow for approximately 2% of the time (**Table 5** & **Figure 10**) and at Manawatū at Teachers College flow has fallen below the minimum flow for just over 1% of the time (**Table 6** & **Figure 11**). Flow in the Manawatū at Teachers College acts as the trigger site for controlling abstraction from Koputaroa Stream. On that basis, Koputaroa Stream has only been subjected to restrictions for approximately 1% of the time. In the Waitohu at Water Supply Intake, flow has fallen below the minimum flow for approximately 3% of the time (**Table 7** & **Figure 12**).

Table 3: Frequency distribution of mean daily flows recorded at Ohau at Rongomatane (1978-2021).

	0	1	2	3	4	5	6	7	8	9
0	183.90	38.40	28.78	23.94	21.09	18.99	17.45	16.12	14.97	14.07
10	13.30	12.63	12.05	11.50	11.00	10.53	10.10	9.71	9.35	9.02
20	8.73	8.45	8.19	7.93	7.69	7.45	7.23	7.03	6.83	6.65
30	6.48	6.32	6.17	6.03	5.89	5.76	5.62	5.49	5.36	5.24
40	5.13	5.02	4.91	4.80	4.70	4.60	4.51	4.41	4.33	4.24
50	4.15	4.07	3.98	3.90	3.83	3.75	3.67	3.60	3.52	3.45
60	3.38	3.31	3.25	3.18	3.12	3.06	3.00	2.94	2.88	2.82
70	2.76	2.70	2.64	2.58	2.52	2.46	2.40	2.34	2.29	2.23
80	2.17	2.11	2.06	2.00	1.94	1.89	1.83	1.78	1.71	1.65
90	1.59	1.53	1.47	1.41	1.33	1.26	1.18	1.10	1.01	0.88
100	0.59									

Frequency distribution tables like that above present the percentage of time the flow exceeds a particular value. In this example, 100% of the time flows exceed 0.59m^3/s (the minimum flow ever recorded). For 0% of the time flows have exceeded 183.9m^3/s (the maximum flow ever recorded). All other percentages can also be interpolated from the table where the various rows contain the 10 percentiles and the columns to 1 percentiles e.g., for 64% of the time flow exceeds 3.12m^3/s and for 22% of the time it exceeds 8.19m^3/s.

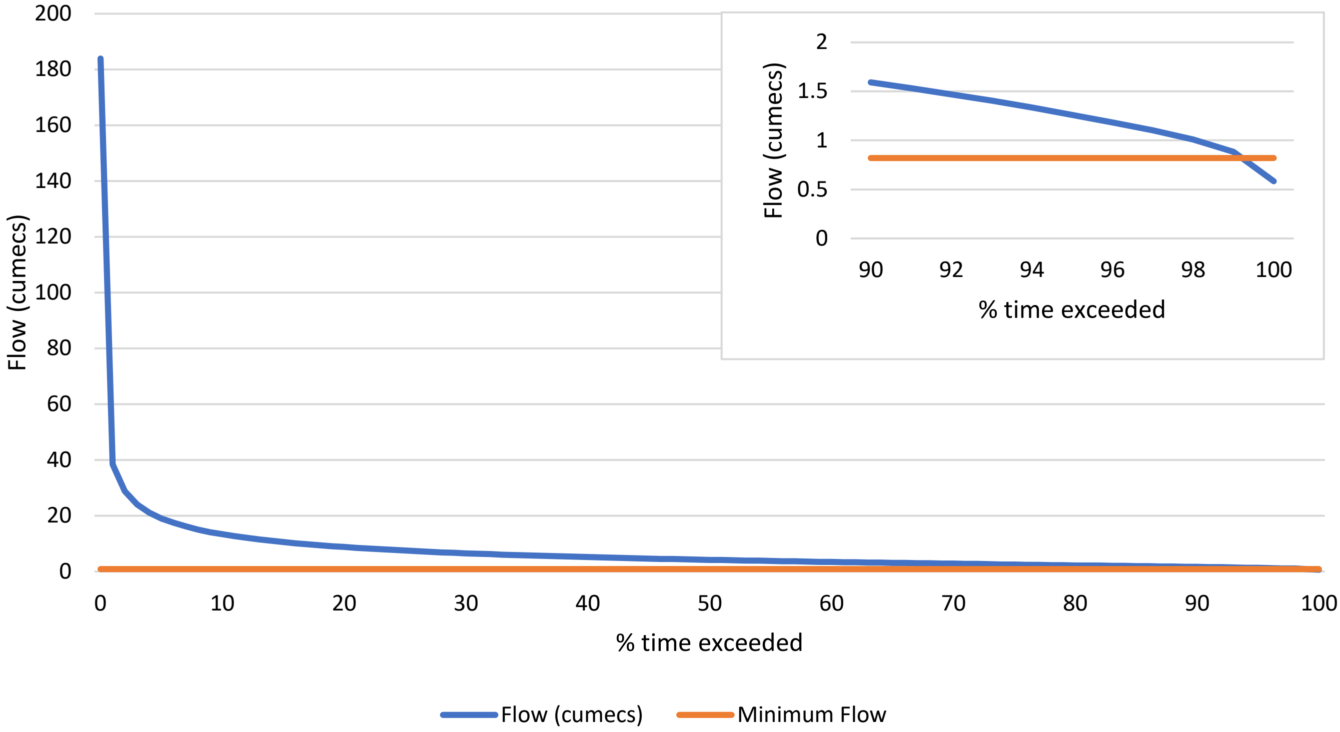


Figure 8: Distribution of mean daily flows at Ohau at Rongomatane (1978-2021) – and the minimum flow.

Table 4: Distribution of mean daily flows recorded at Waikawa at North Manakau Road (2006-2022).

	0	1	2	3	4	5	6	7	8	9
0	44.47	8.21	6.30	5.37	4.76	4.30	3.93	3.64	3.40	3.20
10	3.02	2.87	2.74	2.61	2.50	2.40	2.30	2.21	2.14	2.06
20	2.00	1.94	1.87	1.82	1.77	1.72	1.67	1.62	1.58	1.54
30	1.50	1.46	1.43	1.39	1.36	1.32	1.29	1.26	1.23	1.20
40	1.18	1.15	1.13	1.10	1.08	1.06	1.04	1.01	0.99	0.97
50	0.95	0.93	0.91	0.90	0.88	0.86	0.84	0.83	0.81	0.79
60	0.78	0.76	0.75	0.73	0.72	0.70	0.69	0.67	0.66	0.64
70	0.63	0.62	0.61	0.59	0.58	0.57	0.56	0.55	0.53	0.52
80	0.51	0.50	0.49	0.48	0.47	0.45	0.44	0.43	0.42	0.41
90	0.40	0.39	0.37	0.36	0.34	0.33	0.31	0.29	0.27	0.25
100	0.19									

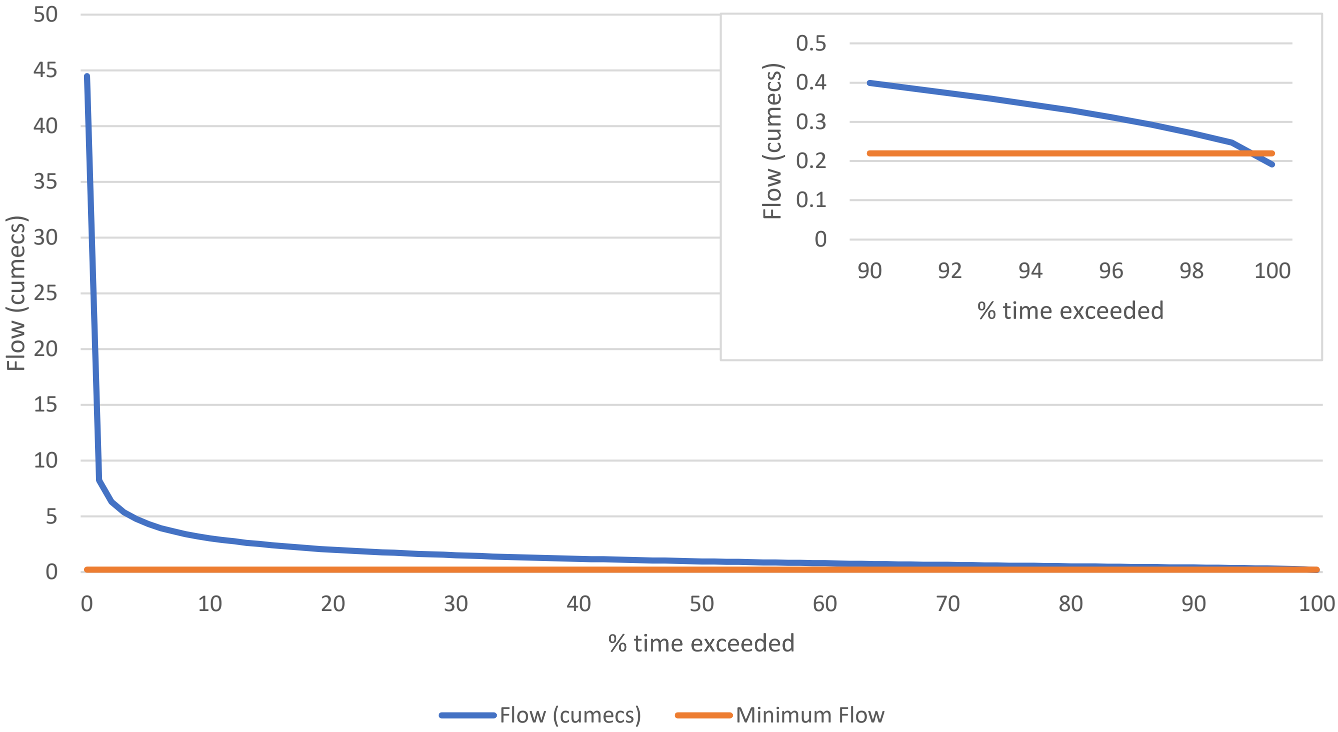


Figure 9: Distribution of mean daily flows at Waikawa at North Manakau Road (2006-2022) – and the minimum flow.

Table 5: Distribution of mean daily flows recorded at Manakau Combined (1978-2021).

	0	1	2	3	4	5	6	7	8	9
0	20.67	1.94	1.41	1.12	0.94	0.82	0.73	0.66	0.60	0.55
10	0.51	0.47	0.44	0.41	0.39	0.37	0.35	0.33	0.31	0.30
20	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20
30	0.19	0.18	0.18	0.17	0.16	0.16	0.15	0.15	0.15	0.15
40	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14
50	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
60	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.11
70	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10
80	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.08
90	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.04	0.03
100	0.01									

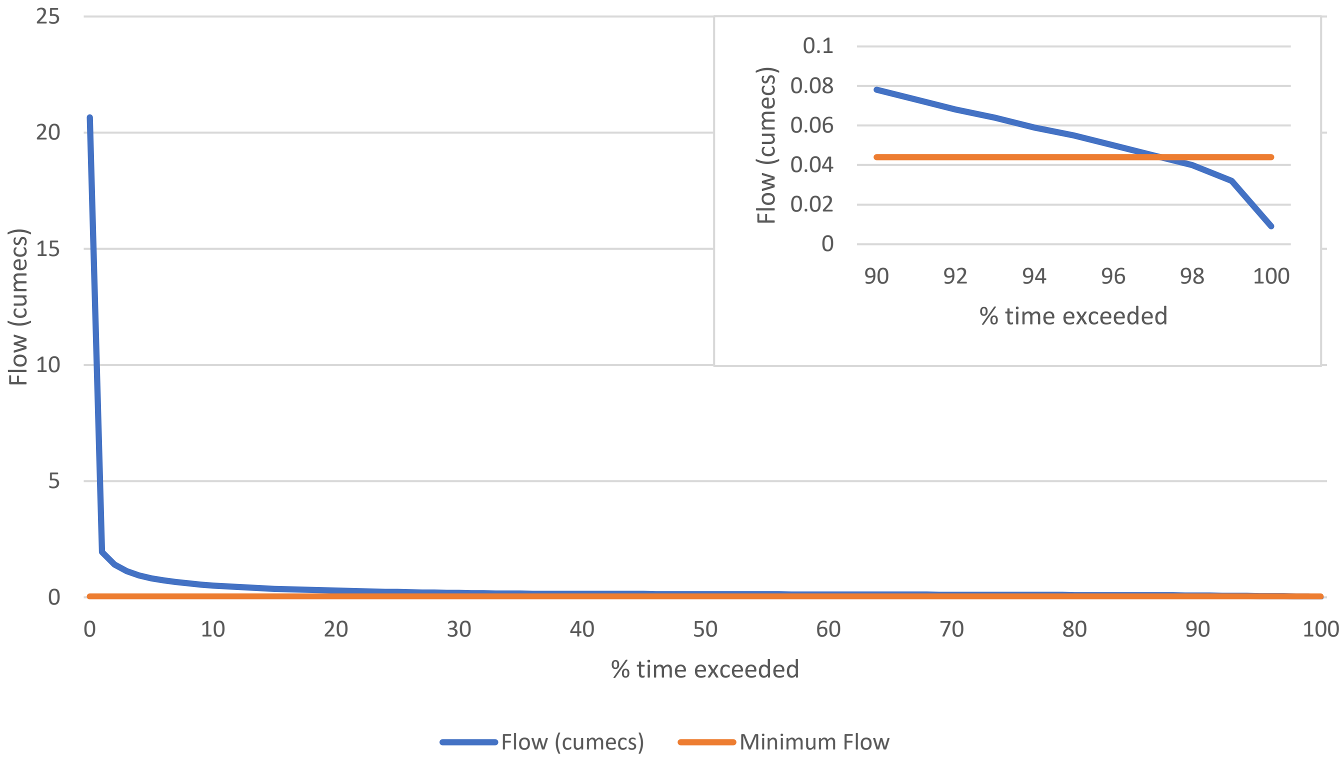


Figure 10: Distribution of mean daily flows at Manakau Combined (1978-2021) – and the minimum flow.

Table 6: Distribution of daily mean flows at Manawatū at Teachers College (1987-2022).

	0	1	2	3	4	5	6	7	8	9
0	2972.11	578.14	451.94	386.38	345.91	313.32	287.76	268.15	251.10	235.82
10	223.16	211.51	201.28	192.23	184.05	176.81	170.20	164.27	158.68	153.33
20	148.42	143.71	139.28	134.86	130.83	127.23	123.87	120.61	117.47	114.54
30	111.67	108.91	106.22	103.59	101.01	98.52	96.09	93.66	91.39	89.13
40	87.03	84.97	82.95	80.99	79.07	77.20	75.38	73.70	72.06	70.45
50	68.82	67.19	65.63	64.07	62.57	61.12	59.67	58.23	56.84	55.49
60	54.17	52.87	51.61	50.38	49.10	47.84	46.57	45.32	44.11	42.90
70	41.75	40.59	39.44	38.29	37.13	36.03	34.97	33.91	32.76	31.64
80	30.54	29.47	28.45	27.48	26.53	25.62	24.60	23.56	22.57	21.70
90	20.85	19.92	18.99	18.05	17.10	16.19	15.37	14.47	13.50	12.15
100	9.02									

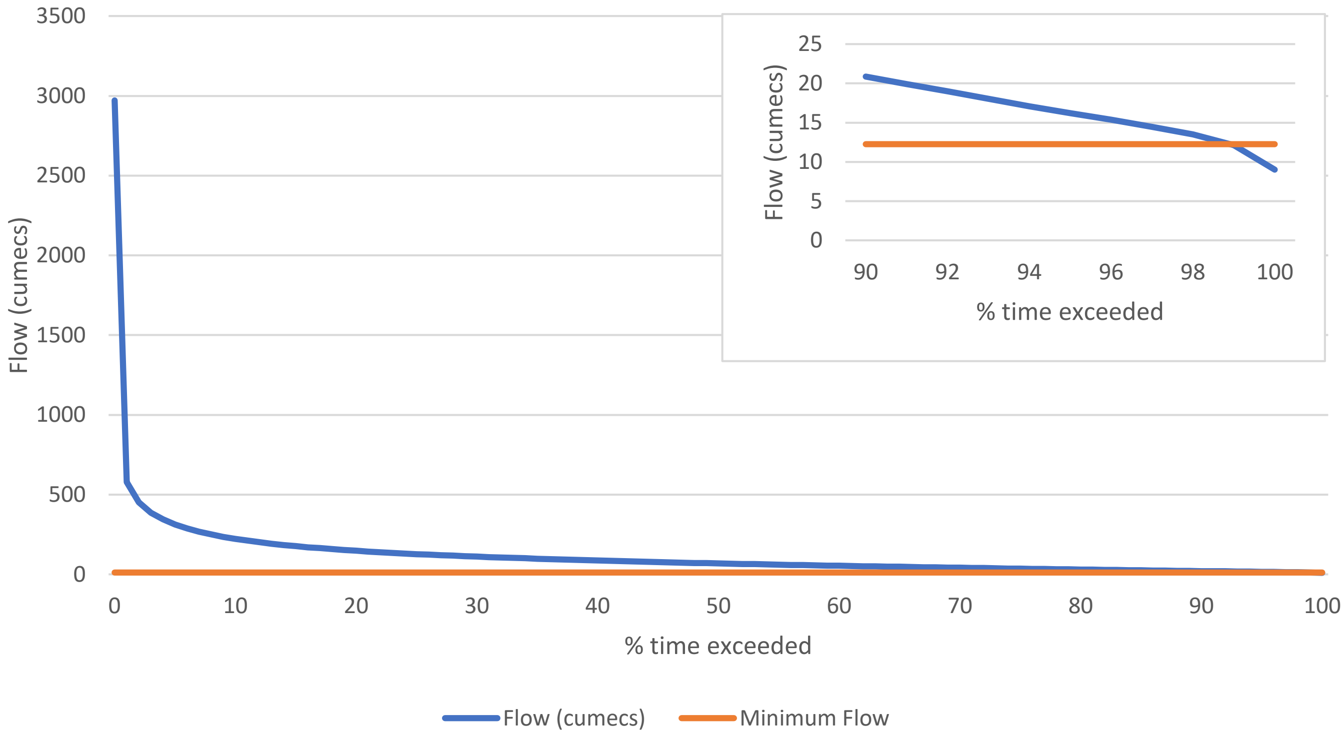


Figure 11: Distribution of mean daily flows at Manawatū at Teachers College (1987-2022) – and the minimum flow. This site is used to apply restrictions to the Koputaroa Stream.

Table 7: Distribution of mean daily flows at Waitohu at Water Supply Intake (1994-2022).

	0	1	2	3	4	5	6	7	8	9
0	34.72	6.51	4.81	4.02	3.48	3.12	2.82	2.59	2.40	2.23
10	2.01	1.99	1.92	1.85	1.75	1.68	1.61	1.55	1.49	1.43
20	1.37	1.32	1.26	1.21	1.16	1.12	1.08	1.04	0.10	0.96
30	0.93	0.90	0.87	0.85	0.82	0.80	0.77	0.75	0.73	0.71
40	0.70	0.68	0.66	0.65	0.63	0.61	0.60	0.58	0.57	0.56
50	0.54	0.53	0.52	0.50	0.49	0.48	0.47	0.46	0.45	0.44
60	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.36	0.35
70	0.34	0.33	0.32	0.31	0.30	0.30	0.29	0.28	0.27	0.27
80	0.26	0.25	0.24	0.24	0.23	0.22	0.22	0.21	0.20	0.20
90	0.19	0.18	0.17	0.17	0.16	0.15	0.15	0.14	0.13	0.12
100	0.07									

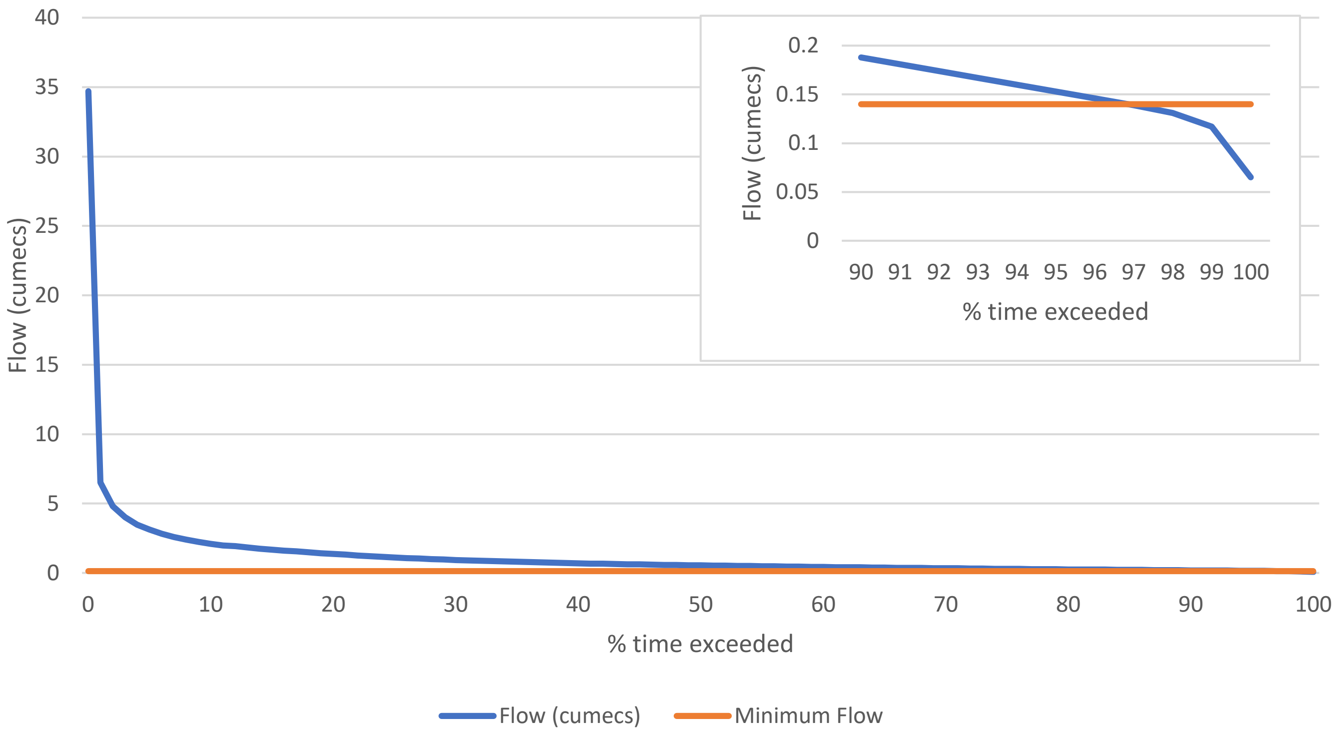


Figure 12: Distribution of mean daily flows at Waitohu at Water Supply Intake (1994-2022) – and the minimum flow.

The above analysis assumes that any abstraction of construction water is downstream of the flow monitoring site used to manage the abstraction. If abstraction was to be from upstream of the monitoring site, this could have a significant effect on the flow measured downstream and therefore the periods of abstraction. As discussed previously, this is only likely to be a potential problem with respect to abstraction from Koputaroa Stream, where any abstraction is likely to be a significant distance upstream of the flow recorder at Tavistock Road.

Since it is likely that the total abstraction of construction water will be from a combination of all five waterways, any abstraction is likely to have minimal impact on the duration of time that flows are below the minimum flow.

The above analysis considers only the percentage of time when abstraction may be restricted over the entire year. However, it is likely that periods of restricted abstraction occur during summer and autumn i.e., during the peak of the construction season when water demand is likely to be highest and river flows lowest. More detailed analysis of the distribution and duration of periods of restricted abstraction is therefore necessary.

8.2 Days below minimum flow

Abstraction of water from the Core Allocation is restricted when the mean daily flow drops below the minimum flow. Consequently, the daily mean flow series from each potential water source were analysed to identify the number of days each year when flow falls below the minimum threshold, and when these low flows occurred.

Figure 13 through **Figure 17** show the total number of days, and the maximum number of consecutive days, when flows fell below each site's respective minimum flow. Note that the time series show the data in 'water years', i.e., 1 July to 30 June. This is to avoid splitting low flow periods over summer across two calendar years and consequently under-estimating the potential effect of prolonged periods when abstraction would be restricted.

At each of the sites, the number of days when flows fall below the minimum flow varies considerably from year to year. Flows dropped below the threshold of 0.820m^3/s in only six years of the 43-year long record from the Ohau at Rongomatane; however, in 2002/03 flow was below this threshold for 50-days. Similarly, in only 2-years of the 16-year record for the Waikawa at North Manakau Road, did flows drop below the threshold of 0.220m^3/s. There were 10-days in 2013/14 where the flow was below the threshold, and six days in 2017/18.

In 29 of the 44-years of the Manakau Combined record, flows remained above the 0.040m^3/s threshold, while 1987/88 had 62-days below this threshold. At Manawatū at Teachers College, flow dropped below the threshold (12.240m^3/s) in 25 of the 35-years for which data are available. The largest number of days (33) occurred in 2012/13. During the 28-year Waitohu at Water Supply Intake flow record, there were 16-years when at least one day had flow below the minimum threshold. In 2002/03, there was 79-days where flow fell below the minimum threshold, the most of any year in the record.

Therefore, prolonged periods of flows below the minimum flow have occurred at each site. The maximum number of consecutive days flows fell below the minimum flow at each site are presented in **Figure 13** through **Figure 17**. At Ohau at Rongomatane, there was a maximum of 25 consecutive days where flows fell below 0.820m^3/s; in 2002/03. In 2013/14, the Waikawa at North Manakau Road recorded a maximum of nine consecutive days when flows fell below 0.220m^3/s. Flow was below the minimum flow for 21 consecutive days in 1987/88 at Manakau Combined and 28 consecutive days in 2012/13 for the Manawatū at Teachers College. Flows in the Waitohu at Water Supply Intake fell below the minimum threshold (0.140m^3/s) for a maximum of 26 consecutive days in 2002/03.

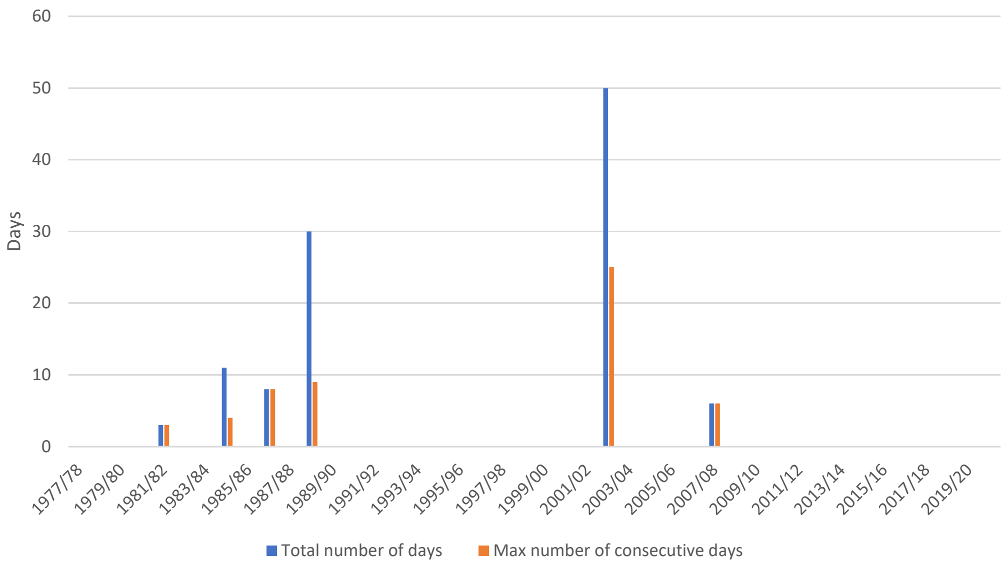


Figure 13: Total number of days, and longest consecutive period, when mean daily flows at Ohau at Rongomatane have fallen below 0.820m^3/s.

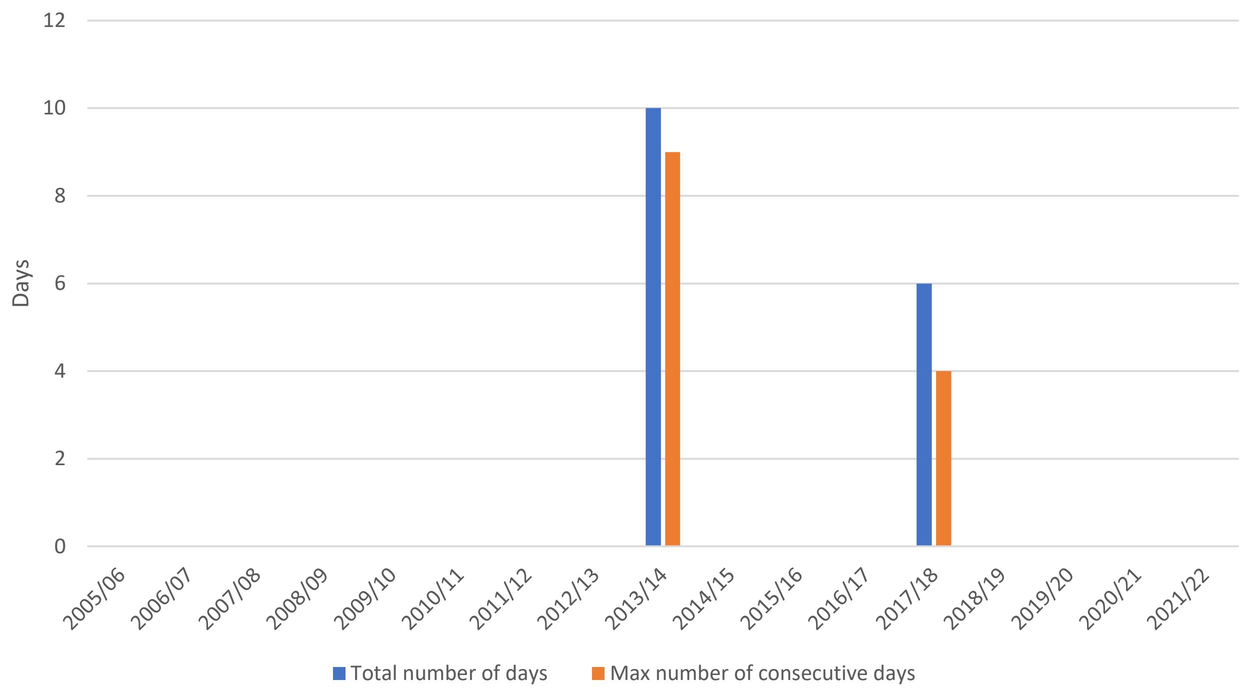


Figure 14: Total number of days, and longest consecutive period, when mean daily flows at Waikawa at North Manakau Road have fallen below 0.220m³/s.

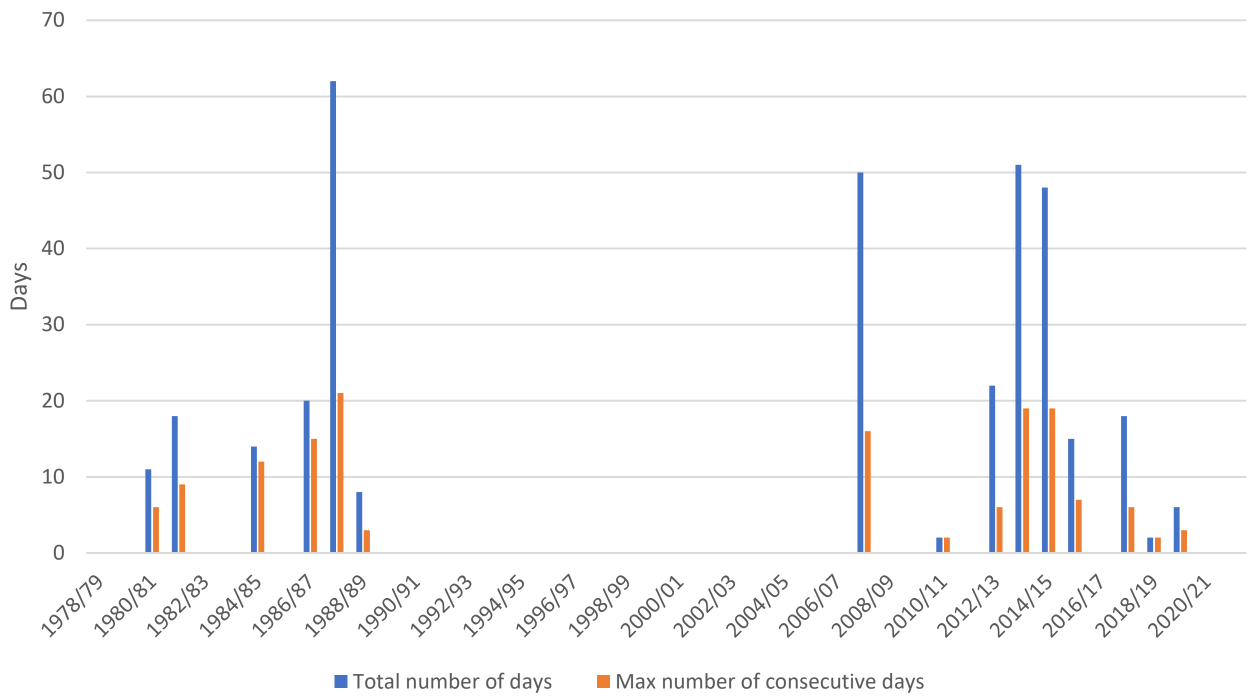


Figure 15: Total number of days, and longest consecutive period, where mean daily flows at Manakau Combined have fallen below 0.040m³/s.

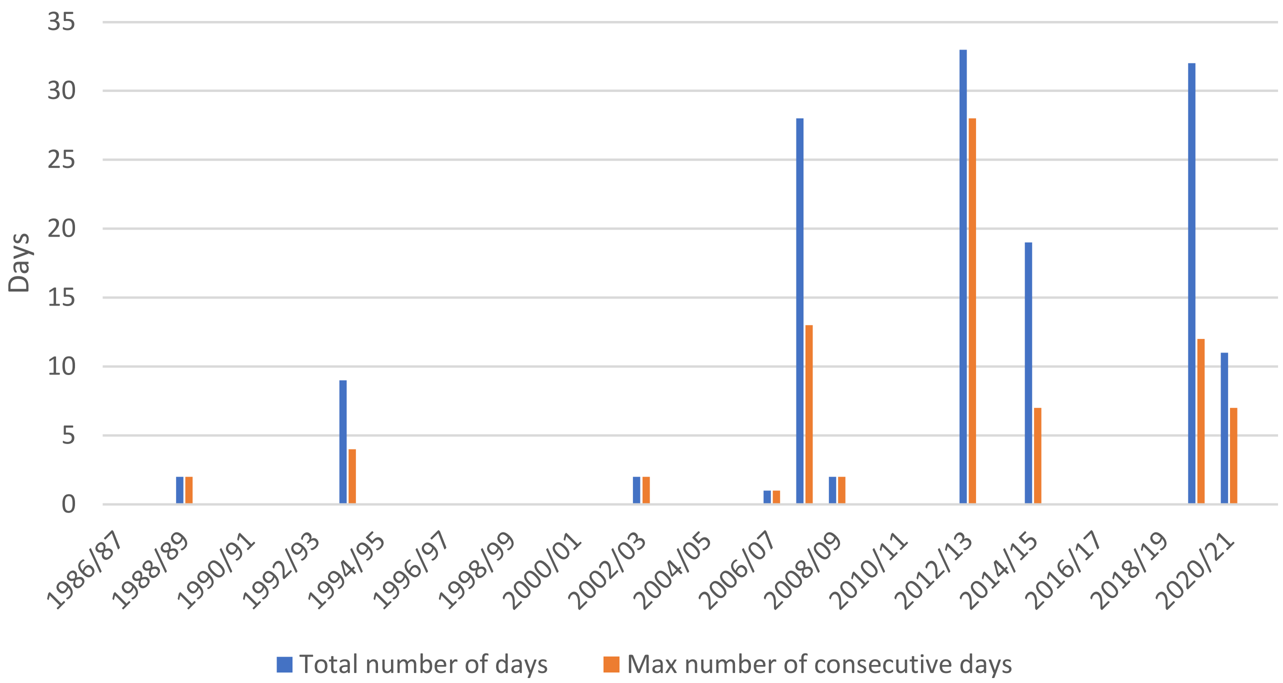


Figure 16: Total number of days, and longest consecutive period, where mean daily flows at Manawatū at Teachers College have fallen below 12.240m³/s.

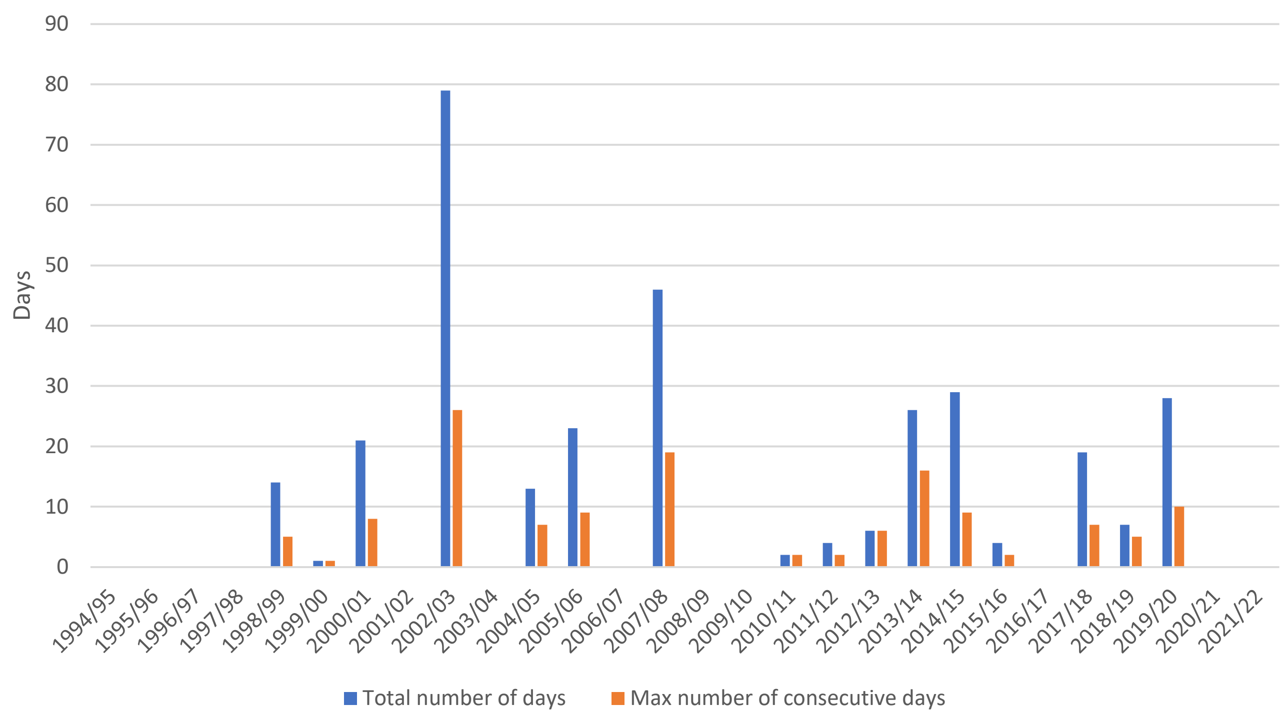


Figure 17: Total number of days, and longest consecutive period, where mean daily flows at Waitohu at Water Supply Intake have fallen below 0.140m³/s.

Table 8 provides a summary of the days when flows fell below minimum flows at each potential water source, and when these occurred. Periods of low flow predominantly occur between January and May i.e., summer/autumn, which is likely to be during the peak of the construction season.

Table 8: Summary of the number of days when flows fell below the minimum flow, and when they occurred, for each of the flow series.

	Total number of days when flows fell below the minimum flow				
	Ohau at Rongomatane	Waikawa at North Manakau Road	Manakau Combined	Manawatū at Teachers College	Waitohu at Water Supply Intake
Jan	13	1	35	7	21
Feb	18	0	77	55	50
Mar	38	1	120	73	115
Apr	29	9	71	4	71
May	10	0	26	0	24
Jun	0	0	0	0	0
Jul	0	0	0	0	2
Aug	0	0	0	0	3
Sep	0	0	0	0	3
Oct	0	0	0	0	0
Nov	0	0	0	0	18
Dec	0	5	18	0	15

Managing the supply of construction water during these periods of restricted abstraction could be achieved by reducing water demand and using water storage ponds along the route. The ponds would provide some security of supply and a buffer between the supply and demand for water. The ability to refill these ponds after a period of restricted abstraction necessitates rates and daily volumes of abstraction that are higher than the average demand for water to support the Project. It may also require the use of a Supplementary Allocation, and consequently the ability to abstract up to 10% of any flow above the median flow for a particular river or stream.

To identify the frequency of prolonged periods below the minimum flow, frequency analyses were conducted on the number of consecutive days below the minimum flow at each site (**Table 9**). It is considered that the consecutive number of days is the critical metric in this analysis since it would be possible to manage individual days below the minimum flow relatively easily using water storage.

Table 9 shows that the long periods of consecutive days below minimum flow are relatively infrequent. At Ohau at Rongomatane, the Average Recurrence Interval (ARI) of a low-flow event that persists for 25 days, such as that which occurred in 2003, is approximately 100-years. At Manawatū at Teachers College, the 28-day event in 2012/13 has an estimated 67-year ARI. The 9-day low-flow event in the Waikawa at North Manakau Road in 2013/1014 had an ARI of approximately 35-years. At Manakau Combined the low-flow event of 1988/89, which persisted for 21 consecutive days, had an ARI of approximately 22-years. At Waitohu at Water Supply Intake the low flow event that occurred in 2002/03, and persisted for 26 days, had an ARI of approximately 50-years.

Table 9: Magnitudes and frequencies of periods of consecutive days when flows fall below the minimum flow at each site. **Note: a Pearson Type 3 statistical distribution is assumed when deriving the design events.**

		Number of consecutive days when flows fall below the minimum flow, rounded to the nearest whole day				
ARI (Years)	AEP (%)	Ohau at Rongomatane	Waikawa at North Manakau Road	Manakau Combined	Manawatū at Teachers College	Waitohu at Water Supply Intake
5	20	0	0	9	1	7
10	10	2	2	14	5	13
20	5	6	5	20	12	18
50	5	16	11	27	23	26
100	1	26	17	33	33	32
200	0.5	37	23	39	44	38
500	0.2	53	32	46	59	47
1000	0.1	66	39	52	72	53

9 Possible Abstraction Regime

It should be noted that the flow at any abstraction point may differ from that at the relevant gauge location. However, with respect to the Ō2NL Project, this is not likely to be a significant issue. The flow recorders on the Ohau River and Waitohu Stream are located a significant distance upstream of the Ō2NL corridor. Consequently, the flows in these rivers and streams used in the above analyses are likely to be slightly conservative i.e., low. Any potential effect of the abstraction of water has therefore been potentially over-estimated.

The flow recorders on both the Manakau and Waikawa Streams are located close to the Project corridor. The flows used in the analysis are therefore likely to be appropriate and realistic.

Flows in Koputaroa Stream have been, and are currently, measured at Tavistock Road. The flow record and flow regime at this location were discussed earlier. However, the Project corridor, and therefore any potential abstraction of construction water, is likely to be a significant distance upstream of this flow recorder. For example, the catchment area upstream of McDonald Road, a possible source of abstraction, is only about 40% of that upstream of Tavistock Road.

Obviously, flow is proportional to catchment area. While flood flows have been shown to vary as a function of catchment area to the power of 0.8, low flows tend to vary in direct proportion to catchment area. This is because while flood flows are affected largely by the characteristics of the storm rainfall, low flows are controlled by those characteristics that affect drainage of the catchment e.g., slope, soil, and geology. Based on data in the River Environment Classification (REC), the areas of the Koputaroa catchment upstream of Tavistock Road and McDonald Road are 19.6km² and 7.6km² respectively (Figure 18). Consequently, flows in the Koputaroa Stream at McDonald Road are likely to be only about 39% of those measured downstream at Tavistock Road.

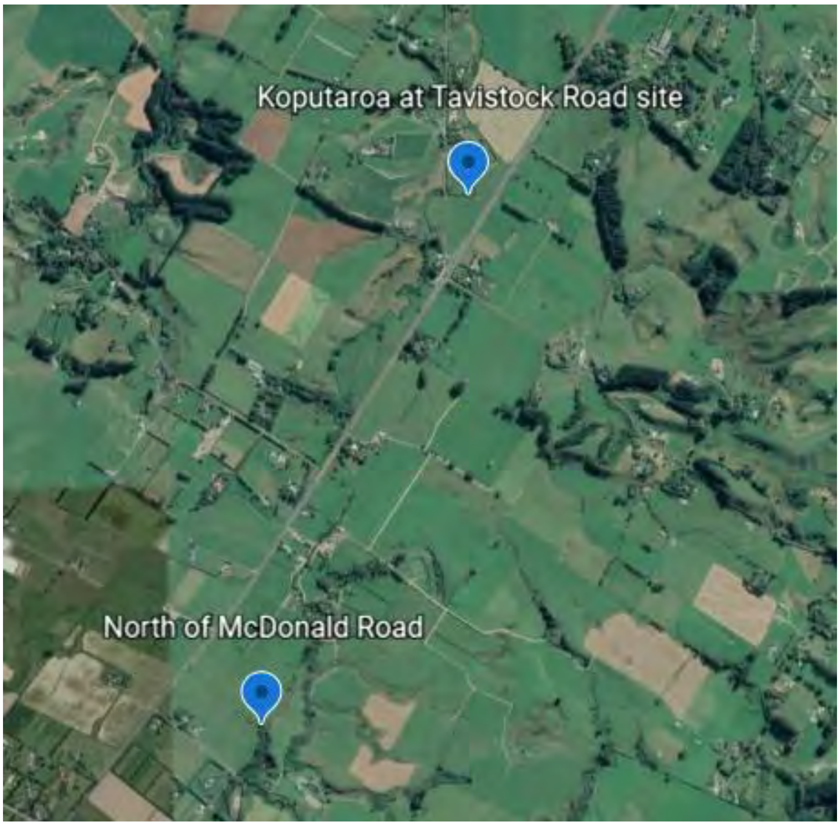


Figure 18: Location of the two sites for which flows have been estimated.

Scaling the flows and various hydrological metrics from the Koputaroa Stream at Tavistock Road, upstream to the vicinity of McDonald Road, gives the estimates shown in Table 10.

Table 10: Summary statistics of the estimated mean daily flows in Koputaroa Stream at McDonald Road (L/s).

Site	Min	Max	Mean	Std Dev	L.Q.	Median	U.Q.
Koputaroa at McDonald Road	5	3120	94	129	27	59	109

Note: *Flows estimated in the Koputaroa Stream at McDonald Road are significantly lower than recorded at Tavistock Road. The minimum flow at McDonald Road would likely be only about 11L/s.*

As discussed previously, this report proposes abstracting water to support the construction of the Ō2NL Project from several rivers and stream traversed by the proposed highway. This will minimise any potential environmental effects of abstraction, while also minimising a range of effects from having to transport water and use it out of the catchment from which it is sourced.

Possible criteria for any abstraction regime for construction water might include:

- Abstraction from the Core Allocation remaining currently within each of the water management zones;

- Abstraction of only up to two-thirds of the remaining core allocation. This will leave at least one-third of the remaining core allocation available for other potential users during the construction of the Project. Because of the small volume of the core allocation remaining within the Ohau catchment, the proposal is to seek the full volume remaining of this allocation;
- A maximum combined volume of 3,900m³/day from the remaining Core Allocation for the various rivers and streams traversed by the Project;
- An average combined volume of 2,350m³/day from the remaining Core Allocation for the various rivers and streams traversed by the Project;
- Abstraction only when flow is above the minimum flow for each river or stream;
- Extensive use of water storage along the proposed alignment to provide a buffer between the supply and demand for water to support construction activities. This will allow any potential environmental effects to be minimised;
- Abstraction only for the duration of the Project; and
- A Supplementary Allocation of 10% of the flow in the rivers and streams once they exceed the median flow.

One possible strategy for obtaining the water necessary for the construction of the Project is provided in Table 11. It should be noted that this scenario involves abstracting water at an extremely low rate (i.e., only 10% of the minimum flow) but continuously throughout the day. Abstraction at 10% of the minimum flow is only slightly higher than the margin of error for open channel flow measurements, generally regarded as ±8%; although many regional councils assume that any flow within ±10% is compliant.

This scenario just fails to provide the maximum required volume of construction water i.e., 3,708m³/day compared to 3,900m³/day. The required volume of water to meet construction needs could, however, be obtained by raising the rate of abstraction slightly. A higher rate of abstraction, but still within the core allocation, would likely have no measurable effect on the flow regimes and hydrology of the various rivers and streams. The simplest approach to meet the demand for construction water might be to abstract water at a rate of up to 10% of the mean daily flow, whenever flows are above the minimum flow. Additional water to support the construction could also be obtained from a Supplementary Allocation, abstracting up to 10% of any flow above the median in each of the rivers and streams.

The Project Aquatic Ecologist should provide advice as to the maximum rates of abstraction that can be sustained at any specific site without affecting instream values significantly. These maximum rates of abstraction, however, will not affect maximum daily abstraction from the Core Allocation proposed for each river or stream.

Table 11: Possible abstraction criteria and water availability under the Core Allocation.

Water course	Available Core Allocation (m³/day)	Proposed maximum abstraction (m³/day)	Remaining Core Allocation (m³/day)	Current Minimum Flow (L/s)	Abstraction rate assuming 10% of minimum flow (L/s)	Daily abstraction volume assuming 10% of minimum flow (m³)
Koputaroa (at McDonald Road)	351	231	120	11*	1	86
Ohau	409	409	0	820	82	409
Waikawa	4,498	2,998	1,500	220	22	1901
Manakau	156	102	54	40	4	102
Waitohu	3,240	2,160	1,080	140	14	1,210
Total	***8,654***	5,900 (but limited to a maximum of ***3,900****)*	***2,754***			**3,708**

Note: ***Estimated by scaling flows from Tavistock Road.***

10 Conclusions

The above review and analyses allow for the following conclusions:

- As part of the investigations for the Ō2NL Project, the potential to abstract 'construction water' from surface water sources has been reviewed. Water could come from several potential sources, including the Ohau River, and the Waikawa, Manakau, Koputaroa and Waitohu Streams. To meet the peak demand, and to minimise any risk to both the Project and the environment, it is likely that water from several sources would need to be used in combination.
- Peak water demand for construction activities is likely to occur during summer and autumn, a period that coincides with the higher risk of prolonged low flows in the potential water sources.
- Peak abstraction has been estimated at 3,900m^3/day i.e., 45L/s if abstracted continuously from the various rivers and streams.
- There is 5,414m^3/day of water currently available from the Core Allocation from the Lower Ohau River (Ohau_1b), Waikawa (West_9a), Manakau (West_9b) and Koputaroa (Mana_13e) management unit sub-zones. The Waitohu Stream has an additional 3240m^3/day available. This provides a maximum possible available core allocation of 8,654m^3/day. Abstraction of 3,900m^3/day to support construction of the Project would represent 45% of this available allocation.
- The lowest mean daily flows recorded at the various sites range from 0.009m^3/s (Manakau Combined) to 0.585m^3/s (Ohau at Rongomatane). If this maximum abstraction of 45L/s was 'distributed' across all potential sites, this would be less than 1% of the lowest flows ever recorded.

- There are minimum flows, below which any abstraction from the Core Allocation is restricted, for each of the potential water sources. These minimum flows have been derived from hydrometric sites on the Ohau at Rongomatane (Ohau River), Waikawa at North Manakau Road (Waikawa Stream), Manakau at SH1 Bridge (Manakau Stream) and Manawatū at Teachers College (Koputaroa Stream). Horizons has set minimum flows for these rivers and streams in the One Plan. The minimum flow restriction for the Waitohu Stream has been set by GWRC and is related to flows measured in the Waitohu at Water Supply Intake.
- In general, flows drop below the minimum flows relatively infrequently. However, periods below the minimum flow, when abstraction would be restricted, are not randomly distributed. These periods are likely to coincide with the construction season and therefore represent a significant risk to continuous abstraction.
- The maximum number of consecutive days when flows have fallen below the minimum flow ranges from nine (Waikawa at North Manakau Road, in 2013/14) to 28 (Manawatū at Teachers College, in 2012/13).
- The return periods of these events range from 22-years (21-day event at Manakau Combined) to 100-years (25-day event at Ohau at Rongomatane). Such events therefore have relatively low probabilities of occurring during construction of the Ō2NL Project but do represent a risk that must be managed.
- To mitigate any potential adverse hydrological effects, abstraction from the Core Allocation should be at relatively low rates but over longer periods. This would also likely avoid any stress on the instream environment. Advice regarding the maximum pumping rates for the various rivers and streams should be should from the Project Aquatic Ecologist.
- The potential impact of periods of restricted abstraction on construction activities can be managed to some extent through the provision of storage along the route. This storage will ensure security of water supply and mitigate any effect of restricted abstraction during short periods of low flow in any of the potential water sources.
- The ability to replenish the storage ponds following periods of restricted abstraction requires slightly higher rates of both instantaneous and daily abstraction than the average rate of water demand.
- The One Plan provides for a Supplementary Allocation, above the Core Allocation considered in this report, of up to 10% of any flow in a river or stream above the median. This option could also be used to mitigate the risk of periods of low flow and restricted abstraction by ensuring that all storage ponds are full prior to a low flow event.

ASIA PACIFIC OFFICES

ADELAIDE
60 Halifax Street
Adelaide SA 5000
Australia
T: +61 431 516 449

BRISBANE
Level 16, 175 Eagle Street
Brisbane QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CAIRNS
Level 1 Suite 1.06
Boland's Centre
14 Spence Street
Cairns QLD 4870
Australia
T: +61 7 4722 8090

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE CBD
Suite 2B, 125 Bull Street
Newcastle West NSW 2302
Australia
T: +61 2 4940 0442

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Grd Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 2 4249 1000

AUCKLAND
Level 4, 12 O'Connell Street
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

WELLINGTON
12A Waterloo Quay
Wellington 6011
New Zealand
T: +64 2181 7186

SINGAPORE
39b Craig Road
Singapore 089677
T: +65 6822 2203

Wellington

Level 13, 80 The Terrace
Wellington 6011
PO Box 13-052, Armagh
Christchurch 8141
Tel +64 4 381 6700

Please visit **www.stantec.com** to learn more about how Stantec design with community in mind.