TE TUPU NGĀTAHI
SUPPORTING GROWTH

North
Assessment of Flooding Effects

August 2023

Version 1.0

WAKA KOTAHI NZ TRANSPORT AGENCY

New Zealand Government

Document Status

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Abbreviations

Acronym/Term	Description
AC	Auckland Council
AC HW	Auckland Council Healthy Waters
AEE	Assessment of Effects on the Environment
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AT	Auckland Transport
AUP: OP	Auckland Unitary Plan Operative in Part
CEMP	Construction Environmental Management Plan
FUZ	Future Urban Zone
GD01	Auckland Council Guideline Document: Stormwater management devices in the Auckland region, GD2017/001 (an update of TP10)
GD05	Auckland Council Guideline Document: Erosion and Sediment Control Guide, GD2016/005
GIS	Geographic Information System
LGA	Local Government (Auckland Council) Act 2009
MfE	Ministry for the Environment
MPD	Maximum Probable Development
NES	National Environmental Standard
NPS	National Policy Statement
NPS: FM	National Policy Statement on Freshwater Management
NPS: UD	National Policy Statement on Urban Development 2020
NoR	Notice of Requirement (under the Resource Management Act 1991)
RCP	Representative Concentration Pathways
RMA	Resource Management Act 1991
SEA	Significant Ecological Area
SGA	Te Tupu Ngātahi Supporting Growth Alliance
SH1	State Highway 1
SMAF	Stormwater Management Area: Flow
SRP	Sediment Retention Pond
Te Tupu Ngātahi	Te Tupu Ngātahi Supporting Growth
Waka Kotahi	Waka Kotahi NZ Transport Agency

Glossary of Acronyms / Terms

Acronym/Term	Description
AT	Auckland Transport an Auckland Council controlled organisation.
Auckland Council	Means the unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
Freeboard	An allowance above the modelled flood level, be it road level or other features (e.g. existing floor level). For buildings freeboard shall be measured from the top water level to the finished floor level. The relevant design manual shall be referred to for the appropriate freeboard and method of calculation.
Lay down areas	An area that has been cleared for the temporary storage of materials and equipment and may include site compounds, stockpiles, sediment retention ponds.
MPD	Maximum Probable Development according to the AUP: OP zonings and the Auckland Council Healthy Waters technical memorandum dated 4/9/2019
Pre-development	Prior to construction of the Project
Post-development	After construction of the Project
Stormwater Wetland	Constructed wetlands that store runoff and support conditions suitable for the growth of wetland plants. Stormwater wetlands provide enhanced water quality treatment of stormwater runoff through vegetation uptake, retention and settling. They can also be used for attenuation to reduce the predicted peak flow from a rainfall event and provide downstream erosion and flooding protection / mitigation.
Terrain	An elevation model which includes the ground levels based on 2016 LiDAR ground levels.

Executive Summary

Overview

The Te Tupu Ngātahi North Projects are a network of planned transport infrastructure with the purpose of responding to planned future growth in the North growth areas. The transport network is made of 13 Notices of Requirement (NORs) including new corridors, existing road upgrades, rapid transit corridor, stations and cycle / walkways.

Flooding is a natural hazard and has therefore been considered as part of the North NORs to assess if the North Projects will impact that flooding (using the models that were recently updated by Te Tupu Ngātahi to understand the existing flood risks). The models have been sent to Auckland Council Healthy Waters (AC HW) for review and acceptance. The flood results have been compared to those published on the AC Geomaps site and compare well, particularly the latest 2023 version which uses the same AC modelling approach as Te Tupu Ngātahi.

The land required for construction areas and mitigating future stormwater impacts has also been considered; along with bridges and culverts, attenuation and treatment of runoff from NOR impervious surfaces and impacts on stream diversions or flow paths.

It is acknowledged that there will be a subsequent outline plan process and process for seeking regional resource consents which will address a wider range of potential stormwater quantity and quality effects and will require additional detailed modelling and design in future.

In the context of this assessment, flood hazard risk may include changes to:

- the flood freeboard to existing habitable buildings, overland flow paths
- the ability to access property by residents and emergency vehicles
- the level of flooding to roads and flooding arising from the blockage of stormwater drainage
- effects to existing habitable buildings / infrastructure and potential future effects on upstream and downstream properties.

Assessment undertaken

The assessment of flooding effects has involved the following steps:

- Desktop assessment to identify potential flooding locations
- Modelling of the pre-development (base case) scenario
- Producing flood level maps for the pre-development scenario to show the flood levels and extents (greater than 50 mm deep) that need to be considered
- Inspection and review of flood maps at key locations such as proposed bridges, culverts, wetlands and major earthworks to identify potential flooding effects
- Modelling of the concept design for areas that are identified as having the greatest flood hazard risk i.e. the predicted overtopping of Dairy Flat Highway (NoR 8) to the west of the existing Bawden Road intersection and both sides of the Green Road intersection; the realigned Bawden Road and bridge (NoR 12); Upgrade to Pine Valley Road (NoR 7) and SH1 improvements (NoR 4) were considered sufficient to warrant modelling of the post Project case.

The pre-development (base case) scenario relates to the existing network model without the North Projects, with future development impervious allowances (as per the AUP:OP zonings and the AC Healthy Waters memo of 4 Sept 2019), 2016 terrain, larger existing pipes or bridges with the 1% AEP return period future storms including climate change scenarios of 2.1 and 3.8° temperature increases. The base case scenario provides water levels and flow paths to be able to complete concept design of the formations (existing raised and widened plus new formations) allowing for freeboard for roads, culverts and bridges.

Apart from NoR 4, NoR 7, NoR 8 and 12, the post-development scenario with the North Projects design added to the model has not been assessed at this stage and is proposed to be done at the later detailed design and modelling stage. This is because the North Projects are not being built anytime soon (some 10 to 30 years + in the future) and therefore the flooding design standards may well change which will require design and flood modelling to be completed again.

For NoR 4, 7, 8 and 12, the post development scenario was modelled based on the indicative design. This confirmed that, subject to design development, the designation area provides sufficient room so the proposed NOR conditions can be met in the future. This will be confirmed at the detailed design stage with further assessment. This provides confidence that the designation conditions can be met in other parts of the study area which have not been modelled post development.

The assessment focuses on flooding effects as this is a district plan matter under the AUP: OP that requires assessment for the purposes of an NoR.

Stormwater effects (stormwater quantity and quality) is a regional plan issue which will be subject to a future regional consenting process during later stages. Provision was made for the potential future stormwater effects by identifying the space required for stormwater management devices (i.e. treatment and/or attenuation wetlands) and incorporating land for that purpose into the NOR and designations.

Results of assessment and recommended measures

The main positive effects associated with the North Project NORs are:

- proposed new transport corridors / stations will be above the predicted future flood plains that allow for climate change of 2.1° temperature increase.
- proposed widened and improved corridors to be above the predicted future flood plains, particularly existing overtopping roads which provides resilience for these roads
- ability to convey flows without worsening flooding impacts upstream or downstream of the works within the proposed designation conditions
- added water quality treatment and attenuation of the total roadway impervious area as opposed to just the additional roadway area for upgraded roads.

Construction effects

The proposed construction works which could potentially result in flooding effects include raised road formations, temporary works for proposed bridges and culverts restricting flows, interruption of flow paths by new wetlands and temporary laydown or construction areas.

The management and mitigation measures for construction flooding effects are:

- Setting the earthwork construction period during typically drier periods

- Locating lay down and construction areas outside of flooding and overland flow paths
- Temporary diversions for bridge, culvert and wetland construction
- Managing overland flow paths to reduce the risk of increased flooding
- Construction methodology planning along with contingency planning for large rainfall events during construction including rainfall monitoring
- Construction Environmental Management Plans developed and implemented, including continuous improvement as necessary.

The proposed designation conditions require that the Construction Environmental Management Plan (CEMP) includes measures to mitigate flood hazard effects such as siting stockpiles out of floodplains, minimising obstruction to flood flows, and actions to respond to warnings of heavy rain.

- Operational effects

The potential operational effects are:

- Increasing impervious areas leading to extra peak runoff and exacerbating flooding
- Altering or obstructing existing overland flow paths which can lengthen flow paths and increase flood risk
- Embankments built within flood plains will reduce flood storage and increase predicted water levels
- Widening embankments will increase the length of existing culverts which can increase upstream water levels due to inlet inverts being higher if widened on the inlet side and the culvert extended on the existing grade. If formation widening on the downstream side the upstream water level will also increase due to greater culvert friction losses due to the increased culvert length
- Widening embankments will increase the channel length under existing bridges and if the waterway area is maintained it will increase upstream water levels due to greater bridge waterway friction losses
- Changing flows through bridge or culvert crossings can increase or decrease upstream and downstream water levels and therefore potentially impact flood levels
- Increased impervious area to treat for treatment, attenuation or both dependent on the location of the device in the catchment.

A Flood Hazard condition is proposed which will require the future detailed design of the transport corridors to be designed to achieve specific flood risk outcomes. The condition includes flood modelling of the pre-Project and post-Project 1% AEP flood levels (for Maximum Probable Development land use and including climate change).

Specifically the condition states that:

a) The Project shall be designed to achieve the following flood risk outcomes:

   i. no increase in flood levels in a 1% AEP event for existing authorised habitable floors that are already subject to predicted flooding or have a freeboard less than 150mm;

   ii. no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard of over 150mm;

   iii. no increase in 1% AEP flood levels for existing authorised community, commercial and industrial building floors that are already subject to flooding;

iv. no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial and industrial building floors;

v. no increase of more than 50mm in flood level in a 1% AEP event on land zoned for urban or future urban development where there is no existing dwelling;

vi. no new flood prone areas; and

vii. no more than a 10% average increase in flood hazard (defined as flow depth times velocity) for main access to existing authorised habitable dwellings existing at the time the Outline Plan is submitted. The assessment shall be undertaken for the 1% AEP rainfall event.

Mitigation measures which may be implemented to meet these outcomes include:

- Optimising bridges, culverts and wetlands to assess cumulative effects of upstream NORs on downstream NORs
- Designing bridge and culvert locations / sizes so that the predicted upstream and downstream water level differences between the 1% AEP pre and post development scenarios comply with the NOR flooding hazard conditions (the Outcomes)
- Providing overland flow paths to avoid creating new flood prone areas
- Installing drains at the toe of the embankment sloping towards the culverts can also provide additional storage to decrease the velocity and peak flow through the culvert crossings
- Installing drains at the top of cuttings to reduce water entering the cutting and thus need conveying through the cutting. This can also be improved using benches in deep cuttings to further reduce the flow entering the cutting base drain
- Providing space for wetlands for treatment and attenuation as needed.

Conclusions

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

The positive flooding effects are primarily associated with raising existing roads out of the flood plain that are currently predicted to flood in the future 1% AEP events plus treatment of existing roads that are widened. However, raising roads needs to be accompanied by providing sufficient new cross drainage capacity so that upstream flood levels are not increased.

The key flooding effects and controls within the North Projects area are associated with:

- the large potential flood flows upstream of NOR 1, 4, 5, 6, 8, 10 and 12 during the construction phase. The proposed CEMP condition includes measures to mitigate flood hazard effects such as siting stockpiles out of floodplains, minimising obstruction to flood flows, and actions to respond to warnings of heavy rain.
- The assessed flood hazards during operation (listed above) can be managed by adjusting the proposed road geometry and changing the culvert and bridge opening areas during detailed design so that the proposed NOR conditions will be met.

The detailed design of stormwater treatment and management will be subject to regional consenting requirements.

1 Introduction

This flooding assessment has been prepared for the Te Tupu Ngātahi Supporting Growth Alliance, North Projects to support 13 Notices of Requirement (NoR) for Auckland Transport (AT) and Waka Kotahi NZ Transport Agency (WK) as the requiring authorities under the Resource Management Act 1991 (RMA). The NoR are to designate land for future strategic transport corridors and two rapid transit corridor stations to enable the future construction, operation and maintenance of transport infrastructure in the North area of Auckland.

The North Project area extends from Albany to Ōrewa through the growth areas of Dairy Flat, Silverdale West, Wainui East, and Redvale (refer to Figure 2-1 below). The North Projects are summarised in Section 2.

This report addresses the flooding effects of the North Projects identified in Section 2.

Refer to the main Assessment of Effects on the Environment (AEE) for a more detailed project description.

During the later outline plan and regional consenting phases, additional detailed modelling and design will be completed to refine the proposed design achieve flood hazard condition requirements.

The detailed design of stormwater management will also be subject to regional consenting requirements.

1.1 Purpose and Scope of this Report

This flooding assessment forms part of the suite of technical reports prepared to support the AEE for the North Projects. Its purpose is to inform the AEE that accompanies the North NoRs for AT and WK.

This report considers the actual and potential effects associated with the construction, operation and maintenance of the North Projects on the existing and likely future environment as it relates to flooding effects and recommends measures that may be implemented to avoid, remedy and/or mitigate these effects.

The key matters addressed in this report are as follows:

- Identify and describe the stormwater and flooding context of the North Projects area;
- Identify and describe the actual and potential flooding effects of each Project corridor;
- Recommend measures as appropriate to avoid, remedy or mitigate actual and potential flooding effects (including any conditions/management plan required) for each Project corridor; and
- Present an overall conclusion of the level of actual and potential flooding effects for each Project corridor after recommended measures are implemented.

This report should be read alongside the AEE, which contains further details on the history and context of the North Projects. The AEE also contains a detailed description of works to be authorised within each NoR, and the typical construction methodologies that will be used to implement this work. Where a description of an activity is necessary to understand the potential effects, it has been included in this report for clarity.

1.2 Report Structure

The report is structured as follows:

a) Project overview with a summary of the North Projects in Section 2;
b) Overview of the methodology used to undertake the assessment and identification of the assessment criteria and any relevant standards or guidelines in Section 3;
c) Identification and description of the existing and likely future flooding/stormwater environment in Section 4;
d) Description of the actual and potential positive effects on flooding/stormwater of the overall network of Projects in Section 5;
e) Description of the actual and potential adverse flooding effects of construction of the Projects, including recommended measures to avoid or mitigate potential adverse effects, in Section 5;
f) Description of the actual and potential adverse flooding effects of operation of the Projects, including recommended measures to avoid or mitigate potential operation adverse effects in Sections 6-18;
g) Overall conclusion of the level of potential adverse flooding effects of the Projects after recommended measures are implemented in Section 19.

This report contains an assessment of the actual and potential effects of the North Project on an overall catchment basis; in addition, the individual corridors have their own sections explaining if there are specific issues for each. Where appropriate, measures to avoid, remedy or mitigate effects are recommended for catchment wide and specific flooding and stormwater issues.

2 North Projects Overview

An overview of the North Projects is provided in Figure 2-1 below, with a brief summary of the North Projects provided in Table 2-1.

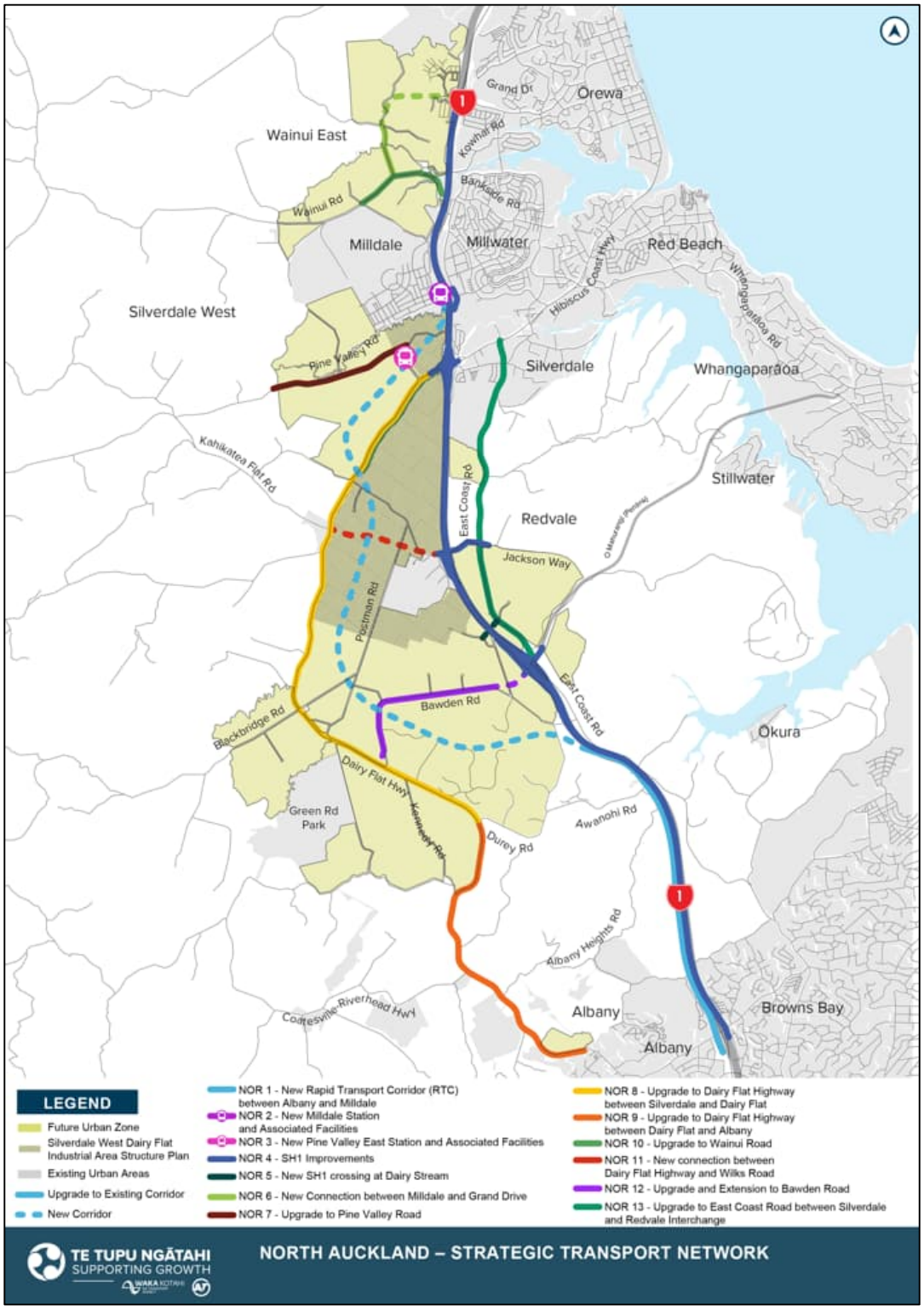

Figure 2-1. Map showing the location of each Project within the North growth area

Table 2-1. North Projects Summary

NOR	Corridor	Description	Requiring Authority
1	New Rapid Transit Corridor (RTC) between Albany and Milldale, including new walking and cycling path between Bawden Road and Dairy Flat Highway	• A 16km-long RTC corridor for public transport and active mode purposes • An 80km/hr operating speed (other than around stations) • Walking and cycling facilities along some of its length from Bawden Road to the point where the RTC crosses Dairy Flat Highway • Grade separated crossings at intersections with other key transport corridors. • The NoR will overlap with the existing motorway designation and SH1 improvements project over some of the length (between Albany and around Bawden Road)	Waka Kotahi
2	New Milldale Station and Associated Facilities	• A new rapid transit station and associated facilities, including: • Station building with associated station facilities • Cycle and shared mobility device parking provision • Local bus layover and stop provision • Taxi and ride share drop-off facilities	Waka Kotahi
3	New Pine Valley East Station and Associated Facilities	• A new rapid transit station and associated facilities, including: • Station building with associated station facilities on structure over New Pine Valley Road with associated stairs and lift towers • Cycle and shared mobility device parking provision • Local bus layover and stop provision • Layover facilities for bus based RTC mode • Taxi and ride share drop-off facilities • Park and ride facility (up to 500 car parking spaces) • Upgrade to Old Pine Valley Road along station frontage	Waka Kotahi
4	SH1 Improvements	• Widening the SH1 carriageway from two lanes to three lanes in each direction from the Lonely Track Road overbridge to the Silverdale interchange	Waka Kotahi

NOR	Corridor	Description	Requiring Authority
	(alteration to designations 6761, 6760, 6759, 6751)	• Upgraded Ō Mahurangi Penlink (Redvale) Interchange (upgrading this proposed interchange to add north facing ramps) • New Wilks Road interchange (south facing ramps only) • Silverdale interchange upgrade for east-west capacity • New walking and cycling path along SH1 -an approximately 16 km long active mode corridor along one side of SH1 from Albany to Grand Drive (starts on east of SH1 at Oteha Valley Road, crosses to west of SH1 around Bawden Road and then back to east around Silverdale interchange.) • Silverdale to Highgate Active mode connection - connection from the strategic active mode corridor at Silverdale to Highgate Parkway • Wainui interchange upgrade for active modes – new bridge for active modes across SH1	
5	New SH1 crossing at Dairy Stream	• A new two-lane urban arterial connection and SH1 motorway overbridge between Top Road and East Coast Road near Huruhuru (Dairy Stream) • Active mode facilities on both sides of the carriageway • The overbridge would cross six lanes of motorway, a two-lane link road to the motorway service centre and the new walking and cycling path on SH1 (refer to NoR 4 above)	AT
6	New Connection between Milldale and Grand Drive	• A new two-lane urban arterial with separated walking and cycling facilities on both sides between Wainui Road (Milldale) and the western edge of the Ara Hills development in Ōrewa. This will connect through to Grand Drive at SH1 via a new 30m road corridor to be vested by the Ara Hills developer.	AT
7	Upgrade to Pine Valley Road	• An upgrade to Pine Valley Road (FUZ section) between Poynter Lane and Argent Lane to a two-lane urban arterial with separated walking and cycling facilities on both sides	AT

NOR	Corridor	Description	Requiring Authority
8	Upgrade to Dairy Flat Highway between Silverdale and Dairy Flat	• An upgrade to a 4-lane urban arterial on sections where FUZ land is located both sides of the road (between Silverdale interchange and Wilks Road and between Richards Road and Durey Road), with separated walking and cycling paths on both sides of the corridor • Upgrade to a 2-lane rural arterial between Wilks Road and Richards Road – with a swale on the west and separated walking and cycling on the east • Upgraded bridge over Huruhuru (Dairy Stream)	AT
9	Upgrade to Dairy Flat Highway between Dairy Flat and Albany	• An upgrade to Dairy Flat Highway between Dairy Flat and Albany for active mode and safety improvements including a central wire rope barrier and wide barriers. • The widened Road corridor will retain two lanes (one in each direction) and will also retain crawler lanes as currently located • Cycle path added on the western side of the carriageway between Durey Road and the Coatesville Riverhead Highway Roundabout and then on the eastern side between the Roundabout and Te Wharau (Albany Village).	AT
10	Upgrade to Wainui Road	• Upgrade to Wainui Road to a 2-lane urban arterial between Lysnar Road and the new Argent Lane • Separate, dedicated, walking and cycling facilities on both sides of the carriageway • Upgraded bridge over Waterloo Creek (tributary to Ōrewa River)	AT
11	New connection between Dairy Flat Highway and Wilks Road	• Segment 1 (Kahikatea Flat Road to Postman Road Segment) will feature a 2-lane urban arterial (24 m wide corridor) with separated walking and cycling facilities on both sides. • Segment 2 (Postman Road to SH1) features a 4-lane urban arterial (30 m wide corridor) with separated cycling and walking facilities, two lanes of general traffic and two-lanes where priority may given to freight traffic.	AT
12	Upgrade and Extension to Bawden Road	• Upgrade and extension to Bawden Road. This will include a 30m four-lane road corridor with walking and cycling facilities on both sides.	AT

NOR	Corridor	Description	Requiring Authority
		Two lanes for general traffic and two lanes for a frequent transit network (likely bus lanes). • Road intersects with the RTC. The road is likely to go under the RTC (grade separated crossing).	
13	Upgrade to East Coast Road between Silverdale and Ō Mahurangi Penlink (Redvale) Interchange	• Upgrade to the footpath on the west side and new footpath on east side between Hibiscus Coast Highway and Silverwater Drive. • Segment 1 (from Silverwater Drive to Newman Road) features a two-lane urban arterial upgrade (24 m) with separated walking and cycling facilities on both sides. • Segment 2 (from Newman Road to Jackson Way, where one or both sides is rural) has a shared path to the west only, with no site works to the existing carrigeway and no swales. • Segment 3 (from Jackson Way to the end of the FUZ) features a 24 m wide cross section with walking and cycling facilities on both sides.	AT

3 Assessment Methodology

3.1 Assessment of Flooding Effects

The assessment of flooding effects has involved the following steps:

- Desktop assessment to identify potential flooding locations using the Auckland Council and Te Tupu Ngātahi GIS and flood model results;
- Flood modelling of the pre-development (base case) scenario using either existing Auckland Council models or updating of the models using the latest AC LiDAR, WK and AT asset data;
- Inspection and review of flood maps at key locations such as proposed bridges, culverts, wetlands and major earthworks;
- Modelling of the concept design for areas that are identified as having the greatest flood hazard risk i.e. parts of NoR 4 – SH1 improvements, NoR 7 – Upgrade to Pine Valley Road, NoR 8 – Upgrade to Dairy Flat Highway; and NoR 12 – Upgrade and Extension to Bawden Road.
- Reviewing flooding information gathered from the community during DBC engagement.

The pre-development (base case) scenario relates to the existing network model without the North Projects, with future development impervious allowances, 2016 terrain, larger existing pipes or bridges with the 1% AEP return period for future storms including climate change scenarios of 2.1 and 3.8° temperature increases. The 2.1° of temperature increase for climate change relates to a 16.8% increase over the existing 1% AEP rainfall, whilst the 3.8° of temperature increase relates to a 32.7% increase of rainfall.

The future development imperviousness is based on the AUP: OP zonings plus the maximum impervious allowance as per the AC Healthy Waters modelling memo of 4 Sept 2019. The base case scenario provides water levels and flow paths to be able to complete concept design of the formations (existing raised and widened plus new formations) allowing for freeboard for roads, culverts and bridges.

Other than for NoRs 4, 7, 8 and 12, the post-development scenario with the North Projects design added to the model has not been assessed at this stage and is proposed to be done at the later detailed design and modelling stage. This is because the North Projects are not being built anytime soon (some 10 to 30 years + in the future) and the flood standards may well change (e.g. 1% AEP event rainfall and climate change).

The proposed NOR designations allow for sufficient land area to be able to refine the design later to comply with the NOR flooding conditions. The assessment focuses on flooding effects as this is a district plan matter under the AUP: OP that requires assessment for the purposes of an NoR.

3.2 Model used for the assessment of flooding effects

A rapid flood hazard model was developed for the Okura North, Dairy Flat and Pine Valley / Silverdale catchments for Auckland Council in 2009 by DHI using Mike 21 software. The model was built using the Auckland Council Rapid Flood Hazard Approach (RFHA). Given the age of the model, large grid size and lack of climate change consideration, new RFHA models were built for these three catchments using the RFHA process using TUFLOW (version 2020-01-AB).

A rapid flood hazard model was developed for the Orewa River West catchment for Auckland Council in 2016 by WSP. The model was built in Infoworks ICM v 5.5.1.1 with a flexible mesh created for the entire catchment using 2010 LiDAR. Model development details are provided in the Opus Orewa West Catchment RFHA report available on the Auckland Council Geomaps.

The four (4) Te Tupu Ngātahi base case (pre-Projects) catchment models were sent to AC Healthy Waters (AC HW) for review in Sept 2020.

3.2.1 Model Limitations

- The effective rainfall estimation is limited by the ARC TP108 rainfall-runoff model which is expected to be within ± 25% at a confidence level of 90% for the 1% AEP ARI storm event (ARC, 1999).
- The extents of flooding and ponding areas were mapped based on 2016 LiDAR data. No specific survey was conducted for flood extent mapping. Therefore, the accuracy of the flood extent maps depends on the compound effects of uncertainties in the TP108 rainfall-runoff model, uncertainties in the hydraulic model parameters, and the accuracy of the LiDAR ground model.
- Hydrological processes are represented in a uniform way without accounting for spatial distribution within the catchment and with losses pre-applied to the rainfall time-series.
- Watercourses are not accurately resolved in the rapid flood hazard assessment model as capacity may be understated due to LiDAR issues.
- Culvert inlet and outlet invert levels have been interpolated from LiDAR where not available.
- The model has not been calibrated to recorded events. TP108 rainfall runoff sense checks have been done.

3.2.2 Model Assumptions

- It is assumed the culverts and bridges included in the 1D model are fully operating with no blockages restricting flows.
- Apart from some larger culverts included in the 1D model, all other culverts in the catchment are assumed blocked in the 1% AEP rainfall with climate change scenario.
- Some smaller bridges have not been modelled which will create artificial ponding areas upstream of the bridge site. The assumption is that there is a higher risk of the bridge being blocked with debris.

3.3 Site assessment of floor levels

Floors within the predicted pre-Project 1% AEP rainfall with 2.1° of climate change flood extent and near the NOR alignments were visited in July 2023 to assess the distance between the existing ground level and the authorised habitable floor level. This was done from roadways (public land) and no entry to private property occurred. The location of the site-assessed ground to floor level distance was noted on a plan so that the ground level could be established later from LiDAR. This LiDAR ground level then provides an estimate of the habitable floor level.

In future, buildings within future development areas may well be demolished or moved therefore this site floor level assessment is only useful to understand which floors may be at risk of flooding or within freeboard conditions now.

3.4 Water level comparisons

Flood modelling was completed for 2.1 and 3.8° temperature increases with the expectation that the higher climate change will show greater water levels and therefore an associated increased risk of flooding.

Appendix 1 shows the water level comparison results for the two climate change events at most of the stream and river crossings the NORs traverse. The water levels are to the Auckland 1946 vertical datum.

3.5 Outcomes based approach

The stormwater and flooding considerations are based on an indicative design designation boundary which incorporates flexibility for design changes to respond to the future environment. The effects assessment is based on being able to meet the requirements of the proposed designation conditions and provide required mitigation within the designation boundary.

Where outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls and overland flow paths, this may be agreed with the affected property owner and Auckland Council.

This assessment identifies where flood effects require consideration and the types of mitigation measures that could be implemented to address the effect. The designation boundary has been confirmed to provide sufficient land to accommodate those potential mitigation measures identified.

4 Existing and Future Flooding environment

4.1 Existing environment

4.1.1 Stormwater Catchment Overview

The North Projects area comprises a stormwater catchment area of approximately 11,029 Ha which all discharges to the Hauraki Gulf except Dairy Flat and Waiokahukura (Lucas Creek) which discharge to the upper reaches of the Waitemata Harbour. The stormwater catchments identified are shown in overview in Figure 4-1 from north to south (highlighted in yellow) and then in Figure 4-2 to Figure 4-6 in more detail:

- Ōrewa River West is approx. 2,124Ha in area and drains to the Ōrewa River;
- Pine Valley is approx. 1,036Ha in area and drains to the Wēiti Stream;
- Silverdale South is approx. 557Ha in area and drains to the John Creek;
- Dairy Flat is approx. 4,903Ha in area and drains to the Huruhuru (Dairy Stream);
- Ōkura North is approx. 1,788Ha in area and drains via the Ōkura River;
- Waiokahukura (Lucas Creek) is approx. 621Ha in area and drains via the Waiokahukura (Lucas Creek).

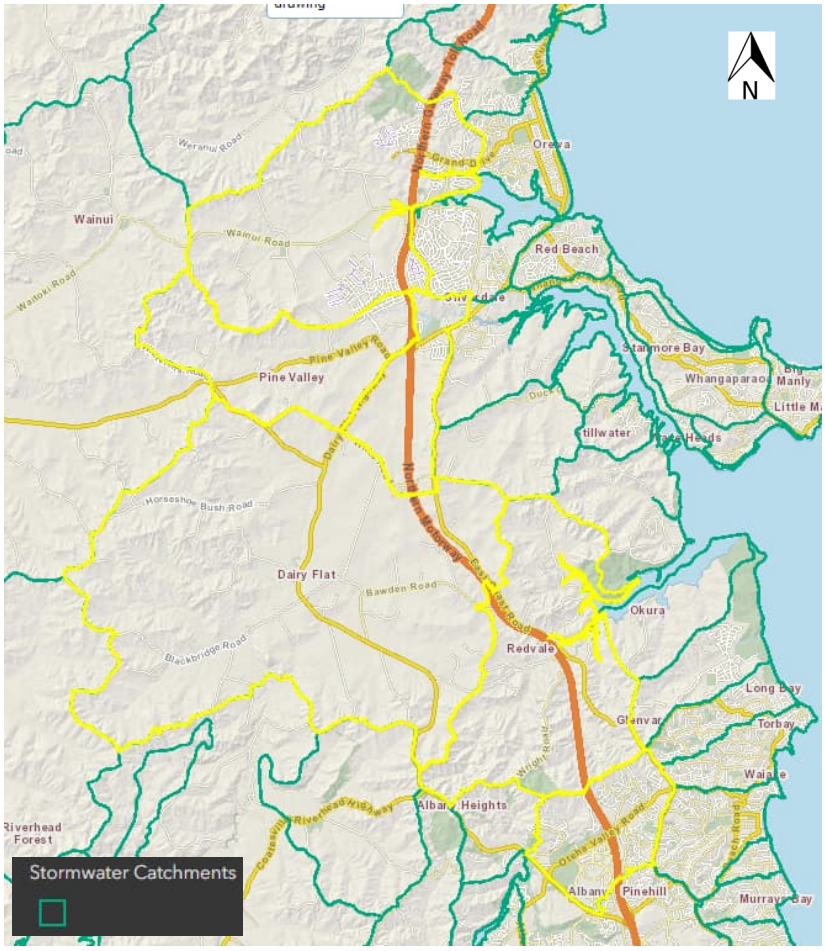

Figure 4-1: North Project stormwater catchments (relevant catchments indicated in yellow)

Figure 4-2: Ōrewa River West catchment boundary with NOR outlines

NOR 2, 4, 6 and 10 are within the Ōrewa River West stormwater catchment extent.

Figure 4-3: Pine Valley and Silverdale South catchment area with NOR shown

NORs 1, 2, 3, 4, 7, 8, 11 and 13 are within the Pine Valley and Silverdale South stormwater catchment extents.

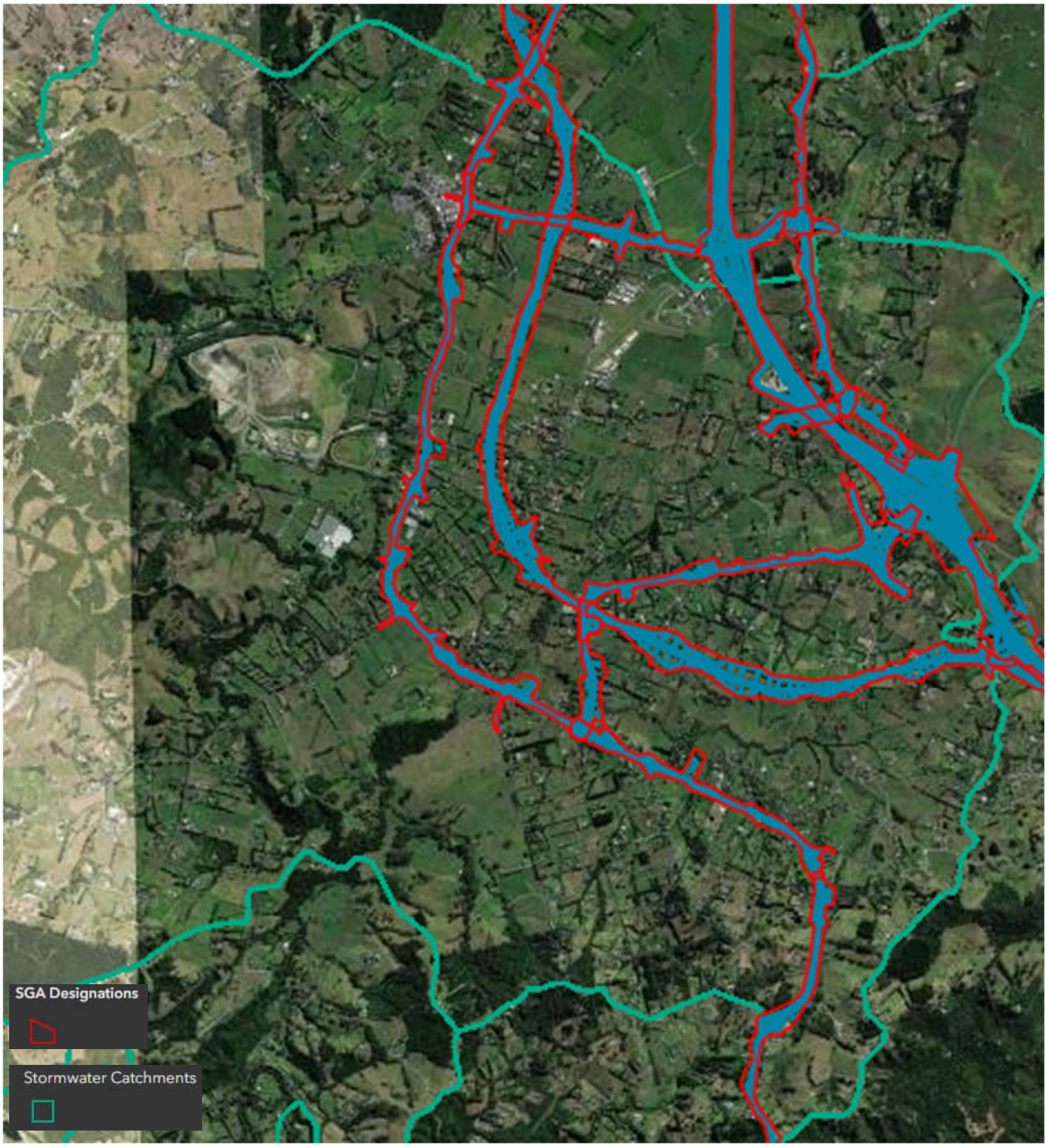

Figure 4-4: Dairy Flat catchment area with NOR shown

NORs 1, 4, 5, 8, 9, 11, 12 and 13 are within the Dairy Flat stormwater catchment extent.

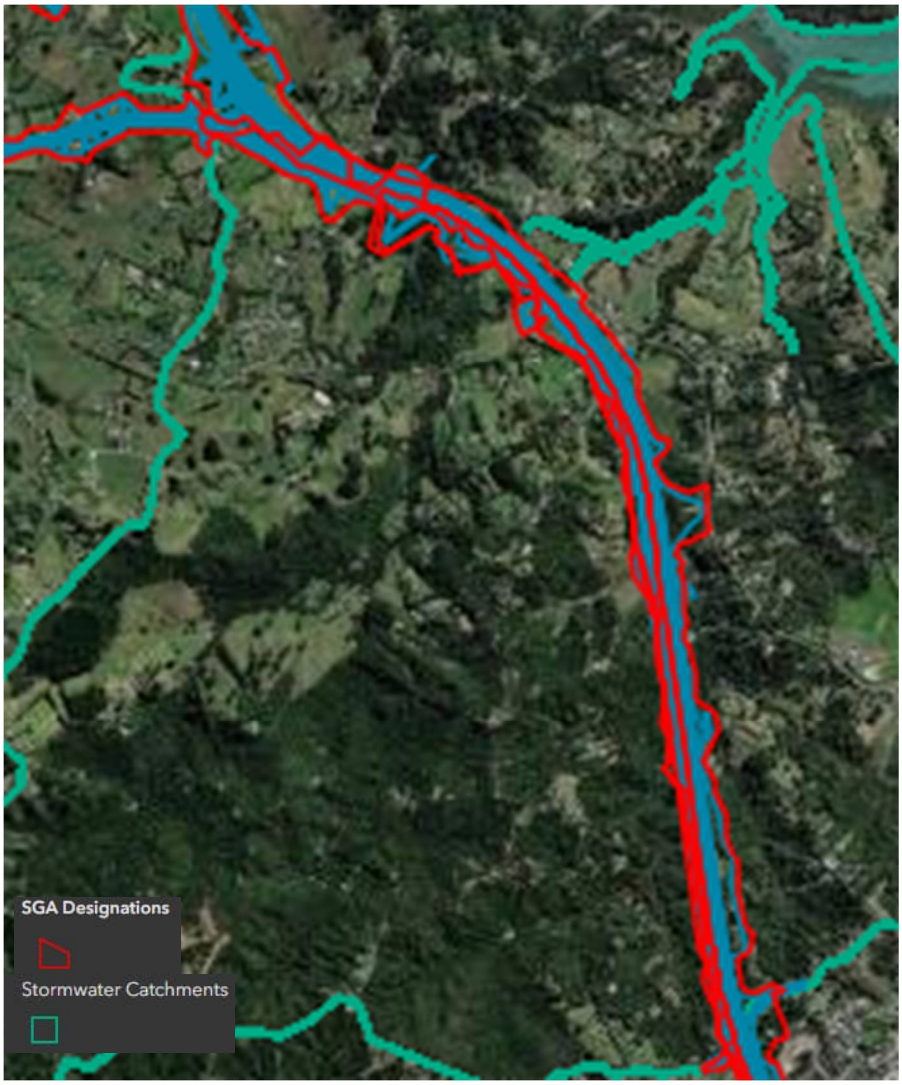

Figure 4-5: Ōkura North catchment area with NOR shown

NORs 1, 4 and 9 are within the Okura North stormwater catchment extent. NOR 9 is on the south west boundary of the catchment on a ridgeline and does not have any associated flood issues in this catchment.

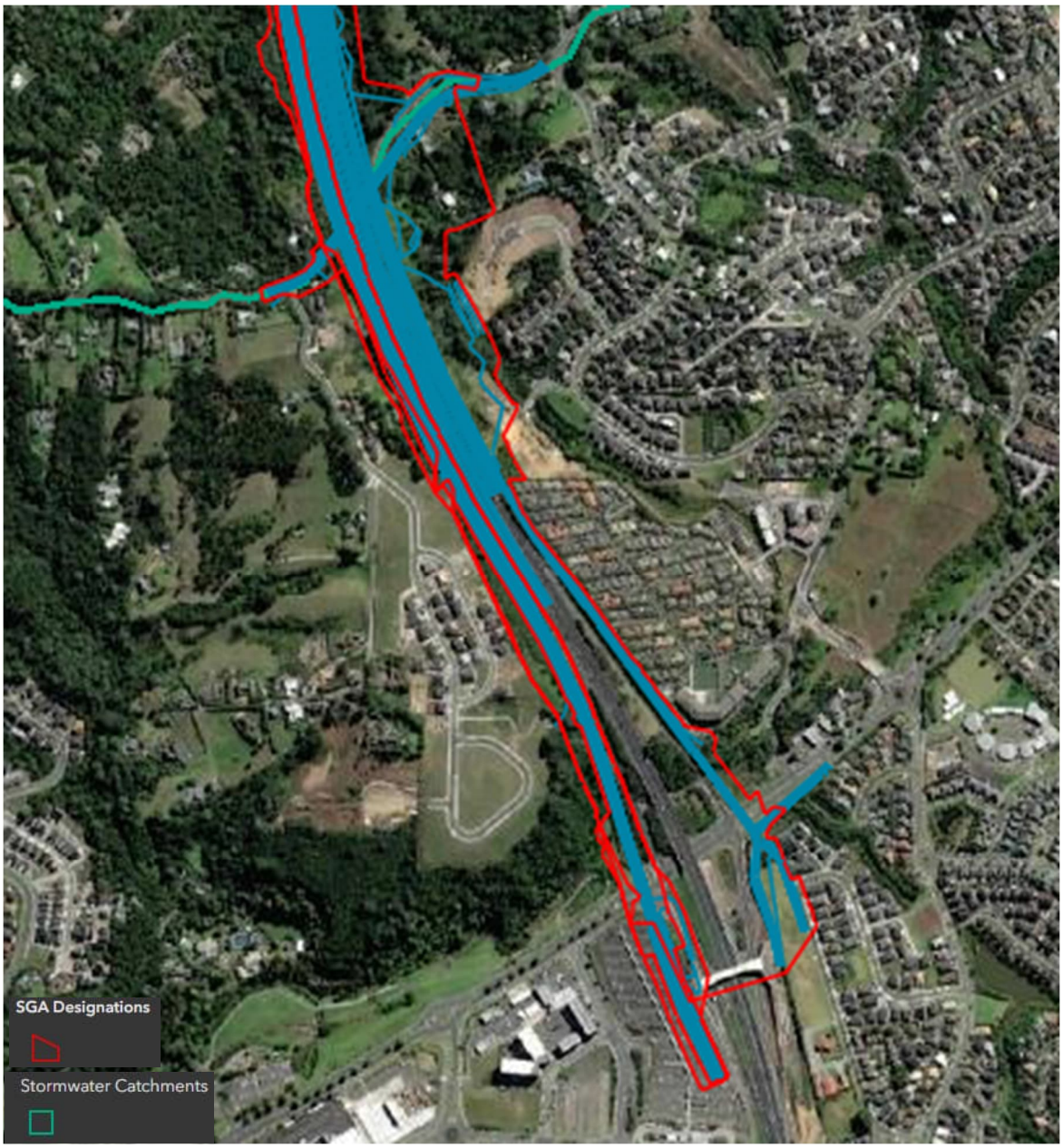

Figure 4-6: Waiokahukura (Lucas Creek) catchment area

NORs 1 and 4 start in the Waiokahukura (Lucas Creek) stormwater catchment extent with bridge crossings over Lucas Creek and upgrading of the existing wetland for attenuation and treatment.

4.1.2 Site Geology

Soil descriptions obtained from the New Zealand Geology Maps five main soil groups in the proposed location of the identified North Projects. The five main soil groups are as follows (GNS Science, 2018):

- East Coast Bays Formation of Warkworth Subgroup (Waitemata Group)
  - ✓ This group has alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits. The rock group includes alternating sandstone/siltstone.
- Late Pliocene to Middle Pleistocene pumiceous river deposits
  - ✓ Pumiceous mud, sand and gravel with muddy peat and lignite: rhyolite pumice, including non-welded ignimbrite, tephra and alluvia. The main rock group is sandstone.

- Hukerenui Mudstone (Mangakahia Complex) in Northland Allochthonous
    - ✓ Commonly highly sheared mudstone with small serpentine bodies. The main rock group is mudstone.
- Mahurangi Limestone (Motatau Complex) in Northland Allochthonous
    - ✓ Main rock group is sandstone.
- Holocene River Deposits
    - ✓ Sand, silt mud and clay with local gravels and peat beds.

4.2 Future Environment

4.2.1 Planning and land use context

The assessment of effects needs to consider both the existing environment and the likely future receiving environment at the time at which effects will likely occur. It is anticipated the North Projects will be constructed between 10 – 30+ years from now, meaning the receiving environment will differ significantly from what is present today.

There are existing rural and urban zonings in the study area, as well as large areas of future urban zone (FUZ) which will influence the likely receiving environment for assessment purposes.

The majority of North Projects will be constructed and operate within (or immediately adjacent to) areas currently zoned as FUZ. The remainder will be constructed and operated within the existing urban environment or planned environment (i.e., what can be built under the existing AUP: OP live zones). However, greater intensification is anticipated in the residential zones, centre zones (and future centres), and land adjacent to the proposed RTC stations, in line with the National Policy Statement on Urban Development (NPS: UD) and Medium Density Residential Standards (MDRS) - noting that the policy context may shift prior to construction.

The adopted Silverdale West - Dairy Flat Industrial Area Structure Plan anticipates the development of a large industrial area within an area of FUZ predominantly between Dairy Flat Highway and SH1.

The remaining areas of FUZ, including Upper Ōrewa, Pine Valley and Dairy Flat have not yet been structure planned by Auckland Council. Auckland Council has, however, released some high-level thinking on future land uses in a draft Spatial Land Use Strategy, which broadly suggests:

- A metropolitan/town centre in Dairy Flat, located adjacent to the Rapid Transit Corridor alignment
- The potential for Terrace Housing and Apartment (THAB) zoning for 800m surrounding this metropolitan / town centre
- Two potential local centres in the Pine Valley area.

All areas of FUZ have a high likelihood of change in planning and land use context. It is anticipated that the likelihood of change in the following areas / zones is low (apart from additional intensification in residential zones envisaged under Plan Change 78):

- Current residential areas/zones, including Single House, Mixed Housing Suburban, Mixed Housing Urban, Terrace and Apartment Buildings, and Large Lot zones
- Current business areas/zones, including Light Industry, Mixed Use, General Business, Neighbourhood Centre, Local Centre, Town Centre, Heavy Industrial zones

- Current open space areas/zones, including Informal Recreation, Community, Sport and Active Recreation, Conservation zones
- Current rural areas which are not FUZ zoned, including Countryside Living zone
- Other areas currently within the Special Purpose zone including Special Purpose – Cemetery, Special Purpose – School, and Special Purpose – North Shore Airport.

Please refer to the AEE for further information on the planning and land use context.

4.2.2 Future flooding environment

Development within the North Projects area will change catchment hydrology (impervious coverage), the terrain, building and property types that will potentially change the extents and areas exposed to flooding.

The flooding assessment has therefore considered effects on potential future development areas without any controls in place based on the existing terrain. To adhere to good practice requirements, it is anticipated that future developments will take account of flood risk and manage that risk within their development as required by the Auckland Council Code of Practise.

Figure 4-7 below shows the Auckland Unity Plan: Operative in Part zones for the North Projects area.

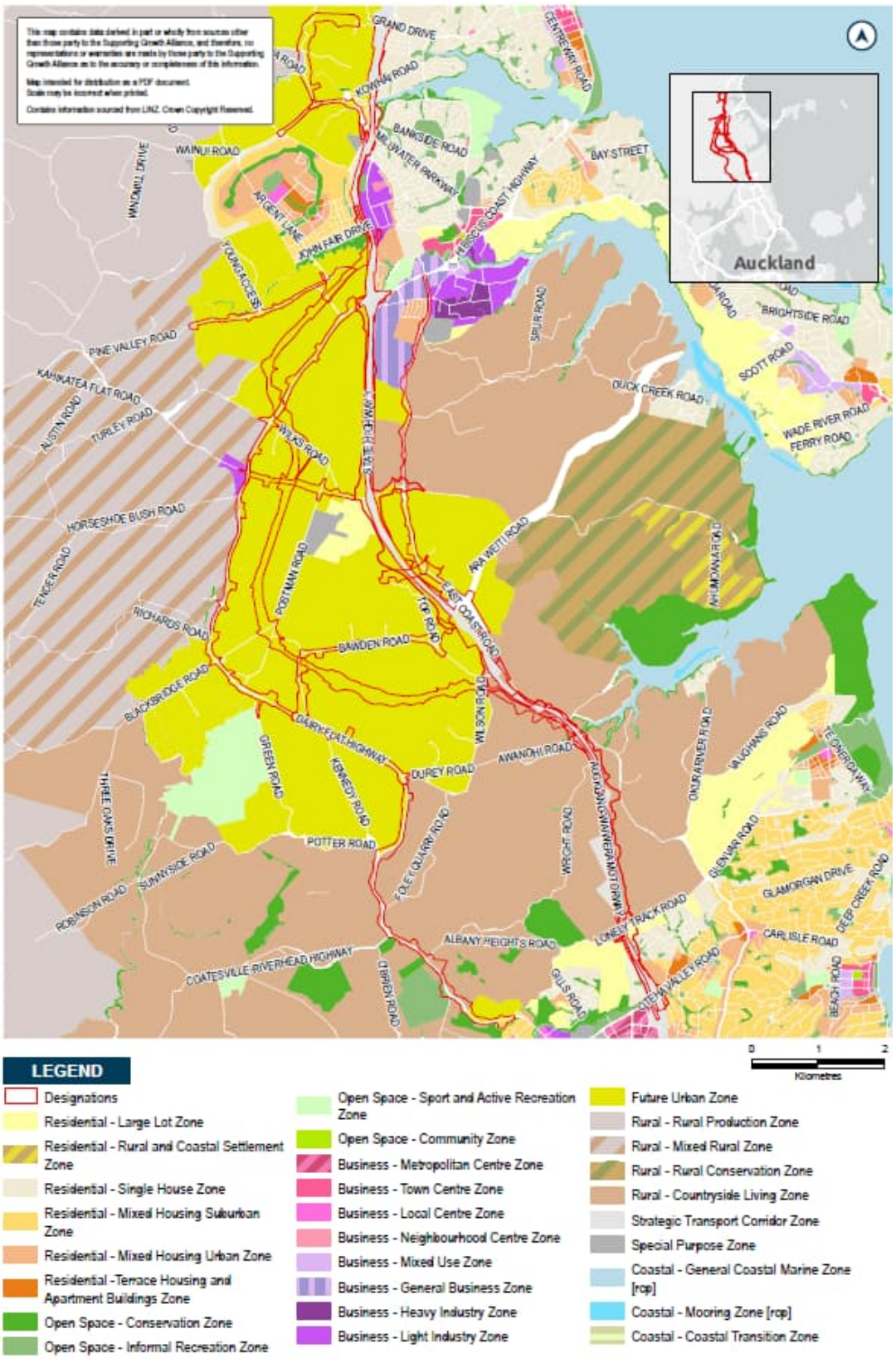

Figure 4-7: Auckland Unitary Plan Zones with North Project NOR overlays

According to the AUP: OP, the North Projects are located within the following development zones.

- Business made up of Light Industry, Mixed Use, General Business, Neighbourhood Centre, Local Centre, Town Centre, Heavy Industrial zones

- Open Space Areas made up of Informal Recreation, Community, Sport and Active Recreation, Conservation zones
- Rural made up of Countryside Living
- Roading made up of Strategic and Local Transport Corridors
- Residential made up of Single House, Future Urban, Mixed Housing Suburban, Mixed Housing Urban, Terrace and Apartment Buildings, and Large Lot zones,
- Special Purpose Zone made up of Cemetery, Schools, and North Shore Airport.

Auckland Council Healthy Waters has provided guidance on the maximum impervious area in the North Projects area through their "Land Use Zone Imperviousness for Hydraulic Modelling based on the Auckland Unitary Plan Operative in Part" memo dated 4 Sept 2019 which has been used in the modelling. Table 4-1 sets out the basis for consideration of the maximum impervious area for future developments within the North Projects area.

Table 4-1: AC Healthy Waters recommended maximum impervious coverage based on AUP: OP zonings

Future zoning	Maximum Impervious Area (% of the site area)
Business: Light Industry	90
Business: - Mixed Use, General Business	80
Business: Neighbourhood Centre, Local Centre and Town Centre	100
Business: Heavy Industrial zones	90
Rural: Countryside Living Zone	25
Rural: Mixed rural zone	10
Road: Strategic transport corridor zone	60
Residential: Single House, Mixed Housing Suburban, Mixed Housing Urban	60
Residential: Future Urban Zone and Terrace and Apartment Buildings	70
Residential: Large Lot zones	35
Special Purpose Zone - Cemetery, School, and North Shore Airport	60
Special Purpose Zone: School	70
Special Purpose Zone: North Shore Airport	80
Open Space Areas: Informal Recreation, and Active Recreation, Conservation Zones	40
Open Space Areas: Informal Recreation	10
Open Space Areas: Community	70
Open Space Areas: Conservation Zones	10

For each stormwater catchment model the following future impervious allowances have been made as shown in Table 4-2 to 4-5 below.

Table 4-2 Impervious coverage for the Okura North catchment model (MPD = maximum probable development)

Zone	Description	Total Area (Ha)	MPD Imperviousness (%)	MPD Area (Ha)
3	Rural - Countryside Living Zone	1301.9	25	325.5
4	Future Urban Zone	4.7	70	3.3
15	Rural - Rural Conservation Zone	263.0	10	26.3
25	Water	1.2	100	1.2
26	Strategic Transport Corridor Zone	69.1	100	69.1
27	Road	53.5	90	48.2
30	Coastal - General Coastal Marine Zone	1.3	100	1.3
31	Open Space- Conservation Zone	91.7	10	9.2
32	Open Space- Informal Recreation Zone	0.9	10	0.1
59	Open Space - Conservation Zone	0.7	10	0.1
Total		1788.0	27%	484.1

Table 4-3 Impervious coverage for the Dairy Flat catchment model

Zone	Description	Total Area (Ha)	MPD Imperviousness (%)	MPD Area (Ha)
3	Rural - Countryside Living Zone	361.0	25	90.3
4	Future Urban Zone	1961.8	70	1373.2
11	Mixed Rural	1894.4	10	189.4
15	Rural - Rural Conservation Zone	0.5	10	0.1
16	Rural Production	289.7	5	14.5
17	Light Industry	11.3	90	10.2
23	Large Lot	46.3	35	16.2
25	Water	7.8	100	7.8
26	Strategic Transport Corridor Zone	26.3	100	26.3
27	Road	188.8	90	169.9
31	Open Space- Conservation Zone	2.8	10	0.3
32	Open Space- Informal Recreation Zone	120.9	40	48.4
56	Special Purpose	23.7	80	19.0
Total		4,935.4	40%	1,965.6

Table 4-4 Impervious coverage for the Silverdale / Pine Valley catchment model

Zone	Description	Total Area (Ha)	MPD Imperviousness (%)	MPD Area (Ha)
3	Countryside living	372.0	25	93.0
4	Future Urban	656.5	80	525.2
5	Heavy Industry	28.8	90	25.9
11	Mixed Rural	264.2	10	26.4
12	Mixed Use	3.8	80	3.1
15	Rural Conservation	0.0	0	0.0
16	Rural Production	346.0	5	17.3
17	Light Industry	71.3	90	64.1
18	Mixed Housing Suburban	13.7	60	8.2
19	Single House	29.2	60	17.5
22	Town Centre	11.0	100	11.0
23	Large Lot	54.5	35	19.1
25	Water	7.1	100	7.1
26	Strategic Transport Corridor	47.0	100	47.0
27	Road	121.0	90	108.9
30	General Coastal marine	33.5	100	33.5
31	Open Space- Conservation Zone	31.2	10	3.1
32	Open Space- Informal Recreation Zone	3.0	10	0.3
33	Public Open Space	10.3	40	4.1
34	Public Open Space	1.1	70	0.8
49	General Business	84.6	80	67.7
53	Special Purpose- Cemetery Zone	15.2	60	9.1
59	Coastal Transition	2.7	10	0.3
60	Mixed Housing	41.3	60	24.8
Total		2249.0	49.7%	1117.4

Table 4-5 Impervious coverage for the Orewa River West catchment model

Zone	Description	Total Area (Ha)	MPD Imperviousness (%)	MPD Area (Ha)
4	Future Urban	519.3	70%	363.5
7	Local Centre	7.5	100%	7.5
8	Terrace Housing and Apartment	11.8	70%	8.2
11	Mixed Rural	10.4	10%	1.0
16	Rural Production	868.2	10%	86.8
17	Light Industry	25.5	100%	25.5
18	Mixed Housing Suburban	94.4	60%	56.7
19	Single House	201.2	60%	120.7
25	Water	2.9	100%	2.9
26	Strategic Transport Corridor	54.4	100%	54.4
27	Road	113.9	90%	102.5
30	General Coastal marine	3.6	100%	3.6
31	Open Space- Conservation Zone	101.2	10%	10.1
32	Open Space- Informal Recreation Zone	15.8	10%	1.6
44	Neighbourhood Centre	6.4	100%	6.4
53	Special Purpose- Cemetery Zone	1.4	60%	0.8
59	Coastal- Coastal Transition Zone	0.4	10%	0.0
60	Mixed Housing	82.0	60%	49.2
63	Special Purpose- School Zone	3.8	70%	2.6
Total		2123.9	42.6%	904.1

Predicted flooding from Te Tupu Ngātahi models for the future fully developed 1% AEP with climate change of 2.1° rainfall without the North Projects are shown in Figure 4-8 to Figure 4-12 below. These scenarios are considered the base line which the proposed designation conditions are measured against. The NOR for each catchment area and predicted base case 1% AEP flooding with 2.1° of climate change are shown for each catchment.

As the Projects are likely to be built in 10 to 30 plus years a lot of other development will likely have occurred. The fact that large scale developments will have potentially occurred prior to the Projects should reduce impacts to less than shown by the SGA base case model, which allows for full development without any controls.

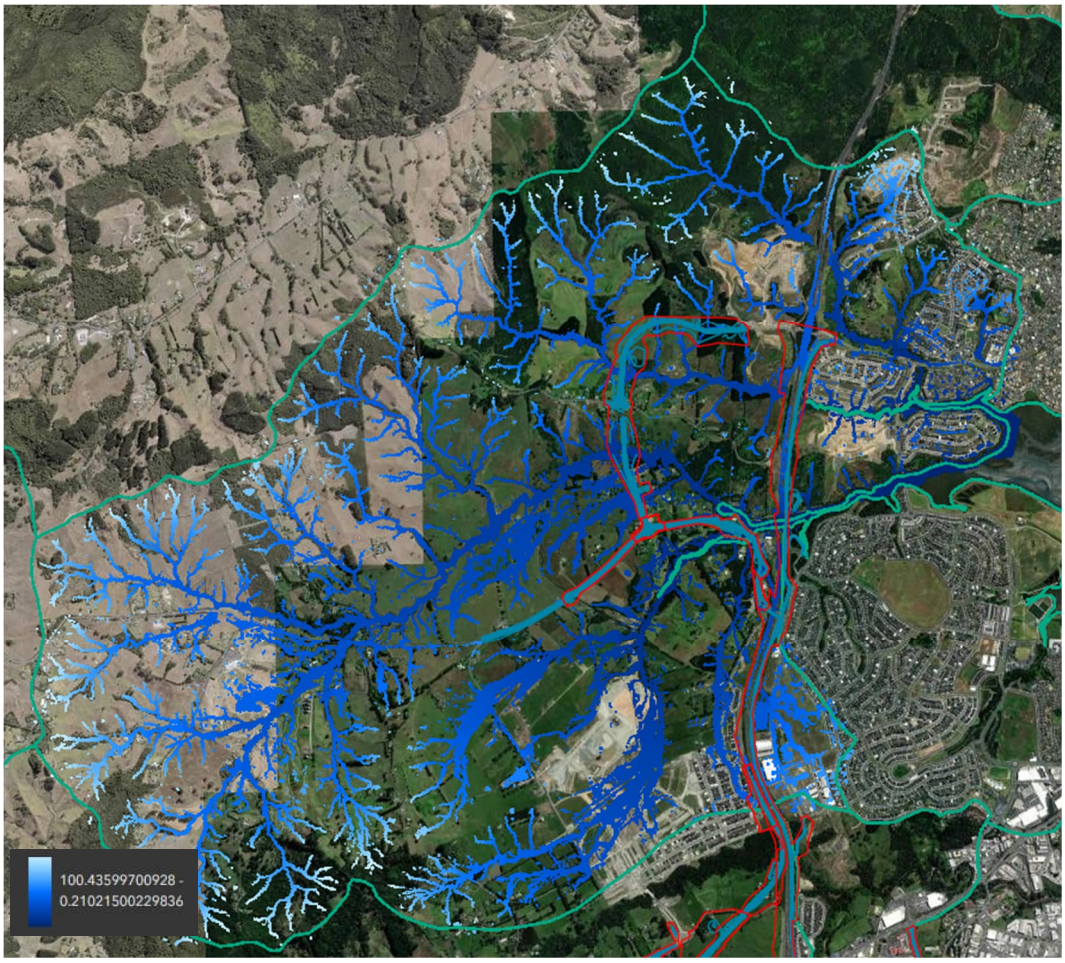

Figure 4-8. Ōrewa River West predicted 1% AEP future flood extents

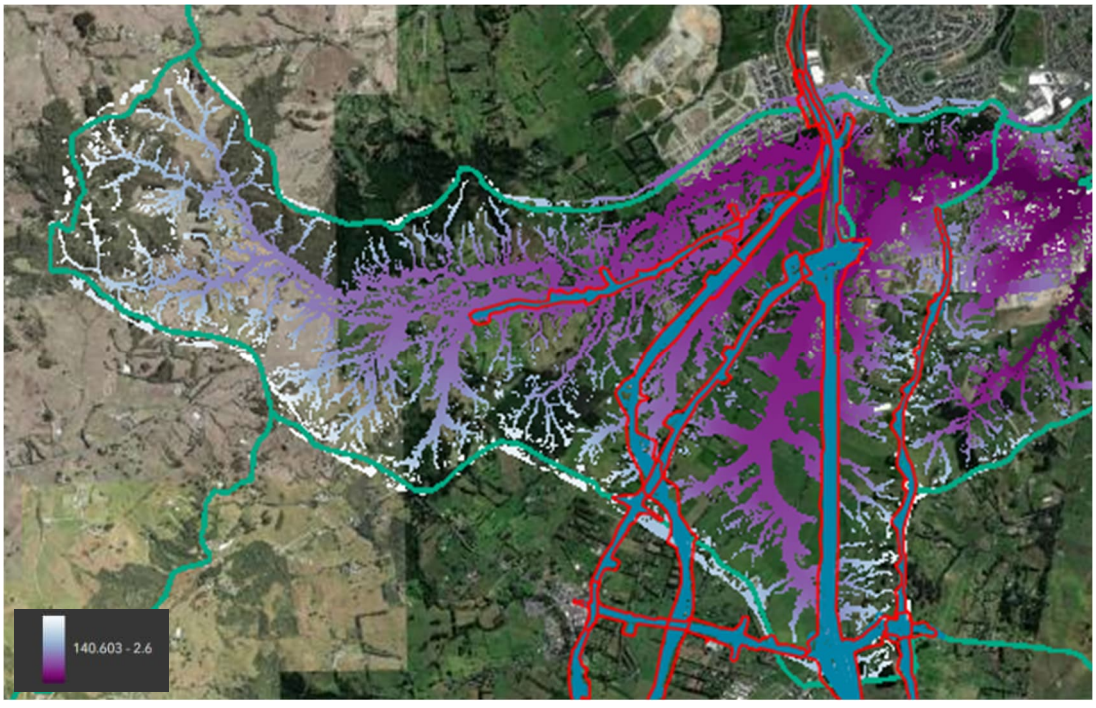

Figure 4-9. Pine Valley and Silverdale predicted future 1% AEP with 2.1° climate change flood extents

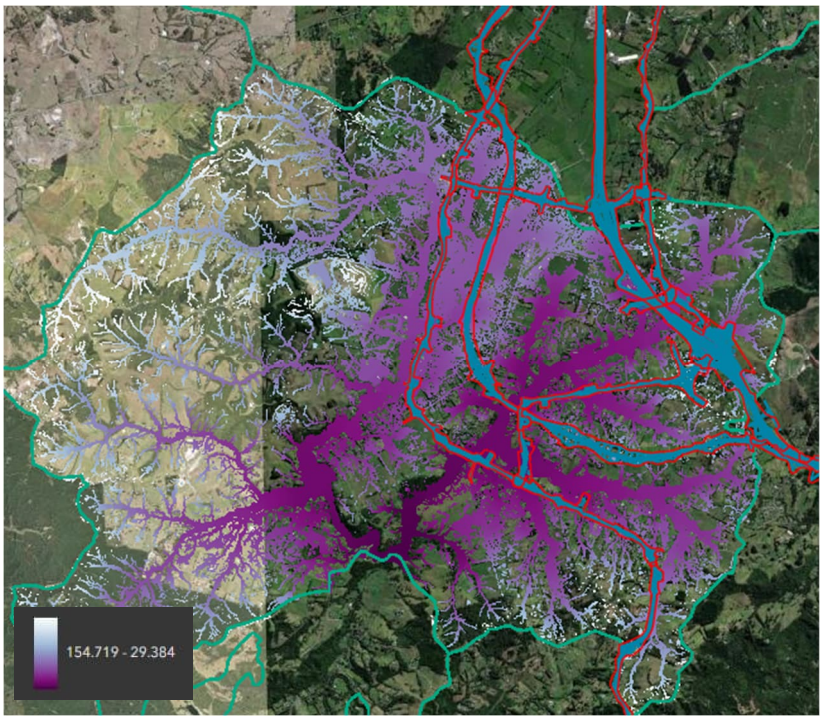

Figure 4-10. Dairy Flat predicted future 1% AEP with 2.1° climate change flood extents

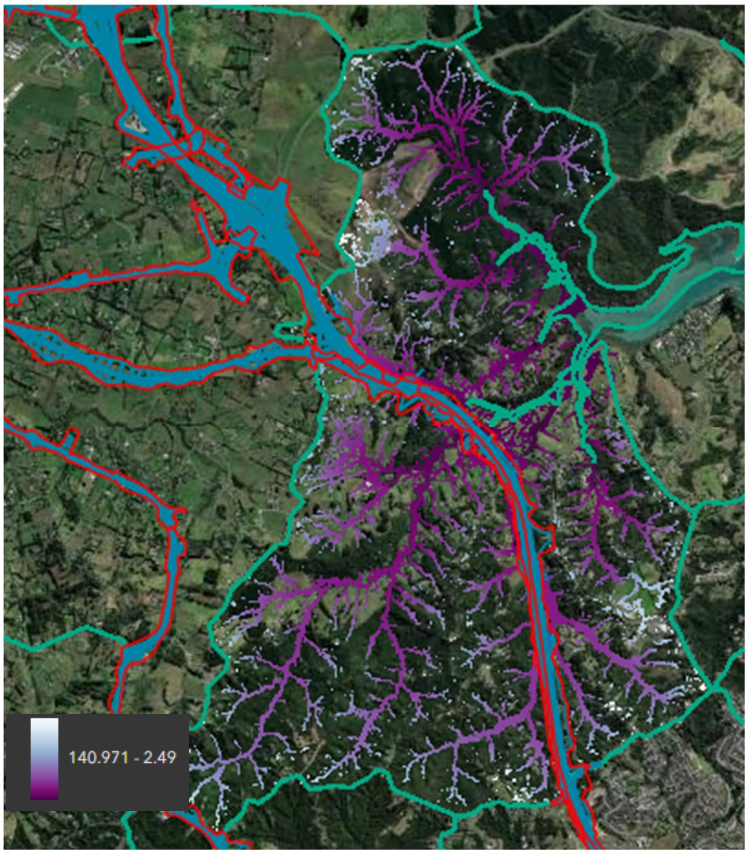

Figure 4-11: Okura North predicted future 1% AEP with 2.1° climate change flood extents

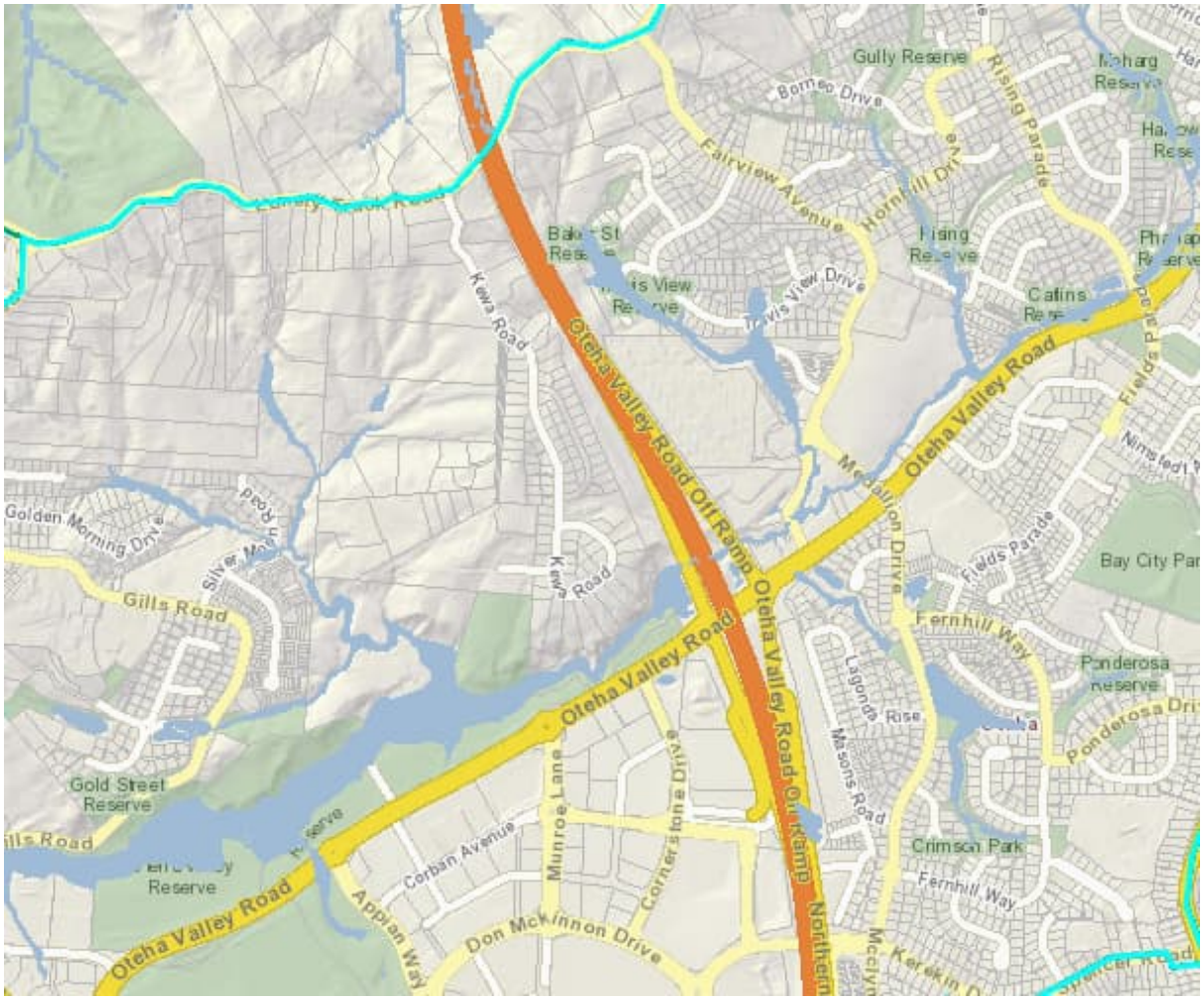

Figure 4-12: Waiokahukura (Lucas Creek) predicted future 1% AEP with 2.1° climate change flood extents (AC Geomaps)

5 North Project Assessment NoRs – Overall network

This section assesses common or general flooding and stormwater matters across the overall North Projects (i.e., the combination of existing road upgrades and new corridors, as well as RTC stations).

This section also recommends measures to avoid, remedy, or mitigate actual or potential adverse effects for the overall network.

Corridor-specific matters are further discussed in the following report sections 6 to 18.

The North Projects all have the same common features:

- New or widened / improved roads (or RTC/station) with formations and bridges / culverts crossing existing streams
- New bridges over existing streams where assessed based on the upstream catchment contributing to the site and if greater than 80Ha a bridge was proposed. This will be refined in the later detailed design stages
- Treatment / attenuation wetlands normally located near an existing stream crossing with the aim to optimise the number, location and sizing of wetlands. Sizing of the wetlands is governed by attenuation needs rather than treatment alone
- Where existing roads are widened, treatment of the entire road impervious area will be designed to improve downstream water quality.
- Streams and floodplains will be impacted by construction and operation of the NORs. The concept designs aim to minimise the impact on flood plains, streams and overland flow paths.

The main rivers or permanent streams running through the catchments are the Waiokahukura (Lucas Creek), Ōkura River, Huruhuru (Dairy Stream), Wēiti Creek and Ōrewa River.

5.1 Assessment Features

Predicted flooding at proposed NOR bridge or culvert crossings needs to be carefully considered in later modelling and design stages to reduce the potential for increased flooding. This will be due to proposed formations reducing available flood storage volume and maintaining as much as possible flood neutrality, particularly within areas of future development (upstream and downstream of the NOR crossings).

5.2 Positive flooding and stormwater effects

The main positive effects of the North NORs relating to flooding are:

- The widened and improved transport corridors are proposed to be above the predicted future flood plains, particularly existing overtopping roads
- The corridors have the ability to convey flows without worsening flooding impacts upstream or downstream of the works
- There is an opportunity to add water quality treatment and attenuation of the total transport corridor impervious area as opposed to just the additional area for upgraded roads.

5.3 Assessment of potential construction effects

The proposed construction works which could result in flooding effects across all NORs include:

- Construction of new culvert crossings or upgrading of existing culvert crossings or bridges
- Installation of diversion drains / realignment of existing overland flow paths or natural streams, as a last resort
- Construction of new attenuation wetlands or upgrading of existing attenuation wetlands
- Temporary use of lay down and construction areas.
- Bulk earthworks to complete the contouring for new landscape features, (e.g. attenuation wetlands and new or upgraded culverts) require a dry works area and can alter overland flow paths or generate erosion and sediment effects
- The siting of attenuation wetlands within an existing overland flow path can obstruct runoff and result in flows being diverted towards existing properties due to the need for embankments
- The location and number of wetlands.

5.4 Recommended measures to avoid, remedy or mitigate construction effects

The recommended management and mitigation measures for construction effects are outlined below.

General

- Carrying out earthworks during the summer / dry months to reduce the risk of flooding
- Regular monitoring of predicted rainfall, particularly extreme events with high volume or intensity can then prepare for impact
- Locating lay down areas outside of predicted overland flow paths and flood plains, where possible
- Managing the overland flow paths to make sure flows are not diverted toward existing buildings or properties
- Construction Environmental Management Plans (CEMP) be developed prior to construction in conjunction with an experienced Stormwater Engineer and shall consider the effects of temporary works, earthworks, storage of materials, temporary diversion and drainage on flow paths, flow levels and velocities. Including (but not limited to):
    - Siting construction yards and stockpiles outside the predicted flood plains
    - Diverting overland flow paths away from area of work
    - Minimizing the physical obstruction to flood flows at the road sag points
    - Staging and programming to provide new drainage prior to raising road design levels and carry out work when there is less risk of extreme flood events
    - Actions to take in response to heavy rain warnings which may include reducing the amount of materials and plant that are considered necessary to be stored or sited within the predicted flood plain or significant overland flow path.

Construction of new and existing culvert crossings and stormwater wetlands:

- Existing culvert extensions should be done prior to commencement of bulk earthworks to allow for the passage of clean water across the site. Pipe extensions can affect pipe capacity by increasing pipe length which could raise the upstream water level
- Installing temporary diversions to allow flows to be maintained while new culverts and wetlands are constructed
- For larger embankments requiring a longer duration of works or for overland flow paths with more regular and higher flow rates diversions should be installed prior to works commencing
- Where no diversion is required a 6m working clearance between any earthworks and designation boundary should be adopted to accommodate access and materials
- For larger diameter pipes (> 600mm in size) a working clearance of ±20m from the upstream extent and ±15m from the downstream extents should be provided.

The proposed designation conditions require that the Construction Environmental Management Plan (CEMP) includes measures to mitigate flood hazard effects such as siting stockpiles out of floodplains, minimising obstruction to flood flows, and actions to respond to warnings of heavy rain.

A Flood Hazard condition is also recommended which will require the future detailed design of the transport corridors to be designed to achieve specific flood risk outcomes – refer NOR condition sets.

Specifically the condition states that:

a) The Project shall be designed to achieve the following flood risk outcomes:

i. no increase in flood levels in a 1% AEP event for existing authorised habitable floors that are already subject to predicted flooding or have a freeboard less than 150mm;

ii. no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard of over 150mm;

iii. no increase in 1% AEP flood levels for existing authorised community, commercial and industrial building floors that are already subject to flooding;

iv. no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial and industrial building floors;

v. no increase of more than 50mm in flood level in a 1% AEP event on land zoned for urban or future urban development where there is no existing dwelling;

vi. no new flood prone areas; and

vii. no more than a 10% average increase in flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings existing at the time the Outline Plan is submitted. The assessment shall be undertaken for the 1% AEP rainfall event.

5.5 Assessment of potential operational effects

There are a range of operational effects that are common to all NORs, particularly from proposed road crossings (formations, cuttings, bridges and culverts).

For the Projects the assessment of operational flooding effects considered:

- New culvert (≥ 600 mm diameter) and bridge crossings
- Areas where the new road embankment encroaches onto predicted flood plain and flood prone land
- Potential bridge and culvert sizing to convey flows and not increase flood levels upstream and downstream of the bridge or culvert in the future 1% AEP 2.1° temperature increase scenario
- Land requirements for stormwater wetlands
- Conveyance through deep cuttings which can be improved with top of cutting cut off drains and bench drains
- The potential for flooding on existing properties due to the new / upgraded Project corridors.

The predicted operational effects include:

- Increasing impervious areas potentially resulting in increased runoff, flows and flood levels
- Altering existing overland flow paths resulting in flows being redirected on a different alignment
- Lengthening existing culverts on the same grade and alignment will increase upstream water levels and reduce conveyance capacity
- Obstructing existing overland flow paths resulting in ponding at existing low points or newly created depressions along the corridor
- Improving flows under the road, thereby reducing upstream flood levels but increasing flood levels at properties further downstream
- Reducing cutting conveyance requirements at the toe of the cutting through bench and cut off drains conveying flows to either end of the cutting
- Increasing Project impervious areas to treat for attenuation, treatment or both and the pond locations for them.

Future detailed design will be subject to a separate detailed flood hazard assessment at the outline plan stage which will refine the design of formations, culverts, bridge crossings and location / size of treatment (attenuation, water quality or both). Regional stormwater consents will also be required closer to construction.

5.6 Recommended measures to avoid, remedy or mitigate operational effects

Mitigation measures which may be implemented to achieve the flood hazard outcomes set out in the proposed flood hazard conditions (detailed in section 5.4) include:

- Detailed flood modelling of the detailed design during the later detailed design stage to meet designation condition requirements and optimise bridges, culverts and wetlands will be needed to assess cumulative effects of upstream NOR on downstream NOR
- Creating new overland flow path diversions to discharge to nearby overland flow paths or streams to mitigate ponding and decrease flood levels at affected properties

- Designing culvert and bridge sizes with the aim that the upstream and downstream water level differences comply with the proposed NOR conditions in the future 1% AEP event. Aim to maintain flood neutrality if downstream flooding issues exist. Culverts will be designed for the 1% AEP future ARI event and checked to ensure that there is no increase in water level upstream or downstream of culverts. Checks will also be made of capacity reduction in accordance with the Auckland Council Code of Practise (Jan 2023) to understand overland flow paths and water level impacts of this capacity reduction. This will be completed in later detailed design stages
- Aim for culvert sizing to maintain freeboard of 0.5m at the upstream inlet and bridges 0.6m and 1.2m freeboard dependent on risk of debris
- Upgrading culverts by adding additional culverts to create a balance between the flood level differences upstream and downstream, particularly for existing road sites that overtop and are to be raised and existing culverts that are lengthened
- Reducing cutting conveyance requirements at the toe of the cutting through bench and cut off drains conveying flows to either end of the cutting
- Installing drains at the toe of the embankment sloping towards the culverts can also allow for additional storage to decrease the velocity and peak flow through the culvert crossings
- Installing treatment wetlands in optimum locations to reduce conveyance to and treatment areas to the wetlands. Fewer optimised wetlands can reduce future maintenance costs along with pipe networks to convey flows to the wetlands.

5.7 Summary and Conclusions

The main positive effects that could be designed in the future works for the North NORs are:

- proposed new roadways to be above the predicted future flood plains,
- proposed widened and improved roadways to be above the predicted future flood plains, particularly existing overtopping roads
- added water quality treatment and attenuation of the total roadway impervious area as opposed to just the additional roadway area for upgraded roads.

The following summary and conclusions can be drawn for the North Projects flooding and stormwater effects as shown in Table 5-1.

Table 5-1 Summary of Assessment of Effects and Recommendations - Overall network

Effect	Assessment	Recommendation
Construction		
New formations over or near existing stream can block flow paths and create upstream flooding if not managed	Increased risk of construction site and upstream flooding	Construction methodology needs to be developed and followed to reduce the risk of construction related flooding. Also ties in with construction contingency planning for larger events with rainfall monitoring as part of the plan.
Laydown and construction areas can block flow paths and create upstream flooding if not managed	Increased risk of construction site and upstream flooding	Laydown and construction areas outside of predicted flood plains. Construction methodology needs to be developed and followed to reduce the risk of construction related flooding. Also ties in with construction contingency planning for larger events with rainfall monitoring as part of the plan.
Building bridges and culverts over existing streams can create flooding by restricting flow paths if not managed	Working in stream and flood plains increases the risk of upstream flooding, uncontrolled flows and construction site flood risk.	Construction methodology needs to be developed and followed to reduce the risk of construction related flooding. Also ties in with construction contingency planning for larger events with rainfall monitoring as part of the plan.
Very large upstream catchments (>200Ha) can create large flows (>40m^3/s). New bridges and piers must be built over existing river and will therefore be exposed to the flood risk	Large flows passing through the bridge construction site could cause scour and temporary works to be washed away or could be obstructed by temporary works and cause upstream flooding. Major diversions are not feasible. Works require controls to reduce the risk.	Construction methodology needs to be developed and followed to reduce the risk of construction related flooding. Also ties in with construction contingency planning for and warning systems for larger events as part of the plan.
Operational		
Existing flood plain storage volume loss with new embankments in flood plains could increase flood levels at culverts/bridges	Flood plain levels upstream and downstream of new formations may not achieve flood mitigation targets unless conveyance beneath the formation (bridges or culverts) is designed appropriately - additional cross conveyance capacity may be needed.	Detailed modelling (of detailed design) to assess best option to meet to meet designation. Flood Hazard condition requirements for upstream and downstream water levels. .
Raising existing roads above the predicted 1%	Greater protection of the road to flooding will require increased flow capacity beneath	Optimisation of bridge or culverts through later detailed modelling (of

Effect	Assessment	Recommendation
AEP future flood levels could increase upstream flood levels.	the road with the aim of flood neutrality upstream and downstream of the raised road formation	detailed design) and design to achieve flood hazard conditions.
Widening of existing roads with existing culvert and bridges can increase predicted upstream flood levels and reduce downstream flood levels	Lengthening existing bridges and culverts will increase head loss with inlet levels being higher thus increasing upstream water levels and potentially reduce downstream due to greater friction losses	Detailed modelling of the bridge and culvert design during later design stages to assess water level changes and if culvert augmentation or bridge waterway conveyance increase is needed.
Deep cuttings without benches will increase flood flows into cuttings thus increasing conveyance needs, concentrating flows at discharge points	Increased flood conveyance and concentrating flows could exacerbate existing flooding needs at discharge points.	Benches for deep cuts to reduce face runoff into cutting. Cutting design needs to optimise top of face drains, benches and base conveyance to reduce concentrated flows and flood risk
Wetlands for treatment only will reduce footprint needs	Downstream wetlands could be water quality only (GD01) as opposed to treatment and attenuation	Detailed modelling (of detailed design) to show attenuation not needed during later design stages.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

6 NOR 1 – New Rapid Transit Corridor (RTC) between Albany and Milldale

6.1 Assessment Features

The Project's concept design allows for the RTC to cross the Wēiti Stream, Huruhuru (Dairy Stream), Ōkura River and Waiokahukura (Lucas Creek) by means of a bridge or viaduct.

The site features and works that could give rise to flooding effects for this NOR relate to the earthworks, minor stream diversion, flood storage volume loss, construction of bridges over the streams and formation / wetland construction adjacent or within the flood plain.

6.2 Positive Flooding and stormwater effects

There are no positive flooding effects apart from the new road formation being constructed above the predicted flood plain.

The proposed swales and wetlands will provide water quality treatment for the added impervious area and also attenuation for some locations.

6.3 Assessment of construction effects

The construction impacts (based on the Project concept designs) are predicted to be (without appropriate mitigation):

- Construction of new culvert and bridges over existing streams which could create flooding impacts dependent on the construction method, particularly if large storms greater than the diversion capacity are predicted
- Installation of diversion drains / realignment of existing natural streams which could create minor flooding issues
- Construction of new wetlands within a predicted flood plain which displaces flood volume and increases flood levels
- Temporary use of lay down and construction areas in flood plains or overland flow paths which can create flooding that are not predicted prior to the work
- Widening embankments (Oteha Valley to Okura River) which can create flooding issues due to formation work and culvert extensions / upgrades blocking during heavy rainfall periods
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

NOR1 and 4 (SH1 upgrade) are interlinked between Albany and Bawden Rd, then they diverge with construction effects discussed in more detail below.

Oteha Valley Rd to Lonely Track Rd

The first section has no potential flooding effects apart from construction of the new bridges over Lucas Creek and an increase in size of the existing wetland. This is shown in Figure 6-1 below.

Figure 6-1: NOR 1 and 4 flooding impacts in Lucas Creek for the 1% AEP future base case scenario

Lonely Track Road to Okura River

There are potential floor flooding impacts upstream and downstream of the NOR due to attenuation or duplication of the existing lengthened culverts, which if blocked during construction in large events could create increased flooding. The two locations are shown in Figure 6-2 below where floors may be at risk of flooding, but this cannot be confirmed without later floor level surveys.

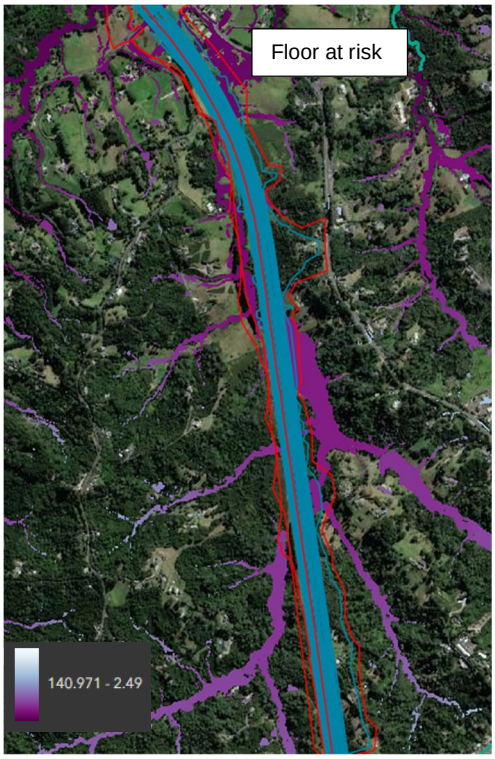

Figure 6-2: NOR1 and 4 Lonely Track to Okura River for the 1% AEP future base case scenario

Okura River to Milldale

Potential construction flooding effects are created by construction of bridges over the Huruhuru (Dairy Stream) and Wēiti Stream which, without appropriate mitigation, may block and flood during large rainfall events. The construction sites are shown in

Figure 6-3 and are associated with two bridges, three underpasses and four culvert sites as shown on the figures.

Figure 6-3: NOR 1 RTC Bawden Rd to Dairy Flat Highway underpass

6.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

6.5 Assessment of operational effects

The following potential operational effects design (without appropriate mitigation) are associated with the proposed NOR:

- bridge crossings over the Huruhuru and Wēiti Streams, which need to be sized to optimise upstream and downstream water levels to within NOR conditions
- construction of new road formation reduces flood storage volume, which could increase tailwater effects and reduce the culvert and bridge capacities
- deep cuttings (south of Bawden Rd) which will increase conveyance requirements to the cutting outlets.

6.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main ones being:

- Later detailed modelling of detailed design to assess the impacts of flood levels / extent / depth due to the culvert extensions and flood storage volume loss and bridges
- Conveyance through deep cuttings at the toe of the cut face can be improved through use of cut off and bench drains.

The detailed design of stormwater management will also be subject to regional consenting requirements.

6.7 Summary and Conclusions

The standard construction and operational conclusions discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

7 NOR 2 New Milldale Station and Associated Facilities

7.1 Assessment Features

This NOR allows for a new Milldale RTC Station to be built alongside SH1 north of the Wēiti Stream. The station will share a wetland to the south of the Wēiti Stream on the western side of the RTC as shown in Figure 7-1.

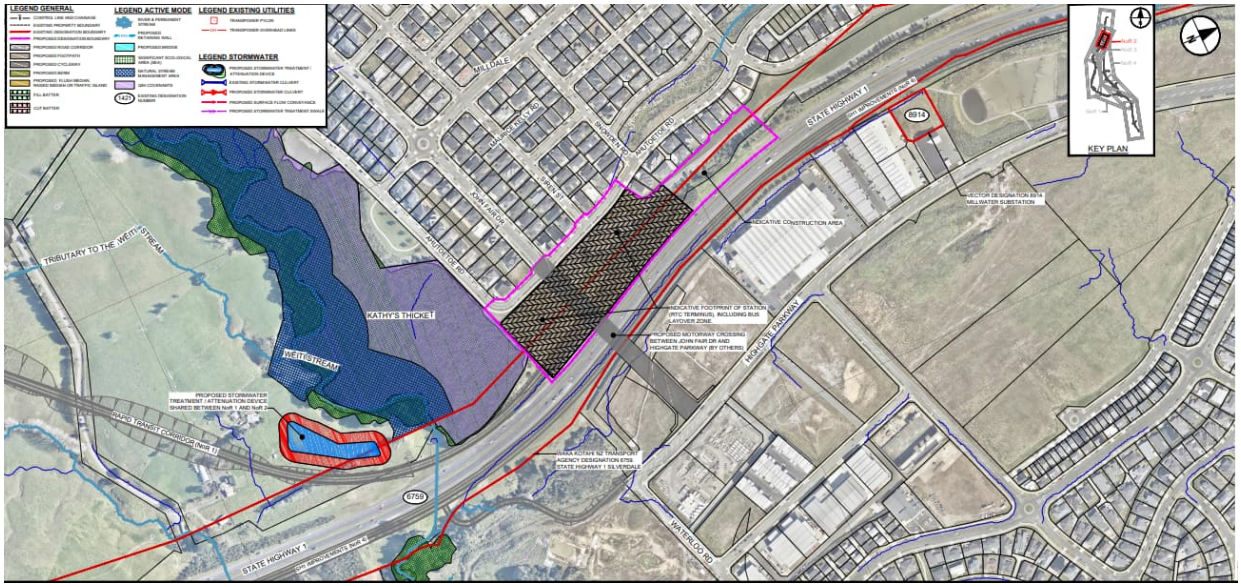

Figure 7-1: NOR2 Milldale Station

There are no major features subject to flooding for this NOR as it is on the boundary between two catchments (Orewa River West and Pine Valley on a ridgeline) and all of the construction is outside of any flood plain, overland flow path or stream as shown in Figure 7-2. Cross catchment discharge will need to be addressed, as Orewa River West runoff is possibly proposed to be discharged to Pine Valley through the wetland.

Figure 7-2: NOR2 Milldale Station predicted 1% AEP base case scenario flood extent

7.2 Positive Flooding and stormwater effects

There are no positive flooding effects.

The proposed wetland will provide water quality treatment for the added impervious area; although attenuation will not be required as it is near the bottom of the catchment.

7.3 Assessment of construction effects

There are no predicted construction impacts (based on the concept design) apart from the new stormwater wetland which is part of the NOR1 RTC assessment.

7.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

7.5 Assessment of operational effects

The potential operational effects (without appropriate mitigation) are related to the proposed stormwater wetland, which is outside a predicted flood plain, and the diversion of surface water from Orewa River West to Pine Valley catchments.

7.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR.

The detailed design of stormwater management will also be subject to regional consenting requirements.

7.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

8 NOR 3 – New Pine Valley East Station and Associated Facilities

8.1 Assessment Features

This NOR allows for the new Pine Valley East Station to be built within the area shown in Figure 8-1.

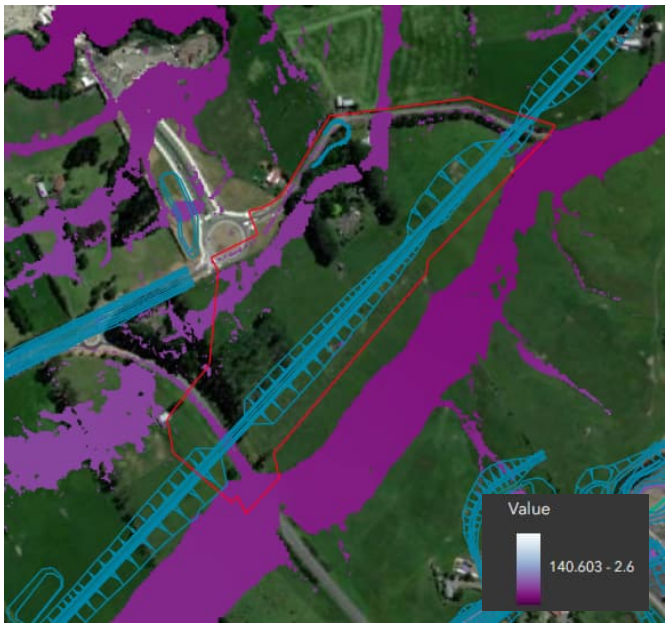

Figure 8-1: NOR3 Pine Valley station 1% AEP future base case scenario flooding extent

The potential flooding effects for this NOR (exclusive of NOR1 RTC) relate to the earthworks, minor overland flow path control and wetland construction within the flood plain extent of 50mm deep. Note the "flood plain" would be classed as an overland flow path as the flow rate is less than 2m^3/s based on the AC modelling specification and AC Geomaps.

8.2 Positive Flooding and stormwater effects

There are no positive flooding effects apart from the new Station being constructed above the predicted flood plain.

The proposed wetland will provide water quality treatment for the added impervious area.

8.3 Assessment of construction effects

The construction impacts of the Project based on the concept design are predicted to be (without appropriate mitigation):

- Construction of pipes and station formation over an existing minor overland flow path which could create minor flooding issues during large storms if blockages occur

- Installation of diversion drains / realignment of an existing overland flow path could create minor flooding issues if blockages occur, or the diversion drain is not sized appropriately
- Construction of new stormwater wetland within a minor overland flow path which could increase flood levels if blockages occur
- Temporary use of lay down and construction areas in overland flow paths which restrict flows and can create flooding.

8.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

8.5 Assessment of operational effects

The following potential operational effect associated with the proposed NOR design (without appropriate mitigation) is piping of an overland flow path through the Station site from Pine Valley Rd north-east towards Old Pine Valley Rd.

The stormwater wetland size is only required for water quality treatment as it is near the lower end of the catchment and attenuating flows will have no positive impacts on Pine Valley flood flows and water levels.

8.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR.

The detailed design of stormwater management will also be subject to regional consenting requirements.

8.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

9 NOR 4 –SH1 Improvements

9.1 Assessment Features

The concept design for this NOR allows for the SH1 upgrade to widen existing bridge crossings of the Orewa River, Wēiti Stream, Huruhuru (Dairy Stream), Ōkura River and Waiokahukura (Lucas Creek) by means of a bridge or viaduct.

The features for this NOR that could give rise to flooding relate to the earthworks, flood storage volume loss, construction of bridges over the streams, extension of existing culverts, and formation / wetland construction adjacent or within the predicted flood plains.

The alignment and flooding effects have been broken into five sections:

1. Oteha Valley Rd to Okura River which is discussed under Section 6 for the NOR1 RTC as the two NORs are interlinked in their flooding effects
2. Okura River to Bawden Rd
3. Bawden Rd to north of Wilks Rd
4. North of Wilks Rd to Orewa River
5. Orewa River to Grand Drive.

The 1% AEP base case flood extents are detailed below.

The post-Project concept design was also modelled for NoR 4 (Silverdale South catchment) as detailed in Appendix 3. This confirmed that the post-Project ground levels are not anticipated to cause impacts to flooding with the detailed design of culverts to maintain existing flow paths.

Okura River to Bawden Rd

The predicted 1% AEP future with climate change of 2.1° flood extent to 50mm deep is shown in Figure 9-1.

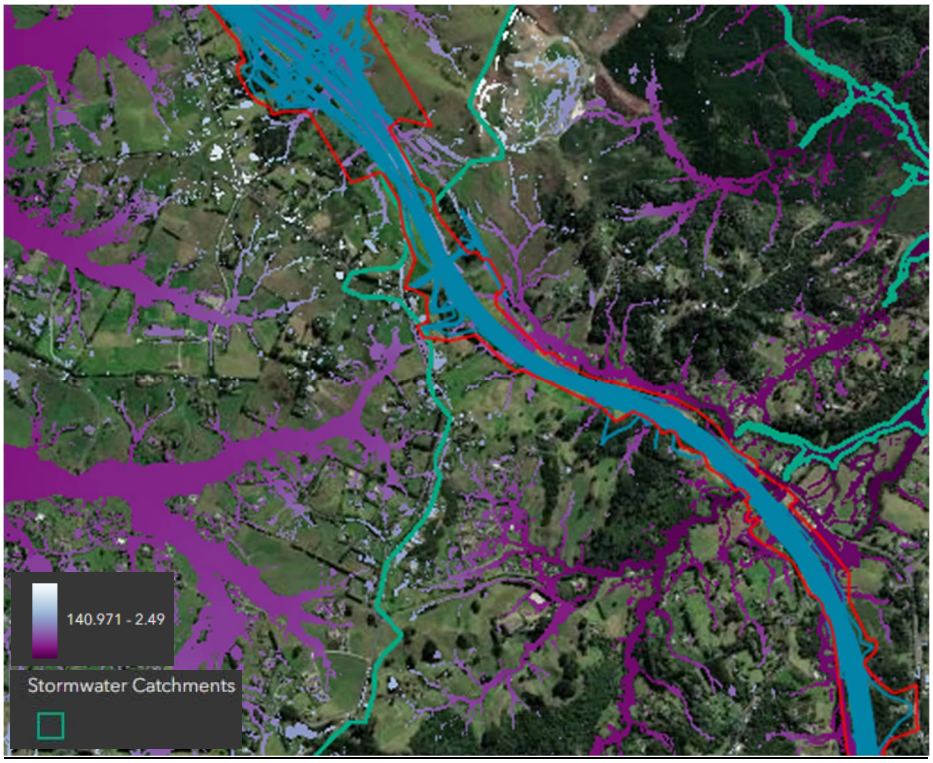

Figure 9-1: NOR4 SH1 predicted 1% AEP base case flood extent Okura River to Bawden Rd

Bawden Rd to north of Wilks Rd

The predicted 1% AEP future with climate change of 2.1° flood extent to 50mm deep is shown in Figure 9-2.

Figure 9-2: NOR4 SH1 predicted 1% AEP base case flood extent Bawden Rd to north of Wilks Rd

North of Wilks Rd to Orewa River

The predicted 1% AEP future with climate change of 2.1° flood extent to 50mm deep is shown in Figure 9-3.

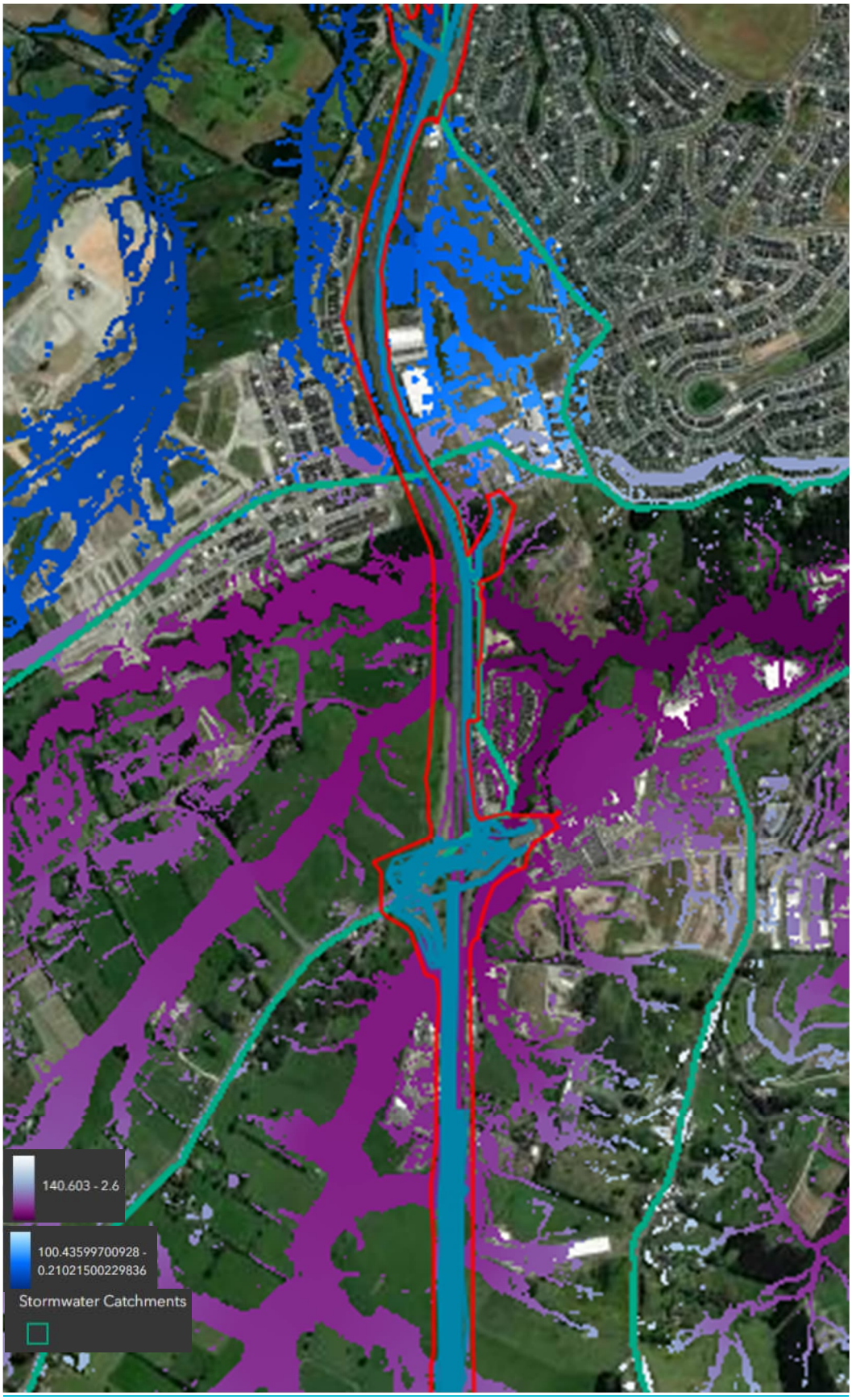

Figure 9-3: NOR4 SH1 predicted 1% AEP base case flood extent north of Wilks Rd to Orewa River

Orewa River to Grand Drive

The predicted 1% AEP future with climate change of 2.1° flood extent to 50mm deep is shown in Figure 9-4.

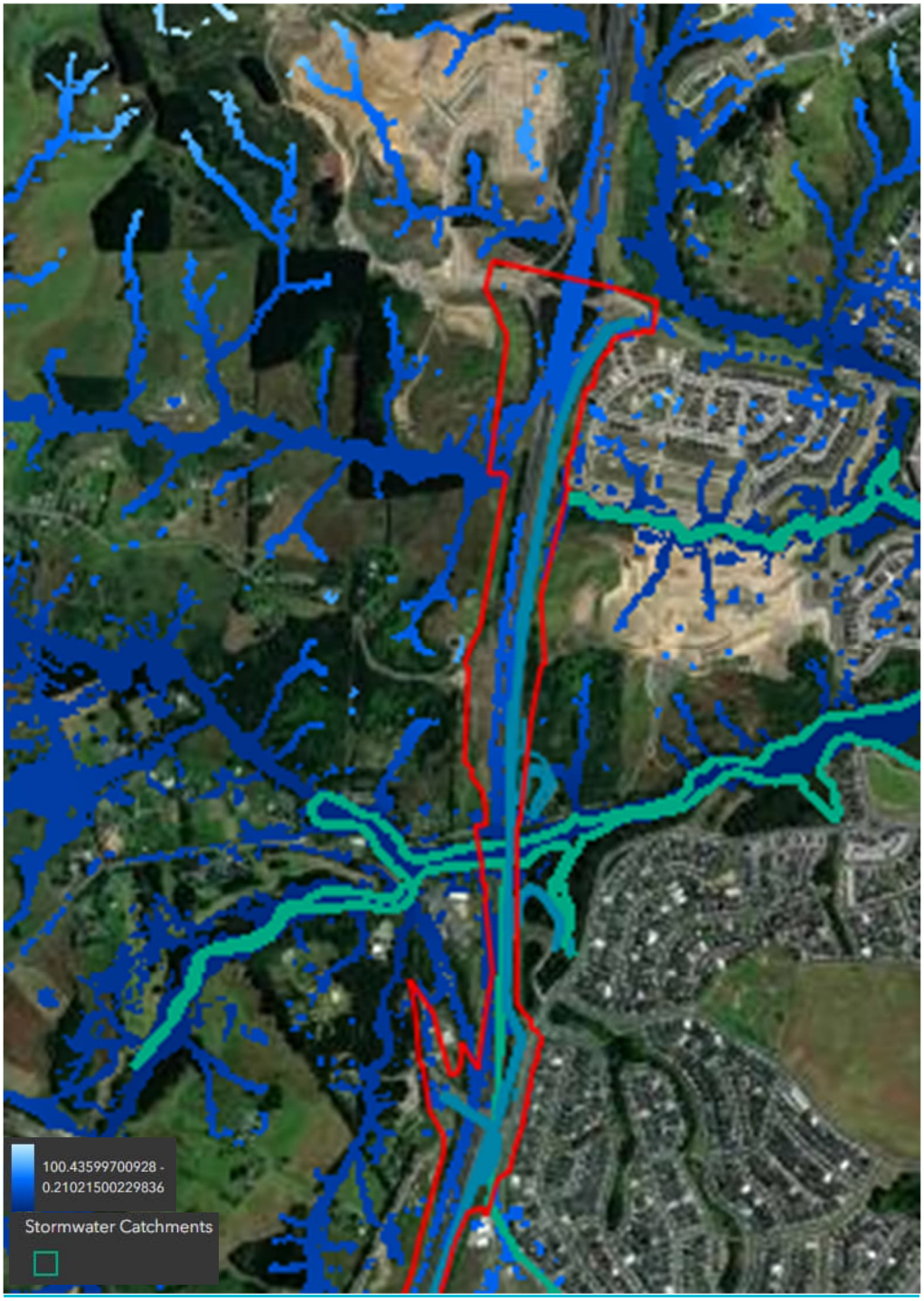

Figure 9-4: NOR4 SH1 predicted 1% AEP base case flood extent Orewa River to Grand Drive

9.2 Positive Flooding and stormwater effects

The positive flooding effects relate to the improvements to the flood resilience of the existing SH1 network by raising or upgrading bridges and culverts to be above the predicted flood plains.

The proposed wetlands will provide water quality treatment for the added impervious area and also attenuation for some locations, particularly at the tops of catchments.

9.3 Assessment of construction effects

The construction impacts of the Project based on the concept design are predicted to be (without appropriate mitigation):

- Construction of upgraded culverts and bridges over existing streams which could create flooding impacts dependent on the construction method (such as blocking flow paths or staging), particularly if large storms are predicted
- Installation of diversion drains / realignment of existing natural streams which could restrict flows and create minor flooding issues
- Construction of new wetlands within a predicted flood plain which displaces flood volume and increases nearby flood levels
- Temporary use of lay down and construction areas in flood plains or overland flow paths which can block flow paths, allow debris to float and block drainage and thereby create flooding
- Widening embankments which can create flooding issues due to formations displacing flooding volume and culvert extensions / upgrades blocking during heavy rainfall periods
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

9.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

9.5 Assessment of operational effects

The following potential operational effects are associated with the proposed NOR design (without appropriate mitigation):

- widening existing bridge crossings could create upstream flooding due to increased inlet levels and greater pipe friction losses which will drive up the upstream water level
- lengthening existing culverts could create upstream flooding due to increased inlet levels and greater pipe friction losses which will drive up the upstream water level
- bridge crossing waterways need to be sized to optimise upstream and downstream waters to within NOR conditions
- minor length reduction of the open permanent stream through culverting or bridging
- construction of new road formation reduces flood storage volume, which could increase tailwater effects and reduce the SH1 culvert and bridge capacities.

9.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main one being later detailed modelling and design to assess the impacts of flood levels / extent / depth due to the culvert extensions, flood storage volume loss and widened bridges. The modelling will optimise the design to comply with the NOR flooding conditions.

The detailed design of stormwater management will also be subject to regional consenting requirements.

9.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

10 NOR 5 – New SH1 crossing at Dairy Stream

10.1 Assessment Features

The concept design for this NOR allows for a new bridge crossing of SH1 near Dairy Stream as shown in Figure 10-1 with the predicted flooding extents for the 1% AEP future with 2.1° climate change base case shown in Figure 10-2.

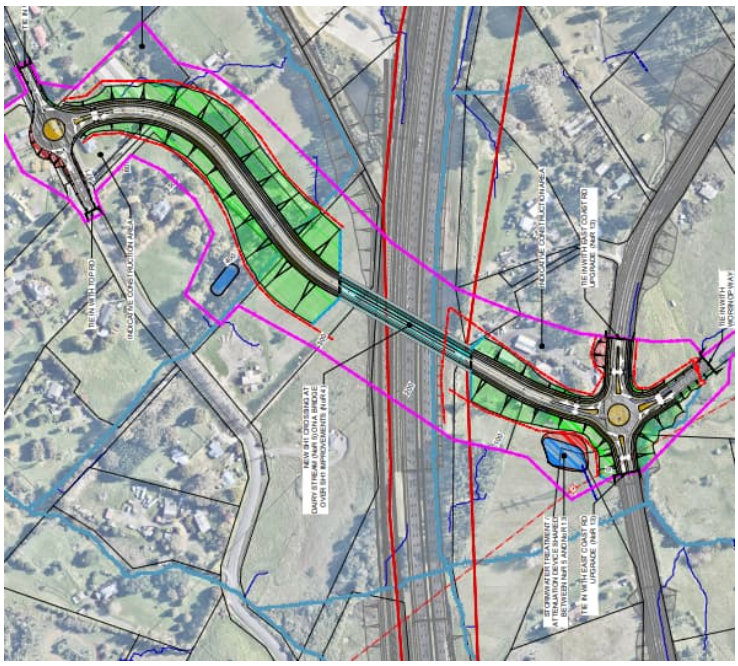

Figure 10-1: NOR5 SH1 bridge crossing near Dairy Stream

Figure 10-2: NOR5 SH1 bridge crossing near Dairy Stream predicted 1% AEP base case flood extent

The site features and works for this NOR that could cause flooding related to the earthworks, minor stream diversion, flood storage volume loss, construction of a culvert over the Dairy Stream tributary and formation / wetland construction adjacent or within the flood plain.

10.2 Positive Flooding and stormwater effects

There are no positive flooding effects apart from the new road formation being constructed above the predicted flood plain.

The proposed wetlands will provide water quality treatment for the added impervious area and also attenuation.

10.3 Assessment of construction effects

The construction impacts of this NOR are predicted to be (without appropriate mitigation):

- Construction of a new culvert over the existing stream which could temporarily reduce capacity and create flooding impacts dependent on the construction method, particularly if large storms are predicted
- Installation of diversion drains / realignment of existing natural streams which could restrict flow and create minor flooding issues
- Construction of new wetlands near a predicted flood plain which could displace flood volume and increase flood levels
- Temporary use of lay down and construction areas in flood plains or overland flow paths which can block flow paths and create flooding
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

10.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

10.5 Assessment of operational effects

The following potential operational effects are associated with the proposed NOR concept design (without appropriate mitigation):

- sizing of the proposed culvert crossing (upstream catchment area approximately 68Ha) which could create upstream or downstream flood differences if not sized appropriately
- minor reduction in the length of the open permanent stream due to culverting
- construction of new road formation which would reduce flood storage volume, which could increase inlet effects.

10.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main one being later detailed modelling and design to assess the impacts of flood levels / extent / depth due to the proposed culvert and flood storage volume loss. Later modelling will optimise the design so that the NOR conditions are met.

The detailed design of stormwater management will also be subject to regional consenting requirements.

10.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

11 NOR 6 – New Connection between Milldale and Grand Drive

11.1 Assessment Features

The concept design for this NOR allows for a new connection between Milldale and Grand Drives as shown in Figure 11-1 with the predicted flooding extents for the 1% AEP future with 2.1° climate change base case shown in Figure 11-2.

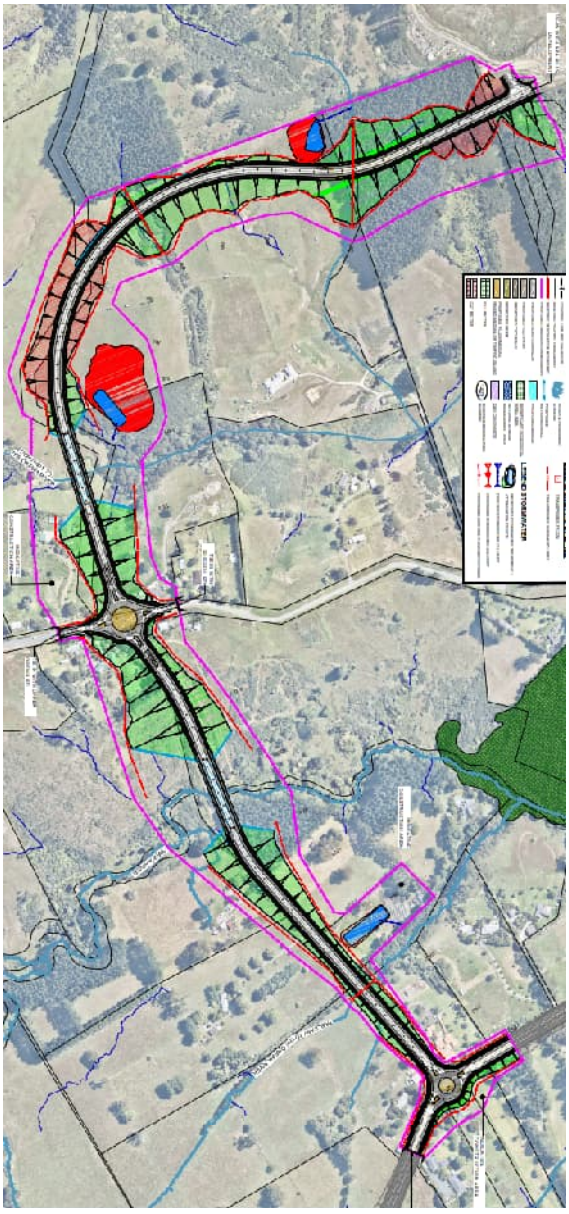

Figure 11-1: NOR6 Milldale to Grand Drive connection

Figure 11-2: NOR6 Milldale to Grand Drive connection predicted future 1% AEP base case flood extents

The features / works for this NOR that could cause flooding relate to the earthworks, flood storage volume loss, construction of bridges and culverts over the streams and formation / wetland construction adjacent or within the flood plain.

11.2 Positive Flooding and stormwater effects

There are no positive flooding effects apart from the new road formation being constructed above the predicted flood plain.

The proposed wetlands will provide water quality treatment for the added impervious area and also attenuation.

11.3 Assessment of construction effects

The construction impacts are predicted to be (without appropriate mitigation):

- Construction of new culverts and bridges over existing streams which could restrict flows and create flooding impacts - dependent on the construction method, particularly if large storms are predicted
- Installation of diversion drains / realignment of existing natural streams which could restrict or divert flows and create minor flooding issues
- Construction of new wetlands within a predicted flood plain which would displace flood volume and increase flood levels

- Temporary use of lay down and construction areas in flood plains or overland flow paths that allow materials to float or divert overland flows and which can create flooding
- Widening embankments which can create flooding issues due to formation work and culvert upgrades blocking during heavy rainfall periods
- Bulk earthworks to complete the formations which require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

11.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

11.5 Assessment of operational effects

The following potential operational effects are associated with the proposed NOR design (without appropriate mitigation):

- Sizing of culvert and bridges restricting and diverting flows
- Minor reduction of open permanent stream due to culverting
- Construction of new road formation reduces flood storage volume
- Location and sizing of wetlands to achieve treatment and attenuation requirements.

11.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with later detailed modelling and design to assess the impacts of flood levels / extent / depth due to new culverts / bridges and flood storage volume loss. The modelling will optimise the design so that the NOR conditions are met.

The detailed design of stormwater management will also be subject to regional consenting requirements.

11.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

12 NOR 7 – Upgrade to Pine Valley Road

12.1 Assessment Features

The concept design for this NOR allows for upgrade to the existing Pine Valley Road as shown in Figure 12-1 with the predicted flooding extents for the 1% AEP future with 2.1° climate change base case shown in Figure 12-2.

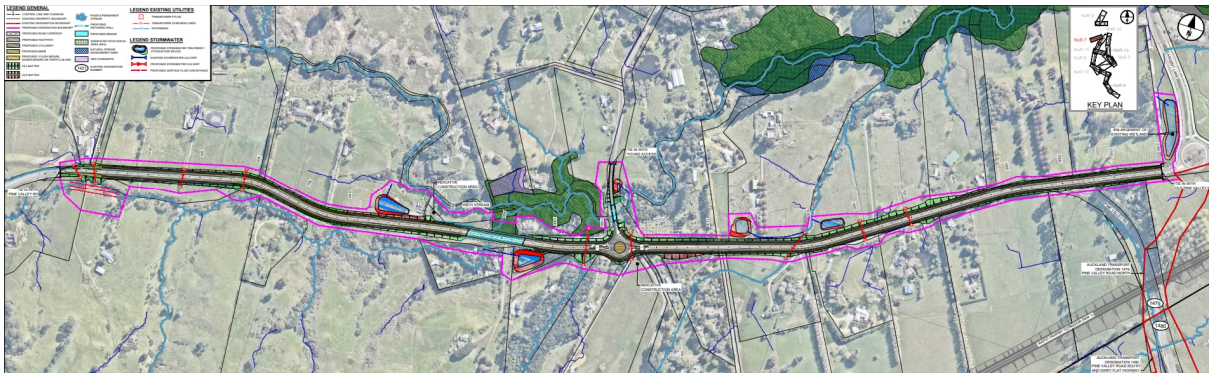

Figure 12-1: NOR7 Pine Valley Upgrade

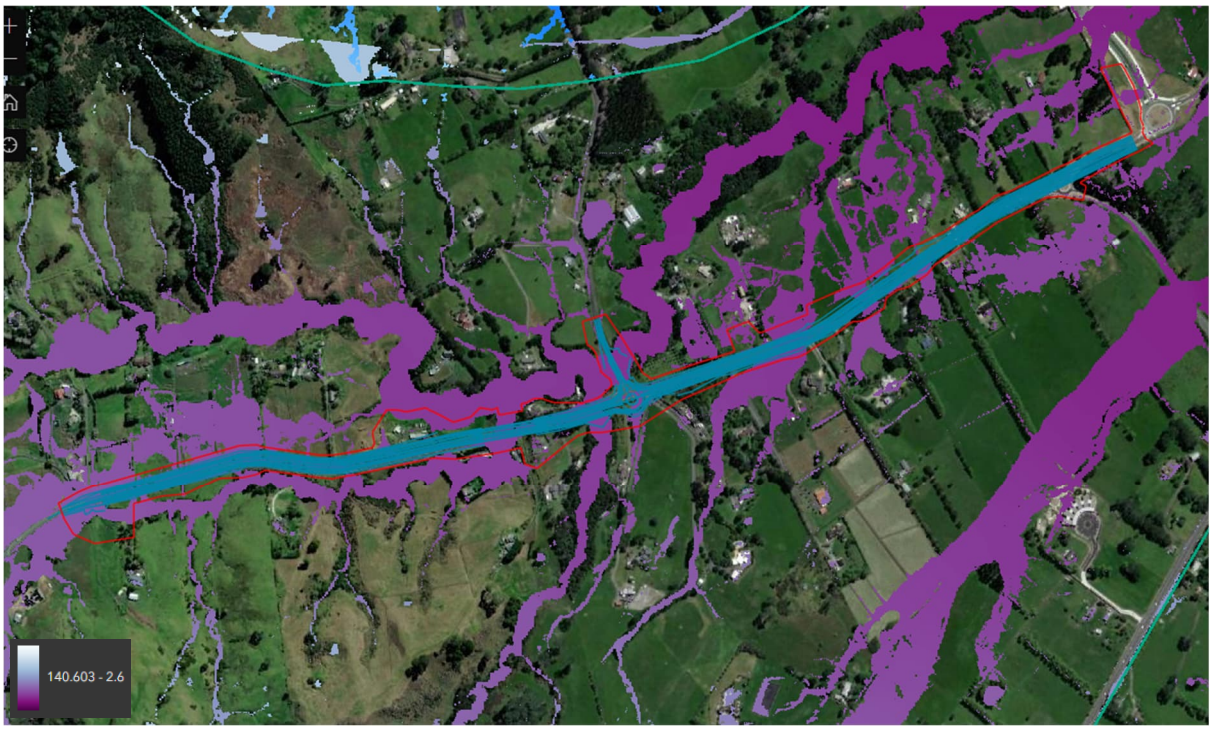

Figure 12-2: NOR7 Pine Valley Upgrade predicted 1% AEP base case flood extent

The potential flooding effects for this NOR relate to the earthworks, road raising, flood storage volume loss, overland flow path impacts, construction of widened bridges and lengthened culverts over existing streams and formation / wetland construction adjacent or within the flood plain.

Refer also to Appendix 3 for details of pre- and post-Project flood modelling undertaken and which led to further refinement to the bridge opening at Pine Valley Road/Young Access Road intersection. The pre and post Project design water level difference at Pine Valley Road/Young Access Road

intersection has been shown to be 14mm compared to the 50mm difference committed to in the proposed flood hazard designation condition.

12.2 Positive Flooding and stormwater effects

The positive flooding effects relate to the upgraded road formation being constructed above the predicted flood plain.

The proposed wetlands will provide water quality treatment for the added impervious area and also attenuation for some locations.

12.3 Assessment of construction effects

The construction impacts are predicted to be (without appropriate mitigation):

- Construction of widened bridges over existing streams which could create flooding impacts by restricting flows - dependent on the construction method, particularly if large storms are predicted
- Installation of diversion drains / realignment of existing natural streams which could restrict flows and create minor flooding issues
- Lengthening of existing culverts on the same grade and alignment could create flooding dependent on the construction method, particularly if large storms are predicted
- Construction of new wetlands within a predicted flood plain which displaces flood volume and increases adjacent flood levels
- Temporary use of lay down and construction areas in flood plains or overland flow paths which can create floating debris, block flow paths and create flooding
- Widening embankments which can create flooding issues due to raised formation work and culvert extensions / upgrades blocking during heavy rainfall periods
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

12.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

12.5 Assessment of operational effects

The following potential operational effects are associated with the proposed NOR concept design (without appropriate mitigation):

- extending the existing culvert crossing which could create upstream flooding due to increased inlet levels and greater pipe friction losses which will drive up the upstream water level
- widened bridge crossings over existing streams which need to be sized to optimise upstream and downstream waters to within NOR conditions
- minor length reduction of an open permanent stream due to culverting of the stream

- construction of new road formation reduces flood storage volume, which could increase upstream water levels.

12.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main one being later detailed modelling of detailed design to assess the impacts of flood levels / extent / depth due to the culvert extensions and flood storage volume loss. The modelling will optimise the design so that the NOR conditions are met.

The detailed design of stormwater management will also be subject to regional consenting requirements.

12.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.

13 NOR 8 – Upgrade to Dairy Flat Highway between Silverdale and Dairy Flat

13.1 Assessment Features

The Dairy Flat Highway alignment and predicted flooding extents for the 1% AEP future with 2.1° climate change base case are shown in Figure 13-1. Figures 13-2 to 13-4 shows more detail of the predicted flooding at three locations where the predicted flooding is greatest.

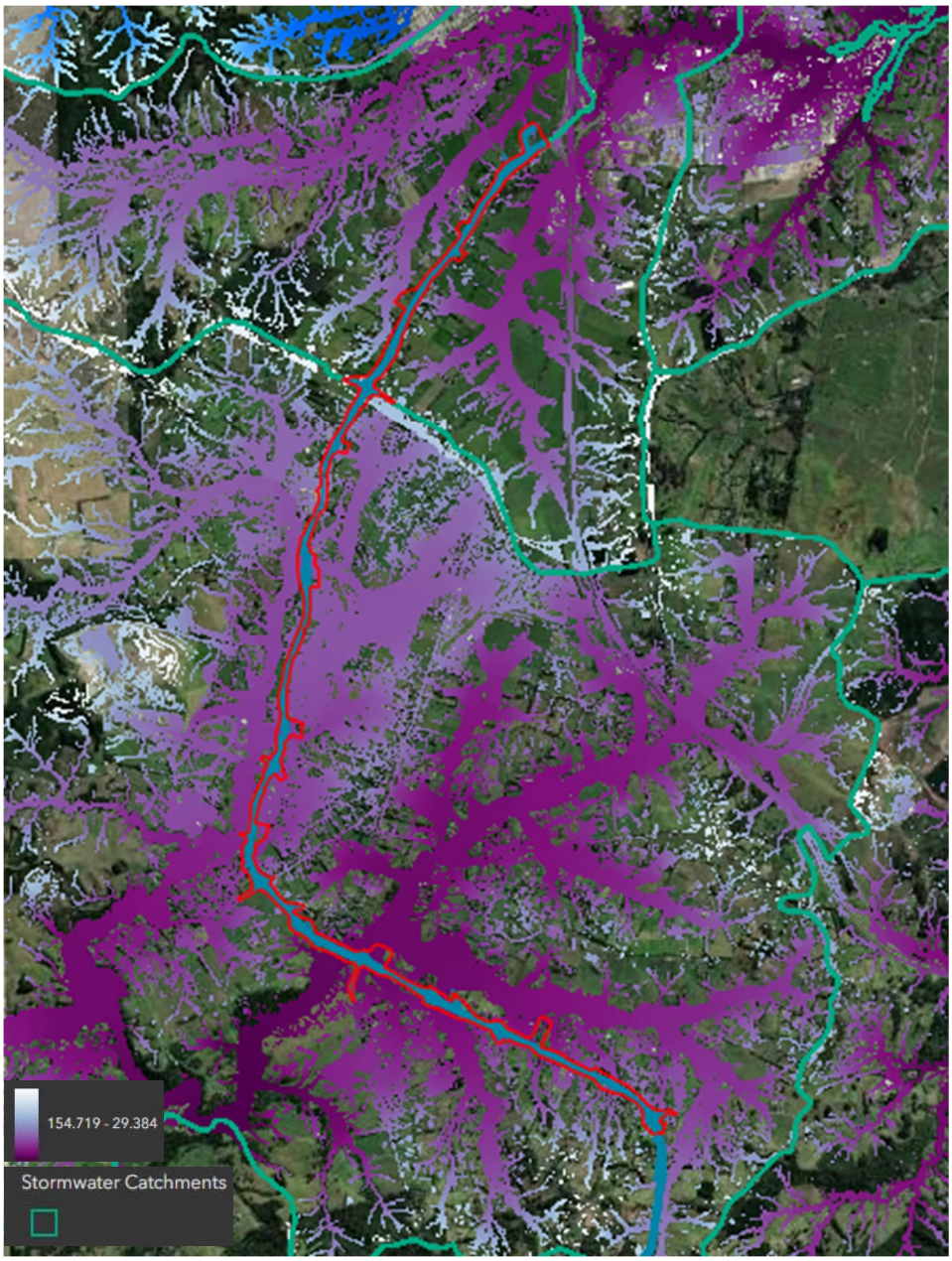

Figure 13-1: NOR8 Dairy Flat Highway Upgrade overall 1% AEP future base case flood extent

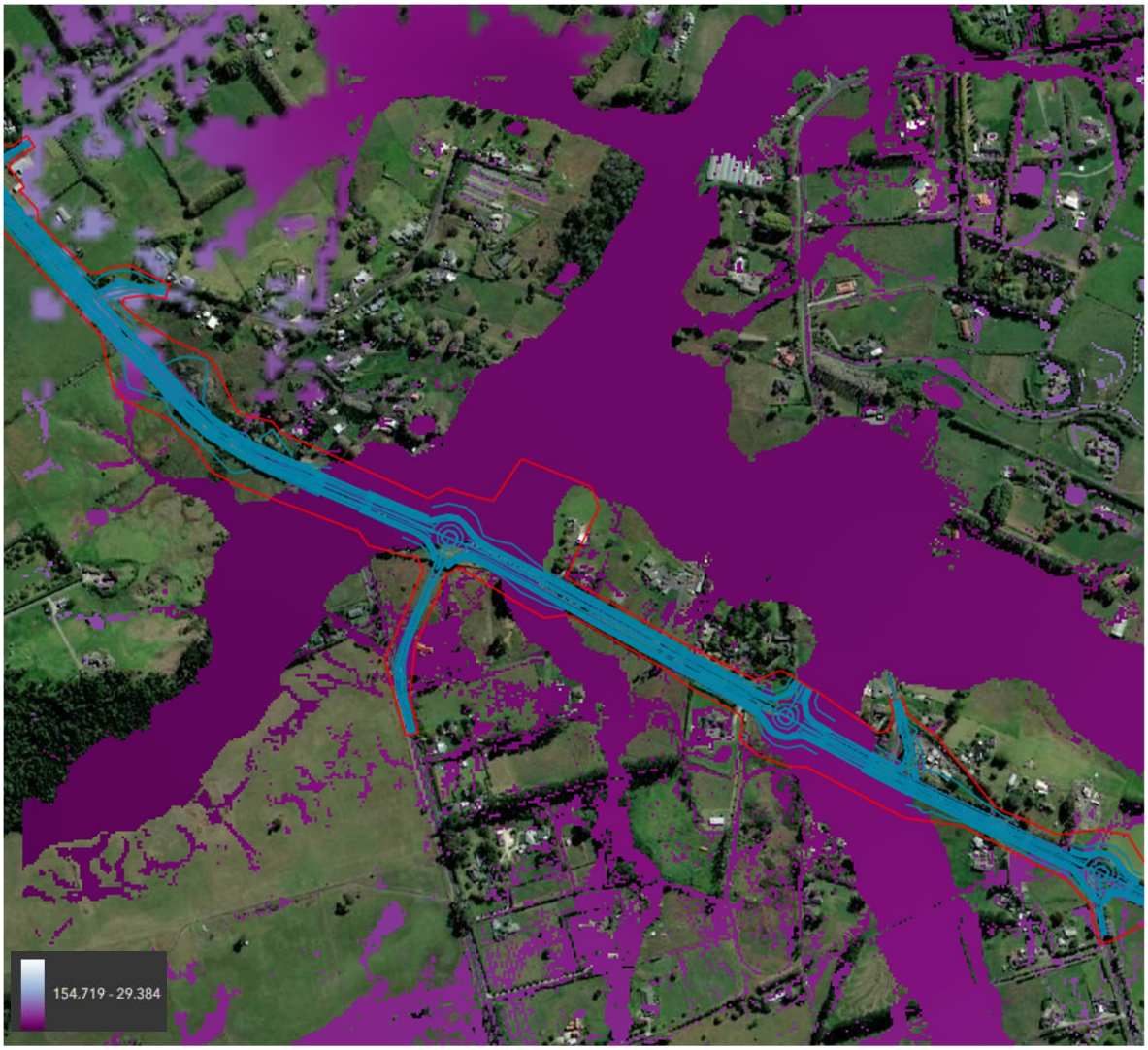

Figure 13-2: NOR8 Dairy Flat Highway Upgrade around Dairy Stream 1% AEP future base case flood extent

Figure 13-3 shows the predicted flood extent around the Dairy Stream crossing of Dairy Flat Highway.

The predicted overtopping of Dairy Flat Highway to the west of the existing Bawden Road intersection and both sides of the Green Road intersection, along with the realigned Bawden Road and bridge were considered sufficient to warrant modelling of the post Project case. This modelling revealed that additional land was needed in the triangle between the old and new Bawden Road alignment and Dairy Flat Highway for ground recontouring. Therefore, the designation was updated to include a small section of land alongside the old Bawden Road alignment. The modelling also showed that the designation conditions could be achieved with further design refinement. The modelling and results are discussed in Appendix 2.

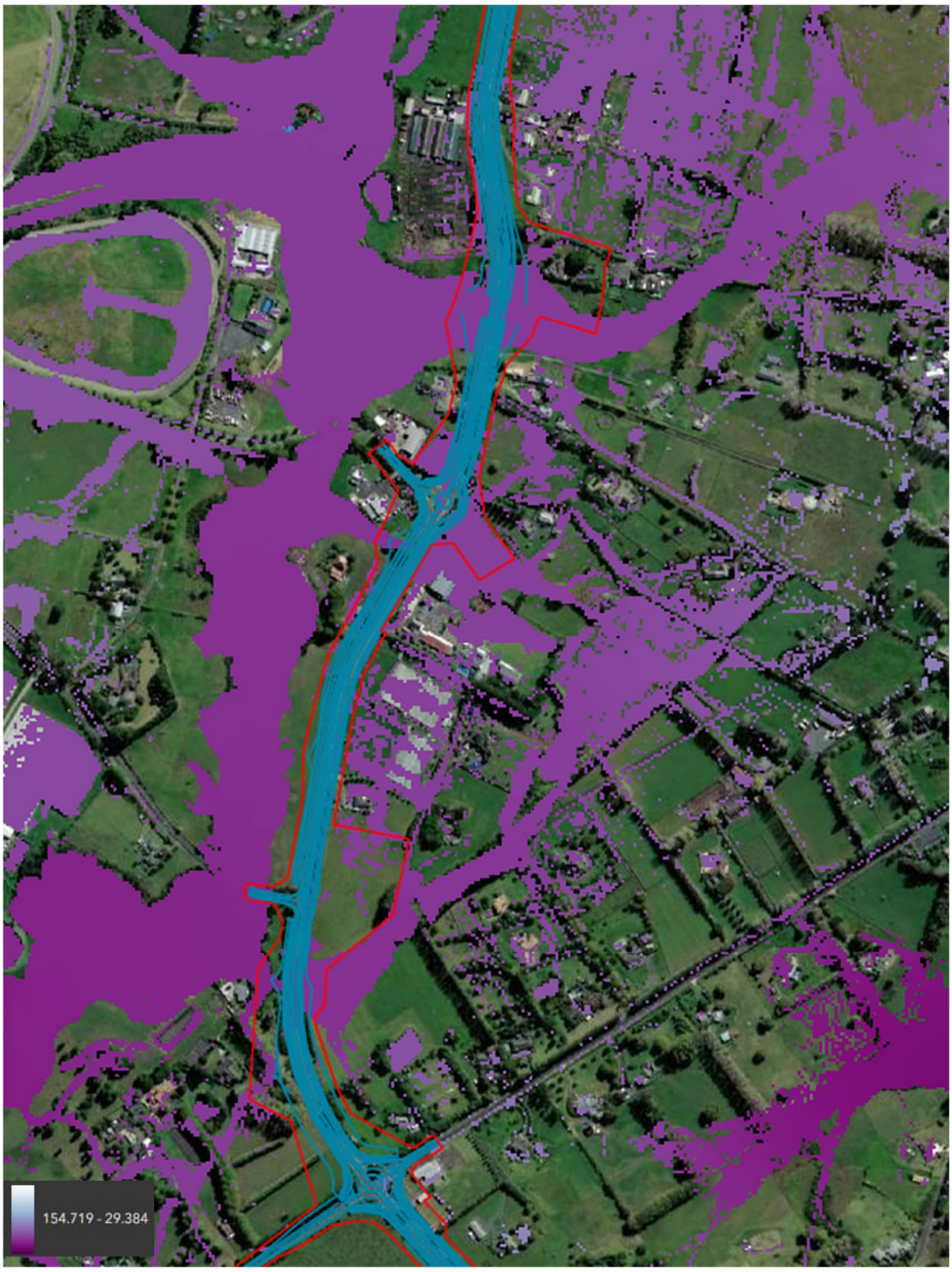

Figure 13-3: NOR8 Dairy Flat Highway predicted 1% AEP flood base case extent around Richards Rd

Figure 13-4: NOR8 Dairy Flat Highway predicted 1% AEP flood base case extent around Kahikatea Flat Rd

The potential flooding effects for this NOR relates to the earthworks, flood storage volume loss, widening of existing bridges and lengthening of existing culverts over the streams and formation / wetland construction adjacent or within the flood plain.

13.2 Positive Flooding and stormwater effects

There are no positive flooding effects apart from the widened road formation being constructed above the predicted flood plain.

The proposed swales and wetlands will provide water quality treatment for the added impervious area and also attenuation for some locations.

13.3 Assessment of construction effects

The construction impacts are predicted to be (without appropriate mitigation):

- Construction of a new culvert and bridges over existing streams which could create flooding impacts by blocking flows - dependent on the construction method, particularly if large storms are predicted

- Installation of diversion drains / realignment of existing natural streams which reduce capacity or divert flows and could create minor flooding issues
- Construction of new wetlands within a predicted flood plain which displaces flood volume and increases flood levels
- Temporary use of lay down and construction areas in flood plains or overland flow paths which can create floating debris, blockage of drainage systems and flooding that are not predicted prior to the work
- Widening embankments which can create flooding issues due to formation work and culvert extensions / upgrades blocking during heavy rainfall periods
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

13.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

13.5 Assessment of operational effects

The following potential operational effects are associated with the proposed NOR design (without appropriate mitigation):

- lengthening existing culverts could create upstream flooding due to increased inlet levels and greater pipe friction losses which will drive up the upstream water level
- bridge crossings over the streams will need to be sized to optimise upstream and downstream water levels to within conditions
- minor length reduction of open permanent stream through lengthened existing culverts
- construction of new road formation reduces flood storage volume, which could increase water levels.

13.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main one being later detailed modelling and design to assess and manage the impacts of flood levels / extent / depth due to the culvert / bridge extensions and flood storage volume loss.

The detailed design of stormwater management will also be subject to regional consenting requirements.

13.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions. NOR 9 – Upgrade to Dairy Flat Highway between Dairy Flat and Albany.

14 NOR 9 – Upgrade to Dairy Flat Highway between Dairy Flat and Albany

14.1 Assessment Features

The Dairy Flat Highway alignment and predicted flooding extents for the 1% AEP future with 2.1° climate change base case are shown in Figure 14-1 (excluding Albany Village). Figure 14-2 shows details of the predicted flooding at the northern end of Albany Village. The majority of this NOR is on a ridgeline; therefore flood effects are minimal except for either end of the alignment.

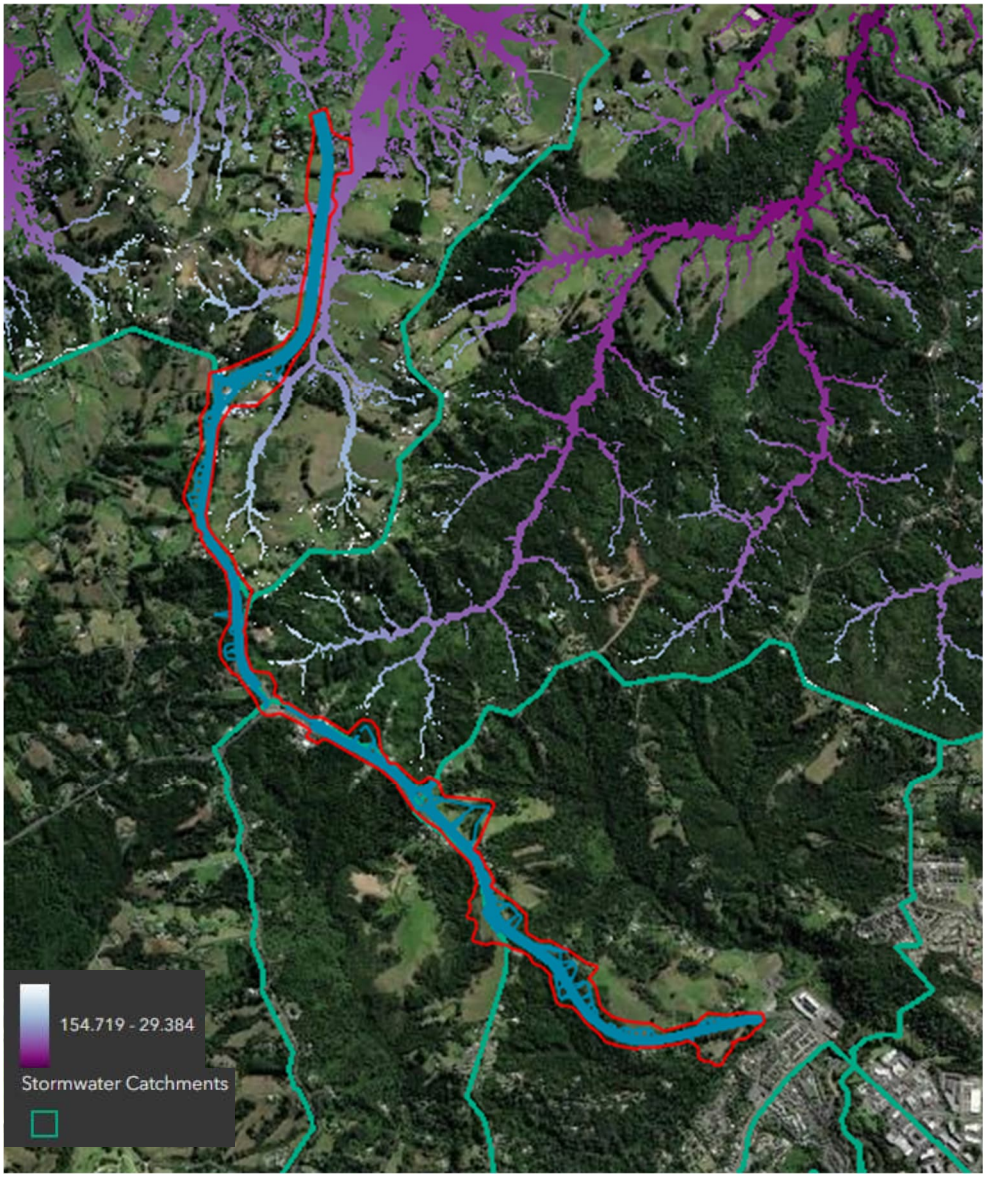

Figure 14-1: NOR9 Dairy Flat Highway predicted 1% AEP flood base case extent (excluding Albany)

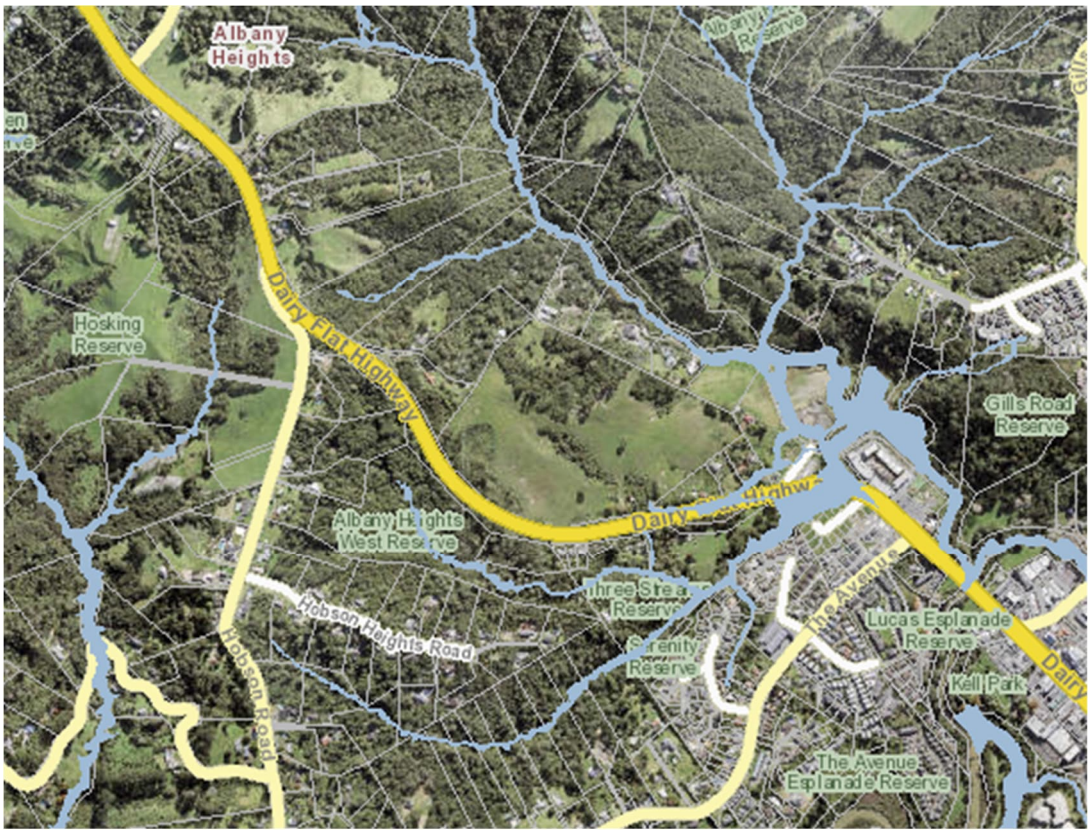

Figure 14-2: NOR9 Dairy Flat Highway predicted 1% AEP flood base case extent around Albany (AC Geomaps)

The site features for this NOR that could cause flooding relate to the earthworks, minor stream diversions, extension of existing culverts over the streams and formation / wetland construction adjacent or within the flood plain.

14.2 Positive Flooding and stormwater effects

The proposed wetlands will provide water quality treatment and attenuation for the existing road impervious area which will improve downstream flood impacts and water quality.

14.3 Assessment of construction effects

The construction impacts are predicted to be (without appropriate mitigation):

- Construction of new culvert and bridges over existing streams which could create flooding impacts by restricting flows - dependent on the construction method, particularly if large storms are predicted
- Installation of diversion drains / realignment of existing natural streams which could create restrict or divert flows and cause minor flooding issues
- Construction of new wetlands within a predicted flood plain which displaces flood volume and increases flood levels
- Temporary use of lay down and construction areas in flood plains or overland flow paths which can create flooding that are not predicted prior to the work

- Widening embankments which can create flooding issues due to formation work and culvert extensions / upgrades blocking during heavy rainfall periods
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts.

14.4 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction mitigation measures as noted in Section 5.4.

14.5 Assessment of operational effects

The following potential operational effects are associated with the proposed NOR design (without appropriate mitigation):

- lengthening existing culverts could create upstream flooding due to increased inlet levels and greater pipe friction losses which will drive up the upstream water level
- bridge crossings over the streams will need to be sized to optimise upstream and downstream water levels to within flooding conditions
- minor length reduction of open permanent stream through lengthened existing culverts
- construction of new road formation reduces flood storage volume, which could increase water levels.

14.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main one being later detailed modelling and design to assess and manage the impacts of flood levels / extent / depth due to the culvert / bridge extensions and flood storage volume loss. The modelling will optimise the design so that the NOR conditions are met.

The detailed design of stormwater management will also be subject to regional consenting requirements.

14.7 Summary and Conclusions

The standard construction and operational impacts discussed under Section 5 apply to this NOR.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions.