Preliminary Design Report
Stream Crossing

Southland Wind Farm, Southland

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Contents

Appendices

Preliminary Design Report
Stream Crossing
Southland Wind Farm, Southland

1.0 Introduction

This report has been prepared by Riley Consultants Ltd (Riley) at the request of Contact Energy Ltd. The report is intended to support the substantive application being made under the Fast-track Approvals Act 2024 for the proposed Southland Wind Farm development, located in the upper Mimihau Stream catchment. Specifically, the report details the preliminary design of the notable stream crossings (NSC) associated with the proposed wind farm track network.

The purpose and scope of the report is:

- Outline the design philosophy that may be applied to new stream crossings associated with the proposed track network.
- Using the design philosophy, carry out preliminary assessment and design for any notable stream crossing locations identified
- Present drawing/s showing the representative design for a stream crossing.

The scope excludes:

- The identification and classification of all potential (minor) streams that may be intercepted by the proposed track network.

2.0 Background

For the purposes of this report, a notable stream has been defined as one with a catchment area greater than 40ha or 0.4km^2. The proposed track network required for the proposed wind farm crosses nine notable streams. These notable stream crossings (NSC) are summarised in Table 1.

The track network includes two track types:

1. Wind Farm Access Tracks
2. Transmission Tower Access Tracks

Transmission tower access tracks will only service light 4-wheel-drive access after construction is completed.

Table 1: Notable Stream Crossings

Location	Track	Chainage	Stream Name	Existing Type
NSC1	Port Blakely Forest	4305	Mimihau Stream North Branch	Ford
NSC2	Matariki Main	1155	Mimihau Stream South Branch	Bridge
NSC3	JED18	670	Mimihau Stream South Branch Tributary 1	Ford
NSC4	JED19	35	Mimihau Stream South Branch Tributary 1	Ford
NSC5	Port Blakely Forest	5010	Mimihau Stream North Branch Tributary 1	Ford
NSC6	Port Blakely Forest	1375	Kaiwera Stream East Branch	Culvert
NSC7	Port Blakely Forest	3180	Mimihau Stream North Branch Tributary 2	Culvert
NSC8	Port Blakely Forest	1590	Kaiwera Stream East Branch	Ford
NSC9	Transmission Tower Access Track A5	255	Mimihau Stream South Branch Tributary 2	Nil

The stream crossing locations are preliminary only and are based on the preliminary turbine and track layout. Culvert designs will be confirmed at detailed design stage – once the track layout has been finalised, adopting the design methodology set out in this report.

Figure 1 presents the site track network (red), along with 50m ground contours (black), and the stream crossing locations (yellow).

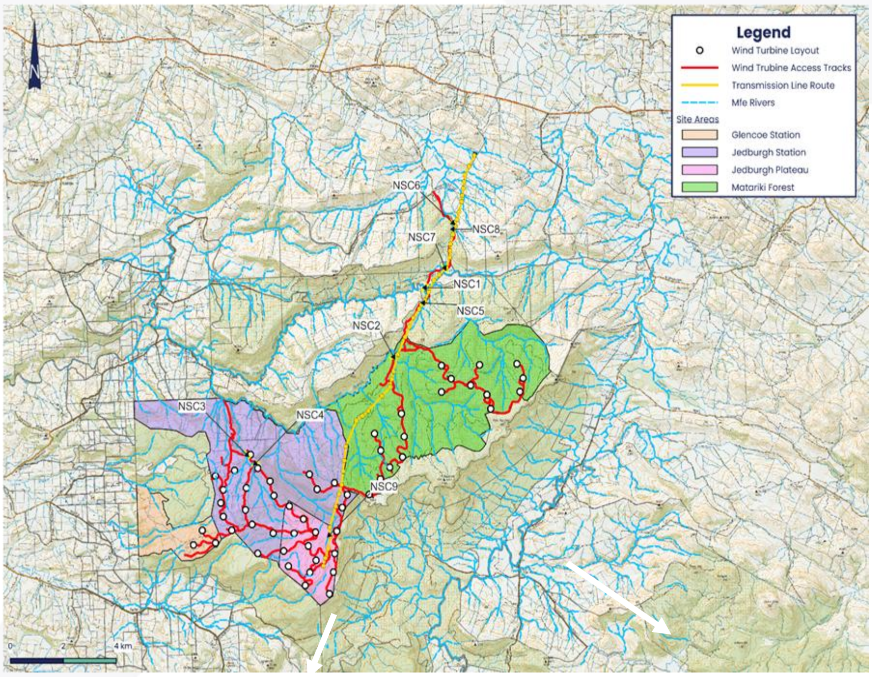


Figure 1: Notable Stream Crossing Layout

3.0 Topographical Information

Roaring40s Wind Power Ltd provided the topographical information for this assessment. The LIDAR information was prepared by Aerial Surveys Limited and provided to Roaring40s Wind Power Ltd on 12 December 2022. We understand the data was captured in 2020 and 2021 for Environment Southland as part of a Provincial Growth Fund project. We note that this information is the same as that presented within the publicly available LINZ database.

The vertical datum is New Zealand Vertical Datum 2016 (NZVD2016), with a vertical accuracy of 200mm (68% confidence interval).

A more detailed topographical survey will be carried out for the proposed stream crossings once their locations have been confirmed at detailed design stage.

4.0 Hydraulic Design Criteria

4.1 Background

The proposed track network is located within both Gore District Council and Southland District Council areas.

The Southland District Council Subdivision, Land Use and Development Bylaw 2012 includes roading design requirements for the district. It is largely based on Land Development and Subdivision Infrastructure (NZS 4404:2010) and states that all bridges and culverts shall be designed in accordance with the NZTA Bridge Manual.

The Gore District Council Subdivision and Land Development Bylaw 2019 also states that all bridges and culverts shall be designed in accordance with the NZTA Bridge Manual.

We note that the proposed tracks will act as private access tracks within the wind farm. The Bridge Manual categorises a bridge 'importance level' from 1 (lowest) to 4 (highest), based on the population served by a bridge.

Table 2 summarises the design flood requirements from the Bridge Manual for permanent bridges. For ease of interpretation, we have only included the three lowest importance level categories. We note that bridges with higher importance levels have the 100 year ARI flood as the design flood event.

Table 2: Bridge Manual Design Floods

Bridge Categorisation	Importance Level	Design Flood Event (SL2) (ARI) (Years)
Bridges on highways classified as National Regional, Arterial, Primary Collector or Secondary Collector.	3	100
Bridges on highways classified as Access or Access (Low Volume), or bridges not falling into other levels or foot bridges.	2	50
Bridges where failure would not be likely to endanger human life and the loss of which would not be detrimental to post-disaster recovery activities for an extended time.	1	25

4.2 Climate Change

The Bridge Manual requires climate change to be allowed for within the design flows and states:

- That climate change scenarios used for design shall be in accordance with regional council or territorial authority requirements.
- In the absence of specific advice, then climate scenario RCP 6.0 shall be used for design with sensitivity testing to RCP 8.5.
- For high-risk sites or where there is a severe consequence of failure, then RCP 8.5 shall be adopted.
- The projected climate date horizon shall match either the design life of the structure or the requirements of the regional council or territorial authority.

4.3 Freeboard

The Bridge Manual provides the freeboard design criteria outlined in Table 3.

For bridges, freeboard is defined as, the difference between the predicted flood level to the underside of the superstructure. For culverts freeboard is defined as, the difference between the predicted flood level to the track surface level.

Table 3: Bridge Manual Freeboard Requirements

Waterway Structure	Situation	Freeboard (mm)
Bridge	Normal circumstances	600
	Where the possibility that large trees may be carried down the waterway exists	1200
Culvert	All situations	500

4.4 Selected Design Criteria

The Council bylaws as discussed describe design criteria for public infrastructure. The stream crossings designed within this report are for private tracks.

For culvert design, we consider some track embankment overtopping is acceptable during a 100-year ARI RCP6.0 flood event. A maximum overtopping flood depth of 200mm has been selected, as this depth of water is unlikely to prevent vehicle access.

For the 10-year ARI RCP6.0 event, we consider the following is acceptable:

- minimum 500mm freeboard for wind farm access tracks.
- maximum overtopping flood depth of 200mm for transmission tower access tracks

The selected the design criteria are summarised in Table 4.

Table 4: Selected Design Criteria

Track Type	Waterway Structure	RCP6.0 Design Flood (ARI) (Years)	Design Criteria
Wind Farm Access Track	Bridge	100	600mm Freeboard
Wind Farm Access Track	Culvert	10	500mm Freeboard
		100	Less than 200mm Overtopping
Transmission Tower Access Track	Culvert	10 and 100	Less than 200mm Overtopping

The RCP8.5 climate change scenario could be considered during detailed design.

4.5 Permitted Activity Rules

The culverts, where applicable, have also been designed to accommodate permitted activity rules from the Proposed Southland Water and Land Plan (May 2024) (SWLP) and the Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-F). Specific rules include:

Proposed Southland Water and Land Plan (May 2024)

Rule 59a

v) the invert (or bottom) of any culvert is installed to a depth of either 300 millimetres below the natural bed level or one-third of the diameter of the culvert, whichever is the lesser;

Resource Management (National Environmental Standards for Freshwater) Regulations 2020

Regulation 70:

(a) the culvert must be laid parallel to the slope of the bed of the river or connected area; and

(d) the culvert's width where it intersects with the bed of the river or connected area (s) and the width of the bed at that location (w), both measured in metres, must compare as follows:

(i) where $w \leq 3$, $s \geq 1.3 \times w$:

(ii) where $w > 3$, $s \geq (1.2 \times w) + 0.6$; and

(e) the culvert must be open-bottomed, or its invert must be placed so that at least 25% of the culvert's diameter is below the level of the bed; and

Other permitted rules for culverts may be included during detailed design.

5.0 Design Philosophy

We consider there are two typical crossing design options; a bridge option or embankment/culvert option. Typically, bridges have a higher flow capacity than a culvert option, and a higher construction cost. Culverts are typically used, where the design flows are relatively small.

One significant disadvantage of culverts is the potential effect on fish passage. The New Zealand Fish Passage Guidelines set out recommended practice for the design of instream infrastructure to provide for fish passage. The guidelines state that single-span bridges are the preferred crossing type to avoid impacts on fish passage, followed by stream simulation culvert designs.

6.0 Fish Passage Design Criteria

6.1 Bridges

There are no specific fish passage design criteria relevant for single span bridges.

6.2 Trout Passage Prevention Culverts

In accordance with the recommendations of Ryder and Goldsmith (2025) and the Department of Conservation (DoC), fish passage will be restricted at three of the proposed stream crossings for the protection of non-migratory galaxiid habitat upstream. Ryder and Goldsmith (2025) and DoC have also advised that the design of these three stream crossings does not need to be designed for galaxiids passage, as these species are non-migratory.

These three stream crossings are presented in Table 5.

Table 5: Trout Passage Prevention Culverts

Location	Track	Stream Name
NSC1	Port Blakely Forest	Mimihau Stream North Branch
NSC3	JED18	Mimihau Stream South Branch Tributary 1
NSC6	Port Blakely Forest	Kaiwera Stream East Branch

The selected culvert invert levels are approximately 1.0m above the natural bed levels to discourage trout passage, in accordance with Section 6 of the New Zealand Fish Passage Guidelines, as suggested by DoC. Trout passage prevention will need to be considered further at detailed design stage.

6.3 Fish Passage Culverts

For the purposes of this assessment, we have assumed all other notable stream crossings are to provide fish (including trout, eel and galaxiids) passage, including NSC4 which is located upstream of NSC3 (one of the trout passage prevention culverts). The New Zealand Fish Passage Guidelines (NIWA, 2024) will be used in detailed design to confirm the fish passage requirements for these culverts.

We note that typically, to comply with the Fish Passage Guidelines, larger culverts are required compared to a culvert sized only considering flood conveyance.

Table 6 presents the estimated bank full width, minimum culvert span, and selected culvert span at each relevant notable stream crossing. The selected culvert sizes exceed the fish passage span criteria. Given the span widths required, box culverts are the preferred crossing options.

Table 6: Fish Passage Culvert Span

Location	Estimated Bank Full Width (m)	Minimum Culvert Span (m)	Selected Culvert Span (m)
NSC4	4.0	5.2	5.5
NSC5	2.0	2.6	3.0
NSC7	1.5	2.0	2.0
NSC8	1.0	1.3	2.0
NSC9	1.0	1.3	2.0

We note at detailed design stage, a topographic survey will be undertaken, which will accurately measure the bankfull width and stream bed profile.

7.0 Hydrological Assessment

7.1 Introduction

In a regional context, flood flows within the site are expected to be relatively low compared to other regions in New Zealand.

The hydrological assessment has been undertaken by comparing the following methods:

- Flood frequency analysis of the most appropriate adjacent flow gauge record.
- Regional methods

A comparison to the rational method used within the Civil Design Report has also been made.

7.2 Flood Frequency Analysis

7.2.1 Available Flow Records

Table 7 presents the three flow records closest to the site. All are maintained by Southland Regional Council.

Table 7: Available Flow Records

Station ID	Site Name	Catchment Area (A) (km^2)	Record Start	Record End	Length (Years)
77524	Mimihau at Stewarts Bridge	225	Dec 1975	May 1978	2
77526	Mokoreta at Crescent Bridge[1.]	370	Dec 1974	Jul 1981	6
77527	Mokoreta at McKays Road[2.]	418	Mar 1981	n/a[3.]	42

[1.] Renamed from Wyndham Stream at Glenham Bridge.
[2.] Replaced Mokoreta at Crescent Bridge
[3.] Record to the end of 2022 obtained for this assessment.

For the purposes of this assessment, the Mokoreta at McKays Road gauge record has been selected for use within the flood frequency analysis. The other gauge records are too short for flood frequency analysis.

7.2.2 Annual Maxima

Figure 2 presents the annual maxima for the period from 1981 to 2022 from the Mokoreta at McKays Road gauge record. The mean annual flood (Q_{MAFF}) over the period is 133m^3/s which equate to a $Q_{MAFF}/A^{0.8}$ ratio of 1.1. As expected, the flood flows appear relatively low compared to other regions in New Zealand, with a typical country-wide ratio of 3.0.

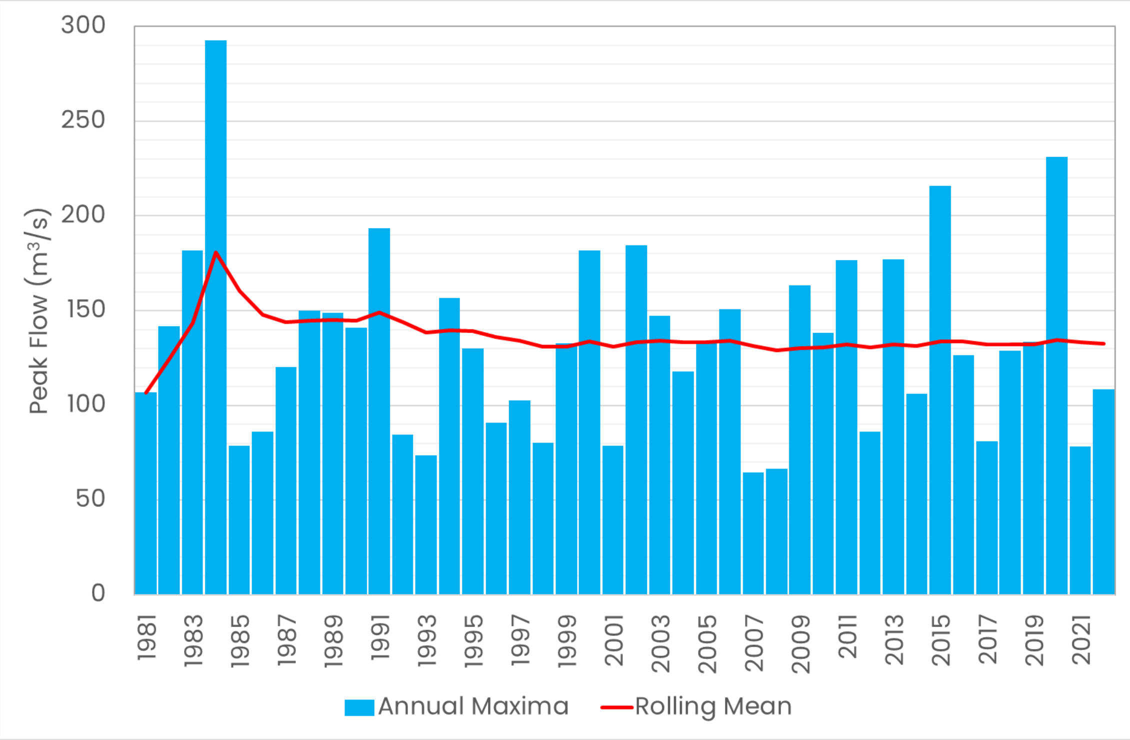


Figure 2: Mokoreta at McKays Road Annual Maxima

7.2.3 Analysis

Flood frequency analysis on the Mokoreta at McKays Road annual maxima was undertaken using a number of statistical distributions:

- Gumbel (EV1)
- Generalised Extreme Value (GEV)
- Pearson Type III (P3)
- Log Pearson Type III (P3)

The flood frequency analysis results are presented within Figure 3. The results across the four statistical distributions are similar, with Pearson Type III the most conservative for ARI greater than 10-years.

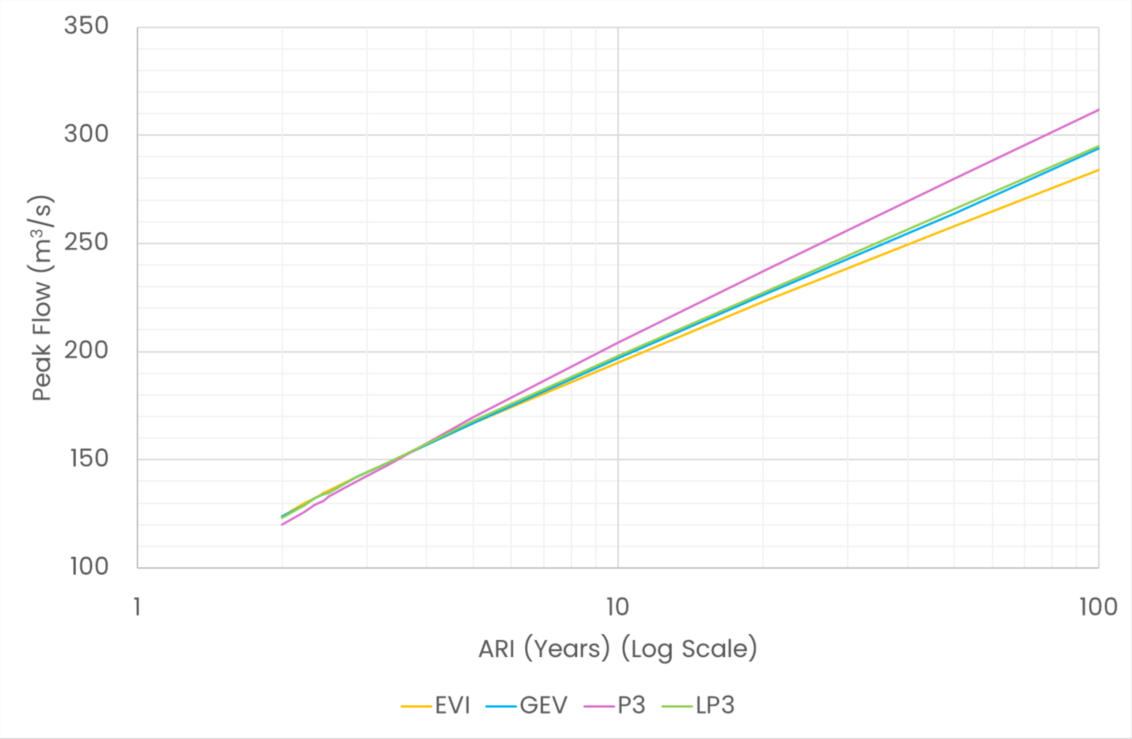


Figure 3: Mokoreta at McKays Flood Frequency Analysis Results

Table 8: Mokoreta at McKays Flood Frequency Analysis Results

ARI (Years)	Flow (Q) (m^3/s)	Q/Q_{MAFF}	$Q/A^{\wedge 0.8}$
10	204	1.5	1.6
100	312	2.3	2.5

7.3 Regional Methods

Both McKerchar and Pearson (1989) and the NIWA web portal "NZ Rivers Flood Statistics" (NIWA, 2018) provides regional flood frequency peak flow estimates across New Zealand.

The NIWA (2018) and McKerchar and Pearson (1989) statistics for and Mokoreta at McKays Road are summarised in Table 9. The results are similar from both methods.

Table 9: Mokoreta at McKays Road

Location	$Q_{MAFF}/A^{0.8}$	Q_{100}/Q_{MAFF}
At Site		
NIWA (2018)	1.1	2.3
McKerchar and Pearson (1989)	1.4	2.5
Regional		
NIWA (2018)	1.1	2.3
McKerchar and Pearson (1989)	1.2	2.4

7.4 Comparison

The NIWA (2018) and McKerchar and Pearson (1989) ratios for and Mokoreta at McKays Road are summarised in Table 10, along with the Riley (2025) Pearson Type III flood frequency analysis results. The results are similar from all three methods.

Table 10: Mokoreta at McKays Road Ratios

Location	$Q_{MAFF}/A^{0.8}$	Q_{100}/Q_{MAFF}
At Site		
Riley (2025)	1.1	2.3
NIWA (2018)	1.1	2.3
McKerchar and Pearson (1989)	1.4	2.5
Regional		
NIWA (2018)	1.1	2.3
McKerchar and Pearson (1989)	1.2	2.4

Figure 4 demonstrates that NIWA (2018) is moderately conservative compared to the Riley (2025) 1981-2022 flood frequency analysis over the range of selected statistical distributions.

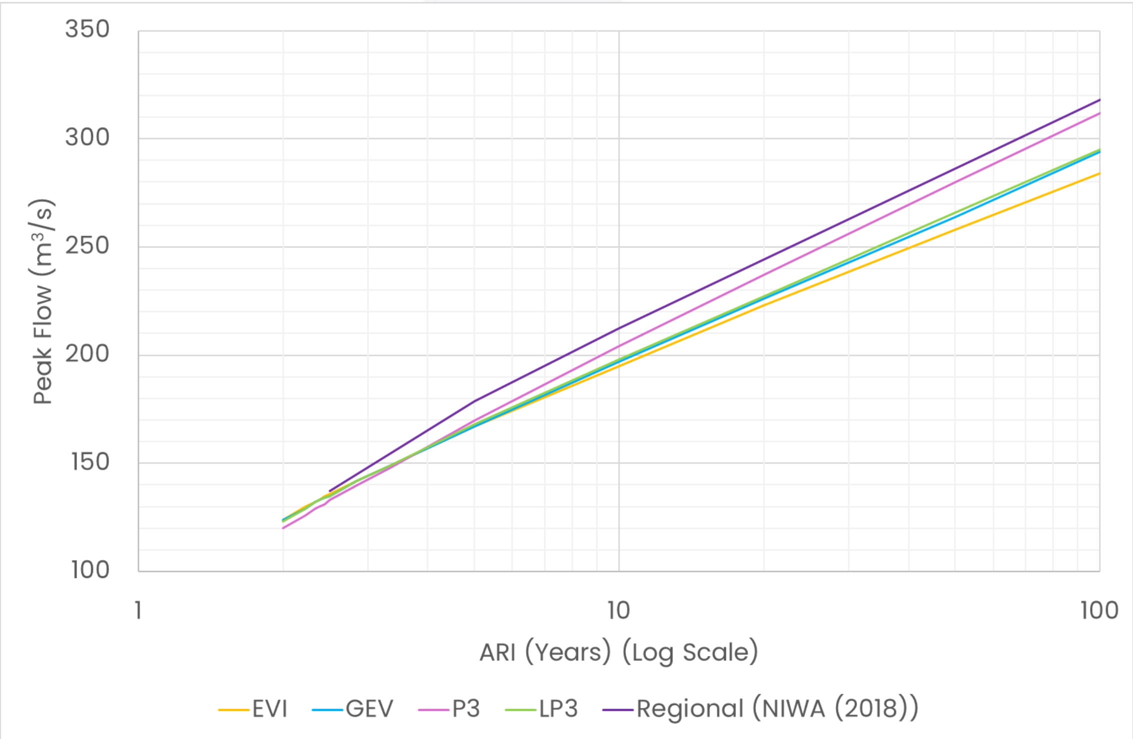


Figure 4: Mokoreta at McKays Peak Flow Estimates (m³/s)

We therefore consider the NIWA (2018) regional estimates are appropriate to be used within this assessment.

7.5 Design Ratios

Table 11 presents the NIWA (2018) statistics for the stream crossing locations. The statistics are similar across all locations and very similar to McKerchar and Pearson (1989).

Based on this comparison, we consider the most appropriate $Q_{10}/A^{0.8}$ and $Q_{100}/A^{0.8}$ ratios to be used within this assessment for all stream crossing locations are 2.2 and 3.4, respectively.

Table 11: Stream Crossing Locations - Regional Method Flood Estimates

Location	Area (A) (km^2)	$Q_{MAFF}/A^{0.8}$	Q_{10}/Q_{MAFF}	Q_{100}/Q_{MAFF}	$Q_{10}/A^{0.8}$	$Q_{100}/A^{0.8}$
NIWA (2018)						
NSC1	17.46	1.4	1.6	2.4	2.2	3.4
NSC2	12.32	1.4	1.6	2.4	2.2	3.4
NSC3	5.62	1.2	1.6	2.4	1.8	2.8
NSC4	2.98	1.2	1.6	2.4	2.0	3.0
NSC5	1.27	1.4	1.6	2.5	2.2	3.4
NSC7	0.65	1.3	1.6	2.5	2.2	3.3
NSC6	1.52	1.3	1.6	2.5	2.1	3.2
NSC8	0.79	1.3	1.6	2.5	2.1	3.3
NSC9	1.14	1.4	1.6	2.4	2.1	3.2
NIWA (2018) Summary						
Minimum	-	1.2	1.6	2.4	1.8	2.8
Mean	-	1.3	1.6	2.4	2.1	3.2
Maximum	-	1.4	1.6	2.5	2.2	3.4
McKerchar and Pearson (1989)						
All Locations	-	1.2	-	2.4	-	3.4

Figure 5 compares the 10-year ARI selected design line and the discrete peak flow estimates from NIWA (2018) for the nine notable stream crossing catchments. The selected design line generally sits above or on the discrete points.

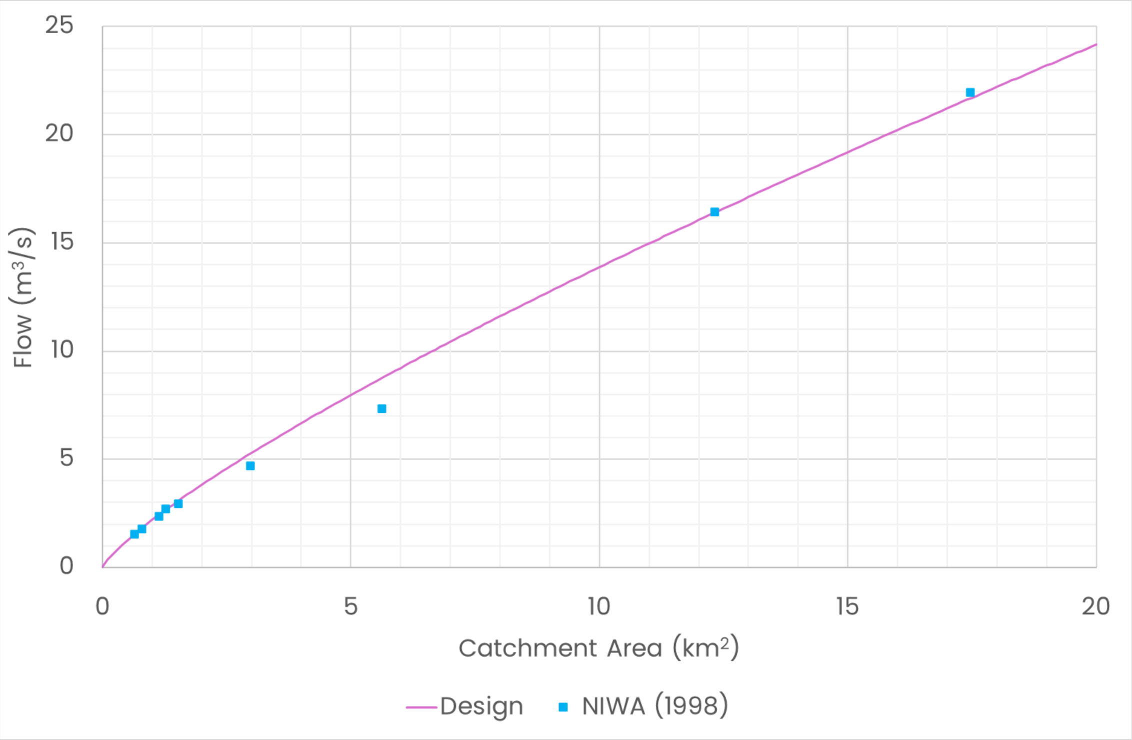


Figure 5: Peak Flow (m^3/s) Design Estimates

7.6 Climate Change

7.6.1 Introduction

The potential effects of climate change are uncertain. Short duration rainfall events may become more intense (i.e. higher intensity rainfall) and antecedent ground conditions may become drier or wetter. The following sections consider:

- HIRDS Version 4 rainfall climate change projections
- The potential effect of climate change on peak flows

7.6.2 HIRDS Rainfall

HIRDS provides rainfall projections for RCP6.0 and RCP8.5 to 2100. Table 12 and Table 13 present HIRDS rainfall information for 2-hour and 24-hour duration events, respectively.

Table 12: 2-Hour Rainfall

ARI (Years)	Depth (mm)			Increase from Historical (%)	
	Historical	RCP6.0	RCP8.5	RCP6.0	RCP8.5
2	16.6	19.7	21.5	19%	30%
10	27.8	33.5	36.9	21%	33%
100	50.2	61.0	67.2	22%	34%

Table 13: 24-Hour Rainfall

ARI (Years)	Depth (mm)			Increase from Historical (%)	
	Historical	RCP6.0	RCP8.5	RCP6.0	RCP8.5
2	51.7	57.8	61.4	12%	19%
10	78.9	89.3	95.3	13%	21%
100	126.0	144.0	154.0	14%	22%

7.6.3 Peak Flow

The predicted climate change induced rainfall increase is likely to increase peak flows, although there is a large uncertainty in the extent of the increase. We note that no climate change induced increases are immediately apparent within the Mokoreta at McKays Road flow record.

Relevant New Zealand studies are summarised as follows:

- New Zealand River Hydrology under Late 21st Century Climate Change (Collins, 2020) projects changes in the Mean Annual Flood Flow (MAFF) in the Southland region of 10% to 50% by 2100 (relative to 1986- 2005 MAFF).
- Both Gardner et al, (2019) and Steel et al, (2019) indicate that peak flow increases may be a further 50% higher than rainfall increases.

7.6.4 Discussion

HIRDS indicates that for the RCP6.0 scenario design rainfall depths may increase by 12 – 22%. For the purposes of this preliminary assessment, we consider a RCP6.0 peak flow increase of 15% is appropriate.

During detailed design rainfall runoff models could be developed to further review the likely change in peak flows due to climate change.

7.7 Design Flows

The NIWA (2018) catchment areas are approximate only and are not location specific. Table 14 compares NIWA catchment areas (taken from the closest downstream NIWA site to the NSC location) to Riley (2025) derived catchment areas using QGIS and the 2020-2021 LiDAR.

The Riley (2025) catchment areas are used for the reminder of the assessment.

Table 14: Catchment Areas (km^2)

Location	Riley (2025)	NIWA
NSC1	17.37	17.46
NSC2	12.28	12.32
NSC3	4.67	5.62
NSC4	2.85	2.98
NSC5	1.39	1.27
NSC6	1.23	1.52
NSC7	0.81	0.65
NSC8	0.80	0.79
NSC9	0.54	1.14

The design peak flow estimates are provided in Table 15.

Table 15: Peak Flow (m^3/s) Design Estimates

Location	10-Year ARI		100-Year ARI	
	2023	RCP6.0	2023	RCP6.0
NSC1	21.6	24.8	33.4	38.4
NSC2	16.4	18.8	25.3	29.1
NSC3	7.5	8.7	11.7	13.4
NSC4	5.1	5.8	7.9	9.0
NSC5	2.9	3.3	4.4	5.1
NSC6	2.6	3.0	4.0	4.6
NSC7	1.9	2.1	2.9	3.3
NSC8	1.8	2.1	2.8	3.3
NSC9	1.3	1.5	2.1	2.4

7.8 Comparison to Rational Method

The rational method is typically only considered appropriate for smaller catchment areas. The rational method has been used for the design of culverts within the smaller catchments within the Civil Design assessment for catchment areas up to 40ha or $0.4km^2$ in size. The rational method uses the following input parameters:

- Rainfall Intensity (mm/hr)
- Runoff Coefficent (dimensionless)
- Catchment Area (km^2)

Medium soakage soils with forest ground cover have a baseline runoff coefficient of 0.20.

Figure 6 presents a comparison between the regional method (noting that NIWA only presents estimates for catchment areas greater than 0.3km^2) and the rational method from the Civil Design assessment (C=0.20), for catchment areas less than 0.5km^2.

The two methods overlap closely between 0.3km^2 and 0.4km^2. We consider this is a favourable comparison and gives further confidence that both methods are appropriate.

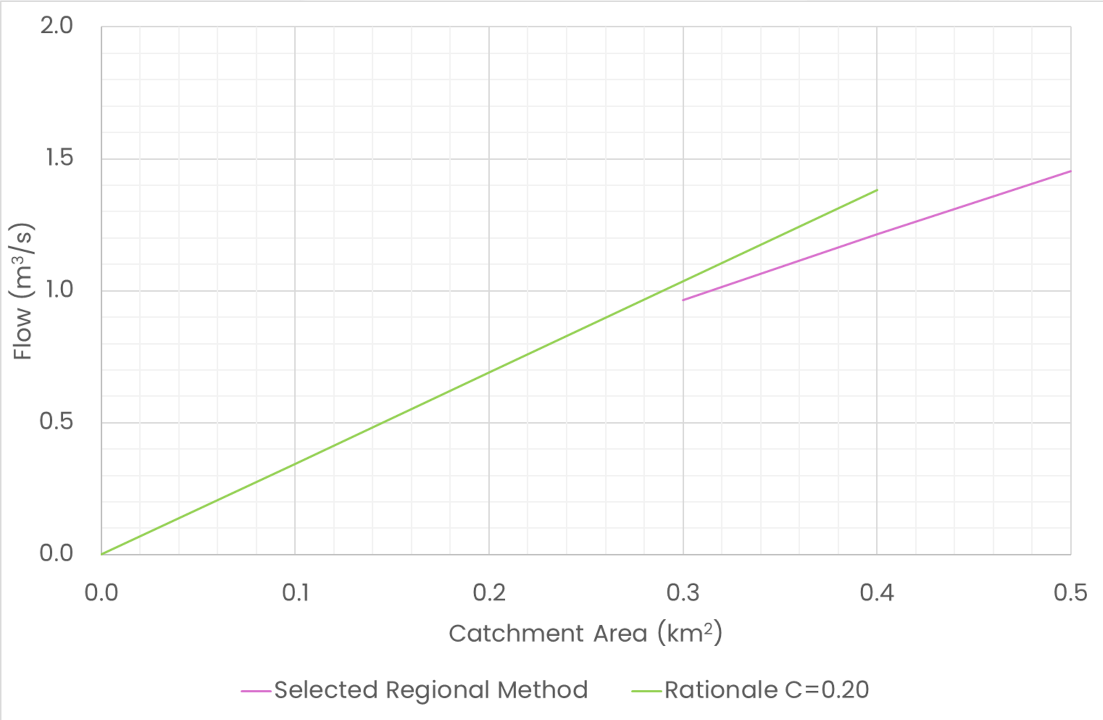


Figure 6: 10-Year (RCP6.0) Rational Method Comparison

8.0 Hydraulic Assessment

8.1 Background

A two-dimensional HEC-RAS hydraulic model was developed to simulate the flow hydraulics at the proposed stream crossings.

The hydraulic model consists of the following components:

- Terrain – a 3D surface representing the ground surface.
- Geometry – defines the extent and hydraulic representation of the modelled area.
- Upstream Boundary Condition – controls inflows to the geometry.
- Downstream Boundary Condition - controls outflows to the geometry.

8.2 Terrain

The LiDAR information was used for the terrain. The data is a digital elevation model (DEM) with a resolution of 1m by 1m. The vertical datum of the data is New Zealand Vertical Datum 2016.

We note the Mimihau Stream South Branch bridge was not included within the LiDAR.

8.3 Geometry

A separate geometry consisting of a single 2D flow area was created for each stream crossing. The 2D flow areas extend approximately 200m upstream and downstream of each stream crossing. A 1m-by-1m computational grid was used.

8.4 Stream Manning's Roughness

Manning's 'n' represents the surface roughness. A higher Manning's 'n' represents a rougher surface, and higher water levels for a given flow. Manning's 'n' is primarily affected by the flow rate, water slope, bed material, and bank vegetation. There is some uncertainty when selecting the most appropriate Manning's 'n'.

We note for each of the reaches, the river channels appear vegetation free, with gravels and cobbles. The floodplains near the proposed crossing locations are generally covered in brush and trees.

Chow (1959) provides descriptions of channels and corresponding Manning's 'n'. The description which is considered most representative of the streams is, "*mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages, with gravels, cobbles, and few boulders along the bottom*," which has a corresponding Manning's n of between 0.03 and 0.05, with a normal value of 0.04.

We have also reviewed Roughness Characteristics of New Zealand Rivers (NIWA 1998) which provides Manning's values for different river reaches throughout the country at different flows (generally similar to the mean flow). The respective sites feature similar characteristics to rivers with a Manning's value between 0.03 and 0.04. As Manning's values are a measure of relative roughness with respect to flow, Manning's values typically decrease as flows increase.

We have selected to use a Manning's value of 0.04 for all modelled streams, which we consider to be a conservative estimate for the design events (10- and 100-year ARI flows). We have also considered a sensitivity scenario, using an upper bound Manning's 'n' of 0.08, for the proposed bridge at NSC2 (Mimihau Stream South Branch).

8.5 Culverts

The culverts were modelled as internal connections within the 2D flow area. The crest of the track embankments have been modelled as weirs, with a coefficient of 1.7. The culvert inverts have been selected based on the stream inverts from the LiDAR data.

Proposed culverts designed to accommodate fish passage include embedment below the stream bed. Embedment depths have been modelled as blocked to represent the intended configuration.

We have also modified the model terrain locally at the culvert inlet and outlet to widen the stream invert and accommodate the culvert, and to set the culvert inverts below the natural stream level/embedment material where appropriate (for fish passage).

The selected Manning's n roughness values within the culverts are presented in Table 16.

Table 16: Culvert Manning's Roughness

Parameter	Value	Material
Bed Manning's n	0.030	Sand/Cobbles
Sidewalls and Obvert Manning's n	0.012	Concrete

Partial culvert blockage has not been allowed for. Such partial blockage could be considered during detailed design.

8.6 Upstream Boundary Condition

Flow hydrographs have been used as the upstream boundary condition for all geometries.

The peak flow estimates presented in Table 15 have been used. Each hydrograph ramps up to the peak flow and remains constant for sufficient time to reach a steady state throughout the 2D flow area.

8.7 Downstream Boundary Condition

We have conservatively used a normal depth downstream boundary condition with an energy slope of 0.01m/m (1%) which conservatively reflects the typical channel slopes of the downstream reaches.

The downstream boundary conditions are located approximately 200m downstream of each of the proposed crossings. We consider the downstream boundary conditions are a sufficient distance downstream from the crossings so that the assumed condition does not affect the hydraulic results near the crossings.

9.0 NSC1 - Mimihau Stream North Branch

9.1 Background

The existing crossing is a ford as shown in Figure 7 and Figure 8. The preferred crossing alignment is upstream of the existing ford. The stream in the area is located within a relatively wide and low-lying floodplain. The floodplain is covered in long brush.

Figure 7: Mimihau Stream North Branch
(Source: LINZ, Southland 0.4m Rural Aerial Photos, 2015-2017)

Figure 8: Mimihau Stream North Branch – View looking downstream from ford

9.2 Crossing Design

Trout passage prevention is required at NSC1, and therefore the culvert invert level has been set approximately 1.0m above the natural bed level. Design parameters are presented in Table 17.

Table 17: Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	6.0 x 1.5	-
Upstream Culvert Invert level (m RL)	263.0	Natural bed level approx. RL 262.0m
Downstream Culvert Invert level (m RL)	263.0	Natural bed level approx. RL 262.0m
Minimum Track Level (m RL)	265.7	-
Culvert Length (m)	20	Approximate

9.3 Hydraulic Model Results

The model results presented in Table 18, demonstrate that the proposed culvert arrangements meet the design criteria.

Table 18: Model Results[1.]

Parameter	10-Year ARI	100-Year ARI
Headwater Level (RL m)	284.12	265.81
Track Crest Level (RL m)	265.70	265.70
Freeboard/(Overtopping Depth) (mm)	580	(110)

1. RCP6.0 Scenario

10.0 NSC2 - Mimihau Stream South Branch

10.1 Background

An existing bridge at NSC2 is located across the Mimihau Stream South Branch as presented in Figure 9 and Figure 10. We understand that a topographical survey of the existing bridge has not been undertaken. The LiDAR indicates that the bridge approaches are at approximately RL 296.0m.

The preferred track alignment will cross the stream at the approximate location of the existing bridge; however, a new stream crossing is required to provide the preferred horizontal and vertical track alignment over the stream. The preferred elevation of the track at the stream crossing is approximately RL 298.0m, 2.0m above the inferred existing deck level.

The stream is relatively steep upstream and downstream of the proposed crossing, with an average longitudinal gradient of approximately 1.9% (over a 50m reach upstream and downstream of the existing bridge).

Figure 9: Mimihau Stream South Branch
(Source: LINZ, Southland 0.4m Rural Aerial Photos, 2015-2017)

Figure 10: Mimihau Stream South Branch - Existing Bridge (looking downstream)

10.2 Hydraulic Model Results

The peak water levels at the upstream side of the bridge are presented in Table 19. The model results indicate that the peak 100-year ARI flood level in both baseline and sensitivity scenarios is well below the existing (RL 296.0m) and proposed bridge track levels (RL 298.0m).

Table 19: Peak 100-Year ARI Water Level at the Upstream Side of the Existing NSC2 Bridge

Scenario	Peak Water Level (RL m)	Proposed Bridge Track Level (RL m)	Difference (m)
100-year Flood - Baseline (n=0.04)	293.5	298.0	4.5
100-year Flood - Sensitivity (n=0.08)	294.1	298.0	3.9

The details of the proposed bridge, such as the underside of the substructure level, will be confirmed during detailed design, however, there is expected to be at least 0.6m freeboard above peak 100-year ARI flood levels, which will comply with the design criteria.

11.0 NSC3 and NSC4 - Mimihau Stream South Branch Tributary 1

11.1 Background

Two notable stream crossings, NSC3 and NSC4 are proposed on Mimihau Stream South Branch Tributary 1. Both existing crossings are fords and are approximately 800m apart as shown in Figure 11. The preferred crossing alignment for NSC3 is directly upstream of the existing ford.

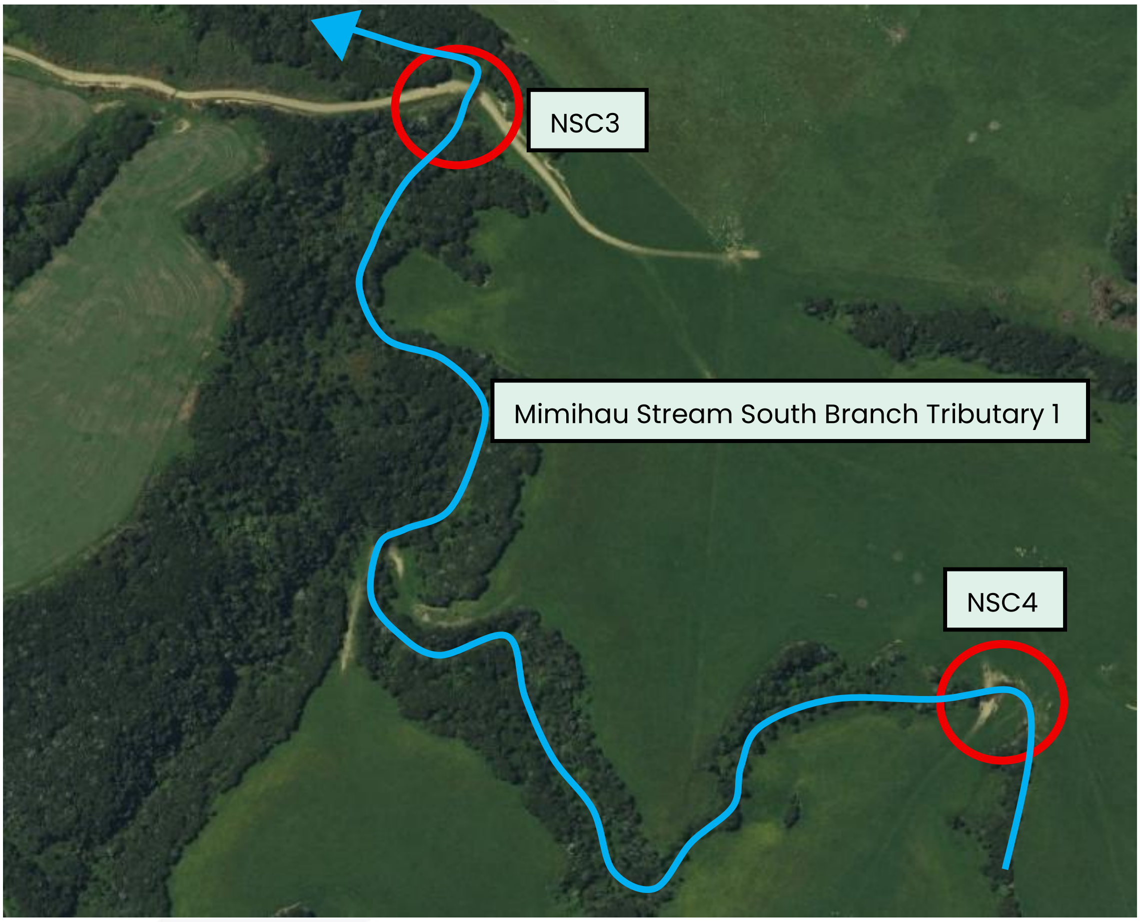


Figure 11: Mimihau Stream South Branch Tributary 1 – NSC3 and NSC4
(Source: LINZ, Southland 0.25m Rural Aerial Photos, 2023-2024)

Figure 12: NSC3 - Existing Ford (flow direction left to right)

11.2 Crossing Design

Trout passage prevention is required at NSC3, and therefore the culvert invert level has been set approximately 1.0m above the natural bed level. The NSC4 culvert invert has been set 300mm below the natural bed level to account for the embedment depth required to meet fish passage design criteria. Design parameters are presented in Table 20 and Table 21.

Table 20: NSC3 Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	3.0 x 1.5	-
Minimum Track Level (m RL)	358.90	-
Upstream Culvert Invert (m RL)	356.7	Natural bed level approx. RL 355.7m
Downstream Culvert Invert (m RL)	356.7	Natural bed level approx. RL 355.0m
Culvert Length (m)	26	Approximate

Table 21: NSC4 Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	3.0 x 1.0	-
Minimum Track Level (m RL)	381.5	-
Upstream Culvert Invert (m RL)	379.2	Natural bed level approx. RL 379.5m
Downstream Culvert Invert (m RL)	378.3	Natural bed level approx. RL 378.6m
Culvert Length (m)	20	Approximate

11.3 Hydraulic Model Results

The model results presented in Table 22 and Table 23, demonstrate that the proposed culvert arrangements meet the design criteria.

Table 22: NSC3 Model Results[1.]

Parameter	10-Year ARI	100-Year ARI
Headwater Level (RL m)	358.37	358.93
Track Crest Level (RL m)	358.90	358.90
Freeboard/(Overtopping Depth) (mm)	530	(30)

1. RCP6.0 Scenario

Table 23: NSC4 Model Results[1.]

Parameter	10-Year ARI	100-Year ARI
Headwater Level (RL m)	380.99	381.55
Track Crest Level (RL m)	381.50	381.50
Freeboard/(Overtopping Depth) (mm)	510	(50)

1. RCP6.0 Scenario

12.0 NSC5 and NSC7 - Mimihau Stream North Branch Tributaries

12.1 Background

Two notable stream crossings, NSC5 and NSC7, are proposed on two separate Mimihau Stream North Branch tributaries, as presented in Figure 13.

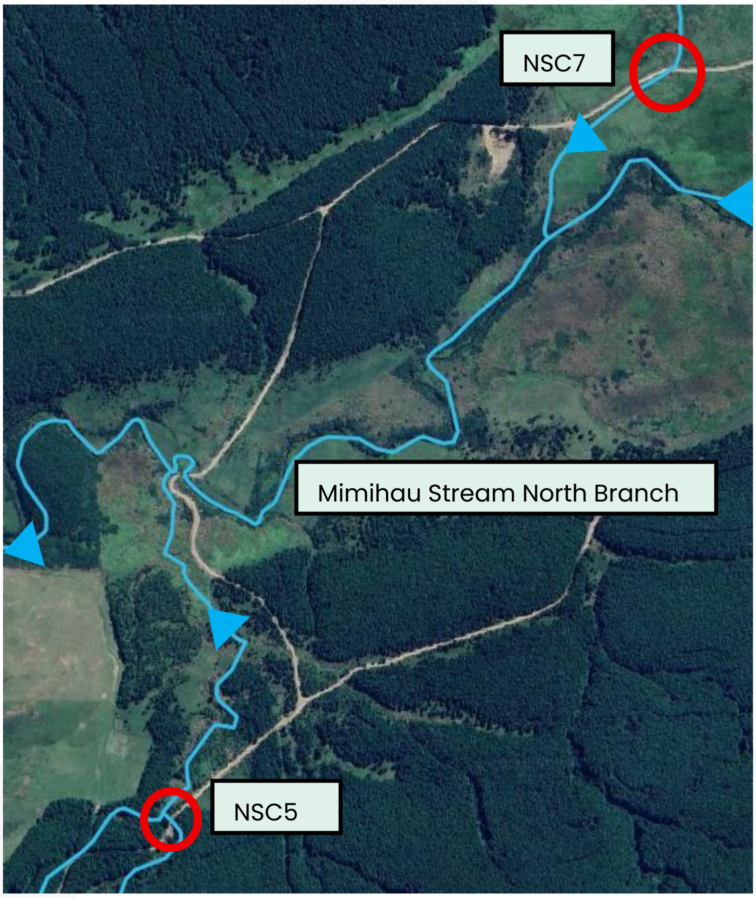


Figure 13: NSC5 and NSC7 Location (Source: Google Satellite 2025)

Figure 14: NSC5 - Existing Ford (downstream to the right)

Figure 15: NSC7- Existing Culvert Crossing(downstream to the left)

12.2 Crossing Design

Both the NSC5 and NSC7 culvert inverts have been set 300mm below the natural bed level to account for the embedment depth required to meet fish passage design criteria. Design parameters are presented in Table 24 and Table 25.

Table 24: NSC5 Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	3.0 x 1.0	-
Minimum Track Level (m RL)	282.07	-
Upstream Culvert Invert (m RL)	280.4	Natural bed level approx. RL 280.7m
Downstream Culvert Invert (m RL)	280.3	Natural bed level approx. RL 280.6m
Culvert Length (m)	20	Approximate

Table 25: NSC7 Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	2.0 x 1.0	-
Minimum Track Level (m RL)	275.65	-
Upstream Culvert Invert (m RL)	274.0	Natural bed level approx. RL 274.3m
Downstream Culvert Invert (m RL)	273.6	Natural bed level approx. RL 273.9m
Culvert Length (m)	20	Approximate

12.3 Hydraulic Model Results

The model results presented in Table 26, demonstrate that the proposed culvert arrangements meet the design criteria.

Table 26: Model Results[1.]

Parameter	NSC5		NSC7	
	10-Year ARI	100-Year ARI	10-Year ARI	100-Year ARI
Headwater Level (RL m)	281.56	282.05	275.15	275.51
Track Crest Level (RL m)	282.07	282.07	275.65	275.65
Freeboard (mm)	510	20	500	140

1. RCP6.0 Scenario

13.0 NSC6 and NSC8 - Kaiwera Stream East Branch

13.1 Background

Two notable stream crossings, NSC6 and NSC8, are proposed on the Kaiwera Stream East Branch approximately 250m apart, as presented in Figure 16.

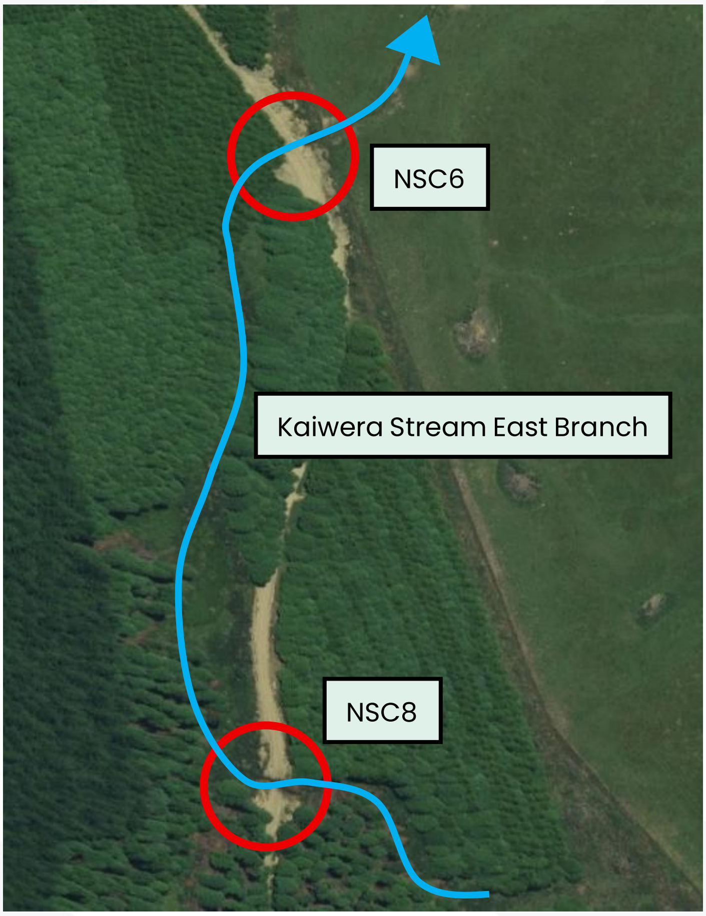


Figure 16: NSC6 and NSC8 Location
(Source: LINZ, Southland 0.25m Rural Aerial Photos, 2023-2024)

Figure 17: NSC6 - Existing Culvert Crossing (downstream to the left)

Figure 18: NSC8- Existing Ford (downstream to the right)

13.2 Crossing Design

Trout passage prevention is required at NSC6, and therefore the culvert invert level has been set approximately 1.0m above the natural bed level. The NSC8 culvert invert has been set 300mm below the natural bed level to account for the embedment depth required to meet fish passage design criteria. Design parameters are presented in Table 27 and Table 28.

Table 27: NSC6 Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	2.0 x 1.0	-
Minimum Track Level (m RL)	286.00	-
Upstream Culvert Invert (m RL)	284.4	Natural bed level approx. RL 283.4m
Downstream Culvert Invert (m RL)	284.1	Natural bed level approx. RL 283.1m
Culvert Length (m)	20	Approximate

Table 28: NSC8 Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	2.0 x 1.0	-
Minimum Track Level (m RL)	290.81	-
Upstream Culvert Invert (m RL)	289.2	Natural bed level approx. RL 289.5m
Downstream Culvert Invert (m RL)	288.8	Natural bed level approx. RL 289.1m
Culvert Length (m)	20	Approximate

13.3 Hydraulic Model Results

The model results presented in Table 29, demonstrate that the proposed culvert arrangements meet the design criteria.

Table 29: Model Results[1.]

Parameter	NSC6		NSC8	
	10-Year ARI	100-Year ARI	10-Year ARI	100-Year ARI
Headwater Level (RL m)	285.47	285.82	290.31	290.67
Track Crest Level (RL m)	286.00	286.00	290.81	290.81
Freeboard (mm)	530	180	500	140

1. RCP6.0 Scenario

14.0 NSC9 - Mimihau Stream South Branch Tributary 2

14.1 Background

NSC9 is located on a proposed transmission tower track. There is no existing crossing at NSC9, as presented in Figure 19.

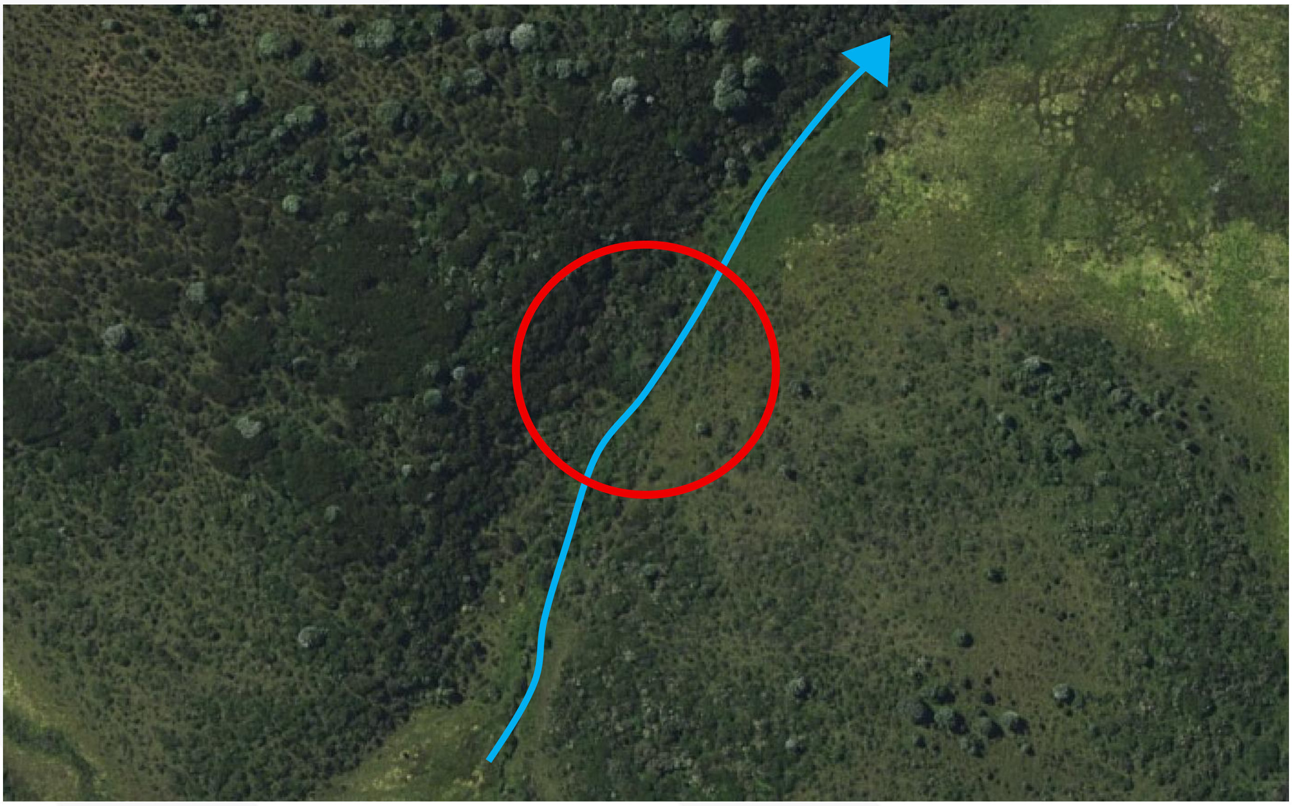


Figure 19: NSC9 Location (Source: LINZ, Southland 0.25m Rural Aerial Photos, 2023-2024)

14.2 Crossing Design

The NSC9 culvert invert has been set 300mm below the natural bed level to account for the embedment depth required to meet fish passage design criteria. Design parameters are presented in Table 30.

Table 30: Culvert Details

Parameter	Value	Comment
Culvert Size (m) (width x height)	2.0 x 1.0	-
Upstream Culvert Invert level (m RL)	560.6	Natural bed level approx. RL 560.9m
Downstream Culvert Invert level (m RL)	560.5	Natural bed level approx. RL 560.8m
Minimum Track Level (m RL)	261.55	-
Culvert Length (m)	13	Approximate

14.3 Hydraulic Model Results

The model results presented in Table 31, demonstrate that the proposed culvert arrangements meet the design criteria for a transmission tower track.

Table 31: Model Results[1.]

Parameter	10-Year ARI	100-Year ARI
Headwater Level (RL m)	261.57	261.63
Track Crest Level (RL m)	261.55	261.55
Overtopping Depth (mm)	20	80

1. RCP6.0 Scenario

15.0 Summary

The report is summarised as follows:

- The proposed track network required for the proposed wind farm crosses nine notable streams.
- The specified bridge hydraulic design criteria is 600mm freeboard above the 100-year ARI RCP6.0 scenario peak flood level.
- For the 100-year ARI RCP6.0 scenario, the specified culvert hydraulic design criteria is a maximum overtopping flood depth of 200mm.
- For the 10-year ARI RCP6.0 scenario, the specified culvert hydraulic design criteria is:
    - minimum 500mm freeboard for wind farm access tracks.
    - maximum overtopping flood depth of 200mm for transmission tower access tracks.
- The fish passage crossings have been designed in general accordance with the permitted activity requirements of NES-F Regulation 70, including a minimum culvert embedment of 300mm in accordance with SWLP Rule 59a.
- The trout prevention culverts will be raised so the culvert invert is 1.0m above the stream bed, creating a 1.0m vertical drop/barrier at the downstream end.
- The design flows have been derived using conservative ratios from the NIWA web portal "NZ Rivers Flood Statistics" and favourable comparisons have been made to other methods.
- The preliminary design culvert sizes for NSC1, and NSC3 - NSC9 are presented within Table 32.
- A new bridge with a track elevation of RL 298.0m is proposed for the Mimihau Stream South Branch crossing (NSC2), which is 4.5m above the predicted 100-year ARI RCP6.0 scenario flood level.
- The details of the proposed culverts and bridge will be confirmed during detailed design, based on topographic site survey information.

Overall, the culvert sizes are similar to each other, and if special culverts need to be manufactured, there may be some construction cost saving in standardising the sizes further. The culvert geometry can be provided by two (or more) box culverts in a parallel.

Table 32: Notable Stream Crossings

Location	Catchment Area (km^2)	River Environment Classification (MfE)	100-Year ARI RCP6.0 Design Flow (m^3/s)	Geometry (W x H) (m)[1.]	Existing Culvert Length (m)	Proposed Culvert Length[2.] (m)
NSC1[3.]	17.37	3	38.4	6.0 x 1.5	Ford	20
NSC2	12.28	3	29.1	Bridge	Bridge	n/a
NSC3[3.]	4.67	3	13.4	3.0 x 1.5	Ford	26
NSC4	2.85	2	9.0	5.5 x 1.0	Ford	20
NSC5	1.39	2	5.1	3.0 x 1.0	Ford	20
NSC6[3.]	1.23	2	4.6	2.0 x 1.0	10	20
NSC7	0.81	1	3.3	2.0 x 1.0	7	20
NSC8	0.80	1	3.3	2.0 x 1.0	Ford	20
NSC9	0.54	1	2.4	2.0 x 1.0	n/a	13

[1.]Internal dimensions presented.
[2.]Culvert lengths are conservatively estimated and will be refined at detailed design stage.
[3.] Trout Prevention Culvert.

Preliminary design drawings of the notable stream crossings are included in Appendix A as follows:

220372-1145 Notable Stream Crossing – Typical Fish Passage Culvert

220372-1146 Notable Stream Crossing 1 – Trout Passage Prevention Culvert

220372-1147 Notable Stream Crossing 3 – Trout Passage Prevention Culvert

220372-1148 Notable Stream Crossing 6 – Trout Passage Prevention Culvert

16.0 Limitation

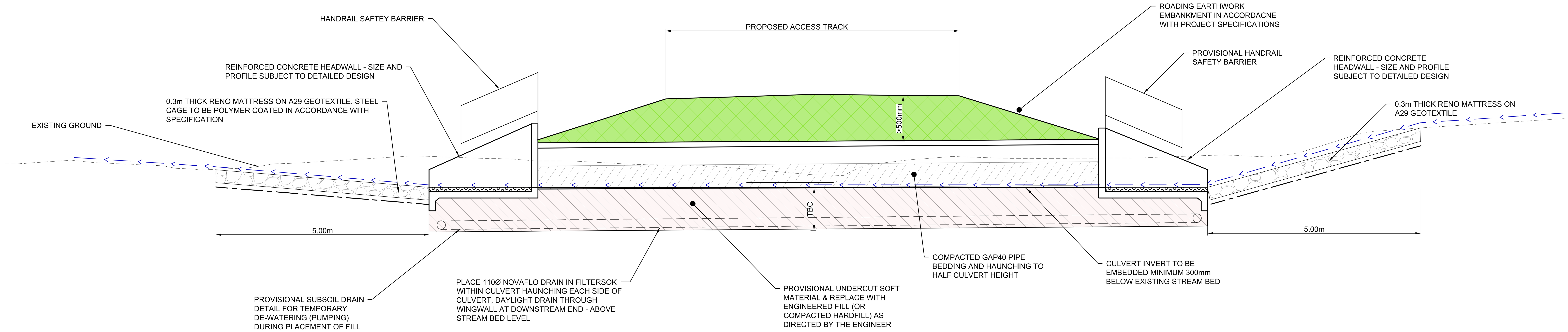
This report has been prepared for Contact Energy Limited (Contact), to inform the Expert Consenting Panel's consideration of Contact's application for approvals under the Fast-track Approvals Act 2024 and any subsequent regulatory processes.

The hydrological and hydraulic analyses and recommendations contained in this report are based on our understanding and interpretation of the available information. The recommendations are therefore subject to the accuracy and completeness of the information available at the time of the study. Should any further information become available, the analyses and findings of this report should be reviewed accordingly.

Appendix A

Riley Drawings:
220372-1145 to -1148

2.5 5 10m
SCALE 1:250



0.5 1 2m
SCALE 1:50

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CLIENT	CONTACT ENERGY
ADDRESS	VENLAW ROAD 794, SLOPEDOWN, SOUTHLAND
PROJECT	SOUTHLAND WIND FARM
SHEET TITLE	TYPICAL NOTABLE STREAM CULVERT DETAILS - FISH PASSAGE

CADFILE	
220372-1145.dwg	
SCALE (A1)	ORIG. SHEET SIZE
AS SHOWN	A1
DRAWING No.	REV.
220372-1145	A

STREAM CROSSING NSC1

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SCALE 1:50

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ADDRESS	VENLAW ROAD 794, SLOPEDOWN, SOUTHLAND
PROJECT	SOUTHLAND WIND FARM
SHEET TITLE	NOTABLE STREAM CULVERT (NSC1) DETAILS - TROUT PASSAGE PREVENTION

CADFILE	
220372-1146to1148.dwg	
SCALE (A1)	ORIG. SHEET SIZE
AS SHOWN	A1
DRAWING No.	REV.
220372-1146	A

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ADDRESS	VENLAW ROAD 794, SLOPEDOWN, SOUTHLAND
PROJECT	SOUTHLAND WIND FARM
SHEET TITLE	NOTABLE STREAM CULVERT (NSC3) DETAILS - TROUT PASSAGE PREVENTION

CADFILE	
220372-1146to1148.dwg	
SCALE (A1)	ORIG. SHEET SIZE
AS SHOWN	A1
DRAWING No.	REV.
220372-1147	A

STREAM CROSSING NSC6

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ADDRESS	VENLAW ROAD 794, SLOPEDOWN, SOUTHLAND
PROJECT	SOUTHLAND WIND FARM
SHEET TITLE	NOTABLE STREAM CULVERT (NSC6) DETAILS - TROUT PASSAGE PREVENTION

CADFILE	220372-1146to1148.dwg
SCALE (A1)	AS SHOWN
ORIG. SHEET SIZE	A1
DRAWING No.	220372-1148
REV.	A

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