REPORT

Tonkin+Taylor

Taumarere to Opua Cycleway

Geotechnical Assessment Report

Prepared for
Far North District Council

Prepared by
Tonkin & Taylor Ltd

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1 Introduction

This geotechnical assessment report (GAR) details the geotechnical engineering input which has been undertaken to support a Resource Consent application for the proposed Taumarere to Opua Cycleway (the Project).

This GAR presents the preliminary geotechnical design for the proposed cycleway Treatment Options, aiming to inform its design specifications and future detailed design. It involves an assessment of geotechnical risks and the effects on neighbouring assets. This includes adjacent landowners and the rail corridor which is operated by Keteriki Ltd.

This report is limited to the geotechnical aspects of the cycleway and does not include other project elements such as planning (RMA consenting), ecology, hydrology, coastal assessment, historic heritage, cultural, and Iwi considerations which are considered separately.

This work has been undertaken in accordance with our existing agreement[1,2] with Far North District Council (FNDC).

1.1 Project overview

The proposed Taumarere to Opua cycleway extends from the historic Taumarere Station, located approximately 50 m south of Long Bridge, through some 6.9 km of coastal landscape to an area known as Colenso Triangle near Opua. Beyond Colenso Triangle the cycleway extends along the existing railway to Opua Marina. However, this section was removed from T+T's design scope (and the wider project team's scope) by FNDC, we understand this is due to complex stakeholder and landowner interfacing. A location plan of the cycleway is shown in the aerial photograph in Figure 1.1.

The cycleway is predominantly located within the existing rail corridor (owned by KiwiRail, operated by Keteriki Ltd). The proposed cycleway route closely follows the existing railway line, within the rail designation however the cycleway also crosses a parcel of Council road reserve. To minimise rail crossings, in an effort to de-couple the cycleway from the railway in the long term, the cycleway remains mostly on the inland side of the existing rail route.

The cycleway will be constructed using a number of design solutions, termed here "Treatment Options" to separate the cycleway from the rail and bring it to the required function and utility. The location and implementation of each Treatment Option have been developed with consideration of the clearance needed from the railway (but not limited to) topography, cost, constructability, minimising ecological impact, planning constraints, heritage constraints and opportunities, and importantly to promote connectivity with the natural environment. Some sections of the new cycleway will require minimal work (e.g., providing a graded and metalled surface) whiles others will need engineering works such as cut slopes and retained ground.

The cycleway alignment and Treatment Options are shown in the Kawakawa to Opua Cycle Trail Consent Drawings, prepared by JAS Civil dated August 2024 which are attached in Appendix A. An overview of the Treatment options is summarised in Table 1.1.

Co-ordinates are provided in terms of NZTM Geodetic 2000 datum and all elevations and levels in this report are presented in terms of reduced level, RL, taken to be the One Tree Point Vertical Datum (OTP-1964).

[1] T+T Letter of Engagement "Taumarere to Opua Cycleway – Detailed Design Services, Rev 2", dated 24 March 2023, Ref. 1090082.0000.

[2] T+T VO2b "Request for Variation Order VO2b – Taumarere to Opua Cycleway Geotechnical investigations and reporting", dated 29 February 2024, Ref. 1090082.0000.

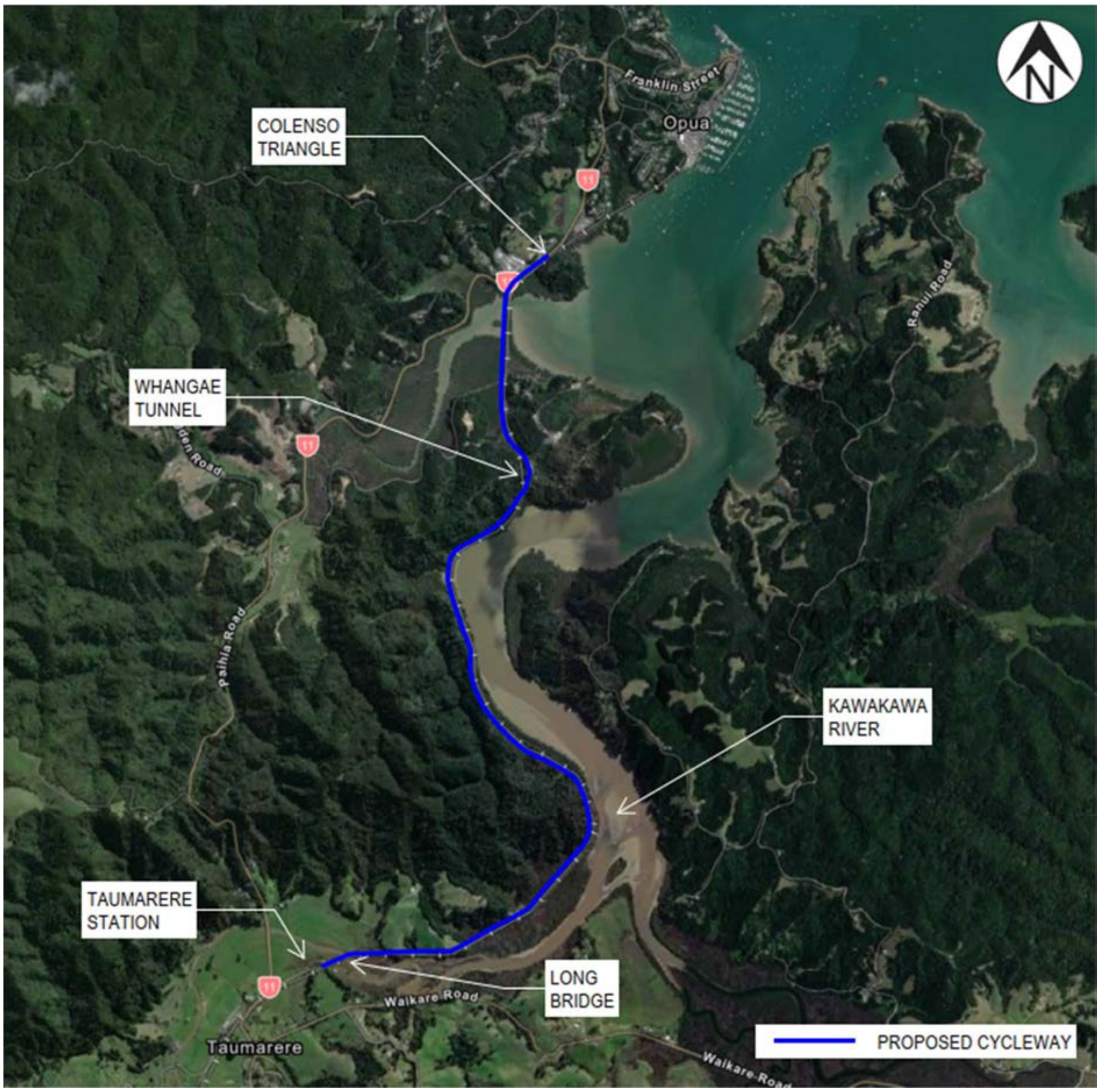

Figure 1.1: Project location plan.

Table 1.1: Treatment options: Overview

Treatment Option	Description
Treatment A & B	Cycleway constructed using fill (up to about 2.4 m height) placed on/adjacent to the rail embankment. Fill is supported using tie-back embedded retaining walls with wall heights: • up to 2.4 m for Treatment A. • up to 1 m for Treatment B.
Treatment C	Cycleway constructed using cuts into existing slopes. Cuts will be generally unsupported except where required to mitigate slope stability risks.
Treatment D	Cycleway constructed by combination of cut and fill at the toe of existing slopes. Cuts will be supported using retaining walls up to 2 m height. Fill will be supported using embedded retaining walls up to 1 m height.
Treatment E, F & G	Cycleway formed by combination of cut and fill at the toe of existing slopes. Cuts will generally be unsupported except where required to mitigate slope stability risks. Fill will be supported using embedded retaining walls with retained heights: • up to 1 m for Treatment E. • up to 1.5 m for Treatment F. • up to 2 m for Treatment G.
Treatment H	Cycleway constructed by earthwork fill (up to about 1.2m height) placed on/adjacent to rail embankment. Fill is unsupported using toe batter of up to about 1v:2h.
Treatment I	Cycleway constructed using MSE wall (up to about 1.4 m height, subject to local topography) placed on existing slopes. This Treatment option is typically proposed away from rail corridor.
Treatment J, J1 & K	Cycleway constructed using elevated timber boardwalk located on, adjacent to, or offset from rail embankment. Primarily the boardwalk is kept low to the ground (less than 1.0 m above surrounding ground level) to enhance interaction with the ecology and environment and to reduce the need for fall protection.
Treatment L	Cycleway constructed at grade adjacent to the rail using very minor cuts and fill. This Treatment is generally proposed where cycleway is on flat ground with adequate space adjacent to rail.
Treatment M	Cycleway constructed using elevated timber boardwalk located on the rail embankment. This Treatment Option is only used for short length (~100 m) near the southern extent of the cycleway to facilitate transition from the existing Long Bridge maintenance walkway (to be used for cycleway access over Long Bridge) to an at section of cycleway and crossing at approximately chainage 4730 m.

1.2 Geotechnical scope

The geotechnical scope of work in this report includes the following:

- Description of site setting, site history and water levels.
- Geotechnical interpretation of the available geotechnical information, including.
  - description of geological setting.
  - ground profile and groundwater overview.
  - geotechnical parameters for design.
- Site seismicity.
- Assessment of geotechnical hazards.
- Summary of geotechnical design criteria.

- Geotechnical assessment and preliminary design for the proposed cycleway Treatment Options (as depicted on the Consent drawings) and assessment of effects on neighbouring assets.
- Assessment of geotechnical risks.
- Clarification of further geotechnical work required to support future stages of the Project.

2 Existing project documentation

2.1 Site investigations and factual reporting

This report should be read in conjunction with the latest revision of T+T Geotechnical Factual Report[3], which details the geotechnical investigations completed for the Project to date. The factual report has been used to inform this report.

The investigations undertaken for the Project include:

- Haigh Workman (2021) investigations: undertaken in August 2021 between approximate chainage 4640 m to 7000 m.
- Haigh Workman (2022) investigations: undertaken in June 2022 between approximate chainage 8800 m to 9300 m.
- T+T (2024) investigations: undertaken in June 2024 between chainage approximate 4780 m and 10600 m.

The investigation locations from these investigations are shown in the site investigation plans included in Appendix B.

2.2 Previous reporting by others

Previous reporting by others that has been provided to us for the purpose of the project includes work completed by Haigh Workman Civil and Structural Engineers referenced below:

- Haigh Workman (2022): Engineering Report for Pou Herenga Tai – Twin Coast Cycle Trail - Relocation of Cycle Trail Taumarere Station to Opua, Stage 1 - Taumarere Station to Te Akeake, Prepared for Far North District Council, Ref. 15 119B, dated September 2021.
- Haigh Workman (2022): Preliminary Geotechnical Report, Pou Herenga Tai – Twin Cost Cycle Trail Whangae Tunnel Bypass, Prepared for Far North District Council, Ref. 21 186, dated August 2022.

3 Site description

3.1 Site history

The proposed cycleway is located within the rail corridor on a section of KiwiRail's North Auckland Line that is currently leased by Keteriki Limited for the purpose of operating its vintage railway activities.

The corridor was established in the late 19th century for the freight of coal from the Kawakawa Hills to the Opua marina where it was sent offshore. We understand that when coal mining ceased operations early in the 20th century, the line was extended to Whangarei and used primarily as a passenger service. From 1985 the section of track between Kawakawa and Opua has been operated

[3] T+T (2024). Taumarere to Opua Cycleway Project. Geotechnical Factual Report. Revision 1. Dated August 2024.

as a scenic railway by various entities until the line was closed in about 2001 due to operational concerns lead the Land Transport Safety Authority to withdraw the lines operating licence.

In about 2010 the Pou Herenga Tai Twin Coast Cycle Trail established a cycle trail over sections of the railway between Kawakawa and Opua under a lease from Bay of Islands Vintage Railway Trust (BOIVRT), now part of Keteriki. Keteriki is now rejuvenating the rail between Taumarere and Opua after successfully improving the performance of Long Bridge, and as a result the cycle trail needs to be re-established within the rail corridor adjacent to the rail.

3.2 Railway embankment construction

We have not been able to locate much useful information on the construction of the rail, which occurred in the late 19th century. From our experience elsewhere on the rail network, we consider that construction was likely achieved through hand excavation by pick and shovel with cut to fill material transported by horse and cart. Fill placement for embankments was likely end tipped and only lightly compacted as construction traffic (horse and cart) progressively worked forward over placed material. Where soft ground was encountered a basal layer often comprising either boulders or criss-crossed brush / small trees (such as Makuka and Kanuku) was often (but not always) placed prior to the placement of fill.

Over time, the sections of embankment that overlie soft compressible ground often become over steepened and narrow due to consolidation settlement of the soft soils and continued “topping up” of the ballast over time.

Local slumping / instability of embankments and cut slopes is also expected to have occurred, with repairs often comprising placement of boulders or higher friction angle fill within the failed section of track to enhance stability of the remaining embankment.

Construction also included various bridges, culverts, and the Whanagae Tunnel near Opua. The historic culverts and tunnel are of significant heritage value and are preserved within the proposed cycleway project. The original bridges have been replaced with more modern timber or steel spans.

3.3 Topography

The site topography generally comprises low lying, flat estuarine and river deposits surrounded by gentle to moderately steep topography comprising weathered greywacke soils. These natural topographies are transected by the railway with sections of cut and fill earthworks. Cuts are generally local to the elevated greywacke topography, and fill placement generally occurs over the low lying estuarine / river deposits.

Evidence of recent and historical slope instability is present on the site and can be observed on site and via Digital Elevation models and aerial photographs. These areas appear to be locally over steepened compared to surrounding land, and where recent failures have occurred and lack mature tree growth.

The proposed cycleway predominantly sticks to the bases of large cut slopes and within the extent of the fill embankments. The exceptions are where the trail diverges from the rail embankment to avoid high value wetlands and achieve an acceptable grade over the existing Whangae Tunnel by traversing bush clad slopes, and where boardwalk has been adopted for the crossing of wetlands and the Coastal Marine Area (CMA).

3.4 Water levels

Significant lengths of the cycleway are located in the low-lying ground close to Kawakawa River groundwater is anticipated to be controlled by tidal fluctuations. The tidal levels, sea level rise and extreme water levels adopted for the Project are presented in Table 3.1.

Coastal inundation is generally controlled by the maximum static water level (extreme static water level) resulting from a combination of storm tide and wave set-up. Wave set up has been ignored based on the sheltered inland setting of the proposed cycleway which is positioned on the left side of the rail.

Table 3.1: Summary of tidal conditions for geotechnical design

Environmental Condition	Component	Level (mRL)
Astronomical tide	Mean High Water Spring (MHWS)	1.1 [2]
	Mean Sea Level (MSL)	0.0
	Mean Low Water Spring (MLWS)	-1.0
Storm tide	100-year ARI	1.57 (average)
Relative sea level rise [1]	Static flood level	2.27 (average)

Notes: Tidal levels based on T+T (2021), Coastal Flood Hazard Assessment for Northland Region 2019-2020, prepared for Northland Regional Council, issued March 2021. Site number #63 Kawakawa River.

1. Coastal Flood Hazard Zone 1 (CFHZ1): Extent of 50-year ARI static water level at 2080 including 0.6 m SLR.
2. MHWS for Opua Wharf = 1.04 mRL. MHWS for Kawakawa River = 1.07 (average). For the geotechnical aspects of the Project the adopted MHWS = 1.1 mRL.

Costal Marine Area (CMA) has been adopted from MHWS which has been inferred at 1.1 mRL for the purposes of the Project.

4 Geology

4.1 Published geology

The published geological maps[4,5]of the area, depicted below in Figure 4.1, indicates that the site is predominantly underlain by Waipapa group Sandstone and Siltstone material. This parent material typically weathers to form several meters of residually weathered interbedded silt and clay layers, grading vertically to unweathered sandstone/siltstone rock.

The geological maps indicate Tauranga Group alluvial deposits in the river/estuary areas close to the site and these types of alluvial soils are also expected to be present within the cycleway corridor.

[4] Edbrooke, S.W.; Brook, F.J. (compilers) 2009: Geology of the Whangarei area. Institute of Geological & Nuclear Sciences 1:250,000 geological map 2. 1 sheet + 68 p. Lower Hutt, New Zealand. GNS Science.
[5] Heron, D.W. (custodian) 2020. Geological map of New Zealand 1:250,000. 3rd ed. Lower Hutt, NZ: GNS Science. GNS Science geological map 1. 1 USB; https://doi.org/10.21420/03PC-H178.

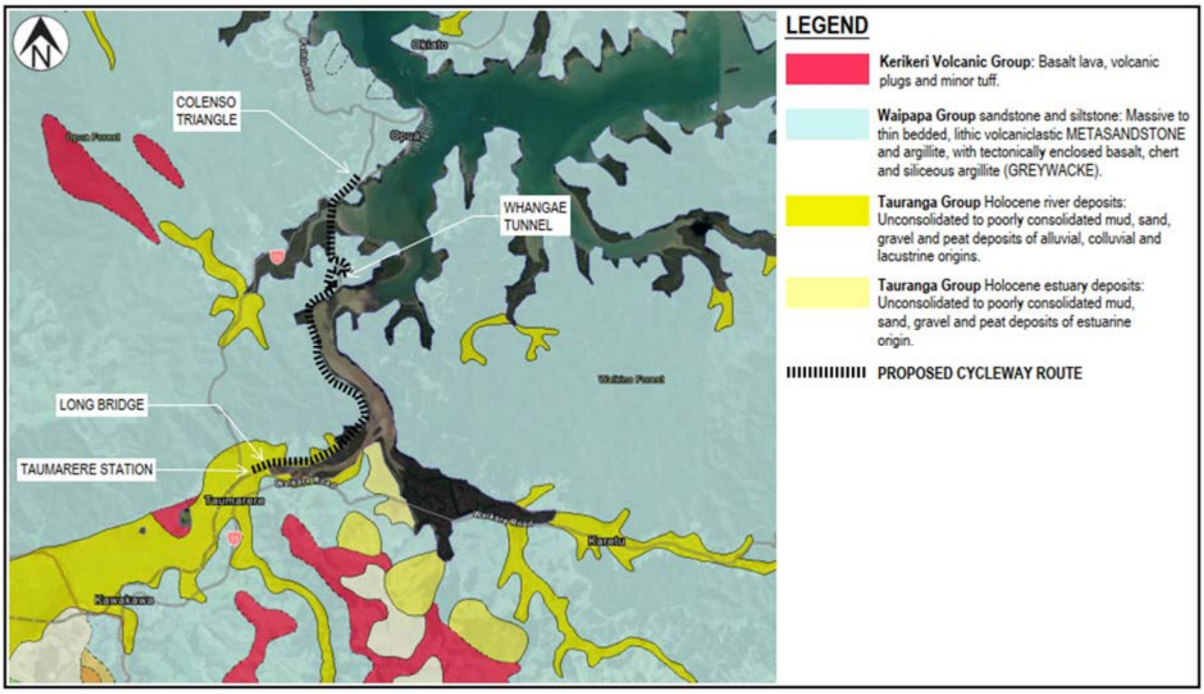

Figure 4.1: Published geological map of the area.

4.2 Regional faulting

The regional faults closest to the Project area include:

- Kawakawa Fault located about 1.5 km west of the project area.
- Kawakawa Overthrust Fault located about 4.5 km southwest of the project area.

Both faults are documented as inactive on GNS website[6].

4.3 Landslide risk

We have undertaken high level risk mapping of potential historical areas of landslide, inferred from review of the topographical contours and our site observations. The landslide mapping is presented in Appendix C. The locations we have considered could be affected by landslide debris (colluvium) are outlined further in Section 4.4.4.

We note that this method of risk mapping is not exhaustive and in some cases, evidence of landslides may only become apparent through intrusive investigation or during construction when cut faces are exposed.

Existing landslide areas provide additional risks to the proposed development, Colluvium (material previously disturbed, or placed by, landslide movement) is typically significantly weaker than its parent soil. In addition to this, landslides often have very weak planes within the soil matrix which can easily reactivated if earthworks are undertaken without consideration of the slope stability.

Where possible landslides are identified, further work could be undertaken at detailed design or prior to construction to better inform the risk and reduce the potential for programme and cost implications.

[6] https://data.gns.cri.nz/geology/.

4.4 Ground profile overview

4.4.1 Introduction

The ground profile across the Project area has been assessed based on site investigation results, site observations and published geology. This is expected to vary along the length of the proposed shared pathway. The Project has been split into two different generalised ground profiles, outlined below.

4.4.2 Ground profile type 1 – Waipapa Group soil and rock

In areas where the cycleway cut through or close to the existing hillsides, or at areas where the cycleway is at elevations significantly above the level of the Kawakawa River (i.e. above Whangae Tunnel), the ground conditions are anticipated to generally comprise residually weathered Waipapa soil silts and clays overlying weathered or unweathered sandstone and siltstone rock. The approximate chainages that ground profile type 1 is expected to occur are summarised in Table 4.4.

The residually weathered Waipapa soil is generally very stiff to hard with undrained shear strengths typically greater than 150 kPa.

The depth to rock is expected to vary along the cycleway alignment depending on the depth of the weathering profile and whether the cycleway is located within an existing cut formed during rail construction.

The hand auger boreholes and Scala penetrometer undertaken by T+T (2024) investigations close to the rail alignment refuse between 0.2 m and 3.8 m depth which we have inferred marks the transition from Waipapa Group soil to rock at these specific locations. Sandstone and siltstone rock were also observed outcropping along some lengths of the rail and within the existing slopes upslope of the rail by T+T during these investigations.

The CPT undertaken in the Haigh Workman (2022) investigations above Whangae Tunnel refuse between 6.6 m to 16.6 m depth which we have inferred marks the transition from Waipapa Group soil to rock in that area of the Project which is away from the rail corridor.

Table 4.1: Approximate chainages anticipated to be Ground profile 1 – Waipapa soil and rock

Start Chainage[1] (m)	End Chainage (m)	Treatment Option
4251	4310	L
4735	4845	E
4935	4980	L
4980	5010	A
5010	5080	E
5080	5180	L/C
6120	6128	Existing Bridge 10
6128	6275	D/G/E
6415	6655	F/G/E
6745	6900	E/G
7050	7105	L
7105	7185	G
7325	7575	F/G

Start Chainage[1] (m)	End Chainage (m)	Treatment Option
7575	7645	L
7645	7985	G/E
7985	8000	L/A
8000	8015	L
8505	8600	G/F
8825	9405	I
9600	9735	B
9735	9885	L
10580	10750	A

Note:

3. The origin of the chainage system is the start of the existing cycleway at Opua. The extent of the project chainage is Ch 4251 to Ch 10950.

4.4.3 Ground profile type 2 – rail embankment fill and/or alluvial soils

Portions of the existing rail (and proposed cycleway alignment) comprise man-made fill embankment which have been constructed on the lower lying banks of the Kawakawa River and neighbouring estuarine/wetland areas. Ground profile type 2 is representative for these areas and generally comprises a combination of existing embankment fill material overlying highly variable alluvial deposits. The approximate chainages that ground profile type 2 is expected to occur are summarised in Table 4.2.

The existing rail fill is anticipated to comprise a mixture of site-won silts and clays with localised zones of gravel and cobbles. This filling was placed as part of the original rail construction is likely to be uncontrolled (i.e. no supervised engineered compaction was undertaken, and no formal compaction records are available).

Percussion boreholes undertaken to pre-drill the CPTs as part of the Haigh Workman (2021) investigations generally describe the fill as “clay” with localised “boulders and gravels”. Haigh Workman (2021) investigations have several CPT undertaken partially within the rail embankment fill (CPT1b, CPT2a, CPT13, CPT17, and CPT18). The CPT indicate the embankment fill to comprise clay with an average undrained shear strength of about 60 kPa. T+T (2024) hand auger boreholes describe the existing embankment fill as stiff to very stiff silty clay with gravel with average undrained shear strength of about 100 kPa.

Based on the investigation information the underlying alluvial soils are shown to be highly variable and generally comprise soft clays with localised zones of medium dense to dense sands and interbedded silts.

The soft alluvial clays have been identified to be between 1 m and 12.5 m thick (average about 6m thick) with an undrained shear strength of about 20 kPa and highly compressible. Greater thicknesses of alluvial deposits are expected than those confirmed in the investigations, particularly where the alluvial soils infill paleo river channels. We expect these soils are normally consolidated although some strength gain and over-consolidation are expected of these soils where located immediately below the rail embankment due to prolonged surcharge loading.

Table 4.2: Approximate chainages anticipated to be Ground profile 2 – alluvial soils

Start Chainage[1] (m)	End Chainage (m)	Treatment Option
4310	4620	Existing Long Bridge walkway
4620	4735	M
4845	4935	A
5180	5345	A
5345	5360	J
5360	5480	A
5480	5530	L
5530	5570	A
5570	5590	L
5590	5690	A
5690	5850	B
5850	6085	J
6085	6120	L
6120	6128	Existing Bridge 10
6128	6275	D/G/E
6275	6415	I
6655	6745	A
6900	6930	I
6930	6985	J
6985	7050	I
7185	7325	I
8015	8030	Existing Bridge 11
8030	8075	L
8075	8160	B
8160	8325	K
8325	8505	L/B
8600	8650	J
8650	8825	L
9405	9600	L
9885	10265	J1
10265	10315	Existing Bridge 12 – Whangarei Bridge
10315	10365	L
10365	10580	A
10750	10950	J

Note:

1. The origin of the chainage system is the start of the existing cycleway at Opua. The extent of the project chainage is Ch 4251 to Ch 10950.

4.4.4 Presence of historical colluvium

Based on a geomorphology assessment we anticipate that historical colluvium could also be present at discrete locations along the cycleway alignment overlying Waipapa Group residual soils (ground profile type 1) or overlying the alluvial soils (ground profile type 2). The approximate chainage locations that colluvium may be present are summarised in Table 4.3, but may also exist elsewhere on the alignment.

This is material which has been deposited as part of historical landslides. As such this material is likely to comprise clays and silts derived from the parent Waipapa Group soils from the slopes above. The properties of the colluvium may be similar to the residual Waipapa Group residual soil however we expect that the strength of the colluvium may be less or more variable than the in-situ undisturbed soil.

We do not have any boreholes at the locations where colluvium may be present. However, CPT8 and CPT14, CPT15 and CPT16 from Haigh Workman (2022) investigations may have encountered a thin layer of colluvium up to about 1m thick immediately below the rail embankment, overlying the softer alluvial soils (described in Section 4.4.3 above). This material is inferred to be firm to stiff silts and clays based on the CPT results.

Further investigation should be considered in these areas during detailed design phase to confirm the presence and nature of the colluvium (if present). The presence of colluvium is not expected to significantly impact the preliminary design undertaken in this report.

Table 4.3: Approximate chainages which may include historical colluvium

Start Chainage[1] (m)	End Chainage (m)	Treatment Option
5380	5480	A
6300	6400	I
6660	6740	A
6900	7020	J
7200	7260	I
7700	7840	E
8360	8400	L
8440	8500	L
9500	9520	L

Note:

1. The origin of the chainage system is the start of the existing cycleway at Opua. The extent of the project chainage is Ch 4251 to Ch 10950

4.5 Groundwater

4.5.1 Ground profile type 1 – Waipapa Group soil and rock

The hand auger boreholes drilled in the Waipapa Group soils were drilled to between 0.6 m and 3.7 m final depth with a typical final depth of about 2 m. Groundwater was not typically encountered in these hand auger boreholes which were drilled in late June 2024. Groundwater was encountered in two of nine T+T (2024) hand auger boreholes (drilled in the Waipapa Group soils) at 1.8 m depth (in HA09) and 2.7 m depth (in HA14). HA09 was drilled near to Kawakawa River level and HA14 was drilled at elevated ground levels above Te Raupo Tunnel.

Haigh Workman (2022) investigations also included four cone penetrometers (CPT) which were undertaken at elevated ground levels above Te Raupo Tunnel (between chainage 8800 m to 9300 m). Groundwater in the CPTs is recorded between 2.7 m and 6.1 m depth, however, it is noted in the Haigh Workman (2022) Geotechnical Report that the 2.7 m groundwater reading may not be reliable.

Preliminary design assumptions

For global stability assessment (Treatment C, D, and I) groundwater has been assumed to be deeper than 2 m under long-term (normal) groundwater conditions. To model the extreme (worst case) groundwater condition, groundwater has been assessed at 2 m below ground surface.

For retaining walls located in ground profile type 1 (typically Treatment D to G), groundwater has been assumed to be below the base of the wall under long-term (normal) groundwater conditions (greater than 2 m depth). To model the extreme (worst credible) groundwater condition, groundwater has been modelled assuming water pressure build up behind the wall on the active side to 1/3 retained height. This assumption is conservative and will need the drains to the walls to be maintained regularly.

4.5.2 Ground profile type 2 – alluvial soils

The investigation locations conducted in the soft alluvial soils typically encountered groundwater at or near ground surface. Groundwater in these investigations locations is expected to be tidally controlled.

Preliminary design assumptions

The preliminary design assumes the groundwater is tidally controlled within ground profile type 2. Noting that the level of the cycleway and rail embankment varies along the proposed alignment the following design assumptions have been adopted for preliminary design to model a moderately conservative worst-case condition.

For global stability assessment (Treatment H) groundwater has been assumed to be at the base of the proposed filling.

For settlement assessment (Treatment H) groundwater has been assumed to be lower than the proposed cycleway filling to model drained weight of the fill.

Liquefaction assessment has assumed water level at MHWS.

For retaining walls located in ground profile type 2 (typically Treatment A and B), groundwater has been assumed to at the base of the wall under long-term (normal) groundwater conditions (worst case). To model the extreme (worst credible) groundwater condition, groundwater has been modelled assuming water pressure build up behind the wall on the active side to 1/3 retained height. This design condition has been included to represent groundwater build-up within the rail embankment, in combination with falling tide levels on the passive side of the wall creating an unequal build-up of groundwater pressure. Typically, the extreme (worst credible) groundwater level is between 0.7 m and 1 m above MWHS on the active side of the wall.

4.6 Geotechnical design parameters

The geotechnical parameters adopted for preliminary design are summarised in Table 4.4. The parameters have been based on the available geotechnical investigations, inferences from testing in other similar local geological materials, published correlations, and local knowledge of the materials.

Table 4.4: Summary of geotechnical parameters

Geological unit	Unit weight (kN/m3)	Effective cohesion, c' (kPa)	Effective friction angle, ϕ' (°)	Undrained Shear Strength, Su (kN/m2)	Drained Young's Modulus (MPa)	Undrained Young's Modulus (MPa)	Poisson's Ratio, v	Coefficient of volume compressibility, Mv (m2/MN)
Existing embankment fill	18	3	28	50-60	10	12	0.30	0.3
Alluvial soft clays/silts	17	1	25	20	5	6	0.30	1.40
Alluvial firm clay/silt (crust)	18	3	26	40-50	10	12	0.30	≤1.40
Alluvial stiff clays/silts (crust)	18	5	28	80	15	18	0.30	≤1.40
Alluvial medium dense sands	18	0	32	-	40	-	0.30	Not considered
Alluvial dense sands	19	0	36	-	60	-	0.30	Not considered
Imported Engineered Fill (granular)	20	0	38	-	60	-	0.30	Not considered
Site-won and imported Engineered Fill (fine grained)	18	5	28	80	20	24	0.30	Not considered
Waipapa Group - very stiff residually weathered soil	18	7	32	160	40	45	0.30	Not considered
Waipapa Group - hard residually weathered soil	18	10	34	200+	60	70	0.30	Not considered
Waipapa Group (rock)	20	100	32	500+	150	200	0.25	Not considered

Table notes:

Coefficient of volume compressibility has only been derived for the fine grained alluvial soils which are potentially susceptible to settlement due to cycleway construction.

We have assumed that the cycleway fill will comprise of site-won or locally sourced Waipapa Group clays/silts. The parameters adopted at preliminary design for this material are lower than typical values to account for the likely construction methodology, limited access within the rail corridor for larger machinery and potential difficulties undertaking earthworks in the tidal environment.

5 Seismicity

5.1 2022 National Seismic Hazard Model (NSHM) update

In October 2022, GNS Science released the revised National Seismic Hazard Model (NSHM)[7]. This represents the latest scientific knowledge of earthquake hazard in New Zealand and is an important factor for understanding and managing earthquake risk in the built environment.

While the NSHM will inform future design standards, it does not provide information that can be directly applied in design applications. Consequently, the current minimum compliance pathway within the Building Code has not changed[8]. However, important updates to Building Code compliance documents that will be informed by the NSHM are expected to be released by 2025.

We have undertaken an initial appraisal of the implications of the 2022 NSHM for geotechnical design. It is uncertain how the updated NSHM will be reflected in future design standards, however it is possible that the code minimum seismic design loadings will increase in some situations.

Seismic hazard models carry an inherent amount of uncertainty, but more important is the uncertainty in what shaking a particular site or building will be subject to during its actual life. This depends on which specific earthquakes actually occur over that time. Therefore, designers and building owners are strongly encouraged to focus on resilient design practices, rather than the specific code minimum demand[9].

Liquefaction triggering and associated consequences are non-linear. Our preliminary liquefaction assessment has considered a range of seismic loadings, including values between the current code minimum limit states of SLS and ULS as well as beyond ULS. This allows us to understand the impact of the uncertainty in seismic loadings on the geotechnical performance of the site, in particular whether there are any step-changes which could be critical. The consequences of this are discussed further in Section 5.3.

The following sections outline the seismic shaking hazard for the site as determined by the current minimum compliance pathway within the Building Code. We recommend that building owners liaise closely with their geotechnical and structural professionals to understand the potential impacts of uncertainty and how this can be managed for the site.

5.2 Ground motion parameters for geotechnical design

The ground shaking hazard for geotechnical assessment and design purposes has been assessed using the NZGS/MBIE (2021) Module 1. The guidelines provide recommended magnitude-unweighted peak ground acceleration (PGA) values and associated earthquake magnitudes (M_w) for geotechnical assessment.

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[7] https://nshm.gns.cri.nz/.

[8] Current relevant compliance documents to meet *Clause B1: Structure* of the Building Code are as shown in Verification Method B1/VM1. For structural seismic design this is *NZS 1170.5:2004 – Structural Design Actions Part 5: Earthquake Actions – New Zealand.* For geotechnical design, although not directly referenced in B1/VM1, the Section 175 MBIE/NZGS guidance document *Earthquake Geotechnical Engineering Practice: Module 1 (November 2021)* is to be continued to be used for seismic design loadings.

[9] NZSEE, SESOC, NZGS (August 2022). *Earthquake Design for Uncertainty: Advisory.* Revision 1. https://www.nzsee.org.nz/db/PUBS/Earthquake-Design-for-Uncertainty-Advisory_Rev1_August-2022-NZSEE-SESOC-NZGS.pdf.

Table 5.1: Summary of seismic loading inputs, earthquake magnitudes, and design PGAs

Input	Parameter	Reference
Site subsoil class	Class C – Shallow soil site	NZS1170.5
Structure importance level	IL1	NZS1170.0, Table 3.1
Structure design life	50 years	NZS1170.0
Return period - ULS	100 years	NZS1170.0, Table 3.3
Effective magnitude (Mw) - ULS	5.8	MBIE Module 1 – Table A1
PGA – ULS	0.07 g	MBIE Module 1 – Table A1
Effective magnitude (Mw) – for SLS	Not required	MBIE Module 1 – Table A1
Return period - SLS	Not required	NZS1170.0, Table 3.3
PGA - SLS	Not required	MBIE Module 1 – Table A1

5.3 Liquefaction assessment

Liquefaction only occurs in some soils, under certain conditions. Liquefaction susceptible soils are typically saturated, non-cohesive, and low to moderate permeability. Sands, low plasticity and non-plastic silts are most susceptible to liquefaction.

Soils which are susceptible to liquefaction require a certain level of earthquake shaking (‘trigger’) to cause it to liquefy. Denser soils require more intense and/or longer duration of shaking (higher ‘trigger’) than less dense soils.

The liquefaction assessment has been undertaken based on the CPT data from the Haigh Workman 2021 site investigations. The liquefaction potential has been carried using the software CPT-Liq.

The liquefaction assessment has identified that some of the more granular alluvial soils (typically located within the Kawakawa River banks and/or low-lying estuarine environment) may be susceptible to liquefaction. However, due to the relatively low seismicity of the Northland region these soils are not expected to trigger in a ULS seismic event. On this basis liquefaction risks are considered to be low.

As noted in Section 5.1 and in response to the publication of the NHSM (2022) we have assessed the liquefaction risks for levels of seismic shaking greater than the design code (i.e. greater than ULS seismic event) to assess if there are any step-changes in geotechnical behaviour which could be critical to the Project. Based on the liquefaction assessment undertaken, little to no expression of liquefaction (less than 5mm of liquefaction induced surface settlement) will occur for seismic shaking equivalent up to 150% the ULS seismic shaking event (PGA = 0.1 g).

There is uncertainty in the liquefaction assessment as there is no borehole information to the same depth as the CPT testing, and no laboratory testing to calibrate the liquefaction assessment. There is also significant portion of the cycleway towards the northern end of the alignment without any CPT investigation locations within the alluvial deposits. The CPT used in the liquefaction assessment are located between Chainage 4600 m to 7000 m only.

5.4 Cyclic softening

Cyclical loading of fine-grained cohesive soils causes the porewater pressure to increase and causes strength loss or softening. The resistance to cyclic loading for silts and clays is controlled by the undrained strength of the soil. Lower strength cohesive soils are more likely to be affected by the cyclic softening and may lose strength at lower levels of earthquake shaking than high strength materials.

The potential for cyclic softening of the soils has been considered using undrained shear strength data and the cyclic softening triggering assessment methodology of Idriss & Boulanger (2008)[10] as proposed in MBIE Module 3 (2021).

It is acknowledged that there are likely to be insufficient cycles of earthquake shaking for cyclic softening to manifest at the site due to the low seismicity of the Northland region. Cyclic softening is therefore not expected to influence the design at the site.

6 Geotechnical hazards

The key geotechnical hazards for the Project area are discussed in the following sections, and include:

- Instability of existing slopes and cuts upslope of the rail.
- Instability of existing rail embankment.
- Instability caused by cycleway filling on soft alluvial soils
- Settlement caused by cycleway filling on compressible alluvial soils
- Soil aggressivity

It should be noted that in some areas the slopes and cuts upslope of the rail are unlikely to achieve normal design standards and FoS for development due to historical construction. For similar reasons we also anticipate that the rail embankment is unlikely to achieve KiwiRail design standards for stability.

Other (non-geotechnical) hazards which may impact the geotechnical elements / structures of the project include:

- Coastal erosion and shoreline slope stability
- River scour
- Flooding
- Rising sea levels
- Tsunami
- Saltwater intrusion / corrosion of structures

Further discussion of these geotechnical hazards discussed in Section 8 under the relevant Treatment Option or in the Geotechnical Risk Register in Appendix D.

7 Design requirements

7.1 Design standards and guidelines

The preliminary design has relied upon the following documents:

- CIRIA C760 (2017): Guidance on embedded retaining wall design.
- KiwiRail (2016): Civil Engineering Standard, Ground Engineering and Earthworks, C-ST-GE-4105, Issue 1
- KiwiRail (2011): W201 Railway Bridge Design Brief, Issue 6
- KiwiRail T200 Network Engineering Track Handbook, March 2017
- MBIE NZCT Design Guide (2019): New Zealand Cycle Trail Design Guide 5th addition.

[10] Idriss & Boulanger (2008). Soil Liquefaction During Earthquakes. *Earthquake Engineering Research Institute MNO-12.*

- New Zealand Building Code (2023): Acceptable Solutions and Verification Methods For New Zealand Building Code Clause B1 Structure, Amendment 21
- NZGS/MBIE Module 1 (2021): Overview of the geotechnical guidelines.
- NZGS/MBIE Module 3 (2021): Identification, assessment and mitigation of liquefaction hazards.
- NZS1170.0:2002. (2016). Structural design actions Part 0: General principles. New Zealand Standards.
- NZS1170.5:2004. (2016). Structural design actions Part 5: Earthquake actions – New Zealand. New Zealand Standards.
- NZS AS 1720.1 (2022): Timber Structures. New Zealand Standards.
- SNZ HB 8630 (2004): New Zealand Handbook, Tracks and Outdoor Visitor Structures
- SNZ TS 3404 (2018): Durability requirement for steel structures and components.
- Far North District Council (2023) Engineering Standards v0.6
- Auckland Council (2023): The Auckland Code of Practice for Land Development and Subdivision, Chapter 2: Earthworks and Geotechnical, v2.0

7.2 Importance level

The importance level (IL) of the cycleway is IL1, as per NZS 1170.0[11] Table 3.1.

7.3 Design life

A design life of 50 years has been adopted for the project for the purposes of design.

We expect that the earthwork components of the project are likely be able to achieve a design life greater than 50 years under typical timber treatment requirements (generally H5). The timber elements of the Project (i.e. timber boardwalk and or timber retaining walls installed in the marine environment) should be treated to an H6 standard (NZS3602:2003, Table 5, marine piles), however, due to the aggressive marine environment these structures are located they may have a shorter design life.

The anticipated design life on structures should be confirmed and agreed with FNDC at detailed design stage.

7.4 Design criteria

7.4.1 Global stability of cycleway

The minimum factor of safety (FoS) adopted in preliminary design for the global stability of the cycleway are shown in Table 7.1.

[11] AS/NZS 1170.0:2002, Structural design actions – Part 0: General principles

Table 7.1: Minimum factor of safety for global stability

Design case	Minimum FoS (1)
Long term groundwater	1.5
Extreme (worst credible) groundwater	1.3
Seismic ULS	1.0 (2)
Temporary case (construction)	1.2

Table notes: [1]The FoS of existing slopes and embankments is expected to vary from the values adopted for design, and no allowance for improving the existing slopes away from the proposed treatment measures has been made. [2]Not considered at preliminary design (refer to Section 7.4.5 for further details). *No specific design guidance is provided for global stability in Far North District Council or Northland Regional Engineering Standards. FoS adopted are based on Auckland Council (2023): The Auckland Code of Practice for Land Development and Subdivision, Chapter 2: Earthworks and Geotechnical, v2.0.

7.4.2 Design intent for global stability of existing slopes and cuts

For areas of the cycleway in cuts, the objectives of the design solutions are to achieve a similar level of risk to that which existed prior to the cycleway construction. For example:

- We do not intend to improve the stability of existing cut slopes (from existing performance/ stability condition) away from the proposed treatment options.
- Where there is an imminent risk or increased risk (from cycleway construction), and the risk is likely to adversely affect the safe operation of the cycleway or rail and therefore deemed unacceptable, this should be mitigated by the proposed solution so far as is practicable.

The existing slopes typically range from 5 m to 15 m height with existing batters between 35 to 45 degrees. We understand that the existing batters have been relatively stable since rail construction (i.e. no significant, deep seated slope stability failure has occurred).

There is an opportunity to seek a balance between accepting the risk of slope failures occurring requiring on-going maintenance to repair the damage and implementing geotechnical design to reduce the risk of slope failures, to achieve the required functionality and service at an acceptable whole of life cost. This should be explored by the design and FNDC team at ensuing design stages to achieve a best for project outcome.

7.4.3 Retaining wall stability

The minimum FoS using the Strength Factor Method for pile embedment in WALLAP are summarised below in Table 7.2.

Table 7.2: Design criteria for retaining wall pile stability

Design case	Minimum FoS
Long term groundwater	1.5
Extreme (worst credible) groundwater	1.2
Seismic ULS	1.0 (1)
Temporary case (construction or scour event)	1.2

Table notes: [1]Not considered at preliminary design (refer to Section 7.4.5 for further details). *Minimum FoS are based on the guidance in CIRIA Report 104 for embedded walls.

7.4.4 Settlements at rail level

As part of the assessment of effects, the design has been undertaken to limit ground settlements at rail level in accordance with KiwiRail tolerable limits which are shown for reference in Table 7.3.

Table 7.3: Allowable ground settlement at rail level

Parameter	Limit
Maximum allowable gradient of any existing railway track due to construction of the proposed works	1/500
Maximum vertical movement of any live railway track	5 mm over a 5.0 metre length of track Maximum total vertical movement 14 mm over 20 metres
Maximum horizontal movement of any live railway track	5mm over a 5.0 metre length of track Maximum total horizontal movement 15mm over 20 metres

Table notes: Allowable limits based on KiwiRail Civil Engineering Standard, Ground Engineering and Earthworks, C-ST-GE-4105 Table 7.1. Allowable track settlement.

7.4.5 Preliminary design – seismic design loads

Based on the relatively low importance level of cycleway, and low design seismic loads for Northland, the seismic design case is not considered critical for retaining wall design or global stability. On this basis the seismic design case has not been considered at preliminary design for the retaining walls or global stability design of the Treatment Options below. Seismic design cases will be checked at detailed design stage for completeness however is not expected to govern the design.

8 Geotechnical assessment of proposed cycleway Treatment Options

8.1 Introduction

The following sections present the geotechnical design of the proposed cycleway Treatment Options, including preliminary design details, alternative options, assessment of effects on adjacent structures and landowners and construction considerations.

The Treatments adopted and the chainages implemented have been developed to achieve a balance between mitigating adverse environmental, archaeological, cultural and planning effects with achieving a cost effective project solution that meets the design and Client requirements.

The proposed typical Treatment Options outlined in the JAS Civil drawings, presented in Appendix A, have been used as a basis for our preliminary design calculations and developing this report. Due to the preliminary design stage of the project, the proposed alignment and cross sections require further refinement throughout ensuing design development and/or construction, subject to the method of design and construction procurement adopted for the project. For the purpose of this report, we have adopted the “worst case” design cross section for each treatment type to assess the design and associated effects.

It should be appreciated that the actual alignment and/or Treatment Options are likely to vary slightly from those presented as the alignment and treatments are optimised during the design development, and therefore flexibility should be afforded to account for possible changes. However, in general the Treatment Options and alternate supporting geotechnical measures discussed below are likely to be adopted for the majority of the cycleway.

The recommendations and opinions presented below are based on the available investigation data (undertaken by Mott McDonald) together with our visual appraisal of the site and our experience and knowledge of the surrounding area. The nature and continuity of the subsoils and rock away from the test locations is inferred but it must be appreciated that actual conditions may vary from the assumed model.

8.2 Treatment L – At grade earthworks

8.2.1 Treatment description

This treatment option is the preferred / default starting position for implementing the cycleway throughout the project as it comprises minimal cuts/fills to construct. Alternating treatment Options H and L are proposed over 1300 m. Over this length we estimate that approximately 30% (390 m) could be assumed to be Option L. Where the existing rail corridor has sufficient width and grade to allow an at-grade cycleway to be built adjacent to the rail tracks with sufficient clearance this will be implemented wherever possible. However, the majority of the cycleway encounters topography that does not allow for this solution to be implemented, hence the Treatment Options in the following sections have been developed to enable construction of the cycleway.

There are minimal geotechnical risks or considerations for this Treatment Option and no preliminary design has been undertaken as part of this report.

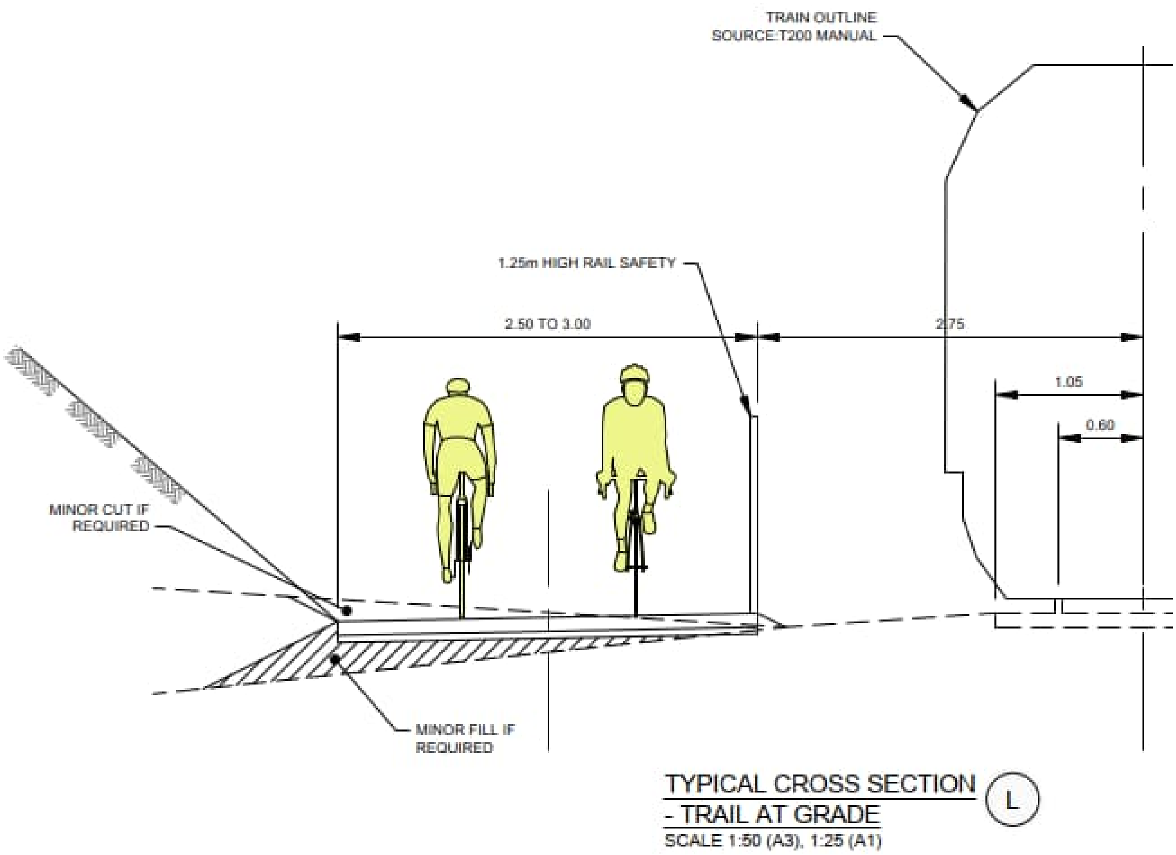


Figure 8.1 Example Treatment L option

8.3 Treatment A and B – Embedded cross-tied retaining wall

8.3.1 Treatment description

Treatment A and B are a proposed option where the existing rail is on a fill embankment extending out over the low-lying ground. The ground profile at these areas is likely to comprise ground profile type 2 (embankment fill overlying alluvial soils).

Treatment A and B show the cycleway constructed using filling placed against toe of the existing rail embankment. The current proposed solution comprises approximately 1500 m of Treatment A or B. The filling will be either site-won or imported fill and will be supported using tied-back embedded retaining wall. The retaining wall is estimated to be up to 2.4 m height for Treatment A and up to 1 m height for Treatment B.

The retaining wall option has been selected to reduce the cycleway footprint within the Costal Marine Area (CMA) compared to Treatment Option H (earthwork filling with toe batter).

A cantilever type wall could normally be expected to be adequate for the relatively low retained heights proposed for Treatment A and B. However, due to the relatively soft alluvial soils that could be expected for pile embedment tie-backs have been incorporated into the wall configuration to control lateral wall deflections and thus minimise ground settlements upslope of the wall at existing rail level. Tie-back retaining walls are a standard KiwiRail solution to widen the formation at rail level, or to remediate existing embankment instability and are well known to rail experienced contractors.

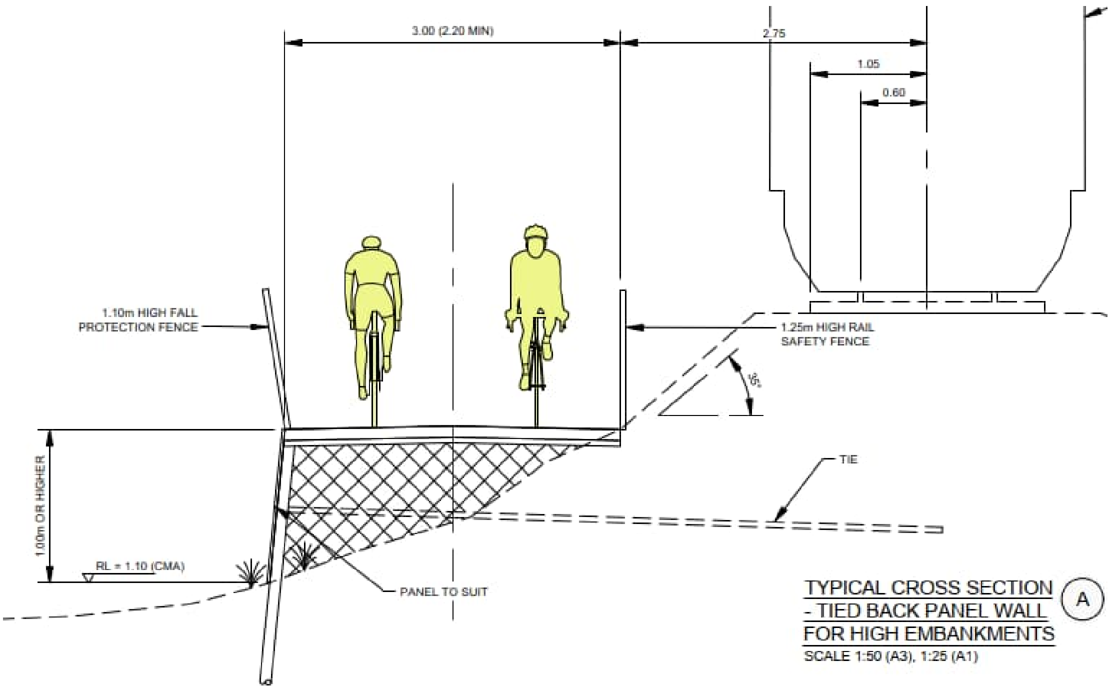


Figure 8.2 Example Treatment A option

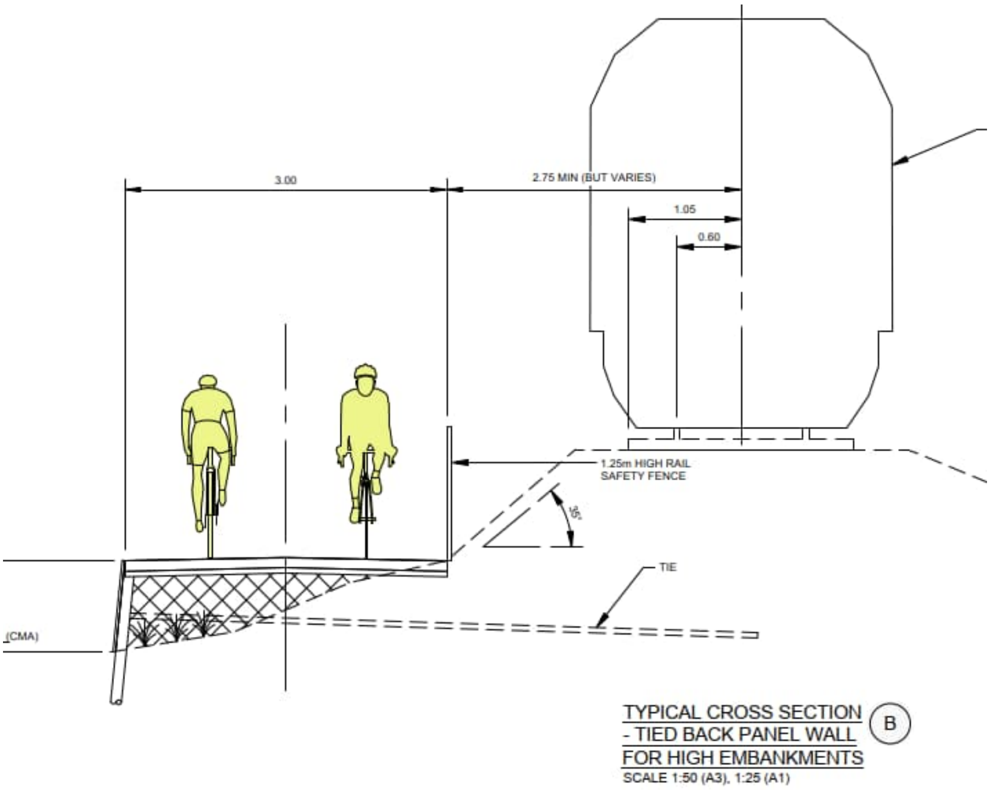


Figure 8.3 Example Treatment B option

8.3.2 Preliminary design and geotechnical considerations

The preliminary design has assessed the proposed retaining wall configuration and settlement effects on the neighbouring rail. The preliminary design has been carried out primarily to confirm:

- Likely pile embedment for stability
- Potential pile sizes and tie-back configurations based on imposed geotechnical actions.
- Lateral wall deflections and associated ground settlements upslope of the retaining wall to check effects of construction on the existing rail.
- Settlement effects on the rail from cycleway filling on compressible alluvial soils

The preliminary design has modelled one representative (worst-case) retaining wall cross section for each of the proposed Treatment A and B using WALLAP software[12]. The retaining walls have been designed using the guidance in CIRIA C760 as best engineering practice. Settlements estimations upslope of the retaining walls due to lateral wall deflections have been based on CIRIA C760.

The settlement assessment has been carried out using Settle3 software[13] and adopts a representative (worst-case) scenario of cycleway fill height up to 2.4 m (maximum fill height proposed) located at and overlying the toe of an existing rail embankment of 3.6 m height.

8.3.3 Indicative design details

Based on the preliminary design the retaining wall configuration for Treatment A may indicatively comprise:

[12] WALLAP version 6.07 by Geosolve
[13] Settle3: Settlement and Consolidation Analysis, Build. 5.021 from Rocscience Inc

- Timber pole retaining wall comprising 200 mm or 250 mm dia. SED timber poles at approximately 1 m c/c. Piles embedded 3.6 m depth.
- Horizontal cross ties are used to tie a waler (running along the front face of the wall) to a deadman anchor (concrete block or additional driven timber pole or rail irons) on the other side of the track.

Based on the preliminary design the retaining wall configuration for Treatment B may indicatively comprise:

- Timber pole retaining wall comprising 150 mm or 200 mm dia. SED timber poles at approximately 1 m c/c. Piles embedded 2.6 m depth.
- Horizontal cross ties are used to tie a waler (running along the front face of the wall) to a deadman anchor (buried timber pole or additional driven timber pole or rail irons) offset about 3 m upslope of the wall (on same side as the retaining wall).
- Alternatively, the tie-backs for both Treatment A and B may use inclined driven anchors (such as Hulk earth anchors[14] or equivalent product). These could be driven behind the wall and embedded into the rail embankment fill or underlying natural soils if ground conditions permit.

Additional considerations for the design and construction of these retaining walls is provided below considering the walls are proposed within the rail corridor:

- The tie-back installation level shall be at least 1.2 m below sleeper level in accordance with KiwiRail standard C-ST-RW-4104 and drawing DWG CE 120 45.
- The minimum horizontal offset from the rail centreline to the deadman shall be minimum 2.75 m to satisfy minimum the requirements of KiwiRail T200 Network Engineering Track Handbook.
- Alternative materials such as driven rail irons used in place of timber poles could be explored at future design stages, subject to satisfying structural and durability requirements.

8.3.4 Design results and assessment of affects

Based on the results of the preliminary design the ground settlements at rail level are expected to be less than KiwiRail allowable limits shown in Table 7.3. On this basis the retaining walls proposed in Treatment A and B are expected to have a less than minor impact on the neighbouring rail asset. Summary results presented below Table 8.1 and Table 8.2 for information.

Table 8.1: Treatment A: Preliminary design analysis results

Design case	Calculated FoS on pile embedment	Lateral wall deflections (mm)	Estimated vertical settlement at rail			
			Settlements due to wall deflections (mm)	Settlements due to filling (mm)	Total settlement (mm)	Settlement gradient across rails
Long term groundwater	≥1.5	≤10-15 mm	≤10 mm	≤5 mm	≤10-15 mm	≤1/500
Extreme (worst credible) groundwater	≥1.2	≤15-20 mm	≤10 mm	≤5 mm	≤10-15 mm	≤1/500

[14] https://www.hulkearthanchors.com/range/anchor-models

Table 8.2: Treatment B: Preliminary design analysis results

Design case	Calculated FoS on pile embedment	Lateral wall deflections (mm)	Estimated vertical settlement at rail			
			Settlements due to wall deflections (mm)	Settlements due to filling (mm)	Total settlements (mm)	Settlement gradient across rails
Long term groundwater	≥1.5	≤10-15 mm	≤10 mm	≤5 mm	≤10-15 mm	≤1/500
Extreme (worst credible) groundwater	≥1.2	≤10-15 mm	≤10 mm	≤5 mm	≤10-15 mm	≤1/500

Table Notes: Estimated settlements consider immediate (elastic) and primary consolidation soils. Secondary settlement has not been considered.

Settlements are estimated at the base of the embankment. No consideration of deformation or soil arching effects through the rail embankment or cycleway filling has been considered.

The time taken for the settlement to occur has not been considered.

8.3.5 Further design and construction considerations

Where a piled footing is needed, it is expected that driven piles will be the preferred solution to reduce concrete volumes on site to minimise costs and carbon footprint. Driven piles are also probably more suited in the soft alluvial soils which will be submerged below the tidal level /groundwater table for most of the time. It is likely that driven piles may encounter obstructions in the embankment fill material that could prevent penetration of the piles to the required depth. A different methodology (Bored piles) or pile type (steel UCs) could be adopted in these cases.

The piles may also be bored and concreted in place if the ground conditions permit, however, this is subject to further consideration at future design stages.

Further calculations will be required to determine the construction equipment and methodology for the driving of piles, this will outline sets and hammer weights etc. once these have been calculated the temporary design should be reviewed to confirm that the plant and construction loads are within the design assumptions.

Pile driving can cause some vibrations and noise during construction, we have assumed there is no issue with this construction methodology. We anticipate that the vibrations caused by pile driving is unlikely to adversely affect the existing rail tracks or local residents.

The horizontal ties shall be placed during backfilling behind the wall and trenched beneath the existing rail tracks (where required). This is standard KiwiRail practice using specialist rail equipment.

We have assumed that the construction of the cycleway/wall could be undertaken progressively using the portion of the cycleway just constructed. Thus, the wall could be subject to temporary construction surcharge loads which have been accounted for in design adopting a uniform surcharge up to 10 kPa across the cycleway width.

Construction methodology should consider and minimise the potential for damage to the cycleway by equipment and plant. This includes damage from using a pile driving rig on the cycle path. Construction using hi-rail excavator mounted piling equipment could be explored.

Environmental hazards such as oil spills from broken plant hoses or from spill during refilling could have immediate impact on the local environment. Spill protection measures should be in place during refuelling or high load activities such as boring and driving. Temporary floating spill protection can be installed in construction areas to manage the spread of any contaminants

As part of safety in design we have identified that a significant issue during construction and use of the cycleway is gaining access out of the water/soft mud back on to the cycleway, especially in areas with vertical retention next to the waters edge making climbing difficult. Designated regular access points along the cycleway would be an effective measure to enable egress from the marine area where the cycleway is elevated above surrounding ground level and should be explored at future design stages.

8.4 Treatment C – Cut slopes

8.4.1 Treatment description

Treatment C comprises cutting the existing ground to allow enough horizontal space for the cycleway, a slope is then cut back at 45^0 to 60^0 until it intercepts with the existing ground level. The current proposed solution comprises approximately 100 m of Treatment C. We note that 45^0 cut slopes have been used for the purpose of this assessment, but steeper slopes of up to about 60^0 may be possible if favourable ground conditions are encountered. Typically, this option is proposed in areas identified as likely to be Waipapa Group residual soil and rock (Ground Profile 1). The existing slopes in the areas of this treatment typically range up to about 8m, but locally extend up to 15 m height with existing batters between 35^0 to 50^0. We understand that the existing batters have been relatively stable since rail construction (i.e. no significant slope instability has been reported over a long timeframe).

It should also be noted that cutting of existing slopes may also be required over some portions of Treatment E, F and G which are described in Section 8.6.

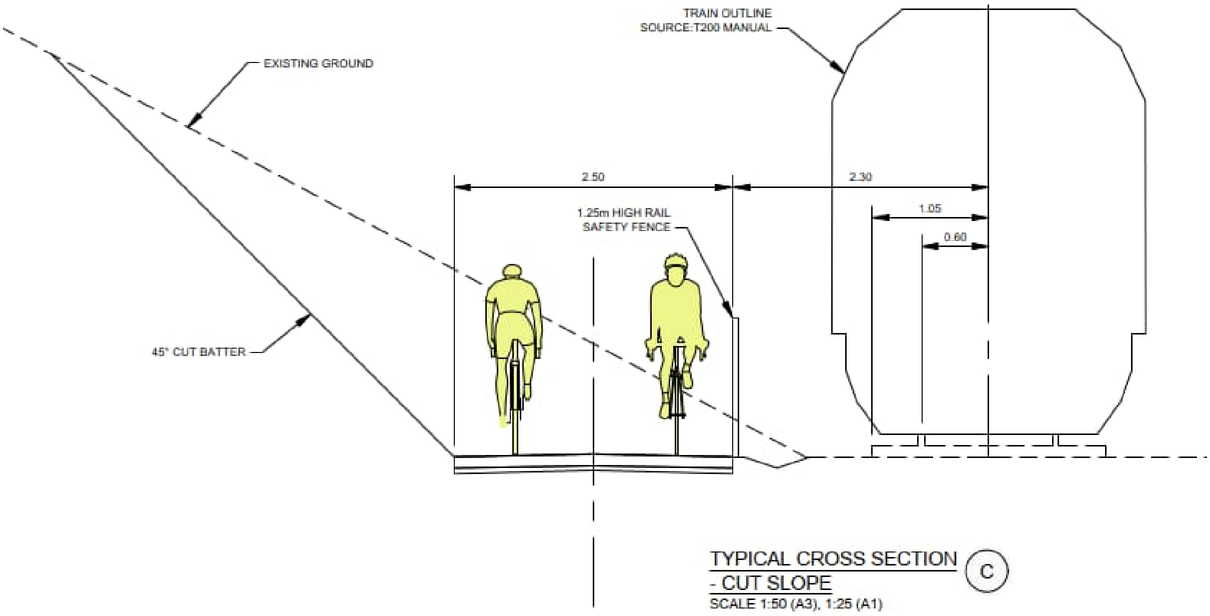


Figure 8.4 Example Treatment C option

8.4.2 Preliminary design and geotechnical considerations

The preliminary design has assessed the slope stability of the proposed cut slopes, importantly, this stability assessment compares the proposed cut slope to the existing slopes in the vicinity of the proposed treatment. The objectives of the proposed cut design is to achieve a similar level of risk to that which existed prior to the cycleway construction. For example:

- The intent is not to improve the stability of existing cut slopes (from existing performance/stability condition).
- Where there is an imminent risk or increased risk (from cycleway construction), and the risk is likely to adversely affect the safe operation of the cycleway or rail and therefore deemed unacceptable, this should be mitigated by the proposed solution so far as is practicable.

To understand the stability of the existing slopes, a back analysis stability assessment has been undertaken using the Hoek Brown design charts under fully drained groundwater conditions. We consider that the back analysis results, outlined in the Sections below, provides a basis to undertake comparative calculations for the proposed cut slopes based on the historical slope stability (i.e. long term there has been no or limited significant landslide failures). It must be appreciated that there is likely to be varying geology (especially regarding the degree of weathering of the Waipapa Group rock) across the alignment that may not have been identified at this stage of the design due to the very limited investigations in the relevant areas given the length of the cycleway project. The stability calculations undertaken in this preliminary report present a simplified model of the actual geological conditions.

Based on our knowledge of the site and proposed works, two representative cross sections have been analysed for the proposed cuts in Treatment C, and those proposed in Treatment E, F and G (described in Section 8.6);

- Cross Section 1 incorporating a 8.5 m high cut slope at 45 degrees comprising either residually weathered very stiff or hard Waipapa Group silts/clays
- Cross Section 2 incorporating a 6.5 m high cut slope at 45 degrees comprising either residually weathered very stiff or hard Waipapa Group silts/clays.

Analysis of the representative cross sections has been undertaken using;

- Hoek Brown design charts for the basic design with under fully drained slope conditions, and
- Slope/W by Geostudio, adopting the limit equilibrium Morgenstern-Price analysis method with the groundwater outlined in Section 4.5.

8.4.3 Design results and assessment of affects

The results of the stability assessment, outputted as Factors of Safety, are presented in Table 8.3. Selected results using the Hoek Brown design charts have been checked using the software package Slope/W.

Table 8.3: Slope stability analysis results

Slope height, m	Waipapa Group (residual weathered very stiff silt/clays) – lower bound		Waipapa Group (residual weathered hard silt/clays)		
	Hoek Brown design charts (fully drained slope)	Slope/W (fully drained slope)	Hoek Brown design charts (fully drained slope)	Slope/W (fully drained slope)	Slope W (high groundwater case)
14	1.0	N/A[1]	1.2	N/A[1]	N/A[1]
8.5	1.2	1.2	1.4	1.4	1.4
6.5	1.3	1.3	1.6	1.6	1.6
5.2	1.5	N/A[1]	1.7	N/A[1]	N/A[1]

[1]Slope/W analysis has only been undertaken on representative cross sections off the proposed Treatment option.

We note that some of results of the stability analysis do not achieve the Factor of Safety requirements outlined in Table 7.1. In addition to this, any excavation which steepens the existing slopes increases the risk of slope instability. However, we consider that the proposed slopes are comparative to the existing slopes in the area under inferred similar geological conditions. On this basis we consider that, while there may be some localised instability risk where slopes are steepened beyond the existing slope angle, the general risk of increased instability for where these cuts are proposed is considered low, any unacceptable risk can be managed through conventional slope stabilisation measures such as soil nails, discussed below.

8.4.4 Further design and construction considerations

8.4.4.1 General discussion

Generally, T+T investigations in the areas where these cuts are proposed is proposed encountered weathered Waipapa rock material close to, or at the face of the slope or below rail level. Our interpretation of the proposed cuts in this assessment considers the stability residual soils which may be present within the existing slope. This assessment does not consider rock stability which will be undertaken at detailed design stage. The presence of rock in the slope is likely to be favourable for stability.

The stability assessment undertaken for the proposed cuts does not consider the presence of any defects/zones of weakness within the soil/rock profile. Existing defects within existing slope, especially where intercepted by a cut slope, may increase the risk of instability. The assessment of defects in the slope requires detailed geological mapping of the existing slope. This should be undertaken at detailed design stage to assist detailed design.

If defects are found to be present in the slope, or suitable cut profiles cannot be achieved on site and are assessed to be detrimental to slope stability, stabilisation measures such as soil nails or rock bolts may be adopted to enhance the stability of the slope. Based on the recent history of the existing slopes we do not expect defects to be persistent in the existing slopes across the length of the cycleway. We expect that slope stabilisation measures (if required) would only be installed at localised critical lengths of the cycleway where defects are observed.

The established vegetation on the cut slopes is likely to be providing stabilisation to the slope through root systems and rainfall protection. We consider that, where possible, vegetation should be retained. Where removal of the existing vegetation is necessary, we recommend, at a minimum, that coconut matting is placed and planting is undertaken to protect exposed soil from local scour, excessive wetting and drying and accelerate revegetation of the cut slopes.

Due to the height of the proposed slopes and the density of the existing vegetation we consider that the larger slopes could present issues with construction access and spoil removal (especially material that cannot be used as site won fill). During the detailed design phase of the project, review of the height of the proposed cut slopes could be undertaken with consideration of reducing cut heights and vegetation removal and optimising construction cost. If pursued, and alternative design option in these areas is presented in Section 8.4.4.2 below that has been used successfully in similar situations.

There is an opportunity to seek a balance between accepting the risk of slope failures occurring during extreme events requiring on-going maintenance to repair the damage, and implementing geotechnical design to reduce the risk of slope failures, to achieve the required functionality and service at an acceptable whole of life cost. This could be explored by the design and FNDC team at ensuing design stages to achieve a best for project outcome.

8.4.4.2 Alternative design options

As outlined above, due to the topography of the slope adjacent to the cycleway, some of the proposed cut slopes may project to extend up the existing slopes a significant distance, this could be mitigated by considering an alternative design option in these localised areas to reduce the extent of earthworks and environmental impacts. An alternative option could consist a number of soil nails or rock anchors which would be used to pin a structural mesh to the cut face, see Figure 8.5, below. This would allow for a stable steeper cut (in the order of 60^0) and reduce the extent of the currently proposed cut face.

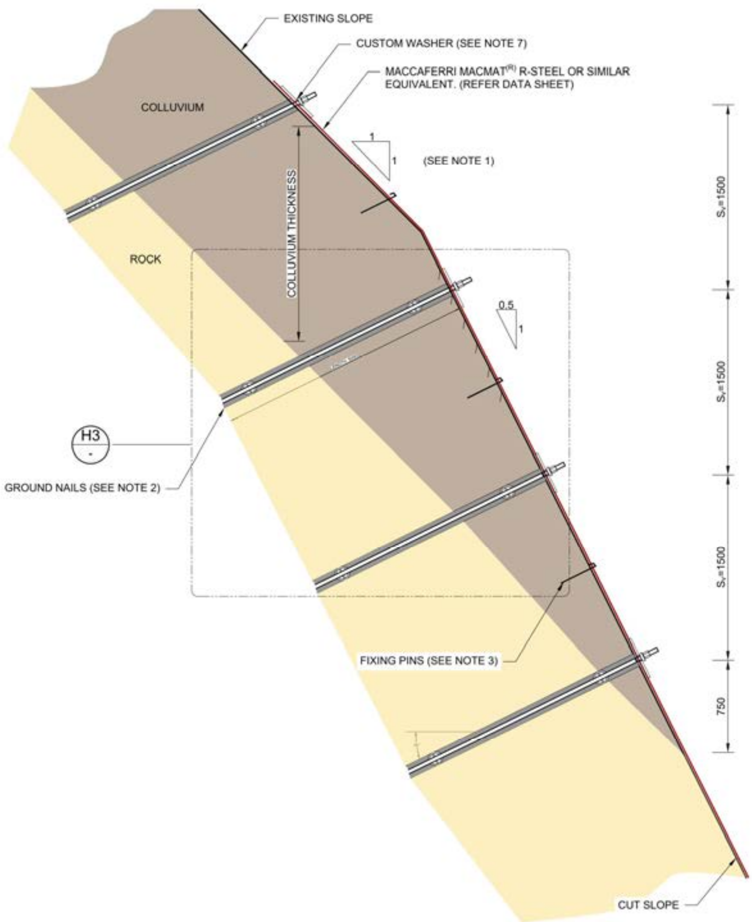


Figure 8.5 Treatment C alternative option.

As another alternative to slope stabilisation measures, the level of the cycleway may also be increased to minimise the height of the cuts at the toe of the existing slopes . If required, the level of the cycleway could be raised to replace Treatment C with retained filling below the cycleway (Treatment E, G or G). This can be confirmed at ensuing design stages.

8.4.5 Residual risk of slope instability

We note that shallow landslide failures, within the upper 1 to 2 m of the soil profile, are common within the residually weathered greywacke soils along the route. It should be appreciated that, as previously mentioned, the intent is not to enhance the slope stability away from the works, and therefore on-going shallow landslide activity on surrounding slopes can be expected, requiring on-going maintenance i.e. the status quo is expected to remain.

8.5 Treatment D – Tiered retaining wall

8.5.1 Treatment description

Treatment D, comprising a tiered retaining wall, is proposed option where the existing rail is in a cutting. The current proposed solution comprises approximately 150 m of Treatment D. The ground profile at these Treatment areas is likely to comprise ground profile type 1 (Waipapa Group soils).

The typical detail shows the cycleway constructed using a cut into toe of the existing slope. The cut is supported using a two-tiered retaining walls. The upslope retaining wall is up to 2 m high and the downslope wall less than 1 m high. Some portions of Treatment D will also include filling behind the downslope wall where the cut/fill interface is positioned between the two walls however this does not impact the premise of the solution or preliminary design below. The retaining wall configuration proposed in Treatment D aims to minimise destabilising the slopes through vegetation removal and large cutting into the toe of the slope.

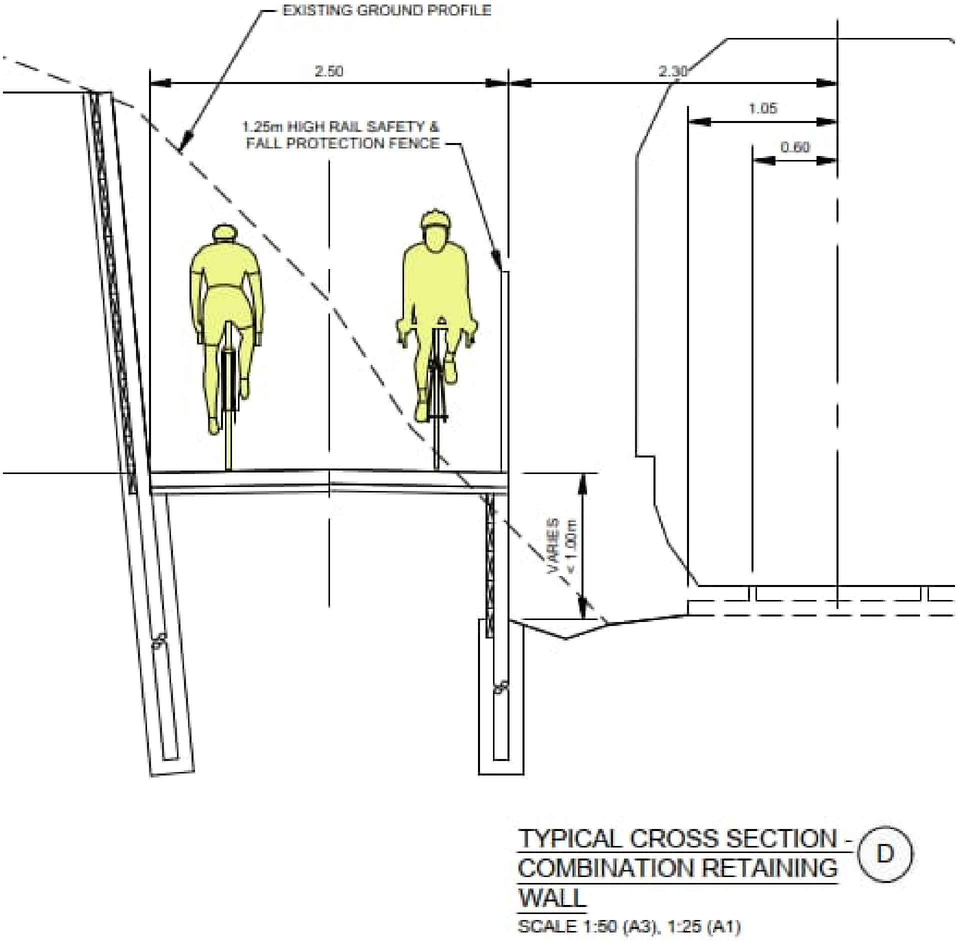


Figure 8.6 Example Treatment D option

8.5.2 Preliminary design and geotechnical considerations

The preliminary design has been undertaken to assess the upslope retaining wall to confirm:

- Likely pile embedment for stability
- Potential pile sizes based on imposed geotechnical actions
- Impact on global stability of the existing slopes upslope of Treatment D

The preliminary design has modelled the worst-case wall configuration which comprises 2 m high upslope wall height constructed at the toe of a 45 degree slope existing slope up to 12 m height. For design purposes the downslope retaining wall has been ignored.

As discussed in Section 7.4.2, the objectives of the retention solution is to achieve a similar level of risk to that which existed prior to the cycleway construction. we do not intend to improve the stability of existing cut slopes (from existing performance/stability condition) however the retaining wall has been sized to ensure that the global factor of safety of the existing slope is not adversely affected by the construction of the wall.

Global stability has used the software package Slope/W by Geostudio, adopting the limit equilibrium Morgenstern-Price analysis method. Global stability has been undertaken to assess pile actions due to lateral earth loads from global stability of the existing slopes due to upper wall cutting into the toe of the slope. A shear reinforcement load is used to model the stabilising effect of the proposed piles in the slope stability analyses. The magnitude of the reinforcement load is increased until the required factors of safety (FoS) are achieved.

The retaining wall analysis has been undertaken using WALLAP software[15] using the guidance in CIRIA C760 as best engineering practice.

8.5.3 Indicative design details

Based on the preliminary design the retaining wall configuration for Treatment D may indicatively comprise:

For the upslope wall:

- timber pole or steel UC pile retaining wall acting in cantilever using 300mm SED timber pole or UC 250 72.9 steel pile @ 1.0 m c/c
- pile length to be 5 m length (3 m embedment below cycleway level)

We expect that the downslope retaining wall up to 1m height may adopt a similar pile size/ configuration as used for Treatment E:

- Timber pole retaining wall comprising 150 dia SED timber poles at 1.2 m c/c
- Piles embedded 1.5 m depth.
- Driven or bored rail irons may also be used in-lieu of timber poles for the downslope retaining wall. Rail iron retaining walls are a standard KiwiRail design detail. This type of wall would have added sustainable benefits through the reuse old rails (circular economy benefits) and also may contribute to the heritage aspect of the project.

8.5.4 Design results and assessment of affects

There doesn't appear to be any existing public or private assets above the retaining walls, and the rail is located on the passive side of the retaining walls used at Treatment D and so settlement effects from these walls is not relevant. Summary results from the preliminary design of these walls is presented in Table 8.6 and Table 8.7 below for information.

Table 8.4: Treatment D: Global stability preliminary design results (2 m high wall)

Design case	Existing slope soil type consistency	FoS for stability		Shear load in pile kN/m
		Existing slope (back analysis on existing conditions)	Proposed 2m high retaining wall	
Long term groundwater	Waipapa Group soils (hard)	1.3	1.3	35
Extreme (worst credible) groundwater	Waipapa Group soils (hard)	1.1	1.1	35
Long term groundwater	Waipapa Group soils (very stiff) - lower bound	1.1	1.1	35

[15] WALLAP version 6.07 by Geosolve

Table 8.5: Treatment D: Retaining wall preliminary design results (2 m high wall)

Design case	Calculated FoS on pile embedment	Lateral wall deflections (mm)
Long term groundwater	≥1.5	≤20 mm
Extreme (worst credible) groundwater	≥1.2	≤20 mm

8.5.5 Further design and construction considerations

The Waipapa Group soil that the piles will be embedded is likely to be very stiff to hard. It is expected that piles will be bored concreted in place to achieve the required embedment. Shallow rock could also be present above the pile toe and therefore some drilling into rock strength material is likely. Where rock is encountered pile embedment may be shortened (to be confirmed based on actual ground conditions on site).

If less stiff soils are found at the pile toe during construction (for example historical colluvium as described in Section 4.4.4) then pile embedment may need to be marginally increased above those presented above, noting that the pile embedment adopted at preliminary design are moderately conservative values.

A general construction sequence described below has been adopted for preliminary design. This will be confirmed during detailed design stage and discussions with contractor.

- Locally excavate small bench to enable pile installation at the toe of the slope. Excavations shall use hit and miss technique to minimise risks of slope instability, i.e. only short portions of the slope shall be excavated prior to pile installation
- Install bored piles from rail mounted rig. Piles to be drilled into cut at toe of slope prior to excavation for lagging
- Excavation between piles for installation of lagging
- Install lagging and drainage backfill.

We have assumed, to enable flexibility for future construction contractors, that the construction of the cycleway/wall could be undertaken progressively using the portion of the cycleway just constructed. Thus, the wall could be subject to temporary construction surcharge loads which have been accounted for in design adopting a uniform surcharge up to 10kPa across the cycleway width.

Further considerations and limitations of current assessment for Treatment D are also provided in Section 8.4.4.

8.6 Treatment E, F and G – Buttress retaining walls

8.6.1 Treatment description

Treatment E, F and G comprising buttress retaining walls are a proposed option where the existing rail is in a cutting. The current proposed solution comprises approximately 1460 m of Treatment E, F or G. The ground profile at these Treatment areas is likely to comprise ground profile type 1 (Waipapa Group soils).

The Treatments show the cycleway constructed using filling placed against toe of the existing slopes to elevate the cycleway above rail level. The filling will be either site-won or imported fill and will be supported using an embedded retaining wall. The retaining walls are estimated to be up to 1 m height for Treatment E, 1.5 m height for Treatment F and up to 2 m height for Treatment G.

These solutions provide some additional stability to the existing slope by forming a buttress fill at the toe. The filling at the toe also reduces the cuts required to provide the cycleway width to minimise destabilising the slopes through vegetation removal and cutting into the toe of the slope.

Some portions of Treatment E, F and G may also require cutting of the existing slope above the cycleway (as shown in the figure 8.7 below). The preliminary design details and geotechnical considerations of these cut slopes are described in Section 8.4.

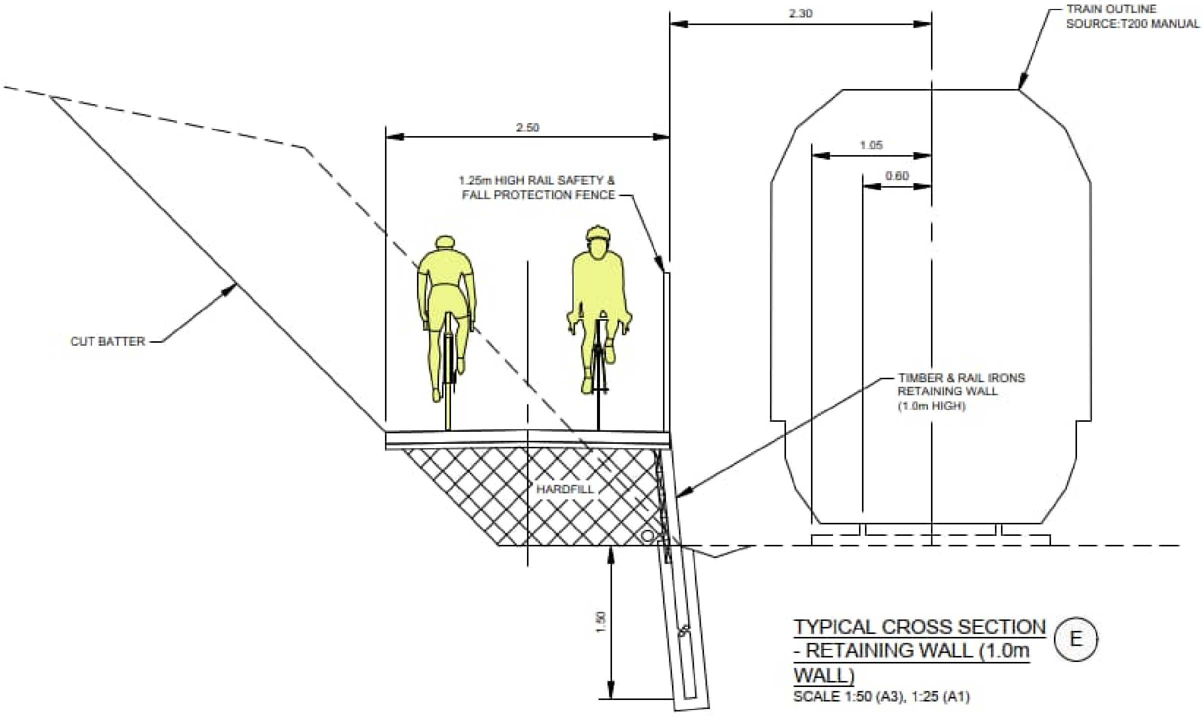


Figure 8.7 Example Type E option (1.0m high variant)

8.6.2 Preliminary design and geotechnical considerations

The preliminary design has assessed the proposed retaining wall configuration to confirm:

- Likely pile embedment for stability
- Potential pile sizes based on imposed geotechnical actions.

The preliminary design has modelled two representative retaining wall cross sections assuming typical 1 m high wall and typical 2 m high wall. The analysis has been undertaken using WALLAP software[16]. The retaining walls have been designed using the guidance in CIRIA C760 as best engineering practice.

8.6.3 Indicative design details

Based on the preliminary design the retaining wall configuration for Treatment E may indicatively comprise:

- Timber pole retaining wall comprising 150 dia SED timber poles at 1.2 m c/c
- Piles embedded 1.5 m depth.

[16] WALLAP version 6.07 by Geosolve

Based on the preliminary design the retaining wall configuration for Treatment F and G may indicatively comprise:

- Timber pole retaining wall comprising 200 dia SED timber poles at 1.2 m c/c
- Piles embedded 2.5 m depth.

Driven or bored rail irons may also be used in-lieu of timber poles for some of these retaining walls. Rail iron retaining walls are a standard KiwiRail design detail. This type of wall would have added sustainable benefits through the reuse old rails (circular economy benefits) and also may contribute to the heritage aspect of the project.

8.6.4 Design results and assessment of affects

There doesn't appear to be any existing public or private assets above the retaining walls, and the rail is located on the downslope passive side of the retaining walls used at Treatment E, F and G and so settlement effects from these walls is not relevant. Summary results from the preliminary design of these walls is presented in Table 8.6 and Table 8.7 below for information.

Table 8.6: Treatment E: Preliminary design results (1 m high wall)

Design case	Calculated FoS on pile embedment	Lateral wall deflections (mm)	Vertical settlement at cycleway (mm)
Long term groundwater	≥1.5	≤20 mm	≤10 mm
Extreme (worst credible) groundwater	≥1.2	≤20 mm	≤10 mm

Table 8.7: Treatment F and G: Preliminary design results (2 m high wall)

Design case	Calculated FoS on pile embedment	Lateral wall deflections (mm)	Vertical settlement at cycleway (mm)
Long term groundwater	≥1.5	≤20 mm	≤10 mm
Extreme (worst credible) groundwater	≥1.2	≤20 mm	≤10 mm

8.6.5 Further design and construction considerations

The Waipapa Group soil that the piles will be embedded is likely to be very stiff to hard. It is expected that piles will be bored concreted in place to achieve the required embedment. Shallow rock could also be present above the pile toe and therefore some drilling into rock strength material is likely. Where rock is encountered pile embedment may be shortened (to be confirmed based on actual ground conditions on site).

If less stiff soils are found at the pile toe during construction (for example historical colluvium as described in Section 4.4.4) then pile embedment may need to be marginally increased than those presented above noting that the pile embedment adopted at preliminary design are moderately conservative values.

We have assumed, to enable flexibility for future construction contractors, that the construction of the cycleway/wall could be undertaken progressively using the portion of the cycleway just constructed. Thus, the wall could be subject to temporary construction surcharge loads which have been accounted for in design adopting a uniform surcharge up to 10 kPa across the cycleway width.

8.7 Treatment H –Fill revetment

8.7.1 Treatment description

Treatment H comprises a fill revetment and is proposed option where the existing rail is on a fill embankment extending over the low-lying ground. The ground profile at these areas is likely to comprise ground profile type 2 (embankment fill overlying alluvial soils). Alternating treatment Options H and L are proposed over 1300 m. Over this length we estimate that approximately 70% (910 m) could be assumed to be Option H.

A low-level fill embankment will be placed against toe of the existing rail embankment, using either site-won or imported fill. The slope will have a toe batter angle of 1V:2H, with typical heights of about 1 m.

A fill revetment is likely to be the most cost-effective solution but carries the highest environmental and planning risk due to the increased footprint near too or within the CMA.

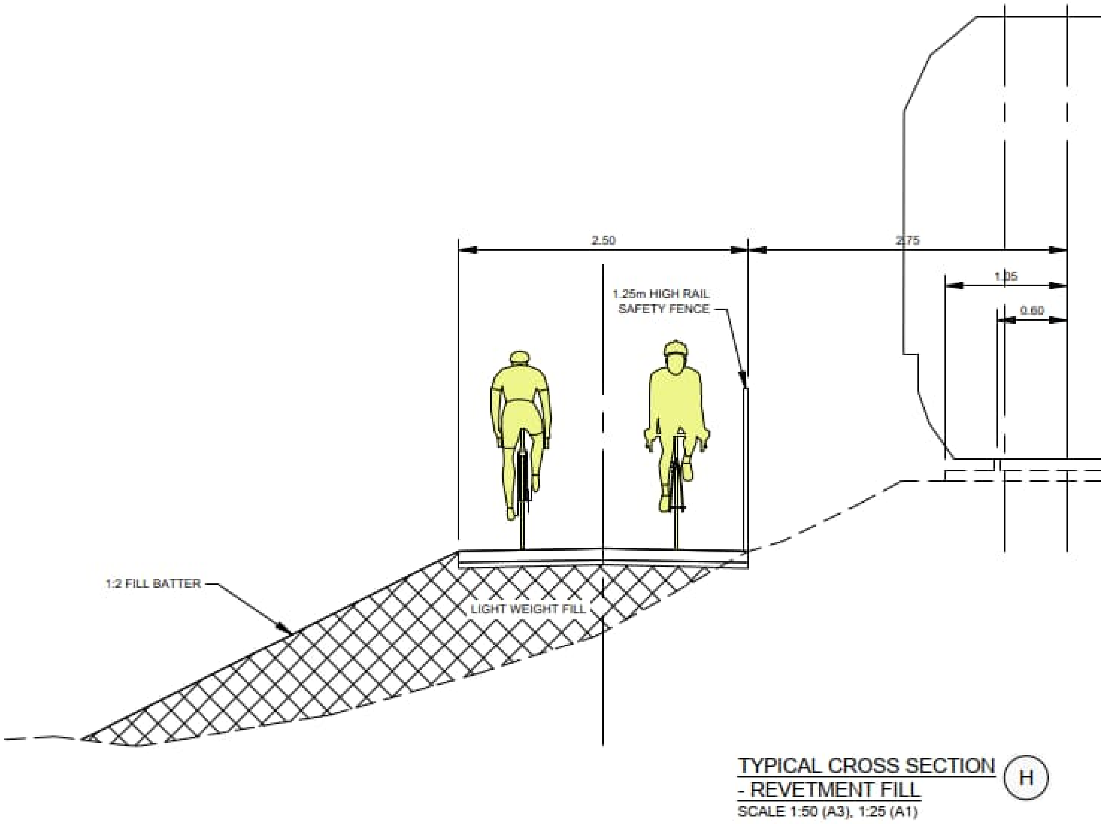


Figure 8.8 Example Treatment H option

8.7.2 Preliminary design and geotechnical considerations

The preliminary design has assessed the proposed revetment stability and settlement effects on the neighbouring rail.

The global stability analyses have been undertaken using the software package Slope/W by Geostudio, adopting the limit equilibrium Morgenstern-Price analysis method. For design purposes two typical rail embankment heights of 3 m and 5 m have been adopted with corresponding revetment fill height of 2 m with batter slope 1v:2h. The ground conditions have assumed soft alluvial soils greater than 6 m depth.

The settlement assessment has been carried out using Settle3 software[17] and adopts a representative (worst-case) scenario of cycleway fill height up to 1.2 m height of cycleway fill (maximum fill height proposed) located on the toe of an existing rail embankment of 1.5 m height

8.7.3 Design results and assessment of affects

The preliminary design indicates that the global stability of the cycleway revetment satisfies the minimum design FoS in Table 7.1. Based on the results of the preliminary design the ground settlements at rail level are expected to be less than KiwiRail allowable limits shown in Table 7.3. On this basis the filling proposed for Treatment H is expected to have a less than minor impact on the neighbouring rail asset. Summary results presented below in Table 8.8 for information.

Note the stability of the revetment is dependent on the stability of the existing rail embankment. The slope stability analysis has indicated that the existing rail embankment may not meet KiwiRail design standards for stability which is not unexpected. The revetment will form a buttress to the rail embankment which the analysis shows will generally improve the overall rail embankment stability.

Table 8.8: Preliminary design results for Treatment H

Typical rail embankment height	Typical revetment height	Estimated settlement		FoS for stability – static case		
		Below revetment	At rail	Rail embankment (back analysis on existing conditions)	Rail embankment (with cycleway filling)	Revetment filling only
3 m	2 m	60 – 120 mm	≤5 mm	1.1 – 1.4	1.4 – 1.6	≥1.5
5 m	2 m	60 – 120 mm	≤5 mm	1.0 – 1.4	1.1 – 1.4	≥1.5

Table Notes: Estimated settlements consider immediate (elastic) and primary consolidation soils. Secondary settlement has not been considered.

Settlements are estimated at the base of the embankment. No consideration of deformation or soil arching effects through the rail embankment or cycleway filling has been considered.

The time taken for the settlement to occur has not been considered at this stage of deisgn.

8.7.4 Further design and construction considerations

The fill will be placed on soft marine mud, and a significant volume may be lost due to “punching” into this mud. A separation geotextile should be placed between the mud and the fill to mitigate against this material loss. Larger rockfill may also be used as a basal layer to aid compaction of the cycleway fill, if required.

We have assumed that the construction of the cycleway/wall could be undertaken progressively using the portion of the cycleway just constructed. Thus, the wall could be subject to temporary construction surcharge loads which have been accounted for in design adopting a uniform surcharge up to 10 kPa across the cycleway width.

Due to the anticipated settlement of the revetment fill, the cycleway could be widened and over filled to accommodate the predicted settlement, or alternatively widened and an allowance made to top up the trail to design levels under regular maintenance.

[17] Settle3: Settlement and Consolidation Analysis, Build. 5.021 from Rocscience Inc

8.8 Treatment I – MSE wall system

8.8.1 Treatment description

Treatment I has been identified as a solution for raising the current ground level on a slope to provide a flat track necessary for the cycleway. Treatment I proposes utilising a MSE wall system similar to 'flexMSE' that incorporates layers of geogrid connected to a flexible facing comprising bags of topsoil. The current proposed solution comprises approximately 960 m of Treatment I.

The typical cross section where Treatment I has been proposed has an existing slope of between 25^0 to 35^0 and is expected to be up to 8.5 m high. The MSE wall itself is expected to reach up to 1.7 m high for a 2.5 m wide cycleway.

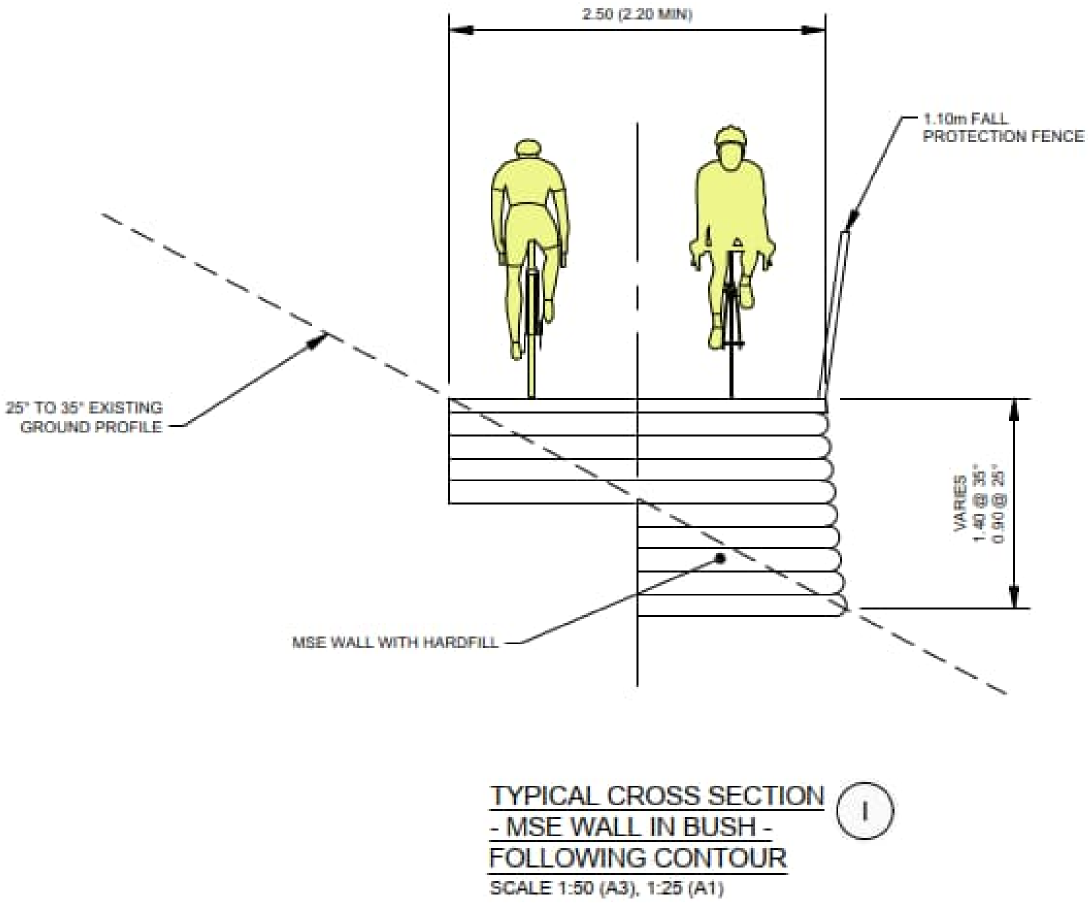


Figure 8.9 Example Treatment I option

8.8.2 Preliminary design and geotechnical considerations

The internal retention design (i.e. number and length of the geogrids) is expected to be undertaken during the detailed design process, we consider that the internal stability of the proposed design will fall within standard designs for this type of wall. We expect this could incorporate approximately 4 layers of 2.5 m long Geogrid for the 1.4 m high wall.

As part of this scope of work, we have undertaken an assessment of the global stability of the slope incorporating the increased loads from the MSE wall and the cycleway loads. The analyses have been undertaken using Slope/W, adopting the limit equilibrium Morgenstern-Price analysis method. For design purposes the worst case retained height (1.7 m height at 35^0 slope angle) has been adopted as a surcharge assuming a fill unit weight of 19 kN/m^3. The live load of 3.5 kPa has been adopted based on the guidance in SNZ HB 8630.2004 and has been incorporated into the surcharge load by adding an equivalent soil weight.

We have undertaken calculations considering both very stiff and hard Waipapa Group soils and Groundwater levels as outlined in Section 4.4.2.

8.8.3 Design results and assessment of affects

The results of the stability assessment, outputted as Factors of Safety, are presented in Table 8.9, below.

Table 8.9: Slope stability results

Ground model	Groundwater	Existing case (back analysis)	Treatment I: 2.5m wide MSE wall
Hard Waipapa Group	long term	1.8	1.6
Hard Waipapa Group	Extreme (worst credible)	1.6	1.5
Very stiff Waipapa Group	long term	1.5	1.4
Very stiff Waipapa Group	Extreme (worst credible)	1.4	1.3

The results indicate that the global stability of the design reduces the existing slope stability but falls within the allowable Factors of Safety as outlined in Section 7.4

8.8.4 Further design and construction considerations

As discussed above, detailed design of the internal stability of the wall will be required during the detailed design phase of the project, this will require confirmation of the MSE facing material/system that is preferred considering the access requirements for construction.

As part of the detailed design, confirmation that the assumptions undertaken in this preliminary design are still relevant, especially with regard to geology, retained height and slope angle of the proposed design.

Following detailed design additional excavation may be required to key the base of the MSE wall into the existing ground, the temporary excavation should be checked for stability and a detailed construction methodology may be required to control excavations.

We note that the geometric design of these sections requires refinement and is limited by the accuracy of existing survey information. Therefore, either detailed topographic survey is required to enable detailed design, or the design afforded flexibility at construction stage and an observational method to construction adopted. The observational method would require additional on-site design support, but enable the contractor flexibility in constructing the route to fit the natural contour while maintaining the design intent. This is a common design and construction practice on linear projects where site survey and investigation information is limited. This should be reviewed and agreed within the project team prior to commencing detailed design.

8.9 Treatment J, J1 and K – Timber boardwalk

8.9.1 Treatment description

These Treatments comprise an elevated timber boardwalk located on, adjacent to or offset from rail embankment to form the cycleway. The current proposed solution comprises approximately 990 m of Treatment J, J1 or K. They are proposed where the existing rail is on a fill embankment extending over the low-lying ground. The ground profile at these areas is likely to comprise ground profile type 2 (embankment fill overlying alluvial soils).

These Treatments are the preferred solution where cycleway filling or retention are avoided to reduce adverse planning and ecological impacts, and to add variety to the cycle route experience and enhance user connectivity to the surrounding environment as the cycleway can deviate from the rail alignment using a timber boardwalk.

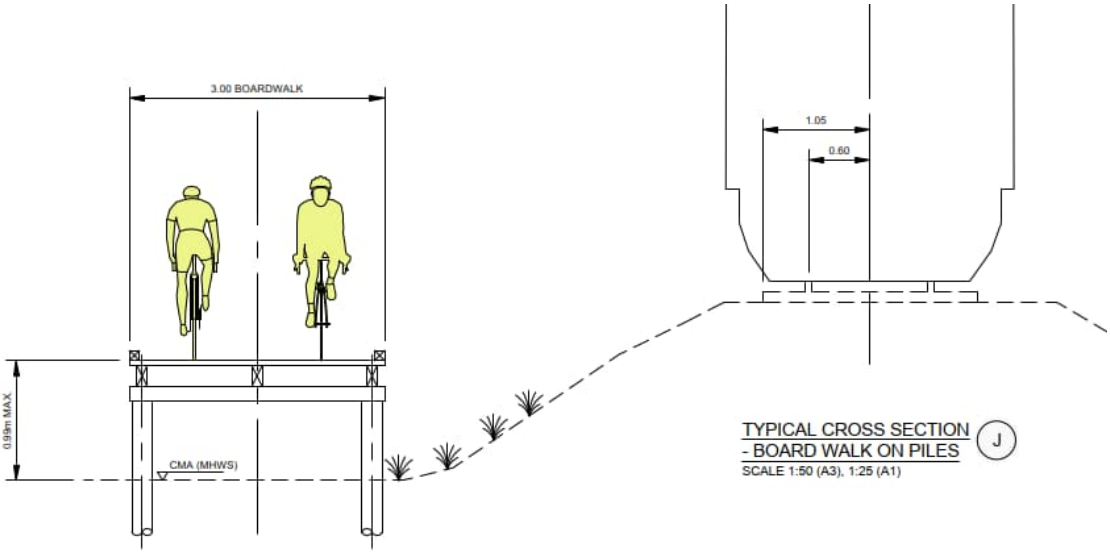


Figure 8.10 Example Treatment J Option

8.9.2 Preliminary design and geotechnical considerations

The preliminary geotechnical design of the boardwalk has considered the vertical loading on the boardwalk piles to determine indicative pile size and embedment. The design has considered a worst-case ground model comprising soft alluvial clay to at least 10 m depth. It is anticipated that the piles will be designed to resist loads through side friction in the soft alluvial soils, rather than relying on end bearing in a competent stratum, due to the likely depth of the soft alluvial sediments.

8.9.3 Indicative design details and assessment of effects

The preliminary design for the boardwalk piles has considered the following pile details:

- H5 treated 250 mm SED timber piles with piers at 3 m centres, 2 piles per pier.
- Indicative pile embedment (to resist vertical loads) = up to 6.5 m
- Minimum pile length (for uplift) = 1.3 m

Alternatively, other conventional piling methods or products may be adopted if preferred by the project team and construction contractor, subject to detailed design. These could comprise elements such as driven steel piles or screw piles and should be assessed with consideration of the constructability and durability of such products within the marine environment.

8.9.4 Further design and construction considerations

It is expected that boardwalk piles will be driven to reduce concrete volumes on site to minimise costs and carbon footprint. Driven piles are also probably more suited in the soft alluvial soils which will be submerged below the tidal level / groundwater table for most of the time.

We have assumed that the construction of the boardwalk could be undertaken progressively using the portion of the boardwalk just constructed to limit construction plant operating on the adjacent open ground. Thus, the boardwalk could be subject to temporary construction surcharge loads which have been accounted for in design by adopting a uniform surcharge up to 10 kPa across the cycleway width.

8.10 Treatment M – Extension of Long Bridge walkway

8.10.1 Treatment description

This is a narrow version of the boardwalk (Treatment Option J) and is proposed west of Long Bridge where the cycleway comprises an extension of the existing Long Bridge access walkway currently used by cyclists and therefore falls under the crossing protection measures and no train clearance is required. This Treatment Option is only used for short length (~115 m) of the southern end of cycleway to facilitate transition from Long Bridge to cut ground.

For Treatment M, the proposed boardwalk is founded on slopes of up to about 36^0. Where these slopes are present, driven timber piles may not be able to be effectively utilised. We have considered that Screw piles may be required in this location.

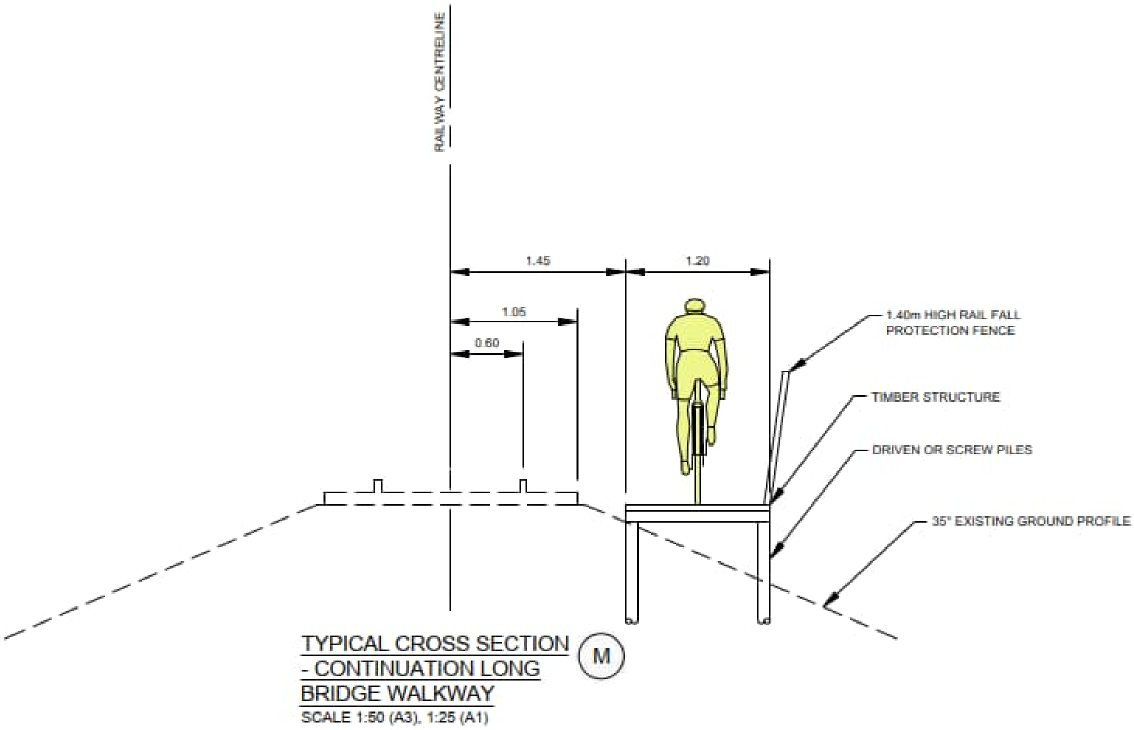


Figure 8.11 Example Treatment M option

8.10.2 Preliminary design and geotechnical considerations

The preliminary geotechnical design of the boardwalk has considered the vertical loading on the boardwalk piles to determine indicative pile size and embedment. The design has considered a worst-case ground model comprising soft alluvial clay to at least 10 m depth. It is anticipated, under these conditions, that the piles will be designed to resist loads primarily through side friction in the soft alluvial soils. We note that the piles are likely to be, at least partially, within the embankment fill, this material is considered to be able to provide higher bearing and shear capacity so there is the opportunity to reduce the pile lengths required during detailed design.

We have considered that there may be some additional stress on the screw piles from the sloping ground, generally a combination of the extension of the downslope pile out of the ground and the uneven soil loading on the sides of the piles. We have assumed a deadman system, as proposed by Treatment A, and bracing the piles will be sufficient to resist the horizontal loading with no further increase to the pile sizes.

8.10.3 Indicative design details and assessment of effects

The preliminary design for the Treatment M screw piles has considered the following pile details:

- Screw piles with 400 mm spiral diameter, with a minimum spiral length of 3 m with piers at 3 m centres, 2 piles per pier.
- Indicative pile embedment (to resist vertical loads) = up to 3.5 m
- Minimum pile length (for uplift) = 1.0 m

Alternatively, other conventional piling methods or products may be adopted if preferred by the project team and construction contractor, subject to detailed design. These could comprise elements such as driven steel or timber piles and should be assessed with consideration of the constructability and durability of such products within the marine environment.

8.10.4 Further design and construction considerations

As outlined above, a worst case model of embedment in alluvium soils has been assumed, however, it is likely that the screw piles will be founded in part in the embankment fill, depending on the alignment compared to the embankment. Where this is the case the pile sizes may be able to be reduced.

There is a risk of encountering rock boulders or other high strength inclusions within the embankment fill material, this could cause early termination of the piling or damage to the screw piles. Where this is the case, other pile options such as driven UCs or bored piles may be able to penetrate the inclusion otherwise review, where this is the case, would be undertaken on a case-by-case basis. The probability of this risk occurring can be determined during the detailed design, further investigation of the embankment fill can give an indication if there is widespread large rock boulders within the fill material.

8.11 Bridges and clip-ons to existing bridges

The cycleway crosses water courses at a number of locations where existing bridges and culverts are present. Where culverts are located the default design solution is to span the gap using a short section of boardwalk that ties into the Treatment Option on either side. At three existing bridges (Bridges 10 to 12), work is being undertaken to develop clip-on structures to the existing bridges. The transition from clip-on to the proposed Treatment Option at either side may require short sections of boardwalk to tie the clip-on structure into the cycleway.

8.11.1 Considerations for consenting

At this design stage piles located within the CMA (or at the abutments outside of the CMA) to support bridges adjacent to existing rail bridge structures are not envisioned. However, the structural design of clip-ons and assessment of the capacity of the existing bridges and foundations remains on-going. Therefore, provision should be made within the consent for bored steel reinforced concrete piles or larger diameter driven timber or steel piles should they be required at detailed design or construction stage. Similarly, sections of boardwalks with longer spans to bridge over existing structures such as culverts or flood channels, or unforeseen ground conditions may also be required and could be supported on larger diameter piles, if required.

9 Conclusions

The cycleway design will be constructed using a number of design solutions, termed here “Treatment Options” to separate the cycleway from the rail and bring it to the required function and utility. The location and implementation of each Treatment Option have been developed with consideration of the clearance needed from the railway (but not limited to) topography, cost, constructability, minimising ecological impact, planning constraints, heritage constraints and opportunities, and importantly to promote connectivity with the natural environment.

The preferred cycleway alignment generally remains within the existing rail corridor designation and at one point also crosses a parcel of Council road reserve in order to meet grade requirements for crossing the elevated topography above Whangae Tunnel.

Wherever possible, the cycleway Treatment Option adopted will be the lowest cost option available that meets the design and client functionality requirements. The default, lowest cost option is an at grade, metalled surface requiring only minor earthworks. Where this is not achievable, then engineering works such as cut slopes, retained ground and sections of boardwalk are required.

Alternative design Treatment Options/solutions are provided for robustness and to enable flexibility during future design and construction stages should they be required. The 6 km length of trail straddles low lying and elevated topography, and the design is based on limited topographical survey and geotechnical investigations. In addition, some elements of the design, such as bridge clip-ons are in the early stages of design. Therefore, flexibility should carry through the consent application to enable development and implementation of alternative solutions at future project stages.

The proposed design solutions will be further refined at detail design. Whilst the design has been undertaken using accepted engineering design codes and standards, there is an opportunity to seek a balance between mitigation of risk through geotechnical design and accepting risk of failures occurring during extreme events. This would be concentrated on areas which could be remediated by on-going maintenance and repair of the damage (i.e. in cut slopes) to achieve the required functionality and service at an acceptable whole of life cost. This could be explored by the design and FNDC team at ensuing design stages to achieve a best for project outcome.

The method of design and construction procurement has not yet been confirmed. The lengths of the cycleway between the Whangae Tunnel and Opua presents well to a conventional detailed design and construction procurement process i.e. NZS 3910 construction only (or similar) with re-measurement. Whereas, due to a number of factors, other sections of the cycleway may be best delivered using a toolbox of design solutions developed for implementation using an “observational method” during construction. This method reduces investigation, survey and detailed design effort but requires a higher level of designer support at construction.

Based on the preliminary design undertaken to date and presented herein, we consider that the proposed treatment options and associated contingency measures provide sufficient flexibility to achieve the functionality requirements of the cycleway project. Provided the advice provided within this report is adhered too, and subject to detailed design and the construction procurement adopted, we consider that the effects to adjacent structures and properties can be suitably managed such that any adverse effect is less than minor.

10 Geotechnical risks and uncertainties

A project-specific geotechnical risk register has been prepared for the project and is included in Appendix D. This will remain live throughout the project and communicated with FNDC regularly. Where risks cannot be suitably mitigated through the design process then the risks will be passed to suitable risk owners prior to construction.

11 Supplementary geotechnical investigations

The design and recommendations outlined in this report are based on limited investigations in in discrete locations. Some areas of the designs pose increased risk due to limited amounts of investigation information including increased settlement risk and slope stability risk. Additional geotechnical investigations could be undertaken to reduce the risk of issues during the construction or life of the cycleway. Additional investigations would also be utilised in detailed design and allow for an increase in confidence of soil conditions, potentially reducing construction costs.

- Test pitting / geological mapping within existing slopes where Treatment C to G at critical locations to assist slope stability modelling at detailed design stage. Piezometers for groundwater monitoring could also be installed at select locations within these existing slopes to assist slope stability modelling at detailed design stage.
- Geomorphological mapping with hand augers or test pits to confirm the presence of historical colluvium at critical locations to assist detailed design.

- Installation of piezometers for groundwater monitoring at select locations above Te Raupo Tunnel to assist slope stability modelling at detailed design stage.
- CPTs in the marine sediments located on the lower lying land in the northern portion of the cycleway (north of chainage 7000km) to confirm nature and depth of softer soils and liquefaction risks to compliment the CPT already undertaken by Haigh Workman between Ch 4600m and 7000m in 2021.
- Test pits within the rail embankment fill to identify the consistency and nature of the rail embankment soils for retaining tie-back and deadman constructability and detailed design.

12 Key design verification requirements / further work

The following further geotechnical work is proposed throughout the project life cycle. This work is contingent on the method on which the design and construction activities are procured:

1. Additional geotechnical site investigations should be considered as described in Section 11.
2. Detailed geotechnical and structural design of Treatment Options
3. Monitor the geotechnical aspects during construction to verify ground conditions adopted in design.
4. Prepare completion documentation for the geotechnical and structural components of the development.

13 Applicability

This report has been prepared for the exclusive use of our client Far North District Council, 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 as part of an application for resource consent and that Far North District Council as the consenting authority will use this report for the purpose of assessing that application.

Recommendations and opinions in this report are based on data from discrete investigation locations. The nature and continuity of subsoil away from these locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Report prepared by:
....	....
Peter Minford Senior Geotechnical Engineer	Jacob Simpson Senior Geotechnical Engineer

Report Reviewed by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Mark Child Project Manager	John Cooper Project Director

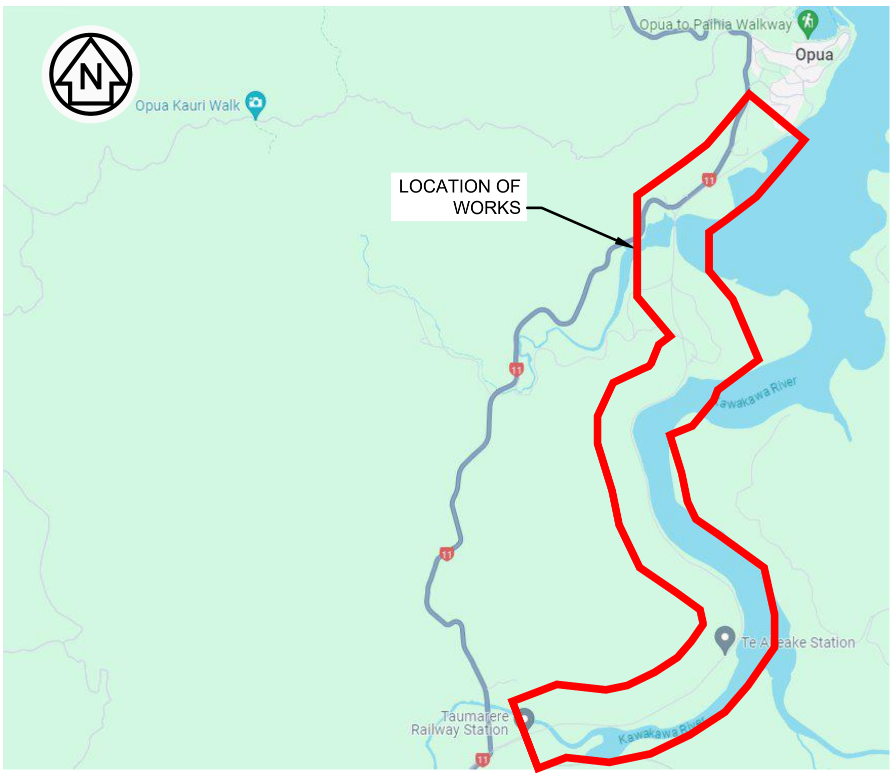
9-Oct-24
\\ttgroup.local\corporate\auckland\projects\1090082\workingmaterial\2.0 - geotech design\3 prelim design\geotechnical assessment report\taumarere to opua cycleway_preliminary geotechnical assessment report_v0.2.docx

Appendix A Resource consent drawings

Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

KAWAKAWA TO OPUA CYCLE TRAIL

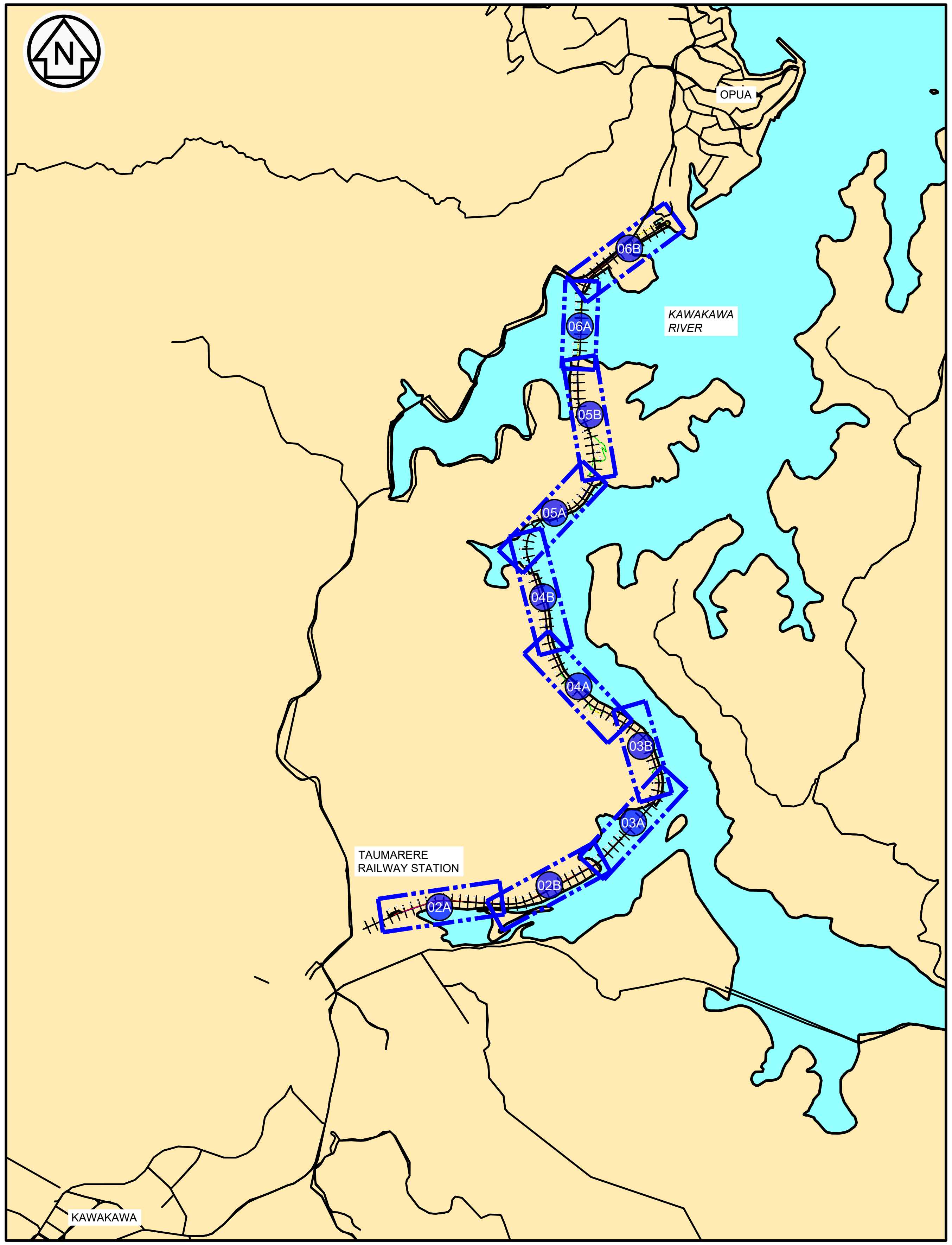
CONSENT DRAWINGS



LOCALITY PLAN
NTS

VISUALISATION

DATE: NOV. 2024
JAS CIVIL LTD
2209-RC-00



INDEX PLAN
SCALE: NOT TO SCALE

DRAWING LIST

DRAWING No: 2209 **JOB NUMBER: 2209-RC**

SHEET No.	SHEET TITLE	REVISION				
		DAY 4				
		MONTH 11				
		YEAR 24				
00	COVER SHEET, LOCALITY PLAN	1				
01	INDEX PLAN & SHEET LIST	1				
02	CONSENT DRAWINGS - CHN 4620 TO 5590	1				
04	CONSENT DRAWINGS - CHN 5590 TO 6770	1				
05	CONSENT DRAWINGS - CHN 6770 TO 8130	1				
06	CONSENT DRAWINGS - CHN 8130 TO 9870	1				
07	CONSENT DRAWINGS - CHN 9870 TO 10940	1				
08	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'A' & VISUALISATION	1				
09	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'B' & VISUALISATION	1				
10	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'C'	1				
11	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'D' & VISUALISATION	1				
12	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'E' & VISUALISATION	1				
13	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'F' & VISUALISATION	1				
14	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'G' & VISUALISATION	1				
15	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'H'	1				
16	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'I' & VISUALISATION	1				
17	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'J' & VISUALISATION	1				
18	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'J1' & VISUALISATION	1				
19	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'K' & VISUALISATION	1				
20	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'L' & VISUALISATION	1				
21	CONSENT DRAWINGS - TYPICAL CROSS SECTION 'M' & VISUALISATION	1				

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

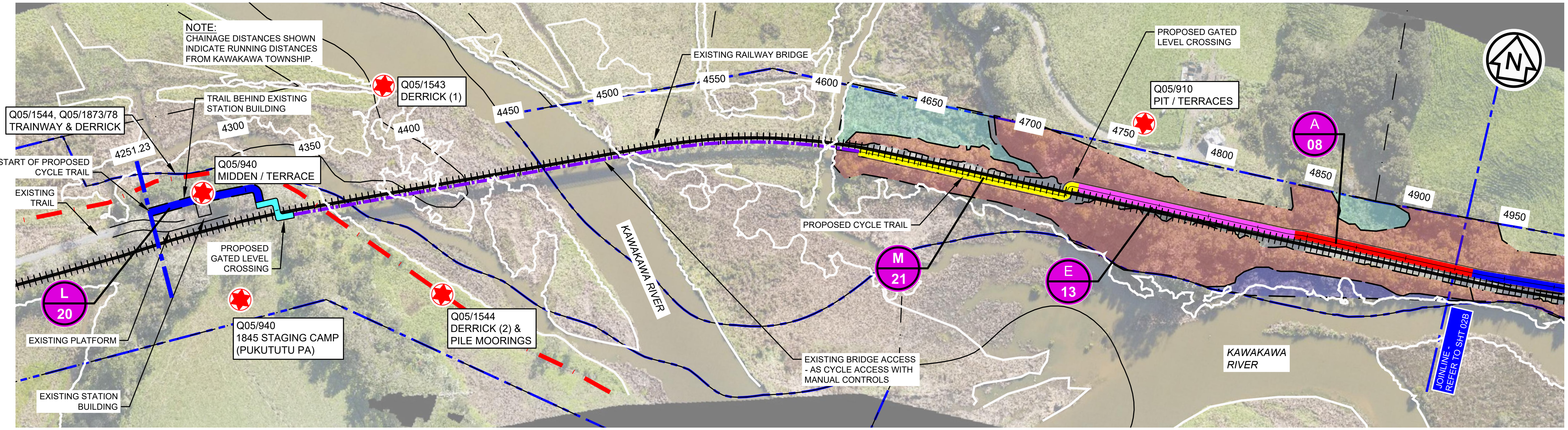
JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

INDEX PLAN & SHEET LIST

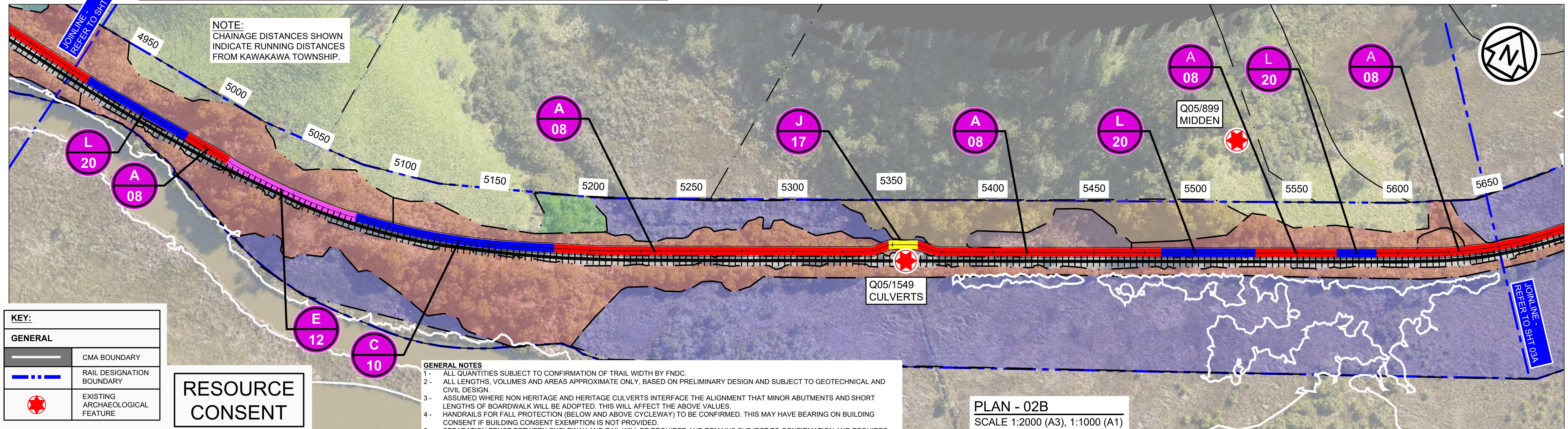
STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:
SCALE: SHOWN
PLOT DATE
JOB: 2209-RC
SHEET: 01
REVISION: 1



PLAN - 02A

SCALE 1:2000 (A3), 1:1000 (A1)

	Wall Length (m)	Wall Area (m²)	Boardwalk Length (m)	Boardwalk Area (m²)	Total CMA Encroachment Area (m²)	Total Area of Permanent Earthworks (m²)	Total Volume of Permanent earthworks - Cut Material (m³)	Total Volume of Permanent earthworks - Fill Material (m³)
Dwg 2 - 4620 to 5590m	760	733	115	162	0	3076	600	809



PLAN - 02B

SCALE 1:2000 (A3), 1:1000 (A1)

KEY:

GENERAL	
	CMA BOUNDARY
	RAIL DESIGNATION BOUNDARY
	EXISTING ARCHAEOLOGICAL FEATURE

KEY:

ECOLOGY AREAS	
	EXOTIC
	KANUKA
	MANGROVE
	MINGIMINGI
	OIOI RUSHLAND
	RAUPO
	RAUPO/ KUTA

RESOURCE CONSENT

KEY:

TRAIL CROSS SECTIONAL TREATMENTS		REFERENCE
	TREATMENT 1 - BOARDWALK	J J1 K M
	TREATMENT 2 - RETAINED WITHIN RAIL EMBANKMENT	A B
	TREATMENT 3 - RETAINED ADJOINING NATURAL SURFACES	D E F G
	TREATMENT 4 - ON GRADE, BATTERED SLOPES - NO STRUCTURES	C H L
	TREATMENT 5 - MTB STYLE TRACK IN BUSH, CUTS, FILLS & MSE SLOPES	I
	TREATMENT 6 - BRIDGES, EITHER NEW OR CLIP ON EXISTING	N

GENERAL NOTES

1 - ALL QUANTITIES SUBJECT TO CONFIRMATION OF TRAIL WIDTH BY FNDC.
2 - ALL LENGTHS, VOLUMES AND AREAS APPROXIMATE ONLY, BASED ON PRELIMINARY DESIGN AND SUBJECT TO GEOTECHNICAL AND CIVIL DESIGN.
3 - ASSUMED WHERE NON HERITAGE AND HERITAGE CULVERTS INTERFACE THE ALIGNMENT THAT MINOR ABUTMENTS AND SHORT LENGTHS OF BOARDWALK WILL BE ADOPTED. THIS WILL AFFECT THE ABOVE VALUES.
4 - HANDRAILS FOR FALL PROTECTION (BELOW AND ABOVE CYCLEWAY) TO BE CONFIRMED. THIS MAY HAVE BEARING ON BUILDING CONSENT IF BUILDING CONSENT EXEMPTION IS NOT PROVIDED.
5 - SEPARATION FENCE BETWEEN CYCLEWAY AND RAIL WILL BE REQUIRED AND REMAINS SUBJECT TO CONFIRMATION AND REQUIRES SAFETY CASE APPROVAL BY BOIVRT, KIWIRAIL AND NZTA REGULATORS. GRADE SEPARATION MAY REDUCE ACTUAL LENGTHS.
6 - CMA ADOPTED FROM MHWS WHICH HAS BEEN INFERRED AT 1.1m R.L. OTP 1964 DATUM FOR THE PURPOSES OF THIS PROJECT. POSITION SHOWN IS APPROXIMATE ONLY. CERTIFICATION BY REGISTERED SURVEYOR REQUIRED TO CONFIRM ACCURACY OF LINE.
7- DO NOT SCALE DRAWING.
8- NOMINAL SCALE IS SHOWN FOR A3 SIZE UNLESS SHOWN OTHERWISE.
9- COORDINATES IN TERMS OF NZTM GEODETIC 2000 DATUM.
10- LEVELS IN TERMS OF MEAN SEA LEVEL ONE TREE POINT DATUM.
11- AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.

0 20 40 60 80 100m

SCALE 1:2000 AT ORIGINAL SIZE

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

Do not scale drawing. Check all dimensions on site before construction

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS CHN 4620 TO 5590

PLAN

STATUS	RESOURCE CONSENT	LOCAL AUTHORITY REF:		
SCALE: SHOWN	PLOT DATE	JOB: 2209-RC	SHEET: 02	REVISION: 1

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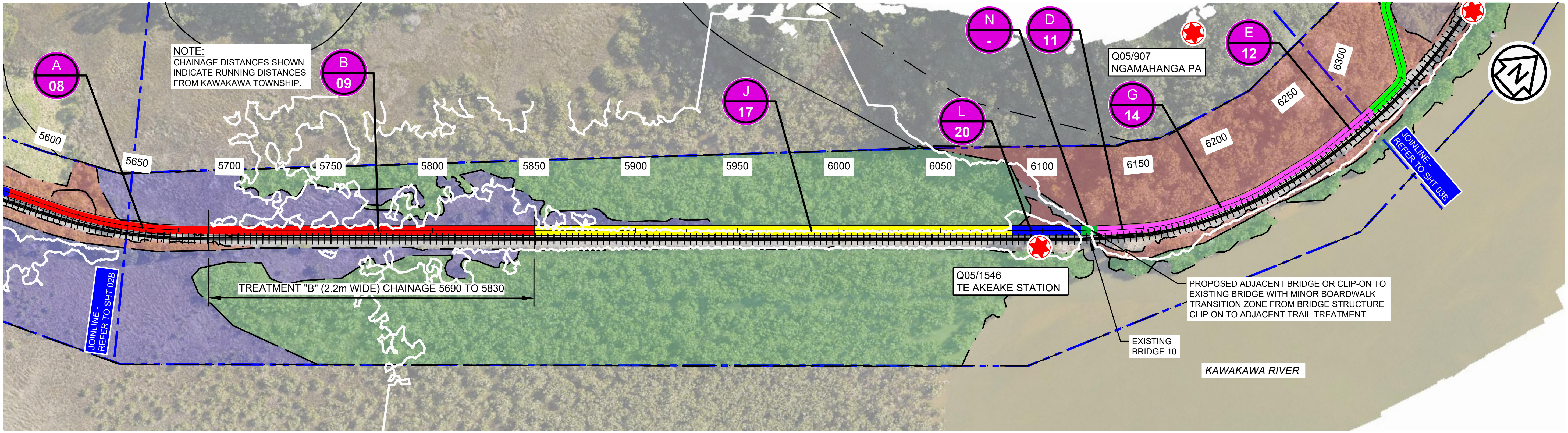

PLAN 03A
SCALE 1:2000 (A3), 1:1000 (A1)

	Wall Length (m)	Wall Area (m²)	Boardwalk Length (m)	Boardwalk Area (m²)	Total CMA Encroachment Area (m²)	Total Area of Permanent Earthworks (m²)	Total Volume of Permanent earthworks - Cut Material (m²)	Total Volume of Permanent earthworks - Fill Material (m²)
Dwg 3 - 5590 to 6770m	1045	1058	235	705	382	3270	297	1821

GENERAL NOTES

1 - ALL QUANTITIES SUBJECT TO CONFIRMATION OF TRAIL WIDTH BY FNDC.
2 - ALL LENGTHS, VOLUMES AND AREAS APPROXIMATE ONLY, BASED ON PRELIMINARY DESIGN AND SUBJECT TO GEOTECHNICAL AND CIVIL DESIGN.
3 - ASSUMED WHERE NON HERITAGE AND HERITAGE CULVERTS INTERFACE THE ALIGNMENT THAT MINOR ABUTMENTS AND SHORT LENGTHS OF BOARDWALK WILL BE ADOPTED. THIS WILL AFFECT THE ABOVE VALUES.
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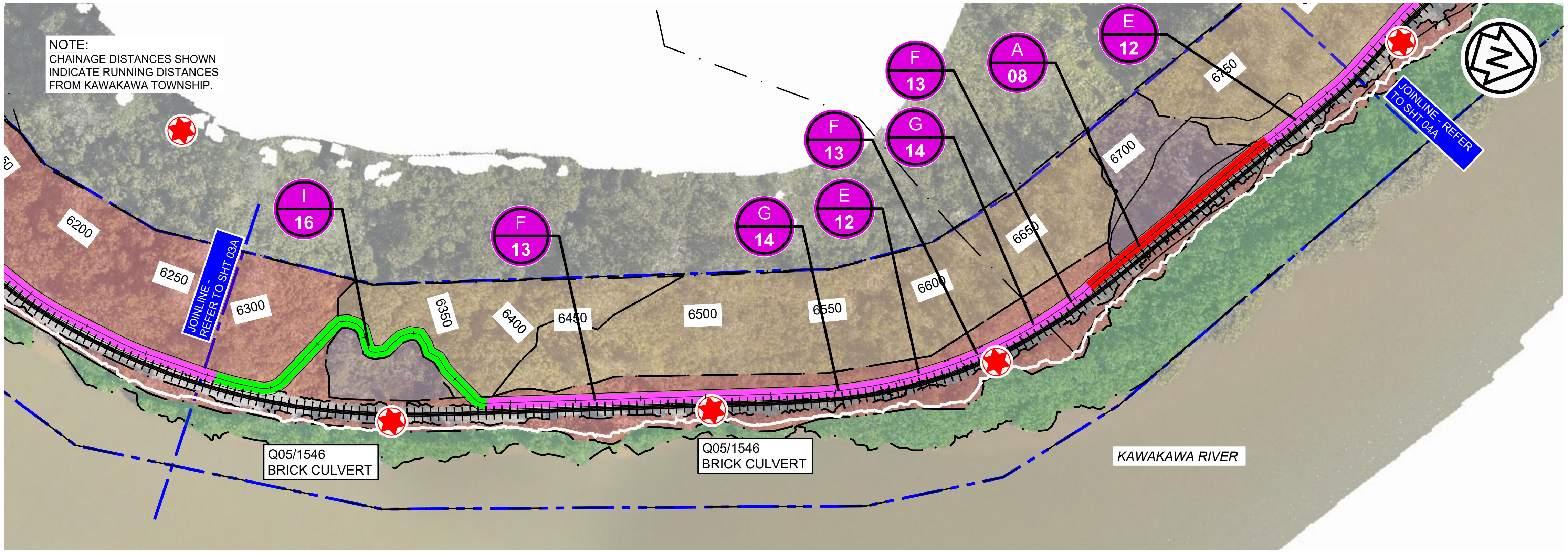
6 - CMA ADOPTED FROM MHWS WHICH HAS BEEN INFERRED AT 1.1m R.L. OTP 1964 DATUM FOR THE PURPOSES OF THIS PROJECT. POSITION SHOWN IS APPROXIMATE ONLY. CERTIFICATION BY REGISTERED SURVEYOR REQUIRED TO CONFIRM ACCURACY OF LINE.
7- DO NOT SCALE DRAWING.
8- NOMINAL SCALE IS SHOWN FOR A3 SIZE UNLESS SHOWN OTHERWISE.
9- COORDINATES IN TERMS OF NZTM GEODETIC 2000 DATUM.
10- LEVELS IN TERMS OF MEAN SEA LEVEL ONE TREE POINT DATUM.
11- AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.



PLAN 03B
SCALE 1:2000 (A3), 1:1000 (A1)

0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

KEY:

GENERAL	
	CMA BOUNDARY
	RAIL DESIGNATION BOUNDARY
	EXISTING ARCHAEOLOGICAL FEATURE

RESOURCE CONSENT

KEY:

ECOLOGY AREAS	
	EXOTIC
	KANUKA
	MANGROVE
	MINGIMINGI
	OIOI RUSHLAND
	RAUPO
	RAUPO/ KUTA

KEY:

TRAIL CROSS SECTIONAL TREATMENTS		REFERENCE
	TREATMENT 1 - BOARDWALK	J J1 K M
	TREATMENT 2 - RETAINED WITHIN RAIL EMBANKMENT	A B
	TREATMENT 3 - RETAINED ADJOINING NATURAL SURFACES	D E F G
	TREATMENT 4 - ON GRADE, BATTERED SLOPES - NO STRUCTURES	C H L
	TREATMENT 5 - MTB STYLE TRACK IN BUSH, CUTS, FILLS & MSE SLOPES	I
	TREATMENT 6 - BRIDGES, EITHER NEW OR CLIP ON EXISTING	N

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

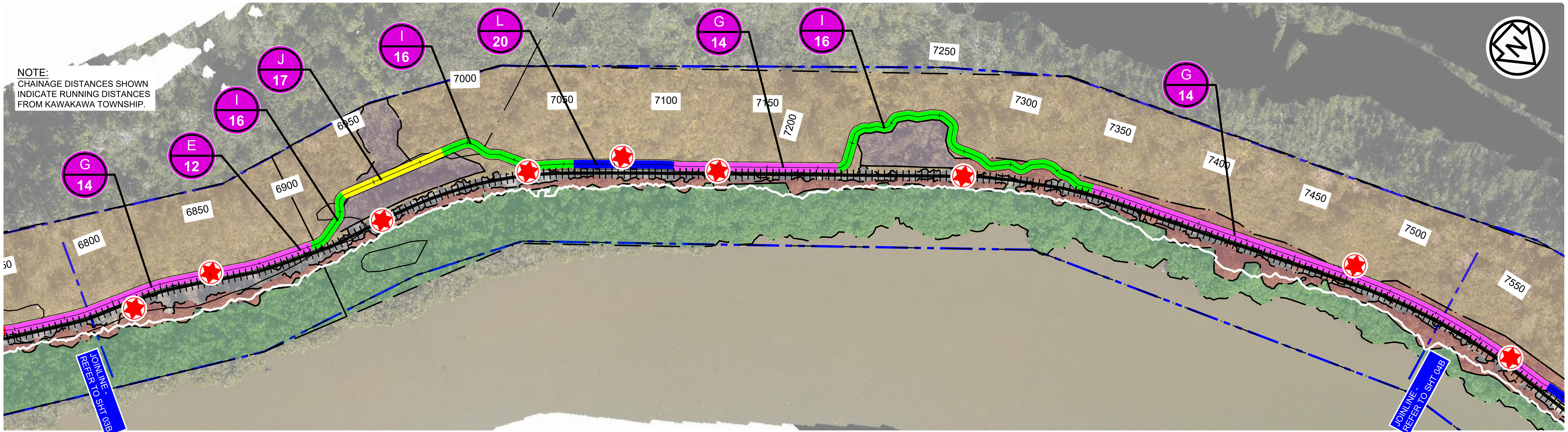
	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

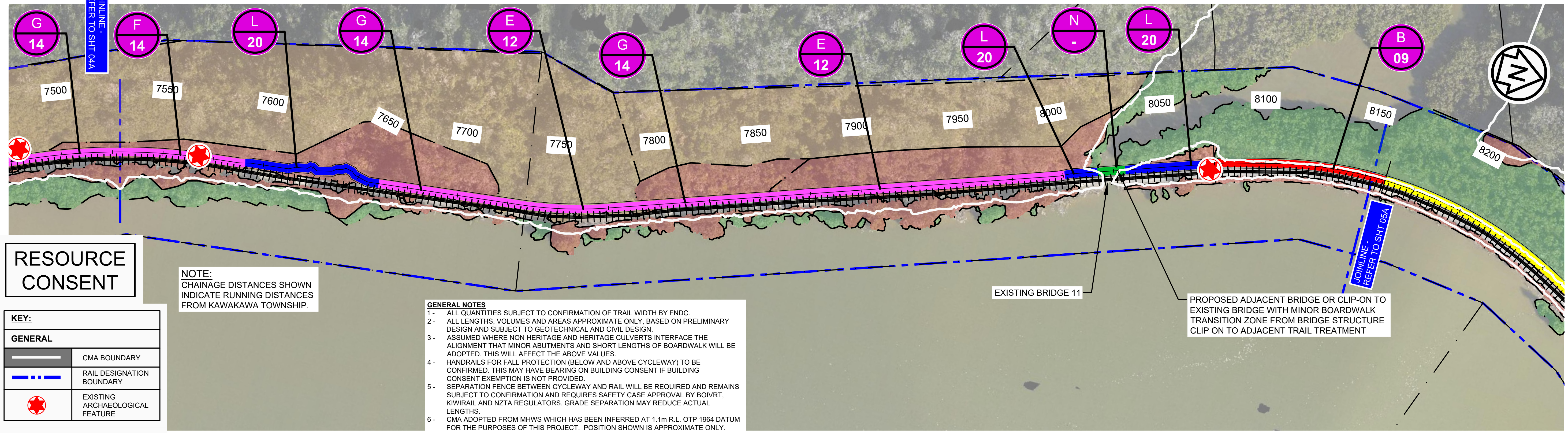
TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS
CHN 5590 TO 6770
PLAN

STATUS RESOURCE CONSENT
LOCAL AUTHORITY REF:
SCALE SHOWN
PLOT DATE
JOB 2209-RC
SHEET 03
REVISION 1



	Wall Length (m)	Wall Area (m²)	Boardwalk Length (m)	Boardwalk Area (m²)	Total CMA Encroachment Area (m²)	Total Area of Permanent Earthworks (m²)	Total Volume of Permanent earthworks - Cut Material (m²)	Total Volume of Permanent earthworks - Fill Material (m²)
Dwg 4 - 6770 to 8130m	1911	2313	53	159	116	5610	2081	1360

PLAN -04A
SCALE 1:2000 (A3), 1:1000 (A1)



NOTE:
CHAINAGE DISTANCES SHOWN INDICATE RUNNING DISTANCES FROM KAWAKAWA TOWNSHIP.

RESOURCE CONSENT

KEY:

GENERAL	
	CMA BOUNDARY
	RAIL DESIGNATION BOUNDARY
	EXISTING ARCHAEOLOGICAL FEATURE

KEY:

ECOLOGY AREAS	
	EXOTIC
	KANUKA
	MANGROVE
	MINGIMINGI
	OIOI RUSHLAND
	RAUPO
	RAUPO/ KUTA

KEY:

TRAIL CROSS SECTIONAL TREATMENTS		REFERENCE
	TREATMENT 1 - BOARDWALK	J J1 K M
	TREATMENT 2 - RETAINED WITHIN RAIL EMBANKMENT	A B
	TREATMENT 3 - RETAINED ADJOINING NATURAL SURFACES	D E F G
	TREATMENT 4 - ON GRADE, BATTERED SLOPES - NO STRUCTURES	C H L
	TREATMENT 5 - MTB STYLE TRACK IN BUSH, CUTS, FILLS & MSE SLOPES	I
	TREATMENT 6 - BRIDGES, EITHER NEW OR CLIP ON EXISTING	N

GENERAL NOTES

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10- LEVELS IN TERMS OF MEAN SEA LEVEL ONE TREE POINT DATUM.
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PLAN 04B
SCALE 1:2000 (A3), 1:1000 (A1)

0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS
CHN 6770 TO 8130

PLAN

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:
SCALE: SHOWN
PLOT DATE:
JOB: 2209-RC
SHEET: 04
REVISION: 1

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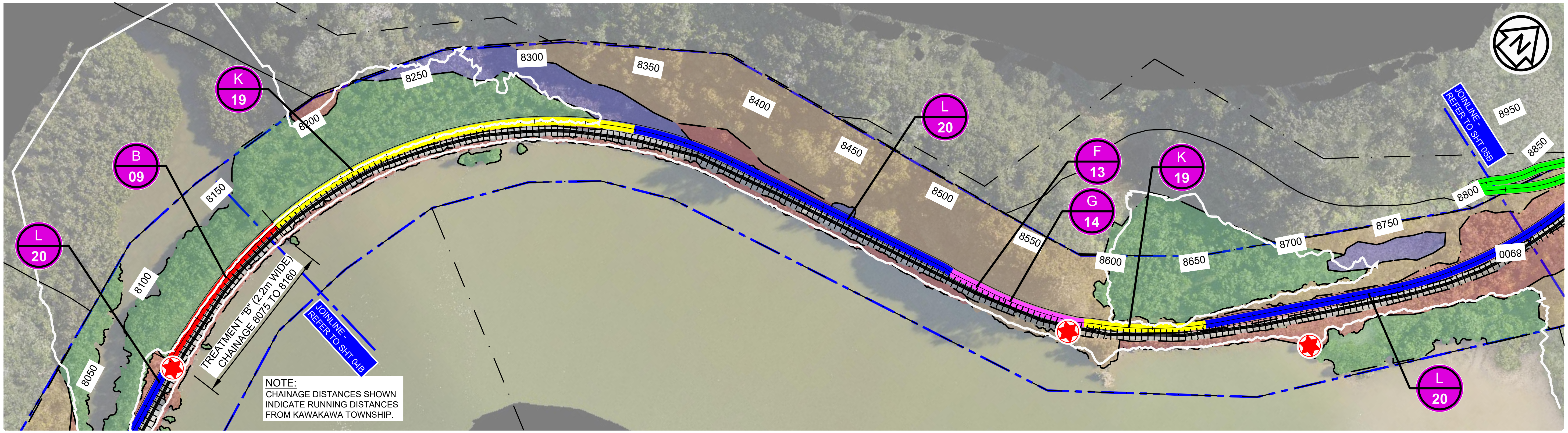
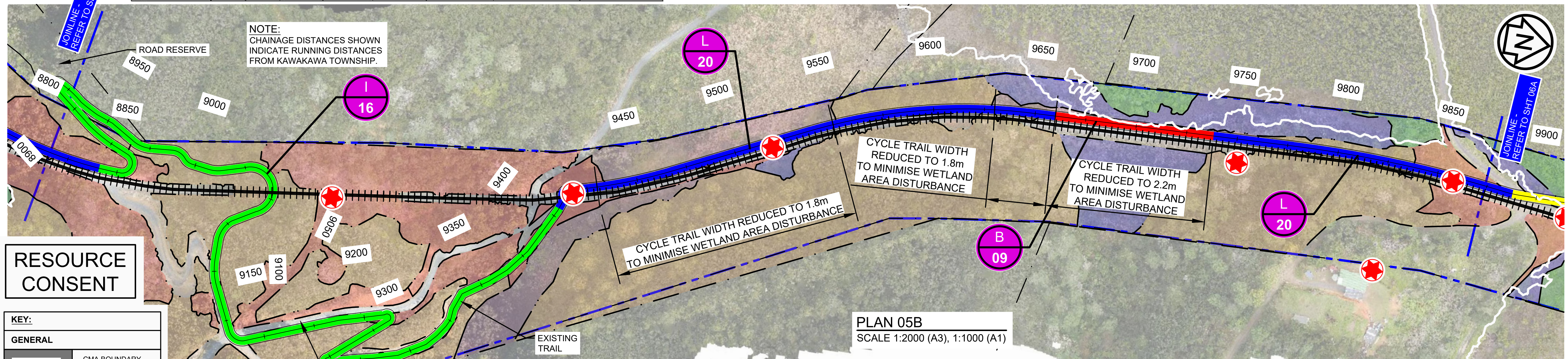


	Wall Length (m)	Wall Area (m²)	Boardwalk Length (m)	Boardwalk Area (m²)	Total CMA Encroachment Area (m²)	Total Area of Permanent Earthworks (m²)	Total Volume of Permanent earthworks - Cut Material (m³)	Total Volume of Permanent earthworks - Fill Material (m³)
Dwg 5 - 8130 to 9870m	370	226	250	750	228	5210	1357	1335

PLAN 05A

SCALE 1:2000 (A3), 1:1000 (A1)



PLAN 05B

SCALE 1:2000 (A3), 1:1000 (A1)

RESOURCE CONSENT

KEY:

GENERAL	
	CMA BOUNDARY
	RAIL DESIGNATION BOUNDARY
	EXISTING ARCHAEOLOGICAL FEATURE

KEY:

ECOLOGY AREAS	
	EXOTIC
	KANUKA
	MANGROVE
	MINGIMINGI
	OIOI RUSHLAND
	RAUPO
	RAUPO/ KUTA

KEY:

TRAIL CROSS SECTIONAL TREATMENTS		REFERENCE
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	TREATMENT 2 - RETAINED WITHIN RAIL EMBANKMENT	A B
	TREATMENT 3 - RETAINED ADJOINING NATURAL SURFACES	D E F G
	TREATMENT 4 - ON GRADE, BATTERED SLOPES - NO STRUCTURES	C H L
	TREATMENT 5 - MTB STYLE TRACK IN BUSH, CUTS, FILLS & MSE SLOPES	I
	TREATMENT 6 - BRIDGES, EITHER NEW OR CLIP ON EXISTING	N

GENERAL NOTES

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11- AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.

0 20 40 60 80 100m

SCALE 1:2000 AT ORIGINAL SIZE

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS
CHN 8130 TO 9870

PLAN

STATUS	RESOURCE CONSENT	LOCAL AUTHORITY REF:		
SCALE: SHOWN	PLOT DATE	JOB: 2209-RC	SHEET: 05	REVISION: 1

GENERAL NOTES

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7- DO NOT SCALE DRAWING.
8- NOMINAL SCALE IS SHOWN FOR A3 SIZE UNLESS SHOWN OTHERWISE.
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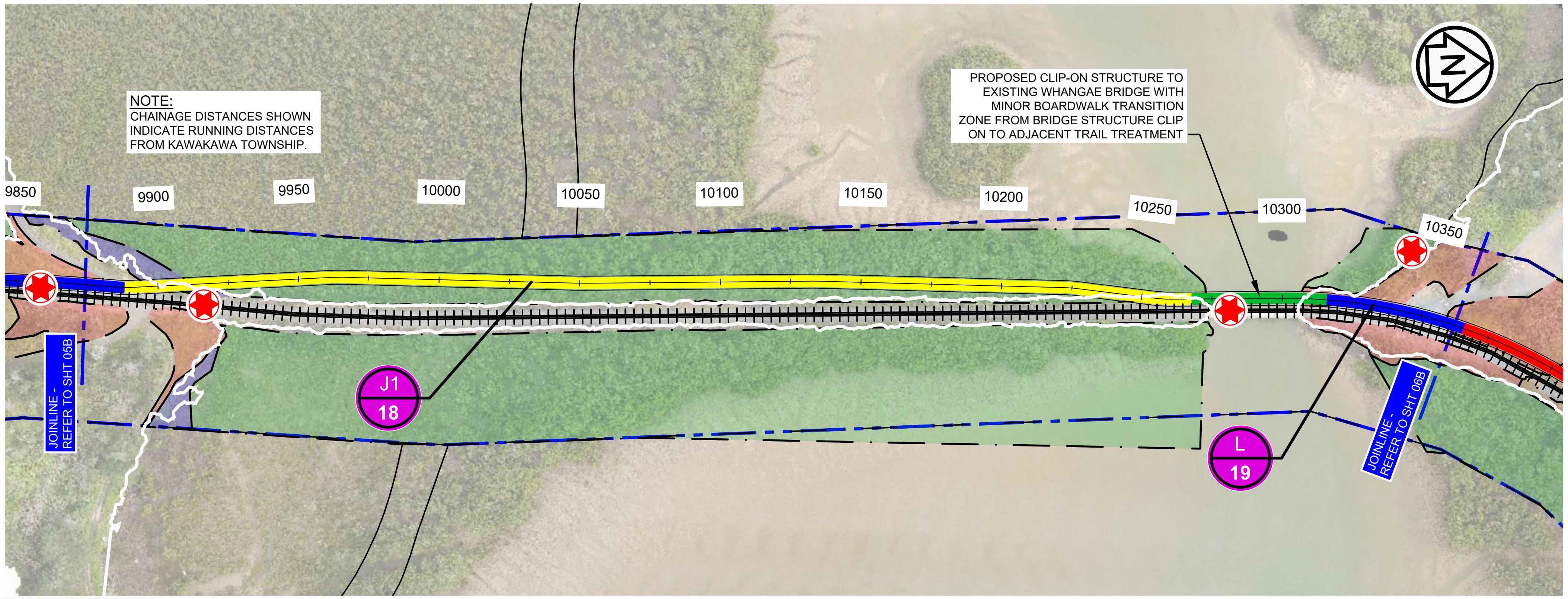
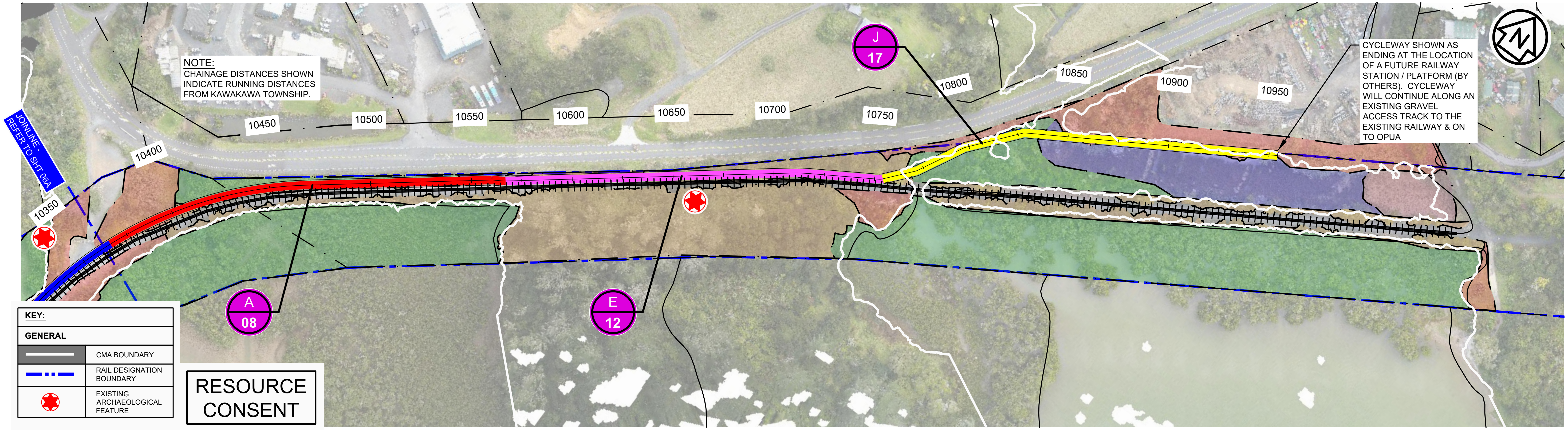
10- LEVELS IN TERMS OF MEAN SEA LEVEL ONE TREE POINT DATUM.
11- AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.



	Wall Length (m)	Wall Area (m²)	Boardwalk Length (m)	Boardwalk Area (m²)	Total CMA Encroachment Area (m²)	Total Area of Permanent Earthworks (m²)	Total Volume of Permanent earthworks - Cut Material (m²)	Total Volume of Permanent earthworks - Fill Material (m²)
Dwg 6 - 9870 to 10940m	250	189	580	1740	1634	1720	221	366

PLAN 06A
SCALE 1:2000 (A3), 1:1000 (A1)



PLAN 06B
SCALE 1:2000 (A3), 1:1000 (A1)

0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

KEY:

GENERAL

- CMA BOUNDARY
- RAIL DESIGNATION BOUNDARY
- EXISTING ARCHAEOLOGICAL FEATURE

RESOURCE CONSENT

KEY:

ECOLOGY AREAS

- EXOTIC
- KANUKA
- MANGROVE
- MINGIMINGI
- OIOI RUSHLAND
- RAUPO
- RAUPO/ KUTA

KEY:

TRAIL CROSS SECTIONAL TREATMENTS	REFERENCE
TREATMENT 1 - BOARDWALK	J J1 K M
TREATMENT 2 - RETAINED WITHIN RAIL EMBANKMENT	A B
TREATMENT 3 - RETAINED ADJOINING NATURAL SURFACES	D E F G
TREATMENT 4 - ON GRADE, BATTERED SLOPES - NO STRUCTURES	C H L
TREATMENT 5 - MTB STYLE TRACK IN BUSH, CUTS, FILLS & MSE SLOPES	I
TREATMENT 6 - BRIDGES, EITHER NEW OR CLIP ON EXISTING	N

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

Do not scale drawing. Check all dimensions on site before construction

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS
CHN 9870 TO 10940

PLAN

STATUS RESOURCE CONSENT
LOCAL AUTHORITY REF:

SCALE	PLOT DATE	JOB	SHEET	REVISION
SHOWN		2209-RC	06	1

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KEY:

GENERAL	
	CMA BOUNDARY
	RAIL DESIGNATION BOUNDARY
	EXISTING ARCHAEOLOGICAL FEATURE

KEY:

ECOLOGY AREAS	
	EXOTIC
	KANUKA
	MANGROVE
	MINGIMINGI
	OIOI RUSHLAND
	RAUPO
	RAUPO/ KUTA

KEY:

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	TREATMENT 4 - ON GRADE, BATTERED SLOPES - NO STRUCTURES	C H L
	TREATMENT 5 - MTB STYLE TRACK IN BUSH, CUTS, FILLS & MSE SLOPES	I
	TREATMENT 6 - BRIDGES, EITHER NEW OR CLIP ON EXISTING	N

PROJECT QUANTITY SUMMARY

Earthworks	Volume (m^3)
Fill (solid)	5691
Cut (solid)	4556
Import Fill (solid)	1135

	Wall Length (m)	Wall Area (m^2)	Boardwalk Length (m)	Boardwalk Area (m^2)	Total CMA Encroachment Area (m^2)	Total Area of Permanent Earthworks (m^2)	Total Volume of Permanent earthworks - Cut Material (m^2)	Total Volume of Permanent earthworks - Fill Material (m^2)
Dwg 2 - 4620 to 5590m	760	733	115	162	0	3076	600	809
Dwg 3 - 5590 to 6770m	1045	1058	235	705	382	3270	297	1821
Dwg 4 - 6770 to 8130m	1911	2313	53	159	116	5610	2081	1360
Dwg 5 - 8130 to 9870m	370	226	250	750	228	5210	1357	1335
Dwg 6 - 9870 to 10940m	250	189	580	1740	1634	1720	221	366
TOTAL	4336	4519	1233	3516	2360	18886	4556	5691

NOTE:
CHAINAGE DISTANCES SHOWN INDICATE RUNNING DISTANCES FROM KAWAKAWA TOWNSHIP.

RESOURCE CONSENT

GENERAL NOTES

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	BWP		5.24
DRAWN	BWP		5.24
SURVEYED	LIDAR		2018
APPROVED			

Do not scale drawing. Check all dimensions on site before construction

JAS CIVIL Ltd

CLIENT: Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

KEY & PROJECT IMPACT SUMMARIES

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:

SCALE	PLOT DATE	JOB	SHEET	REVISION
SHOWN		2209-RC	07	1

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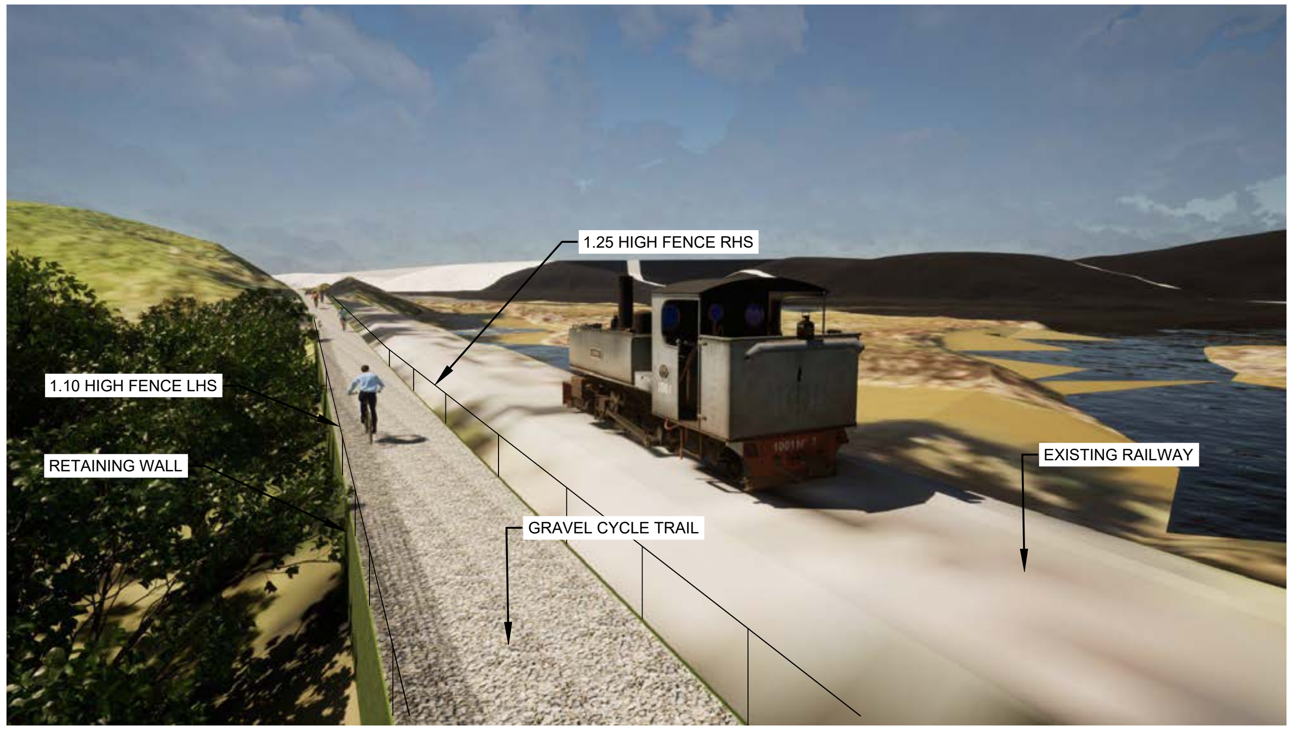
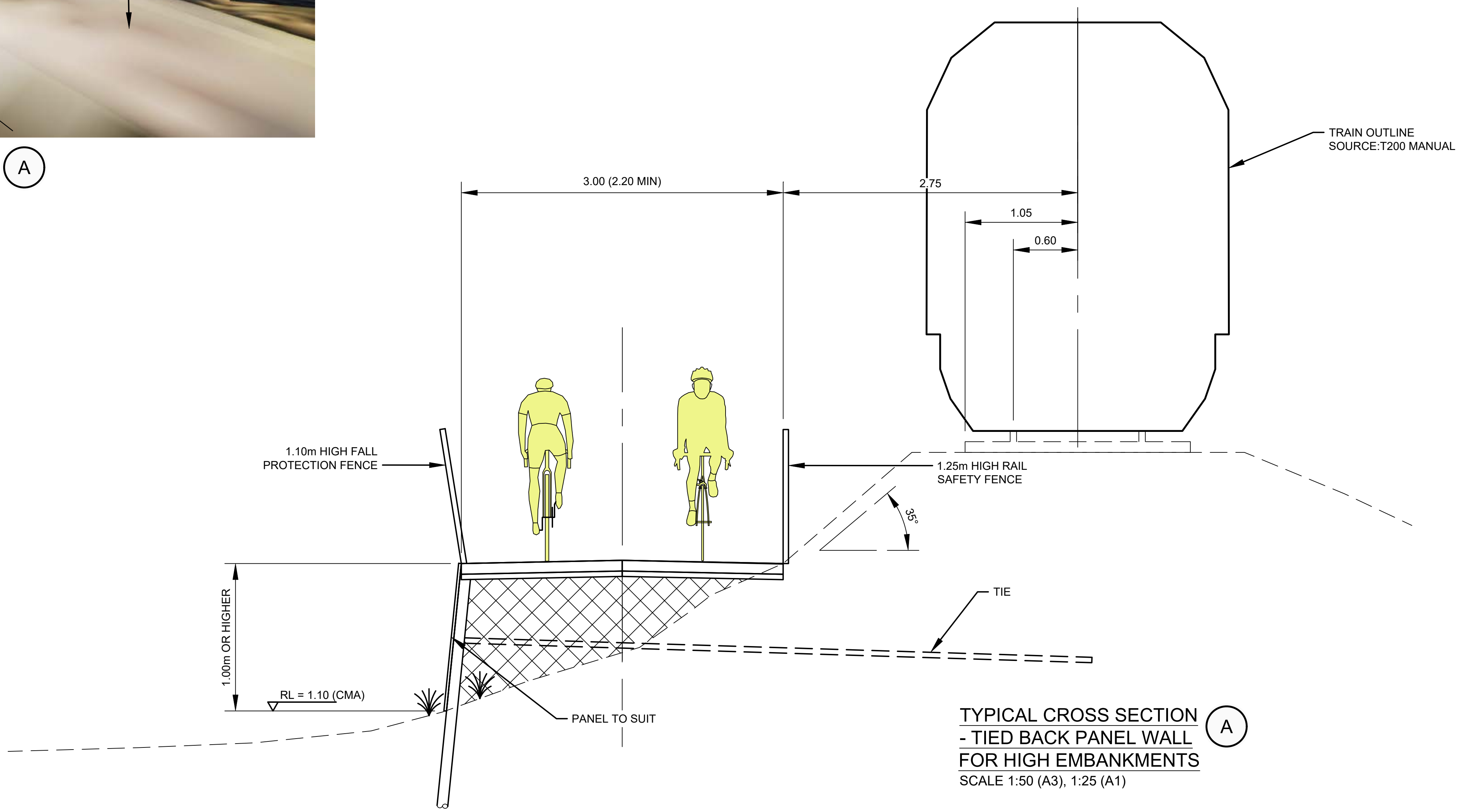


VISUALISATION - TIED BACK PANEL WALL FOR HIGH EMBANKMENTS (A)
NTS



TYPICAL CROSS SECTION - TIED BACK PANEL WALL FOR HIGH EMBANKMENTS (A)
SCALE 1:50 (A3), 1:25 (A1)

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `A' & VISUALISATION

STATUS: RESOURCE CONSENT | LOCAL AUTHORITY REF:

SCALE: SHOWN | PLOT DATE: | JOB: 2209-RC | SHEET: 08 | REVISION: 1

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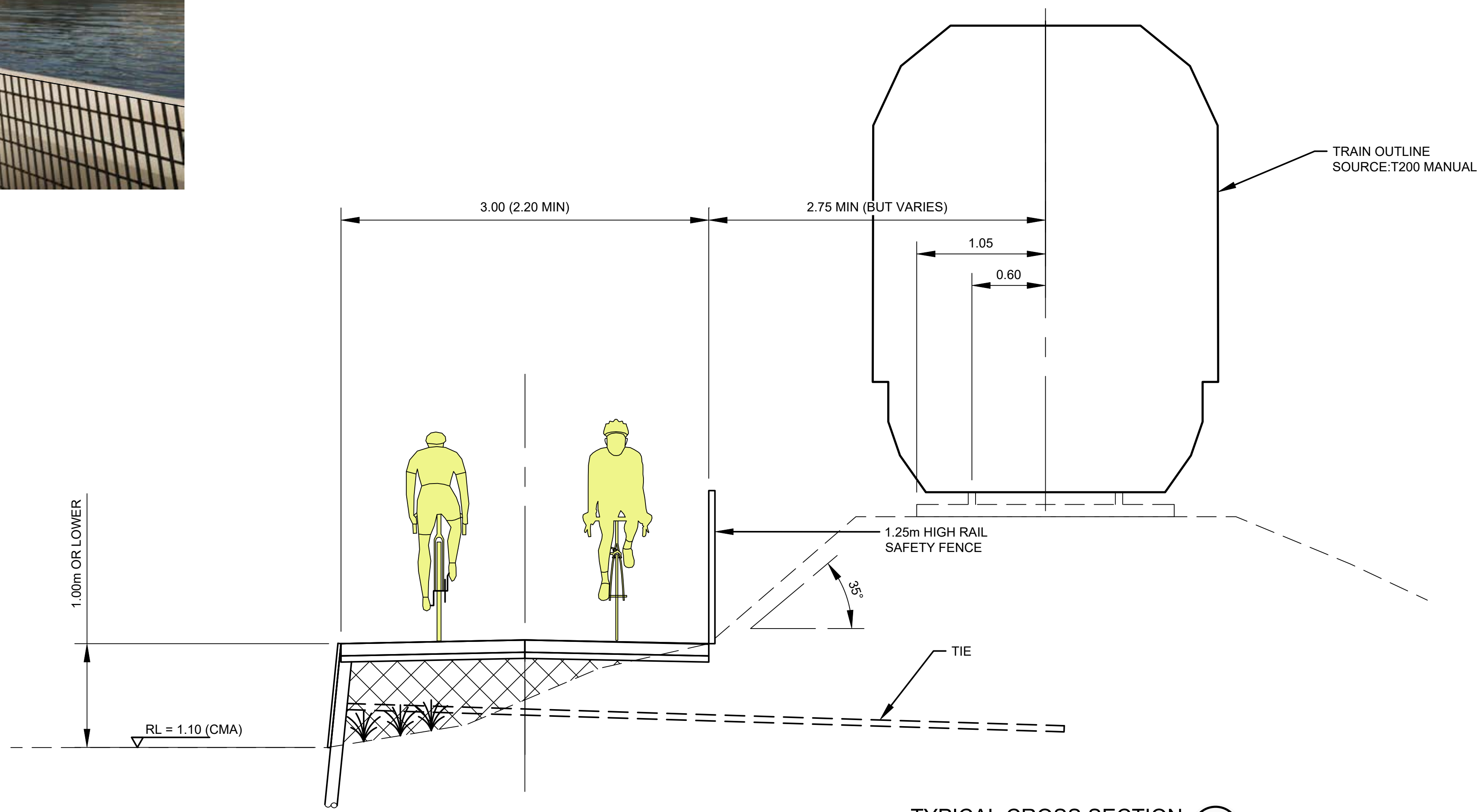
VISUALISATION - TIED BACK PANEL WALL FOR HIGH EMBANKMENTS (B)
NTS



TYPICAL CROSS SECTION - TIED BACK PANEL WALL FOR HIGH EMBANKMENTS (B)
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council – Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `B' & VISUALISATION

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:
SCALE: SHOWN
PLOT DATE:
JOB: 2209-RC
SHEET: 09
REVISION: 1

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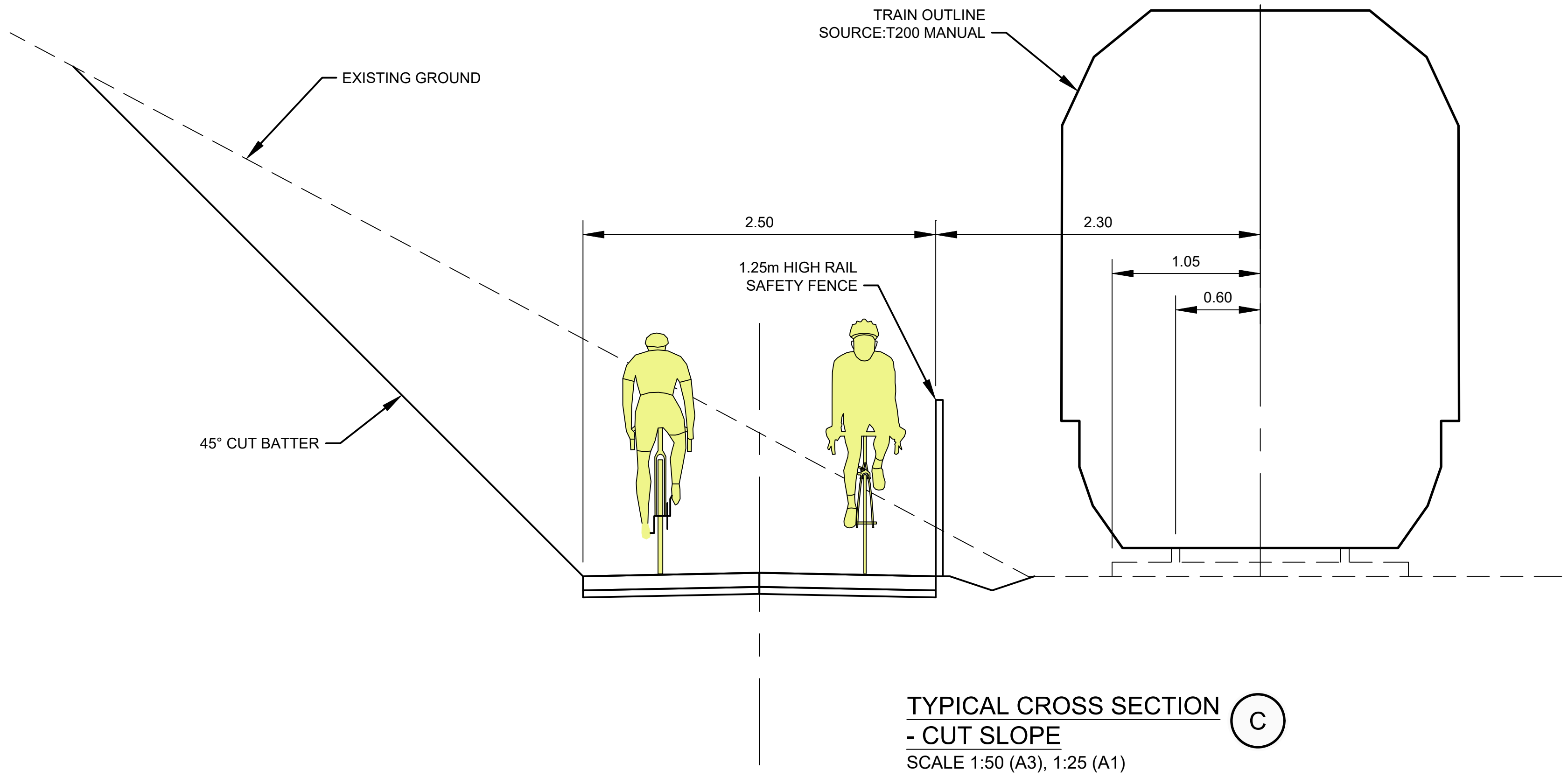

TYPICAL CROSS SECTION
- CUT SLOPE
C
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE
CONSENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

TYPICAL CROSS SECTION `C'

STATUS	RESOURCE CONSENT	LOCAL AUTHORITY REF:		
SCALE: SHOWN	PLOT DATE	JOB: 2209-RC	SHEET: 10	REVISION: 1

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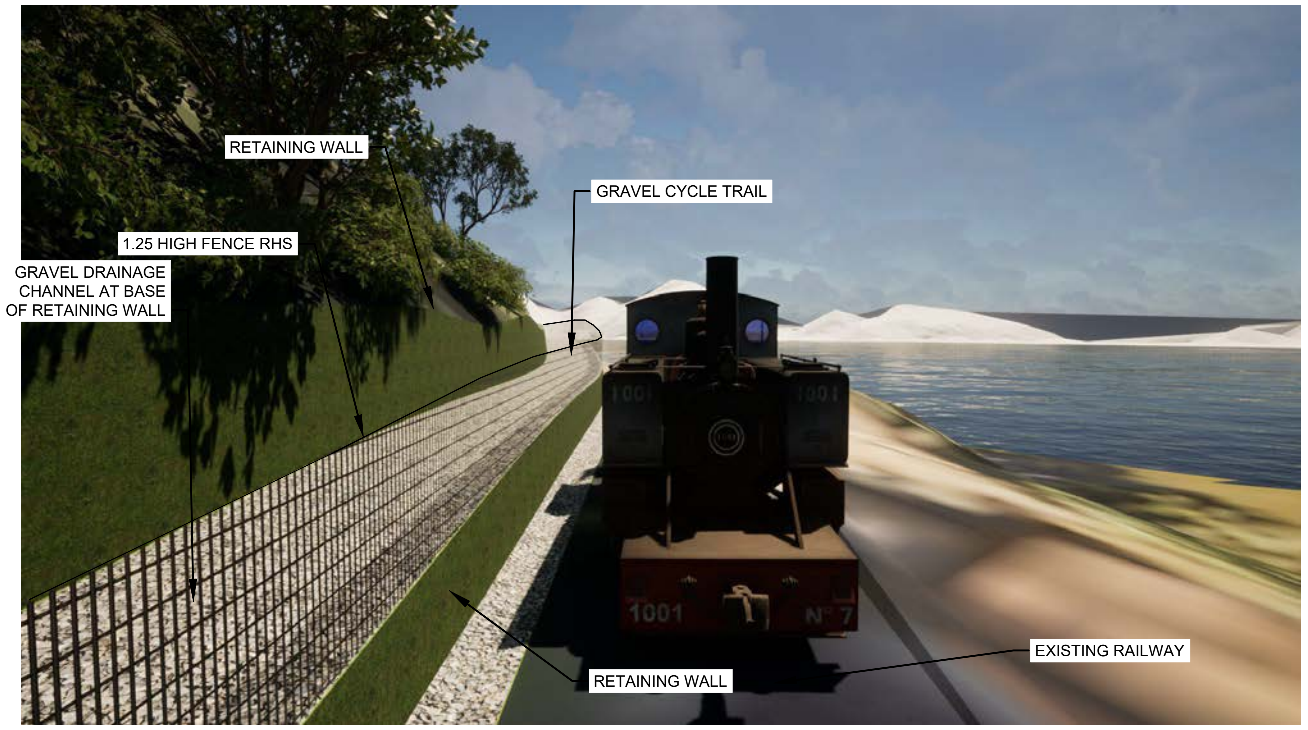
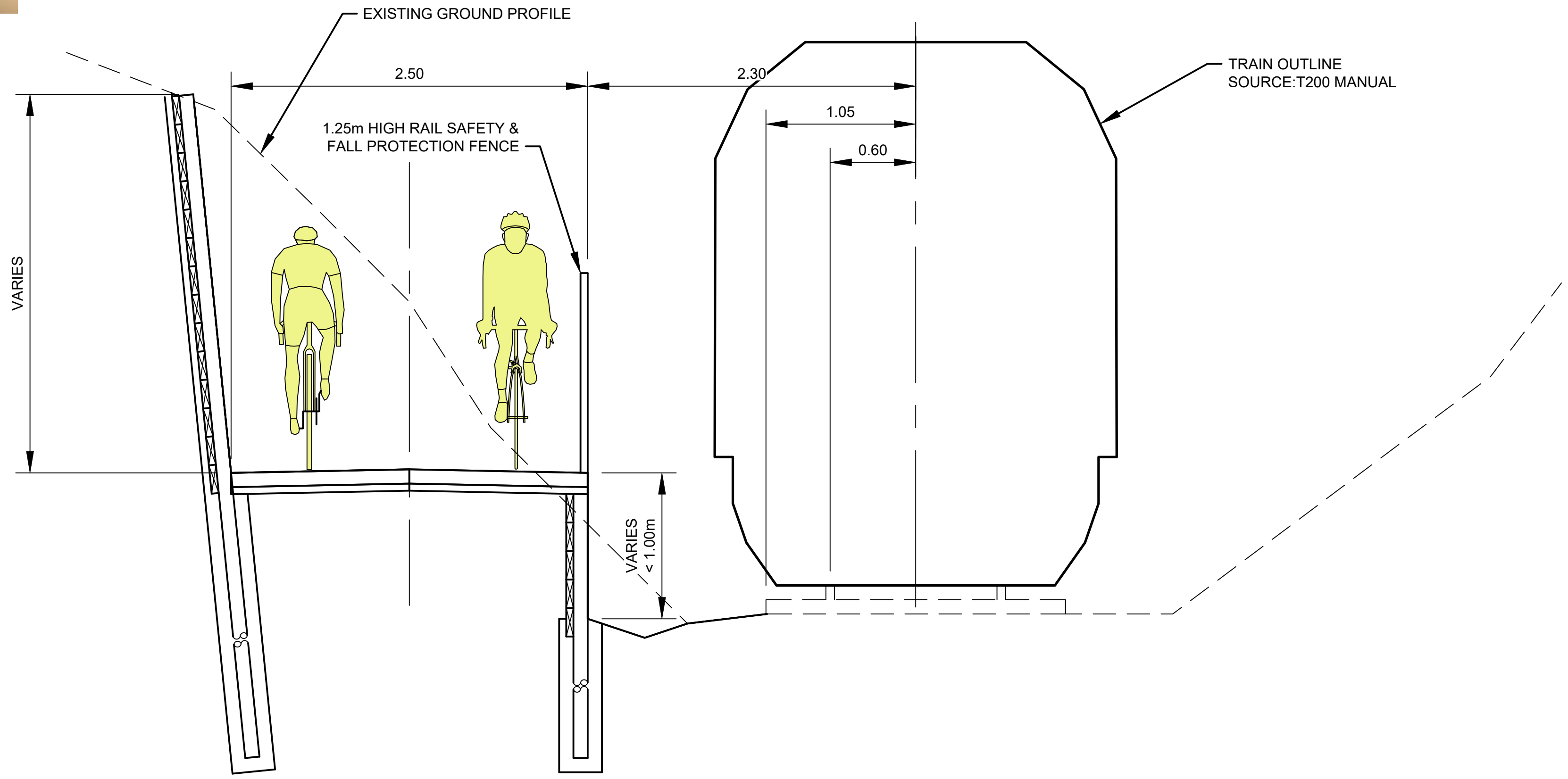


VISUALISATION - COMBINATION RETAINING WALL (D)

NTS



TYPICAL CROSS SECTION - COMBINATION RETAINING WALL (D)

SCALE 1:50 (A3), 1:25 (A1)

0 0.5 1.0 1.5 2.0 2.5m

SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `D' & VISUALISATION

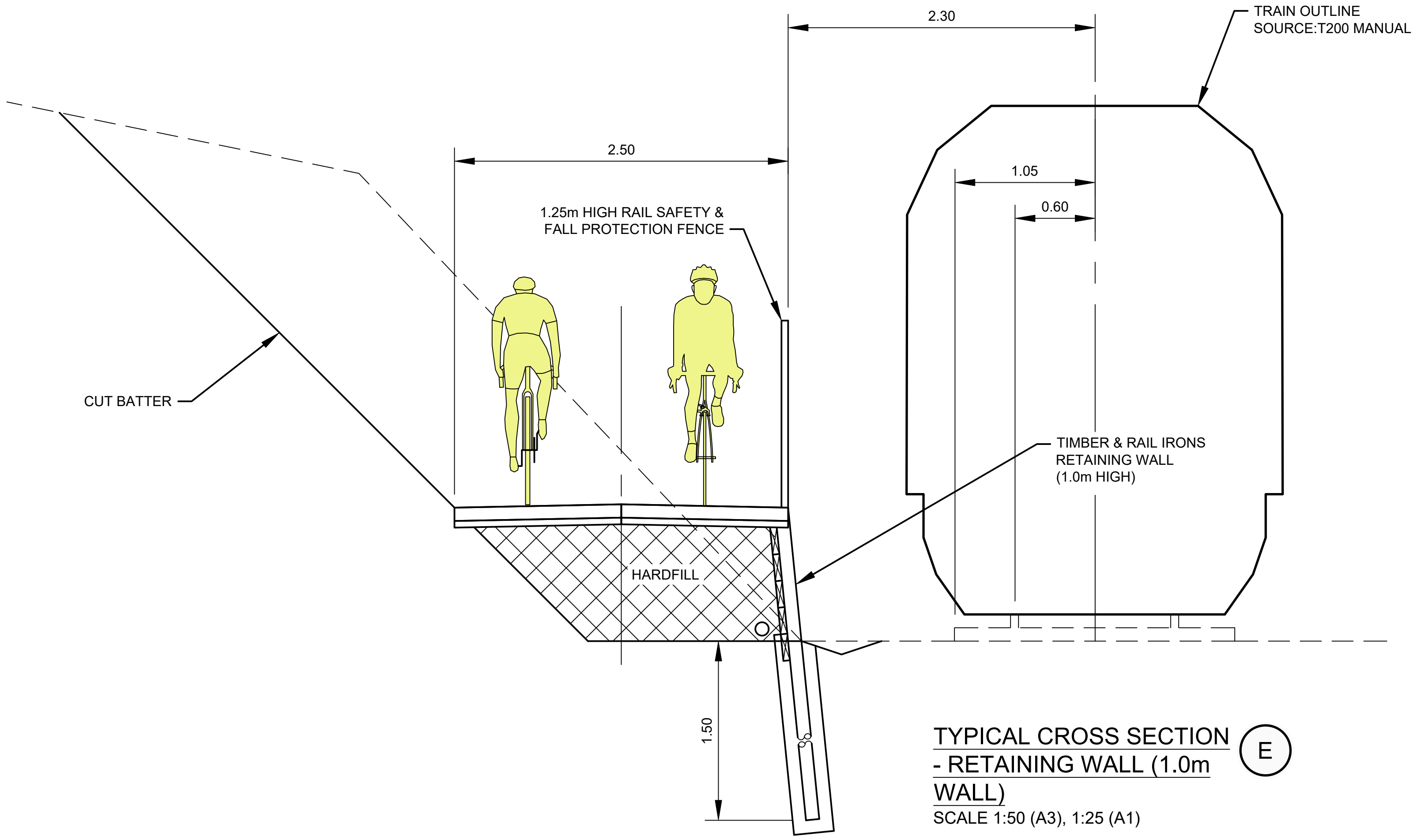
STATUS: RESOURCE CONSENT

LOCAL AUTHORITY REF:

SCALE: SHOWN | PLOT DATE: | JOB: 2209-RC | SHEET: 11 | REVISION: 1

VISUALISATION - RETAINING WALL - RAIL IRONS (1.0m WALL) (E)

NTS



TYPICAL CROSS SECTION - RETAINING WALL (1.0m WALL) (E)

SCALE 1:50 (A3), 1:25 (A1)

0 0.5 1.0 1.5 2.0 2.5m

SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

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AMENDMENT	APPRVD	DATE
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SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

TYPICAL CROSS SECTION `E' & VISUALISATION

STATUS	LOCAL AUTHORITY REF:		
RESOURCE CONSENT			
SCALE	PLOT DATE	JOB	SHEET / REVISION
SHOWN		2209-RC	12 / 1

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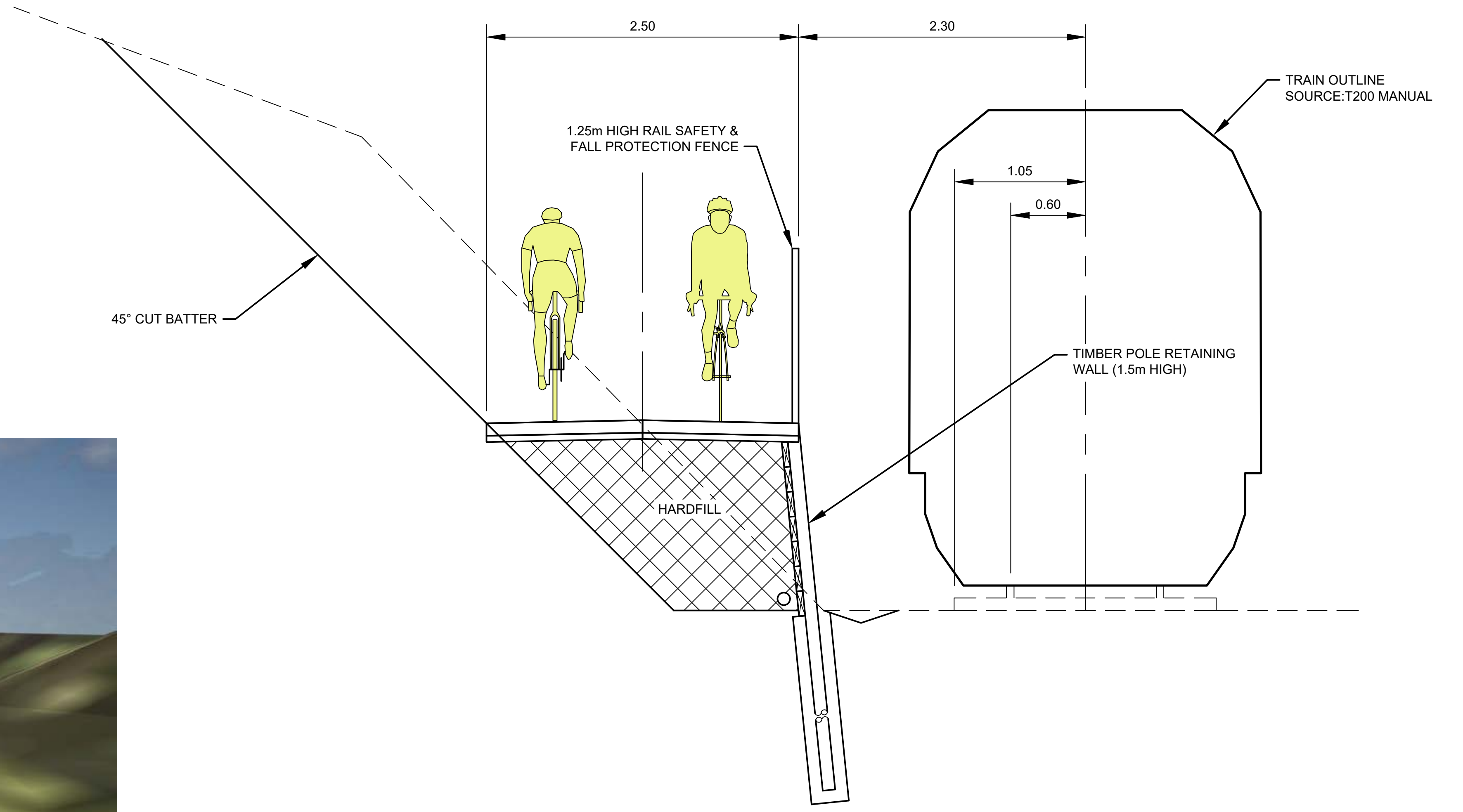

TYPICAL CROSS SECTION - RETAINING WALL (1.5m WALL) (F)

SCALE 1:50 (A3), 1:25 (A1)

VISUALISATION - RETAINING WALL - RAIL IRONS (1.5m WALL) (F)

NTS

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m

SCALE 1:50 (A3), 1:25 (A1)

GENERAL NOTES

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10- LEVELS IN TERMS OF MEAN SEA LEVEL ONE TREE POINT DATUM.
11- AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `F' & VISUALISATION

STATUS: RESOURCE CONSENT | LOCAL AUTHORITY REF:

SCALE: SHOWN | PLOT DATE: | JOB: 2209-RC | SHEET: 13 | REVISION: 1

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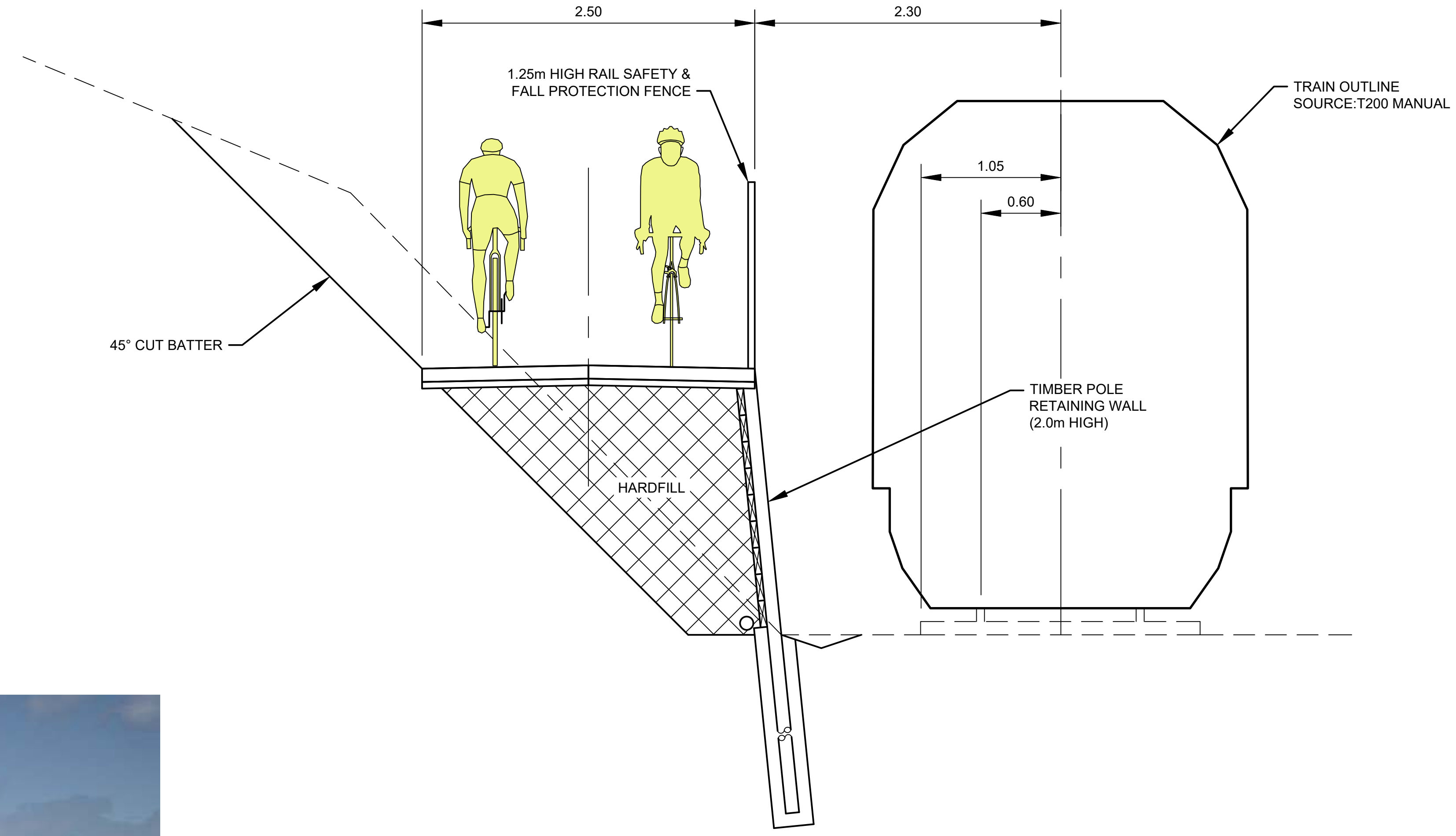
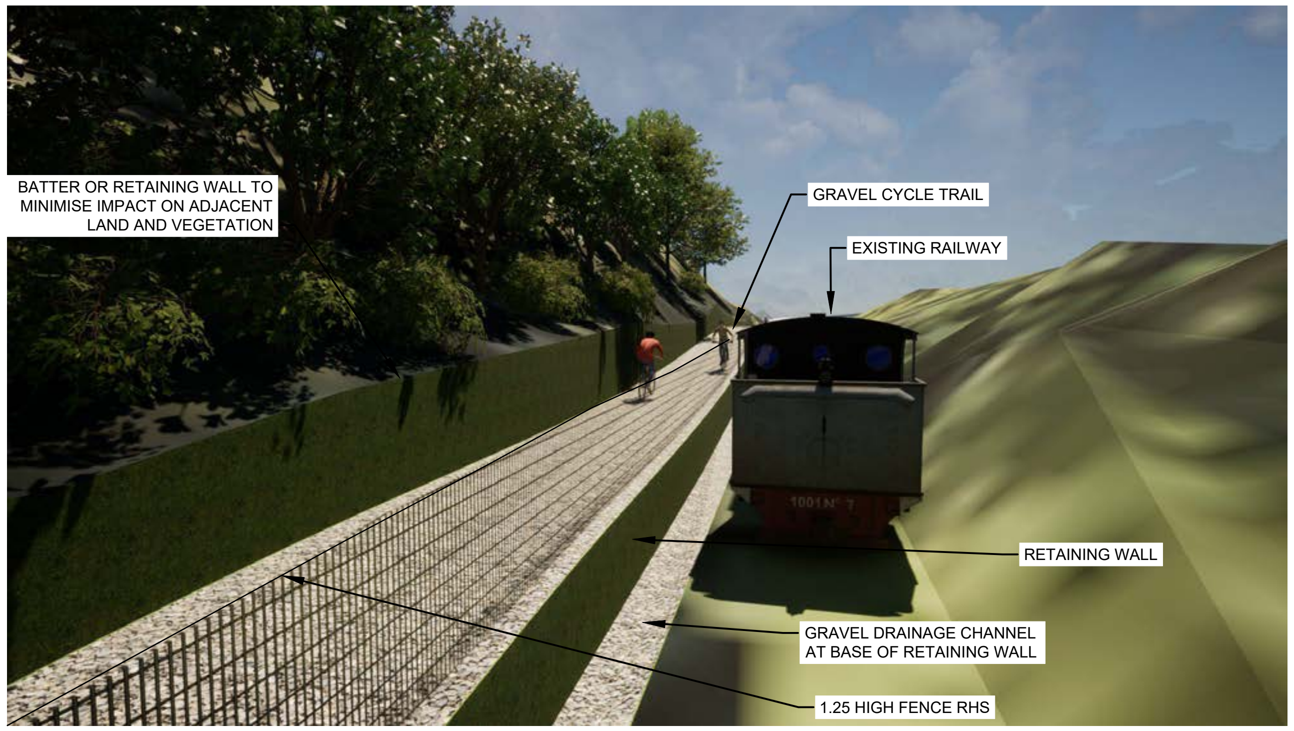


TYPICAL CROSS SECTION - RETAINING WALL (2.0m WALL) G

SCALE 1:50 (A3), 1:25 (A1)



VISUALISATION - RETAINING WALL - RAIL IRONS (2.0m WALL) G

NTS

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m

SCALE 1:50 (A3), 1:25 (A1)

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `G' & VISUALISATION

STATUS: RESOURCE CONSENT | LOCAL AUTHORITY REF:

SCALE: SHOWN | PLOT DATE: | JOB: 2209-RC | SHEET: 14 | REVISION: 1

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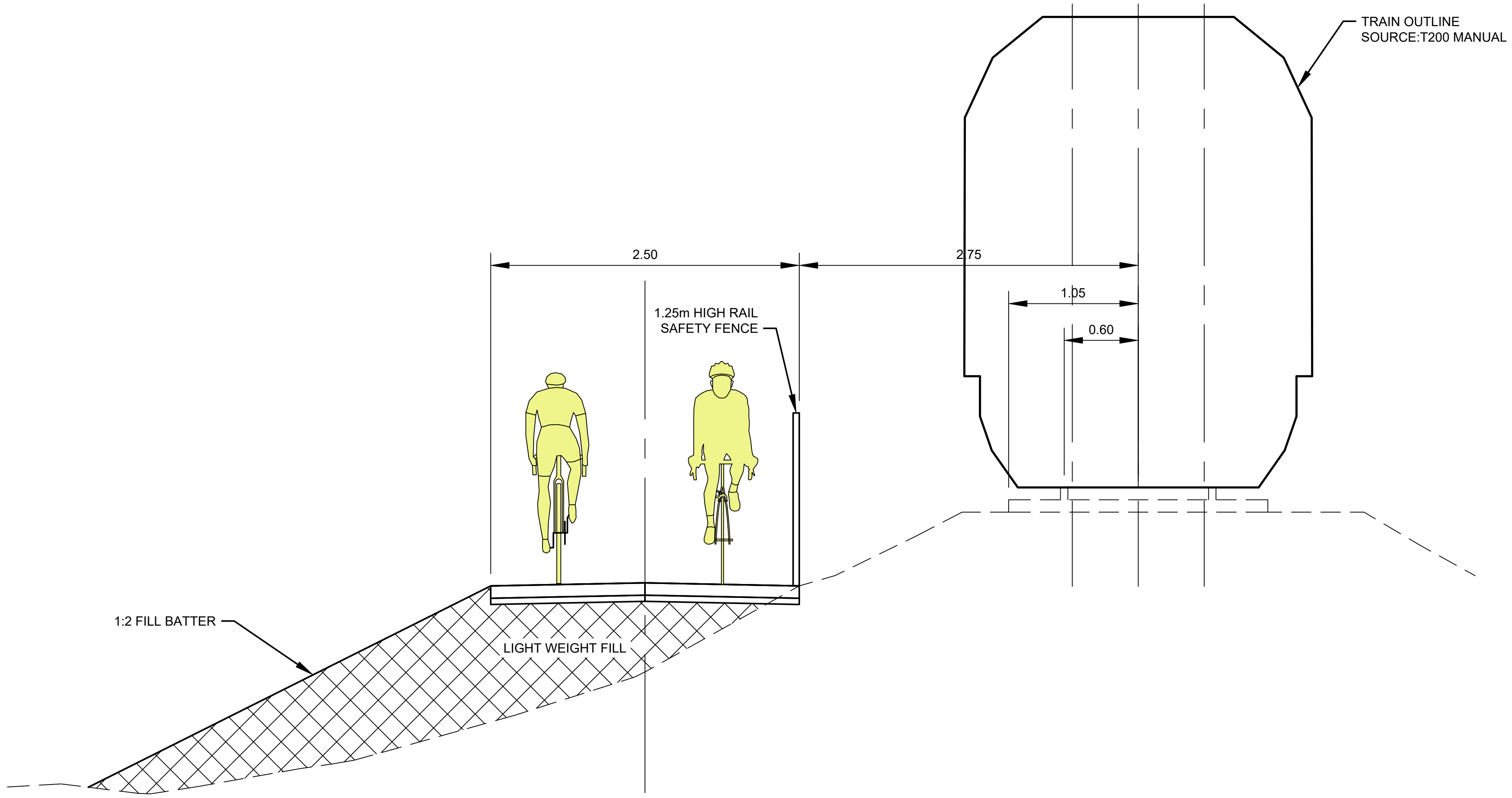
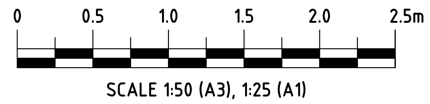


TYPICAL CROSS SECTION
- REVETMENT FILL
H
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT



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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

Do not scale drawing. Check all dimensions on site before construction

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

TYPICAL CROSS SECTION `H'

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:
SCALE: SHOWN
PLOT DATE:
JOB: 2209-RC
SHEET: 15
REVISION: 1

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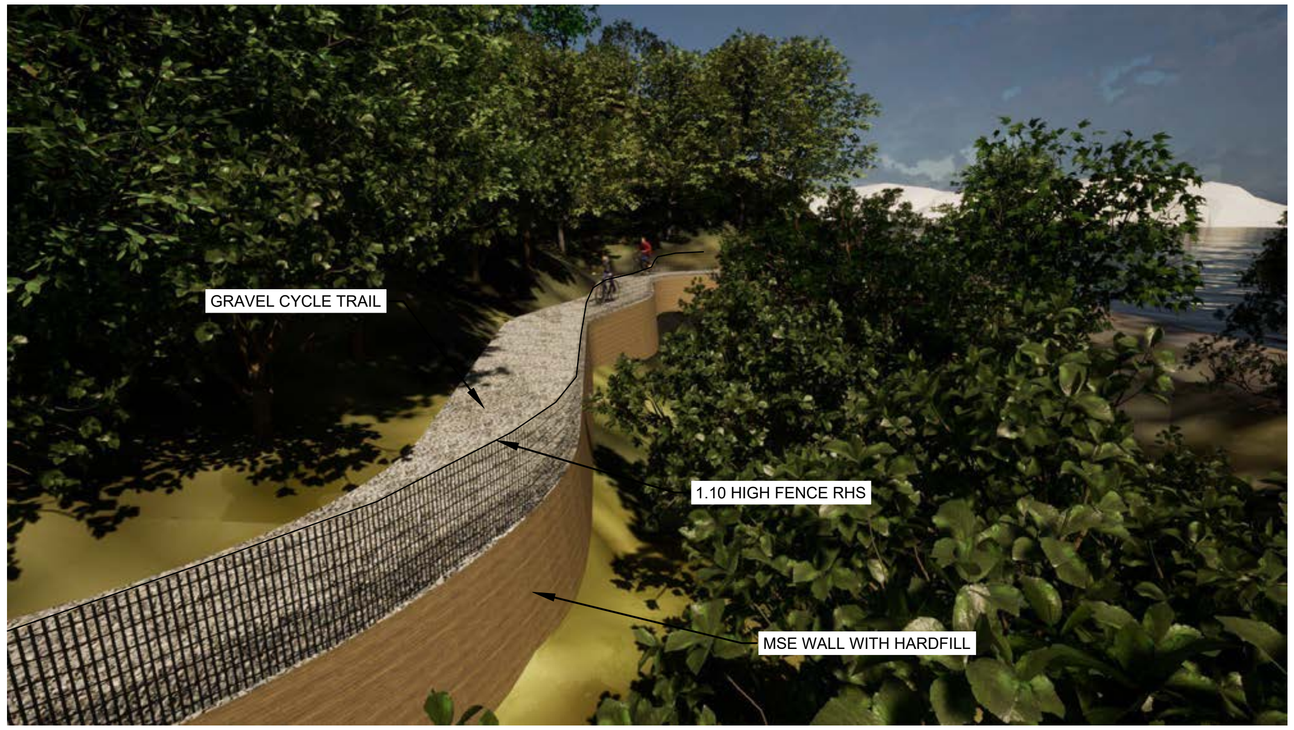
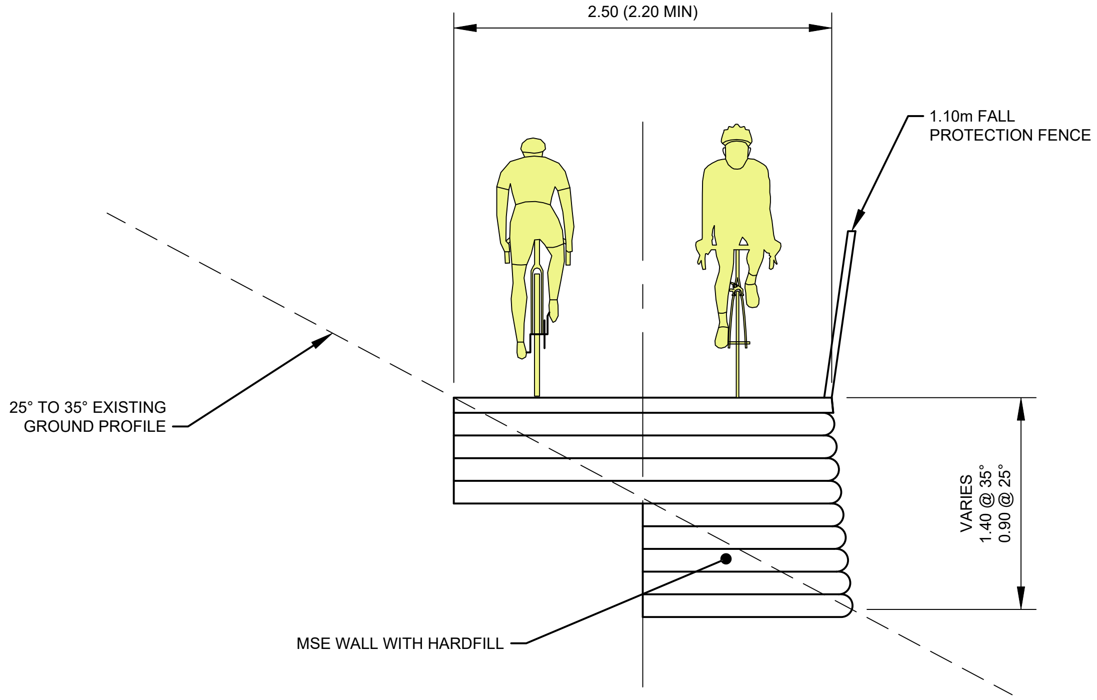


VISUALISATION - MSE WALL IN BUSH - FOLLOWING CONTOUR (I)
NTS



TYPICAL CROSS SECTION - MSE WALL IN BUSH - FOLLOWING CONTOUR (I)
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

TYPICAL CROSS SECTION `I' & VISUALISATION

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:
SCALE: SHOWN
PLOT DATE:
JOB: 2209-RC
SHEET: 16
REVISION: 1

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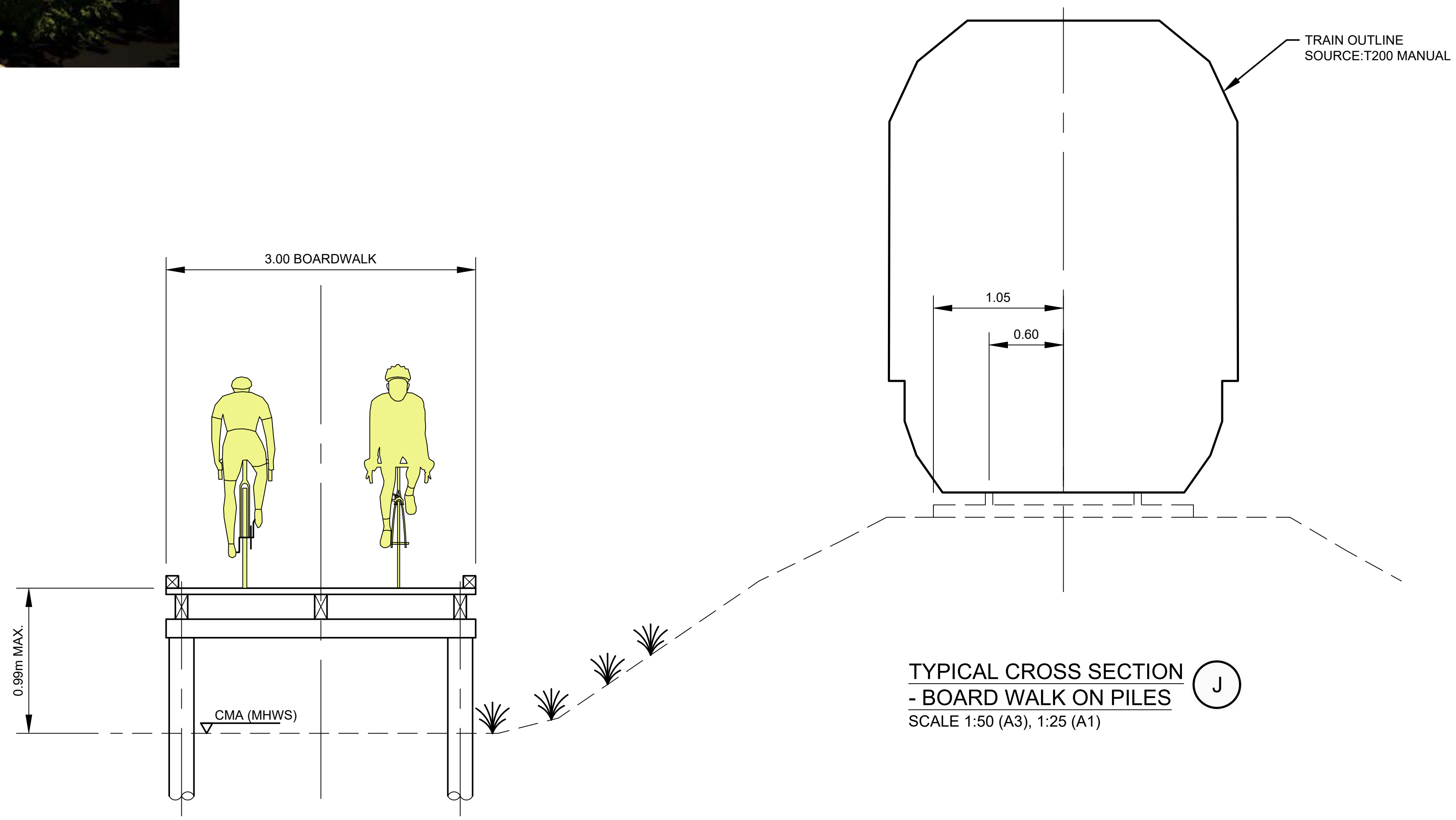
VISUALISATION - BOARD WALK ON PILES (J)
NTS



TYPICAL CROSS SECTION - BOARD WALK ON PILES (J)
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

Do not scale drawing. Check all dimensions on site before construction

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

TYPICAL CROSS SECTION `J' & VISUALISATION

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:

SCALE	PLOT DATE	JOB	SHEET	REVISION
SHOWN		2209-RC	17	1

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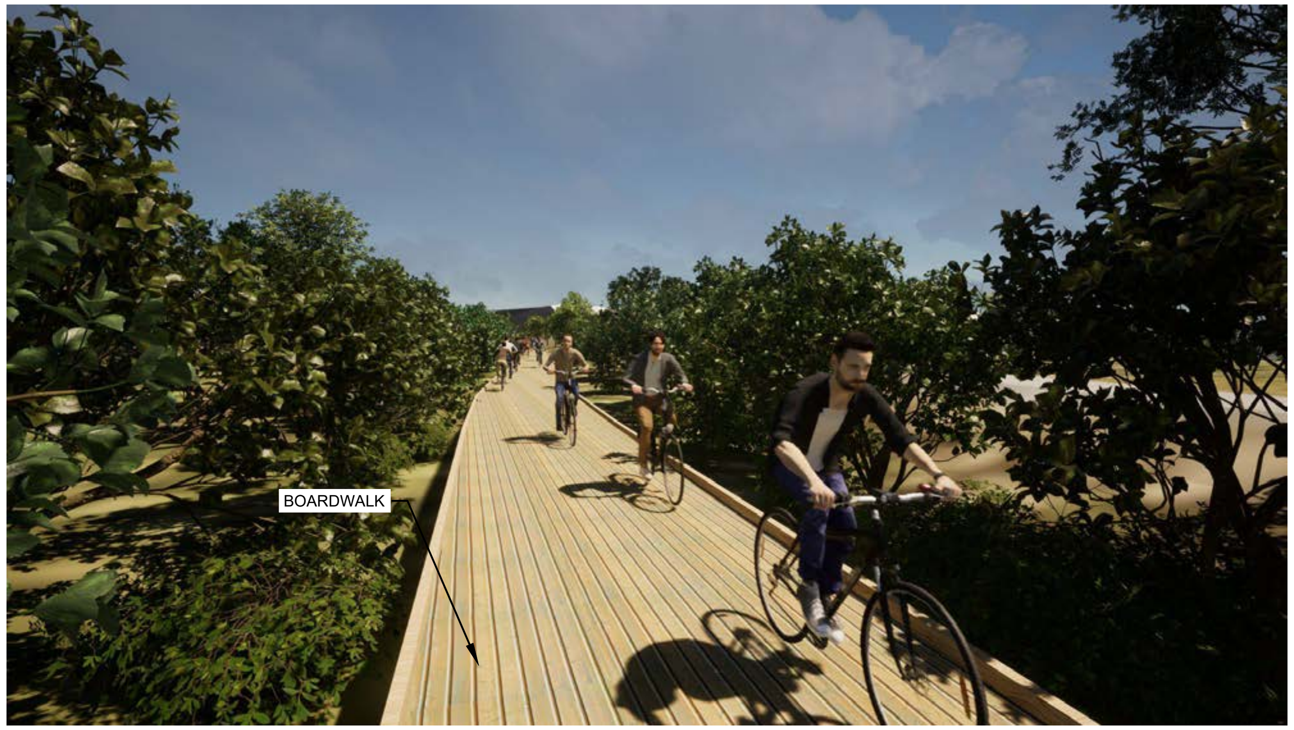
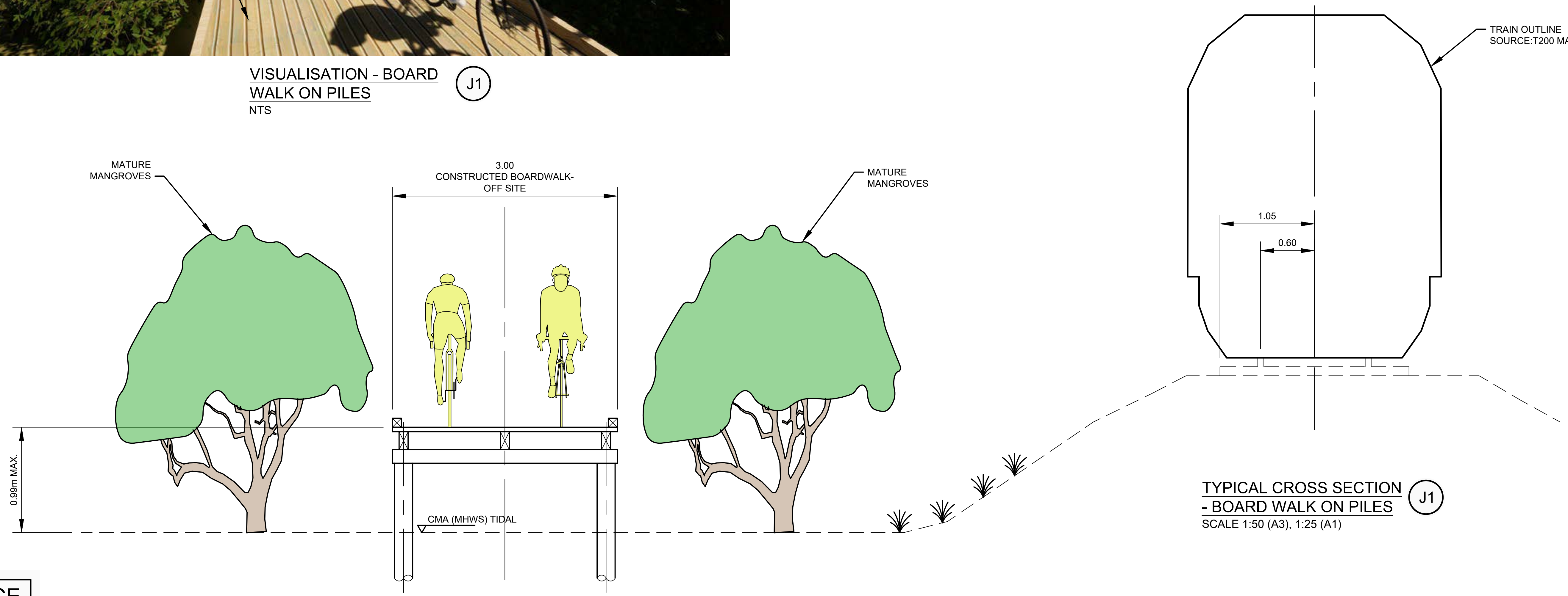


VISUALISATION - BOARD WALK ON PILES (J1)
NTS



TYPICAL CROSS SECTION - BOARD WALK ON PILES (J1)
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

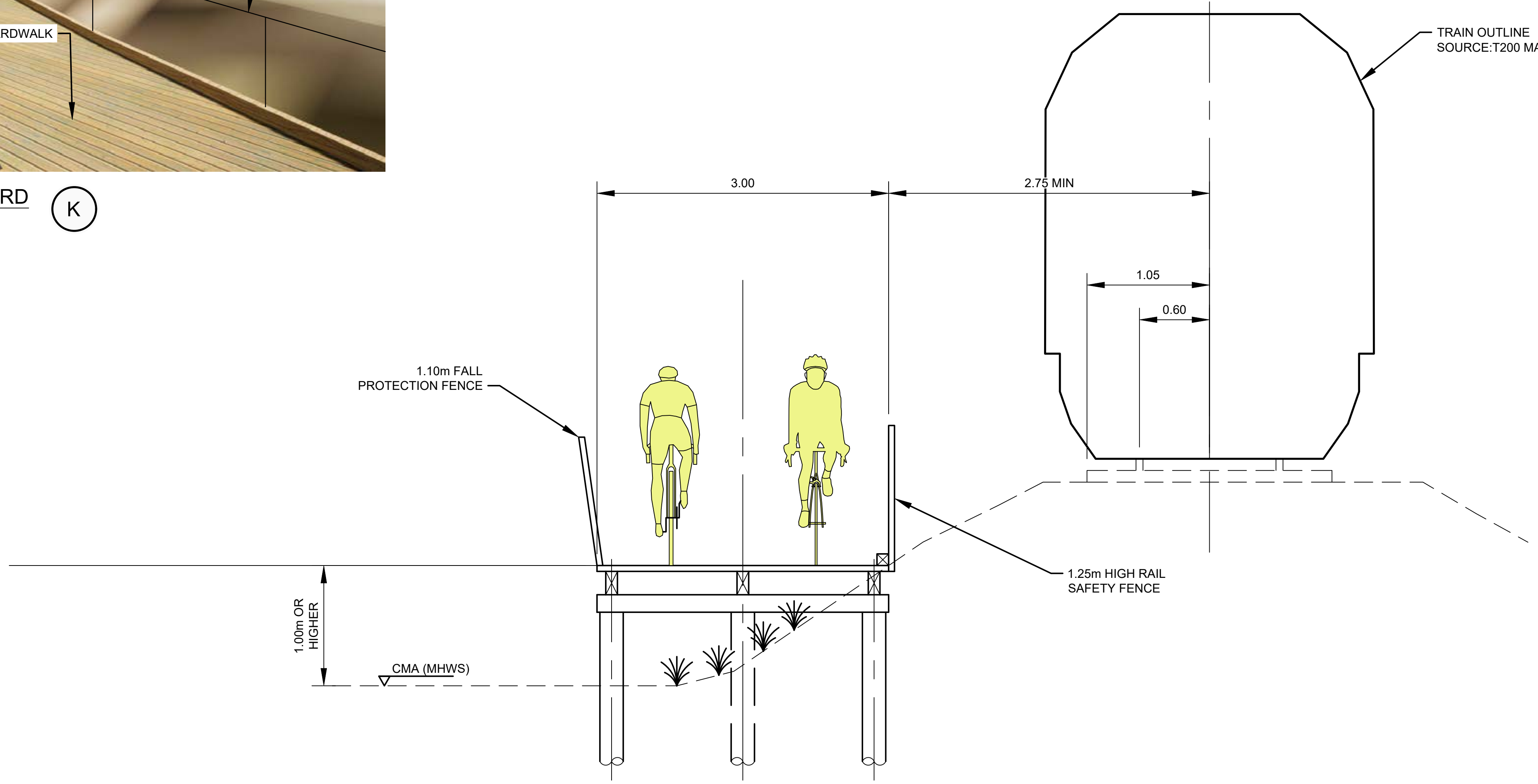
TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `J1' & VISUALISATION

STATUS: RESOURCE CONSENT | LOCAL AUTHORITY REF:

SCALE: SHOWN | PLOT DATE: | JOB: 2209-RC | SHEET: 18 | REVISION: 1

VISUALISATION - BOARD WALK ON PILES (K)
NTS



TYPICAL CROSS SECTION - BOARD WALK ON PILES (K)
SCALE 1:50 (A3), 1:25 (A1)

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

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AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

TITLE
KAWAKAWA TO OPUA CYCLE TRAIL
CONSENT DRAWINGS

TYPICAL CROSS SECTION `K' & VISUALISATION

STATUS	LOCAL AUTHORITY REF:		
RESOURCE CONSENT			

SCALE	PLOT DATE	JOB	SHEET	REVISION
SHOWN		2209-RC	19	1

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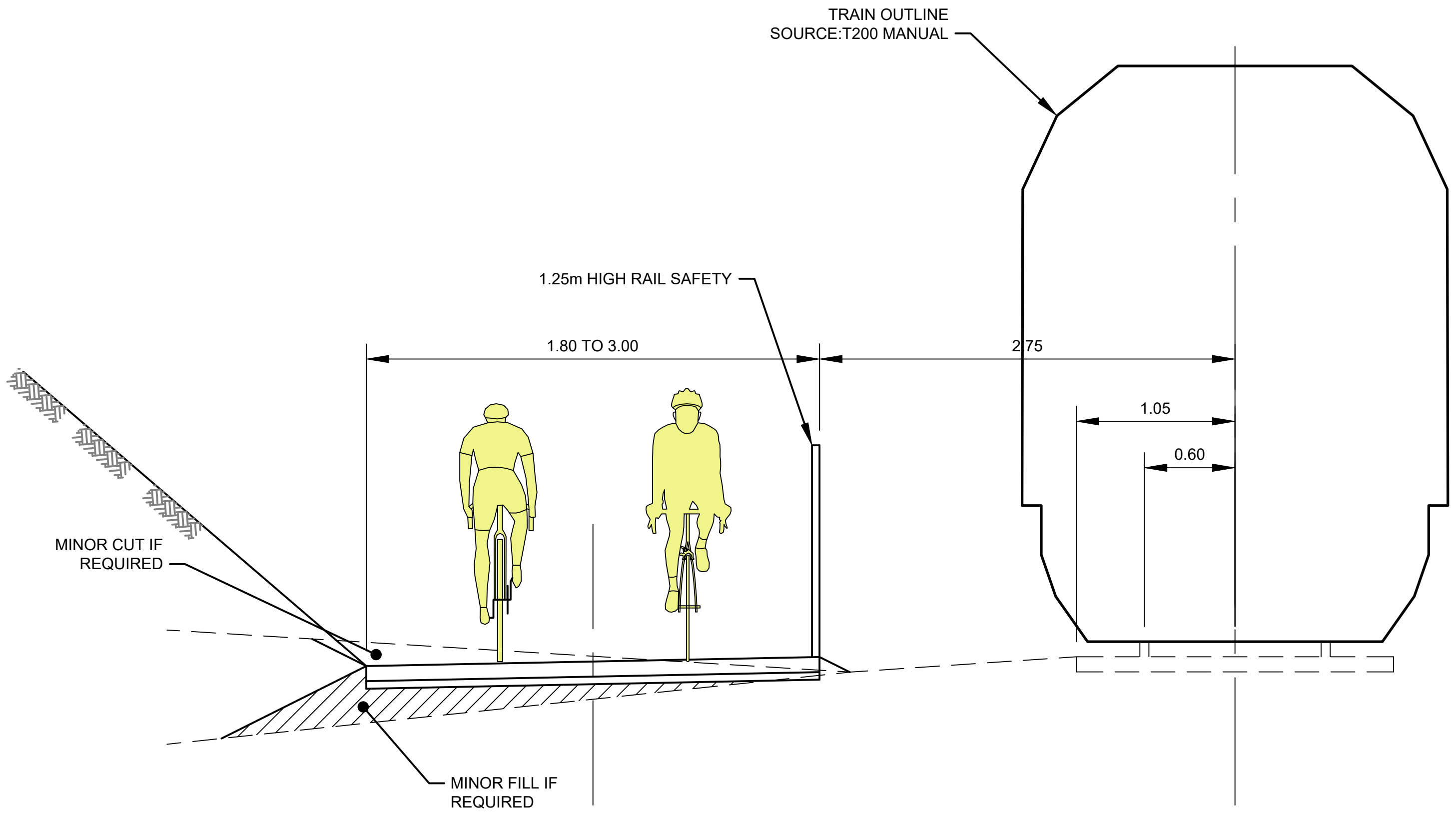
VISUALISATION - TRAIL AT GRADE (L)
NTS



TYPICAL CROSS SECTION - TRAIL AT GRADE (L)
SCALE 1:50 (A3), 1:25 (A1)

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

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AMENDMENT	APPRVD	DATE
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	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT: Far North District Council — Te Kaunihera o Tai Tokerau ki te Raki

TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `L' & VISUALISATION

STATUS: RESOURCE CONSENT
LOCAL AUTHORITY REF:

SCALE	PLOT DATE	JOB	SHEET	REVISION
SHOWN		2209-RC	20	1

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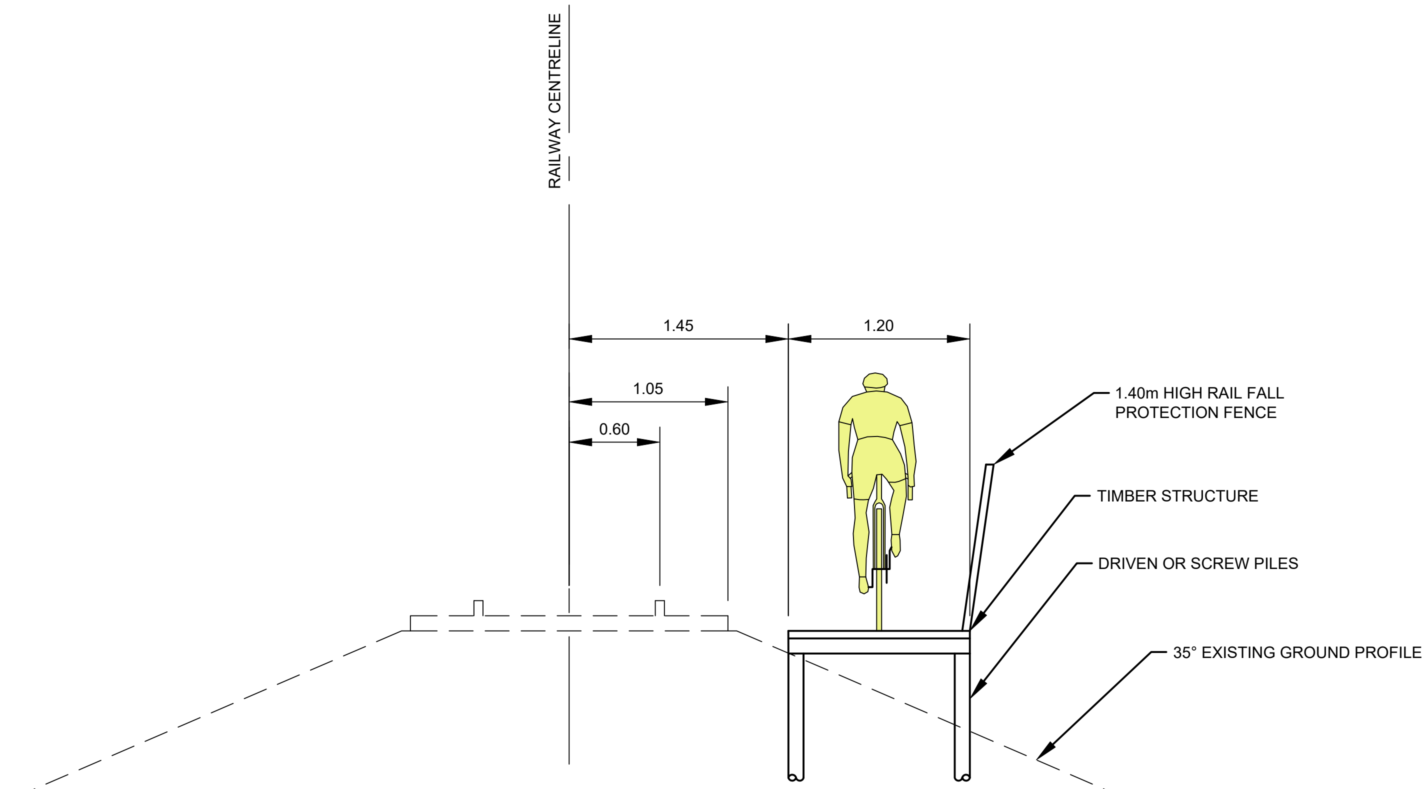
VISUALISATION - CONTINUATION LONG BRIDGE WALKWAY (M)
NTS



TYPICAL CROSS SECTION - CONTINUATION LONG BRIDGE WALKWAY (M)
SCALE 1:50 (A3), 1:25 (A1)

RESOURCE CONSENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:50 (A3), 1:25 (A1)

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1 - ALL QUANTITIES SUBJECT TO CONFIRMATION OF TRAIL WIDTH BY FNDC.
2 - ALL LENGTHS, VOLUMES AND AREAS APPROXIMATE ONLY, BASED ON PRELIMINARY DESIGN AND SUBJECT TO GEOTECHNICAL AND CIVIL DESIGN.
3 - ASSUMED WHERE NON HERITAGE AND HERITAGE CULVERTS INTERFACE THE ALIGNMENT THAT MINOR ABUTMENTS AND SHORT LENGTHS OF BOARDWALK WILL BE ADOPTED. THIS WILL AFFECT THE ABOVE VALUES.
4 - HANDRAILS FOR FALL PROTECTION (BELOW AND ABOVE CYCLEWAY) TO BE CONFIRMED. THIS MAY HAVE BEARING ON BUILDING CONSENT IF BUILDING CONSENT EXEMPTION IS NOT PROVIDED.
5 - SEPARATION FENCE BETWEEN CYCLEWAY AND RAIL WILL BE REQUIRED AND REMAINS SUBJECT TO CONFIRMATION AND REQUIRES SAFETY CASE APPROVAL BY BOIVRT, KIWIRAIL AND NZTA REGULATORS. GRADE SEPARATION MAY REDUCE ACTUAL LENGTHS.
6 - CMA ADOPTED FROM MHWS WHICH HAS BEEN INFERRED AT 1.1m R.L. OTP 1964 DATUM FOR THE PURPOSES OF THIS PROJECT. POSITION SHOWN IS APPROXIMATE ONLY. CERTIFICATION BY REGISTERED SURVEYOR REQUIRED TO CONFIRM ACCURACY OF LINE.
7- DO NOT SCALE DRAWING.
8- NOMINAL SCALE IS SHOWN FOR A3 SIZE UNLESS SHOWN OTHERWISE.
9- COORDINATES IN TERMS OF NZTM GEODETIC 2000 DATUM.
10- LEVELS IN TERMS OF MEAN SEA LEVEL ONE TREE POINT DATUM.
11- AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.

AMENDMENT	APPRVD	DATE
1 ISSUED TO FNDC FOR RESOURCE CONSENT		4.11.24

	BY	CHECKED	DATE
DESIGN	SG/BWP		5.24
DRAWN	BWP		5.24
SURVEYED	NRC LIDAR		2018
APPROVED			

JAS CIVIL Ltd

CLIENT
Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

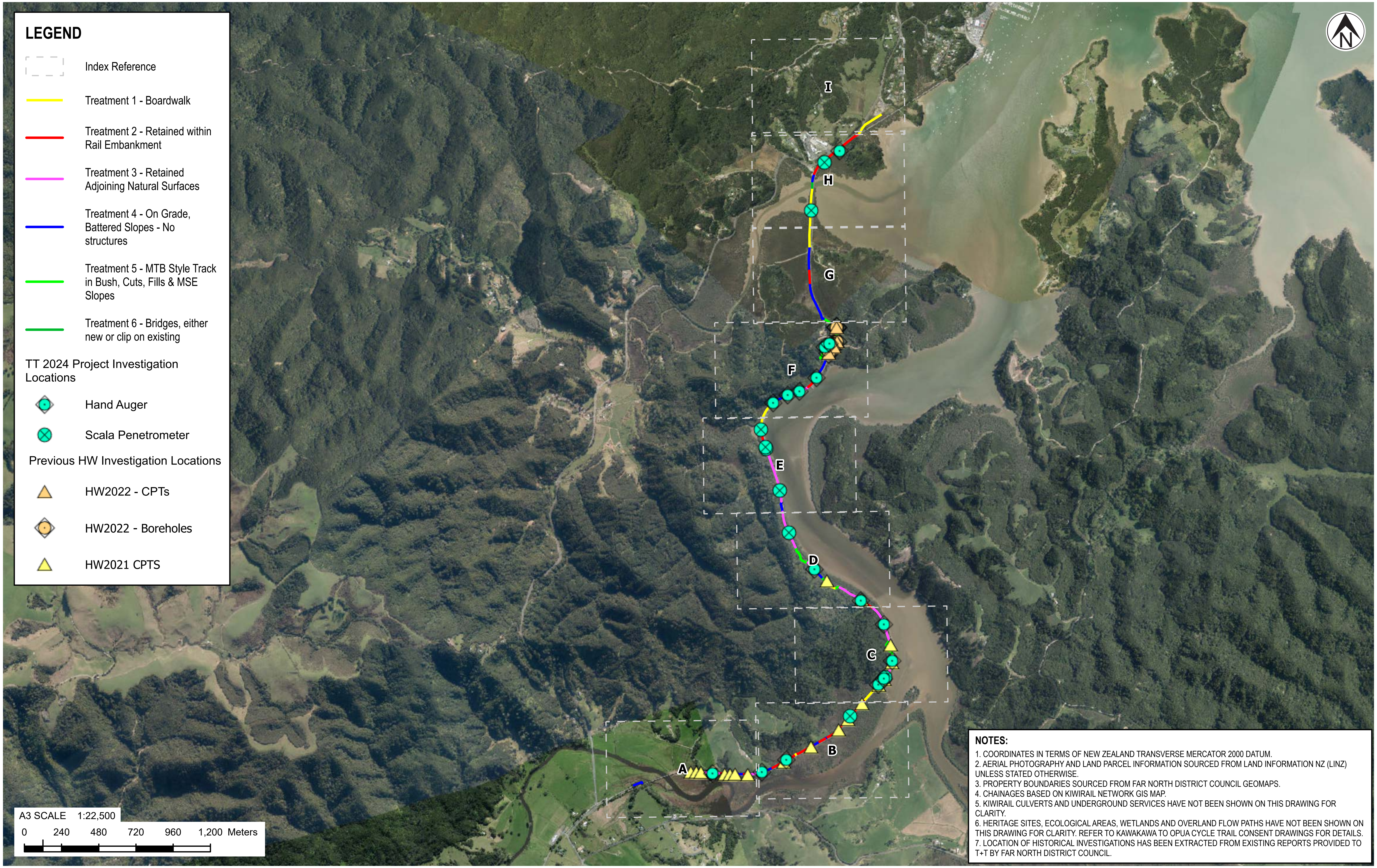
TITLE: KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS

TYPICAL CROSS SECTION `M' & VISUALISATION

STATUS	LOCAL AUTHORITY REF:			
RESOURCE CONSENT				
SCALE	PLOT DATE	JOB	SHEET	REVISION
SHOWN		2209-RC	21	1

c:\users\prest\onedrive\documents\pds design\projects\2209 opua cycleway\dwgs\2209_rc_08.dwg

Appendix B Site investigation plans



NOTES:

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3. PROPERTY BOUNDARIES SOURCED FROM FAR NORTH DISTRICT COUNCIL GEOMAPS.
4. CHAINAGES BASED ON KIWIRAIL NETWORK GIS MAP.
5. KIWIRAIL CULVERTS AND UNDERGROUND SERVICES HAVE NOT BEEN SHOWN ON THIS DRAWING FOR CLARITY.
6. HERITAGE SITES, ECOLOGICAL AREAS, WETLANDS AND OVERLAND FLOW PATHS HAVE NOT BEEN SHOWN ON THIS DRAWING FOR CLARITY. REFER TO KAWAKAWA TO OPUA CYCLE TRAIL CONSENT DRAWINGS FOR DETAILS.
7. LOCATION OF HISTORICAL INVESTIGATIONS HAS BEEN EXTRACTED FROM EXISTING REPORTS PROVIDED TO T+T BY FAR NORTH DISTRICT COUNCIL.

Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
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REV	DESCRIPTION	GIS	CHK	DATE
0	First version	CATA	PEMI	JUL.24

LOCATION PLAN

PROJECT No.	1090082	
DESIGNED	CATA	JUL.24
DRAWN	CATA	JUL.24
CHECKED	PEMI	JUL.24
APPROVED		DATE

CLIENT **FAR NORTH DISTRICT COUNCIL**

PROJECT **TAUMARERE TO OPUA CYCLEWAY**

TITLE GEOTECHNICAL INVESTIGATION PLAN INDEX MAP

SCALE (A3) 1:22,500 FIG No. FIGURE 1 REV 0

\\ttgroup.local\corporate\Auckland\Projects\1090082\WorkingMaterial\2.0 - Geotech Design\1 Site Invest\Stage 1\01 site investigation data\site plan\arcgis\Opua Kawakawa.aprx   Layout: Geotechnical Investigations   2024-Jul-05 3:37 pm   Drawn by CATA

LEGEND

TT 2024 Project Investigation Locations

Hand Auger

Previous Site Investigations (Haigh Workman)

HW2021 CPTS

Trail + Treatments

Treatment 1 - Boardwalk

Treatment 2 - Retained within Rail Embankment

Treatment 3 - Retained Adjoining Natural Surfaces

Treatment 4 - On Grade, Battered Slopes - No structures

Parcel + Property Boundaries

Property Boundary

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

NOTES:

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LOCATION PLAN

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DESIGNED	CATA	JUL.24
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CHECKED	PEMI	JUL.24
APPROVED		DATE

CLIENT FAR NORTH DISTRICT COUNCIL

PROJECT TAUMARERE TO OPUA CYCLEWAY

TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET A

SCALE (A3) 1:2,500   FIG No. FIGURE 2   REV 0

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LEGEND

TT 2024 Project Investigation Locations
- Hand Auger
- Scala Penetrometer

Previous Site Investigations (Haigh Workman)
- HW2021 CPTS

Trail + Treatments
- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 3 - Retained Adjoining Natural Surfaces
- Treatment 4 - On Grade, Battered Slopes - No structures

Parcel + Property Boundaries
- Property Boundary

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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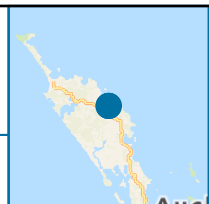
LOCATION PLAN



PROJECT No.	1090082	
DESIGNED	CATA	JUL.24
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CHECKED	PEMI	JUL.24
APPROVED		DATE

CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET B

SCALE (A3) 1:2,500 FIG No. FIGURE 3 REV 0

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LEGEND

TT 2024 Project Investigation Locations

- Hand Auger
- Scala Penetrometer

Previous Site Investigations (Haigh Workman)

- HW2021 CPTS

Trail + Treatments

- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 3 - Retained Adjoining Natural Surfaces
- Treatment 4 - On Grade, Battered Slopes - No structures
- Treatment 5 - MTB Style Track in Bush, Cuts, Fills & MSE Slopes

Parcel + Property Boundaries

- Property Boundary

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

NOTES:

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LOCATION PLAN

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CLIENT FAR NORTH DISTRICT COUNCIL

PROJECT TAUMARERE TO OPUA CYCLEWAY

TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET C

SCALE (A3) 1:2,500 FIG No. FIGURE 4 REV 0

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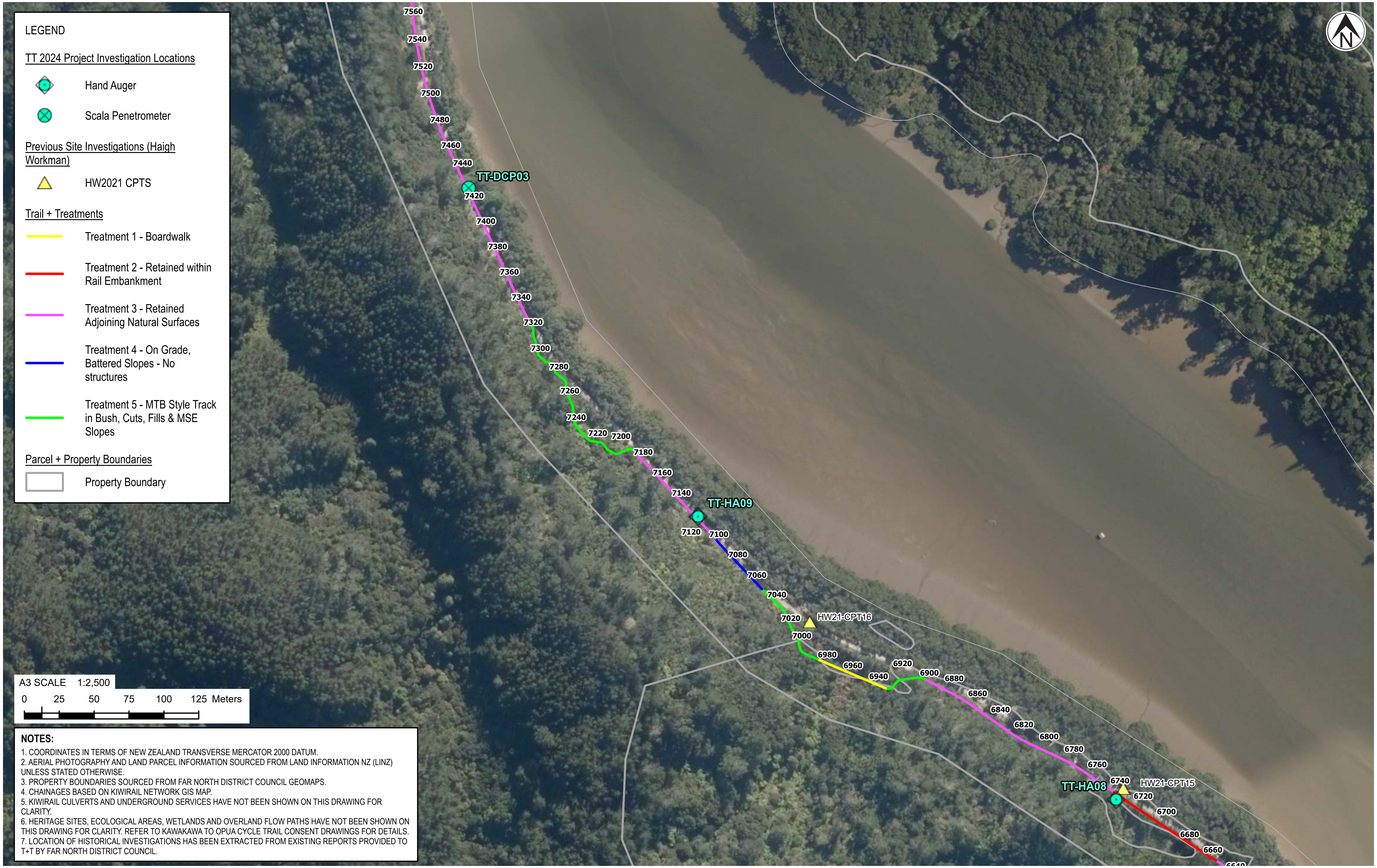

LEGEND

TT 2024 Project Investigation Locations
- Hand Auger
- Scala Penetrometer

Previous Site Investigations (Haigh Workman)
- HW2021 CPTS

Trail + Treatments
- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 3 - Retained Adjoining Natural Surfaces
- Treatment 4 - On Grade, Battered Slopes - No structures
- Treatment 5 - MTB Style Track in Bush, Cuts, Fills & MSE Slopes

Parcel + Property Boundaries
- Property Boundary

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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LOCATION PLAN

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CHECKED	PEMI	JUL.24
APPROVED		DATE

CLIENT FAR NORTH DISTRICT COUNCIL

PROJECT TAUMARERE TO OPUA CYCLEWAY

TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET D

SCALE (A3) 1:2,500 FIG No. FIGURE 5 REV 0

NOTES:

1. COORDINATES IN TERMS OF NEW ZEALAND TRANSVERSE MERCATOR 2000 DATUM.
2. AERIAL PHOTOGRAPHY AND LAND PARCEL INFORMATION SOURCED FROM LAND INFORMATION NZ (LINZ) UNLESS STATED OTHERWISE.
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APPROVED		DATE

CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET E

SCALE (A3) 1:2,500 FIG No. FIGURE 6 REV 0

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LEGEND

TT 2024 Project Investigation Locations

- Hand Auger

Previous Site Investigations (Haigh Workman)

- HW2022 - CPTs
- HW2022 - Boreholes

Trail + Treatments

- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 3 - Retained Adjoining Natural Surfaces
- Treatment 4 - On Grade, Battered Slopes - No structures
- Treatment 5 - MTB Style Track in Bush, Cuts, Fills & MSE Slopes

Parcel + Property Boundaries

- Property Boundary

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

NOTES:

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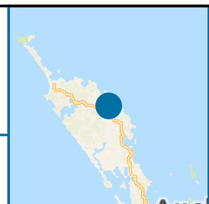
LOCATION PLAN



PROJECT No.	1090082	
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DRAWN	CATA	JUL.24
CHECKED	PEMI	JUL.24
APPROVED		DATE

CLIENT FAR NORTH DISTRICT COUNCIL

PROJECT TAUMARERE TO OPUA CYCLEWAY

TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET F

SCALE (A3) 1:2,500 FIG No. FIGURE 7 REV 0

NOTES:
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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET G
SCALE (A3) 1:2,500 FIG No. FIGURE 8 REV 0

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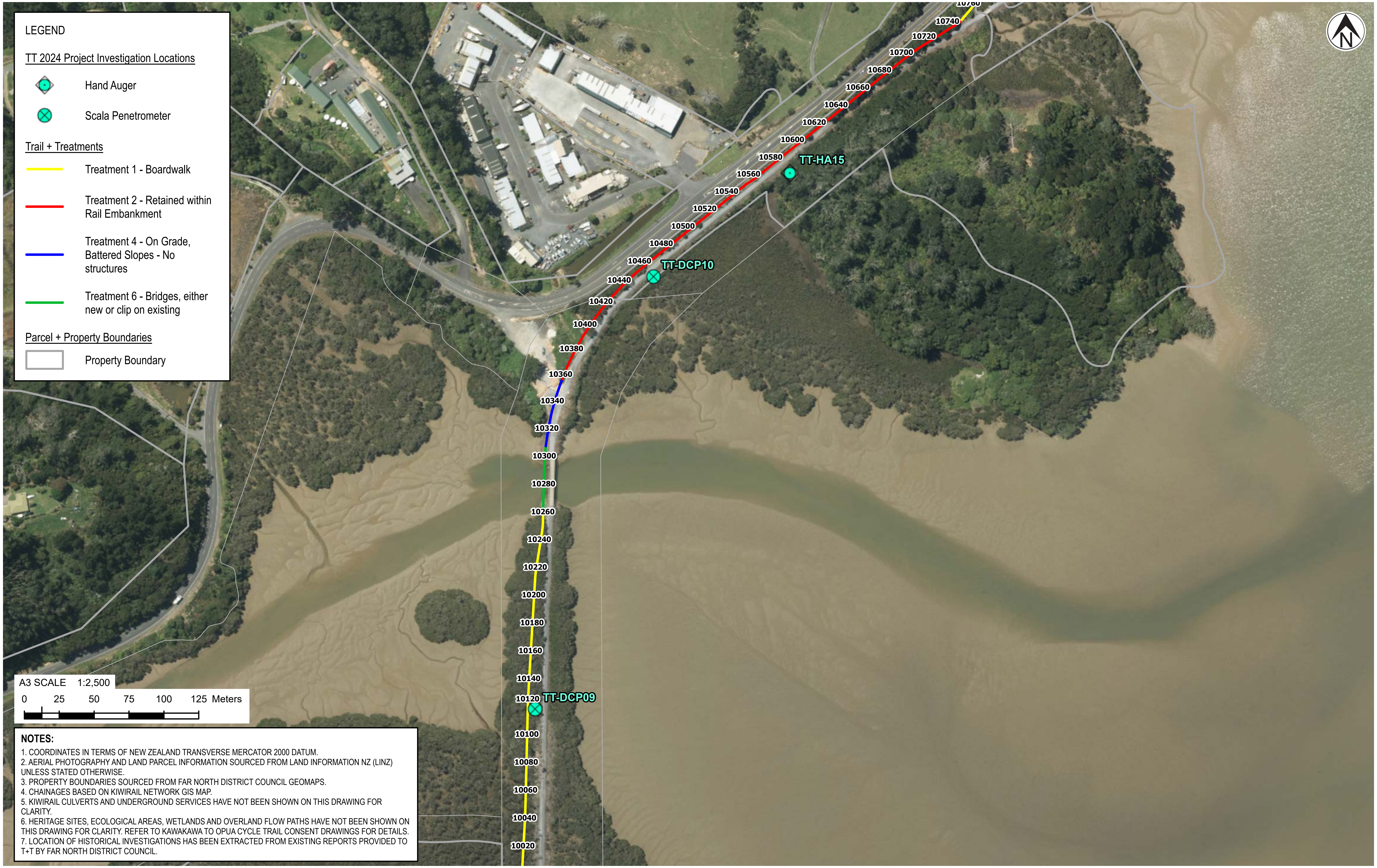

LEGEND

TT 2024 Project Investigation Locations

- Hand Auger
- Scala Penetrometer

Trail + Treatments

- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 4 - On Grade, Battered Slopes - No structures
- Treatment 6 - Bridges, either new or clip on existing

Parcel + Property Boundaries

- Property Boundary

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

NOTES:

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APPROVED		DATE

CLIENT **FAR NORTH DISTRICT COUNCIL**

PROJECT **TAUMARERE TO OPUA CYCLEWAY**

TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET H

SCALE (A3) 1:2,500 FIG No. FIGURE 9 REV 0

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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE GEOTECHNICAL INVESTIGATION PLAN - SHEET I
SCALE (A3) 1:2,500 FIG No. FIGURE 10 REV 0

Appendix C Landslide mapping

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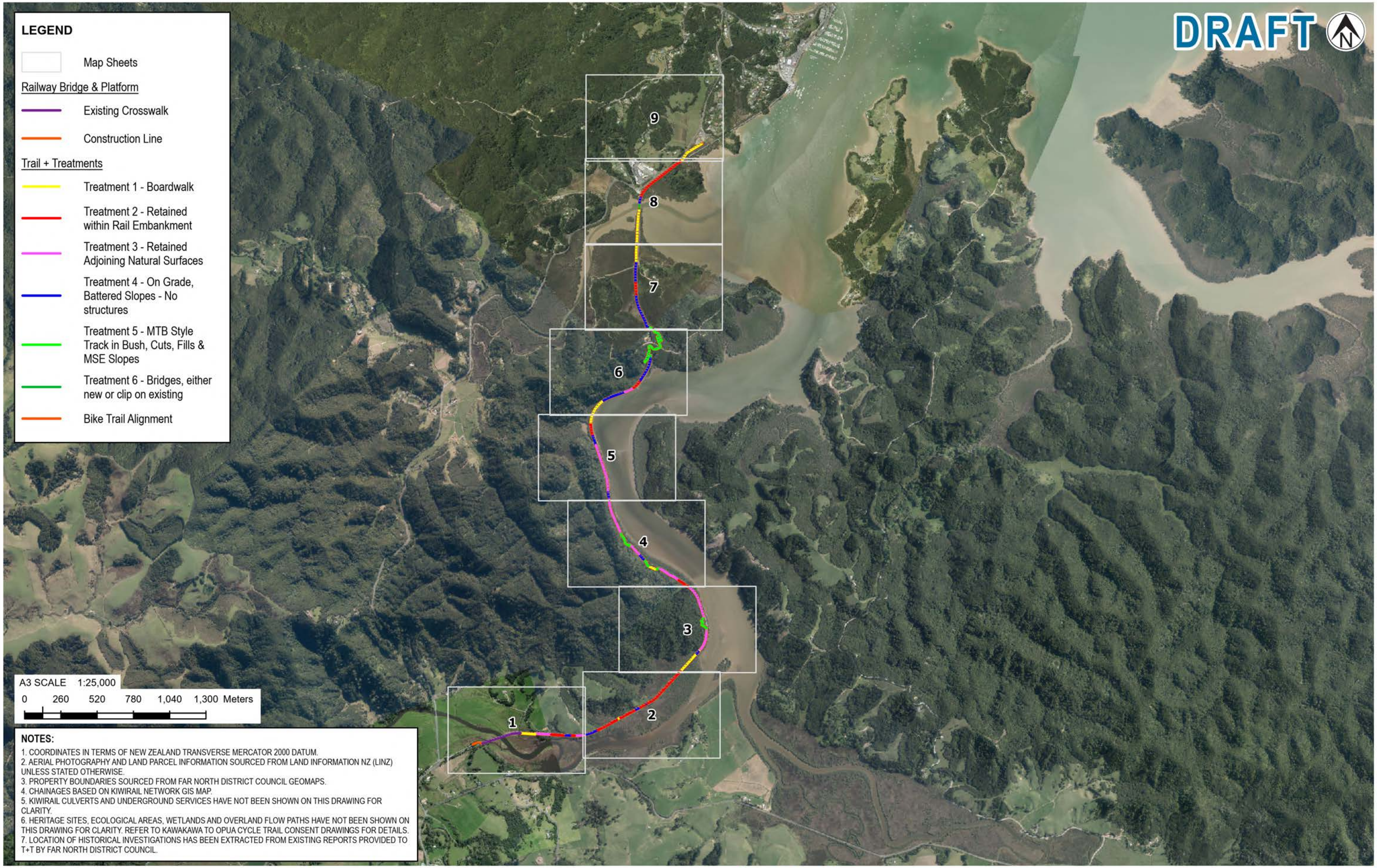

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0	First version	DSMI	XXXX	JUL.24

LOCATION PLAN

PROJECT No.	1090082	
DESIGNED	DSMI	AUG.24
DRAWN	DSMI	AUG.24
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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE LANDSLIDE FEATURES - INDEX MAP
SCALE (A3) 1:25,000 FIG No. APPENDIX A - FIGURE 1-0 REV 0

NOTES:

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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE LANDSLIDE FEATURES - SHEET 1

SCALE (A3) 1:2,500   FIG No. APPENDIX C FIGURE 1-1   REV 0

LEGEND

Landslide Features

- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)

- 1m
- 10m

Chainage

- Chainage 20m (GIS)

Railway Bridge & Platform

- Existing Crosswalk
- Construction Line

Trail + Treatments

- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 3 - Retained Adjoining Natural Surfaces
- Treatment 4 - On Grade, Battered Slopes - No structures
- Treatment 5 - MTB Style Track in Bush, Cuts, Fills & MSE Slopes
- Treatment 6 - Bridges, either new or clip on existing
- Bike Trail Alignment

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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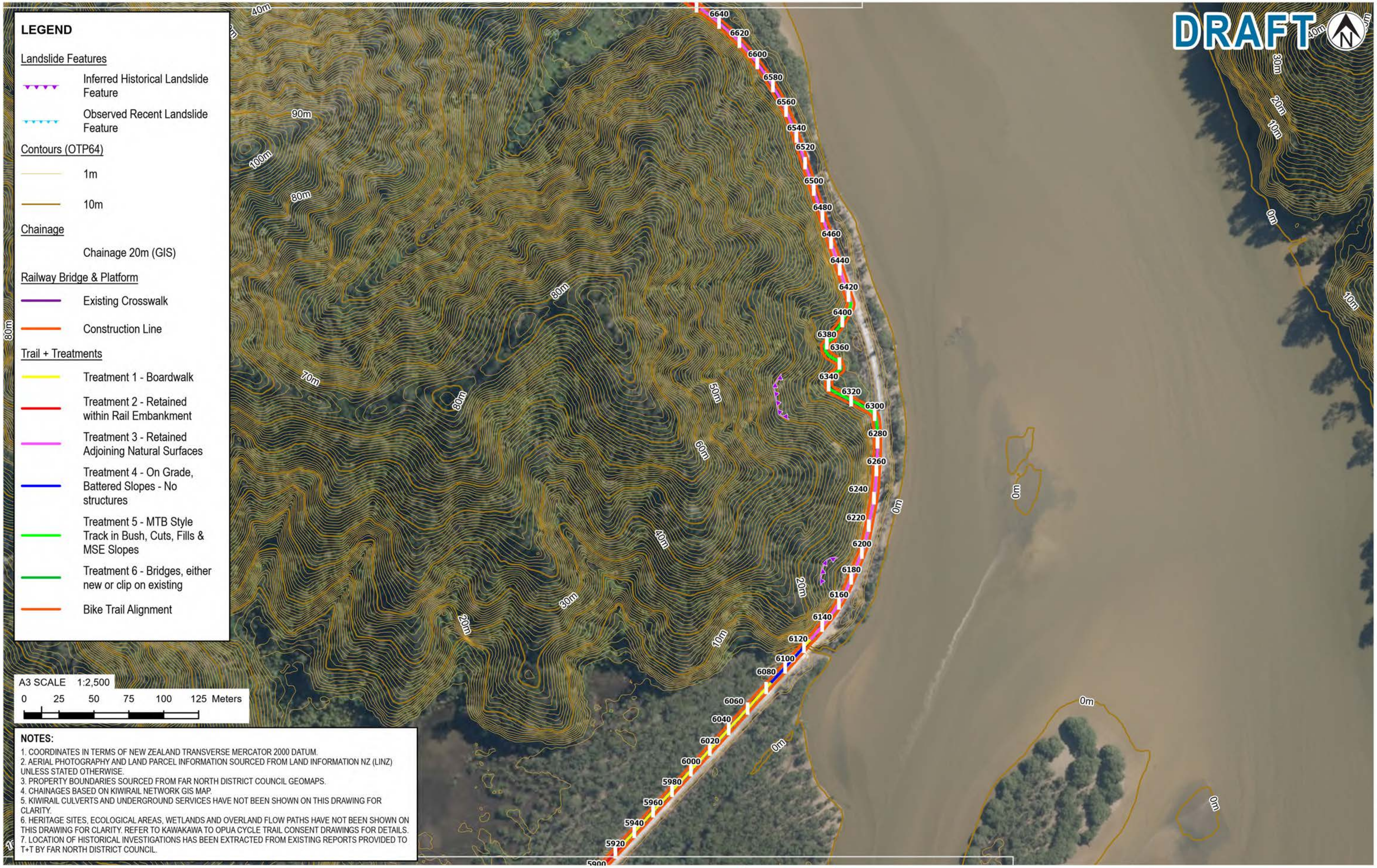
CLIENT FAR NORTH DISTRICT COUNCIL

PROJECT TAUMARERE TO OPUA CYCLEWAY

TITLE LANDSLIDE FEATURES - SHEET 2

SCALE (A3) 1:2,500 FIG No. APPENDIX C FIGURE 1-2 REV 0



LEGEND

Landslide Features
- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)
- 1m
- 10m

Chainage
- Chainage 20m (GIS)

Railway Bridge & Platform
- Existing Crosswalk
- Construction Line

Trail + Treatments
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A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE LANDSLIDE FEATURES - SHEET 3

SCALE (A3) 1:2,500 FIG No. APPENDIX C FIGURE 1-3 REV 0

LEGEND

Landslide Features
- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)
- 1m
- 10m

Chainage
- Chainage 20m (GIS)

Railway Bridge & Platform
- Existing Crosswalk
- Construction Line

Trail + Treatments
- Treatment 1 - Boardwalk
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- Treatment 6 - Bridges, either new or clip on existing
- Bike Trail Alignment

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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CLIENT: FAR NORTH DISTRICT COUNCIL

PROJECT: TAUMARERE TO OPUA CYCLEWAY

TITLE: LANDSLIDE FEATURES - SHEET 4

SCALE (A3): 1:2,500   FIG No. APPENDIX C FIGURE 1-4   REV 0

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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE LANDSLIDE FEATURES - SHEET 5
SCALE (A3) 1:2,500 FIG No. APPENDIX C FIGURE 1-5 REV 0

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LEGEND

Landslide Features
- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)
- 1m
- 10m

Chainage
- Chainage 20m (GIS)

Railway Bridge & Platform
- Existing Crosswalk
- Construction Line

Trail + Treatments
- Treatment 1 - Boardwalk
- Treatment 2 - Retained within Rail Embankment
- Treatment 3 - Retained Adjoining Natural Surfaces
- Treatment 4 - On Grade, Battered Slopes - No structures
- Treatment 5 - MTB Style Track in Bush, Cuts, Fills & MSE Slopes
- Treatment 6 - Bridges, either new or clip on existing
- Bike Trail Alignment

A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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CLIENT FAR NORTH DISTRICT COUNCIL
PROJECT TAUMARERE TO OPUA CYCLEWAY
TITLE LANDSLIDE FEATURES - SHEET 6
SCALE (A3) 1:2,500 FIG No. APPENDIX C FIGURE 1-6 REV 0

LEGEND

Landslide Features
- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)
- 1m
- 10m

Chainage
- Chainage 20m (GIS)

Railway Bridge & Platform
- Existing Crosswalk
- Construction Line

Trail + Treatments
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A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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PROJECT	TAUMARERE TO OPUA CYCLEWAY
TITLE	LANDSLIDE FEATURES - SHEET 7

SCALE (A3) 1:2,500   FIG No. APPENDIX C FIGURE 1-7   REV 0

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LEGEND

Landslide Features
- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)
- 1m
- 10m

Chainage
- Chainage 20m (GIS)

Railway Bridge & Platform
- Existing Crosswalk
- Construction Line

Trail + Treatments
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A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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CLIENT **FAR NORTH DISTRICT COUNCIL**

PROJECT **TAUMARERE TO OPUA CYCLEWAY**

TITLE LANDSLIDE FEATURES - SHEET 8

SCALE (A3) 1:2,500   FIG No. APPENDIX C FIGURE 1-8   REV 0

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LEGEND

Landslide Features
- Inferred Historical Landslide Feature
- Observed Recent Landslide Feature

Contours (OTP64)
- 1m
- 10m

Chainage
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Railway Bridge & Platform
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A3 SCALE 1:2,500

0 25 50 75 100 125 Meters

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PROJECT TAUMARERE TO OPUA CYCLEWAY

TITLE LANDSLIDE FEATURES - SHEET 9

SCALE (A3) 1:2,500 FIG No. APPENDIX C FIGURE 1-9 REV 0

Appendix D Geotechnical risk register

Project Name Kawakawa to Opua Cycleway Detailed Design
Project Number 1090082
Revision 0.2

Prepared by: Mark Child + Project Team
Reviewed by:
Date : 11/07/2024

Tonkin+Taylor

Ref ID #	Threat/ Opportunity	Risk Name	Risk Description	Risk Category (edit on Reference Tab)	Risk Status	Treatment Status	Existing Control(s) (if any)	Risk Assessment (with Existing Controls) Likelihood	Consequence	Risk Rating	Possible treatment/mitigation	Risk Assessment (after treatment) Likelihood	Consequence	Risk Rating	Risk Owner
1	Threat	Misalignment of stakeholders affecting decision making	The project has a complex stakeholder arrangement and misalignment of stakeholders has resulted in the project being abandoned at concept design stage in the past. If stakeholders are misaligned then important decision making milestones may not be resolved resulting in adverse project impacts with respect to cost and programme, or may result in the project being abandoned once again.	Stakeholder	Live - Treat	Live	FNDC to assign stakeholder engagement lead to enable stakeholders to be heard and "bring them on the journey".	Likely	Extreme	High	FNDC and stakeholders to agree decision making protocols, such as a governance board or Project Steering Group (PSG) to enable effective project decision making.	Unlikely	Extreme	Moderate	FNDC Project Manager
2	Threat	Resource Consent requirements affect the delivery programme	Lack of understanding of the Resource Consent requirements associated with the preferred concept route result in programme delays.	Consenting	Live - Treat	Live	Early engagement of Planner to provide planning advice during the GAP analysis phase, prior to confirming the conceptual alignment and project staging.	Likely	Major	High	Adopt planning advice and separate out stages of the project that present onerous Resource Consent requirements from those that are permitted.	Possible	Major	Moderate	FNDC Project Manager
3	Threat	Resource & Building Consent processing time affects the delivery programme	There are currently significant delays in the processing of Resource and Building Consents by FNDC which may result in programme delays	Consenting	Emerging	Proposed	Early engagement of Planner to provide advice on likely consenting timeframes	Possible	Major	Moderate	Consider staged consent application to progress lower impact sections in early works. Allow adequate float in the design and construction programme to allow for consent processing delays	Possible	Moderate	Moderate	FNDC Project Manager
4	Threat	KiwiRail approvals	KiwiRail has an exceptional workload at the moment due to the recent adverse weather events. In addition, KiwiRail is known for long approvals processes.	Project Risk	Emerging	Live	Early submission of the shared path application to KiwiRail. Early advice received by RIC during previous phase of project.	Likely	Extreme	High	Use existing relationships to drive the approvals process. Welcome engagement with KiwiRail approvals team. Engage RIC to provide pragmatic rail design advice.	Possible	Extreme	High	Design Manager
5	Opportunity	Decouple cycleway from trains over Long Bridge	There is an opportunity to be explored with respect to decoupling the cycleway from interaction with trains over Long Bridge. This would improve user experience & safety for both the train and the cycle trail by removing the physical barrier across both ends of Long Bridge.	Engineering/Design	Emerging	Proposed	Undertake early concept level optioneering, design and pricing exercise to inform high level cost estimate.	Likely	Major	High					
6	Threat	Ground conditions worse than anticipated	Findings from site investigations (or during construction) identify that the ground conditions are worse than originally assumed for the design, resulting in potential design changes and programme delays	Engineering/Design	Emerging	Live	Design considers moderately conservative ground conditions. Undertake geotechnical investigations early in the design stage to inform understanding of ground conditions and variability.	Likely	Extreme	High	Design to allow for variation in conditions between investigation locations to minimise impact to construction programme if adverse ground conditions are encountered. Contractor to consider pre construction trials to better understand ground conditions early in construction.	Likely	Major	High	T+T, FNDC PM, contractor
7	Threat	Brownfield site	The site (or portions of it) have previously been built on and are now abandoned or underutilised; resulting in possible contamination along the route that could potentially increase workload to remove contaminants, affecting programme and cost.	Project Risk	Emerging	Live	Engage Contam land expert to review alignment and identify potential risk areas. Early communication with client to track down as built to check previous structures of the site. Existing site investigations showing geology and potential contaminants in subject site.	Almost Certain	Moderate	High	Undertake contamination assessment and focussed testing. Develop contamination management plan for implementation during construction	Unlikely	Minor	Low	PM
8	Threat	Ecology of local environments	Local ecology (flora & fauna) present on alignment resulting in design changes / alternative route options with adverse cost and programme implications	Environmental	Live - Treat	Live	Undertake ecological assessment to identify potential habitats of important species.	Likely	Major	High	Undertake detailed ecological assessment to identify ecological constraints and opportunities.	Unlikely	Major	Moderate	NZ Environmental
9	Threat	Freshwater wetlands restricting design	Presence of freshwater wetlands (areas that are difficult to construct on based on potential settlement and capacity limitations) located on proposed cycleway alignment resulting in design / alignment restrictions	Engineering/Design	Live - Treat	Live	Undertake ecological assessment to delineate freshwater wetlands. Develop consenting strategy to mitigate risk to project.	Likely	Major	High	Early delineation of wetlands (mapping) and understanding of freshwater legislation and what types of cycleways are feasible within fresh water wetlands. Develop alternative options for the cycleway that divert around the margin of freshwater wetlands and/or remain within the extent of the existing embankments.	Unlikely	Major	Moderate	NZ Environmental
10	Threat	Wildlife permits are required resulting in a risk to Project Programme	Currently DoC require 6 to in excess of 12 months to process wildlife permits for authority to handle protected wildlife presenting a risk to programme.	Environmental	Live - Treat	Live	Delineate wetlands and ecology of importance / habitats	Likely	Major	High	If high value ecological area are identified then undertake detailed surveys to confirm presence of fauna. Lodge wildlife permits early (including management plans) to reduce the risk of adverse impact to programme	Possible	Major	Moderate	NZ Environmental

11	Threat	Lack of understanding on bridge abutments and foundations	Lack of knowledge from a resource-consenting point of view regarding bridge abutments and foundations resulting in delays to the consenting process through inability to confirm consenting strategy and lodge consent	Engineering/Design	Live - Treat	Proposed	Early submission of abutment / foundation designs to get a good understanding of what is required for resource consenting (i.e. early communication to fix problems). Requires early ground investigations to inform design and enable consenting strategy	Likely	Major	High	Undertake ground investigations and develop concept design options for bridge abutments and foundations. Delineate wetlands and CMA before planning can advise on constraints around solutions. Engage with Heritage NZ around archaeology constraints at bridges etc. Minimise impact of bridge foundations on the existing environment.	Possible	Major	Moderate	T+T B&A
12	Threat	Pinch points that encroach within minimum rail offsets	Proposed design might not be accepted by KiwiRail due to rail offset limitations resulting in potential delays due to redesign	Engineering/Design	Live - Treat	Live	Early submission of design to KiwiRail get initial feedback regarding alignment. Communications with KiwiRail team to get an understanding of minimum rail offsets and possible solutions for areas encroaching minimum rail offsets.	Possible	Major	Moderate	Sections D, E, and F - Rail safety case required to support reduced offsets - 2.75 generally applied - 2.30 at squeeze points applied to concept drawings (based on RIC's initial advice). Identify and pass to designer of the specific project stages to close out. Produce conceptual design of a "typical" clip on structure that can be achieved structurally. Adopt siding clearance requirements for offsets. Put this to Alan to advise	Unlikely	Major	Moderate	JAS Civil T+T RIC Kakariki
13	Opportunity	Exotic species vegetation encroaching within rail and cycleway	Exotic species of vegetation have overgrown to block the proposed alignment of the rail / cycleway. There is an opportunity to undertake detailed inspection of proposed alignment during / following enabling vegetation clearance of the area	Engineering/Design	Emerging	Proposed	Ecological assessment to identify high value ecology.	Likely	Moderate	Moderate	Undertake enabling vegetation clearance to enable detailed design inspection of the cycleway alignment including wetlands	Rare	Moderate	Low	DM PM NZ Enviro
14	Threat	Limited Construction Access	Portions of the cycleway alignment are difficult to access, leading to a delay in programme to accommodate for appropriate access to undertake works.	Project Risk	Emerging	Proposed	Detailed design of cycleway avoids areas that are likely to be hard to access. Early contractor involvement to identify problem areas based on prelim design	Possible	Major	Moderate	Early work to identify suitable construction access over / around / through Whangae Tunnel to enable conventional traffic to access from the north	Unlikely	Moderate	Moderate	DM T+T JAS Civil
15	Opportunity	Limited material to borrow for embankment construction	Difficulty in acquiring material to use for embankment construction, leading to potential cost and programme implications (i.e. the need to purchase and acquire material elsewhere and incur increased cost for material due to shortage, and increased wait times for material to be delivered onto site).	Project Risk	Emerging	Proposed	Early contractor involvement to assist in material procurement advise and alternate solutions using locally sourced materials.	Likely	Major	High	Undertake early work to identify suitable borrow areas local to the rail reinstatement and north of Te Akeake platform. Potential opportunity to win borrow in tunnel bypass design that could complement the construction access	Possible	Major	Moderate	Design Manager T+T JAS Civil
16	Opportunity	Regional significant infrastructure legislation enables more flexible consenting pathway	Regionally significant infrastructure legislation enables consenting pathway and flexibility around activities within and around freshwater wetlands / NES requirements.	Consenting	Closed	Completed - Successful	Early planning advice received from B&A confirming that the project can be classed as regionally significant infrastructure.	Rare	Insignificant	Low	Regionally significant infrastructure - review NCR plans and definition of 'Regionally significant infrastructure' and provide initial advice of interpretation. This is key for determining relevance of the NPS-Freshwater and NPS-FM and how we deal with the wetlands	Rare	Insignificant	Low	Closed - B&A Advice Memo
17	Threat	Uncertainty around the definition of MHWS and the CMA	Lack of understanding regarding the terms 'MHWS' and 'CMA' leading to miscommunication between parties and implications on cost / programme if not clearly understood	Project Risk	Live - Treat	Completed - Successful	MHWS and CMA plotted on plans and relevant caveats conveyed on plans. Undertake Ecological Assessment to delineate freshwater wetlands.	Possible	Major	Moderate	Present the Project's understanding of the CMA and freshwater wetland extents, along with management plans and consenting strategy to NRC for advice and approval.	Unlikely	Major	Moderate	B&A JAS to plot council data to drawings (step 1) Detailed environmental mapping (step 2) NR Council meeting (Step32)
18	Threat	Cultural values interface - planning	Potential risk to design / construct alignment near or on cultural sites of significance (i.e. locations of site near the coast / archaeology). This can lead to delays in programme and project success	Stakeholder	Emerging	Live	Early engagement with relevant cultural parties and stakeholders regarding cultural sites of significance in close proximity to proposed design / alignment	Possible	Major	Moderate	Kevin to provide Makarena Polly's contact details Early engagement with stakeholders, Mana Whenua Draft CIA is under development.	Unlikely	Major	Moderate	PM B&A
19	Threat	Complex stakeholder relationship toward Opua beyond Colenso Triangle	Potential delays in programme and implications to project delivery due to complex relationship with Opua beyond Colenso Triangle	Project Risk	Emerging	Proposed	Early engagement with these stakeholders to ensure amicable and productive solutions throughout the project life	Likely	Major	High	Early engagement with stakeholders Opportunity to break this section out as a separate Stage to prevent adverse impacts to the project south of Colenso Triangle.	Possible	Moderate	Moderate	PM T+T B&A
20	Threat	Tunnel Options (Over / Through)	Potential design and construction risks to the tunnel that go with either going over a certain route or through the tunnel could result in adverse programme implications and alternate design being required.	Engineering/Design	Emerging	Proposed	Early engagement with clients for their input regarding the best course of action. Early engagement with tunnel design consultant to identify risks to the tunnel based on cycleway design	Likely	Major	High	Allow flexibility in design through presenting various options that cover a range of basis i.e. well clear of the tunnel, through tunnel, over tunnel etc Consider pricing options for passing through tunnel to understand the constraints and enable effective decision making from stakeholders	Possible	Major	Moderate	PM DM JAS Civil
21	Opportunity	Retaining wall options	Given the proximity to the rail environment, live rail and non active rail there is an opportunity to develop a suite of retaining wall options that benefit the wider environment and project.	Engineering/Design	Emerging	Proposed	Early engagement with stakeholders and contractors to understand appetite to explore a suite of options to retain cut slopes	Likely	Major	High					PM T+T
22	Threat	Extent of boardwalk required	Uncertainty remains on the extent of boardwalk that is required. Factors such as soft soils underlying embankment fill and ecological areas of significance will influence the extent of boardwalk which comes at increased cost and presents adverse impacts to programme and budget.	Engineering/Design	Live - Treat	Proposed	Early engagement of ecologist to understand environmental constraints and early procurement of geotechnical investigations. Efficient design and construction to save on budget to carry out additional scope	Likely	Extreme	High	Aim to reduce the length of boardwalk as much as possible.	Possible	Extreme	High	PM JAS Civil T+T NZ Enviro.

23	Threat	Design finished levels	Uncertainty regarding the finished levels of the alignments and associated embankments / boardwalks (if required) to account for flood and sea-level rise. Higher embankments reduce grade separation from the rail may result in the need for fencing which will add cost implications to the project.	Engineering/Design	Live - Parked	Rejected	Consider flood levels and high level sea-level rise in developing preliminary alignment options. Agree with FNDC project requirements with respect to flood and sea-level rise.	Likely	Major	High	Early engagement of coastal and flood engineering services to confirm required elevations, agreement with stakeholders and Council on project requirements.	Likely	Moderate	Moderate	PM
	Opportunity	Accept reduced design finished levels	Adopting finished levels that are susceptibility to flooding present significant cost savings and a higher level of useability for the trail. This does present an elevated risk of sections of the trail flooding under storm events, which are expected to increase with climate change, including sea-level rise. Embankments and walkways elevated above flood and sea-level rise are unlikely to meet budget and stakeholder requirements.	Project Risk	Impacted	Completed - Successful	Adopting lower levels that are susceptible to flooding and sea-level rise present opportunities to reduce cost and increase useability. Boardwalk and associated structures that may be susceptible to flooding will require consideration of buoyancy in design.	Almost Certain	Extreme	High	Levels have been adopted that are susceptable to flooding in places due to cost benefits realise dthrough not having to elevate the treatments above flood levels and maintaining conenction to the surrounding environment, such as not requiring hand rails on boardwalks whcih are significant cost components. If flooding becomes a nusance, then raising the affected areas in the future can be considered.	Likely	Moderate	Moderate	
24	Opportunity	Construction methods	At developed design stage there is an opportunity to explore potential construction methods with experienced contractors. This provides an opportunity to find simple yet efficient ways of construction that can potentially cut down cost through efficiency.	Construction	Emerging	Proposed	Early construction input to explore opportunities in cutting costs.	Likely	Major	High	Progress simple designs with flexibility to change				DM PM T+T
25	Opportunity	Long term lease agreement not yet agreed with KiwiRail / BOIVRT / Council	Physical works cannot start until this lease has been agreed upon by the relevant parties. Delay in agreement may cause programme delays. This does however provide an opportunity for the design to get progressed through to IFC pre-construction while the lease is being agreed upon / confirmed.	Project Risk	Live - Treat	Live	Early engagement with Keteriki / BOIVRT / FNDC / KiwiRail	Possible	Extreme	High	Settle on long-term lease agreement prior to construction start to ensure seamless transition into construction period. Kevin to engage with Keteriki, Cycleway Trust, KiwiRail to draft a document. Need to keep Planning up to speed with the specifics of the lease agreement as it may impact the consent requirements.	Possible	Extreme	High	PM
26	Threat	Lack of knowledge regarding design requirements	There may be a lack of knowledge / misunderstanding between relevant design parties regarding the design requirements of the alignment. Miscommunication of design requirements will potentially delay the programme due to re-design, and incur additional cost to the project for the corresponding works,	Engineering/Design	Live - Treat	Live	Confirm design teams understanding of the design philosophy with client and stakeholders. Is the client requirements document fit for purpose?	Likely	Major	High	Confirm IL Use relevant Design codes and manuals Issue design to relevant stakeholders for comment	Possible	Moderate	Moderate	DM PM T+T
27	Opportunity	Re-align rail to enable clearance from cycleway at pinch points	We understand that the rail north / up chainage from Te Akeake requires removal and replacement. The opportunity therefore exists to re-align the rail over this section of track to accommodate that cycleway at known pinch points. Embankment widening or cut extension to slew tracks is possible.	Engineering/Design			Identify pinch points, engage with BOIVR if opportunity exists to slew track	Likely	Major	High					
28	Threat	Adverse impacts of cycleway on railway assets	Revetment and retained fill on embankments cause deformation to the rail assets that is not acceptable to rail operators	Engineering/Design	Emerging	Proposed	Early engagement with BOIVRT / Keteriki regarding acceptable deformations to existing assets	Possible	Major	Moderate	Adopt alternate designs and construction materials to reduce deformations. Additional costs incurred due to less available materials being adopted.	Unlikely	Major	Moderate	TT PM
29	Threat	Capacity of existing structures	The condition and capacity of existing structures within the corridor remains unknown. Therefore, working around or joining in to these structures requires adequate assessment early in the design stage to reduce the risk to programme and adverse cost impacts the sturctures not have capacity to support the proposed work. i.e. Bridges, culverts, retaining walls	Engineering/Design	Emerging	Proposed	Identify structures that may require interface with the proposed cycleway and structures i.e. bridges	Likely	Major	High	Undertake detailed assessment of structures that require interface with the new cyccleway	Unlikely	Major	Moderate	TT Kakariki
30	Threat	risk of drowning/getting stuck in the mud during construction and use of cycleway	risk of drowning/getting stuck in the mud during construction (during tie off of anchors etc.) and use of cycleway, especially in areas where there is lagging for retaining walls blocking access to the embankment	Safety	Emerging	Proposed	handrails	Possible	Major	high	provide regular locations of ladders to exit the river	Unlikely	Major	moderate	T+T
31	Threat	Excess settlement of rail lines	geological conditions have been inferred between mlimited number of investigation points, if worse conditions are encountered in critical areas greater settlements than calculated could eventuate	Engineering/Design	Emerging	Proposed	currently designed so settlement is not affecting the rail lines	Unlikely	Major	Moderate	additional investigations targeting critical areas, construction observations in these areas to confirm soil assumptions	Rare	Major	Moderate	T+T
32	Threat	piling within embankment fill	hard inclusions may be present within the embankment fill which could cause early termination of embedded piles/poles	Construction	Emerging	Proposed	variable design options to be able to pivot	Possible	Minor	moderate	additional site investigations could be undertaken to identify the risk of this. Option for an increased span where inclusion cannot be broken through	Possible	Minor	moderate	T+T

Consequence/Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain	Moderate	Moderate	High	High	High
Likely	Moderate	Moderate	Moderate	High	High
Possible	Low	Moderate	Moderate	Moderate	High
Unlikely	Low	Low	Moderate	Moderate	Moderate
Rare	Low	Low	Low	Moderate	Moderate

Risk Scoring

Cost Banding

	Cost ($)		
Catastrophic		>	$ 590,000
Major	$ 59,001	to	$ 590,000
Moderate	$ 5,901	to	$ 59,000
Minor	$ 591	to	$ 5,900
Negligible		<	$ 591

Delivery Banding

	Duration (days)		
Catastrophic		>	30
Major	15	to	30
Moderate	10	to	14
Minor	5	to	9
Negligible		<	5

Probability Banding

	Probability (%)		
Almost Certain		>	95%
Likely	81%	to	95%
Possible	36%	to	80%
Unlikely	10%	to	35%
Rare		<	10%