Northland Rail Upgrade
Detailed Design Report

Tunnel 7- Ross Hill

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1 Introduction

1.1 Background

KiwiRail are delivering the Northland Rail Upgrade (NRU) project which is a large refurbishment project to address deferred maintenance issues and increase capacity of the North Auckland Line (NAL).

'Phase 1' of the project includes the renewal of five existing bridges and lowering of one bridge (adjacent to Tunnel 5), as well as the modification of thirteen tunnels to allow for capacity improvements, ballast renewal and drainage improvements. In addition to the work on tunnels and bridges, significant civil works comprising drainage, ballast placement, sleeper replacement and vegetation clearance are also proposed.

1.2 Purpose

KiwiRail have commissioned Vitruvius Ltd to undertake the design rail alignment and drainage design of Tunnel 7, located 135.465Km to 135.800km. KiwiRail are considering options for increasing the spatial clearance of the tunnel to accommodate Hi-cube container wagons and future proof for the potential to electrify the route.

The tunnel track clearance design is required to consider drainage solutions which will be incorporated into the design package.

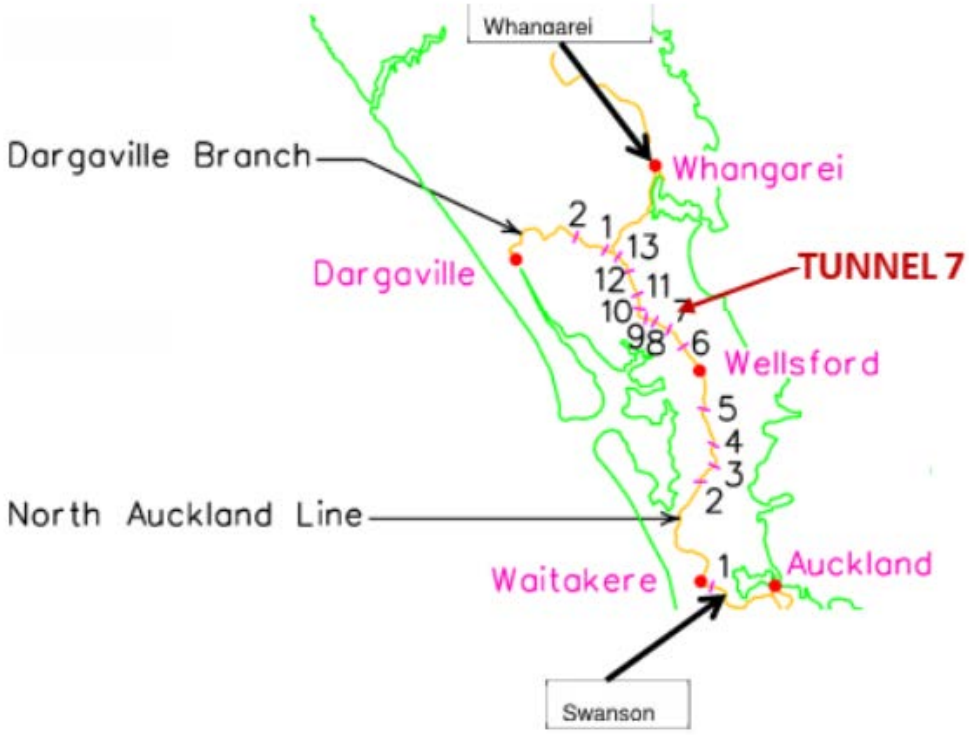

Figure 1: Site Location

The design objective (determined by KiwiRail) is to achieve the minimum electrification tunnel crown height of 4.690m from the low rail level and structural clearance for 50km/hr track operating speed as per requirements of NRSS/06. This operating speed has been determined from existing track geometry.

This design report has been developed as part of the scope of the Northland Rail Upgrade (NRU) project's Category A Tunnel design package. The Category A package of designs delivered by Vitruvius includes:

Table 1: NRU Category A Tunnels

Tunnel No.	Name	Start KM	End KM	Length
Tunnel 7	Ross Hill	135.460	135.807	343
Tunnel 8	Ranganui	146.850	147.019	171
Tunnel 11	Golden Stairs	159.290	159.891	604

1.3 Scope

This report refers to the following design elements for Tunnel 7:

- Alignment design and assessment of proposed structural clearances.
- Track design including consideration of subgrade strengths (investigations managed by KiwiRail).
- Track formation drainage within the tunnel.
- Drainage design of rail corridor outside the tunnel and within extents of tack lowering.

These elements have been developed to an 100% level of design, considered as 'Detailed Design'. Assessment of geotechnical (except for existing subgrade stiffness based on testing information provided by others) and groundwater conditions are not considered within the scope of this report.

This report and the corresponding design drawings have identified areas of earthworks which will require geotechnical assessment prior to undertaking any physical earthworks. This includes re-profiling of the tunnel floor where exiting bedrock will need to be milled. KiwiRail shall ensure there is no tunnel structure instability risks as a result of the proposed milling to accommodate the new track formation and alignment. This has been highlighted in the enclosed Safety in design register appended to this report.

1.4 Assumptions

In developing the scope and design solutions for this tunnel track lowering, the following assumptions have been made:

- Existing sub-grade strengths will meet or exceed a CBR of 15.
- No new drainage outfalls or discharge points will be required and hence no new consents required.
- All track and ballast will be replaced within the extents of the track lowering.
- Lowering and improvement of the existing subgrade may be required to accommodate deeper track set (50kg rail and concrete sleepers) and conforming ballast depth.

1.5 Previous Designs

A previous 85% Design has been undertaken by Vitruvius[1], which was considered as Preliminary Design. The scope of this included an alignment design and preliminary drainage assessment. This 100% Design Report builds on this previous design, and seeks to address KiwiRail Professional Head review comments (received at 20% design only), as well as responding to subsequent design requirement changes.

Note at the date of this report issue, no professional head comments have been received for the 85% design. KiwiRail have instructed Vitruvius to continue developing the 100% detailed design on the assumption that there will be no design changes requested. If design changes are required as a result of PH reviews, these shall be implemented as a revised 100% design issue, prior to Issuing for Construction.

[1] *Vitruvius Ltd report Northland Rail Upgrade Concept Design Report Tunnel 7 Ross Hill, 25 February 2020*

There have been no changes to the proposed rail alignment design between 85% and 100% design.

The resulting design was able to maintain the line speed at the existing 50 km/h.

1.6 Professional Head Design Reviews

A review of the 20% Design report and drawings has been undertaken by KiwiRail's Professional Head of Track (PHoT).

The key areas of concern raised by the PHoT are summarised below, with the designer responses included:

Table 2: KiwiRail Professional Head design review responses

Reviewer Comment (PHoT)	Designer Response	Addressed in Report
Confirm 4.620m rail crown clearance allows for 25mm cant	Yes - the assessment is static dynamic and allows for design cant	Yes
We should be designing for ballasted track not slab track	100% design will reflect latest design criteria which refers to ballast track minimum CWH of 4270mm. Next phase of design (100%) will be designed for ballast track	Yes

The full detail of design review comments is appended to this report. Designer responses have been provided in the review sheet. It is intended that the PHoT provides feedback on the designer responses in parallel with reviewing this report which seeks to address some of the comments raised.

These comments and design responses are still considered valid and live, as no feedback on the 85% design has been received yet, therefore these comments cannot yet be formally closed as part of this 100% Detailed Design issue.

2 Existing Situation

2.1 Geometry

Tunnel 7 is located on the North Auckland Line between 135.464 and 135.807km. The original horizontal geometry has curves at each end of the tunnel, with a back to back reverse curve to the north (See Figure 2). Within 600m of the tunnel at each end there are 201m radius curves which will govern the speed to 50km/hr in this section of track; this corresponds with the published linespeed in the Local Network Instruction.

The vertical geometry is on a constant gradient of 1:80 through the tunnel, followed by a steep 1:50 gradient to the south of the tunnel. While assessing the survey data it appears that the existing track has been over lifted outside the tunnel at both ends, creating a sharp crest in the track geometry and lifting it above the constant gradient line from within the tunnel. This may potentially have been caused by tamper smooth lining up to the tunnel portals.

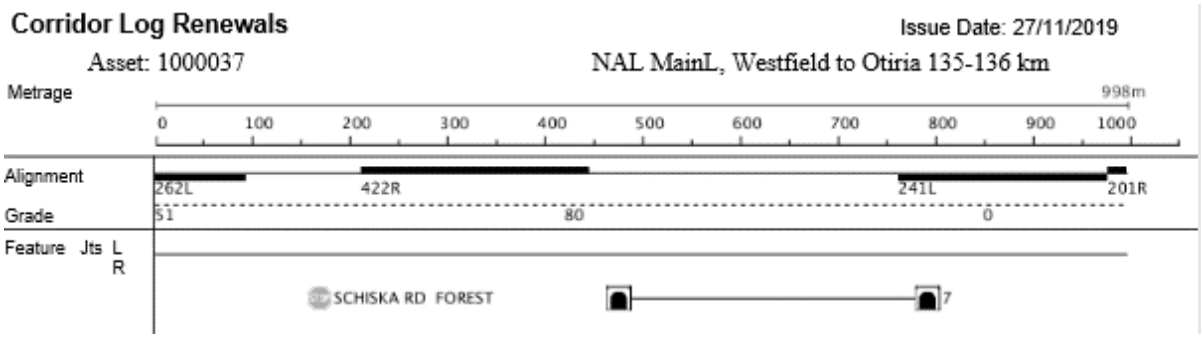

Figure 2: Track Logs 135-136km

There is an existing sealed level crossing at Schiska Road which is located at the southern tie in. Visual observations on site indicate this level crossing is non-compliant and may pose a risk during on-tracking. It is recommend KiwiRail undertake thorough inspection of the level crossing to ensure it is safe for the contractor to use for on-tracking, and there is no risk of damage to the rail head which will jeopardise the safe running of trains post construction, as the level crossing is outside the extent of proposed track renewal as part of this design.

2.2 Clearances

An assessment of existing clearances for the design vehicles, considering static and dynamic effects, has been previously undertaken by Vitruvius. This study identified several areas of non-compliance within Tunnel 7. Further information can be obtained within the Vitruvius Report titled North Auckland Line Upgrade Dynamic Clearance Assessment Report Tunnel 7 dated November 2019.

The minimum existing structural clearance identified was 27mm which did not meet the minimum structural clearance for this tunnel of 150mm for a 50kmph existing governing speed. This is presented in the figure below located at the north portal of Tunnel 7.

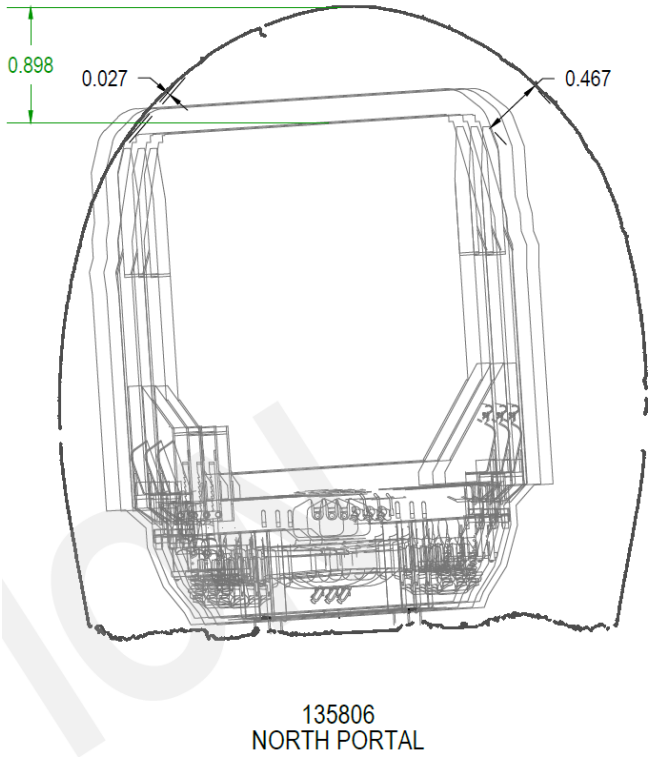

Figure 3: Existing clearances at Tunnel 7 North Portal (135.806km)

2.3 Track

According to KiwiRail's corridor logs, the existing track is constructed of 85lb/yd rail supported on TPR sleepers. This was confirmed during the site visit undertaken on the 16th March 2020. The sleepers and rail were installed in 1982, with 50% of the sleepers replaced in 1998.

2.4 Test Pit Investigations

2.4.1 Overview

KiwiRail engaged Tonkin + Taylor Ltd to undertake trial pit excavations at certain areas within the tunnel. The pits were required to determine and record the tunnel floor / invert profile and to identify any other existing features such as ballast depth and condition, presence of any softened material, groundwater condition, any encountered underlying geology, location of any existing drainage. This information[2] has been considered in the development of the preliminary material presented in this report.

The test pit investigations were undertaken between 13 and 16th March 2020 and comprised of:

- 24 no. Test Pits (TPs)
- 9 no. Invert Trenches (ITs)

In situ testing in the form of scala penetrometers were also undertaken at the base of the test pit and trenches where natural ground was encountered. Tests were generally undertaken to refusal (10+ blows per 50mm).

The location of test pits and invert trenches were specified by KiwiRail. The investigation locations were targeted at specific areas with the intent of providing adequate information at areas of concern such as the tunnel portals, or where extensive track lowering was anticipated. An overview of the investigation locations is provided in Figure 4, referenced from the T+T investigation report.

[2] *NAL Upgrade Tunnel 7 Test Pit Investigation Factual Report Version 2, Tonkin + Taylor Ltd, March 2020*

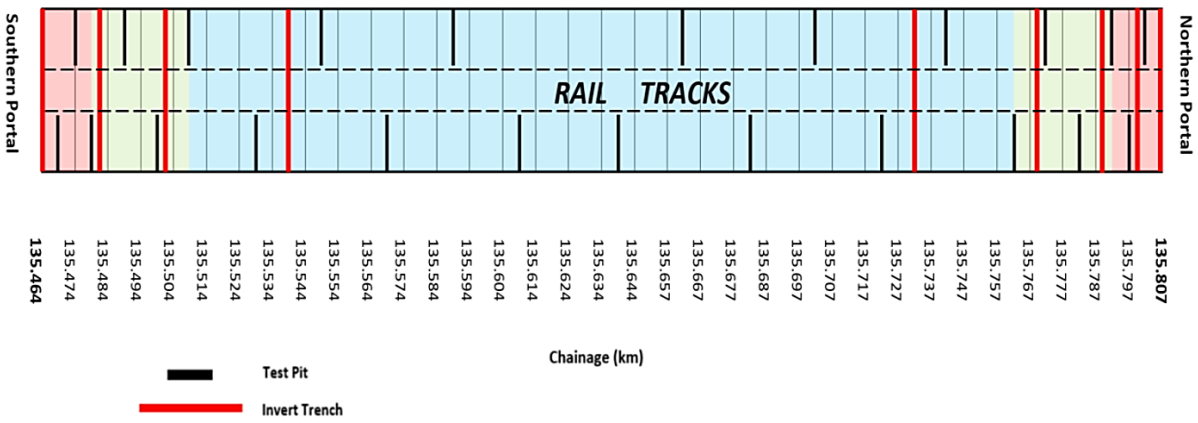

Figure 4: Tunnel 7 investigation locations (ref T+T report Fig 2.1)

2.4.2 Investigation Findings

2.4.2.1 Tunnel Invert

The investigations indicate that for Tunnel 7 the ballast overlies a bedrock tunnel floor. The bedrock material varied along the length of the tunnel but was generally described as weak, dark grey, sandstone/mudstone.

This factual report does not consider the constructability or suitability of the design as it omits strength, structural integrity, loading from the tunnel structure, or suitability for milling if required for track lowering.

Some test pits identified a concrete footing at the base of the tunnel wall which ranged between 0.3 and 0.4m wide. From assessing the test pit records provides (sketches and photos) the presence of the concrete footing is unlikely to impact on the proposed track lowering through the tunnel.

The findings from the invert trenches have been transferred onto the Vitruvius design drawings and used to inform the proposed tunnel drainage solution. A typical tunnel profile including bedrock tunnel floor is shown in the figure below.

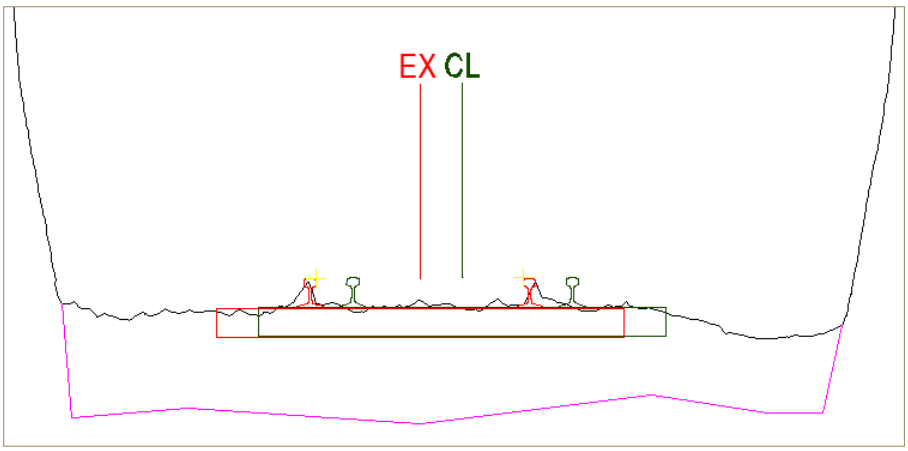

Figure 5: CH 135.464KM profile of tunnel floor relative to existing and design rail levels

2.4.2.2 Subgrade Strength

Scala penetrometer testing results of the existing subgrade (bedrock) were provided in the form of number of blows per 50mm. The tests penetrated between 50mm and 300mm and generally refused within the first 100mm. The report did not provide corresponding CBR% values for each test however almost all of the results indicate a strength of CRB15% or higher when referenced against KiwiRail Standard C-TI-FO-4206 Formation

Investigation. Therefore, it is assumed that a minimum ballast depth of 250mm is achievable within the tunnel, as per the design requirements.

The actual formation strengths along all sections of track renewal (inside and outside of the tunnel) will need to be determined on site by an engineer. This testing and hold point shall be identified in the contract inspection and testing plan (ITP).

2.4.2.3 Ballast Depth

An important finding from the site investigations is the depth of existing ballast. This has been recorded at four locations across the tunnel for invert trenches, and two locations for test pits on each side of the track. The depth of ballast has been determined from the report findings (T+T Report table 2.1) by taking the A, B, C, D and E measurements from the top of rail (allowing for cant) to bottom of ballast and subtracting by 300mm to allow for the depth of existing rail and sleeper. This based on the existing rail being 85lb and sleepers being TPR.

This exercise has determined that the depth of existing ballast ranges from 240mm to 350mm.

A detailed assessment of design top of rail level relative to the exiting tunnel floor layer has been undertaken in the design sections of this report. This will identify areas of track lowering where 250mm of bottom ballast may not be achievable without modifications to the tunnel invert or if a design departure is proposed to reduce the ballast depth below 250mm.

2.4.2.4 Groundwater

The test pit sketches and photos show the groundwater table to be within the bottom ballast layer, and that the excavations generally filed with water quickly. There was no information provided with regards to the source of the water, however it is noted that the investigations were undertaken in summer and during a particularly dry weather season, which would imply the water is from either weeping through the tunnel lining or groundwater.

Figure 6: Photos of IT09-RHS (left) and TP01-LHS (right)

The presence of a perforated subsoil drains was evident from the photos appended to the report, although these do not appear to have been included in the sketch records. From the level of the pipe relative to the ballast layer and groundwater level observed in the photos, this drainage system appears largely ineffective for ensuring a dry bottom ballast layer. The photos also show high levels of ballast contamination with fines which will have a negative effect on the track performance.

An existing layer of geotextile was identified in the investigations generally (but not always) between the bedrock and bottom ballast layers.

2.5 Utilities

A review of available service provider plans (sourced via B4UDIG) show an existing Vodafone cable runs along the rail corridor between Tunnels 3 to 8, including Tunnel 7. The Vodafone cable appears to be located within a small diameter conduit and fixed to the upper sector of the tunnel, as shown in the photo in Figure 7. As the proposed track re-alignment within the tunnel avoids the need for any modifications to the tunnel lining, the cable should not be affected by the works within the tunnel.

However, to confirm the cable location outside of the tunnels and to ensure the risk of service strike is managed during construction, a service locate and mark out on site should be undertaken prior to any excavations. This will also be required to confirm the proposed design does not affect the cable.

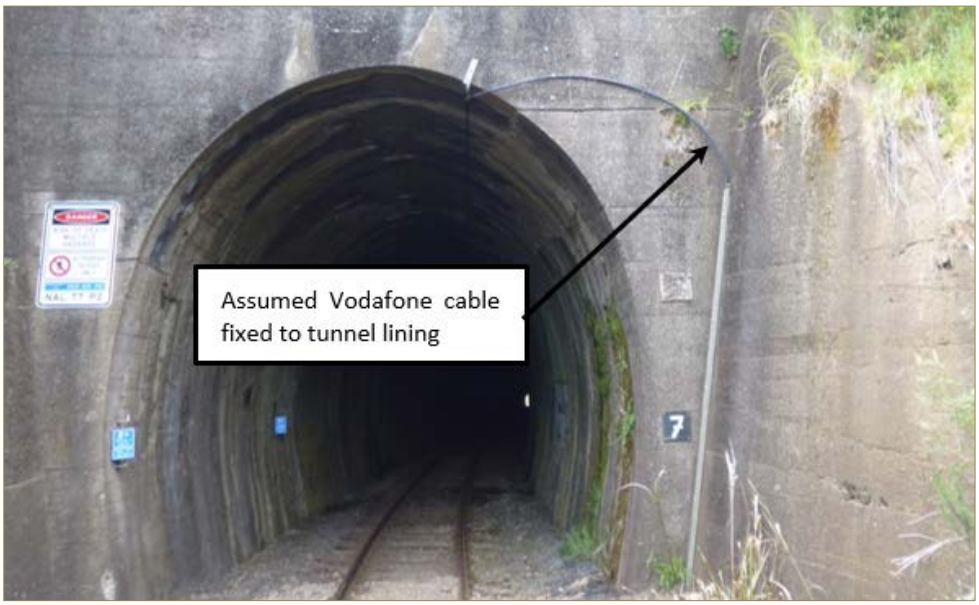

Figure 7: Vodafone cable location Tunnel 7

Before any excavations are carried out on site a separate service locate request shall be undertaken by the contractor. This should include pot holing to confirm no KiwiRail or other service provider utilities are present.

2.6 Site Observations

A site visit to Tunnel 7 was undertaken on 16th March 2020 by Vitruvius engineering staff. The sections below provide further photos and commentary gathered from the site visit.

2.6.1 Tunnel Interior Observations

The tunnel interior appeared relatively dry with little evidence of poor drainage (Note the inspection was undertaken on a hot dry day, in summer, in drought conditions). Evidence was found of shallow slotted pipes placed along the sides of the tunnel which are assumed to have been located to improve drainage of the track ballast layer. They appear to be 100mm Nexus-type slotted pipes and are in a poor condition. Additionally, there were patches of damp ballast where trial holes had been dug historically, giving an indication of the condition of underlying (bottom) ballast.

Table 3: Tunnel 7 Tunnel interior Site Photos

	Ballast is heavily contaminated throughout with clay, with the slotted pipe protruding from the ballast in several locations (this may have been as a result of the trial pits undertaken for the NRU project). Sleepers are damaged in such a way that indicated a derailment had occurred in the tunnel at some time. This observation was also made within the T+T Investigation report for Tunnel 7. Track componentry was confirmed to correspond with corridor log records.
	The surface of the tunnel was found to be generally uniform but in a small number of locations water was observed to be dripping from the roof of the tunnel onto the track below. These were not causing any serious concerns to the track, however they should be observed during the winter periods of high water pressure to determine if weep drains are required as per the KiwiRail standard for water ingress in tunnels.

2.6.2 South Portal Observations

The south portal of the tunnel is the downhill so represents the outfall for the tunnel drainage. A culvert had been registered in Maximo as a potential outfall for the tunnel centre drain and its conditions were checked on site.

Table 4: Tunnel 7 South Portal Site Photos

	To the southeast, a small open surface drainage channel has been dug from the mouth of the tunnel to feed into a half pipe steel drainage carrier channel.

The steel channel, acting as a cess carrier drain, is flowing and appears to have had some recent maintenance.

Silt debris and vegetation remains and further maintenance is required to provide a clear channel and pathway from the tunnel.

The steel channel leads away from the tunnel and track corridor to feed into a farm channel in the adjacent land.

No outlet from this outfall or farm channel was visible. It is believed that the stormwater run-off from tunnel and cess drain is/has ponded here, draining down to the subsoil and crossing the railway to the west below ground. The inlet of the existing culvert (135.398km) is located in a hollow which is not connected with the farm channel.

Therefore, the drainage system requires further investigation and analysis before it can be determined functional and adequate to meet the winter, high rainfall periods.

The ponding area in the easthern farm channel may be undermining the existing formation as evidence of track instability and sleeper replacement has been identified.

To the southwest, a small drainage channel has been dug from the mouth of the tunnel to feed into a half pipe steel drainage channel.

The steel channel leads away from the tunnel and track alignment to feed in a farm channel in the adjacent land.

As the steel channel exits KiwiRail property, it enters a large farm channel and continues towards the southwest. From here it enters a hollow which appears to be an outlet to the culvert located at 135.398km.

	The south approach to the tunnel has been buttressed and reinforced to prevent damage to the portal wingwalls. These are not showing any signs of stress and are constructed in such a manner to allow free drainage.
	The joints of the blockwork are free draining, preventing a build up of ground water. There is no indication whether these were installed during construction of the tunnel.

2.6.3 North Portal Observations

The north portal is at the 'upstream' end of the tunnel. The rail is built on an embankment therefore surface flows from north of the tunnel and are diverted away from the track and do not flow into the tunnel. The approach to the tunnel is built on an embankment therefore no corridor drainage existed. Very little water entered the tunnel via the North portal.

Table 5: Tunnel 7 North Portal Site Photos

	The North Portal is approached on a large embankment, with a large culvert (2258671) identified at 135.948 km and approximately 10 metres below the track.

On the approach to the tunnel, the track enters a short section of cutting to the North West and embankment to the North East. The vegetation to the North West appears to reflect that the slope is damp, and water is present in the cess. However, there is little evidence of any comprehensive drainage configuration to retain or upgrade.

To the North East of the tunnel, the slope is gradual and covered in vegetation that thrives in damp areas. This area should be cleared back and maintained appropriately to ensure the track is free draining.

There is evidence on site of sleeper refurbishment, which has required the replacement of approximately 1 in 3 of the TPR sleepers with concrete.

At 135.832, approximately 30m north of the tunnel a culvert has been located transporting water from the northwest face to the northeast face. The culvert was open on the North West side.

The invert of the culvert was estimated to sit approximately 1200mm below rail level and, although cracked, the pipe was clear and free draining.

The outfall from the culvert had been covered in redundant timber sleepers to the North East. It was found to consist of a 500mm concrete pipe in a poor condition.

The culvert appeared to outfall into a large steel pipe toward the embankment to the North East. The outfall from the steel pipe was unable to be detected due to vegetation and a large drop at the fence line.

2.6.4 Level crossing

There is an existing level crossing located at 153.150km which was used to on-track for the site visit. The level crossing is not within the scope of the NRU upgrade project, and the realignment design extents terminate at the level crossing. It is recommended that mitigation measures are put in place during construction to ensure the rail is not damaged if this location is to be used for on and off-tracking.

Figure 8: Level Crossing 135.150km

3 Permanent Way Design

3.1 Requirements

The design has been prepared to meet the requirements set out in the NAL Tunnel Modelling Criteria document (reference 82-1-001-01-INI-KRG-RPT-000053 Revision 4).

3.2 Clearances

The clearances to the structure comply with KiwiRail standard T-ST-DE-5212.

Static clearances and centre / end throws have been checked for the following vehicles as part of the design and clearances assessment:

- FE
- FIH (FE replacement)
- FIB (FE replacement)
- ULA (identified as ruling forestry loading gauge)

Vehicle centre and end throw checks have also been undertaken for DL locomotives and IM wagons loaded with 60ft Hi-cube (9ft 6in) ISO shipping containers.

The design presented in this report has also considers potential future electrification clearances based on a minimum contact wire height (CWH) of 4.270m above rails + 10 mm construction tolerance (KiwiRail Specification E-SP-AE-61319 AEA Table 7.1 for Ballast Track). The pantograph considered in this design is the Schunk-Wippe pantograph profile, as requested by KiwiRail.

The specification requirements between pantograph and fixed asset can be operationally accepted at a minimum of 150mm +/-10mm but new work is required to provide no less than 200mm structural clearance to allow for maintenance work and discrepancies in the relationship between track and wire over time.

The project design requirements state 400mm vertical clearance is required between the contact wire and the crown of the tunnel, with an additional 10mm construction tolerance allowance as defined by the project design requirements.

The table below outlines the vertical clearance requirements set out in the NAL Tunnel Modelling Criteria[3] (Revision P04) document, which have been applied to this design.

Table 6: Vertical clearance requirements summary

Vertical Clearance Requirement	Vertical Clearance	Comment
Contact Wire Height	4270 mm	Ballasted track (E-SP-AE-61319 AEA)
Track Construction Tolerance	10 mm	As specified by KiwiRail NAL project requirements
OHLE Equipment	400 mm	As specified by KiwiRail NAL project requirements
OHLE Construction Tolerance	10 mm	As specified by KiwiRail NAL project requirements
Total	**4690 mm**	Overall top of rail to tunnel crown clearance

[3] *KiwiRail Document Reference 82-1-001-01-INI-KRG-RPT-000053*

The figure below provides an overview of the vehicles and pantograph consideration used for this alignment design. Note the dimensions are shown indicatively only.

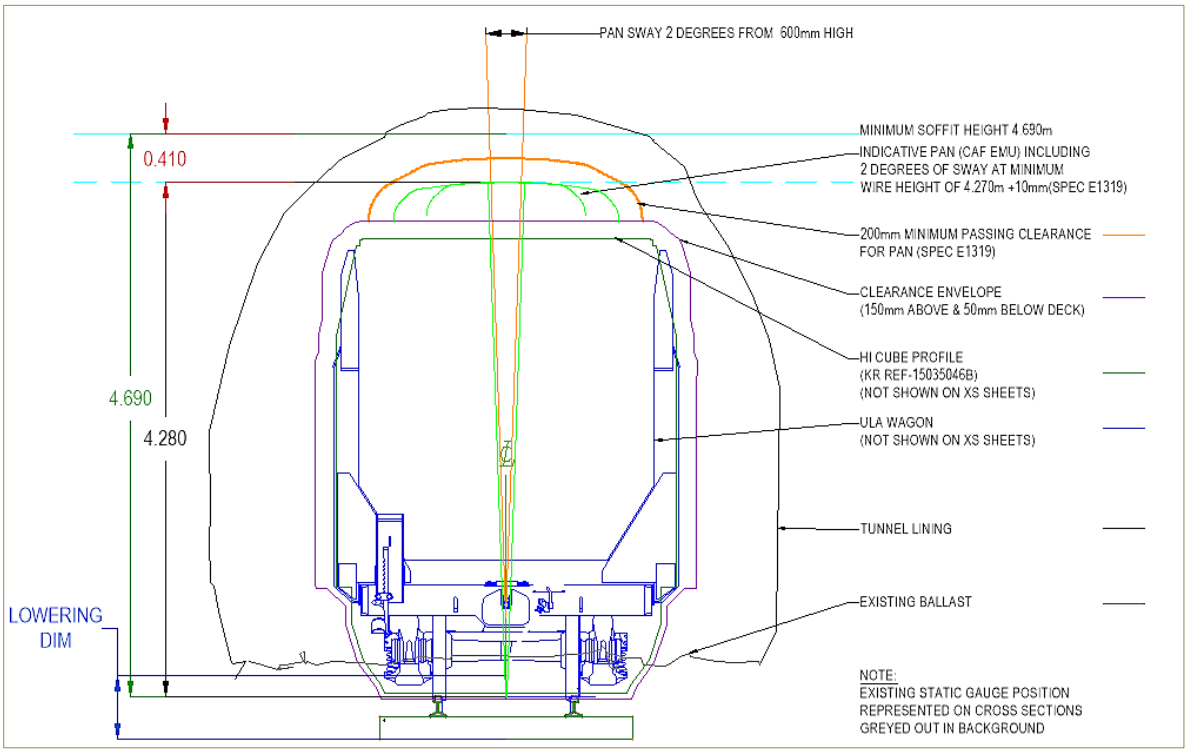

Figure 9: Typical vehicle and pantograph clearances assessed in this design

3.3 Alignment Design

3.3.1 General

The track design complies with KiwiRail Standard T-ST-DE-5200. The track alignment has been designed as a "best fit" alignment to the existing situation, with aim to centralise the track clearance envelope within the tunnel. The existing geometry has not been compromised to establish the design layout.

The geometry has been designed to allow for a linespeed of 50km/h, with the 242m radius curve reduced to 232m. Alignment is acceptable for 50km/h.

It is recommended that if implemented the track design be monumented every 10m on tangent track and 5m on curve track, plus all S and CTP points are to be monuments and tamped to design.

3.3.2 Horizontal Geometry

The design horizontal geometry parameters are detailed in the table below.

Table 7: Horizontal Geometry Main Left

CURVE NUMBER		SPEED (km/h)	RADIUS (m)	CANT EQUILIBRIUM (Eq) (mm)	CANT DEFICIENCY (Ed) (mm)	ACTUAL CANT (Ea) (mm)	TRANS 1 LENGTH (m)	RATE OF CHANGE OF CANT (mm/s)	RATE OF CHANGE OF DEFICIENCY (mm/s)	TRANS 2 LENGTH (m)	RATE OF CHANGE OF CANT (mm/s)	RATE OF CHANGE OF DEFICIENCY (mm/s)
1	V_{MAX}	65	420	89.4	49.4	40	40	18.1	22.3	40	18.1	22.3
	V	50		52.9	12.9			13.9	4.5		13.9	4.5
	V_{TSR}	25		13.2	-26.8			6.9	-4.6		6.9	-4.6
2	V_{MAX}	55	232	115.9	45.9	70	35	30.6	20.0	35	30.6	20.0
	V	50		95.8	25.8			27.8	10.2		27.8	10.2
	V_{TSR}	25		23.9	-46.1			13.9	-9.1		13.9	-9.1

Design track slews of up to 350 mm have been adopted within the design extents north of the tunnel. Slews up to 236mm were adopted at the south end of the Tunnel 7 to achieve minimal clearances.

This will require a de-stress of the rails and reconstruction of the formation / track support in this area.

3.3.3 Vertical Geometry

The design vertical alignments has a minimum curve radius of 2650m which meets KiwiRail requirements for this design speed of 50kph.

Between 135.400km and 135.800km track requires lowering to meet the required clearances inside Tunnel 7. The maximum lowering within the tunnel is 169mm at approx. middle of the tunnel at location 135.61km.

3.4 Track Structure

3.4.1 Design Requirements

The specification requires design for 18T axle loads, which will future proof the Line Classification to be upgraded to Class A.

This will require:

- 50kg/m rail (153mm deep)
- Concrete sleepers (195mm deep, including 5mm pad)
- Minimum 250mm of ballast in tunnels
- Minimum 300mm of ballast in outside tunnels
- Formation with a CBR of more than 15, and
- The use of galvanised Pandrol Clips for use in tunnels.

The requirement to design the formation was not included in the scope of our design, so it is assumed that the formation complies with KiwiRail standard C-ST-FO-4110. The strength of the formation will need to be confirmed before the ballast is installed to ensure it meets a CBR of more than 15.

3.4.2 Track Construction & Tamping

A value engineering (VE) exercise was undertaken in collaboration with the NRU Project Team to identify scope reduction and cost saving measures. A key outcome of this VE meeting was to identify sections of track realignment that can be undertaken by tamper, rather than reconstruction of the entire track form including ballast.

The 100% Design Drawings appended to this report identify sections of track that can be tamped without the need for reconstruction. The following parameters were assessed to determine which sections of track can be tamped. All the following requirements need to be met for the area to be considered suitable for tamping:

- No track lowering is required and;
- Track lifts are <50mm, and;
- Track slews are <100mm.

This assessment does not consider the actual site condition of the sleepers, rail fastenings and rail, to confirm their suitability to withstand tamping. It is recommended that KiwiRail undertake onsite condition assessments of the sections of track to be tamped to confirm they are suitable.

Any slew towards the outside of the curve will increase the stress in the rails. These will need to be assessed to ascertain whether a de-stress is required and whether the existing fastening system can withstand the additional tensile forces.

The slewing and lifting of the track may result in the 45-degree loading zone falling outside of the existing formation. Where this is the case the existing formation shall need to be extended to ensure the live loads on the track are suitably transferred to the sub-grade. An assessment shall be required on site to ensure this is not the case. The following assessments shall also be made where existing track is to be lifted and slewed by tamping:

a) KiwiRail shall review the condition of timber sleepers / fastening systems that are subject to lifting / aligning by tamper. Where the fastening system is unsuitable it shall be replaced with a P-type (Pandrol) fastening system. The sleeper shall be replaced with a concrete sleeper if deemed incapable of withstanding tamping forces.

b) KiwiRail shall review the condition of the existing fastening systems that are subject to be de-stressing or falling within stress transition zones / anchor lengths. Where deemed unsuitable / non-compliant, these shall be replaced with P-type fastening systems suitable for Class A lines (18T axle loads). See T-TI-WO-5960 for further information.

c) The ballast profile shall be reviewed where the existing track is subject to lifting or slewing. Additional ballast shall be dropped to ensure it is level with sleeper tops between sleepers and ballast shoulders comply with the requirements of T-ST-DE-5200 at the ends of the sleepers.

3.4.3 Ballast Profile

Ballast profile has been designed to comply with the requirements of T-ST-DE-5200 outside of the tunnel, See Figure 9 for CWR track.

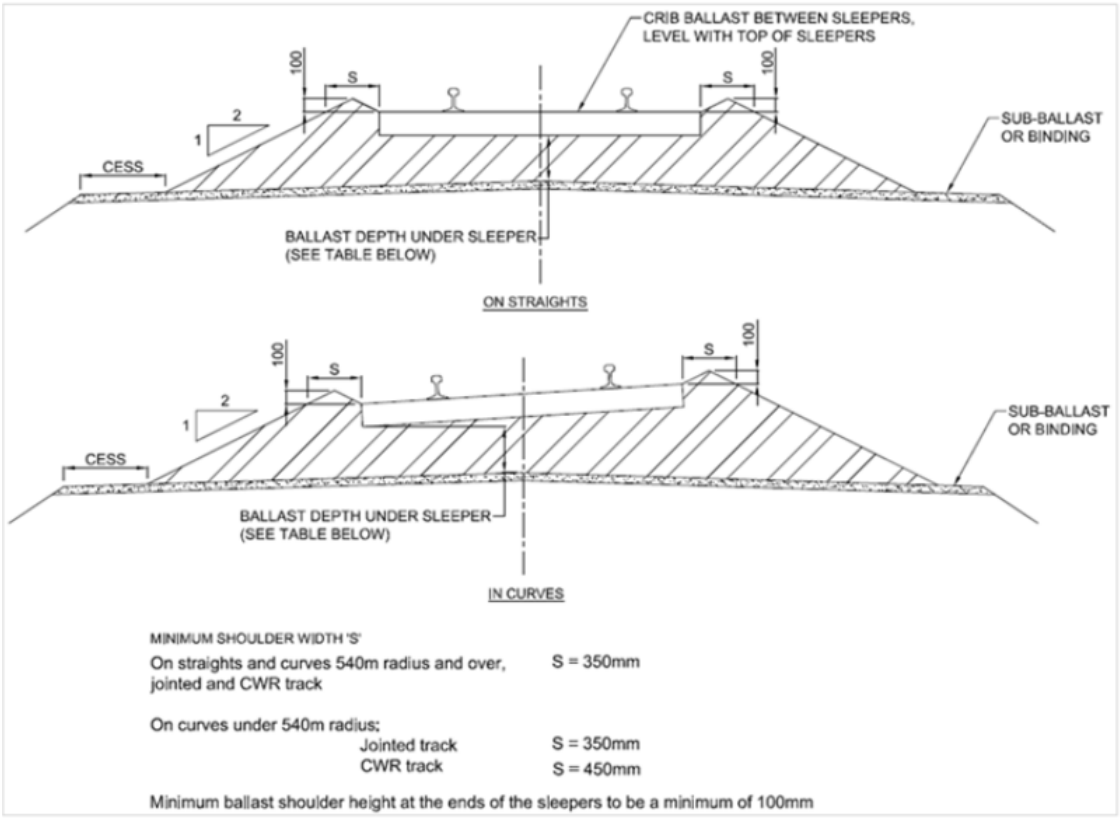

Figure 10: Ballast profile outside of tunnel

Within the tunnel it is proposed to remove the ballast shoulder. This will create a safe walking passage within the tunnel. Due to the ambient temperatures within the tunnel the likelihood of buckling is much lower, therefore the lateral restraint provided by the ballast shoulder can be removed.

For Tunnel 7 the curve radius is less than 540m therefore the ballast will extend horizontally form the top of sleeper (S) 450mm to meet the requirements of the Figure 10 above.

3.5 Sub-ballast and Structural Layer

3.5.1 General

The sub-ballast and structural layer have been assumed to comply with C-ST-FO-4110. This includes:

- CBR at least 15
- Soil quality of SQ3
- Rock Quality of RQ2 or RQ3.

Where this is found not to be the case, additional measures shall be required to meet the requirements of C-ST-FO-4110. The contractor shall undertake CBR testing on the formation layer to confirm it has achieved the minimum strength, before geotextile and sub-ballast layers are placed. Testing intervals shall be as per the project specification.

3.5.2 Tunnel Interior

The track within the tunnel will be constructed on a reshaped tunnel floor profile to ensure positive fall into the proposed centre drain. Milling of up to 185mm (135.600Km) is expected in some areas based on the test pit information provided, however this may be more if a shallower tunnel floor is uncovered during construction and the exiting track and formation material is removed.

Any voids between the tunnel floor and sub-ballast layer will be filled with either well compacted GAP65 material or a levelling course. This will provide a sound formation layer for the ballast to be built, and form a central dish drain below the ballast.

Geotextile is only proposed between formation and ballast if there is considered to be a high risk of fines being generated and migrating into the ballast. The proposed type of geotextile and lapping details are Bidim A29 or similar, with minimum 500mm overlaps.

No sub-ballast is proposed within the tunnel interior, based on the assumed reasonable subgrade strength in the tunnel meeting requirements.

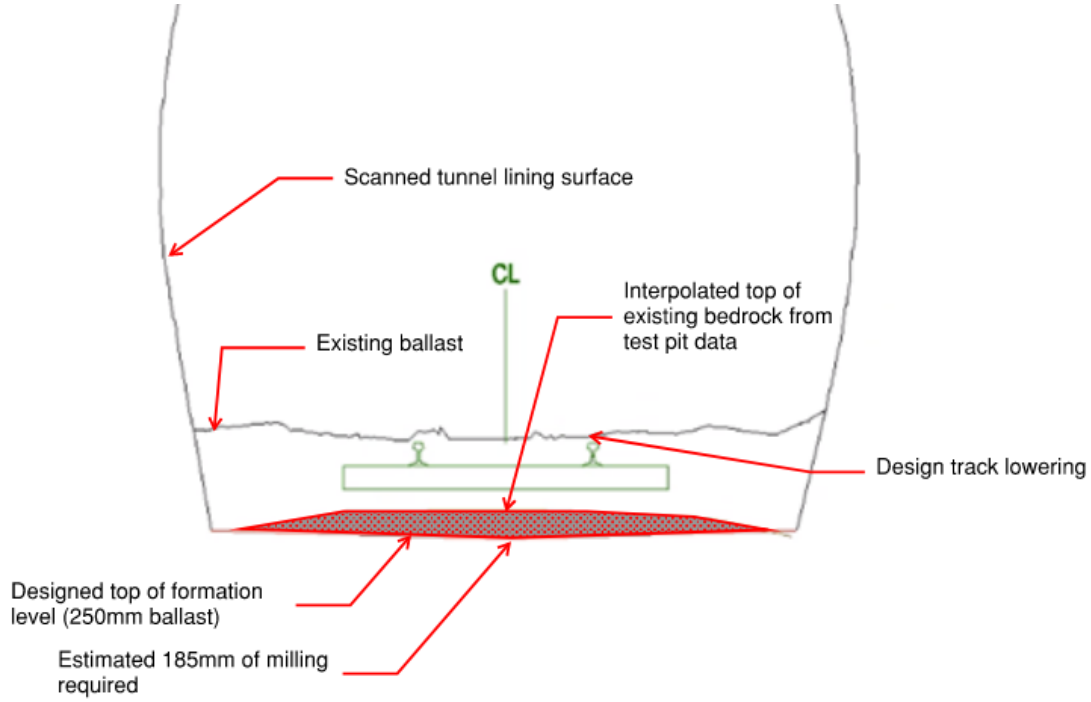

Figure 11: Tunnel Cross-section showing interpolated bedrock and design top of formation (136.600KM)

The actual tunnel floor profiles at the investigation locations have been superimposed onto the surveyed tunnel profiles and are shown in the attached design drawings. These sections indicate the expected depths of milling along the tunnel floor.

A preferable solution to forming the re-profiled tunnel floor would be to use a low strength cementitious mix. This would prevent any 'ponding' or saturated areas below the sub-ballast which could in time lead to mud pumping or weakened subgrade. However due to the complexity of site access, and costs, this may not be an acceptable solution for KiwiRail and imported hardfill (GAP65) may be more suitable. This shall be well compacted and sealed to ensure water is able to drain towards the proposed centre subsoil drain.

4 Corridor Drainage Design

4.1 Design Approach

The overarching design philosophy for drainage of the tunnels is:

- Reduce contributing flows into the tunnel by cutting off overland flows from the upstream portal(s).
- Surface flows preferred over buried pipe conveyance for inspection, maintenance, and access reasons.
- Use existing culverts and discharge structures where possible to avoid potential consenting requirements.
- Tunnel drainage arrangement to not induce the need for additional excavation at base of tunnel structure i.e. centre drain subsoil system preferred over lateral subsoil drains.
- Adopt standard corridor arrangements where applicable.

The proposal is to install drainage through the tunnel and connect it to the first available culvert or discharge structure to ensure the ballast and formation remain as dry as reasonably practicable. This will be using a subsoil pipe.

4.2 Site Location & Topography

Tunnel 7 is on the North Auckland Line (NAL) located between 135.465Km and 135.800km, approximately 2.5km south-west of Kaiwaka village. The surrounding landform is rolling hill country used for agriculture and grazing, and has well defined streams, gullies and overland flow paths. The area has scattered dense vegetation but considered largely bare land.

Tunnel 7 passes through a hillside with the highest amount of cover approximately halfway along the tunnel, forming a ridge over the tunnel, which a farm access track traverse.

4.3 Stormwater Assessment

4.3.1 Hydrological Catchment Assessment

A catchment assessment using the Rational Method has been undertaken for the contributing catchments to the North and South portals. The table below provides a summary of the key assessment parameters and determination of design flows. This assessment aligns with the methodology outlined in the KiwiRail Standard for small catchment hydrology.

The following criteria have been used for the calculation of the peak discharge for the design storm events i.e. design flows:

- GIS data was queried to determine catchment area, catchment slope, and land cover.
- The Rational Method is considered the most appropriate method to use for small ungauged catchments across the majority of New Zealand.
- The Modified Taylor Method is used to calculate catchment slope, as this tends to provide more representative estimates of channel slope.
- The catchment coefficient factor in The Building Code Verification Method E1 is used to calculate the catchment coefficient for these catchments.

The publicly available Land Information New Zealand (LINZ) contours have been obtained to inform this assessment and combined with topographic survey data captured by Vitruvius in late 2019. The LINZ contours are at 20m intervals and therefore should not be considered a highly accurate hydrological assessment. KiwiRail

is currently sourcing more accurate LiDAR survey data for each of the NAL tunnel sites, which will be assessed against this design and confirmed by the designer on site prior to any excavations.

Table 8: Tunnel 7- Catchments assessment summary

Parameter	Culvert Location			
	North-A 135.948 KM	**North-B 135.838 KM**	**South-A 135.398 KM**	**South-B 135.258 KM**
Catchment (ha)	6.7996	2.1752	4.2386	1.3175
Length (m), of longest flow path	392.71	308.05	317.34	163.13
Fall, elevation drop (m)	84.53	61.071	64.277	16.337
Time of Concentration (mins)	10.00	10.00	10.00	10.00
Rainfall Intensity, (mm/hr) (ARI 10yr)	44.2	44.2	44.2	44.2
Rainfall Intensity, mm/hr (ARI 100yr)	156.5	156.5	156.5	156.5
C Value (total)	0.55	0.50	0.55	0.50
Design Flow (m3/s) (Ari 10 yr)	0.46	0.13	0.29	0.29
Design Flow (m3/s) (Ari 100 yr)	1.63	0.47	1.01	0.29

In determining the C factors, it has been assumed that the soils are moderate over slow drainage soils based on the NZ Building Code E1/VM1 method. There may be opportunity to refine this if soil information can be provided at the next stage of design.

The Ramser Kirpich method has been applied to calculate the time of concentration, Tc, for catchments where the longest flow line has an average slope between 3% and 10%. Where the average slope is outside this range or Tc appears unrealistic, the Griffiths and McKerchar (2012) method has been used.

Design Rainfall information, for the calculated time of concentration, has been gathered from HIRDS-v4. Also, an allowance to climate change projected temperature increase by 2090 has been considered during the hydrology design.

A catchment assessment has only been undertaken for the contributing flows to the existing culverts at each portal, within the alignment design extension, which the proposed tunnel drainage system will discharge to. It is assumed that the existing track side drainage outside of the tunnel portal and culvert inlet areas, have capacity to meet design requirements. It is recommended that KiwiRail assess the capacity of the wider corridor drainage network as part of the NRU programme.

4.3.2 Culvert Hydraulic Assessment

The existing culverts at each portal have been assessed to determine whether they can meet the performance requirements set out in the KiwiRail drainage standards. These requirements are:

- 10% AEP storm flow without extending above the pipe soffit level (surcharge), with allowance to climate change projected temperature increase by 2090.
- 1% AEP storm flow without heading up closer than encroaching above 725 mm from the top of rail level, with allowance to climate change projected temperature increase by 2090.

The table in Appendix E provides a summary of the key assessment parameters and determination of the performance drainage requirements. This approach has been discussed and agreed by the wider NRU design team, as it considers a suite of factors to inform decision making and recommendations for this design:

- Existing information from Maximo, survey and site observations;

- Assessment of impacts as a result of track realignment e.g. lifts and slews which may impact available freeboard for the ARI 100-year event, or compromise pipe cover;
- Hydraulic capacity of the culvert and comparison to design flows;
- Other site-specific considerations such as flooding history, debris management and risk to the rail embankment due to pipe failure or blockage;
- Environmental considerations such as evidence of existing scour, sensitive downstream receiving environments, and potential for scour by assessing discharge velocities;
- Assessment of confidence of design parameters and identification of additional information required to confirm recommendations before the next design stage.

In summary, most of the culvert assessed comply with the KiwiRail Standard except culverts denominated North-A and North-B culverts that do not comply with the minimum freeboard of 725mm required by KiwiRail Standard.

The confidence of the design parameters is Medium to Low due to:

- The low accuracy on contours used to determine design flows, i.e. 20m contours from LINZ.
- The few Culvert Invert Level Information.
- Inaccurate Maximo Data information.

We recommend carrying out further investigations prior to any work commence to determine the real risk of flooding hazard and risk to the railway and downstream environments. The relatively minor extent of track lifts and lowers are unlikely to have a significant impact on the existing drainage system, however it is the NRU's projects objective to ensure new track infrastructure is installed with, and protected by compliant drainage infrastructure.

4.3.3 Overland Flow

The secondary flow path, or overland flow path, is the path the stormwater would take if the primary drain was rendered inoperable or is overwhelmed by a flow exceeding the drain's design capacity.

The existing or proposed structures are not affected by the secondary flow during the design secondary storm event. Storage within the pipe and cess network has been sized to cater for larger rainfalls than the 1% AEP 10-minute storm. The secondary flow path is only required to convey the secondary system level of service event, less the design capacity of the primary system, regardless of secondary intakes.

Several overland flow paths have been identified in the surrounding properties for overflow events beyond the design for these devices (1% AEP 10-minute storm). All flows in excess of the 1% AEP 10 minute-event are to be directed through an overland flow-path and assumes that the primary storage/infiltration device is blocked or full when this occurs.

4.4 Proposed Design

The general design philosophy for the tunnel drainage works associated with the track lowering is:

- Ensure track ballast and formation is kept well drainage to protect subgrade;
- Positive fall of sub-ballast formation (either crowned or inverted);
- Drain to existing discharge points and culverts where possible to avoid consenting requirements;
- Existing and proposed outfalls within the extent of track lowering to have erosion protection required;
- Consideration to Safety in Design principles and ensure safe access for ongoing maintenance of the drainage network, particularly within the tunnel. This will include debris management and outlet protection;

- Assess capacity and suitability of existing drainage infrastructure to determine if renewals or upgrades are necessary, to ensure new track and formation works are protected from poor drainage and effects such as ballast contamination.
- Water quality improvements do not form part of the scope and design requirements for the NRU project; however, the design will ensure the impacts on the downstream receiving environments are no worse as a result of the proposed works.

Few culverts where found during the site investigation and we are not aware of the condition of the inlet and outlet areas, therefore we recommend to clear vegetation around the inlet and outlet structures and checking all culvert outlet to look for any evidence of outlet erosion.

The sections below provide rationale and detail of the proposed drainage works associated with Tunnel 7 track lowering, required to provide adequate structural clearance for the design wagons, and future potential electrification of the line.

4.4.1 Design Development Overview

A Value Engineering meeting was held with members of the NRU project team, where the 85% designs were reviewed. From this meeting it was identified that the vertical and horizontal alignment design could be amended to reduce the extent of track renewal works required, which would result in a less desirable alignment design, however, would still meet KiwiRail standards. A fall out of this new design was a reduced scope of drainage works required to support the track realignment and renewal.

An overview of the design changes at each portal area is described below. These are further discussed in the following sections of the report and represented in the appended design drawings.

- **South Portal Area**
  - Proposed culvert alignment has been shifted a few metres to the south to ensure that the outlet discharges in the proposed mitre drain, requiring reduced earthworks. The culvert diameter has been reduced to the minimum (375mm) as per KiwiRail standards, which will meet the design flow capacity required.
  - At the proposed tunnel internal drainage pipe outlet, we propose to install a riprap discharge detail instead of a sump.
  - New cess drains within tamped areas have been removed from the scope as we are now only looking and drainage improvements within the extents for track renewal. Onsite inspections will be required to ensure there is no risk of ponding on on-going maintenance issues to the track as a result of leaving the existing cess drains in place through the taped areas.
- **North Portal Area**
  - The designed track alignment extension has been shorted at the North end, furthermore we have shortened the length of proposed drainage design as well.
  - Proposed culvert alignment has been shifted few metres to the north to ensure that the proposed manhole can be installed in the same alignment of the existing outlet pipe and the proposed culvert can cross straight the rail track.
  - We removed proposed cess drains in tamping areas and track renewal areas where surrounding profile ground slope away of the rail track.
  - At the western side of the track we propose to install a subsurface drain instead an opened cess drain because of the reduce space.

4.4.2 South Portal Area

The existing cess drains will require some degree of vegetation clearances and re-forming to comply with KiwiRail drainage standards. The cess drain design will reduce the risk of blockages with debris and mitigate against issues related with sediment. The design cess drain profiles and interface with existing ground levels are shown in the Designed Track Alignment Sections. Some geotechnical inputs will be required where new cut slopes are needed near the portals. Prior to any site work commencing it is evident that further survey and geotechnical assessments will be required to ensure cuttings and modified fill embankments meet KiwiRail standards for Factor of Safety.

The design proposes to replace the existing half steel pipe located in the cess drain at the mouth of the tunnel by new well-formed KiwiRail standard cess drains.

The proposed subsoil drainage pipe coming out of the tunnel will be diverted in a 45-degree angle, through a uPVC Solid Pipe (closed system), to an outlet in the proposed cess drain. This will be protected from erosion by placing small rip rap material at the outlet. A rodding eye will be installed at the end of the tunnel subsoil pipe at the 45-degree angle bend for easy maintenance.

KiwiRail has reviewed the alternative design options presented in the previous 85% Design report to mitigate existing cess drain ponding issues around the south poral area. The preferred solution is to divert all the stormwater runoff through the new proposed cess drain toward the south to a new culvert located at 135,400KM. We propose to install a new 1050DN Scruffy Dome Manhole in the same alignment of the eastern cess drain and cross the corridor formation with a new 375NB PVC-U PN16 culvert with Standard Precast Wingwalls at the outlet.

The proposed western cess drain will run to the south up to the proposed culvert outlet location, where the runoff flows will be diverted into a mitre drain which will tie into an existing farm channel which outfalls into a hollow at the southwest of Tunnel.

Also, we propose to CCTV the existing culvert (2258669) to confirm pipe condition and ensure free from blockage, as this is a critical part of the overall drainage network across the corridor.

4.4.3 North Portal Area

The existing cess drains are draining toward the north and they will require some degree of vegetation clearances and re-forming to comply with KiwiRail drainage standards. The cess drain design will reduce the risk of blockages with debris and mitigate against issues related with sediment. The design cess drain profiles and interface with existing ground levels are shown in the Designed Track Alignment Sections. Some geotechnical inputs will be required where new cut slopes are needed near the portals. Prior any site work commence it is evident that further survey and geotechnical assessments will be required to ensure cuttings and modified fill embankments meet KiwiRail standards for Factor of Safety.

The proposed western subsurface drain acting as a cess drain will run up to 135.920 KM before getting diverted into a mitre drain which will tie into the bottom of the embankment where an existing culvert (2258671) is located. The proposed design is to install the mitre drain as flat as practicable, installing a rip rap bed at the outlet to avoid erosion if mitre drain is steeper than 1 in 50.

At the eastern side we propose to form a standard cess drain up to 135.910 KM before getting diverted into a mitre which will tie into the bottom of the embankment where an existing open farm channel is running away of the railway corridor. The proposed design is to install the mitre drain as flat as practicable, installing a rip rap bed at the outlet to avoid erosion if mitre drain is steeper than 1 in 50.

We proposed to remove the existing culvert '228570' and install, few meters to the south, a new 675DN Reinforce Concrete Rubber Ring Jointed (RCRRJ) Class 4 culvert with a 1050DN Scruffy Dome Manhole at the Inlet. This culvert will outfall into a proposed Scruffy Dome Manhole that will be installed in the same alignment of the existing steel outlet pipe. The existing pipe outlet and condition could not be determined during site investigation. Therefore, we recommend to CCTV the above-mentioned asset to confirm its alignment and discard any possible blockage. The contractor will need to locate that pipe and report to the Engineer prior to any work commencement. From the plans it appears that this pipe discharges within the KiwiRail corridor boundary. This will need to be confirmed on site as specific landowner permission will be required if this pipe is proven to discharge outside of the corridor.

4.5 Tunnel Drainage

4.5.1 Design Approach

The existing and proposed alignment geometry has a constant gradient of approximately 1 in 80 running from north to south. Surface flow from north of the North portal will be diverted away from the portal to ensure they do not enter the tunnel. Within the tunnel, a centre drain will be installed with the formation falling towards the track centreline at 3% grade. The drain will be placed in a trench below the 250mm ballast layer, in a subsoil trench wrapped in geotextile and filled with drainage aggregate, as shown in the design drawings.

A side drain option with a crowned formation running at 3% cross-fall was also considered. However, upon review of the T+T test pit investigations, and from discussions with the KiwiRail NAL project team, it was agreed that a central drain was more preferable, particularly for ongoing maintenance and reduced risk of damage or lifting through tamping. This type of damage to side drains was evident in site observations where the subsoils along the tunnel footings had 'lifted' to near the surface, likely as a result of previous tamping. This has resulted in the drains being ineffective and a high standing water table within the ballast layer.

A typical track profile through the tunnel is shown in the figure below.

The 160mm dia Nexus Hi Way pipe has been proposed due to its high flow capacity (smooth bore), particularly as the pipe will be laid at a constant 1 in 80 grade to follow the track vertical alignment. This will future proof for any potential increased flow requirements (e.g. seasonal water ingress flows) and allow easier rodding. The subsoil pipe will be laid in a subsoil trench as per the KiwiRail standard shown in drawing CE-100-862 detail B, shown below.

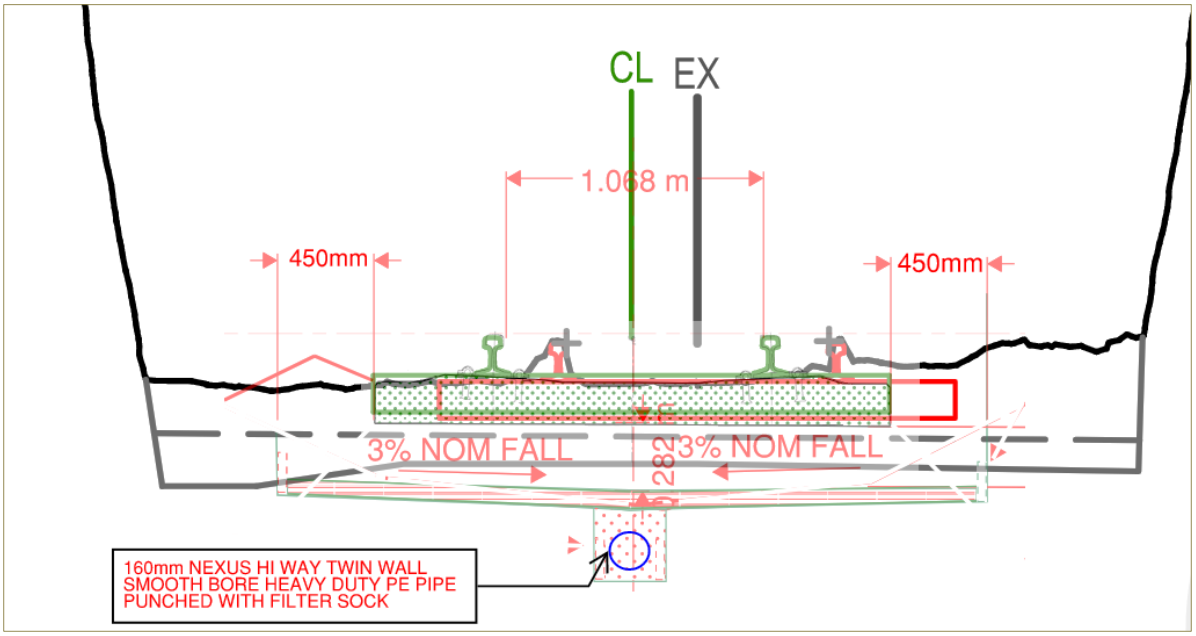

Figure 12: Typical track and subsoil drainage detail through extent of Tunnel

4.5.2 Design Flows

During the site visit there were no evident sources of seepage through the surface, however the standing water within the track formation is evidence of water ingress. It should be noted that the site visit was not intended as a detailed mapping exercise for seepage, rather an inspection of existing track and drainage condition within the tunnel. The impacts of introducing the new drainage system has not been assessed in terms of potentially lowering the groundwater table and dewatering effects on the structure.

A hydraulic capacity assessment of the proposed 160 mm dia Nexus HIWY pipe laid at 1 in 80 grade (to match tunnel vertical alignment) shows the pipe can convey flows of up to 19 l/s. Based on the tunnel length of 343m this means the proposed subsoil drain can cope with contributing flows from seepage of up to 0.06 l/s/m of tunnel.

If significant seepage is encountered during construction (or ongoing inspections) then the engineer shall be notified. The section of water ingress management below outlines the process to be followed for addressing water ingress in tunnels.

4.5.3 Maintenance

To provide KiwiRail with the ability to flush and maintain the subsurface drains, 45-degree flushing points shall be installed every 200m using a coupler and rodding pipe. These rodding points shall be located within the existing tunnel refuges and will be connected to the Wye junction on the subsoil pipe with a flexible 160 PE pipe. Locating the rodding eyes in refuges will prevent from getting damaged during tamping. This 200m spacing will require a departure as it exceeds the 50m specified in the KiwiRail Corridor Drainage standard.

Details and specific locations for these rodding points is specified in the attached 100% design drawings. The locations of rodding eyes are:

- South Portal at 135.460 KM
- Refuge at 135.570 KM
- Refuge at 135.690 KM
- North Portal at 135.805 KM

The proposed design is like that shown in KiwiRail Design Standard C-ST-CD-4102 (Figure 15 below) from Caversham Tunnel on the MSL, however the wye junction will be rotated 45 degree so that it protrudes laterally towards the rodding point (i.e. refuge). If there are no refuges within 200m of the adjacent rodding location, then they shall be located on the outside of the track at the foot of the tunnel. These shall be clearly located on the tunnel lining for easy identification and accessing the future. They should not protrude above the ballast shoulder level as they could pose a trip hazard to staff or contractors walking through the tunnel.

Figure 13: Example Rodding eye connection within a tunnel (Source KiwiRail C-ST-CD-4102)

Ballast shall be prevented from entering the flushing point using an endcap and a reduction in ballast level in these bays only.

The assumption is that tampers operate within 300mm of the running edge, leaving the central 468mm safe from damage. The end cap and access are will be maintained below the surface of the sleeper thus reducing the likelihood of damage via other activities including ballast brushes and the handling of materials.

4.5.4 Water Ingress Management

The management and treatment of water ingress within tunnels is important to reduce the risk of asset degradation and operational disruptions caused by water ingress. During the site visit there were no visible water ingress through the tunnel lining that was having a direct impact on rail fixings, however it needs to be noted that the site visits were undertaken in the peak of summer.

The presence of standing groundwater during the test pit investigations is evidence of significant ground water ingress. This will be managed by the tunnel drainage system described above. Any surface water ingress entering the tunnel from the portals will be diverted as part of this design to ensure it does not enter the tunnel. The details of this is provided in the corridor drainage sections below.

However, the management of any potential water ingress through the tunnel lining needs to be mitigated if there is a risk to the asset. KiwiRail Standard B-ST-TU-3117 'Management of Water Ingress within Tunnels' has been referenced in the design presented within this report. It is assumed that any water seepage identified on-site during construction (or any other time in the future) will be at discrete locations, therefore installation of direct collector drains will be preferred over drip shields, troughs or other similar measures. This is in accordance with the process outlined in section 5 of B-ST-TU-3117.

Prior to the contractor being instructed to install any seepage mitigations, the following actions should be taken:

- Record location of ingress, nature and qualitative assessment of flow volume, and the impact it is having on the assets;
- Tunnel engineer to inspect to ensure it is not a symptomatic or structural issue;
- Check structural clearances will not be compromised once drains are installed.

5 Safety in Design

An internal Safety in Design workshop was held on 2nd April 2020 with attendance from the Vitruvius alignment, track and drainage engineers. A project wide SID workshop was subsequently held on 24 April 2020, with all consultant designers present, as well as KiwiRail engineering and NRU project team members. The Vitruvius SiD procedure was amended to meet the requirements of the KiwiRail SiD procedure. This resulted in adjustments to the risk matrix to ensure the residual risks identified were aligned.

Handover actions were also identified to ensure risks can be communicated to KiwiRail and the contractor as part of the physical works procurement process.

The full Safety in Design (SiD) undertaken based on the 100% designs is found in Appendix B, a summary of key considerations for SiD at this site shall include:

- Developing an optimal alignment which reduces extent of track lowering required and hence risk to contractors working in the tunnel, and ongoing residual risk to the tunnel foundation.
- Ongoing access and maintenance of drainage.
- Survey control and as built of new track to ensure compliance with KiwiRail standards.
- Post construction clearance certification and hand back to KiwiRail for the safe operation of trains.
- Confirmation of slope stability for proposed modifications to cuttings and embankments to accommodate track lifts and slews, and deepened cess drains. It is recommended geotechnical assessments and LiDAR survey are undertaken to confirm the slope stability meets KiwiRail standards.
- Modifications to the tunnel floor (up to approx. 190mm milling) is assessed by KiwiRail or their tunnelling experts, to ensure there is not an unacceptable risk to the tunnel structure during construction or ongoing. Geotechnical or structural assessments of the tunnel is outside the scope of the Category A tunnel packages of works.

After assessing each risk with mitigations and controls in place the residual risk was determined to be either Low or Medium 4 i.e. the highest residual risk did not exceed Medium 4.

6 Risk

A risk register across the three Category A Tunnels within the Vitruvius scope of work (Tunnel 7, 8 and 11) has been developed as part of the 20% and 85% design phases. The risk register will be continuously updated as the project and designs develop and should be treated as a live document.

It is acknowledged that KiwiRail has a separate overarching project risk register, which can make reference to or include the risks identified in the Vitruvius Risk Register.

Table 9: Summary of Key Design Risks

Risk Description	Owner	Current Mitigation	Status
Accommodation of overhead catenary system	KiwiRail	Design for ballast track CWH with additional construction tolerances, and NAL Project Team consulting with KiwiRail Traction engineers	Live - Being managed
Depth of track lowering required relative to existing tunnel invert	KiwiRail	Undertaking trial excavations to determine tunnel invert depth and condition, and reducing minimum ballast depth through tunnel	Needs attention – geotechnical and structural assessment recommended prior and during construction
Existing ballast depth and subgrade condition may determine undercutting and deeper cess drains required	KiwiRail	Awaiting investigation data and LiDAR survey to determine drain invert and earthworks required to accommodate – to ensure ballast free draining	Live - Being managed Geotechnical assessment of proposed cut and fill batter slopes required prior and during construction.
Track construction meeting alignment tolerances, ballast depth and high stresses in rail	KiwiRail	Engage competent contractors and assign appropriate level of controls and construction observations during physical works As-builts to verify clearances have been achieved	Live - Being managed
Modification to tunnel floor required based on track realignment and test pit information showing depth of existing ballast.	KiwiRail	This report seeks feedback and input from KiwiRail tunneling specialist to review and recommend modification to tunnel floor to accommodate new track position and drainage.	New Risk – needs attention
Track slew required on existing rail embankment north of the tunnel. A geotechnical assessment for the proposed embankment widening and rising needs to be undertaken	KiwiRail	Closed as part of this 100% design process following re-design of the alignment to reduce slews and lifts beyond the tunnel portals where possible.	Closed

7 Summary

7.1 Track Design

Track geometry has been designed with an alignment solution that meets the requirements of the existing line speed of 50 km/h.

The proposed design track alignments represent geometry needed to meet the required structure clearances and provision for future potential electrification while maintaining a ballasted track form.

A value engineering review was undertaken between 85% and 100% designs, resulting in reduced slews and extent of track renewal required. Sections of track realignment which may be achievable by tamping techniques have been identified on the design alignment drawings, in an effort to reduce scope and cost of the physical works.

7.2 Drainage Design

The proposed drainage solutions at each portal area have been designed to ensure the proposed track alignment and formation are well drained and not at risk of ponding in the 10 year and 100 year design events as per KiwiRail standards.

The scope of works has been reduced following a Value Engineering meeting with NRU staff, based on the 85% design submitted. The reduced scope is largely based on the reduced extent of track renewal works required.

Additional investigations of asset condition and survey of existing ground is required to confirm the design. Based on site access restrictions at the time of writing this report (COVID-19 Level 3), this will need to be assessed prior to construction once the contractor has mobilised.

7.3 Additional Information & Client Input Required

- KiwiRail are currently sourcing additional LiDAR information at each tunnel site. This information will be considered in developing the 100% design for the track lowering and corridor drainage improvements.
- Geotechnical assessment is required for the embankment works north of the tunnel 7.
- Geotechnical and structural assessment of the tunnel as a result of the proposed modifications to the tunnel floor by milling or other forms of excavation, to accommodate the lowered track and centre drain.

7.4 Departures

The following departures from standard shall require approval from the Professional Head of Track:

- Ballast shoulders shall be omitted within the tunnel to provide a safe, level emergency walkway
- Ballast depth in tunnels may be reduced to 250mm to allow for deeper rail, deeper sleepers, a sub-ballast layer, larger vehicles and OLE clearance. This has already been approved for the NAL project by Professional Heads.

The following departures shall require approval from the Professional Head of Civils:

- The tunnel centre drain design which is located within the track loading zone.
- Spacing of rodding eyes to be increased from 50m to 200m, and placed within the refuges where practicable, otherwise to the side of the track outside of the tamping zone.

VITRUVIUS

Appendix A

Drawings

NOTES:

1. THE SURVEY GRID AS SUPPLIED BY VITRUVIUS SURVEYORS IS:
   BEARING & COORDINATE DATUM - MOUNT EDEN CIRCUIT 2000
   VERTICAL DATUM- NZVD 16
2. DESIGN KILOMETREAGES USES TUNNEL 11 PORTAL 1 AT 159.287KM AS DATUM
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
5. CONTOURS SOURCED FROM LINZ LAND ONLINE DATABASE AT 20.0m INTERVALS ONLY. THERE IS NO GUARANTEE TO THE SPATIAL CATCHMENT ACCURACY OF THE 10.0m CONTOURS.

LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- CATCHMENT AREA
- OVERLAND FLOWPATH
- FIBREOPTIC CABLE

TO WHANGAREI

TUNNEL 7

SEE DRG VT-TB-700-006 FOR DESIGN

CATCHMENT AREA SOUTH A 4.2 ha

LONGEST STORMWATER RUN-OFF FLOW PATH LENGTH : 317m SLOPE : 20.3%

SEE DRG VT-TB-700-005 FOR DESIGN

LONGEST STORMWATER RUN-OFF FLOW PATH LENGTH : 137m SLOPE : 10.0%

CATCHMENT AREA SOUTH B 1.3 ha

EXISTING KIWIRAIL CULVERT "2258669". 750mmØ RCRRJ @135,398KM

LONGEST STORMWATER RUN-OFF FLOW PATH LENGTH : 137m SLOPE : 9.6%

SEE DRG VT-TB-700-004 FOR DESIGN

CATCHMENT AREA SOUTH C 0.3 ha

EXISTING KIWIRAIL CULVERT "2258668". 500mmØ RCRRJ @135,258KM

SEE DRG VT-TB-700-003 FOR DESIGN

EXISTING KIWIRAIL CULVERT "2258666". 300mmØ RCRRJ @159,280KM

EXISTING KIWIRAIL CULVERT "2258667". 450mmØ EARTHENWARE @159,280KM

NAL

TO AUCKLAND

ALIGNMENT DESIGN EXTENT

0 40 80 Metres

VITRUVIUS

	Signed	Date
Drawn RS	RS	03/04/20
Designed CA	CA	03/04/20
Verified SW	SW	03/04/20
Approved SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 07
SOUTH PORTAL
CATCHMENT OVERVIEW 1 / 2

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.
1:1000	A1

Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	001	B

NOTES:

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   VERTICAL DATUM- NZVD 16
2. DESIGN KILOMETREAGES USES TUNNEL 11 PORTAL 1 AT 159.287KM AS DATUM
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
5. CONTOURS SOURCED FROM LINZ LAND ONLINE DATABASE AT 20.0m INTERVALS ONLY. THERE IS NO GUARANTEE TO THE SPATIAL CATCHMENT ACCURACY OF THE 10.0m CONTOURS.

LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- CATCHMENT AREA
- OVERLAND FLOWPATH
- FIBREOPTIC CABLE

TO WHANGAREI

NAL

EXISTING KIWIRAIL CULVERT "225867/1", 700mmØ RCRRJ @135,948KM

ALIGNMENT DESIGN EXTENT

SEE DRG VT-T7-700-008 FOR DESIGN

EXISTING KIWIRAIL CULVERT "225867/0", 500mmØ RCRRJ @135,832KM

SEE DRG VT-T7-700-007 FOR DESIGN

CATCHMENT AREA NORTH A 6.8 ha

LONGEST STORMWATER RUN-OFF FLOW PATH LENGTH : 393m SLOPE : 21.5%

SEE DRG VT-T7-700-006 FOR DESIGN

TUNNEL 7

CATCHMENT AREA NORTH B 2.18 ha

LONGEST STORMWATER RUN-OFF FLOW PATH LENGTH : 308m SLOPE : 19.8%

SEE DRG VT-T7-700-005 FOR DESIGN

TO AUCKLAND

0 40 80 Metres

	Drawn	Signed	Date	Rev.	Date	Revision Details	By	App.
	RS	RS	03/04/20	.	.	.	.	.
	Designed	Signed	Date	.	.	.	.	.
	CA	CA	03/04/20	.	.	.	.	.
	Verified	Signed	Date	.	.	.	.	.
	SW	SW	03/04/20	.	.	.	.	.
	Approved	Signed	Date	B	01/05/20	100% DETAIL DESIGN	RS	SW
	SW	SW	03/04/20	A	03/04/20	85% DETAIL DESIGN	RS	SW

VITRUVIUS

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. NAL - TUNNEL 07
NORTH PORTAL
CATCHMENT OVERVIEW 2 / 2

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:1000	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	002	B

NOTES:

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   VERTICAL DATUM- NZVD 16
2. DESIGN KILOMETREAGES USE 135 KILOMETRE MARK AS DATUM.
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
5. CONTRACTOR IS TO ENSURE ALL RELEVANT KIWIRAIL PERMITS ARE OBTAINED AND THE REQUIRED LEVEL OF RAIL PROTECTION IS ON SITE PRIOR TO ACCESSING THE RAIL CORRIDOR.
6. CONTRACTOR TO FOLLOW WORK SAFE GOOD PRACTICE GUIDELINES ON EXCAVATION SAFETY.
7. SERVICES ARE KNOWN IN THIS AREA. THE SERVICES SHOWN ARE FROM BEFORE U DIG AND ARE INDICATIVE ONLY. KIWIRAIL SERVICES ARE NOT SHOWN. SERVICES ARE TO BE ACCURATELY LOCATED IN THE GROUND BY THE CONTRACTOR BEFORE ANY WORK IS CARRIED OUT IN THE AREA SHOWN IN THIS DRAWING. THE CONTRACTOR WILL SHALL DISCUSS THE LAYOUT OF THESE WITH THE ENGINEER PRIOR TO EXCAVATION.
8. FORMATION OUT THE TUNNEL TO BE AS PER KIWIRAIL DRAWING 300 182 S1-S2 REV-D AS INDICATIVE.
9. FOR SUBSOIL PIPE USE AS2439 "CLASS 500" PIPE, TWIN WALL SMOOTH BORE HEAVY DUTY PE, PUNCHED.
10. FOR SUBSOIL PIPE TRENCH USE GEOTEXTILE FILTER IN ACCORDANCE WITH KIWIRAIL TRACK FORMATION GUIDELINES - NON WOVEN STRENGTH CLASS C OR D (I.E. BIDIM A29 OR A39, DURAFORCE AS410 OR AS440). ALSO IT SHALL BE IN ACCORDANCE WITH SECTION 2.3 NZTA SPECIFICATION FOR PIPE SUBSOIL DRAIN CONSTRUCTION F/2:2013.

LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- OVERLAND FLOWPATH
- CESS DRAIN
- MITRE DRAIN
- FIBREOPTIC CABLE
- DES TOP OF BALLAST
- DES BOTTOM OF BALLAST

CLEAR VEGETATION AROUND THE INLET AND OUTLET STRUCTURE. CHECK FOR EVIDENCE OF OUTLET EROSION AN REPORT TO ENGINEER PRIOR TO ANY WORK COMMENCEMENT.

EXISTING KIWIRAIL CULVERT "2258667". 300mmØ RCRRJ @159,216KM

EXISTING KIWIRAIL CULVERT "2258666". 500mmØ RCRRJ @135,258KM

135200

EXISTING KIWIRAIL CULVERT "2258667". 450mmØ EARTHENWARE @159,216KM

EXTENT OF TRACK REALIGNMENT

720.00

JOIN LINE - VT-T7-700-004

0 5 10 Metres

VITRUVIUS

	Signed	Date
Drawn RS	RS	03/04/20
Designed CA	CA	03/04/20
Verified SW	SW	03/04/20
Approved SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. NAL - TUNNEL 7
SOUTH PORTAL
DRAINAGE DESIGN PLAN 1 / 6

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.
1:250	A1

Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	003	B

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8. FORMATION OUT THE TUNNEL TO BE AS PER KIWIRAIL DRAWING 300 182 S1-S2 REV-D AS INDICATIVE.
9. FOR SUBSOIL PIPE USE AS2439 "CLASS 500" PIPE, TWIN WALL SMOOTH BORE HEAVY DUTY PE, PUNCHED.
10. FOR SUBSOIL PIPE TRENCH USE GEOTEXTILE FILTER IN ACCORDANCE WITH KIWIRAIL TRACK FORMATION GUIDELINES - NON WOVEN STRENGTH CLASS C OR D (I.E. BIDIM A29 OR A39, DURAFORCE AS410 OR AS440). ALSO IT SHALL BE IN ACCORDANCE WITH SECTION 2.3 NZTA SPECIFICATION FOR PIPE SUBSOIL DRAIN CONSTRUCTION F/2:2013.

LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- OVERLAND FLOWPATH
- CESS DRAIN
- MITRE DRAIN
- FIBREOPTIC CABLE
- DES TOP OF BALLAST
- DES BOTTOM OF BALLAST

EXISTING HOLLOW

EXISTING CULVERT OUTLET

EXISTING OPEN FARM CHANNEL

160mm Ø PVC-U DWV SN16 SOLID WALLED PIPE TO CONNECT FROM TRACK SUBSOIL TO CESS DRAINAGE CHANNEL AT 1 IN 100 MINIMUM GRADE LEVELS TO BE CONFIRMED ONSITE PRIOR TO WORK COMMENCEMENT. INSTALL RIP-RAP OUTFALL PROTECTION. TUNNEL DRAINAGE PIPE D50 = 100mm DEPTH = 150mm WITH GEOTEXTILE BIDIM-A29. REFER TO VT-T7-700-102 DETAIL

PROPOSED MITRE DRAIN. TO BE INSTALLED AS FLAT AS POSSIBLE TO TIE INTO EXISTING OPEN FARM CHANNEL. REFER TO VT-T7-700-102

PROPOSED CESS DRAIN TO DRAIN BELOW THE FORMATION LEVEL TO ENSURE POSITIVE DRAINAGE TO THE SOUTH. TIE INTO PROPOSED MITRE DRAIN. REFER TO VT-T7-700-102

TUNNEL 7 SOUTH PORTAL

PROPOSED NEXUS 160mm Ø HI-WAY TWIN WALL SMOOTH BORE HEAVY DUTY PERFORATED PE PIPE WITH FILTER SOCK IN DRAINAGE FILL. 650mm MINIMUM BELOW TOP OF RAIL. REFER TO VT-T7-700-101

EXISTING KIWIRAIL CULVERT "2258669". 750mmØ RCRRJ @135,398KM

WING WALL TO DISCHARGE

INSTALL Ø1050mm CONCRETE SCRUFFY DOME MANHOLE. REFER TO VT-T7-700-103.

REMOVE EXISTING STEEL HALF PIPE

PROPOSED SHORT LENGTH OF CESS DRAINS TO DRAIN POSITIVE TO THE NORTH IN ORDER TO TIE INTO THE PROPOSED MITRE DRAINS

PROPOSED 375NB PVC-U PN16 CULVERT INSTALLED 944mm BELOW TOP OF RAIL. REFER TO VT-T7-700-103

PROPOSED 45° RODDING EYE REQUIRED AT 45° BEND REFER TO VT-T7-700-101

135400

135500

FILL EXISTING HOLLOW AREA WITH COMPACTED SITE SOURCE MATERIAL. SHAPE TO ENSURE POSITIVE FALL TO THE PROPOSED CESS DRAIN.

PROPOSED CESS DRAIN TO DRAIN BELOW THE FORMATION LEVEL TO ENSURE POSITIVE DRAINAGE TO THE SOUTH. TIE INTO EXISTING OPEN FARM DRAIN

EXISTING CULVERT INLET

EXISTING HOLLOW

JOIN LINE - VT-T7-700-003

JOIN LINE - VT-T7-700-005

0 5 10 Metres

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	03/04/20
	Designed	Signed	Date
	CA	CA	03/04/20
	Verified	Signed	Date
	SW	SW	03/04/20
	Approved	Signed	Date
	SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. TUNNEL 7
SOUTH PORTAL
DRAINAGE DESIGN PLAN 2 / 6

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.				
1:250	A1				
Consultant.	Area.	Discipline.	Sheet No.	Rev.	
VT	T7	700	004	B	

NOTES:

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2. DESIGN KILOMETREAGES USE 135 KILOMETRE MARK AS DATUM.
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
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8. FORMATION OUT THE TUNNEL TO BE AS PER KIWIRAIL DRAWING 300 182 S1-S2 REV-D AS INDICATIVE.
9. FOR SUBSOIL PIPE USE AS2439 "CLASS 500" PIPE, TWIN WALL SMOOTH BORE HEAVY DUTY PE, PUNCHED.
10. FOR SUBSOIL PIPE TRENCH USE GEOTEXTILE FILTER IN ACCORDANCE WITH KIWIRAIL TRACK FORMATION GUIDELINES - NON WOVEN STRENGTH CLASS C OR D (I.E. BIDIM A29 OR A39, DURAFORCE AS410 OR AS440). ALSO IT SHALL BE IN ACCORDANCE WITH SECTION 2.3 NZTA SPECIFICATION FOR PIPE SUBSOIL DRAIN CONSTRUCTION F/2:2013.

LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- OVERLAND FLOWPATH
- CESS DRAIN
- MITRE DRAIN
- FIBREOPTIC CABLE
- DES TOP OF BALLAST
- DES BOTTOM OF BALLAST

PROPOSED NEXUS 160mm Ø
HI-WAY TWIN WALL SMOOTH BORE HEAVY DUTY PERFORATED PE PIPE WITH FILTER SOCK IN DRAINAGE FILL 650mm MINIMUM BELOW TOP OF RAIL.
REFER TO VT-T7-700-101

TUNNEL 7

DN100 PVC DWV
SN16 PIPE

PROPSED RODDING EYE
REFER TO VT-T7-700-101

REFUGE CAVITY

135500

135600

JOIN LINE - VT-T7-700-004

JOIN LINE - VT-T7-700-004

JOIN LINE - VT-T7-700-006

0 20 40 Metres

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Drawn RS | Signed RS | Date 03/04/20
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VITRUVIUS

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. TUNNEL 7
SOUTH PORTAL
DRAINAGE DESIGN PLAN 3 / 6

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:250	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	005	B

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LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
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- BOUNDARY
- MAJOR CONTOURS
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- CESS DRAIN
- MITRE DRAIN
- FIBREOPTIC CABLE
- DES TOP OF BALLAST
- DES BOTTOM OF BALLAST

DN100 PVC DWV SN16 PIPE

PROPSED RODDING EYE REFER TO VT-T7-700-101

TUNNEL 7

REFUGE CAVITY

PROPOSED NEXUS 160mm Ø HI-WAY TWIN WALL SMOOTH BORE HEAVY DUTY PERFORATED PE PIPE WITH FILTER SOCK IN DRAINAGE FILL 650mm MINIMUM BELOW TOP OF RAIL. REFER TO VT-T7-700-101

130.00

110.00

90.00

135700

135800

JOIN LINE - VT-T7-700-005

JOIN LINE - VT-T7-700-007

0 20 40 Metres

Drawn	Signed	Date
RS	RS	03/04/20
Designed	Signed	Date
CA	CA	03/04/20
Verified	Signed	Date
SW	SW	03/04/20
Approved	Signed	Date
SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. TUNNEL 7
NORTH PORTAL
DRAINAGE DESIGN PLAN 4 / 6

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:250	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	006	B

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LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- OVERLAND FLOWPATH
- CESS DRAIN
- MITRE DRAIN
- FIBREOPTIC CABLE
- DES TOP OF BALLAST
- DES BOTTOM OF BALLAST

PROPOSED NEXUS 160mm Ø
HI-WAY TWIN WALL SMOOTH BORE HEAVY DUTY PERFORATED PE PIPE WITH FILTER SOCK IN DRAINAGE FILL 650mm MINIMUM BELOW TOP OF RAIL.
REFER TO VT-T7-700-101

TUNNEL 7
NORTH PORTAL

REMOVE EXISTING KIWIRAIL CULVERT
"2258570" Ø500mm RCRRJ @ 135,833KM

PROPOSED Ø1050mm SCRUFFY DOME MANHOLE
REFER TO VT-T7-700-104

PROPOSED SUBSOIL DRAIN ACTING AS CESS DRAIN TO DRAIN BELOW THE FORMATION LEVEL. ENSURE POSITIVE DRAINAGE TO THE NORTH.
TIE INTO PROPOSED MITRE DRAIN.
REFER TO VT-T7-700-102

RIP RAP BED TO BE INSTALLED IF MITRE DRAIN IS STEEPER THAN 1 IN 50.
DIMENSIONS TO BE CHECKED WITH THE ENGINEER PRIOR TO ANY WORK COMMENCEMENT.
REFER TO VT-T7-700-102 DETAIL 2

PROPOSED 45° RODDING EYE
REQUIRED AT 45° BEND
REFER TO VT-T7-700-101

PROPOSED CESS DRAIN TO DRAIN BELOW THE FORMATION LEVEL TO ENSURE POSITIVE DRAINAGE TO THE NORTH.
TIE INTO PROPOSED MITRE DRAIN
REFER TO VT-T7-700-102

INSTALL A Ø1050mm CONCRETE SCRUFFY DOME MANHOLE AND CONNECT TO THE EXISTING OUTLET PIPE.
REFER TO VT-T7-700-104

PROPOSED Ø675mm RCRRJ CULVERT @135,836KM.
INSTALLED AT 1512mm BELOW TOP OF RAIL.
REFER TO VT-T7-00-104

EXISTING OUTLET PIPE.
CLEAR VEGETATION AROUND THE INLET AND OUTLET STRUCTURE.
CCTV TO CHECK THE EXISTING PIPE CONDITION. CHECK FOR ANY EVIDENCE OF OUTLET EROSION AND REPORT TO ENGINEER PRIOR TO ANY WORK COMMENCEMENT

PROPOSED MITRE DRAIN.
TO BE INSTALLED AS FLAT AS POSSIBLE TO TIE INTO EXISTING OPEN FARM CHANNEL.
REFER TO CT-ST-CD-4102.

RIP-RAP OUTFALL PROTECTION
MITRE DRAIN AT 135.920KM
D50 = 100mm DEPTH = 150mm

135800
135900
90.00
88.00

JOIN LINE - VT-T7-700-006
JOIN LINE - VT-T7-700-008

0 5 10 Metres

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	03/04/20
	Designed	Signed	Date
	CA	CA	03/04/20
	Verified	Signed	Date
	SW	SW	03/04/20
	Approved	Signed	Date
	SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. TUNNEL 7
NORTH PORTAL
DRAINAGE DESIGN PLAN 5 / 6

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:250	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	007	B

NOTES:

1. THE SURVEY GRID AS SUPPLIED BY VITRUVIUS SURVEYORS IS:
   BEARING & COORDINATE DATUM - MOUNT EDEN CIRCUIT 2000
   VERTICAL DATUM- NZVD 16
2. DESIGN KILOMETREAGES USE 135 KILOMETRE MARK AS DATUM.
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
5. CONTRACTOR IS TO ENSURE ALL RELEVANT KIWIRAIL PERMITS ARE OBTAINED AND THE REQUIRED LEVEL OF RAIL PROTECTION IS ON SITE PRIOR TO ACCESSING THE RAIL CORRIDOR.
6. CONTRACTOR TO FOLLOW WORK SAFE GOOD PRACTICE GUIDELINES ON EXCAVATION SAFETY.
7. SERVICES ARE KNOWN IN THIS AREA. THE SERVICES SHOWN ARE FROM BEFORE U DIG AND ARE INDICATIVE ONLY. KIWIRAIL SERVICES ARE NOT SHOWN. SERVICES ARE TO BE ACCURATELY LOCATED IN THE GROUND BY THE CONTRACTOR BEFORE ANY WORK IS CARRIED OUT IN THE AREA SHOWN IN THIS DRAWING. THE CONTRACTOR WILL SHALL DISCUSS THE LAYOUT OF THESE WITH THE ENGINEER PRIOR TO EXCAVATION.
8. FORMATION OUT THE TUNNEL TO BE AS PER KIWIRAIL DRAWING 300 182 S1-S2 REV-D AS INDICATIVE.
9. FOR SUBSOIL PIPE USE AS2439 "CLASS 500" PIPE, TWIN WALL SMOOTH BORE HEAVY DUTY PE, PUNCHED.
10. FOR SUBSOIL PIPE TRENCH USE GEOTEXTILE FILTER IN ACCORDANCE WITH KIWIRAIL TRACK FORMATION GUIDELINES - NON WOVEN STRENGTH CLASS C OR D (I.E. BIDIM A29 OR A39, DURAFORCE AS410 OR AS440). ALSO IT SHALL BE IN ACCORDANCE WITH SECTION 2.3 NZTA SPECIFICATION FOR PIPE SUBSOIL DRAIN CONSTRUCTION F/2:2013.

LEGEND

- TUNNEL 7
- DESIGN CENTRE LINE
- EXISTING CENTRELINE
- BOUNDARY
- MAJOR CONTOURS
- MINOR CONTOURS
- OVERLAND FLOWPATH
- CESS DRAIN
- MITRE DRAIN
- FIBREOPTIC CABLE
- DES TOP OF BALLAST
- DES BOTTOM OF BALLAST

RIP RAP BED TO BE INSTALLED IF MITRE DRAIN IS STEEPER THAN 1 IN 50.
DIMENSIONS TO BE CHECKED WITH THE ENGINEER PRIOR TO ANY WORK COMMENCEMENT.
REFER TO

EXISTING KIWIRAIL CULVERT "2258671". 700mmØ RCRRJ @135,948KM

PROPOSED MITRE DRAIN.
TO BE INSTALLED AS FLAT AS POSSIBLE TO TIE INTO EXISTING OPEN FARM CHANNEL.
REFER TO CT-ST-CD-4102.

136000

156100

EXTENT OF TRACK ALIGNMENT DESIGN

JOIN LINE - VT-T7-700-007

80.00

70.00

0 5 10 Metres

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	03/04/20
	Designed	Signed	Date
	CA	CA	03/04/20
	Verified	Signed	Date
	SW	SW	03/04/20
	Approved	Signed	Date
	SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client: KiwiRail

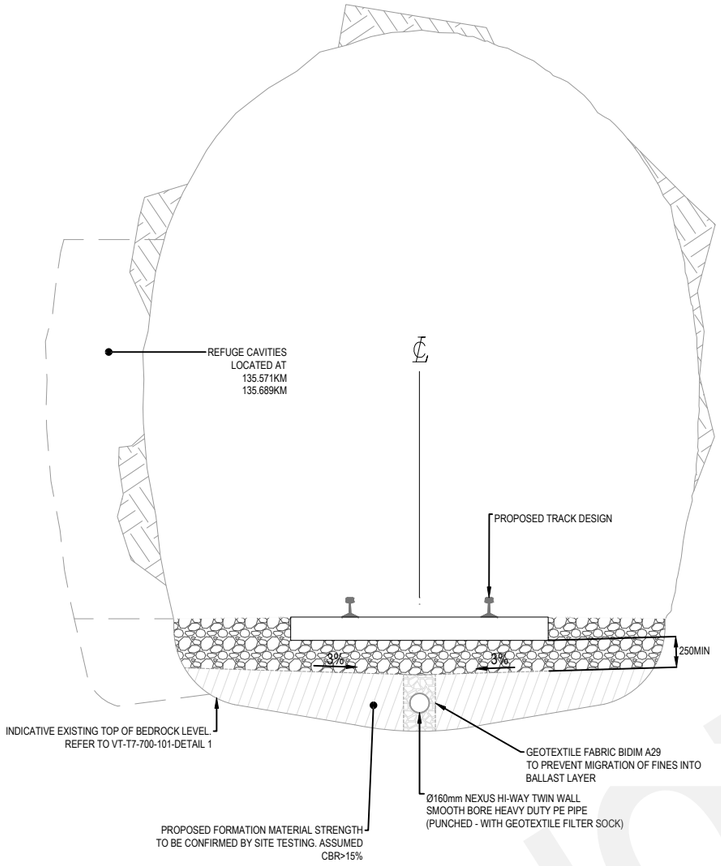
Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: TUNNEL 7
NORTH PORTAL
DRAINAGE DESIGN PLAN 6 / 6

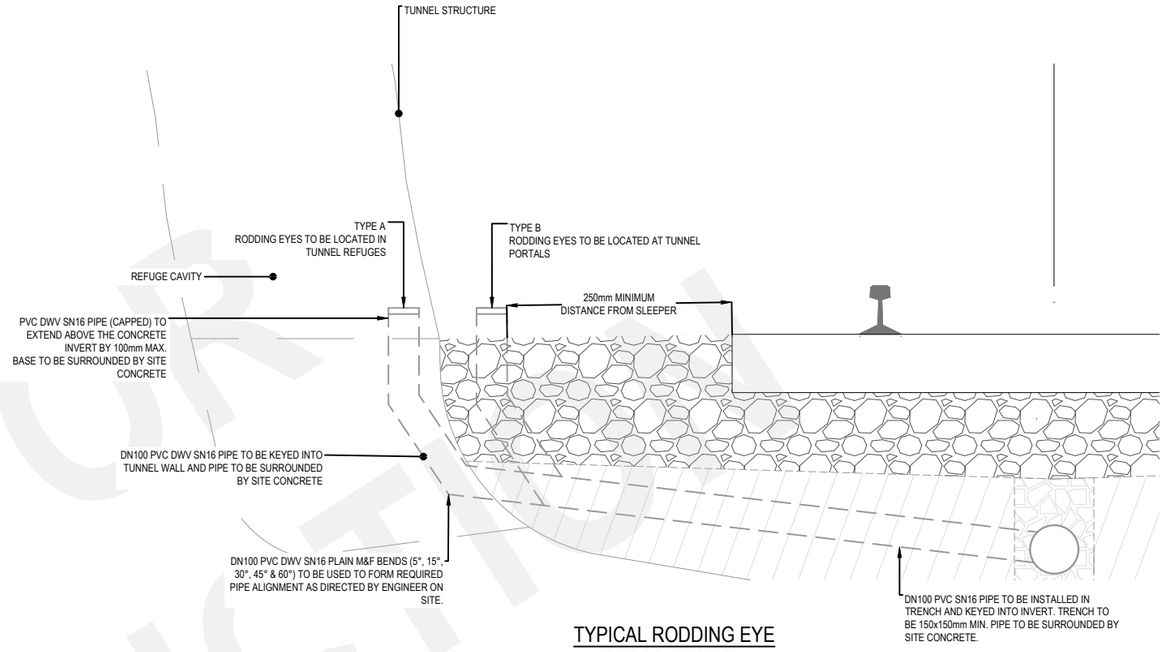
Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:250	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	008	B

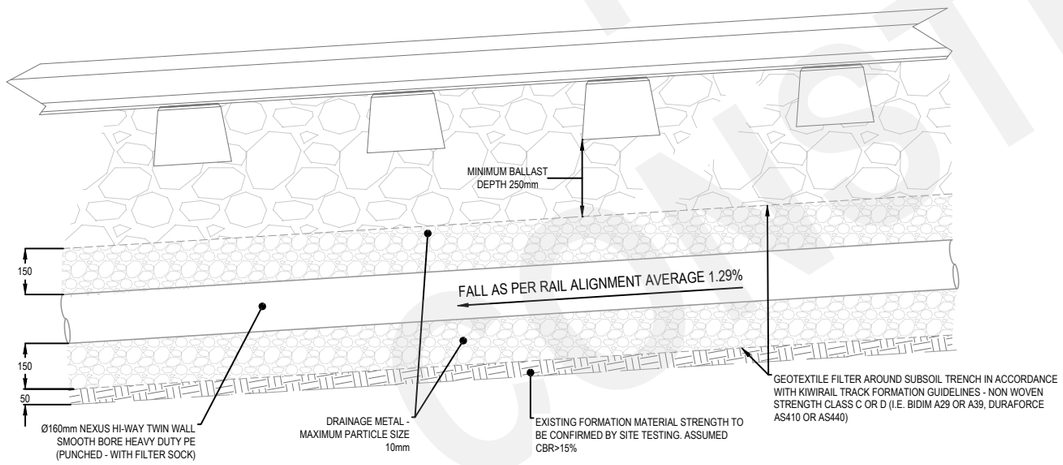
NOTES:
1. DIMENSIONS SHALL NOT BE OBTAINED BY SCALING THE DRAWINGS.
2. ALL DIMENSIONS SHALL BE CHECKED ON SITE PRIOR TO FABRICATION AND CONSTRUCTION
3. ALL DIMENSIONS ARE IN MILLIMETRES.



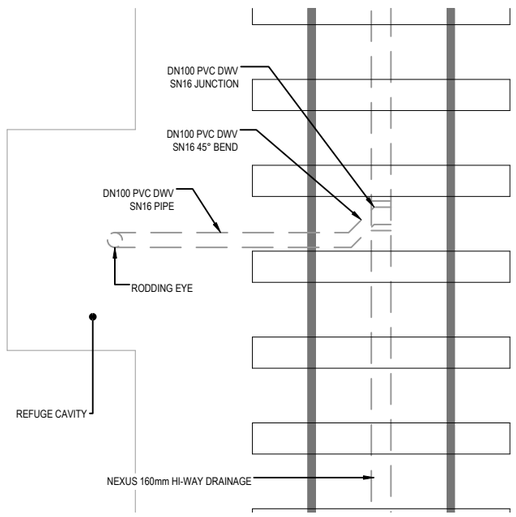
PROPOSED TYPICAL TUNNEL CROSS SECTION
SCALE 1:25



TYPICAL RODDING EYE CROSS SECTION
SCALE 1:10



TYPICAL TUNNEL DRAINAGE SECTION
SCALE 1:10



TYPICAL RODDING EYE PLAN
SCALE 1:25

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	03/04/20
	Designed	Signed	Date
	CA	CA	03/04/20
	Verified	Signed	Date
	SW	SW	03/04/20
	Approved	Signed	Date
	SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

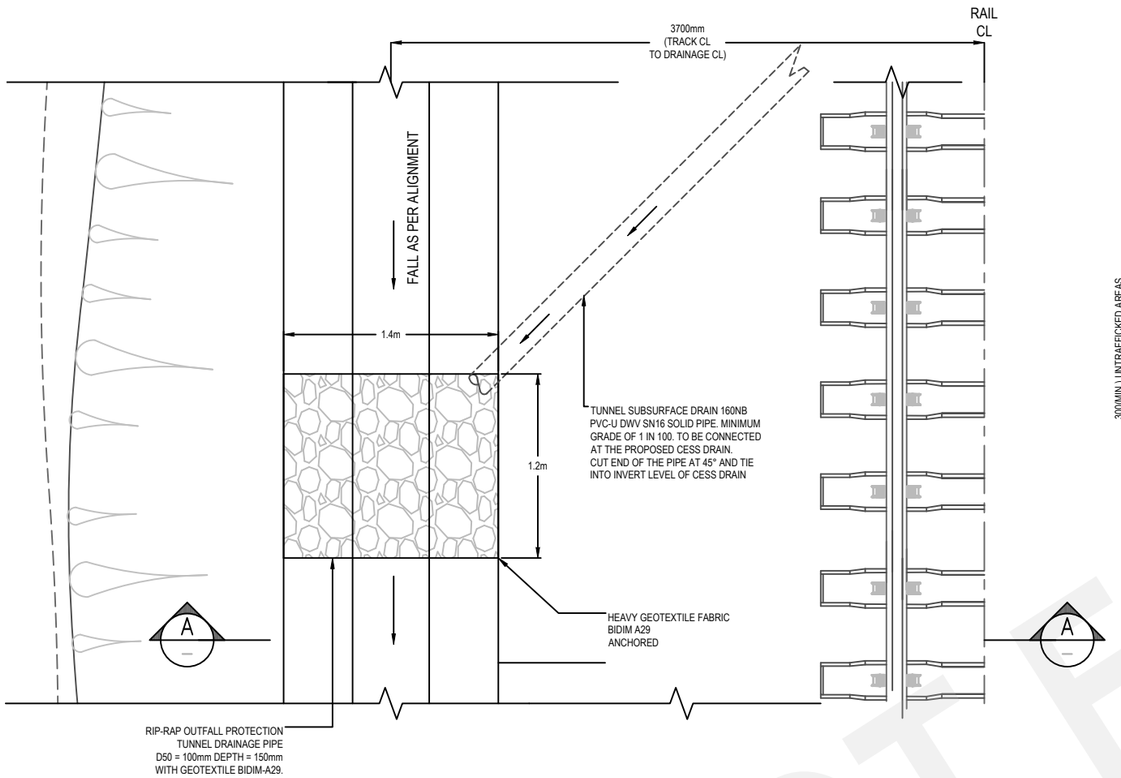
Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

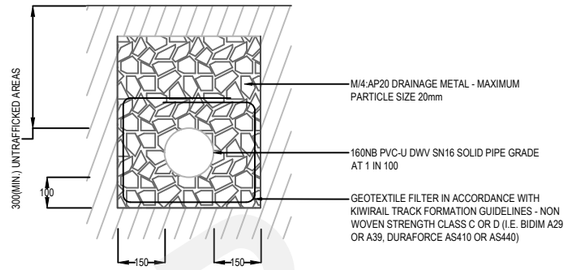
Drawing Title. NAL - TUNNEL 07
TYPICAL TUNNEL DRAINAGE DETAILS

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
AS NOTED	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	101	B

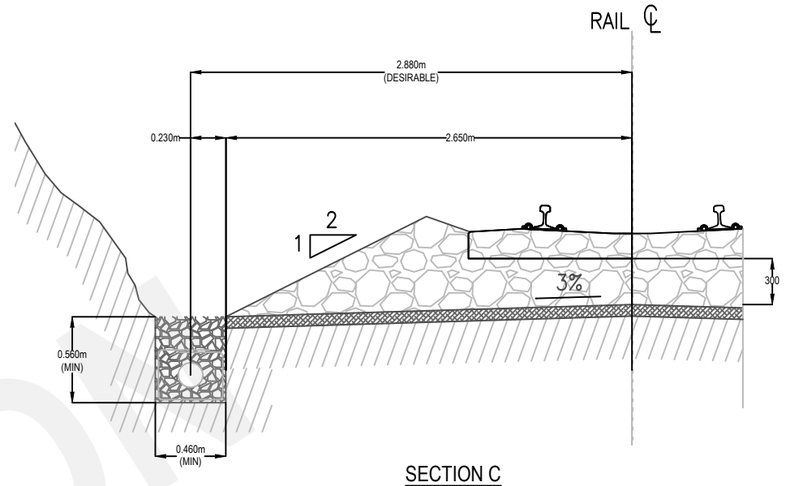


TYPICAL CESS DRAIN
PLAN
SCALE 1:50

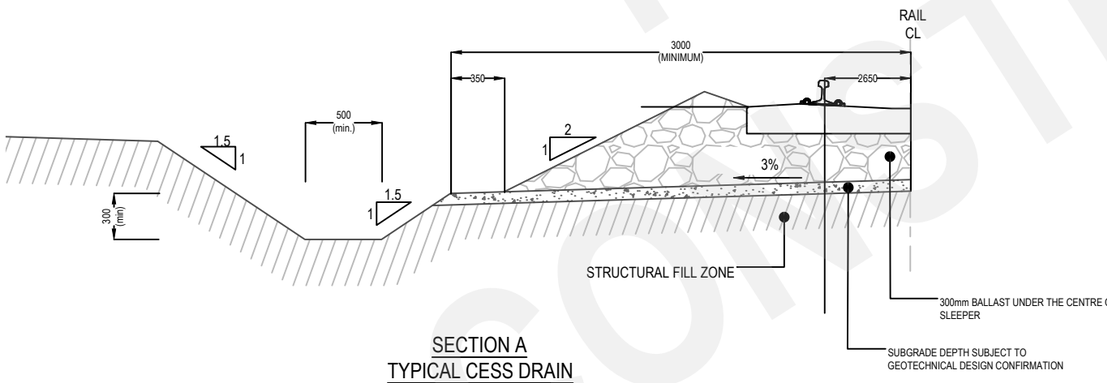


SECTION B
TYPICAL DRAINAGE TRENCH SECTION
OUTSIDE THE TUNNEL
SCALE 1:50

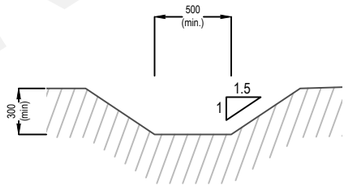
NOTES:
1. DIMENSIONS SHALL NOT BE OBTAINED BY SCALING THE DRAWINGS.
2. ALL DIMENSIONS SHALL BE CHECKED ON SITE PRIOR TO FABRICATION AND CONSTRUCTION
3. ALL DIMENSIONS ARE IN MILLIMETRES



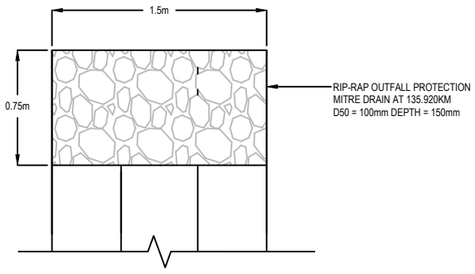
SECTION C
TYPICAL SUBSURFACE DRAIN AT
PROPOSED NORTH WEST CESS DRAIN
SCALE 1:50



SECTION A
TYPICAL CESS DRAIN
CROSS SECTION
SCALE 1:50



TYPICAL MITRE DRAIN
CROSS SECTION
SCALE 1:50



TYPICAL MITRE DRAIN
PLAN
SCALE 1:50

VITRUVIUS

	Signed	Date
Drawn RS	RS	03/04/20
Designed CA	CA	03/04/20
Verified SW	SW	03/04/20
Approved SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client: KiwiRail

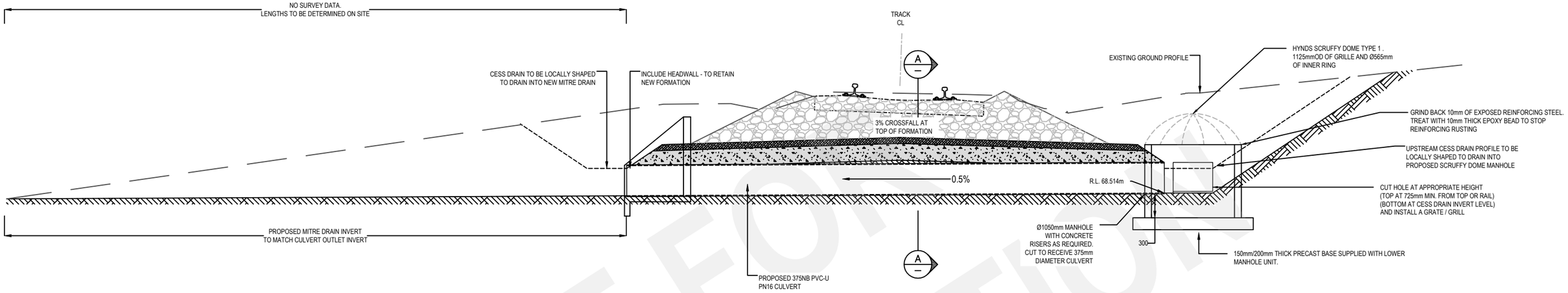
Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 07
TYPICAL EXTERIOR DRAINAGE DETAILS

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

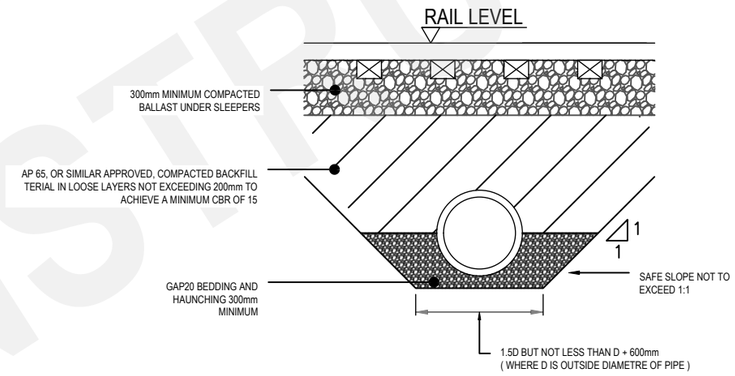
Scale	Sheet Size.			
AS NOTED	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	102	B

NOTES:
1. DIMENSIONS SHALL NOT BE OBTAINED BY SCALING THE DRAWINGS.
2. ALL DIMENSIONS SHALL BE CHECKED ON SITE PRIOR TO FABRICATION AND CONSTRUCTION
3. ALL DIMENSIONS ARE IN MILLIMETRES.
4. FOR CULVERT COVER LESS THAN 1000mm REFER TO HS2 TYPE SUPPORT IN AS/NZs 3725:2007R BEDDING AND BACKFILL DETAILS.
5. PLEASE REFER TO DRAWING 100862 AND THE T200 FOR MORE DETAILS ON TRACK AND DRAINAGE CROSS SECTIONS.



TYPICAL CROSS SECTION
SCALE 1:50

MANHOLE SUMP
INLET DETAIL
SCALE 1:50



TRENCH PROFILE DETAIL
SCALE 1:50

0 1 2 Metres

	Drawn	Signed	Date
	RS	RS	03/04/20
	Designed	Signed	Date
	CA	CA	03/04/20
	Verified	Signed	Date
	SW	SW	03/04/20
	Approved	Signed	Date
	SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client: KiwiRail

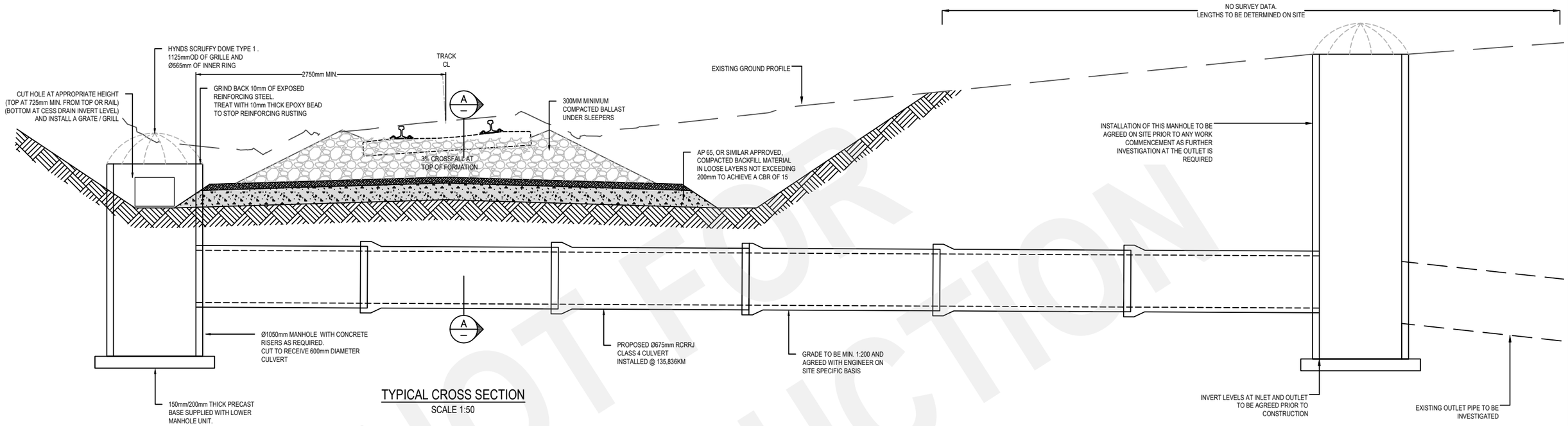
Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 07
SOUTH PORTAL
CULVERT CROSS SECTIONS
@ 135,400KM

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

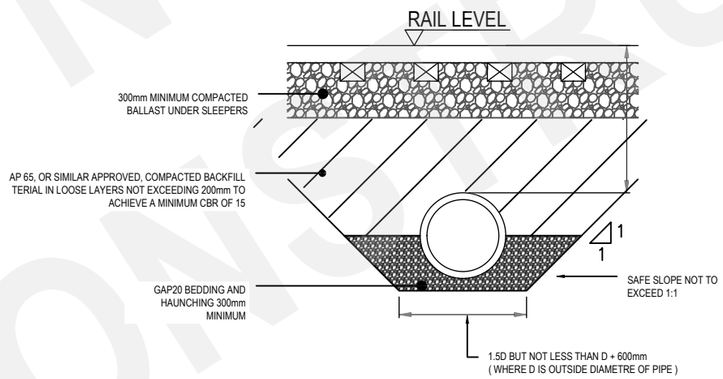
Scale	Sheet Size.				
1:50	A1				
Consultant.	Area.	Discipline.	Sheet No.	Rev.	
VT	T7	700	103	B	

NOTES:
1. DIMENSIONS SHALL NOT BE OBTAINED BY SCALING THE DRAWINGS.
2. ALL DIMENSIONS SHALL BE CHECKED ON SITE PRIOR TO FABRICATION AND CONSTRUCTION
3. ALL DIMENSIONS ARE IN MILLIMETRES.
4. FOR CULVERT COVER LESS THAN 1000mm REFER TO HS2 TYPE SUPPORT IN AS/NZs 3725:2007R BEDDING AND BACKFILL DETAILS.
5. PLEASE REFER TO DRAWING 100862 AND THE T200 FOR MORE DETAILS ON TRACK AND DRAINAGE CROSS SECTIONS.



TYPICAL CROSS SECTION
SCALE 1:50

MANHOLE SUMP
INLET DETAIL
SCALE 1:50



TRENCH PROFILE DETAIL
SCALE 1:50

0 1 2 Metres

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	03/04/20
	Designed	Signed	Date
	CA	CA	03/04/20
	Verified	Signed	Date
	SW	SW	03/04/20
	Approved	Signed	Date
	SW	SW	03/04/20

Rev.	Date	Revision Details	By	App.
B	01/05/20	100% DETAIL DESIGN	RS	SW
A	03/04/20	85% DETAIL DESIGN	RS	SW

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. NAL - TUNNEL 07
NORTH PORTAL
CULVERT CROSS SECTION
135,836KM

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	700	104	B

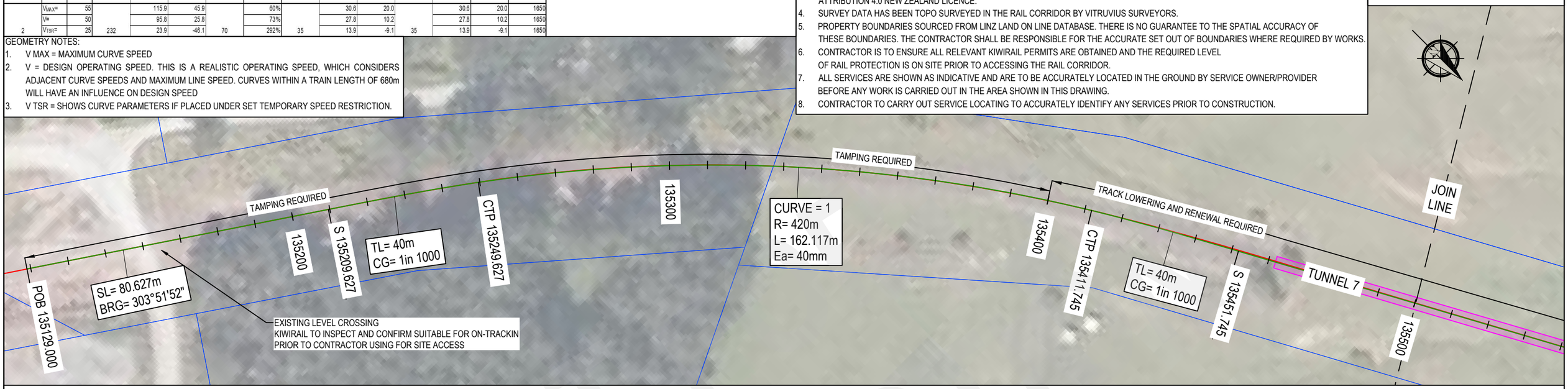
TRACK GEOMETRY DETAILS

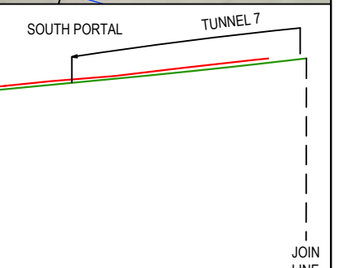
CURVE NUMBER	SPEED [km/h]		RADIUS [m]	CANT EQUILIBRIUM(Eq) [mm]	CANT DEFICIENCY (Ed) [mm]	CANT (Ea)[mm]	CANT % OF Eq	TRANSITION LENGTH [m]	RATE OF CHANGE OF CANT [mm/s]	RATE OF CHANGE OF DEFICIENCY [mm/s^2]	TRANSITION LENGTH [m]	RATE OF CHANGE OF CANT [mm/s]	RATE OF CHANGE OF DEFICIENCY [mm/s^2]	MINIMUM VERTIVAL RADIUS
	V_{MAX}=	65		89.4	49.4		45%		18.1	22.3		18.1	22.3	1650
	V=	50		52.9	12.9		76%		13.9	4.5		13.9	4.5	1650
1	V_{TSR}=	25	420	13.2	-26.8	40	302%	40	6.9	-4.6	40	6.9	-4.6	1650
	V_{MAX}=	55		115.9	45.9		60%		30.6	20.0		30.6	20.0	1650
	V=	50		95.8	25.8		73%		27.8	10.2		27.8	10.2	1650
2	V_{TSR}=	25	232	23.9	-46.1	70	292%	35	13.9	-9.1	35	13.9	-9.1	1650

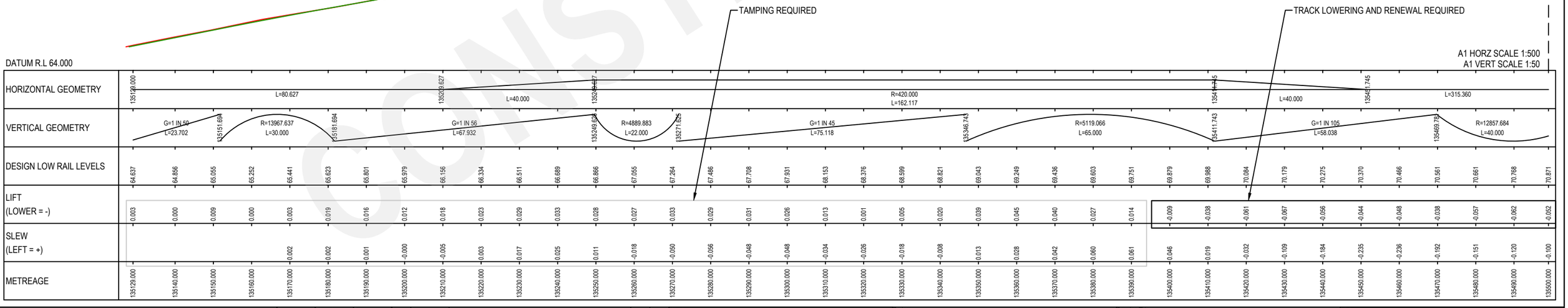
GEOMETRY NOTES:
1. V MAX = MAXIMUM CURVE SPEED
2. V = DESIGN OPERATING SPEED. THIS IS A REALISTIC OPERATING SPEED, WHICH CONSIDERS ADJACENT CURVE SPEEDS AND MAXIMUM LINE SPEED. CURVES WITHIN A TRAIN LENGTH OF 680m WILL HAVE AN INFLUENCE ON DESIGN SPEED
3. V TSR = SHOWS CURVE PARAMETERS IF PLACED UNDER SET TEMPORARY SPEED RESTRICTION.

NOTES:
1. THE SURVEY GRID AS SUPPLIED BY VITRUVIUS SURVEYORS IS:
   BEARING & COORDINATE DATUM - MT EDEN 2000
   VERTICAL DATUM - NZVD 2016
2. DESIGN KILOMETREAGES USE 135 KILOMETRE MARK AS DATUM.
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. SURVEY DATA HAS BEEN TOPO SURVEYED IN THE RAIL CORRIDOR BY VITRUVIUS SURVEYORS.
5. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
6. CONTRACTOR IS TO ENSURE ALL RELEVANT KIWIRAIL PERMITS ARE OBTAINED AND THE REQUIRED LEVEL OF RAIL PROTECTION IS ON SITE PRIOR TO ACCESSING THE RAIL CORRIDOR.
7. ALL SERVICES ARE SHOWN AS INDICATIVE AND ARE TO BE ACCURATELY LOCATED IN THE GROUND BY SERVICE OWNER/PROVIDER BEFORE ANY WORK IS CARRIED OUT IN THE AREA SHOWN IN THIS DRAWING.
8. CONTRACTOR TO CARRY OUT SERVICE LOCATING TO ACCURATELY IDENTIFY ANY SERVICES PRIOR TO CONSTRUCTION.

LEGEND
- DESIGN CENTRELINE
- EXISTING CENTRELINE
- BOUNDARY
- TUNNEL







VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
PLAN AND LONG SECTIONS
SHEET 1 OF 3

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.
1:500	A1

Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	001	D

TRACK GEOMETRY DETAILS

CURVE NUMBER	SPEED [km/h]		RADIUS [m]	CANT EQUILIBRIUM(Eq) [mm]	CANT DEFICIENCY (Ed) [mm]	CANT (Ea)[mm]	CANT % OF Eq	TRANSITION LENGTH [m]	RATE OF CHANGE OF CANT [mm/s]	RATE OF CHANGE OF DEFICIENCY [mm/s^2]	TRANSITION LENGTH [m]	RATE OF CHANGE OF CANT [mm/s]	RATE OF CHANGE OF DEFICIENCY [mm/s^2]	MINIMUM VERTIVAL RADIUS
	V_{MAX}=	65		89.4	49.4		45%		18.1	22.3		18.1	22.3	1650
	V=	50		52.9	12.9		76%		13.9	4.5		13.9	4.5	1650
1	V_{TSR}=	25	420	13.2	-26.8	40	302%	40	6.9	-4.6	40	6.9	-4.6	1650
	V_{MAX}=	55		115.9	45.9		60%		30.6	20.0		30.6	20.0	1650
	V=	50		95.8	25.8		73%		27.8	10.2		27.8	10.2	1650
2	V_{TSR}=	25	232	23.9	-46.1	70	292%	35	13.9	-9.1	35	13.9	-9.1	1650

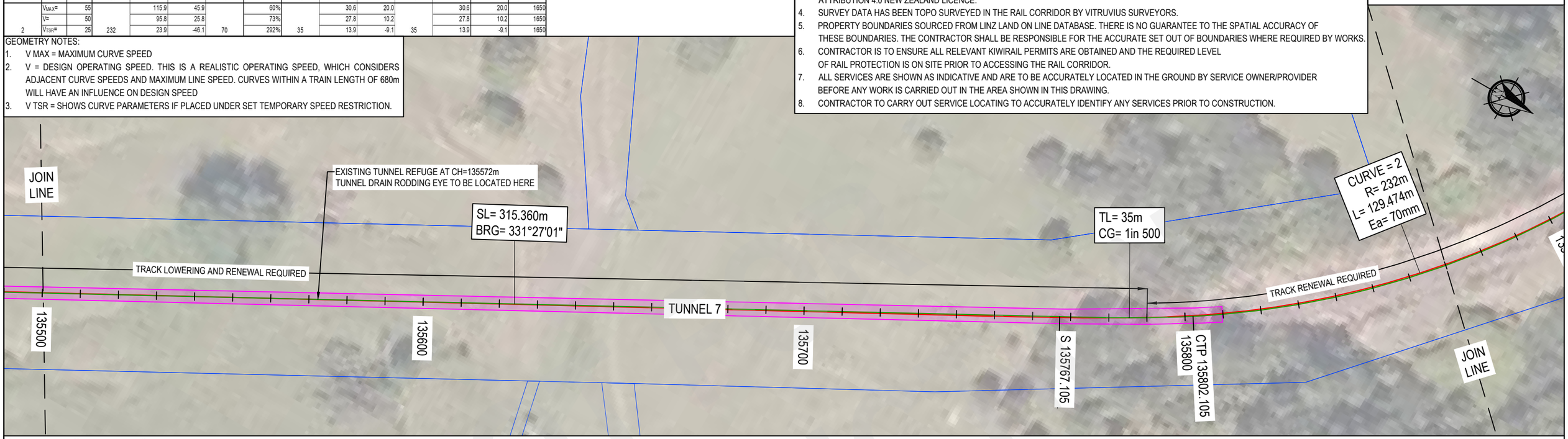
GEOMETRY NOTES:

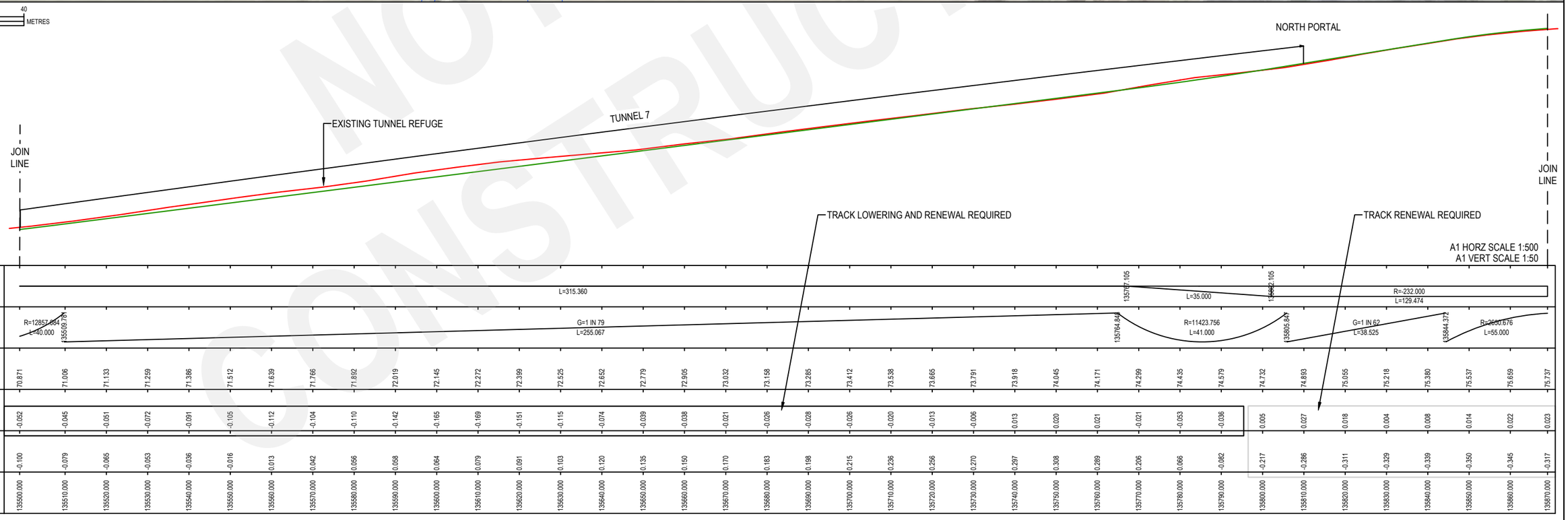
1. V MAX = MAXIMUM CURVE SPEED
2. V = DESIGN OPERATING SPEED. THIS IS A REALISTIC OPERATING SPEED, WHICH CONSIDERS ADJACENT CURVE SPEEDS AND MAXIMUM LINE SPEED. CURVES WITHIN A TRAIN LENGTH OF 680m WILL HAVE AN INFLUENCE ON DESIGN SPEED
3. V TSR = SHOWS CURVE PARAMETERS IF PLACED UNDER SET TEMPORARY SPEED RESTRICTION.

NOTES:

1. THE SURVEY GRID AS SUPPLIED BY VITRUVIUS SURVEYORS IS:
   BEARING & COORDINATE DATUM - MT EDEN 2000
   VERTICAL DATUM - NZVD 2016
2. DESIGN KILOMETREAGES USE 135 KILOMETRE MARK AS DATUM.
3. IMAGES SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE.
4. SURVEY DATA HAS BEEN TOPO SURVEYED IN THE RAIL CORRIDOR BY VITRUVIUS SURVEYORS.
5. PROPERTY BOUNDARIES SOURCED FROM LINZ LAND ON LINE DATABASE. THERE IS NO GUARANTEE TO THE SPATIAL ACCURACY OF THESE BOUNDARIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE ACCURATE SET OUT OF BOUNDARIES WHERE REQUIRED BY WORKS.
6. CONTRACTOR IS TO ENSURE ALL RELEVANT KIWIRAIL PERMITS ARE OBTAINED AND THE REQUIRED LEVEL OF RAIL PROTECTION IS ON SITE PRIOR TO ACCESSING THE RAIL CORRIDOR.
7. ALL SERVICES ARE SHOWN AS INDICATIVE AND ARE TO BE ACCURATELY LOCATED IN THE GROUND BY SERVICE OWNER/PROVIDER BEFORE ANY WORK IS CARRIED OUT IN THE AREA SHOWN IN THIS DRAWING.
8. CONTRACTOR TO CARRY OUT SERVICE LOCATING TO ACCURATELY IDENTIFY ANY SERVICES PRIOR TO CONSTRUCTION.

LEGEND
- DESIGN CENTRELINE
- EXISTING CENTRELINE
- BOUNDARY
- TUNNEL





Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

VITRUVIUS

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
PLAN AND LONG SECTIONS
SHEET 2 OF 3

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:500	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	002	D

TRACK GEOMETRY DETAILS

CURVE NUMBER	SPEED [km/h]		RADIUS [m]	CANT EQUILIBRIUM(Eq) [mm]	CANT DEFICIENCY (Ed) [mm]	CANT (Ea)[mm]	CANT % OF Eq	TRANSITION LENGTH [m]	RATE OF CHANGE OF CANT [mm/s]	RATE OF CHANGE OF DEFICIENCY [mm/s^2]	TRANSITION LENGTH [m]	RATE OF CHANGE OF CANT [mm/s]	RATE OF CHANGE OF DEFICIENCY [mm/s^2]	MINIMUM VERTIVAL RADIUS
	V_{MAX}=	65		89.4	49.4		45%		18.1	22.3		18.1	22.3	1650
	V=	50		52.9	12.9		76%		13.9	4.5		13.9	4.5	1650
1	V_{TSR}=	25	420	13.2	-26.8	40	302%	40	6.9	-4.6	40	6.9	-4.6	1650
	V_{MAX}=	55		115.9	45.9		60%		30.6	20.0		30.6	20.0	1650
	V=	50		95.8	25.8		73%		27.8	10.2		27.8	10.2	1650
2	V_{TSR}=	25	232	23.9	-46.1	70	292%	35	13.9	-9.1	35	13.9	-9.1	1650

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3. V TSR = SHOWS CURVE PARAMETERS IF PLACED UNDER SET TEMPORARY SPEED RESTRICTION.

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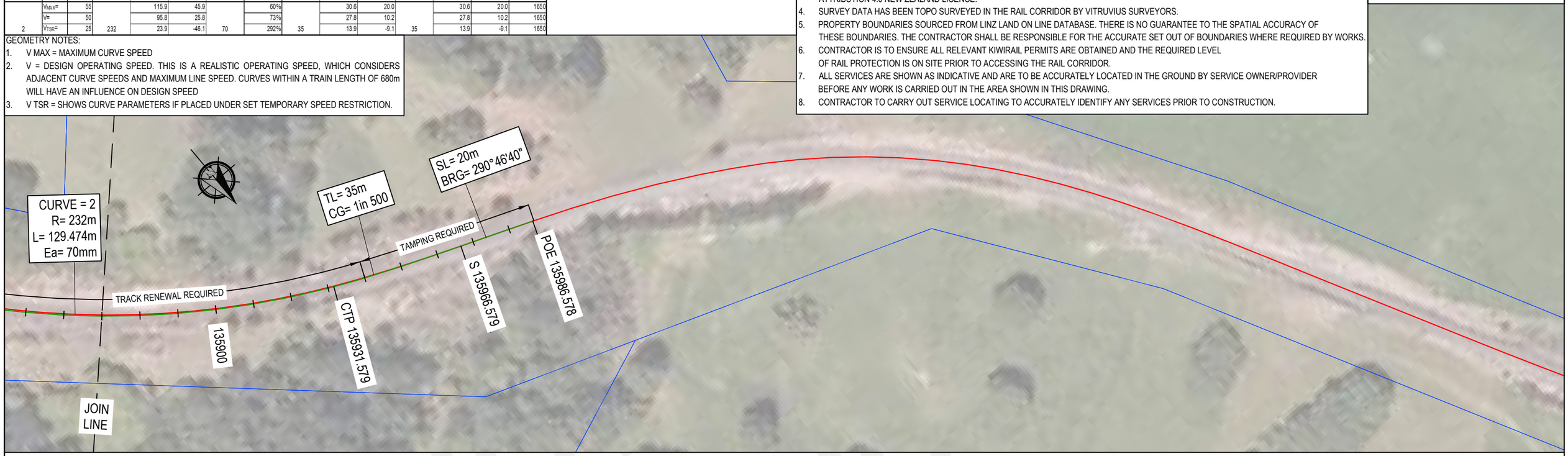
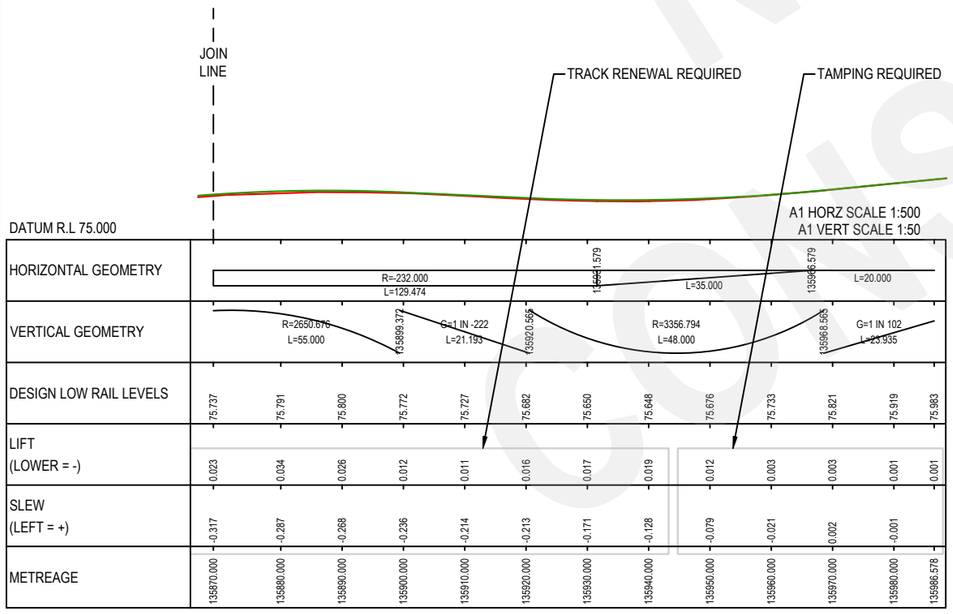
LEGEND
- DESIGN CENTRELINE
- EXISTING CENTRELINE
- BOUNDARY
- TUNNEL



0 20 40 METRES



Rev.	Date	Revision Details	By	App.
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C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Drawn	Signed	Date
RS	RS	13/02/20
Designed	Signed	Date
BH	BH	25/02/20
Verified	Signed	Date
NM	NM	14/02/20
Approved	Signed	Date
DB	DB	25/02/20

VITRUVIUS

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

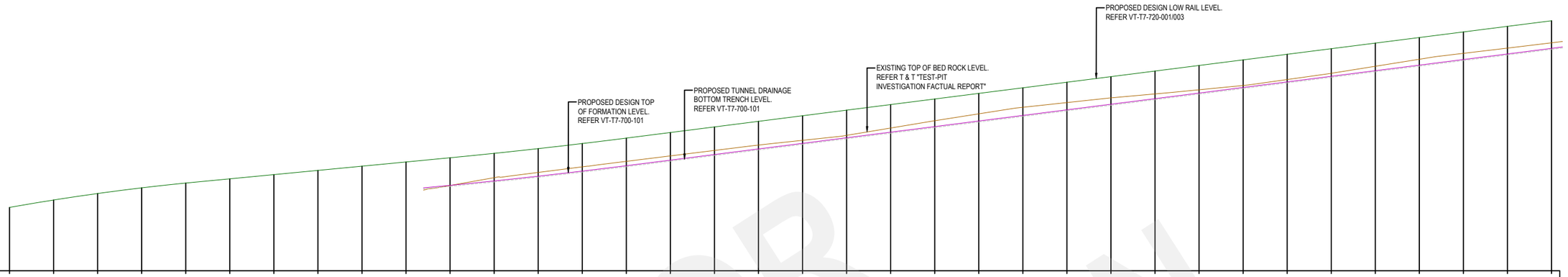
Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
PLAN AND LONG SECTIONS
SHEET 3 OF 3

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:500	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	003	D

LEGEND

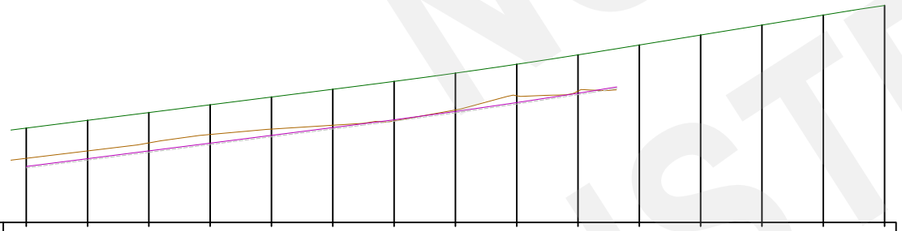
PROPOSED DESIGN LOW RAIL LEVEL
EXISTING TOP OF BED ROCK LEVEL
PROPOSED DESIGN TOP OF FORMATION LEVEL
PROPOSED TUNNEL DRAINAGE BOTTOM TRENCH LEVEL



DATUM R.L 68.000

METREAGE	DESIGN LOW RAIL LEVELS	DESIGN TOP OF FORMATION	TOP OF BEDROCK	DEPTH = DESIGN LOW RAIL TO TOP OF BEDROCK
135370.000	69.436			
135380.000	69.603			
135390.000	69.751			
135400.000	69.879			
135410.000	69.988			
135420.000	70.084			
135430.000	70.179			
135440.000	70.275			
135450.000	70.370			
135460.000	70.466			
135470.000	70.561	69.936	69.933	-0.628
135480.000	70.661	70.036	70.110	-0.550
135490.000	70.768	70.143	70.229	-0.539
135500.000	70.883	70.258	70.355	-0.528
135510.000	71.006	70.381	70.480	-0.526
135520.000	71.133	70.508	70.603	-0.529
135530.000	71.259	70.634	70.726	-0.533
135540.000	71.386	70.761	70.848	-0.538
135550.000	71.512	70.887	70.956	-0.557
135560.000	71.639	71.014	71.068	-0.571
135570.000	71.766	71.141	71.234	-0.532
135580.000	71.892	71.267	71.399	-0.493
135590.000	72.019	71.394	71.556	-0.463
135600.000	72.145	71.520	71.704	-0.441
135610.000	72.272	71.647	71.811	-0.461
135620.000	72.399	71.774	71.918	-0.481
135630.000	72.525	71.900	72.007	-0.519
135640.000	72.652	72.027	72.101	-0.551
135650.000	72.779	72.154	72.199	-0.580
135660.000	72.905	72.280	72.333	-0.572
135670.000	73.032	72.407	72.474	-0.557
135680.000	73.158	72.533	72.634	-0.525
135690.000	73.285	72.660	72.793	-0.492
135700.000	73.412	72.787	72.927	-0.485
135710.000	73.538	72.913	73.045	-0.493
135720.000	73.665	73.040	73.165	-0.499

LONGITUDINAL SECTION
A1 HORZ SCALE 1:500
A1 VERT SCALE 1:50



DATUM R.L 72.000

METREAGE	DESIGN LOW RAIL LEVELS	DESIGN TOP OF FORMATION	TOP OF BEDROCK	DEPTH = DESIGN LOW RAIL TO TOP OF BEDROCK
135710.000	73.538	72.913	73.045	-0.493
135720.000	73.665	73.040	73.165	-0.499
135730.000	73.791	73.166	73.296	-0.495
135740.000	73.918	73.293	73.434	-0.484
135750.000	74.045	73.420	73.522	-0.523
135760.000	74.171	73.546	73.584	-0.587
135770.000	74.299	73.674	73.655	-0.644
135780.000	74.435	73.810	73.833	-0.601
135790.000	74.579	73.954	74.066	-0.513
135800.000	74.732	74.107	74.142	-0.590
135810.000	74.893			
135820.000	75.055			
135830.000	75.218			
135840.000	75.380			
135850.000	75.537			

LONGITUDINAL SECTION
A1 HORZ SCALE 1:500
A1 VERT SCALE 1:50

VITRUVIUS

	Drawn	Signed	Date
	DM	DM	01/05/20
	Designed	Signed	Date
	CA	CA	01/05/20
	Verified	Signed	Date
	SW	SW	01/05/20
	Approved	Signed	Date
	SW	SW	01/05/20

Rev.	Date	Revision Details	By	App.
A	01/05/20	100% DETAIL DESIGN	DM	SW

Client: KiwiRail

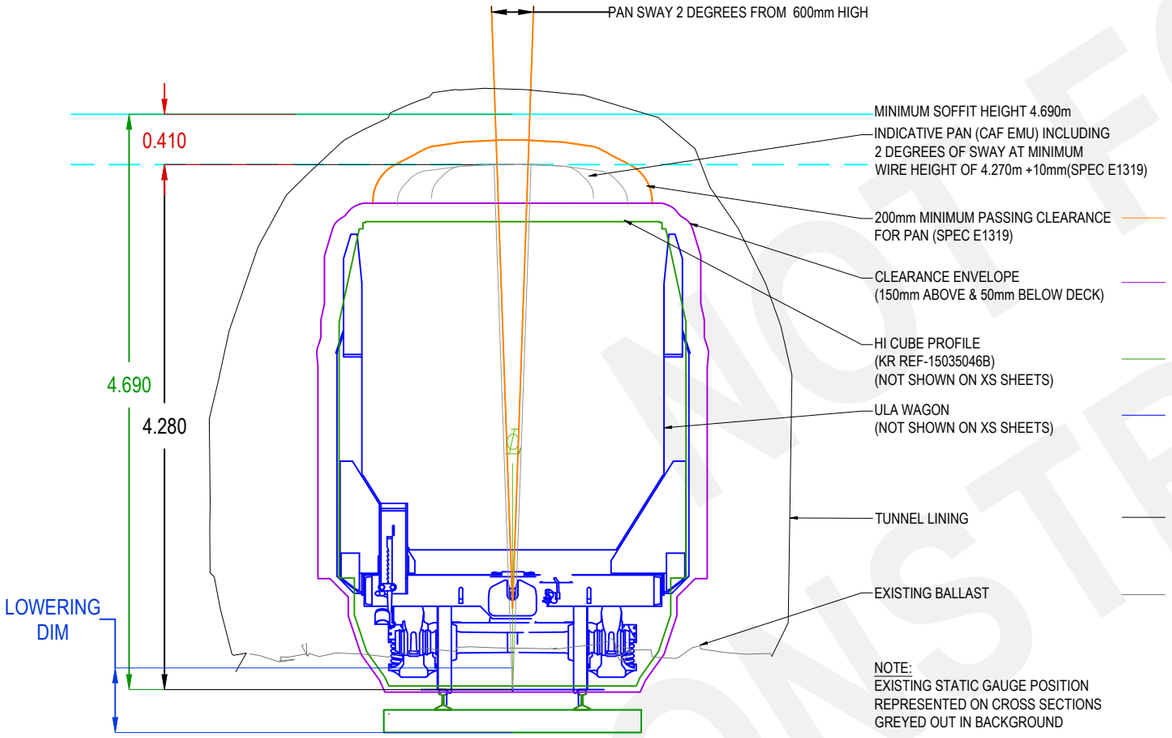
Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
INTERNAL DRAINAGE DESIGN
LONGSECTION

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

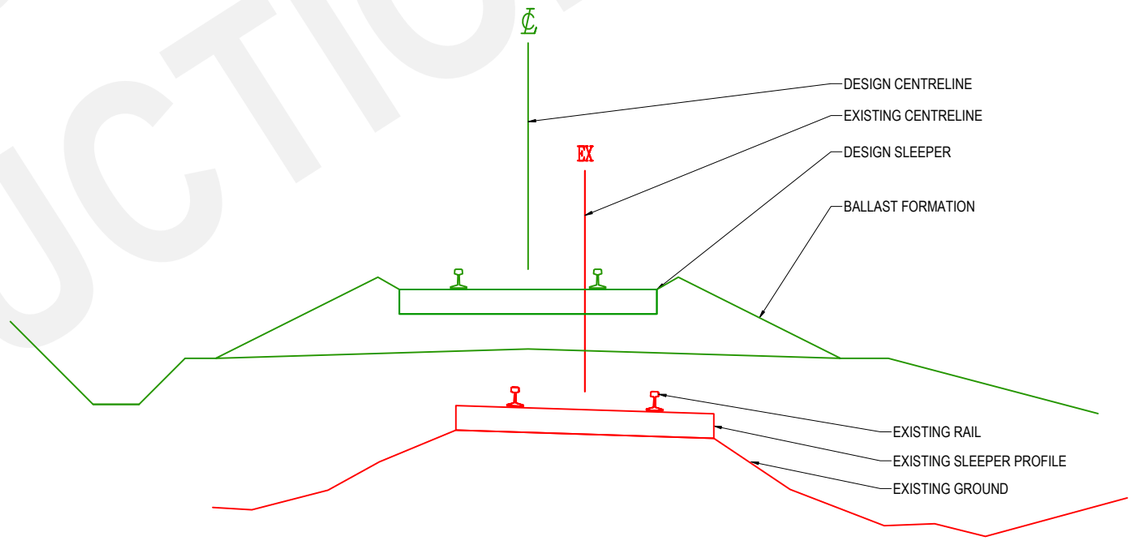
Scale	Sheet Size.			
1:500	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	010	A

TUNNEL CROSS SECTION LEGEND



NOTE:
EXISTING STATIC GAUGE POSITION REPRESENTED ON CROSS SECTIONS GREYED OUT IN BACKGROUND

OPEN AIR CROSS SECTION LEGEND



VITRUVIUS

	Signed	Date
Drawn: RS	RS	13/02/20
Designed: BH	BH	25/02/20
Verified: NM	NM	14/02/20
Approved: DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
LEGEND AND NOTES
CROSS SECTIONS
SHEET 1 OF 16

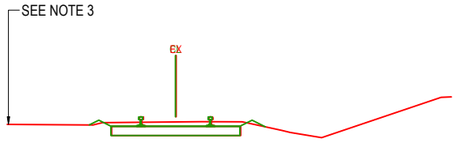
Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.
1:25	A1

Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	100	D

NOTES:

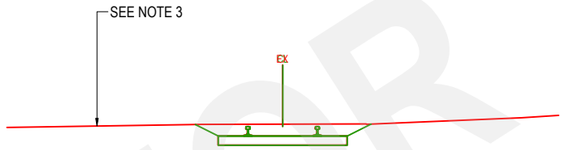
1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
3. FOR TRACK REALIGNMENT BY TAMPING CONTRACTOR TO CONFIRM EXISTING SLEEPERS, FASTENING AND RAIL ARE CAPABLE OF WITHSTANDING TAMPING FORCES. TAMPING TO PROVIDE COMPLIANT BALLAST SHOULDERS AS PER KIWIRAIL STANDARDS
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.63.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.64.856	RL.64.856	RL.64.856
EXIST CL OFFSETS		OS 0.012 RL.64.856	

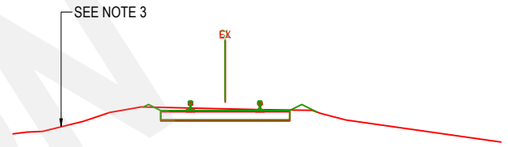
METREAGE 135140



DATUM RL.63.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.65.252	RL.65.252	RL.65.252
EXIST CL OFFSETS		OS -0.004 RL.65.254	

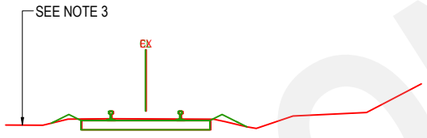
METREAGE 135160



DATUM RL.64.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.65.623	RL.65.623	RL.65.623
EXIST CL OFFSETS		OS 0.002 RL.65.625	

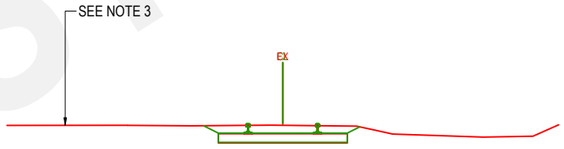
METREAGE 135180



DATUM RL.63.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.64.657	RL.64.657	RL.64.657
EXIST CL OFFSETS		OS 0.013 RL.64.656	

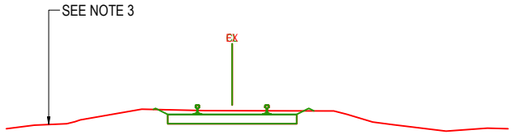
METREAGE 135130



DATUM RL.63.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.65.055	RL.65.055	RL.65.055
EXIST CL OFFSETS		OS 0.001 RL.65.046	

METREAGE 135150



DATUM RL.63.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.65.441	RL.65.441	RL.65.441
EXIST CL OFFSETS		OS 0.002 RL.65.438	

METREAGE 135170

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

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C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 2 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	101	D

NOTES:

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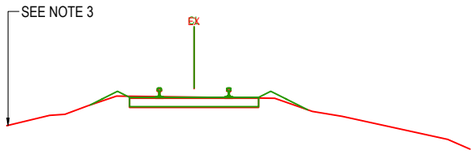
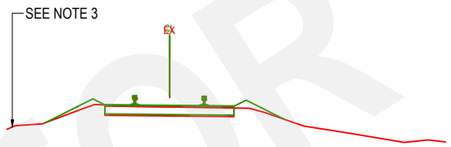


DATUM RL.64.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.65.979	RL.65.979	RL.65.979
EXIST CL OFFSETS		OS -0.000 RL.65.966	

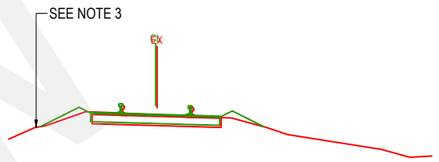
METREAGE 135200



DATUM RL.64.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.66.344	RL.66.334	RL.66.334
EXIST CL OFFSETS		OS 0.003 RL.66.311	

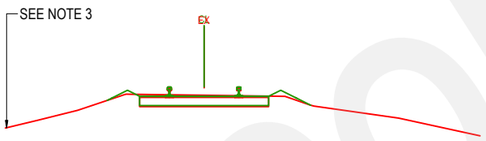
METREAGE 135220



DATUM RL.65.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.66.719	RL.66.689	RL.66.689
EXIST CL OFFSETS		OS 0.025 RL.66.655	

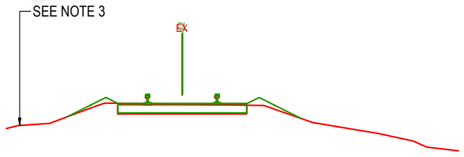
METREAGE 135240



DATUM RL.64.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.65.801	RL.65.801	RL.65.801
EXIST CL OFFSETS		OS 0.001 RL.65.785	

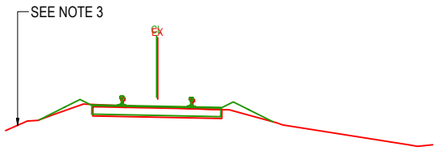
METREAGE 135190



DATUM RL.64.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.66.156	RL.66.156	RL.66.156
EXIST CL OFFSETS		OS -0.005 RL.66.138	

METREAGE 135210



DATUM RL.64.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.66.531	RL.66.511	RL.66.511
EXIST CL OFFSETS		OS 0.017 RL.66.482	

METREAGE 135230

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

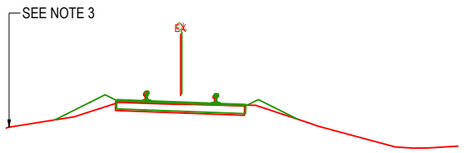
Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 3 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	102	D

NOTES:

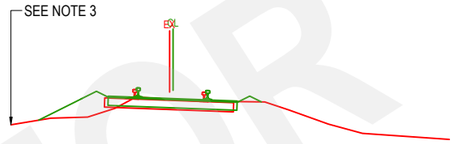
1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
3. FOR TRACK REALIGNMENT BY TAMPING CONTRACTOR TO CONFIRM EXISTING SLEEPERS, FASTENING AND RAIL ARE CAPABLE OF WITHSTANDING TAMPING FORCES. TAMPING TO PROVIDE COMPLIANT BALLAST SHOULDERS AS PER KIWIRAIL STANDARDS
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.65.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.67.095	RL.67.055	RL.67.055
EXIST CL OFFSETS		OS -0.018 RL.67.027	

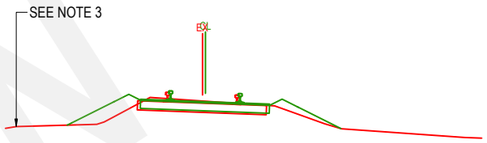
METREAGE 135260



DATUM RL.65.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.67.526	RL.67.486	RL.67.486
EXIST CL OFFSETS		OS -0.056 RL.67.456	

METREAGE 135280



DATUM RL.66.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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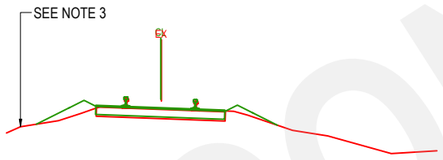
EXIST CL OFFSETS		OS -0.048 RL.67.905	

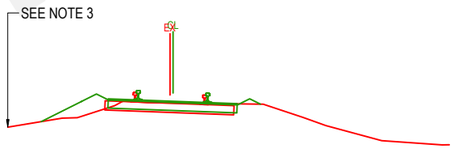
METREAGE 135300



DATUM RL.65.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.66.906	RL.66.866	RL.66.866
EXIST CL OFFSETS		OS -0.011 RL.66.838	

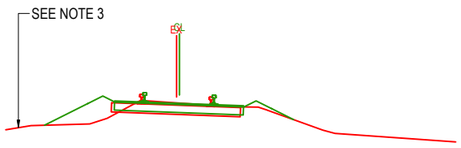
METREAGE 135250



DATUM RL.65.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.67.304	RL.67.264	RL.67.264
EXIST CL OFFSETS		OS -0.050 RL.67.231	

METREAGE 135270



DATUM RL.66.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.67.748	RL.67.708	RL.67.708
EXIST CL OFFSETS		OS -0.048 RL.67.677	

METREAGE 135290

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

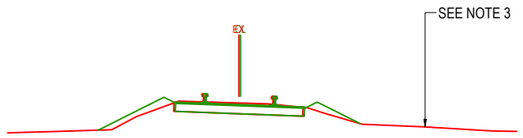
Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 4 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	103	D

NOTES:

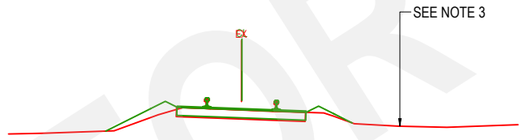
1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
3. FOR TRACK REALIGNMENT BY TAMPING CONTRACTOR TO CONFIRM EXISTING SLEEPERS, FASTENING AND RAIL ARE CAPABLE OF WITHSTANDING TAMPING FORCES. TAMPING TO PROVIDE COMPLIANT BALLAST SHOULDERS AS PER KIWIRAIL STANDARDS
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.66.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.68.416	RL.68.376	RL.68.376
EXIST CL OFFSETS		OS -0.026 RL.68.375	

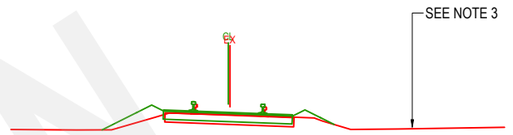
METREAGE 135320



DATUM RL.67.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.68.861	RL.68.821	RL.68.821
EXIST CL OFFSETS		OS -0.008 RL.68.801	

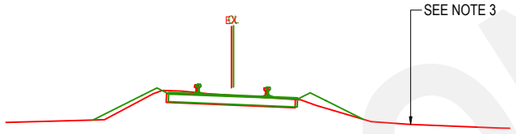
METREAGE 135340



DATUM RL.67.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.69.289	RL.69.249	RL.69.249
EXIST CL OFFSETS		OS 0.028 RL.69.204	

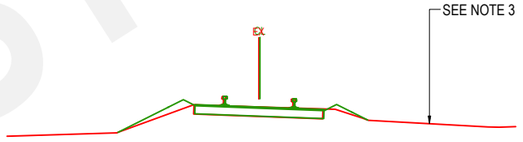
METREAGE 135360



DATUM RL.66.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.68.193	RL.68.153	RL.68.153
EXIST CL OFFSETS		OS -0.034 RL.68.140	

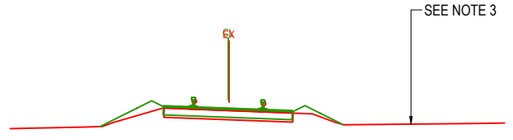
METREAGE 135310



DATUM RL.66.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.68.639	RL.68.599	RL.68.599
EXIST CL OFFSETS		OS -0.018 RL.68.594	

METREAGE 135330



DATUM RL.67.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.69.083	RL.69.043	RL.69.043
EXIST CL OFFSETS		OS 0.013 RL.69.003	

METREAGE 135350

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 5 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	104	D

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
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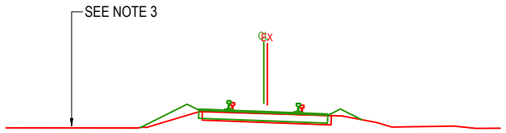
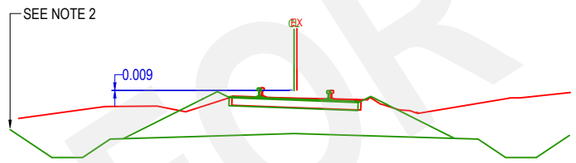
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.67.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.69.643	RL.69.603	RL.69.603
EXIST CL OFFSETS		OS 0.060 RL.69.576	

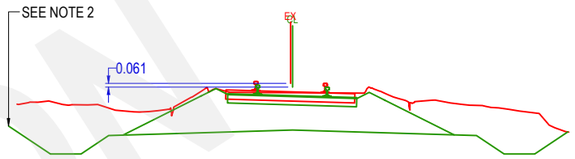
METREAGE 135380



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.69.919	RL.69.879	RL.69.879
EXIST CL OFFSETS		OS 0.046 RL.69.888	

METREAGE 135400



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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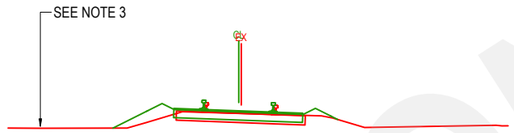
EXIST CL OFFSETS		OS -0.032 RL.70.145	

METREAGE 135420



DATUM RL.67.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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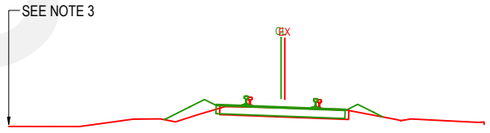
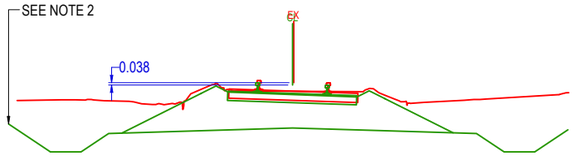
METREAGE 135370



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.69.791	RL.69.751	RL.69.751
EXIST CL OFFSETS		OS 0.061 RL.69.736	

METREAGE 135390



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.70.028	RL.69.988	RL.69.988
EXIST CL OFFSETS		OS 0.019 RL.70.026	

METREAGE 135410

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 6 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.
1:50	A1

Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	105	D

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
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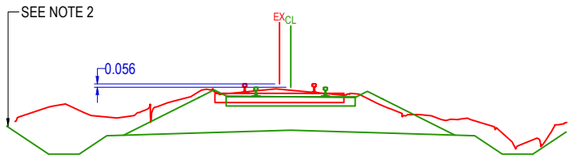
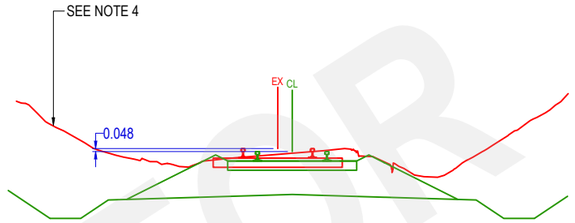
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.70.286	RL.70.275	RL.70.275
EXIST CL OFFSETS	OS -0.184 RL.70.330		

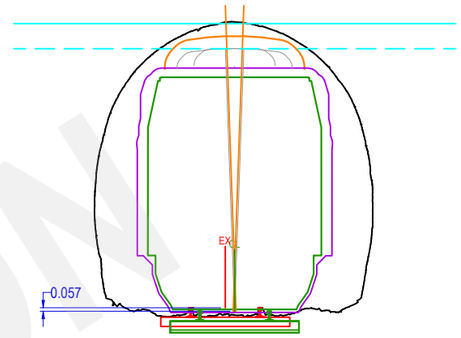
METREAGE 135440



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.70.466	RL.70.466	RL.70.466
EXIST CL OFFSETS	OS -0.236 RL.70.514		

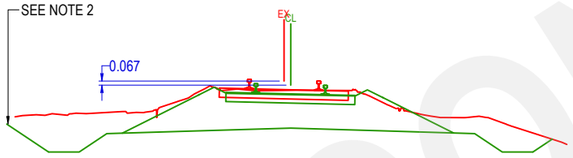
METREAGE 135460



DATUM RL.70.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.70.661	RL.70.661	RL.70.661
EXIST CL OFFSETS	OS -0.151 RL.70.718		

METREAGE 135480



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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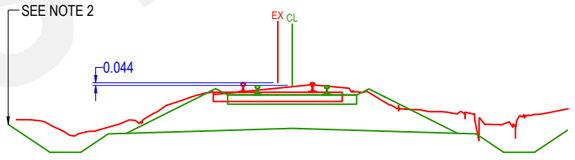
METREAGE 135430



DATUM RL.68.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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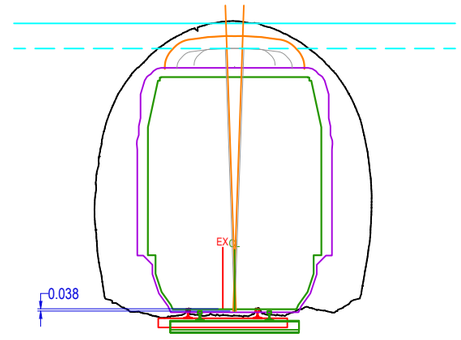
EXIST CL OFFSETS	OS -0.235 RL.70.414		

METREAGE 135450



DATUM RL.69.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.70.561	RL.70.561	RL.70.561
EXIST CL OFFSETS	OS -0.192 RL.70.599		

METREAGE 135470

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 7 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.				
1:50	A1				
Consultant.	Area.	Discipline.	Sheet No.	Rev.	
VT	T7	720	106	D	

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
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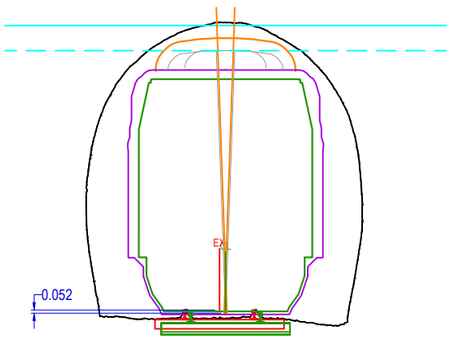
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.70.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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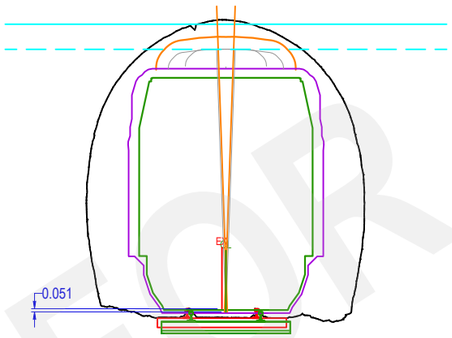
EXIST CL OFFSETS	OS -0.088 RL.70.933		

METREAGE 135500



DATUM RL.70.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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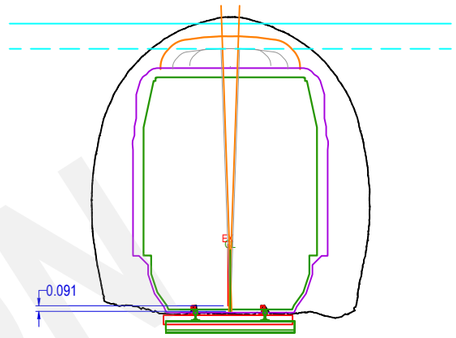
EXIST CL OFFSETS	OS -0.065 RL.71.184		

METREAGE 135520



DATUM RL.70.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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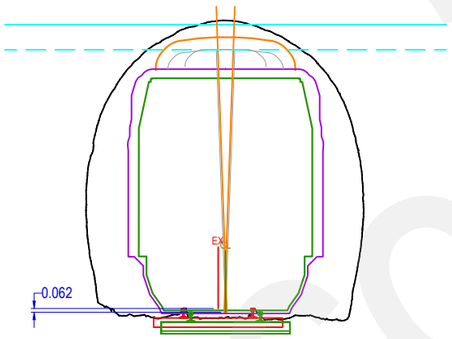
EXIST CL OFFSETS	OS -0.095 RL.71.477		

METREAGE 135540



DATUM RL.70.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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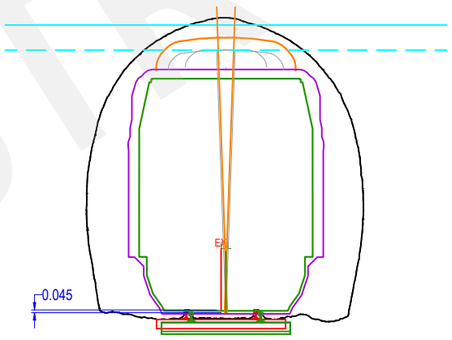
EXIST CL OFFSETS	OS -0.120 RL.70.830		

METREAGE 135490



DATUM RL.70.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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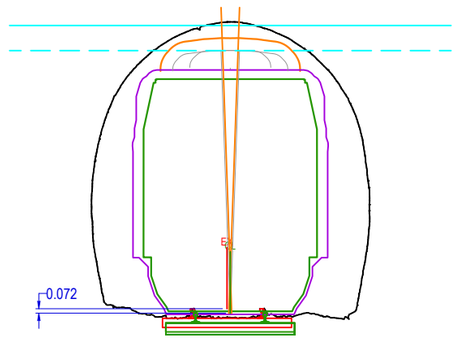
EXIST CL OFFSETS	OS -0.079 RL.71.060		

METREAGE 135510



DATUM RL.70.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
DESIGN LEVELS	RL.71.259	RL.71.259	RL.71.259
EXIST CL OFFSETS	OS -0.053 RL.71.331		

METREAGE 135530

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client. KiwiRail

Project. NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title. NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 8 OF 16

Status. 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	107	D

NOTES:

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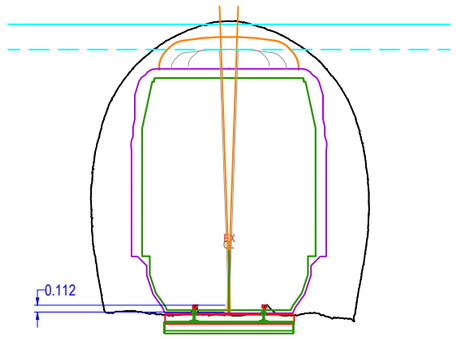

DATUM RL.70.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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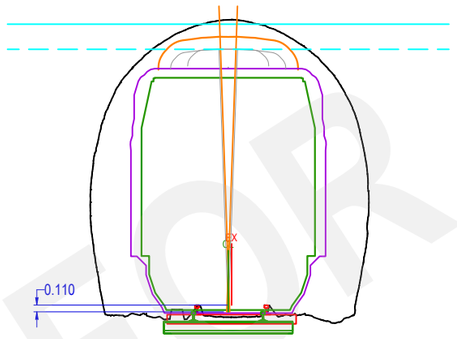
EXIST CL OFFSETS		OS -0.013 RL.71.751	

METREAGE 135560



DATUM RL.71.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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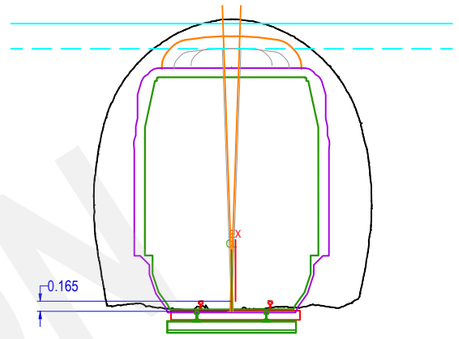
EXIST CL OFFSETS		OS 0.055 RL.72.052	

METREAGE 135580



DATUM RL.71.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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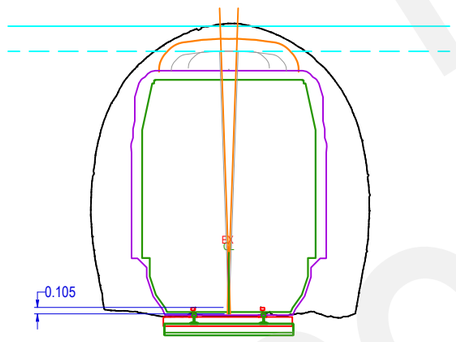
METREAGE 135600



DATUM RL.70.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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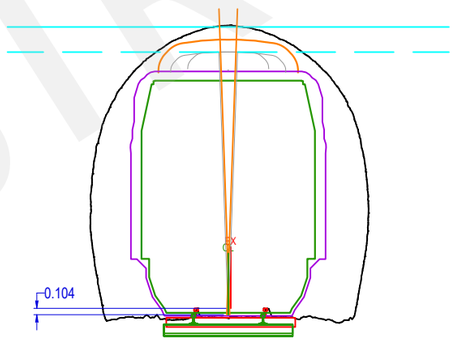
EXIST CL OFFSETS		OS -0.016 RL.71.617	

METREAGE 135550



DATUM RL.71.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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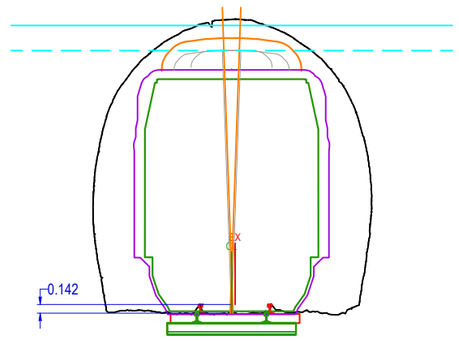
METREAGE 135570



DATUM RL.71.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.72.019	RL.72.019	RL.72.019
EXIST CL OFFSETS		OS 0.058 RL.72.161	

METREAGE 135590

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 9 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	108	D

NOTES:

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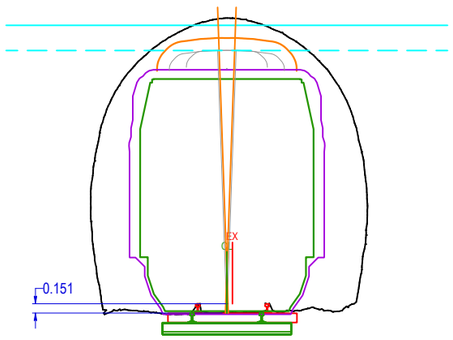

DATUM RL.71.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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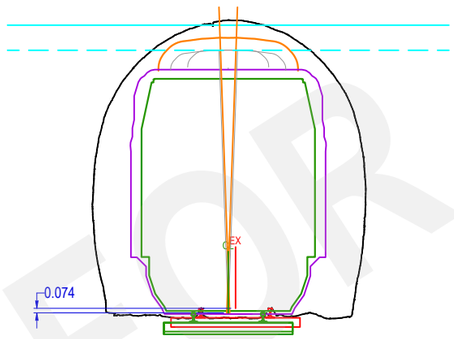
EXIST CL OFFSETS		OS 0.091 RL.72.550	

METREAGE 135620



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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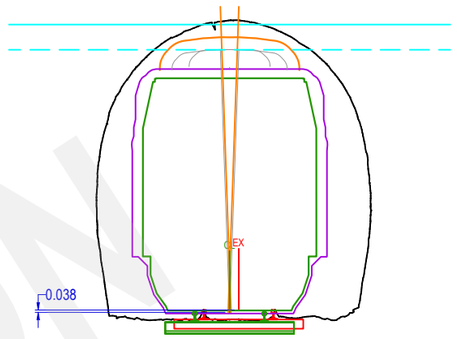
EXIST CL OFFSETS		OS 0.120 RL.72.726	

METREAGE 135640



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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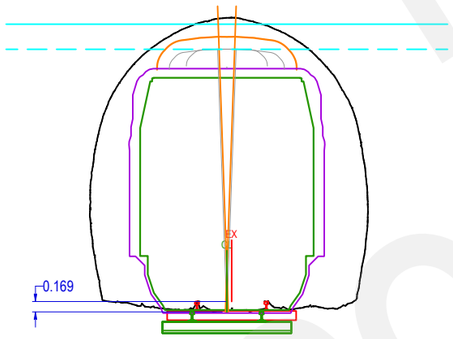
EXIST CL OFFSETS		OS 0.150 RL.72.943	

METREAGE 135660



DATUM RL.71.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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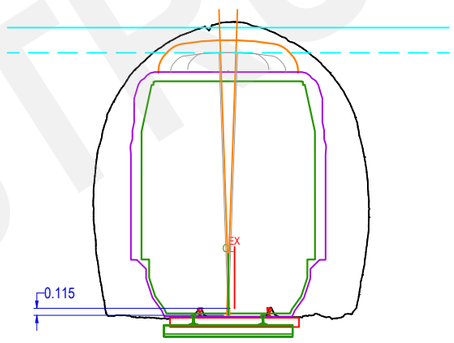
EXIST CL OFFSETS		OS 0.079 RL.72.441	

METREAGE 135610



DATUM RL.71.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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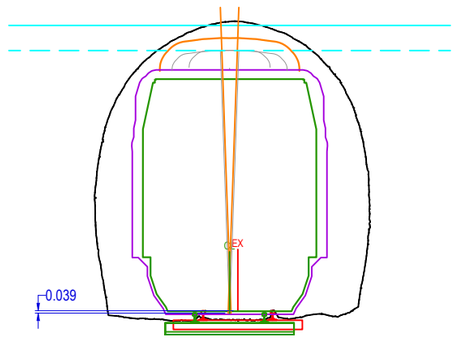
EXIST CL OFFSETS		OS 0.103 RL.72.640	

METREAGE 135630



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
DESIGN LEVELS	RL.72.779	RL.72.779	RL.72.779
EXIST CL OFFSETS		OS 0.135 RL.72.816	

METREAGE 135650

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 10 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	109	D

NOTES:

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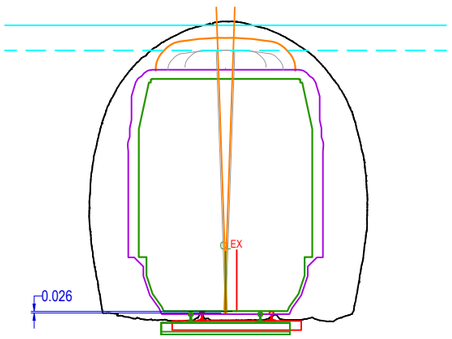

DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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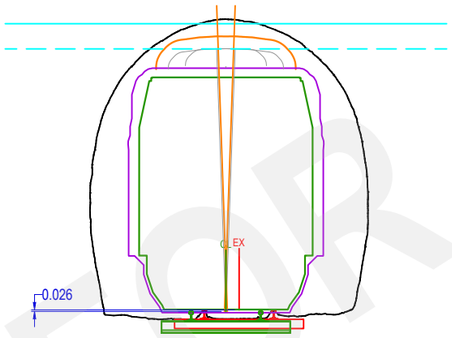
EXIST CL OFFSETS		OS 0.183 RL.73.184	

METREAGE 135680



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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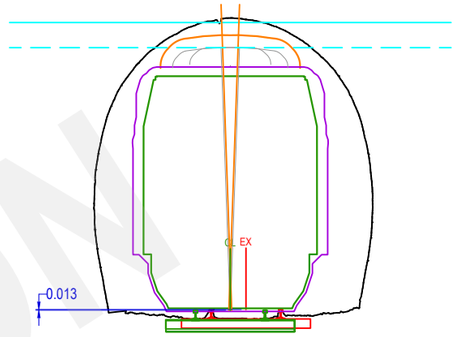
EXIST CL OFFSETS		OS 0.215 RL.73.438	

METREAGE 135700



DATUM RL.73.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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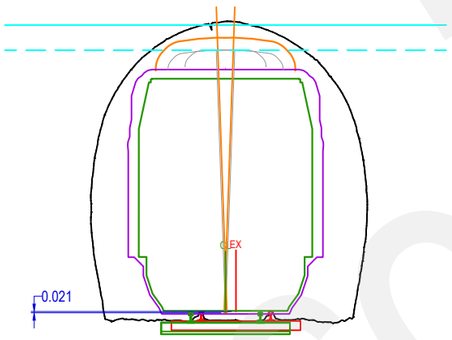
EXIST CL OFFSETS		OS 0.256 RL.73.678	

METREAGE 135720



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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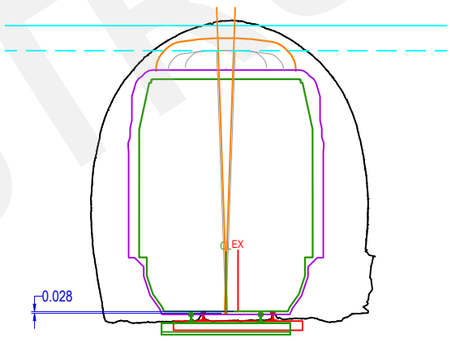
EXIST CL OFFSETS		OS 0.170 RL.73.053	

METREAGE 135670



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
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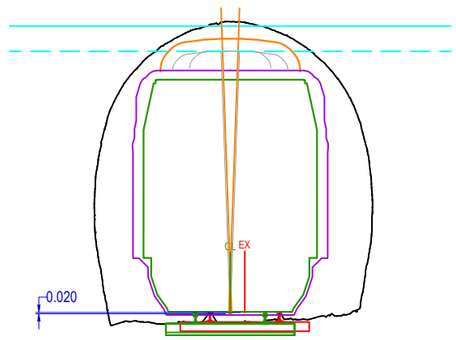
EXIST CL OFFSETS		OS 0.198 RL.73.313	

METREAGE 135690



DATUM RL.72.000

	RAIL LEFT	CL	RAIL RIGHT
DESIGN FEATURES			
DESIGN LEVELS	RL.73.538	RL.73.538	RL.73.538
EXIST CL OFFSETS		OS 0.236 RL.73.598	

METREAGE 135710

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 11 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	110	D

NOTES:

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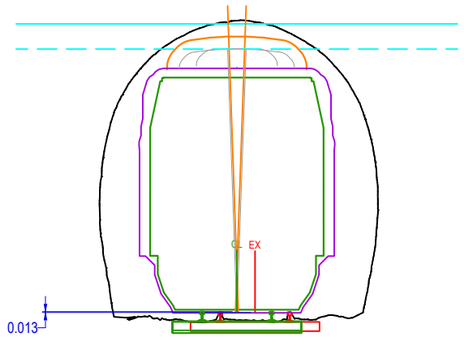
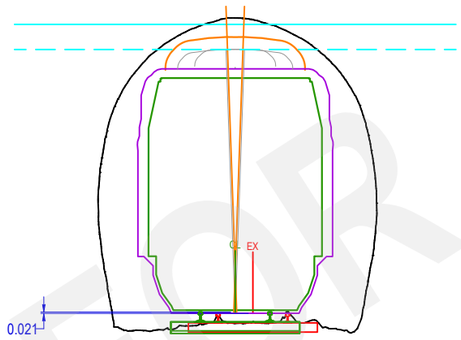


DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.73.918	RL.73.918	RL.73.918
EXIST CL OFFSETS		OS 0.297 RL.73.905	

METREAGE 135740



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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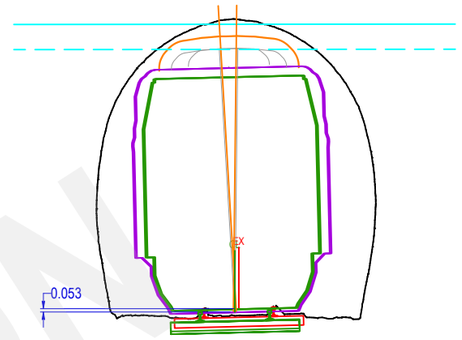
EXIST CL OFFSETS		OS 0.289 RL.74.151	

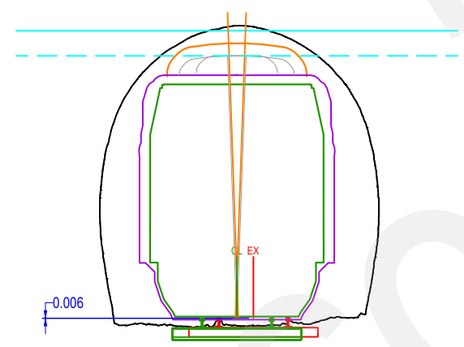
METREAGE 135760



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.74.435	RL.74.435	RL.74.460
EXIST CL OFFSETS		OS 0.066 RL.74.488	

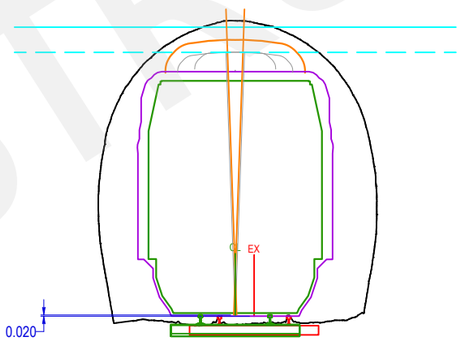
METREAGE 135780



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.73.791	RL.73.791	RL.73.791
EXIST CL OFFSETS		OS 0.270 RL.73.797	

METREAGE 135730



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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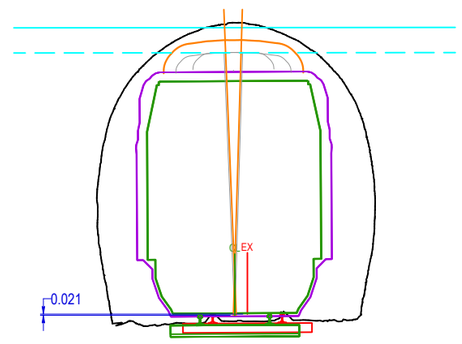
EXIST CL OFFSETS		OS 0.308 RL.74.024	

METREAGE 135750



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.74.299	RL.74.299	RL.74.305
EXIST CL OFFSETS		OS 0.206 RL.74.320	

METREAGE 135770

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

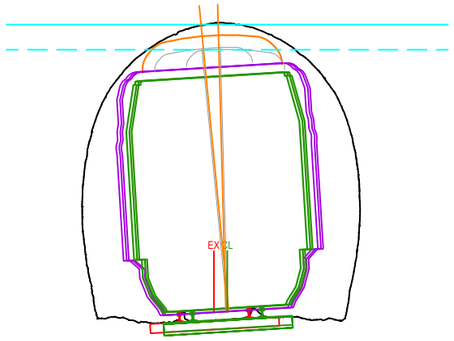
Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 12 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	111	D

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
3. FOR TRACK REALIGNMENT BY TAMPING CONTRACTOR TO CONFIRM EXISTING SLEEPERS, FASTENING AND RAIL ARE CAPABLE OF WITHSTANDING TAMPING FORCES. TAMPING TO PROVIDE COMPLIANT BALLAST SHOULDERS AS PER KIWIRAIL STANDARDS
4. CONTRACTOR TO NOTIFY ENGINEER PRIOR ANY EXCAVATIONS AT PORTAL AREA. GEOTECHNICAL STABILITY ASSESSMENT REQUIRED TO INFORM EAERTHWORK AND DRAINAGE REQUIREMENTS



DATUM RL.74.000

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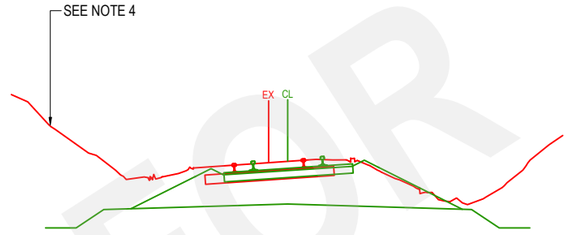
EXIST CL OFFSETS	OS -0.217 RL.74.727		

METREAGE 135800



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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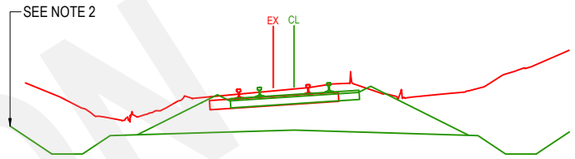
EXIST CL OFFSETS	OS -0.311 RL.75.038		

METREAGE 135820



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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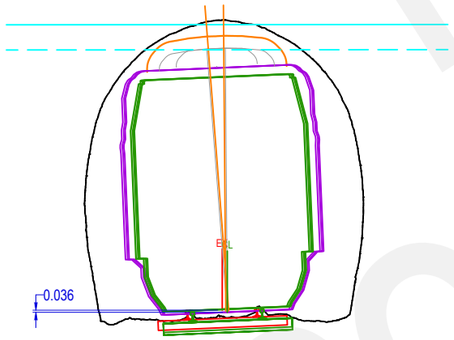
METREAGE 135840



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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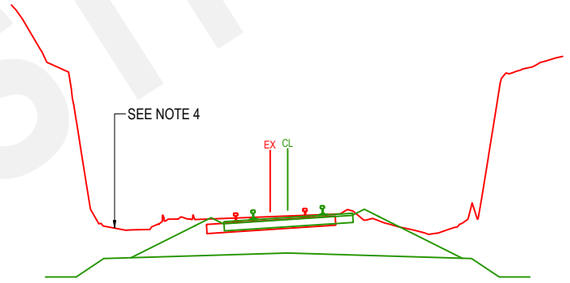
METREAGE 135790



DATUM RL.73.000

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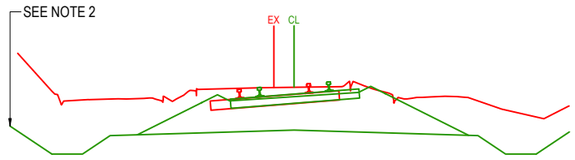
EXIST CL OFFSETS	OS -0.286 RL.74.866		

METREAGE 135810



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.75.218	RL.75.218	RL.75.288
EXIST CL OFFSETS	OS -0.323 RL.75.213		

METREAGE 135830

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 13 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.			
1:50	A1			
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	112	D

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
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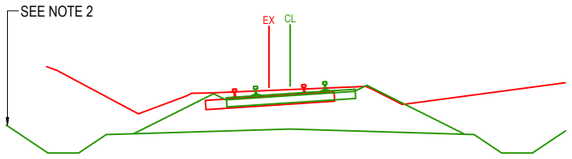

DATUM RL.74.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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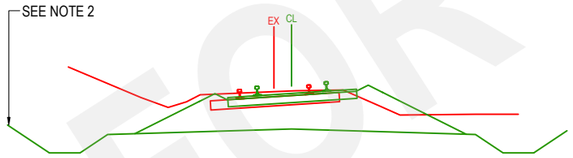
EXIST CL OFFSETS	OS.-0.345 RL.75.637		

METREAGE 135860



DATUM RL.74.000

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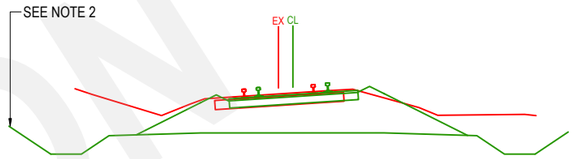
EXIST CL OFFSETS	OS.-0.287 RL.75.757		

METREAGE 135880



DATUM RL.74.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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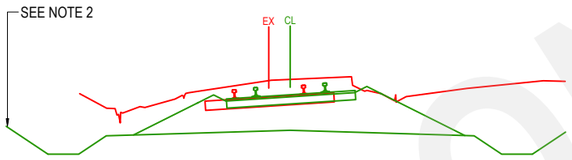
EXIST CL OFFSETS	OS.-0.236 RL.75.760		

METREAGE 135900



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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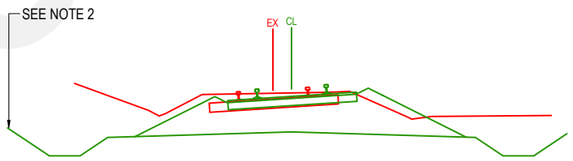
EXIST CL OFFSETS	OS.-0.350 RL.75.523		

METREAGE 135850



DATUM RL.74.000

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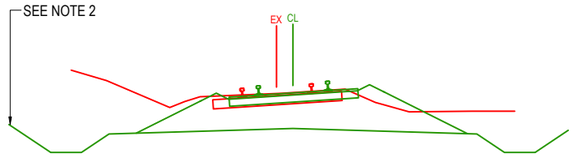
METREAGE 135870



DATUM RL.74.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.75.800	RL.75.800	RL.75.870
EXIST CL OFFSETS	OS.-0.268 RL.75.775		

METREAGE 135890

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 14 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.				
1:50	A1				
Consultant.	Area.	Discipline.	Sheet No.	Rev.	
VT	T7	720	113	D	

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
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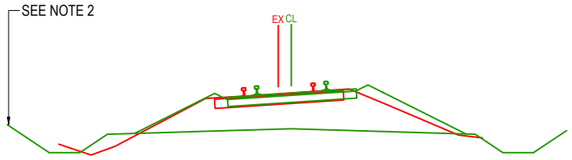

DATUM RL.74.000

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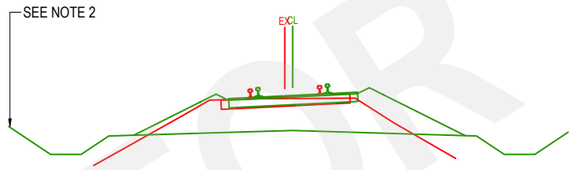
METREAGE 135920



DATUM RL.73.000

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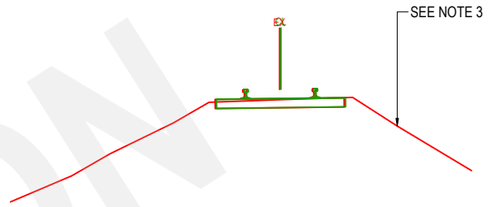
METREAGE 135940



DATUM RL.73.000

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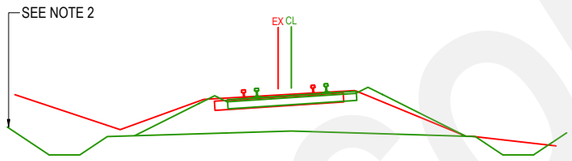
METREAGE 135960



DATUM RL.74.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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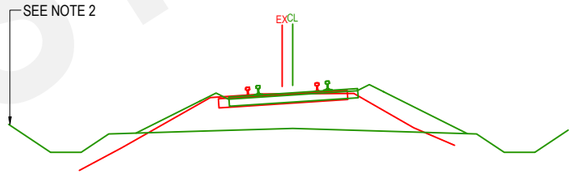
EXIST CL OFFSETS	OS -0.214 RL.75.716		

METREAGE 135910



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
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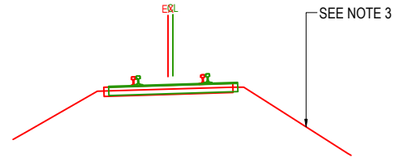
METREAGE 135930



DATUM RL.73.000

DESIGN FEATURES	RAIL LEFT	CL	RAIL RIGHT
DESIGN LEVELS	RL.75.676	RL.75.676	RL.75.709
EXIST CL OFFSETS	OS -0.073 RL.75.663		

METREAGE 135950

VITRUVIUS

	Signed	Date
Drawn: RS	RS	13/02/20
Designed: BH	BH	25/02/20
Verified: NM	NM	14/02/20
Approved: DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 15 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.				
1:50	A1				
Consultant.	Area.	Discipline.	Sheet No:	Rev.
VT	T7	720	114	D

NOTES:

1. FOR LEGEND AND NOTES PLEASE REFER TO DRAWING V-T7-720-100-D
2. INSUFFICIENT SURVEY DATA TO CONFIRM TIE IN WITH EXISTING GROUND. CONTRACTOR TO ADVISE ENGINEER PRIOR TO UNDERTAKING EXCAVATIONS FOR PROPOSED CESS DRAIN.
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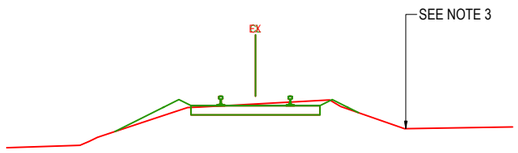
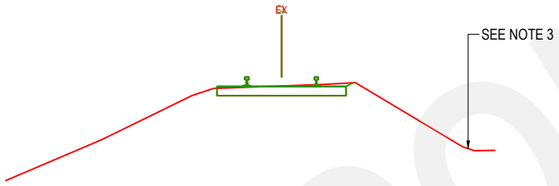


DATUM RL.74.000

DESIGN FEATURES			RAIL LEFT	CL	RAIL RIGHT	
DESIGN LEVELS			RL.75.919	RL.75.919	RL.75.919	
EXIST CL OFFSETS				OS-0.001 RL.75.917		

METREAGE 135980



DATUM RL.73.000

DESIGN FEATURES			RAIL LEFT	CL	RAIL RIGHT	
DESIGN LEVELS			RL.75.821	RL.75.821	RL.75.821	
EXIST CL OFFSETS				OS 0.002 RL.75.818		

METREAGE 135970

VITRUVIUS

	Drawn	Signed	Date
	RS	RS	13/02/20
	Designed	Signed	Date
	BH	BH	25/02/20
	Verified	Signed	Date
	NM	NM	14/02/20
	Approved	Signed	Date
	DB	DB	25/02/20

Rev.	Date	Revision Details	By	App.
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D	01/05/20	100% DETAIL DESIGN	JM	SW
C	17/04/20	85% DETAIL DESIGN REVISED	JM	DB
B	03/04/20	85% DETAIL DESIGN	JM	DB
A	25/02/20	20% DETAIL DESIGN	BH	DB

Client: KiwiRail

Project: NORTHLAND RAIL UPGRADE
CATEGORY A TUNNELS
KIWIRAIL PROJECT NO. 821010

Drawing Title: NAL - TUNNEL 7
TRACK DESIGN
CROSS SECTIONS
SHEET 16 OF 16

Status: 100% DETAIL DESIGN
NOT FOR CONSTRUCTION

Scale	Sheet Size.				
1:50	A1				
Consultant.	Area.	Discipline.	Sheet No.	Rev.
VT	T7	720	115	D

VITRUVIUS

Appendix B

Safety in Design Register

Safety in Design Risk Register

VITRUVIUS

PROJECT

Reference:	**Northland Rail Upgrade (Vitruvius ref V-581)**	Author Sign:	Privacy	Author:	Privacy	Date: **1 May 2020**
Name:	**NAL Tunnel Design (Category A & B)**					
Stage:	**Rail Alignment and Drainage - Preliminary Design (100%)**	Reviewer Sign:		Reviewer:	Privacy	Date: **1 May 2020**
Location:	**NAL Tunnels 7, 8, 10, 11, 12 & 13**					

RISKS ASSOCIATED WITH DESIGN ELEMENT - CONSIDERING ESTABLISHED CONTROLS								STAGE			ADDITIONAL DESIGN MITIGATION MEASURES AND RESIDUAL RISK						HANDOVER NOTES
				Raw Risk			Who is at Risk?										
Number	Activity	Risk or Circumstance	Consequence	Likelihood	Consequence	Risk	Principal / Contractor	Public	Construction	Operation & Maintenance	Demolition	Design Mitigation Measures (over and above established controls)	Likelihood	Consequence	Risk	Risk Owner	Expected Date to Complete Action	Comments	Treatment / Controls / Post construction measures to be conveyed to principal, constructor or maintainer
1	Track Geometry set out and construction	Track not built to design or moved out of position during future tamping etc	Train derailment	2	3	Medium 6	Y	N	Y	Y	N	• Design to provide accurate set out data	1	3	Low 3	Principal / Contractor	Sep-20	Consequence based on freight train derailment, not passenger as no services in place	Design set out close to time of construction to avoid disturbance of set out marks • Recommend speed restriction be set in place until track is confirmed to be built to design • As-built survey to confirm track geometry is built within construction tolerances set in KiwiRail Track Design Standard T-ST-DE-5200, prior to opening the track to line speed.
2	Track Geometry set out and construction		Train collision with fixed structure	3	4	High 12	Y	Y	Y	Y	N	• Design to provide accurate set out data • Design specifies monument plates to be installed to inform ongoing maint.	1	4	Medium 4	Principal / Contractor	Sep-20	Nil	Design set out close to time of construction to avoid disturbance of set out marks • As-built survey to confirm track geometry is built within construction tolerances set in KiwiRail Track Design Standard T-ST-DE-5200, prior to opening the track to line speed. • Install monument / datum plates for future tamping etc.
3	Track Geometry set out and construction	Disturbs stress in existing track at tie ins (buckle)	Buckling causing train derailment	2	3	Medium 6	Y	N	Y	Y	N	Nil - construction and maint. risk	1	3	Low 3	Principal / Contractor	Sep-20	Public not currently affected, but will need to be assessed if passenger service is online in future	• As-built survey to confirm track geometry is built within construction tolerances set in KiwiRail Track Design Standard T-ST-DE-5200, prior to opening the track to line speed.
4			Increased maintenance due to having to restress post construction	2	3	Medium 6	Y	N	Y	Y	N	Nil - construction and maint. risk	1	3	Low 3	Principal / Contractor	Sep-20	Nil	Follow T-TI-WO-5960 De-stressing CWR, confirm existing stability analysis factor
5			Train collision with fixed structure caused by buckling	1	4	Medium 4	Y	N	Y	Y	N	Nil - construction and maint. Risk.	1	4	Medium 4	Principal / Contractor	Sep-20	Ambient temperature in tunnel - main risk is outside at portals where rail temperatures can be high/.	Follow T-TI-WO-5960 De-stressing CWR, confirm existing stability analysis factor
6	Track Geometry set out and construction	Error in Survey set-out leading to incorrect geometry	Train derailment	3	3	Medium 9	Y	N	Y	Y	N	Design as per survey datum and coordinate system - same as specified for construction to reduce risk of error in transferring to different system. Same controls used for topo survey to be used for set out	1	3	Low 3	Principal / Contractor	Sep-20	Nil	Independent survey control checks and QA. Ensure set out to correct datum and coordinate system.
7	Track Geometry set out and construction		Train collision with fixed structure	3	4	High 12	Y	N	Y	Y	N	Design as per survey datum and coordinate system - same as specified for construction to reduce risk of error in transferring to different system. Same controls used for topo survey to be used for set out	1	4	Medium 4	Principal / Contractor	Sep-20	Nil	Independent survey control checks and QA. Ensure set out to correct datum and coordinate system.
8	Track Geometry set out and construction	Depth, Profile and Type of ballast not installed to design	Not enough ballast	2	1	Low 2	Y	N	Y	Y	N	Nil - construction Risk.	1	1	Low 1	Principal / Contractor	Sep-20	Nil	Follow KiwiRail Task Instruction and ensure enough material is on site.
9	Track Geometry set out and construction		Inadequate ballast shoulder outside of tunnels causing buckling	2	1	Low 2	Y	N	Y	Y	N	Design and Build to KiwiRail Ballast formation Standard C-ST-FO-4110 Design cross sections for tamping areas show compliant ballast shoulder, used to quantify ballast amounts needed	1	1	Low 1	Principal / Contractor	Sep-20	Tamping specified in areas where design lifts <50mm, no lowering, and slews <100mm	Contractor to ensure existing track sets are capable of withstanding taming loads. Risk of screws pulling etc die to rotten TPR.
10	Track Geometry set out and construction		Depth of ballast not meeting requirements and causing geometry and drainage faults	2	3	Medium 6	Y	N	Y	Y	N	Design and Build to KiwiRail Ballast formation Standard C-ST-FO-4110	1	3	Low 3	Principal / Contractor	Sep-20	Nil	As-built survey of top of formation prior to placing ballast to ensure correct formation levels constructed, therefore reducing risk of inadequate ballast being placed, 300mm outside tunnels, 250mm within tunnels
11	Track Geometry set out and construction	Ballast and formation not well drained due to inadequate drainage	Increased mud spots and required maintenance	2	1	Low 2	Y	N	Y	Y	N	installation of correct design, including but not limited to geotextile cloth and sand blankets follow C-TI-FO-4207	1	1	Low 1	Principal / Contractor	Sep-20		Contractor to notify engineer of any soft spots to determine whether undercut and hardfill required, or additional subsoil drainage not identified in drawings. Provisional item for bidim A29 geotextile in case needed on site to prevent migration of fines into ballast.
12	Track Geometry set out and construction		Flooding, ballast contamination leading to degradation to track geometry	2	1	Low 2	Y	N	Y	Y	N	• Apply KiwiRail standard drainage profiles, and inspect prior to leaving site - Notes added to drawings requiring contractor to inspect culverts, open drains etc	1	1	Low 1	Principal / Contractor	Sep-20	Nil	Ensure no culverts are blocked before leaving site • Ensure flow paths to existing or designed outlets are clear and free draining • Check all low points to ensure the water has somewhere to go.
13	Track Geometry set out and construction	Saturated formation and subgrade weakened	Track geometry faults leading to potential derailment or increased maintenance	2	3	Medium 6	Y	N	Y	Y	N	• Install subsoil drainage and ensure cess drains and culverts at correct levels and location. • Carry out geotechnical survey	1	3	Low 3	Principal / Contractor	Sep-20	Nil	Test pit information required for existing track and formation outside of tunnels.
14	Track Geometry set out and construction	Formation strength	Track geometry faults leading to potential derailment or increased maintenance	2	4	Medium 8	Y	N	Y	Y	N	Carry out geotechnical investigation to confirm CBR values. These need to be passed back to designer engineer to confirm prior to constructing formation. Improvements maybe required if <15%	1	4	Medium 4	Principal / Contractor	Sep-20	Nil	Contractor to allow for existing formation strength testing (at design bottom of ballast level) as per project specification
15	Track Geometry set out and construction	Level crossing unsuitable for vehicles	Vehicle stuck on crossing	3	4	High 12	Y	Y	Y	Y	N	Nil - construction and maint. Risk. Road reprofiling may be required to remove high rail level relative to road pavement	1	4	Medium 4	Contractor	Sep-20	not currently in the design scope	To be assessed by KiwiRail engineer if crossing is suitable and possible upgrade of crossing at construction stage to allow vehicles to OnTrack
16	Track Geometry set out and construction	Overload existing structures e.g. culverts through track lifts and replacing ballast, sleepers and rail	Structural failure of the culvert, causing flooding and geometry fault leading to derailment	2	3	Medium 6	Y	N	Y	Y	N	• Building track to design • Minimize lift and packing • KiwiRail structural review of design and sign off required on all structures • KiwiRail to confirm culvert capable of withstanding additional load	1	3	Low 3	Principal / Contractor	Sep-20	structural assessment of culverts regards the increased axle loads hasn't been assessed.	CCTV inspection of culverts within tamping and track renewal areas to confirm condition and suitability to take construction and train loads

Safety in Design Risk Register

Number	Activity	Risk or Circumstance	Consequence	Raw Risk			Who is at Risk?		Construction	Operation & Maintenance	Demolition	Design Mitigation Measures (over and above established controls)	Likelihood	Consequence	Risk	Risk Owner	Expected Date to Complete Action	Comments	Treatment / Controls / Post construction measures to be conveyed to principal, constructor or maintainer
				Likelihood	Consequence	Risk	Principal / Contractor	Public											
17	Track Geometry set out and construction	Track component failure (rail break, bed plate break, screw fastening failure, etc.) during construction and operation	Unable to open line to trains	3	1	Low 3	Y	N	Y	Y	N	Nil - construction risk	1	1	Low 1	Contractor	Sep-20	Nil	• Ensure correct methods of track moving are used, as per KiwiRail task instructions. • Carry spare parts to repair any damage • All track components inspected before opening line to trains
18	Track Geometry set out and construction		Train derailment	3	3	Medium 9	Y	N	Y	Y	N	Nil - construction risk	1	3	Low 3	Contractor	Sep-20	Nil	All track components inspected before opening line to trains
19	Track Geometry set out and construction		Increased Maintenance	3	2	Medium 6	Y	N	Y	Y	N	Nil - construction risk	1	2	Low 2	Contractor	Sep-20	Nil	• Ensure correct methods of track moving are used, as per KiwiRail task instructions. • Carry spare parts to repair any damage • All track components inspected before opening line to trains
20	Track Geometry set out and construction		Corrosion of components within the tunnel due to water ingress	3	2	Medium 6	Y	N	Y	Y	N	Install weep drains as per KR B-ST-TU-3117	1	2	Low 2	Contractor	Sep-20		Contractor to notify Engineer of any observed weeping through lining
21	Track Geometry set out and construction		Train collision with fixed structure	3	4	High 12	Y	Y	Y	Y	N	Nil - construction risk	1	4	Medium 4	Contractor	Sep-20	Nil	All track components inspected before opening line to trains
22	Track Geometry set out and construction	Damage to services during construction	Unable to open line to trains	3	1	Low 3	Y	Y	Y	Y	N	Designer undertaken B4UDIG, digitised serves and show on design drawings. These are indicative only and to be positively located on site.	1	1	Low 1	Contractor	Sep-20	Vitruvius completed B4Udig and referenced in plans, contractor to still complete service location on site	• Contractors to carry out Before U Dig checks and service locate in areas of work before commencing work • KiwiRail services shall also be identified and located before starting work
23	Track Geometry set out and construction		Electrocution - low voltage potential in these tunnels	3	4	High 12	Y	N	Y	Y	N	• Contractors to carry out Before U Dig checks and service locate in areas of work before commencing work • KiwiRail services shall also be identified and located before starting work	1	4	Medium 4	Contractor	Sep-20	Nil	• Contractors to carry out Before U Dig checks and service locate in areas of work before commencing work • KiwiRail services shall also be identified and located before starting work
24	Track Geometry set out and construction		Disruption to public	3	3	Medium 9	Y	Y	Y	Y	N	Design drawings and report identify Vodafone cables in some tunnels, not considered to require relocation within tunnel and fixed to structure and no lining improvement works proposed. Contractor will need to confirm cable location outside of tunnels and ensure outside extent of proposed earthworks	1	3	Low 3	Contractor	Sep-20	Nil	• Contractors to carry out Before U Dig checks and service locate in areas of work before commencing work • KiwiRail services shall also be identified and located before starting work
25	Track Geometry set out and construction		Disruption to KiwiRail comms	3	3	Medium 9	Y	N	Y	Y	N	- B4UDIG request by designer, digitised plans and shown indicative service locations on design drawings	1	3	Low 3	Contractor	Sep-20	Nil	• Contractors to carry out Before U Dig checks and service locate in areas of work before commencing work • KiwiRail services shall also be identified and located before starting work
26	Design philosophy	Tunnel collapse caused by tunnel invert modifications (Cat A tunnels only)	Death or serious injury to LE or workers in tunnel	2	4	Medium 8	Y	N	Y	Y	N	• Design an optimal rail alignment to reduce the amount of track lowering	1	4	Medium 4	Principal	Sep-20	Likelihood for raw risk based on KR assessing these tunnels as category A and minimal track lowering required. No assessment of structural impacts undertaken yet.	Project TARP to be applied • KiwiRail undertaking structural and geotechnical assessments of the Tunnels
27	Design philosophy	Train striking tunnel structure	Damage to tunnel, derailment	3	4	High 12	Y	N	Y	Y	N	• Accurate survey of the tunnels and track to allow good design • Additional construction tolerances have been allowed for in the design requirements	1	4	Medium 4	Contractor	Sep-20	Nil	• As-built survey to confirm Design and clearance has been achieved - KiwiRail to carry out ongoing regular inspections and verification if clearances as part of their asset management plans
28	Drainage & Earthworks	Slope stability	Slope failure, cause drainage blockages and overflows, blocking rail line, or under slip failures comprising tack stability	2	3	Medium 6	Y	Y	Y	Y	N	Geotechnical investigation is required for cut batters - notified on 100% drawings where these areas are. Design open drains to catch debris and prevent blockage Enable easy Regular inspections form local track inspector	1	3	Low 3	Principal/Contractor	Sep-20	Requirement for cut slopes above drains cannot be determined until LiDAR survey complete. Assume will be available at 100% design stage	KiwiRail to engage geotechnical engineer to assess proposed cut and fill slopes within Cat A package of works. Contractor not to undertake any earthworks which may compromise a slope without direction from the Engineer
29	Drainage	Drainage structures	Pipe failure due to loading leading to derailment	3	4	High 12	Y	Y	Y	Y	N	To meet minimum depths and specify pipe materials to meet standards	1	4	Medium 4	Contractor	Sep-20	Nil	CCTV of existing culverts remaining in place. Send report to Engineer to confirm suitable for train loads.
30	Drainage	Debris blockage	Debris blockage	2	2	Low 4	Y	Y	Y	Y	N	• To have open drains at minimum falls and velocities for self-flushing • Install rodding eyes in the tunnels for cleaning. To be kept clear from areas where damage may be incurred by tamping • Vegetation clearance to reduce the source of debris	1	2	Low 2	Contractor	Sep-20	Nil	
31	Drainage	Adequacy of provisions against flooding	Drainage system being overwhelmed causing flooding issues	3	1	Low 3	Y	Y	Y	Y	N	Design drainage system for a flooding event of 1 in 100 years	1	1	Low 1	Contractor/designer	Sep-20	Nil	
32	Drainage	Open structures or low structures	People falling in manholes	3	4	High 12	Y	Y	Y	Y	N	Place scruffy dome on structures	1	4	Medium 4	Contractor	Sep-20	Nil	
33	Drainage	Deep excavations	Fall and trench collapse	3	4	High 12	Y	Y	Y	Y	N	• Minimize the depth of proposed services	1	4	Medium 4	contractor	Sep-20	Nil	• Contractor to use trench shields or benched batters • Contractor to use adequate fencing around deep excavations
34	General construction, earthworks and drainage	Exposure to contaminated materials	Worker health, sickness or possible in the long term death	3	4	High 12	Y	Y	Y	Y	N	Construction risk. Earthworks minimised to reduce likelihood of encountering contaminated soils	1	4	Medium 4	principal	Sep-20	outside of Vitruvius's scope	KiwiRail to undertake contamination testing prior to works

Safety in Design Risk Register

Number	Activity	Risk or Circumstance	Consequence	Raw Risk: Likelihood	Raw Risk: Consequence	Raw Risk: Risk	Who is at Risk?: Principal / Contractor	Who is at Risk?: Public	Construction	Operation & Maintenance	Demolition	Design Mitigation Measures (over and above established controls)	Likelihood	Consequence	Risk	Risk Owner	Expected Date to Complete Action	Comments	Treatment / Controls / Post construction measures to be conveyed to principal, constructor or maintainer
35	Excavation of ex tunnel floor	Exposed tunnel floor gets saturated by water ingress and	reduced soil strength, compromise tunnel structure, tunnel collapse	2	4	Medium 8	Y	N	Y	N	Y	Removal of ballast and ex drainage will expose bedrock.	1	4	Medium 4	contractor	Sep-20		Contractor to control exposure of bedrock and ensure collector drainage in place to keep off bedrock.
36																			
37																			

Frequency Description	Qualitative Description	Rating					
LIKELIHOOD							
> 10 times per year	Is expected to occur, almost inevitable	*Almost certain*	MEDIUM 5	HIGH 10	VERY HIGH 15	EXTREME 20	EXTREME 25
At least annually and up to 10 times per year	Is expected to occur in most circumstances, Not surprised if it happens	*Likely*	LOW 4	MEDIUM 8	HIGH 12	VERY HIGH 16	EXTREME 20
Once in the next 2 to 10 years	Might occur in some circumstances	*Possible*	LOW 3	MEDIUM 6	MEDIUM 9	HIGH 12	VERY HIGH 15
Once in the next 11 to 50 years	Could occur in some circumstances, Surprised if it happens	*Unlikely*	LOW 2	LOW 4	MEDIUM 6	MEDIUM 8	HIGH 10
Not in the next 50 years	May occur but only in exceptional circumstances, It would be highly unexpected.	*Rare*	LOW 1	LOW 2	LOW 3	MEDIUM 4	MEDIUM 5
			IMPACT / CONSEQUENCE				

	Negligible	*Minor*	*Moderate*	*Major*	*Catastrophic*
Safety Incident and Health Illness or Injury (passengers, public and staff)	• Illness or injury not requiring medical treatment.	• Minor illness/ injury requiring medical treatment (e.g. First Aid and MTI).	• Short term (reversible) harm on health/body function. • Multiple medical treatment injuries (MTI's). • Immediate admission to hospital for treatment.	• Life Threatening injury or multiple moderate injuries causing hospitalisation • Permanent total disability • Severe and irreversible loss to quality of life.	• Death
Environmental	**Environmental Setting:** • No habitat or faunal population (internal building/asphalt or sealed surface/highly industrialised area). **Environmental Impact:** • No adverse impact/ impact contained prior to damage/ discharge • No cultural impact/interest. **External Factors:** • Regulator notification not/unlikely required. • No community impact.	**Environmental Setting:** • Highly modified environment (urbanised), non-native population **Environmental Impact:** • Impact questionable with existing poor quality soil/water/air. • Unintentional death of pest/invasive species. • May be of cultural impact/interest. **External Factors:** • Regulator notification likely required- purely advisory stance. • Possible limited community impact (Up to 1 member).	**Environmental Setting:** • Not or partially modified environment. • Potential for native and or protected species to be present. **Environmental Impact:** • Localised observable or measurable det/mental impact to soil/water/air/ fauna/ habitat/heritage etc. • Likely to be of cultural impact/interest **External Factors:** • Regulator notification/ investigation. Enforcement potential. • Several community impacts (2-4 residents).	**Environmental Setting:** • Low /Non- modified environment (e.g. recreation/ regional significance) • Native species, likely endangered/ protected. **Environmental Impact:** • Widespread impact to soil/water/air /fauna /habitat which will require significant remediation. Potential for partial/full restoration of value • Cultural impacts to habitat/fauna/ heritage (Taonga). **External Factors:** • Regulator notification, investigation. Enforcement likely. • Impact to section of local community (5 – a suburb/village)	**Environmental Setting:** • Pristine environment and/or national park/wildlife reserve. • Endangered/critically endangered species impacted **Environmental Impact:** • Permanent species/ habitat loss. Contamination of drinking water supply. • Impact/destruction of scenic area significant for tourism/income. • Cultural impact to significant habitat, fauna, heritage (Taonga) and likely breach of cultural regulations. **External Factors:** • Regulatory agencies local and central (e.g. EPA) involvement.Enforcement expected. • Regional or national community impact (town/region)

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Appendix C

Risk Register

Risk Register - Category A Tunnels Design (NAL Tunnel 7, 8 & 11)

Project Name:	**North Auckland Line Tunnel - Category A track design**			**Project Ref:**	V-581
Updated By:	Keith Ashington	**Date Updated:**	3/04/2020	**Verified By:**	Scott Williamson	**Date Verified:**	3/04/2020

Risk ID	Risk Title	Description / Cause / Consequence	Risk Owner	Status	Date Raised	Threat / Opportunity	Established Control(s)	Pre-Treatment			Treatment plan summary	Post-treatment			Residual controls
								Likelyhood	Consequence	Risk rating		Likelihood	Consequence	Risk rating	
1	Unknown ballast condition	Risk is that there will be insufficient depth to install the required ballast. This will cause an increase in maintenance costs	KiwiRail	Open	5/02/2020	Threat	GPR survey has been carried out but is deemed by KR as unreliable. T+T undertaking trial excavations ot determine ballast epth and bottom of tunnel floor relative to ex rail levels. T	Likely	Moderate	VERY HIGH	Investigation has been carried out and considered in design. Some areas of milling required - additional risk outlined below in the register	Unlikely	moderate	MEDIUM	
2	Insufficent track depth in tunnel	The proposed line category (18T = Cat A) requires a change to the ballast depth, sleeper type and rail type. All are deeper than that used currently, increasing the risk that there will be insufficient space in the tunnels to install a compliant track system. Compromise may be needed which will increase the risk of higher maintenance costs or redesign of subsoil drainage system.	KiwiRail	Open	5/02/2020	Threat	Separate surveys are being undertaken to determine drop depths, which appear to show the current rail position is almost compliant	Likely	Moderate	VERY HIGH	Highlight the risk to the Professional Head at the design stage. Reduced ballast depth within tunnels (250mm) accepted by PHoT subject to minimum CBR being achieved on subgrade Undertake Trial holes	Possible	Minor	MEDIUM	Maintainer to monitor the track. Reduced ballast depth accepted within tunnels to reduce extent of works within tunnel.
3	Accommodation of pantograph	Work being undertaken to check available height for Contact wire does not take into account width of pantograph. Risk of pantograph striking side of tunnel	KiwiRail	Open	5/02/2020	Threat	Assumptions are being made that any electric vehicle in this area shall have the same pantograph as the AM class EMU; however, it is more likely that the line would be used by a 'new' freight locomotive. Design for ballast track CWH	Unlikely	Major	HIGH	Propose re-evaluation using the EF locomotive, which is likely to be used for the basis of any future electric locomotive or may be cascaded to this area if the NIMT fleet is replaced.	Unlikely	Moderate	MEDIUM	KiwiRail engaging with traction team to assess spatial requirements for potential future electrification
4	Accommodation of rigid overhead catenary	Insufficient space to install rigid catenary system (height checked but not width). Design may not eb able to accommodate catenary	KiwiRail	Open	5/02/2020	Threat	Assumption made regarding overhead clearance required and additional 10mm construction tolerance	Possible	Major	VERY HIGH	Engage with traction team	Rare	Major	MEDIUM	
5	Overhead clearance	Assumption based on rigid track system (4220mm CWH). Current track is ballast. Professional heads may not accept proposed rigid track systems such as glued ballast or confined ballast with concrete side drain system	KiwiRail	Closed	20/03/2020	Threat	Now allowing for ballast track CWH and additional construction tolerance	Possible	Major	VERY HIGH	Revised design modelling criteria issued - CWH of 4280mm	Unlikely	Moderate	MEDIUM	Closed
6	Drainage outfalls	Consent reequipments	KiwiRail	Closed	20/03/2020	Threat	Site visit and review of Maximo data to confirm existing outfalls	Possible	Moderate	HIGH	Site visit and design to use existing outfalls	Unlikely	Moderate	MEDIUM	Consider closed
7	Insufficient culvert depth	Track lowering inside and outside tunnels may compromise culvert depth and structural integrity. Structural failure may induce track fault, leading to derailment or ongoing maintenance issues	KiwiRail	Open	20/03/2020	Threat	alignment design to inform drainage design. Some track lifts have been identified.	Likely	Moderate	VERY HIGH	Survey culverts and assess against design. Replace if cover depth compromised. If not replaced may be risk of pipe crushing failure affecting track geometry. CCTV recommended for some at risk culverts in the design reports	Unlikely	Moderate	MEDIUM	Some Culverts require replacement due to capacity
9	Track movement over time - during maintenance or vibrations	Derailment caused by track geometry issues or collision with tunnel	KiwiRail	Open	20/03/2020	Threat	Proposed post construction and 2-years scans to confirm relative clearance between tunnel and track. Datum / monument plates to be installed for design position	Likely	Major	VERY HIGH	Monitor position of track regularly using EM80 and survey markers in the tunnel	rare	major	MEDIUM	Ongoing KiwiRail monitoring an track management required
10	Water from lining of tunnel drips damages track via ballast contamination	Failure of track components. Installation of drip trays compromises structural envelope causing collision. Preference for weep drains as per KiwiRail standard for managing water ingress in tunnels	KiwiRail	Open	20/03/2020	Threat	Design to refer to standard weep drain details (consistent across NAL project) and determine requirement for drains on site. Note site visit was in summer so actual seepage potential not yet known	Unlikely	Moderate	MEDIUM	Install complaint drainage to protect track subgrade and ballast from contamination	Unlikely	Minor	LOW	Being managed
11	Hydro geology and groundwater impacts not considered	design, construction or ongoing maintenance issues	KiwiRail	Open	20/03/2020	Threat	Drainage assessment still undertake, no major seepage identified on site although standing water in track ballast in some areas. Assume due to clogged or no subsoil drainage	Possible	Moderate	HIGH	Assess surface drainage - and install subsoil tunnel drains by default to protect ballast	Unlikely	Minor	LOW	Being managed
12	Existing sediment contamination on tunnel lining being mobilised and contamination of new ballast	Ballast contamination, poor drainage, track moving and clearances compromised, track defects etc	KiwiRail	Open	20/03/2020	Threat	Deconstruction to avoid disturbing lining sediment - as a potential source of ballast contamination	Possible	Minor	MEDIUM	Contractor methodology to consider this risk	Rare	Minor	LOW	
13	Private landowner access	Drainage clearance work and exposure of culvert outfalls will require access to private land. Affected tunnels: - Tunnel 11 north portal - other sites tbc as designs progress	KiwiRail	Open	20/03/2020	Threat		Possible	Moderate	HIGH	KiwiRail to engage with landowners. Design to be amended if necessary to avoid works in private land	Unlikely	Moderate	MEDIUM	
14	Service strike during excavations	Unknown or unidentified services on site damaged, or death or serious injury to a worker. Programme delays and cost implications for 3rd party losses or remedial works	Contractor	Open	20/03/2020	Threat	Service plan requests and show on plans. Contractor to undertake service locate and test pitting prior to excavations on site	Unlikely	Major	HIGH	Service locate and test pits. Designer to show known service on design drawings	Rare	Major	MEDIUM	Limited services within tunnels. Vodafone cable in T 7 and 8
15	Track not built to design	Train derails due to misalignment, twist fault or cyclic top fault or hits the tunnel wall	Contractor	Open	20/03/2020	Threat	KiwiRail to use competent and qualified track constructors	Unlikely	Major	HIGH	Design to provide accurate Setout data Design Setout close to time of construction to avoid disturbance of Setout marks Recommend TSR to be set in place until track is confirmed as built to design AS built survey to confirm track geometry within construction tolerances Setout in T-ST-DE-5200	Unlikely	Moderate	MEDIUM	
16	Stresses in rail too high	Track buckles, train derails or hits structure, additional maintenance costs to restress the track	KiwiRail	Open	20/03/2020	Threat		Possible	Major	VERY HIGH	Destress rails as per KiwiRail requirements Ballast profile to KiwiRail requirements to provide enough lateral restraint	Rare	Major	MEDIUM	Identify requirement for stress assessment before cutting in
17	Track incorrectly set out	Train derailment due to misalignment, twist fault, cyclic top or collision with tunnel	Contractor	Open	20/03/2020	Threat		Possible	Major	VERY HIGH	Survey team to check set out prior to construction	Rare	Major	MEDIUM	
18	Insufficient ballast installed	Track buckles, train derails or hits structure, additional maintenance costs to restress the track	Contractor	Open	20/03/2020	Threat		Possible	Major	VERY HIGH	Ensure ballast profiles meet minimum requirements prior to track reopening to traffic	Rare	Major	MEDIUM	
19	Load increases on existing culverts beyond its limit	Culvert collapses, causing twist / cyclic top fault. Long term, water unable to drain causing formation to fail	Contractor	Open	20/03/2020	Threat		Possible	Major	VERY HIGH	Ensure strength of culvert has been checked and will not be overloaded by new construction	Rare	Major	MEDIUM	
20	Failure of track components	Rails not restrained, resulting in gauge / cyclic top / twist fault and derailment	Contractor	Open	20/03/2020	Threat		Possible	Major	VERY HIGH	Check all components prior to installation and prior to reopening to traffic. Ensure all clips clear of ballast	Rare	Major	MEDIUM	
21	Modification to existing tunnel floor to accommodate 250mm ballast	compromising structural integrity	KiwiRail	Open	2/04/2020	Threat	Consult with KR project tunnel advisor. Test pit excavations undertaken and recorded	Unlikely	Major	High	Identify milling areas, and design a centre drain arrangement which reduces required extent of milling	Rare	Major	Medium	
22	Tunnel 7 - lifting and minor slews on existing rail embankment	Slope stability issue, potential filling on private land	KiwiRail	Open	2/04/2020	Threat	None yet - have only identified the potential risk	Possible	Moderate	High	Review design footprint once LiDAR information available to confirm extents of filling. Geotec to confirm slope stability FOS meets KiwiRail requirements				Unknown post treatment risk until geotec assessment
23	Existing level crossings used for on-tracking for construction are not suitable	Risk of damaging vehicles or rail head due to poor condition. Low risk but not yet fully assessed. Disruption to services	Contractor	Open	2/04/2020	Threat	KiwiRail undertaking site access assessment for each tunnel. Work will be undertaken during BoL so unlikely to affect services unless not addressed before opening track	Possible	Minor		Have hand back process in place before end of BoL to ensure rail not damaged	Unlikely	Minor	LOW	

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Appendix D

Professional Head Design Review Register’

Comment Category	Category Title	Description
4	Critical Issue	Critical to functionality, safety and RAM. Must be addressed.
3	Important Issue	Major concern for functionality, safety and RAM. Should be addressed at this stage, but can be addressed at next stage if Reviewer is provided with sufficient supporting evidence that requirements can be met
2	Discussion Item	Not a concern for functionality, safety and RAM however should be addressed for accuracy or completeness of the package.
1	Suggestion	Reviewer suggestion that may improve the package but is not mandatory.

Design Document Number	Comment Category	Reviewer Comments	Open Date	Designer Comments	Closed Date	Reviewer Sign Off	Sign Off Date
V-581-07-BH-CDR-20200213	2	Section 1 Confirm 4.620m rail to crown clearance allows for 25mm cant	20/03/2020	Yes the assessment is static dynamic and allows for the cant.			
V-581-07-BH-CDR-20200213	2	Section 1 Speed refers to 50kmph (governing line speed based on ex geometry). This should read 55kmph to reflect the design geometry maximum speed	20/03/2020	Noted - no action needed			
V-581-07-BH-CDR-20200213	1	Section 2 Line will change to Speed category 2 - 70kph	20/03/2020	This table refers to the previous survey and clearance assessment work and only provided as background to the design report. This assessment did not consider future electrification therefore largely irrelevant to the proposed design. Clearance assessment tables from 2019 reports will not be shown in future design reports			
V-581-07-BH-CDR-20200213	1	Section 3.2 Can these clearances please be shown on the cross-sections	20/03/2020	To discuss with NAL team as were removed to unclutter the drawing.			
V-581-07-BH-CDR-20200213	3	Section 3.2 We should be designing for ballasted track not slab track	20/03/2020	85% design will reflect latest design criteria which refers to ballast track minimum CWH of 4270mm. Next phase of design (85%) will be designed for ballast track			

Appendix E

Culvert Assessments

Northland Rail Upgrade
Culvert Assessment

Exisiting Information (Maximo & Site Observations)										Modified Depth			
Portal (Nth/Sth)	**Asset Type**	**Asset ID**	**Location (KM)**	**No. barrels**	**Condition**	**dia (mm)**	**Length (m)**	**Material**	**Ex.Depth (m) (MAXIMO)**	**Design Track lift (m +/-)**	**Depth after realignment (m)**	**Cover of Culvert (m)**	**>1.2m (Y/N)**
North-A	Culvert	Not in Register	136.131	1	Unknown	Unknown. So Assumed 375mm	5.814	Unknown	1.802	0.066	1.868	1.268	Y
North-B	Culvert	2258672	136.06	1	Unknown	900	Unknown	STEEL	7	0.055	7.055	6.155	Y
North-C	Culvert	2258671	135.948	1	Unknown	700	Unknown	CONCRETE	1.2	0.191	1.391	0.691	N
North-D	Culvert	2258670	135.832	1	Unknown	600 (500mm as per survey)	4.58	CONCRETE	1.3	-0.214	1.086	0.486	N
South-A	Culvert	2258669	135.398	1	Unknown	750	Unknown	STEEL	3	-0.123	2.877	2.127	Y
South-B	Culvert	2258668	135.258	1	Unknown	500	Unknown	CONCRETE	6	0	6	5.5	Y
South-C	Culvert	2258667	135.216	1	Unknown	450	Unknown	EARTHENWARE	6	0.005	6.005	5.555	Y
South-D	Culvert	2258666	135.216	1	Unknown	300	Unknown	CONCRETE	6	0.005	6.005	5.705	Y

	Capacity Assessment						Specific Considerations / Issue				
Portal (Nth/Sth)	**Des Q10 (m3/s)**	**Surcharge in Q10 event? (Y/N)**	**Des Q100 (m3/s)**	**Meets Hw+725mm requirements? (Y/N)**	**Confidence in design paramaters (H/M/L)**	**Comments**	**History of flood issues?**	**Risk of pipe failure**	**Risk of embankment failure**	**Debris management**	**Other**
North-A	0.05	N	0.18	Y	M	Existing Diameter assumed (375mm) as no Maximo or Survey Records.	UNKNOWN	Unknown	L	Unknown	This culvert is not under KiwiRail Register. So no MAXIMO DATA.
North-B	0.06	N	0.23	Y	M	Rely on Maximo data	UNKNOWN	Unknown	L	Unknown	Unknown
North-C	0.46	N	1.63	N	L	If Rely on Maximo data the culvert doesn't meet KR Criteria. Site visit looks like Invert Level is lower than 1.2 from Top of Rail therefore maximo data may be incorrect	UNKNOWN	H	M	Unknown	Additional loading on pipe as we are lifting the rail 191mm. However need to confirm actual cover depth and pipe class to be able to asses the freeboard requirement. Embankment to be inspected by a Geotechnical Engineer.
North-D	0.13	N	0.47	N	H	Either Survey or Maximo Data doesn't comply with KR standard	UNKNOWN	H	L	Poor - evidence of siling up	Unsafe open inlet and outlet structure.
South-A	0.29	N	1.01	Y	M	Rely on Maximo data	UNKNOWN	M	L	Poor - evidence of siling up. Muddie spot	High risk of track flooding as the existing eastern cess drain is draining out into a ponding area.
South-B	0.08	N	0.29	Y	M	Rely on Maximo data	UNKNOWN	L	L	Unknown	Unknown
South-C	0.02	N	0.06	Y	M	Rely on Maximo data	UNKNOWN	L	L	Unknown	Unknown
South-D	0.02	N	0.06	Y	M	Rely on Maximo data	UNKNOWN	L	L	Unknown	Unknown

	Environmental Considerations					Proposed Works					Departures
Portal (Nth/Sth)	**Outlet condtition**	**Discharge Velocity Q10 (m/s)**	**Evidence of scour**	**Scour protection required (Y/N)**	**Sensitive recieveing environemnt (Y/N)**	**Design solutions**	**KiwiRail Standard Reference**	**Benefits to construct now vs after NRU project**	**Recommendation**	**Additional Informtation Required**	
North-A	No Records	1.65	No Records	To be checked on site. Low outlet velocity so no not expect scour issues	Unknown	Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement.		It is recommended to clear vegetation now to avoid any possible blockage which could results in flooding the formation. Good value operation.	Vegetation Clearences Check Erosion Evidence at Outlet	None	Nil
North-B	No Records	0.36	No Records	No	Unknown	Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement.		It is recommended to clear vegetation now to avoid any possible blockage which could results in flooding the formation. Good value operation.	Vegetation Clearences Check Erosion Evidence at Outlet	None	
North-C	No Records	1.19	No Records	To be checked on site. Low outlet velocity so no not expect scour issues	Unknown	Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement. CCTV to assess structural integrity of pipe as the 191mm lifting could have an impact into it. Survey Actual Invert Level as the MAXIMO Depth record of 1.2m seems to be wrong, after viewed it on site. Existing Embakment to be checked by a Geotechnical Eng.		It is recommended to clear vegetation now to avoid any possible blockage which could results in flooding the formation. Good value operation. CCTV is a cheap procedure that could avoid a pipe collapsing because of the overload.	Vegetation Clearences Check Erosion Evidence at Outlet CCTV Footage Geotech Assestment	Survey Invert Level and Check Diameter. CCTV Footage of the existing conditions.	
North-D	The Outlet tie into another culvert inlet with a gap in between which need some renewal work. The Outlet is in lower level and it is cover with wooden sleeper.	1.67	No Outlet Found	To be checked on site	Unknown	Replace with 600dia culvert at 1,5m cover, lower cess drains below formation level to ensure positive drinage. Replace inlet with scrify dome strucutre with sum for debris capture. Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement.	As per Typical Dwg Details	The new lower track alignment design has an impact in this culvert. It has to be replaced to avoid any risk of flooding the formation.	Culvert Renewal Check Erosion Evidence at Outlet CCTV Footage	No more for this one. Rest of them IL, dIameters check and confirm catcment area (therefore culvert size) once LiDAR data received.	
South-A	Outlet into a pond in a low level at the western side. No work needed here	0.65	No evidence	N	Unknown	Existing Culvert is hydraulically fine. Just work on cess drains ponding issue. Eastern Cess Drain is draining into a ponding area which potentially get drained out throught the subsoil crossing the railway formation. Three solutions: Preferred Option-Run the proposed Cess drain 40m to the south and install a new culvert. Alternative 1) Run the proposed Cess drain 200m and connect into next existing culvert. Alternative 2) Connect Cess Drain Ponding Area with Existing Steel Culvert,involved excavation on Private Property.	As per Typical Dwg Details	Draining the Eastern Cess Drain properly will avoid the new proposed formation to be undermine.	1)Just new cess drain 2)Earthwork to unblock eastern cess drain. 3)cess drain and new culvert	CCTV existing culvert to prevent any blockage.	
South-B	No Records	1.46	No Records	To be checked on site	Unknown	Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement.		It is recommended to clear vegetation now to avoid any possible blockage which could results in flooding the formation. Good value operation.	Vegetation Clearences Check Erosion Evidence at Outlet	None	
South-C	No Records	0.38	No Records	To be checked on site	Unknown	Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement.		It is recommended to clear vegetation now to avoid any possible blockage which could results in flooding the formation. Good value operation.	Vegetation Clearences Check Erosion Evidence at Outlet	None	
South-D	No Records	0.86	No Records	To be checked on site	Unknown	Clear Vegetation around the Inlet and Outlet Structure. Check any evidence of Outlet Erosion an report to engineer prior to any work commencement.		It is recommended to clear vegetation now to avoid any possible blockage which could results in flooding the formation. Good value operation.	Vegetation Clearences Check Erosion Evidence at Outlet	None	

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