TE TUPU NGĀTAHI
SUPPORTING GROWTH

Warkworth Assessment of Flooding Effects

May 2023

Version 1.0

WAKA KOTAHI
NZ TRANSPORT AGENCY

New Zealand Government

Document Status

Responsibility	Name
Author	Luciano Lanham /Anna Liu
Reviewer	Mike Summerhays
Approver	Roger Seyb

Revision Status

Version	Date	Reason for Issue
1.0	12/05/2023	Issue for lodgement

Table of Contents

Glossary of Abbreviations, Defined Terms and Acronyms

Abbreviations

Acronym/Term	Description
AEE	Assessment of Effects on the Environment report
ARI	Average Recurrence Interval
AT	Auckland Transport
AUP: OP	Auckland Unitary Plan: Operative in Part
CEMP	Construction Environmental Management Plan
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
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
NoR	Notice of Requirement
P2W	Puhoi to Warkworth State Highway currently under construction
RCP	Representative Concentration Pathways relating to future climate change scenarios
SEA	Significant Ecological Area
SH1	State Highway 1
SMAF	Stormwater Management Area: Flow
SRP	Sediment Retention Pond
Te Honohono ki Tai	Te Honohono ki Tai / Matakana Link Road project
Te Tupu Ngātahi	Te Tupu Ngātahi Supporting Growth Alliance
Waka Kotahi	Waka Kotahi New Zealand Transport Agency

Defined Terms and Acronyms

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.
Dry Pond	A permanent pond that is normally dry but during rainfall events temporarily stores stormwater runoff to control discharges. Dry wetlands provide limited water quality treatment.
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 wetlands.
MPD	Maximum Probable Development according to the AUP: OP zonings and the Auckland Council Healthy Waters technical memorandum dated
Pre-development	Prior to construction of the Project
Post-development	After construction of the Project
Warkworth Assessment Package	Made up of eight Notice of Requirement
Stormwater Wetland	Constructed wetlands that temporarily 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.
Terrain	An elevation model which includes the ground levels based on 2016 LiDAR and the concept design ground levels.
Wetland	A permanent pond that has a standing pool of water and provides water quality treatment, and storage of stormwater runoff to reduce the peak water volume from a rainfall event and provide downstream erosion protection.

1 Executive Summary

1.1 Overview

The Warkworth Assessment Package is a network of planned transport infrastructure with the purpose of responding to planned future growth in the Warkworth growth areas. The transport network is made of eight notice of requirements (NOR) including new corridors, existing road upgrades, and a public transport interchange with park and ride.

Flooding is a natural hazard and has therefore been considered as part of the Warkworth NOR to assess if the SGA proposals will impact that flooding using the Auckland Council Healthy Waters (ACHW) model that AECOM recently updated to understand the existing flood risks. Note that the model has not been sent to AC HW for review and acceptance so the results are preliminary and have been compared to those published on the AC Geomaps site and the proposed NOR has not been modelled to assess the impacts.

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

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions. It is also acknowledged that there will be a subsequent outline plan process and process for seeking regional resource consents which will address 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.

1.2 Methodology

The assessment of flooding effects for the Warkworth NoR involved the following steps:

- Desktop assessment to identify potential flooding locations
- Modelling of the pre-development terrain with future Maximum Probable Development (MPD) and 100year Average Recurrence Interval (ARI) plus climate change rainfall using the latest AC HW model. MPD allows for the maximum allowable impervious coverage as per the AUP: OP zonings and the AC Healthy Waters memo of 4 Sept 2019.Two future climate scenarios were modelled, allowing for 2.1°C and 3.8°C of temperature increase
- 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.

While stormwater effects (apart from flooding) were not assessed, provision is made for the future mitigation of potential stormwater effects (stormwater quantity, stormwater quality and instream structures) by identifying the space required for stormwater management devices (for example wetlands) and incorporating land for that purpose into the proposed boundaries.

1.3 Assessment of effects

1.3.1 Overall Warkworth Network

The flooding assessment for the Warkworth catchment has been completed using the pre-Te Tupu Ngātahi development (base case) and AC Geomaps model results.

The main flood effects that may impact the proposed Te Tupu Ngātahi transport corridors and adjacent property are associated with streams, ponding / depression areas and overland flow paths rather than urban pipe network issues. Flooding is associated with excess flow that the primary network cannot cope with and where ponding can occur, or overland flow exceeds Auckland Council hazard criteria (flow and depth).

Positive effects

The main positive effects that could be designed for are:

- proposed roadways to be above the 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, previously existing impervious road areas may not have been treated
- attenuation of the total impervious area associated with the new or widened roadways which reduces the overall runoff rates back to pre-SGA development.

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 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
- Manage overland flow paths to reduce the risk of increased flooding
- Construction Environmental Management Plans developed and implemented, including continuous improvement as necessary.

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
- Changing flows through bridge or culvert crossings

- Increased impervious area to treat for treatment, attenuation or both dependent on the location of the device in the catchment.

Mitigation measures which may be implemented include:

- Detailed flood modelling of the detailed final corridor design during the later 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 (e.g NOR 8 on 2, NOR 3 on 2 and NOR 7 on 5)
- Designing culvert sizes so that the upstream and downstream water level differences do not increase by more than 0.05m on land zoned for urban development or no increase for existing floors at risk of flooding. Culverts will be designed for the 100yr 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
- Providing overland flow paths to avoid creating flood prone areas
- Installing drains at the toe of 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
- Providing space for wetlands for treatment and attenuation as needed.

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.

1.3.2 Warkworth Network Summary of Effects and Recommendations

The main potential flooding issues within the proposed Warkworth SGA Network are:

- Very large catchment flows and potential flood effects for NOR associated with the Mahurangi River upstream of Woodcocks Rd (NOR 2 and 8)
- Existing roads predicted to overtop and proposed to be raised to flood protect the roads (e.g. NOR 2, 3 and 5)
- New formations /bridges / culverts over or near existing streams
- Earthworks for roadway, construction of wetlands, deep cuttings and large fills
- Flood plain storage loss
- Treatment for water quality only in areas near downstream ends of catchments

The summary of the main issues and recommendations are shown in Table 1 below.

Table 1. Warkworth Network summary of Effects and Recommendations

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	All: 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.	All: 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.
Mahurangi River bridges require works in river (such as temporary works) which can restrict flows. Also the very large upstream catchments can create very large flows. 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	NOR2 and NOR8: 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.
SH1 culvert upgrade at PT Hub will increase downstream water levels and flows therefore increasing construction flood risk in PT Hub	Greater flood flows from the larger pipe along with works which could reduce flood storage (wetland, embankment and bridge construction) could cause the site to become inundated and spill over on to adjoining land during construction.	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.
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	NOR1, 2, 7 and 8: Detailed modelling to assess best option to meet Flood Hazard condition requirements for upstream and downstream water levels.

Effect	Assessment	Recommendation
	designed appropriately - additional cross conveyance capacity may be needed.	
Raising existing roads above the predicted 100yr future flood levels could increase upstream flood levels.	Greater protection of road to flooding will require increased flow capacity beneath the road with the aim of flood neutrality upstream and downstream of the raised road formation	NOR 2, 3 and 5 Optimisation of bridge or culverts through later detailed modelling (of the detailed design) and design to achieve flood consent conditions.
Mahurangi River bridges with large predicted flood flows could have significant effects on flood levels if not carefully designed to achieve flood level requirements	Bridge opening could impact upstream and downstream water levels so it needs to be optimised to minimise changes to flood levels.	NOR2 and NOR8: Detailed modelling (of the detailed design) of the bridge and associated formation design during later design stages to optimise bridge opening to meet consent conditions.
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.	NOR6 and NOR7: 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
SH1 pipe upgrade from 1.2 to 2.4m will increase downstream flows and water levels in PT Hub area.	The increased flow rate and water levels downstream of the 2.4m culvert and the available flood storage needs to be understood as it will impact wetland, embankment and bridge design.	NOR1. Design of wetland, embankments and bridge needs to be optimised to reduce flood levels in line with consent conditions. Detailed design and modelling needed at later stages.
Wetlands for treatment only will reduce footprint needs	Downstream wetlands could be water quality only (GD01) as opposed to treatment and attenuation	NOR4 and NOR5: Detailed modelling (of detailed design) to show attenuation not needed during later design stages.
Bridge over existing stream could create upstream flood water level increase	Bridge opening size needs to be optimised in line with consent conditions	Detailed modelling (of the detailed design) of the bridge and associated formation design during later design stages also ties in with Sandspit Rd bridge to meet consent conditions

1.3.3 Conclusions

Later detailed design and any associated modelling of this design will give further consideration to potential NOR flooding effects to identify how the post SGA flooding effects of the final design will be managed to achieve the consent conditions.

The positive flooding effects are primarily associated with raising existing roads out of the flood plain (NOR 2, 3 and 5) that are currently predicted to flood in the future 100yr events .

The construction management and mitigation controls apply to all NOR.

The flooding effects and controls within the Warkworth assessment area are associated with:

- P2W increase of the existing SH1 culvert from 1.2 to 2.4m which will increase downstream flows and water levels. This needs to be modelled to fully understand the risk.
- the large potential flood flows upstream of NOR 2 (Woodcocks Rd) and 8 (Wider Western Link Rd). Monitoring of rainfall upstream of these sites should be completed to prepare and control effects of any large rainfall flood flows;
- the raising of Sandspit Rd where the current bridge is predicted to overtop will require construction controls and flood modelling / design to optimise the bridge level / opening to meet consent conditions, and;
- raising of SH1 Southern section above the predicted 100yr flood plain will also require optimisation of the construction method and number / size of bridge openings through later detailed design and modelling to meet consent conditions.

The assessed flood effects can be managed by adjusting the proposed road geometry and changing the culvert and bridge opening areas so that the proposed NOR conditions will be met. In particular, the conditions require that there will be no increase in flooding of existing identified flooded habitable floors and no more than 50mm change to flood levels within properties.

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

2 Introduction

This stormwater flooding assessment has been prepared for the Te Tupu Ngātahi Supporting Growth Alliance, Warkworth Package of Notices of Requirement (NoRs) for Auckland Transport (AT) and Waka Kotahi NZ Transport Agency (WK) as requiring authorities under the Resource Management Act 1991 (RMA). The notices are to designate land for future strategic transport corridors as part of Te Tupu Ngātahi Supporting Growth Alliance to enable the future construction, operation and maintenance of transport infrastructure in the Warkworth area of Auckland.

2.1 Warkworth Growth Area

Warkworth is located at the northernmost extent of the Auckland Region, approximately 60km from the Auckland city centre, and 30km north of Orewa. It is identified as a satellite town in the Auckland Unitary Plan: Operative in Part (AUP: OP) and will act as a rural node that serves both the surrounding rural communities as well as connecting to urban Auckland.

The Warkworth growth area will be less than 5km north-south and east-west and will make a significant contribution to the future growth of Auckland's population. 1,000Ha of currently rural land has been rezoned (Future Urban Zone) to support significant business and residential growth. At full build out it is anticipated to provide for approximately 8,200 new dwellings and employment activities that will contribute to 4,600 new jobs across Warkworth. This growth area will be development ready in the stages outlined below:

- **Stage 1** Warkworth North – Business land is already live zoned and remainder to be development ready by 2022.
- **Stage 2** Warkworth South – To be development ready between 2028 – 2032
- **Stage 3** Warkworth Northeast – To be development ready between 2033 – 2037

Furthermore, the Warkworth Structure Plan was adopted by the Council in 2019 and sets out the framework for transforming Warkworth from a rural environment to an urbanised community over the next 15 – 20 years.

The Warkworth Assessment Package will provide route protection for the local arterials, which include walking, cycling and public transport linkages needed to support the expected growth in Warkworth. The Warkworth Package of projects is summarised in Section 2.

This report addresses the stormwater flooding effects of the Warkworth Package (NOR 1 – NOR8) identified in Table 4 and Figure 3 in Section 3.

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

2.2 Purpose and scope of this Report

This Flooding and Stormwater assessment forms part of the suite of technical reports prepared to support the assessment of effects (AEE) for the Warkworth Package. Its purpose is to inform the AEE that accompanies the eight Warkworth Network NoRs sought by AT and WK.

This report considers the actual and potential effects associated with the construction, operation and maintenance of the Warkworth Package on the existing and likely future environment as it relates to

Flooding effects and recommended measures that may be implemented to avoid, remedy and/or mitigate these effects.

The key matters addressed in this report are as follows:

a) Identify and describe the Flooding context of the Warkworth Assessment Package area;
b) Identify and describe the actual and potential Flooding effects of each Project corridor within the Warkworth Assessment Package;
c) Recommend measures as appropriate to avoid, remedy or mitigate actual and potential Flooding effects (including any conditions/management plan required) for each Project corridor within the Warkworth Assessment Package; and
d) Present an overall conclusion of the level of actual and potential effects for each Project corridor within the Warkworth Assessment Package after recommended measures are implemented.

This report should be read alongside the AEE, which contains further details on the history and context of the Warkworth project. 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.

During the later outline plan and regional consenting phase additional detailed modelling and design will be completed to refine the proposed design to quantity and optimise the Flooding and Stormwater effects to meet to meet designation Flood Hazard condition requirements. The detailed design of stormwater management will also be subject to regional consenting requirements.

2.3 Report Structure

In order to provide a clear assessment of each NoR, this report follows as appropriate, the structure set out in the AEE and shown in Table 2 below. Table 2 below the extent of each corridor, and which section covers the description of effects can be found.

This report contains an assessment of the actual and potential effects of the Warkworth project on an overall catchment basis as well as the individual corridors having 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.

Section 6 identifies general predicted flooding and stormwater effects on an overall catchment basis whilst section 7 to 14 covers specific issues for each NOR.

Table 2. Report Structure

Sections	Section number
Description of the Project	3
Overview of the methodology used to undertake the assessment and identification of the assessment criteria and any relevant standards or guidelines	4

3 Warkworth Package Overview

The Warkworth package is a network of planned transport infrastructure with the purpose of responding to planned future growth in the Warkworth growth areas. The transport network is made of eight NoRs including public transport interchanges, existing road upgrades, and new corridors.

An overview of the Warkworth network is set out in Table 3 and shown in Figure 1.

Table 3. Warkworth NOR Package

Corridor	NOR	Description	Requiring Authority
Northern Public Transport Hub and Western Link – North	1	New northern public transport hub and associated facilities including a park and ride at the corner of State Highway 1 (SH1) and the new Western Link – North. New urban arterial cross-section with active mode facilities between the intersection of SH1 and Te Honohono ki Tai (Matakana Link Road) to the proposed bridge crossing, enabling a connection for development in the Warkworth Northern Precinct as provided for in the Warkworth North Precinct.	Auckland Transport
Woodcocks Road - West	2	Upgrade of the existing Woodcocks Road corridor between Mansel Drive and Ara Tūhono (Puhoi to Warkworth) to an urban arterial cross-section with active mode facilities.	Auckland Transport
State Highway 1 – South Upgrade	3	Upgrade of the existing SH1 corridor between Fairwater Road and the southern Rural Urban Boundary to an urban arterial cross-section with active mode facilities.	Auckland Transport
Matakana Road Upgrade	4	Upgrade of the existing Matakana Road corridor between the Hill Street intersection and the northern Rural Urban Boundary to an urban arterial cross-section with active mode facilities.	Auckland Transport
Sandspit Road Upgrade	5	Upgrade of the existing Sandspit Road corridor between the Hill Street intersection and the eastern Rural Urban Boundary to an urban arterial cross-section with active mode facilities.	Auckland Transport
Western Link – South	6	New urban arterial cross-section with active mode facilities between the intersection of SH1 and McKinney Road and Evelyn Street.	Auckland Transport
Sandspit Link	7	New urban arterial cross-section with active mode facilities between the intersection of Matakana Road and Te Honohono ki Tai (Matakana Link Road) and Sandspit Road.	Auckland Transport

Corridor	NOR	Description	Requiring Authority
Wider Western Link – North	8	New urban arterial cross-section with active mode facilities between Woodcocks Road and the Mahurangi River.	Auckland Transport

Figure 1. Warkworth NOR package Overview

4 Assessment Methodology

The assessment of flooding effects has involved the following steps using the Auckland Council and Te Tupu Ngātahi GIS.

- Desktop assessment to identify potential flooding locations, namely:

– Existing buildings appear to be near/within the existing flood plains.
– Where works are near stream crossings and major overland flow paths.

- Flood modelling of the pre-development (without Te Tupu Ngātahi) terrain, including:

– Flood modelling of the proposed future land use using Maximum Probable Development (MPD) development with the 100year ARI plus climate change rainfall using both 2.1 and 3.8° temperature increases. MPD allows for the maximum allowable impervious coverage as per the AUP: OP zonings and the AC Healthy Waters memo of 4 Sept 2019.
– Model results were used to identify potential changes in the flood water levels for the two climate change scenarios to understand the risk of future increased climate change impacts.

- Inspection of the flood maps to identify flooding effects, including:

– At key cross drainage locations such as culverts and where there are noticeable deep flood levels, consideration was given to flood hazard issues.
– Properties and buildings with habitable floors showing potential to flooding hazard through flood extent within the existing building footprints.

Stormwater effects apart from flooding were not assessed, with this to be undertaken through the regional consenting phase at detailed design**,** provision was made for the future management of potential stormwater effects (stormwater quantity and quality) by identifying the space required for stormwater management devices (i.e. treatment and attenuation wetlands) and incorporating land for that purpose into the NORs and designations.

In identifying the land required for these devices, preliminary sizing and siting has been undertaken and extra space allowed for constructing the works. Potential sites are shown for each of the specific NORs.

Some key assumptions that were used to identify the amount of land sought for stormwater management works within the designation include the following:

- Wetlands are sized to attenuate 100year peak flows from the corridor (as this gives the largest footprint) using a rule of thumb of 10% of the specific impervious catchment area provides the wetland footprint
- Quality and retention/detention requirements are able to fit within the footprint
- Allowance is made for wetland attenuation storage and hydraulic gradients from corridor inlet to discharge point (typically a minimum of 2.0 to 2.5m vertically)
- Wetland geometry and footprints were modelled to determine the required cut and fill and a 15m buffer added for construction purposes and maintenance access
- A minimum 6m buffer is provided around the corridor earthworks extents to provide space for construction purposes and allow for works such as drainage channels and culvert inlets/outlets and flexibility in the vertical alignment

- Diversion channels are identified where they are needed to prevent upstream flooding.

These allowances are considered appropriate for sizing the devices at this early stage of the design process and also provide some flexibility for future refinement. The design of devices is not discussed further in this report as this is considered a matter that will be developed further for the future regional consenting phase and implementation processes.

4.1 Methodology

The assessment looked at the construction and operational impacts associated with each of the NOR using the Rev B drawings to understand the potential locations for flooding and stormwater effects to occur.

Overland flow paths are shown as blue lines in Figure 2 below with line thickness and solidness indicating the relative order of the flow rate (dotted = < 0.5m^3/s, thinner solid blue 0.5 to <2 m^3/s and thicker solid blue > 2 m^3/s).

Flood prone areas (black hatched areas in Figure 2) are where there is a potential depression upstream of an inlet which will create flooding / ponding if that inlet blocks (e.g. culvert inlet).

Flood plains are based on ponding areas, and overland flow rates (> 2 m^3/s). If there are areas of flooding upstream associated with a depression (that exceeds certain criteria) then downstream overland flow from that flooding depression area only needs to exceed 0.5 m^3/s to be considered flood plain.

Note the flood plain extent shown in Figure 3 is based on AC Geomaps which shows the modelling was completed in August 2017 by Auckland Council. It is understood that Auckland Council are in the process of updating this modelling and when complete will update Geomaps accordingly.

The required freeboard for bridges and culverts used to assess the suitability of the indicative design is set out in Table 4: Freeboard allowance for the level of serviceability to traffic (NZ Bridge Manual).

Table 4: Freeboard allowance for the level of serviceability to traffic (NZ Bridge Manual)

Waterway Structure	Situation	Freeboard	
		Measurement Points	Level (m)
Bridge	Normal circumstances	From the predicted peak flood water level to the underside of the superstructure	0.6
	Where the possibility that large trees may be carried down the waterway exists		1.2
Culvert	All situations	From the predicted flood water level to the road surface	0.5

Figure 2: Overland flow paths, flood prone areas and flood plains (source AC Geomaps January 2023)

4.1.1 Construction

Construction effects apply to the entire project, however, are more likely at locations within or adjacent to overland flow paths, permanent streams, flood prone or flooding areas.

4.1.2 Operational

There are a range of operational effects particularly from proposed road crossings (formations, bridges and culverts) over permanent steams / rivers and overland flow paths.

Future detailed design will be subject to a separate flooding assessment at the outline plan and regional consenting stage and location / size plus type of treatment (attenuation, water quality or both).

For the project the assessment of operational flooding and stormwater effects considered:

- Proposed culvert and bridge crossings

- Areas where the new road embankment encroaches onto predicted flood plain and flood prone land
- Raised road levels where previously the road overtopped
- Land requirements for treatment wetlands and devices.
- The potential of flooding on existing properties due to the new project corridor and associated works.

4.2 Preparation for this Report

In preparation of this report several resources were used to support the assessment. These included technical specialist inputs, previous reports including Auckland Council Geomaps, catchment flood models and team workshops. The Auckland Council Mahurangi flood hazard model was used as the basis for this assessment and minor improvements made to the model to reduce model instabilities and issues.

While Project wide site visits were undertaken, no site specific site visits were undertaken for this assessment as the work has been based on publicly available information discussed above and flood modelling done by Te Tupu Ngātahi.

The AUP: OP was used to identify the existing and likely future environment.

Information from the Project Team and Te Tupu Ngātahi Warkworth base case model was used to assess the flood water levels and extents of the existing (pre-development) terrain based on the Auckland Council 2016 LiDAR.

5 Existing and likely receiving flooding environment

The projects encompassing the Warkworth NOR package will be constructed 15-20 years from now. The implementation timeframe for each project will vary and correspond with future land release within the area. Assessing the effects on the environment solely as it exists today (i.e., at the time of assessment) will not provide an accurate reflection of the environment in which some of the effects will be experienced. Accordingly, the assessment of effects considers both the existing environment, and the likely receiving environment in which the effects will likely occur.

The Warkworth NOR package falls within the Warkworth stormwater catchment with an overall area of approx. 5,893Ha, with the township of Warkworth at its outlet. The extent of the catchment is shown in Figure 3 with its outlet environment being the Mahurangi Harbour.

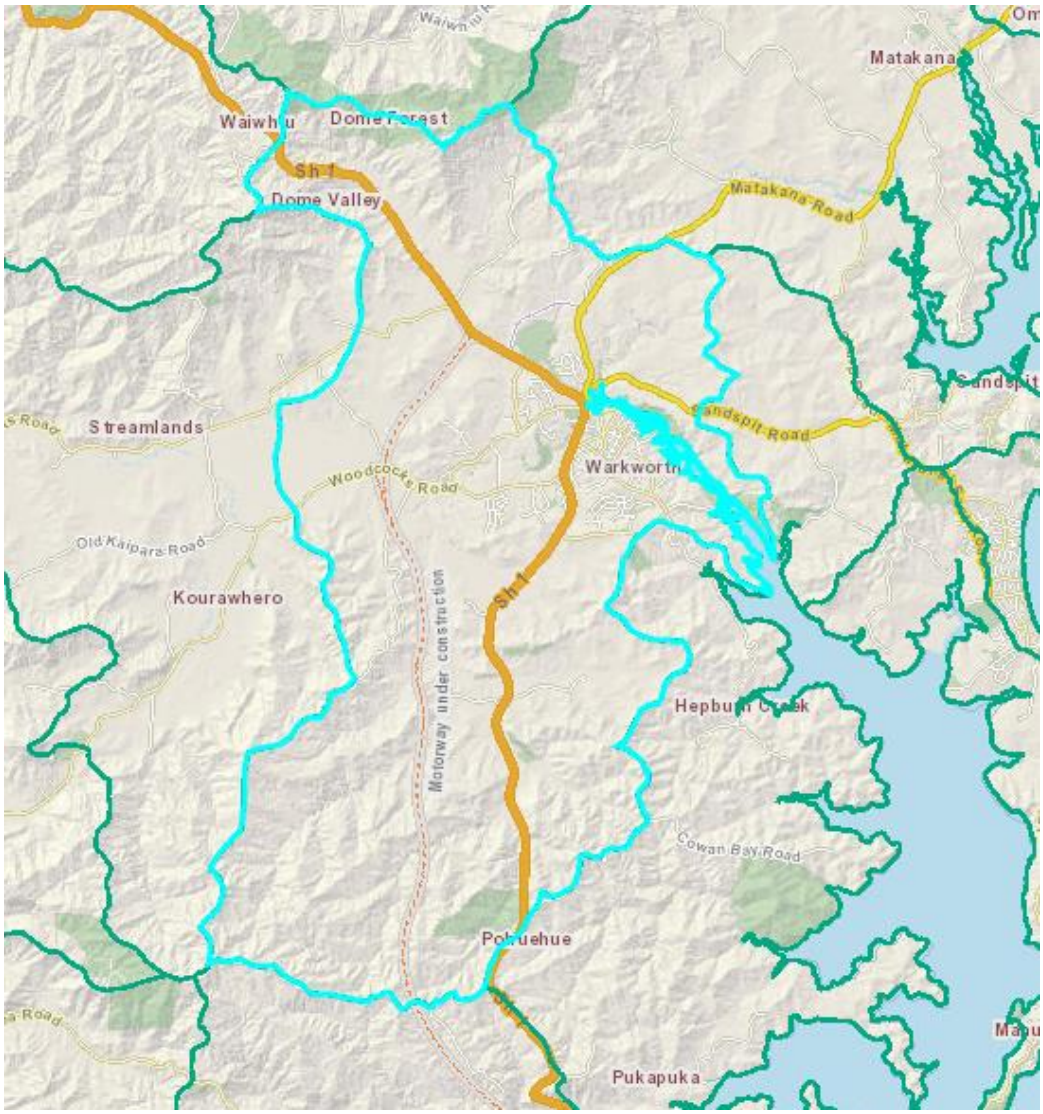

Figure 3: Warkworth stormwater catchment boundary

The main river running through the catchment is the Mahurangi River with over 2,454Ha of rural land upstream of the Wider Western Link. The main floodplains and permanent streams for the catchment are shown in Figure 4.

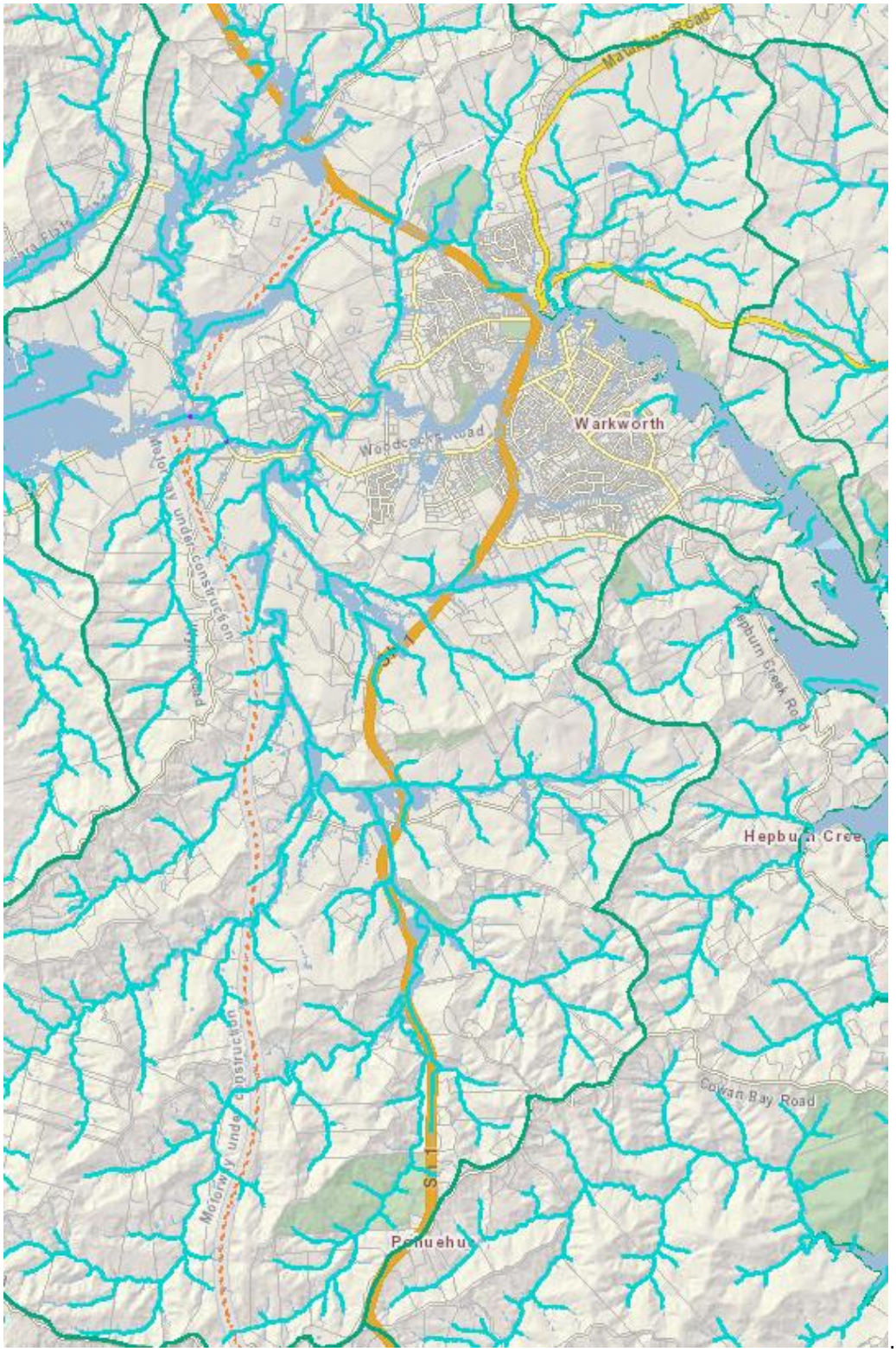

Figure 4: Permanent streams and flood plains (AC Geomaps 2023)

The Warkworth NOR package will be constructed and will operate alongside existing urban environments or planned future environments (i.e. what can be built under the existing Auckland Unitary Plan: Operative in Part (AUP: OP) and what is identified in the Warkworth Structure Plan):

1. **Existing environment:** A number of corridors comprising the Warkworth NOR package are partially located within / alongside existing urban areas.

a) Matakana Road Upgrade – residential land uses (single house zone, mixed housing suburban zone, mixed housing urban zone) comprise the western and north-western extents of the corridor.
b) Western Link South – residential land uses are situated to the north and northwest of the corridor and existing industrial land use on the eastern extent of the corridor.
c) State Highway 1 (Southern Section) – residential land uses are adjacent to the northwest and southeast of the northern extent of the corridor, additionally there are established business land uses to the northeast of the northern extent of the corridor.
d) Woodcocks Road – the eastern extent of the corridor has existing residential land uses to the north and south.

2. **Future environment**: All the corridors in the Warkworth NOR package will partially or wholly be constructed and implemented on land identified for future growth (Future Urban Zone) and as a result are anticipated to change to urban or industrial land uses.

The likelihood and magnitude of land use change regarding the land use planning context has been identified in Table 5. Likelihood and magnitude of land use change below. This has been used to inform the assumptions made on the likely future environment.

Table 5. Likelihood and magnitude of land use change

Existing environment	Current AUP: OP Zoning	Likelihood of Change for the environment[1]	Magnitude of potential change	Likely Receiving Environment[2]
Residential[3]	Residential (Mixed Housing Suburban)	Low	Low	Residential
	Residential (Mixed Housing Urban)	Low	Low	Residential
	Residential (Single House)	Low	Low	Residential
Business	Business (Mixed Use)	Low	Low	Business (Industrial)
	Business (General Business)			Business (General Business)
	Business (Light Industry)	Low	Low	Business (Industrial)
	Business (Local Centre Zone)	Low	Low	Business (Neighbourhood Centre)
Open Space	Open Space – Conservation Zone	Low	Low	Informal Recreation
Greenfield areas	Future Urban Zone	High	High	Urban

[1] Based on AUP:OP zoning/policy direction
[2] Based on Warkworth Structure Plan and AUP:OP zoning/policy direction

Existing environment	Current AUP: OP Zoning	Likelihood of Change for the environment[1]	Magnitude of potential change	Likely Receiving Environment[2]
Other	Special Purpose – Quarry Zone	Low	Med	Quarry

Refer to the AEE in Volume 2 for a detailed description of the existing and likely receiving environment for the Warkworth NOR package.

6 Warkworth NoRs – Overall network

This section assesses common or general flooding and stormwater matters across the overall Warkworth Project (i.e. the combination of public transport interchanges, existing road upgrades and new corridors).

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 7 to 14.

The Warkworth network projects all have the same common features:

- New or widened / improved roads with formations and bridges / culverts over existing streams;
- Treatment / attenuation wetlands normally located near an existing stream crossing with the aim to optimise number, location and sizing of wetlands. Sizing of the wetlands 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 impacted by construction and operation of the NORs.

6.1 Overview and description of works

The Warkworth NOR package falls within the Warkworth stormwater catchment with an overall area of approx. 5,893Ha, with the township of Warkworth at its outlet. The extent of the catchment is shown in Figure 5.

Figure 5: Warkworth stormwater catchment boundary

The main river running through the catchment is the Mahurangi River.

The works covered in this technical assessment were as follows:

- Assessment of the future predicted flood plains based on Auckland Council Geomaps and the Te Tupu Ngātahi modelling for the network and terrain that exists now
- Flooding impacts associated with new road alignments
- Location and sizing of wetlands for stormwater quality treatment, retention and attenuation

6.2 Assessment Features

Existing 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 due to proposed formations reducing available flood storage volume and maintaining as much as possible flood neutrality, particularly areas of future development (upstream and downstream of the NOR).

Predicted flooding impacts of the Warkworth network become greater the closer you get to Warkworth, particularly along the Mahurangi River branch.

6.3 Positive flooding and stormwater effects

The main positive effects that could be designed in the Warkworth NOR 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 (e.g. Sandspit Rd and SH1 Southern section)
- ability to convey flows without worsening flooding impacts upstream or downstream of the works
- added water quality treatment and attenuation of the total roadway impervious area as opposed to just the additional roadway area for upgraded roads.

6.4 Assessment of construction effects

The proposed construction works which could result in flooding effects 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.

6.5 Recommended measures to avoid, remedy or mitigate construction effects

The 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 conveyance 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 and 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.

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.

6.6 Assessment of operational effects

There are a range of operational effects particularly from proposed road crossings (formations, bridges and culverts).

Future detailed design will be subject to a separate detailed flood assessment at the outline plan and regional consenting phase which will refine the design of formations, culverts, bridge crossings and location / size of treatment (attenuation, water quality or both).

For the project the assessment of operational flooding and stormwater 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 100yr 2.1° temperature increase scenario
- Land requirements for wetlands
- The potential of flooding on existing properties due to the new project corridor.

The effects of these are:

- Increasing impervious areas resulting in increased runoff and potentially increased flood levels
- Altering existing overland flow paths resulting in flows being redirected on a different alignment
- Obstructing an existing overland flow path resulting in ponding at existing low points or newly created depressions along the corridor
- Improving flows under the road reducing upstream flood levels and increasing flood levels at properties further downstream
- Increased impervious area to treat for attenuation, treatment or both and pond locations.

Further details of these are covered in Sections 7 to 14 for each NOR.

The assessed flood effects can be managed by adjusting the proposed road geometry and changing the amount of culvert and bridge opening area, so that the proposed NOR conditions will be met. In particular, the conditions require that there will be no increase in flooding of existing identified flooded habitable floors and no more than 50mm change to flood levels within properties.

6.7 Recommended measures to avoid, remedy or mitigate operational effects

Mitigation measures which may be implemented 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 (e.g. NOR 8 on 2, NOR 3 on 2 and NOR 7 on 5)

- 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. This is where existing predicted overland flow paths run parallel to the proposed roads and do not cross under the road
- Designing culvert and bridge sizes so that the upstream and downstream water level differences do not increase by more than 0.05m on land zoned for urban development or no increase for existing floors at risk of flooding. Aim to maintain flood neutrality if downstream flooding issues exist. Culverts will be designed for the 100yr 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 smaller 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
- 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.

Further details of these are covered in Sections 7 to 14 for each NOR.

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.

6.8 Summary and Conclusions

The main positive effects that could be designed in the future works for the Warkworth NOR 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 (e.g. Sandspit Rd and SH1 Southern section)
- ability to convey flows without worsening flooding impacts upstream or downstream of the works
- 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 over Warkworth Network flooding and stormwater effects as shown in Table 6.

Table 6. Summary of Assessment of Effects of 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	All: 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.	All: 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.
If Mahurangi River bridges require works in river (such as temporary works) which can restrict flows. Also the very large upstream catchments can create very large flows. 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	NOR2 and NOR8: 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.
SH1 culvert upgrade at NOR1 will increase downstream water levels and flows therefore increasing construction flood risk in NOR1	Greater flood flows from the larger pipe along with works which could reduce flood storage (wetland, embankment and bridge construction) could cause the site to become inundated and spill over on to adjoining land during construction.	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.
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	NOR1, 2, 7 and 8: Detailed modelling (of detailed design) to assess best option to meet to meet designation. Flood Hazard condition requirements for

Effect	Assessment	Recommendation
	cross conveyance capacity may be needed.	upstream and downstream water levels. .
Raising existing roads above the predicted 100yr future flood levels could increase upstream flood levels.	Greater protection of road to flooding will require increased flow capacity beneath the road with the aim of flood neutrality upstream and downstream of the raised road formation	NOR 2, 3 and 5 Optimisation of bridge or culverts through later detailed modelling (of detailed design) and design to achieve flood consent conditions.
Mahurangi River bridges with large predicted flood flows could have significant effects on flood levels if not carefully designed to achieve flood level requirements	Bridge opening could impact upstream and downstream water levels so it needs to be optimised to minimise changes to flood levels.	NOR2 and NOR8: Detailed modelling of the bridge and associated formation design during later design stages to optimise bridge opening to meet consent conditions.
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.	NOR6 and NOR7: 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
SH1 pipe upgrade from 1.2 to 2.4m will increase downstream flows and water levels in PT Hub area.	The increased flow rate and water levels downstream of the 2.4m culvert and the available flood storage needs to be understood as it will impact wetland, embankment and bridge design.	NOR1. Design of wetland, embankments and bridge needs to be optimised to reduce flood levels to within consent conditions. Detailed design and modelling needed at later stages.
Wetlands for treatment only will reduce footprint needs	Downstream wetlands could be water quality only (GD01) as opposed to treatment and attenuation	NOR4 and NOR5: 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.

7 NOR 1 – Northern Public Transport Hub and Western Link – North

This section assesses specific flooding and stormwater matters relating to NOR 1 – Northern Public Transport Hub and Western Link - North

7.1 Overview and description of works

The Northern PT Hub and Park & Ride is located adjacent to the intersection of State Highway 1 and the proposed new Western Link - North. This project involves:

- Construction of a PT Hub
- Park and Ride facilities with 228 car park spaces attached to the PT Hub
- Construction of the new Western Link - North, a four-lane urban arterial with cycle lanes and footpaths on both sides

The PT Hub crosses two existing streams with the stream impacted the most crossing under SH1 by the SH1 / PT Hub intersection.

The indicative design allows for the existing SH1 culvert to be diverted to west of the proposed SH1 / PT Hub connection formation though a new open channel then flow through a new bridge under the formation as shown in Figure 6. As noted previously, future detailed design will be subject to a separate detailed flood assessment at the outline plan and regional consenting stage which will refine the design of formations, culverts, bridge crossings and location / size of treatment (attenuation, water quality or both).

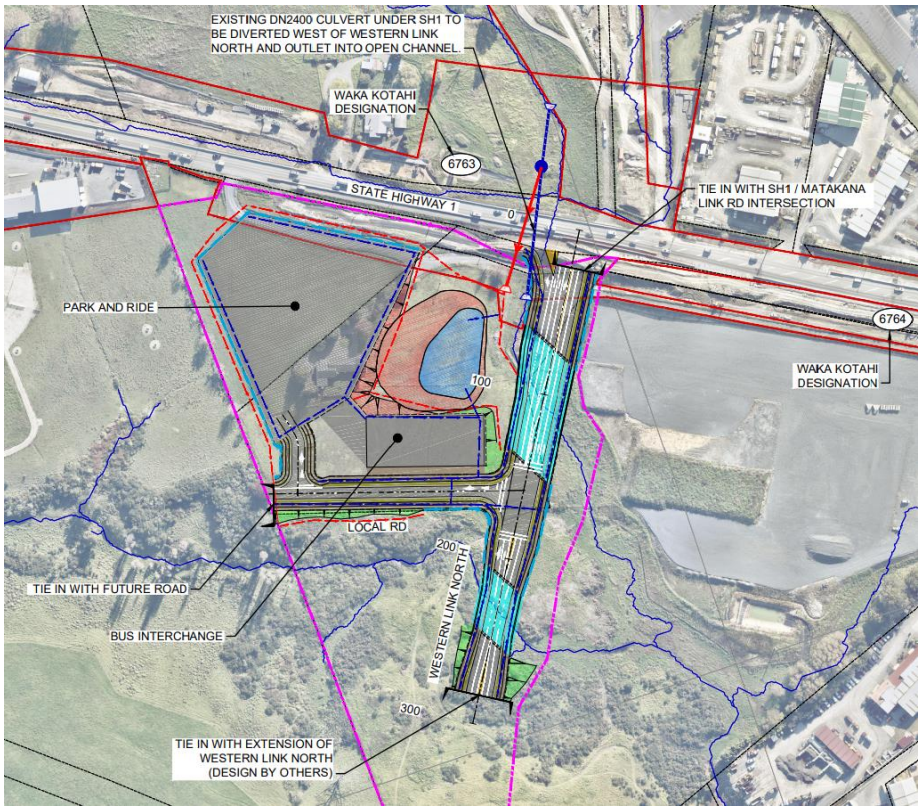

Figure 6: Indicative PT Hub layout

A new treatment wetland is proposed to allow for treatment of the impervious area associated with the PT Hub, Park and Ride, Bus interchange for water quality and attenuation.

7.2 Assessment Features

The flooding and stormwater features for this NOR relates to the earthworks, minor stream diversion, flood storage volume loss, construction of bridges over the two streams and formation / wetland construction within the flood plain.

Waka Kotahi (P2W) is understood to be replacing the existing culvert under SH 1 (1.2m diameter) with a larger 2.4m diameter culvert on the same existing culvert alignment. This will reduce the risk of SH1 overtopping and flooding of the SH1 and Te Honohono ki Tai (Matakana Link Road) intersection including upstream of this culvert inlet but may increase flood flows and water levels downstream of SH1. The flow capacity of the SH1 culvert can increase by a factor of four due to the diameter increase alone thus increasing flow directly into the downstream outlet area.

7.3 Positive Flooding and stormwater effects

The proposed PT Hub connection to SH1 is affected by the existing flooding of SH1 (shown in Figure 7 below) due to the existing SH1 culvert.

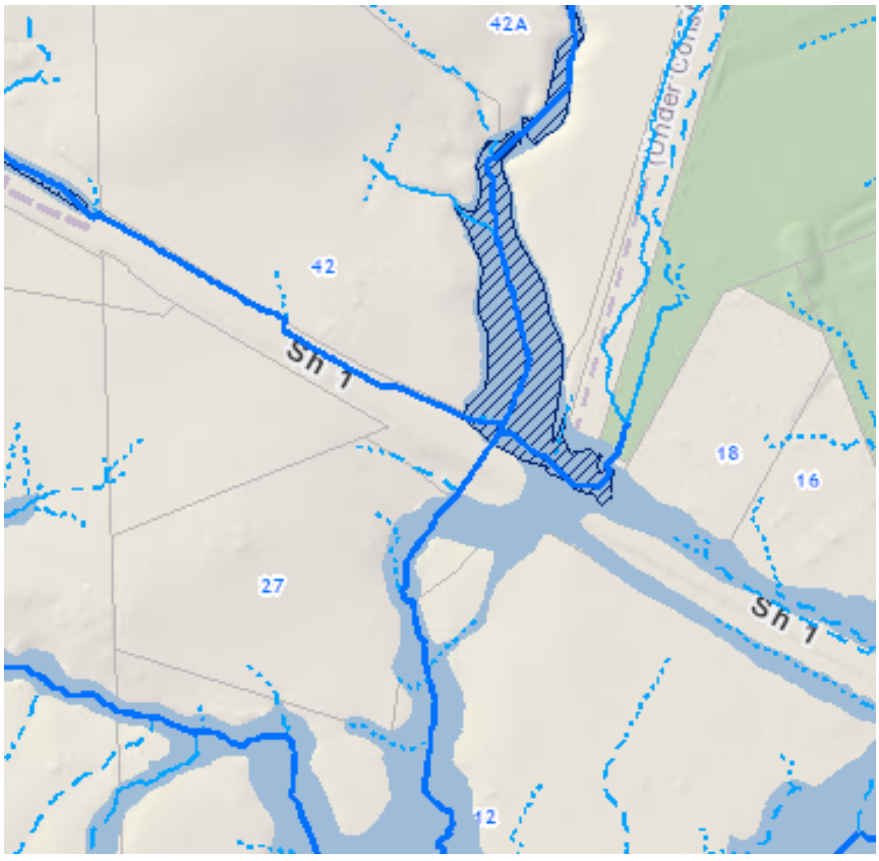

Figure 7: PT Hub overland flow, flood prone area, permanent stream and flooding extent (Source: AC Geomaps Jan 2023)

There is an opportunity for Te Tupu Ngātahi to work with P2W (through Waka Kotahi) to locate the culvert outlet for the benefit of both projects.

A proposed wetland will provide water quality treatment for the PT Hub impervious area.

7.4 Assessment of construction effects

The Rev B design construction impacts are predicted to be:

- Construction of new culvert and bridges over existing streams which could 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 create minor flooding issues
- Construction of new wetland 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.
- 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

7.5 Recommended measures to avoid, remedy or mitigate construction effects

The proposed NOR has the same general construction measures as noted in Section 6.5.

- 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 which could be achieved by using the proposed Park and Ride area
- Managing the overland flow paths
- Construction Environmental Management Plans (CEMP) shall consider the effects of temporary works, earthworks, storage of materials, temporary diversion and drainage on flow paths, flow levels and velocities.
- Existing culvert extensions should be done prior to commencement of bulk earthworks to allow for the passage of clean water across the site.
- Installing temporary diversions to allow flows to be maintained while new culverts and wetland are constructed
- 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.

7.6 Assessment of operational effects

With the existing SH1 culvert being upsized greater flow will pass through the culvert to increase flood risk downstream. This flood risk assessment will be addressed by P2W for the upsized culvert and future detailed modelling and design associated with this NOR should take account of this issue.

The following potential operational effects are associated with the proposed NOR design.

- diversion of the existing stream and flood plain to the west of the formation which could increase flooding in a constrained area

- construction of a wetland within a constrained flood plain. Greater flows and increased flooding potential will occur with the proposed upgrade of the exiting SH1 culvert by P2W and outlet to this western area
- minor length reduction of open permanent stream
- construction of new road formation reduces flood storage volume, which could increase tailwater effects and reduce the SH1 culvert capacity
- bridge openings sized to maintain flood neutrality.

7.7 Recommended measures to avoid, remedy or mitigate operational effects

The following operational measures are proposed:

- Work with P2W and Waka Kotahi to optimise the proposed 2.4m SH1 culvert alignment and outlet location.
- Later detailed modelling of detailed design to assess flood levels / extent / depth due to the P2W SH1 culvert upgrade downstream of SH1 and through the PT Hub site so as to provide for the refinement of the design of bridges, wetland location / footprint and footprint of the proposed formation to meet the proposed designation Flood Hazard condition requirements.
- The detailed design of stormwater management will also be subject to regional consenting requirements.
- Locate the wetland as near the Park and Ride as possible to reduce the flood storage volume loss issue.

7.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects shown in Table 7.

Table 7. Summary of Assessment of Effects and Recommendations - Northern Public Transport Hub, Park and Ride and Western Link - North

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.
Wetland construction within constrained flood plain due increased flow, new embankment and bridge	Increased risk of construction site 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.
Temporary use of lay down and construction areas can create flooding risk.	Potential flood damage 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.
SH1 culvert upgrade at PT Hub will increase downstream water levels and flows therefore increasing construction flood risk in PT Hub	Greater flood flows from the larger pipe along with works which could reduce flood storage (wetland, embankment and bridge construction) could cause the site to become inundated and spill over on to adjoining land during construction.	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.
Operational		
Flood plain storage volume loss and minor stream loss	New SH1 culvert outlet reduces natural stream length and outlets near wingwall plus earthworks for embankments and wetland	Detailed modelling and design to assess impacts with 2.4m diameter culvert (associated with non-SGA SH1 upgrade works) in place and proposed SGA works in later stages.
Wetland	Loss of flood storage volume with wetland potentially in flood plain	Optimise wetland attenuation as close to Park and Ride as possible

Effect	Assessment	Recommendation
		which can be assessed during the later detailed design / modelling stages.
SH1 pipe upgrade from 1.2 to 2.4m (associated with non-SGA SH1 upgrade works) will increase downstream flows and water levels in PT Hub area.	The increased flow rate and water levels downstream of the 2.4m culvert and the available flood storage needs to be understood as it will impact wetland, embankment and bridge design.	Design of wetland, embankments and bridge needs to be optimised to reduce flood levels to within consent conditions. Detailed design and modelling needed at later stages.

Flood modelling will be required at the detailed design phase to confirm the final corridor design will comply with the NOR conditions. This modelling will also identify any potential issues of increasing the SH1 culvert from 1.2 to 2.4m diameter, particularly at the outlet end of the culvert.

So far as practicable, collaboration with P2W should occur to ensure that the proposed 2.4m diameter culvert upgrade under SH1 provides the best outcomes for NOR1in terms of the proposed culvert outlet.

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

8 NOR 2 – Woodcocks Road Upgrade (Western Section)

This section assesses specific Flooding and Stormwater matters relating to NOR 2 – Woodcocks Road Upgrade (Western Section).

8.1 Overview and description of works

Flooding and stormwater Rev A design allows for and is shown in Figure 8:

- The existing single lane Mahurangi Bridge to be widened, raised and lengthened on a slightly different alignment
- The existing two-lane bridge (to the west of Mahurangi River) is to be widened, raised and lengthened
- Western end of Woodcocks Rd connects to the part of the road being realigned as part of the P2W Highway
- Two wetlands, plus the Wider Western Link wetland.

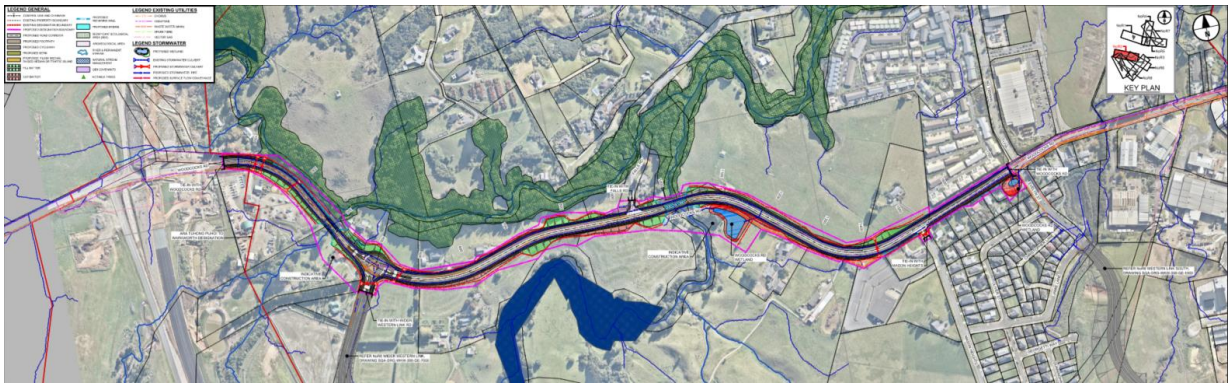

Figure 8: Woodcocks Rd layout

8.2 Assessment Features

This assessment focusses on flood, stream / river and water quality / attenuation effects.

Refer to the AEE Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

8.3 Positive Flooding and Stormwater effects

The following positive effects are noted.

- Raising of Woodcocks Rd at the two bridges crossing will reduce the potential for road overtopping and flooding
- Treating all of the proposed road surface will improve water quality.

8.4 Assessment of construction effects

There are no additional construction effects that apply to NOR 2 that are not set out in section 6.4.

8.5 Recommended measures to avoid, remedy or mitigate construction effects

Rainfall radar and long weather forecasts need to be monitored to ensure that no large volume or high intensity / short duration rainfall events occur during construction to prepare for and mitigate flood damage and reduce downstream flood impact risks, particularly the Mahurangi Road proposed bridge.

There are no additional construction effects that apply to NOR 2 that are not set out in Section 6.5.

8.6 Assessment of operational effects

The following specific operational effects need to be considered for the proposed Woodcocks Rd upgrade.

- Flood flows from the Mahurangi River are large and increasing the flow capacity beneath the Mahurangi River bridge by lengthening and raising it needs to be controlled to reduce downstream flood impacts
- The need for attenuation within wetlands.

8.7 Recommended measures to avoid, remedy or mitigate operational effects

Recommended measures are to maintain the same waterway capacity beneath the two upgraded bridges and check the flood impacts upstream and downstream of the two proposed bridges through detailed modelling in the later detailed design stage. The aim is to stay within flood design criteria, particularly with the downstream catchments identified for future development, which could occur before this NOR is constructed.

Confirm with later design modelling that wetland attenuation is not required for Mahurangi River bridge.

The P2W design for the western end of the Woodcocks Rd upgrade needs to be considered so that construction effects are not impacted by the design and measures (if needed) to minimise the effect implemented.

8.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 8.

Table 8. Summary of Assessment of Effects and Recommendations – Woodcocks Road Upgrade (Western Section)

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.
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.
Mahurangi River bridges require works in river (such as temporary works) which can restrict flows. Also the very large upstream catchments can create very large flows. 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		
Mahurangi River bridges with large predicted flood flows could have significant effects on flood levels if not carefully designed to achieve flood level requirements	Bridge opening could impact upstream and downstream water levels so it needs to be optimised to minimise changes to flood levels.	Detailed modelling (of detailed design) of the bridge and associated formation design during later design stages to optimise bridge opening to meet consent conditions.
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. The main potential flooding effects and controls within the Woodcocks NOR are associated with:

- the large potential flood flows upstream of NOR 2 (Woodcocks Rd). Monitoring of rainfall upstream of these sites should be completed to prepare and control effects of any large rainfall flood flows;
- raised and lengthened Woodcocks Rd bridges could increase flow rates and downstream impacts. Aim to maintain the existing waterway capacity under bridges.

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

9 NOR 3 – State Highway 1 Upgrade - South

This section assesses specific Flooding and Stormwater matters relating to NOR 3. The SH1 corridor which NOR 3 (SH1 - South) is located extends from the Northern Gateway Toll Road, Silverdale in the south to its intersection with Auckland Road in the northeast. The proposed upgrades covered by NoR3 extend from the RUB boundary in the south to the intersection with Fairwater Road in the north. The SH1 (southern section) upgrade involves the urbanisation of the corridor to a 24m two-lane urban arterial with cycle lanes and footpaths on both sides of the entire corridor length.

9.1 Overview and description of works

SH1 is an existing arterial extending from the Northern Gateway Toll Road in the south to its intersection with Auckland Road in the northeast, with the extents of the proposed upgrade from the Future Urban Zone boundary in the south to its intersection with Fairwater Road in the north.

The SH1 - South upgrade involves the urbanisation of the corridor to two-lane urban arterial with cycle lanes and footpaths on both sides of the entire corridor length.

The two existing culvert crossings shown as sites 1 and 2 on Figure 9 below are proposed to be upgraded to bridges with raised road formations and longer / wider bridge spans. The treatment wetland near site 1 on the downstream side will be out of the flood plain after the road is raised.

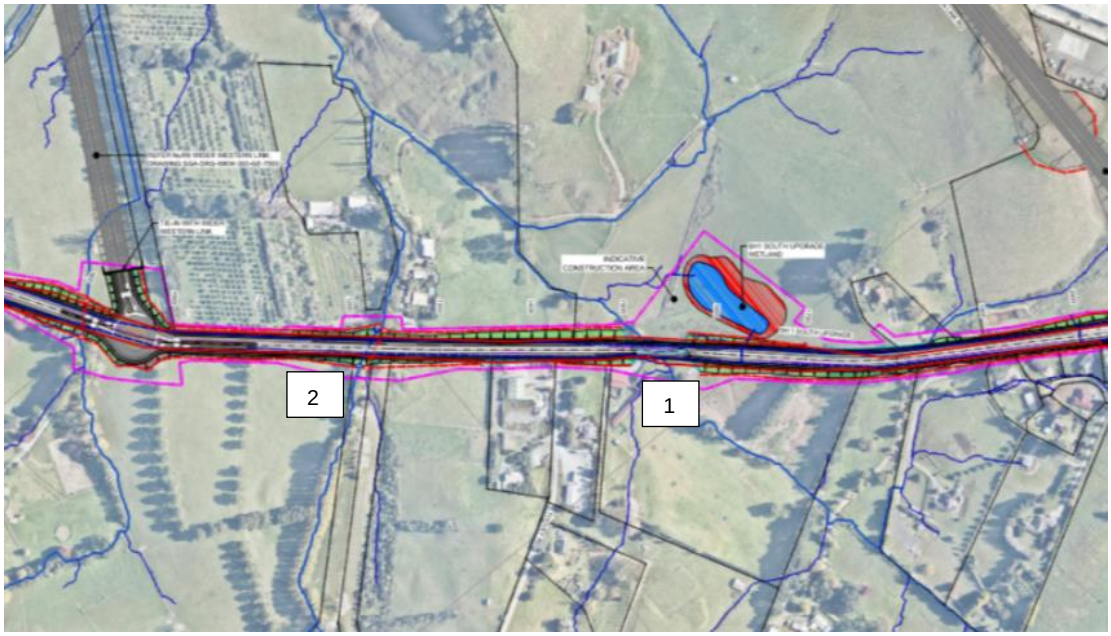

Figure 9: SH1 upgrade (southern section) area assessed

9.2 Assessment Features

Both proposed bridge sites are predicted to overtop in the existing 100yr 2.1° and 3.8° temperature increase scenarios due to the existing culverts being under capacity.

It is unclear what the Wider Western Link Rd connection to SH1 impact will have on treatment needs for SH1.

Refer to the AEE in Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

9.3 Positive Flooding and Stormwater effects

Raising of SH1 at the two bridges crossing will reduce the potential for road overtopping and flooding.

The wetland location has been selected to be downstream of SH1 and reduce the flood risk to the wetland.

The wetland associated with Western Link will provide treatment and attenuation opportunities for the SH1 upgrade as well.

Treating and attenuating all of the road surface will improve water quality and provide attenuation for 10 and 100yr flood flows associated with the added impervious road area.

9.4 Assessment of construction effects

Construction of bridges over streams to replace the existing culverts and wetland construction has the same construction effects as noted in Section 6.4.

9.5 Recommended measures to avoid, remedy or mitigate construction effects

A bridge is proposed at the existing culvert crossings to significantly increase the flow conveyance capacity and therefore maintain the flood levels upstream of the corridor. The proposed bridge site should be reviewed at the detailed design phase with the possibility of adding extra culvert capacity to improve performance which will also reduce construction impacts associated with new bridges.

Renewing the bridges, raising of the road formation and wetland construction has the same general construction measures as noted in Section 6.5.

9.6 Assessment of operational effects

The two existing culverts are predicted to have the following performance issues for the design rainfall events shown below in Table 9.

Table 9: SH1 southern section culvert performance

Culvert # (as shown on Figure 9)	**100yr 2.1° results**				**100yr 3.8° results**			
	Peak culvert flow (m^3/s)	US Water level (RL m)	DS Water level (RL m)	Peak flow over road (m^3/s)	Peak culvert flow (m3/s)	US Water level (RL m)	DS Water level (RL m)	Peak flow over road (m3/s)
1	8.4	41.4	40.9	19.6	8.4	41.5	41	27.8
2	8.9	43.1	41.7	10	9.1	43.1	41.9	15.4

Table 11 indicates the following:

- Culvert 1 (with the largest upstream catchment) and potential development of 66% imperviousness has little predicted upstream to downstream water level difference due mainly to the predicted wide area of road overtopping balancing out the head difference. The existing culvert can only cope with:
  - approximately 30% of the total approach flow in the 100yr 2.1° temperature increase,
  - dropping to 23% in the 100yr 3.8° temperature increase
- Culvert 2 (with the smaller upstream catchment) and potential development of 60% imperviousness has a much higher predicted upstream to downstream water level difference due to less predicted road overtopping with potentially greater existing freeboard. The existing culvert can only cope with:
  - approximately 47% of the total approach flow in the 100yr 2.1° temperature increase,
  - dropping to 37% in the 100yr 3.8° temperature increase

9.7 Recommended measures to avoid, remedy or mitigate operational effects

As the upstream catchments currently could pose a tree debris risk the freeboard should be set at 1.2m to the underside of the bridge which will create greater embankment length needing to be raised and sizing of the waterway to maintain the predicted upstream water levels. With the upstream catchment being fully developed (AC Geomaps shows approx. 88% imperviousness) the risk of tree debris would reduce but this will be a development timing issue.

With the existing SH1 predicted to overtop, raising the road formation will act like a stop bank and added capacity will be needed beneath the proposed road to reduce upstream flood impacts to within 500mm of the existing scenario. This may change with future development upstream and floor levels being based on the existing predicted flood levels with freeboard which will then impact works needed to reduce upstream flood water level impacts.

If multiple culverts could be utilised alongside the existing culvert the road formation raising would be reduced due to freeboard from the predicted water level only being 500mm.

Added culvert sizes would be developed based on the predicted upstream and downstream water levels to optimise the pipe sizes with the aim of maintaining flood neutrality and achieving freeboard. The existing culvert inverts would be maintained with added culvert inverts being slightly higher to maintain low flows through the existing culvert at each site and the added culvert/s provided added higher flow capacity.

Adding culverts would be confirmed at the later detailed design stage using a detailed flood model to assess upstream / downstream impacts and freeboard.

The treatment pond locations and sizes to be optimised with potential for two sites being adjacent to the two existing steams on the downstream (west) side of SH1. Two wetlands although creating greater construction disruption will reduce the need to convey the road flows from site 2 to site 1 pond.

9.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 10.

Table 10. Summary of Assessment of Effects and Recommendations - Existing State Highway 1 Upgrade (Southern Section)

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.
Wetland construction within constrained flood plain can increase flooding by obstructing overland flow and displacing flood volume	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.
Operational		
Raising existing roads above the predicted 100yr future flood levels could increase upstream flood levels.	Greater protection of road to flooding will require increased flow capacity beneath the road with the aim of flood neutrality upstream and downstream of the raised road formation	Optimisation of bridge or culverts through later detailed modelling (of detailed design) and design to achieve flood consent conditions.

It is anticipated that flood modelling the final design will be required at the detailed design phase to assess the final corridor design, to confirm the flood effects, with the aim that the confirmed detailed design, so far as it relates to flooding effects, will give effect to the NOR conditions.

The main potential flooding effects and controls within the SH1 Southern upgrade are associated with the raised formation to stop road overtopping which is between 85 and 240m in length. This may require added culverts to balance upstream water levels and provide conveyance under SH1.

The assessed flood effects can be managed by adjusting the proposed road geometry and changing the amount of culvert and bridge opening area, so that the proposed NOR conditions will be met. In particular, the conditions require that there will be no increase in flooding of existing identified flooded habitable floors and no more than 50mm change to flood levels within properties.

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

10 NOR 4 – Matakana Road Upgrade

This section assesses specific Flooding and Stormwater matters relating to NOR 4 – Matakana Road Upgrade.

10.1 Overview and description of works

Upgrading Matakana Road to accommodate a two-lane cross-section with cycle lanes and footpaths on both sides of the corridor. Two treatment and attenuation wetlands are proposed near the intersections with Sandspit Link and Sandspit Rd. The layout is shown in Figure 10.

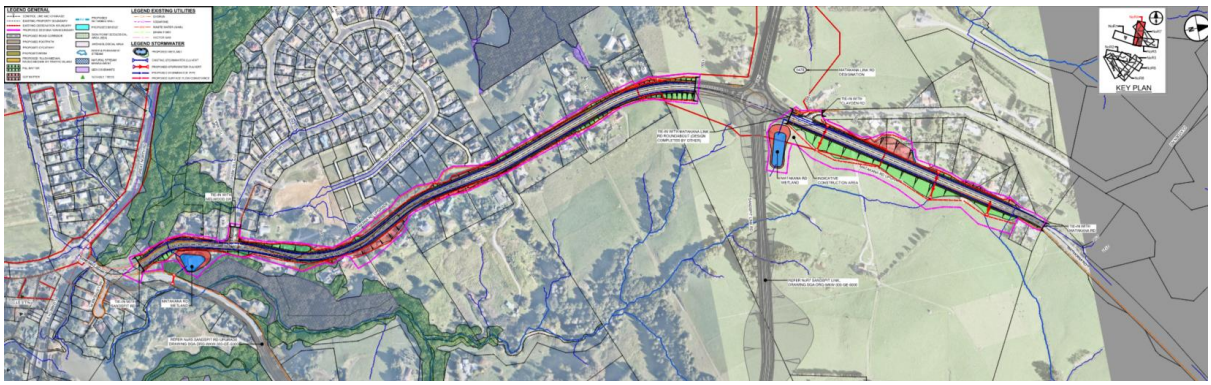

Figure 10: Matakana Road upgrade layout

10.2 Assessment Features

Matakana Road does not impact on any flood plains or overland flow paths therefore flooding is not an issue, apart from near the lower pond location by Sandspit Road.

The two proposed wetlands can provide water quality and attenuation.

Refer to AEE Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

10.3 Positive Flooding and Stormwater effects

Improved water quality treatment / retention in the proposed wetlands.

10.4 Assessment of construction effects

The main construction effects are the two treatment wetlands with the lower one (wetland 1) having the greatest impact as it is closer to the predicted flood plain plus the formation construction.

There are no additional construction effects that apply to NOR 4 that are not set out in section 6.4.

10.5 Recommended measures to avoid, remedy or mitigate construction effects

There are no additional construction effects that apply to NOR 4 that are not set out in section 6.**5**

10.6 Assessment of operational effects

There are no predicted flooding impacts associated with this NOR although wetland 1 is proposed adjacent to a flood plain.

10.7 Recommended measures to avoid, remedy or mitigate operational effects

Wetland 1 (near Sandspit Rd) location and size to be checked during detailed design phase to confirm that it is outside of the predicted flood plain through detailed flood modelling, particularly larger events.

10.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 11.

Table 11. Summary of Assessment of Effects and Recommendations - Matakana Road Upgrade

Effect	Assessment	Recommendation
Construction		
New wetland near existing flooding can block flow paths and create upstream flooding if not managed	Increased risk of construction site and upstream flooding	All: 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.
Operational		
Existing flood plain storage volume loss with new wetlands 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 Flood Hazard condition requirements for upstream and downstream water levels.

The wetland layout and location with regard to the flood plain will be confirmed at the detailed design phase , although it is anticipated that it will be out of any flood plain and therefore minimise any potential constructional and operational impacts.

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

11 NOR 5 – Sandspit Road Upgrade

This section assesses specific flooding and stormwater matters relating to NOR 5 – Sandspit Road Upgrade

11.1 Overview and description of works

Sandspit Road is an existing arterial providing east-west connection between the Warkworth growth area and the towns of Sandspit and Snells Beach.

This project extends from the tie in with the Hill Street intersection upgrade Project (a non Te Tupu Ngātahi project) in the west and to the eastern Future Urban Zone boundary. It is proposed to upgrade Sandspit Road to a two-lane urban arterial with cycle lanes and footpaths on both sides as shown in Figure 11.

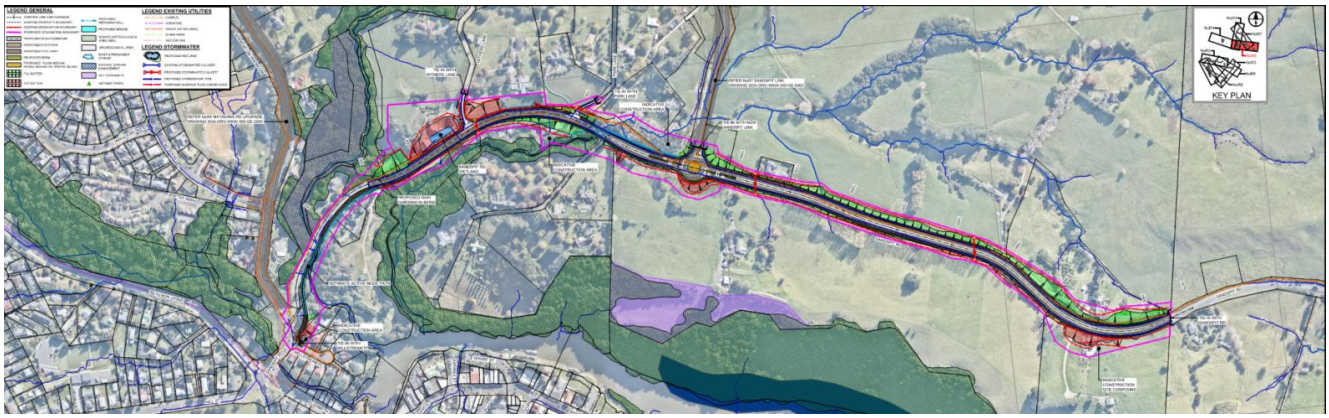

Figure 11: Sandspit Road upgrade

11.2 Assessment Features

The proposed road formation, upgraded bridge and wetlands are the features that could impact flooding and stormwater.

Refer to the AEE Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

11.3 Positive Flooding and Stormwater effects

Raising the bridge over the existing stream (downstream of Sandspit Link intersection) and associated road formation which is predicted to flood in the existing scenario.

Improved water quality outcomes through two new wetlands providing treatment and attenuation along with Sandspit Link Rd wetland 2 providing treatment and attenuation.

11.4 Assessment of construction effects

There are no additional construction effects that apply to NOR 5 that are not set out in section 6.4.

.

11.5 Recommended measures to avoid, remedy or mitigate construction effects

Renewing the bridge, raising of the road formation and wetlands construction has the same general construction measures as noted in Section 6.5.

Specific retaining may be required to minimise the impact on the permanent stream with the road formation raising with the upgraded bridge.

11.6 Assessment of operational effects

The existing Sandspit Rd bridge is predicted to be overtopped in the 100yr future event.

Water quality and attenuation is achieved through proposed wetlands.

Specific retaining may be required to minimise the impact on the permanent stream should the road formation need raising with the upgraded bridge.

11.7 Recommended measures to avoid, remedy or mitigate operational effects

Sizing of the bridge opening and associated road formation needs to be confirmed with detailed modelling during later detailed design stages which will have no impact on designation boundaries.

Opportunity for the proposed wetland near Matakana Road intersection could be converted to treatment only as attenuation may not be required. This could be achieved through bio-retention devices.

11.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 12.

Table 12. Summary of Assessment of Effects and Recommendations - Sandspit Road Upgrade

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.
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.
Wetland near Matakana Road could create flood risk during construction	Type of wetland near flood plain could increase flood risk	Opportunity to change to bio-retention device to minimise diversion of flood flows during construction.
Operational		
Bridge over existing stream could create upstream flooding	Bridge opening may be increased to reduce formation levels based on increased downstream flows	Detailed modelling (of detailed design) of the bridge and associated formation design during later design stages also ties in with Sandspit Link Rd bridge with aim to meet flood consent conditions
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.

It is anticipated that flood modelling of the final design will be required at the detailed design phase to assess the final corridor design, to confirm the flood effects, with the aim that the confirmed detailed design, so far as it relates to flooding effects, will give effect to the NOR conditions. The flooding effects and controls within the Sandspit Rd upgrade NOR are associated with the raised formation and bridge lengthening to stop road overtopping. Construction method and contingency plans need to allow for large rain events to reduce flood risk whilst monitoring rainfall events.

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

12 NOR 6 – Western Link South

This section assesses specific flooding and stormwater matters relating to NOR 6 – Western Link South.

12.1 Overview and description of works

The Western Link South is located at the end of Evelyn Street in the north to SH1 in the south and runs through existing greenfield land. The Western Link South Project involves the construction of a new two-lane urban arterial with walking and cycling facilities on both sides and upgrading the intersection with McKinney Road as shown in Figure 12.

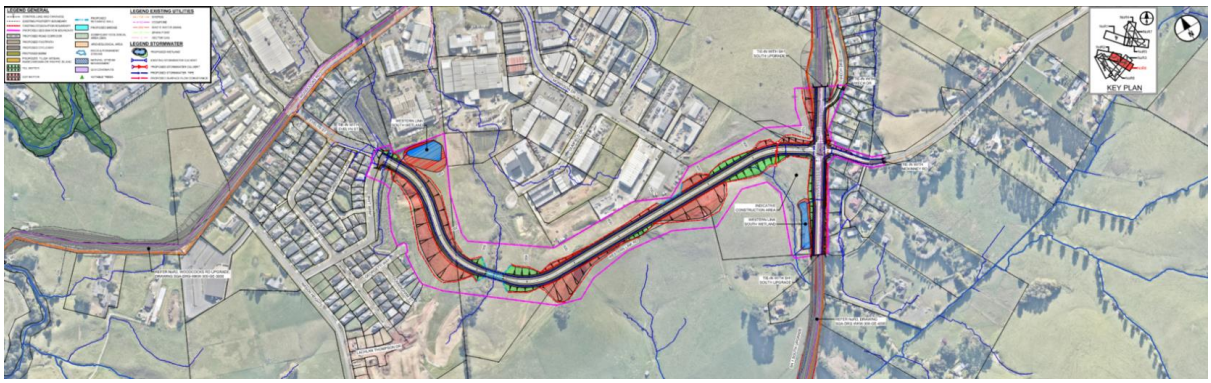

Figure 12: Western Link layout

12.2 Assessment Features

The Western Link South alignment crosses a small stream near the centre of the alignment and has two proposed wetlands at either end of the alignment (one near Evelyn Rd and the other adjacent to SH1).

Refer back to the AEE in Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

12.3 Positive Flooding and Stormwater effects

There are minor potential flooding and stormwater issues associated with this alignment.

The proposed wetlands can provide water quality improvement and flood attenuation associated with the new road alignment carriageway.

The second NOR6 wetland by SH1 can also be used for the SH1 South upgrade, particularly the McKinney Road, SH1 and Western Link South intersection to provide improved water quality and attenuation effects.

12.4 Assessment of construction effects

There are no additional construction effects that apply to NOR 6 that are not set out in section 6.4.

12.5 Recommended measures to avoid, remedy or mitigate construction effects

See Section 6.5 for measures to avoid, remedy and mitigate predicted construction effects.

12.6 Assessment of operational effects

There are no predicted flooding impacts associated with this NOR.

At detailed design stage consideration can be given to siting the proposed wetland near SH1 closer to the proposed Western Link South alignment to facilitate its combined use.

Conveyance of flows through the deep cuttings will be required.

12.7 Recommended measures to avoid, remedy or mitigate operational effects

Improvements on the proposed NOR design are suggested below.

- The siting of the proposed wetland near SH1 could be located closer to the proposed Western Link South alignment and intersection
- The proposed bridge could be changed to a culvert with upstream catchment of approx. 8.5Ha and 100yr RCP8.5 flow rate of 6.1m^3/s. A culvert will provide easier conveyance of road flows over the culvert to the wetland to the north. A culvert will also provide greater freeboard (0.5m culvert compared to 1.2m bridge) between the predicted flood and road level.

These will have no impact on the NOR designation required and can be refined in the later detailed design / modelling phase.

12.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 13.

Table 13. Summary of Assessment of Effects and Recommendations - Western Link South

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	All: 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.	All: 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.
Operational		
Bridge over existing stream	Proposed as bridge but could be culvert as upstream catchment is small and low flood impacts.	Confirm culvert will maintain water levels and flow capacity in later detailed modelling / design stages.
SH1 wetland location and catchment	Utilise wetland for SH1 and Western Link Rd	Relocate wetland closer to intersection for treatment and attenuation.

It is anticipated that flood modelling of the final design will be required at the detailed design phase to assess the final corridor design, to confirm the flood effects, with the aim that the confirmed detailed design, so far as it relates to flooding effects, will give effect to the NOR conditions.

There are no significant flooding effects and controls within this NOR.

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

13 NOR 7 – Sandspit Link

This section assesses specific flooding and stormwater matters relating to NOR 7 – Sandspit Link.

13.1 Overview and description of works

Sandspit Link is a proposed new road with the purpose of providing strategic east-west movements to Matakana and Kowhai Coasts and providing local access to the northern growth area.

The corridor extends from Matakana Road in the north-west and connects to Sandspit Road in the southeast.

The alignment provides a resilient alternative to SH1 and Hill Street Intersection whilst improving dual accessibility between the northern growth area and Warkworth.

The Sandspit Link Project involves the construction of a two-lane urban arterial with cycle lanes and footpaths on both sides and a new intersection at the connection with Sandspit Road as shown in Figure 13.

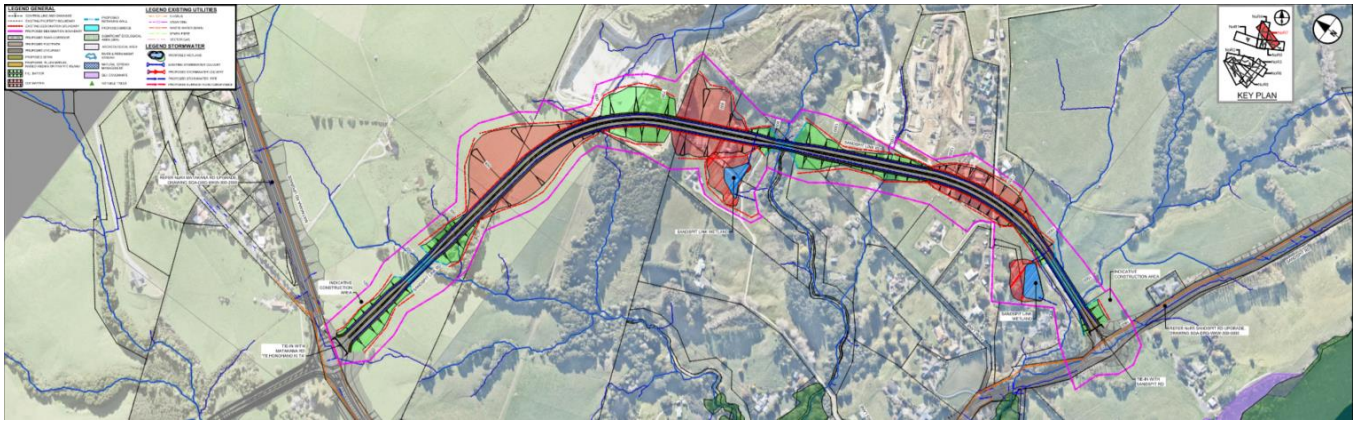

Figure 13: Sandspit Link Rd

13.2 Assessment Features

The design allows for a new formation to be built between Sandspit Rd and Matakana Rd. This alignment crosses six (6) existing streams varying in upstream catchment size from 2.8 Ha up to 190.2Ha. There are predicted flood plains along the three major streams, with minor flooding along the three other streams.

The road slopes from Sandspit Rd intersection at approx. 42m RL to approx. 65m RL at the Matakana Road intersection. There are deep cuttings at the Matakana Road end of the alignment where flow will need to be conveyed through them and drains at the top of the cuttings to divert water away from the cutting faces.

There are two proposed wetlands with one near the centre of the alignment and the second by Sandspit Road.

Refer to AEE Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

13.3 Positive Flooding and Stormwater effects

The road alignment allows for the road surface to be well above any predicted flood plains and treatment wetlands to treat and attenuate flows.

13.4 Assessment of construction effects

The main construction effects are diversion of flows due to the earthworks for the two treatment wetlands, bridges, culverts and formation construction with very deep cut and fill sections.

See Section 6.4 for issues associated with bridge, culvert, wetland and road formation construction.

13.5 Recommended measures to avoid, remedy or mitigate construction effects

See Section 6.5 for other measures to avoid, remedy and mitigate predicted construction effects.

13.6 Assessment of operational effects

The greatest area of predicted flooding is near the proposed bridge by Sandspit Road (shown above) due to potential reduced waterway.

The treatment of proposed road surface will be achieved in the two proposed wetland with water quality and attenuation outcomes.

13.7 Recommended measures to avoid, remedy or mitigate operational effects

The Sandspit Link Rd bridge opening (near Sandspit Rd) needs to be assessed in terms of further refinement to be optimised for flooding, along with the Sandspit Rd bridge renewal / raising at the same time through detailed modelling during the later design stages.

13.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 14.

Table 14. Summary of Assessment of Effects and Recommendations - Sandspit Link

Effect	Assessment	Recommendation
Construction		
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.
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.
Operational		
Bridge over existing stream could create upstream flood water level increase	Bridge opening size needs to be optimised to meet consent conditions	Detailed modelling (of the detailed design) of the bridge and associated formation design during later design stages also ties in with Sandspit Rd bridge to meet consent condtions
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

It is anticipated that flood modelling of the final design will be required at the detailed design phase to assess the final corridor design, to confirm the flood effects, with the aim that the confirmed detailed design, so far as it relates to flooding effects, will give effect to the NOR conditions, ,There are no notable flooding effects and controls within this NOR.

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

14 NOR 8 – Wider Western Link - North

This section assesses specific flooding and stormwater matters relating to NOR 8 – Wider Western Link – North

14.1 Overview and description of works

The Wider Western Link is a proposed new arterial extending from Woodcocks Road in the north to SH1 in the south.

The extent of the proposed new Wider Western Link – North is from Woodcocks Road in the north to the midway point of the Warkworth South Future Urban Zone and is inclusive of the Mahurangi River. The Wider Western Link – North project involves the construction of a two-lane urban arterial with walking and cycling facilities on both sides with layout shown in Figure 14.

The Wider Western Link (southern section) is not being taken forward to NoR.

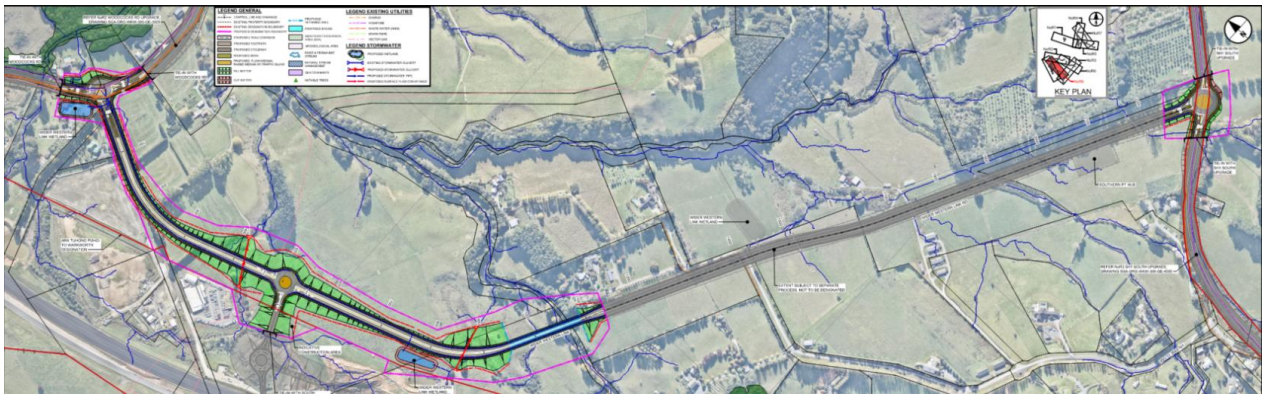

Figure 14: Overall Wider Western Link Rd with northern section designation shown

14.2 Assessment Features

The main flooding impact is the proposed bridge crossing the Mahurangi River with some estimated 2,454Ha upstream and a predicted 100yr RCP8.5 flow rate of approximately 307m^3/s. Although most of the area remains rural with low imperviousness the peak flow rate is large due to the very large catchment size.

Wetland locations are downstream of the connection to P2W Highway and by Woodcocks Rd.

Refer to the AEE Volume 2 for a detailed description of the existing and likely receiving environment for the overall Warkworth package.

14.3 Positive Flooding and Stormwater effects

No impacts are predicted to flood plains if bridge and culverts are appropriately sized and meet the proposed NOR conditions.

New impervious area from road carriageway will be diverted to the proposed wetlands for treatment and attenuation as required.

14.4 Assessment of construction effects

Main issues are construction of the proposed bridge over Mahurangi River and smaller culverts on smaller tributaries, plus two wetlands and road formation.

See Section 6.4 for issues associated with bridge, culvert, wetland and road formation construction.

14.5 Recommended measures to avoid, remedy or mitigate construction effects

See Section 6.5 for measures to avoid, remedy and mitigate predicted construction effects.

14.6 Assessment of operational effects

Mahurangi River bridge design may increase the upstream or downstream flooding effects.

Two wetlands will treat and attenuate the road impervious area.

Culverts designed to convey smaller catchment flows beneath the formation on the same alignment as the existing streams without creating increased upstream / downstream flooding issues.

14.7 Recommended measures to avoid, remedy or mitigate operational effects

Mahurangi River bridge length as shown in Figure 14 covers the predicted flood plain therefore, with no change to the existing terrain under the proposed bridge it will have no flood impacts upstream or downstream of the proposed bridge site.

The wetland discharging to Mahurangi River should be designed for water quality treatment / retention only as defined by GD01 whilst the wetland by Woodcocks Rd would be water quality treatment / retention and attenuation.

14.8 Summary and Conclusions

The standard construction and operational impacts discussed under Section 6 apply to this catchment with the following catchment specific effects as shown in Table 15. Specifically rainfall monitoring for the Mahurangi River bridge site.

Table 15. Summary of Assessment of Effects and Recommendations - Wider Western Link - North

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.
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.
Operational		
Mahurangi River bridges with large predicted flood flows could have significant effects on flood levels if not carefully designed to achieve flood level requirements	Bridge opening could impact upstream and downstream water levels so it needs to be optimised to minimise changes to flood levels.	NOR2 and NOR8: Detailed modelling (of the detailed design) of the bridge and associated formation design during later design stages to optimise bridge opening to meet consent conditions.

It is anticipated that flood modelling of the final design will be required at the detailed design phase to assess the final corridor design, to confirm the flood effects, with the aim that the confirmed detailed design, so far as it relates to flooding effects, will give effect to the NOR conditions.

The main potential flooding effects and controls within the Wider Western Link NOR are associated with the large potential upstream flood flows. Monitoring of rainfall upstream of the site should be completed to prepare and control effects of any large rainfall flood flows and flood risk.

The proposed indicative Mahurangi Bridge design spans the predicted 100yr future flood extent therefore the bridge should have no impact on upstream or downstream flood flows and water levels but this needs to be confirmed with detailed modelling associated with the final detailed bridge design.

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

15 Conclusions

15.1 Summary

The following Summary of the Flooding and Stormwater effects in shown in Table 16.

Table 16: Summary of flooding and stormwater effects

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	All: 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.	All: 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.
Mahurangi River bridges require works in river (such as temporary works) which can restrict flows. Also the very large upstream catchments can create very large flows. 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	NOR2 and NOR8: 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.
SH1 culvert upgrade at PT Hub will increase downstream water levels and flows therefore increasing construction flood risk in PT Hub	Greater flood flows from the larger pipe along with works which could reduce flood storage (wetland, embankment and bridge construction) could cause the site to become inundated and spill over on to adjoining land during construction.	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.
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.	NOR1, 2, 7 and 8: Detailed modelling (of detailed design) to assess best option to meet to meet designation. Flood Hazard condition requirements for upstream and downstream water levels. .

Effect	Assessment	Recommendation
Raising existing roads above the predicted 100yr future flood levels could increase upstream flood levels.	Greater protection of road to flooding will require increased flow capacity beneath the road with the aim of flood neutrality upstream and downstream of the raised road formation	NOR 2, 3 and 5 Optimisation of bridge or culverts through later detailed modelling (of detailed design) and design to achieve flood consent conditions.
Mahurangi River bridges with large predicted flood flows could have significant effects on flood levels if not carefully designed to achieve flood level requirements	Bridge opening could impact upstream and downstream water levels so it needs to be optimised to minimise changes to flood levels.	NOR2 and NOR8: Detailed modelling (of detailed design) of the bridge and associated formation design during later design stages to optimise bridge opening to meet consent conditions.
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.	NOR6 and NOR7: 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
SH1 pipe upgrade from 1.2 to 2.4m will increase downstream flows and water levels in PT Hub area.	The increased flow rate and water levels downstream of the 2.4m culvert and the available flood storage needs to be understood as it will impact wetland, embankment and bridge design.	NOR1. Design of wetland, embankments and bridge needs to be optimised to reduce flood levels to within consent conditions. Detailed design and modelling needed at later stages.
Wetlands for treatment only will reduce footprint needs	Downstream wetlands could be water quality only (GD01) as opposed to treatment and attenuation	NOR4 and NOR5: Detailed modelling (of detailed design) to show attenuation not needed during later design stages.

15.2 Conclusions

Later detailed design and any associated modelling of this design will give further consideration to potential NOR flooding effects to identify how the post SGA flooding effects of the final design will be managed in line with the consent conditions.

The positive flooding effects are primarily associated with raising existing roads out of the flood plain (NOR 2, 3 and 5) that are currently predicted to flood in the future 100yr events.

The construction management and mitigation controls apply to all NOR.

The significant flooding effects and controls within the Warkworth assessment area are associated with:

- P2W increase of the existing SH1 culvert from 1.2 to 2.4m which will increase downstream flows and water levels. This needs to be modelled to fully understand the risk.
- the large potential flood flows upstream of NOR 2 (Woodcocks Rd) and 8 (Wider Western Link Rd). Monitoring of rainfall upstream of these sites should be completed to prepare and control effects of any large rainfall flood flows;
- the raising of Sandspit Rd where the current bridge is predicted to overtop will require construction controls and flood modelling / design to optimise the bridge level / opening to meet consent conditions, and;
- raising of SH1 Southern section above the predicted 100yr flood plain will also require optimisation of the construction method and number / size of bridge openings through later detailed design and modelling to meet consent conditions.

The assessed flood effects can be managed by adjusting the proposed road geometry and changing the amount of culvert and bridge opening area, so that the proposed NOR conditions will be met. In particular, the conditions require that there will be no increase in flooding of existing identified flooded habitable floors and no more than 50mm change to flood levels within properties.

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

References

- Auckland Council GD01
- Auckland Council Geomaps
- Auckland Council Code of Practice
- Te Tupu Ngātahi Warkworth base case modelling
- Te Tupu Ngātahi Rev B drawings
- Te Tupu Ngātahi Warkworth Specialist Briefing Pack – 10 August 2022