

Roads of national significance



Ara Tühono - Pühoi to Wellsford

This document records technical and factual information used to support the NZTA's Assessment of Environmental Effects for the Pūhoi to Warkworth Project. It has been supplied to the Environmental Protection Authority by the NZTA in response to a section 149(2) Resource Management Act 1991 request. This document did not form part of the NZTA's application for the Project, which was lodged on 30 August 2013.





Pūhoi to Warkworth

Water Assessment Factual Report 10
Flood Assessment
August 2013



Pūhoi to Warkworth

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Glossary of abbreviations

Abbreviation	Definition
AEE	Assessment of Environmental Effects
ARI	Average Recurrence Interval
ICM	InfoWorks Integrated Catchment Modelling Software
NZTA	NZ Transport Agency
OWAR	Operational Water Assessment Report
RL	Reduced Level
RMA	Resource Management Act 1991
RoNS	Roads of National Significance
SHx	State Highway (number)



Glossary of defined terms

Term	Definition			
Alignment	The route or position of a proposed motorway or state highway.			
Average Recurrence Interval	The average time period between rainfall or flow events which equal or exceed a given magnitude. Similar to return period.			
Culvert	A pipe with an inlet from a watercourse and outlet to a watercourse, designed to convey water under a specific structure (such as a road).			
Diversion of stormwater	The turning aside of stormwater from its natural course of flow; causing it to flow by a different route.			
Motorway	Motorway means a motorway declared as such by the Governor-General in Council under section 138 of the PWA or under section 71 of the Government Roading Powers Act 1989.			
Overland Flow Path	The flow path of stormwater over the ground.			
The Project	Ara Tūhono Pūhoi to Wellsford Road of National Significance Project: Pūhoi to Warkworth section.			
Project Area	From Johnstone's Hill portals in south to Kaipara Flats Road in the north.			
Reduced Level	Equating levels / elevations to a common datum.			
Secondary flow path	The flow path of stormwater or floodwater that activates for larger storm events.			

Water Assessment Factual Report 10 Flood Assessment



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Appendix A – High level review of RFHM by Auckland Council



1. Introduction

This report provides a factual basis for the Operational Water Assessment Report (OWAR) prepared for the New Zealand Transport Agency (NZTA). The OWAR provides an assessment of the environmental effects associated with water, arising from the operational aspects of the Pūhoi to Warkworth section (the Project) of the Pūhoi to Wellsford Road of National Significance Project. The OWAR supports the Assessment of Environmental Effects (AEE) resource consent applications and Notices of Requirement for the Project.

Flooding in the Carran Road Sector (refer to Section 2.2 of the OWAR for a description of the Project sectors) is a major consideration for the Project indicative alignment. The main issues are the potential impacts from the Project on the floodplain of the Mahurangi River Left Branch and an associated major secondary flow path. This secondary flow spills from the Mahurangi River Left Branch and flows north before returning via the Hudson Road area to the Mahurangi River downstream of Falls Road.

Prior to this assessment avoidance measures were undertaken by changing the indicative alignment from an earlier alignment developed through the scheme assessment phase to avoid the floodplain as much as possible. Two crossings of the floodplain are required and bridges are proposed, namely the Woodcocks Road Viaduct and Carran Road Flood Relief Bridge.

This report documents our analysis of the flooding in this area and provides a basis for the OWAR to assess potential effects on flood risk due to the Project. Our methodology includes:

- Strategic flood risk assessment;
- Flood modelling of two options to avoid and mitigate effects on the floodplain;
- Potential at-risk buildings identification and floor-level survey results; and
- Summary of the outputs for informing the OWAR.

The flooding effects that are identified by this factual report are assessed in Section 8 of the OWAR.



2. Catchments

The Project crosses two major catchments; the Mahurangi River catchment in the north and the Pūhoi River catchment in the south, as shown in Figure 1 below. Details of these catchments and the existing environment are described to OWAR Section 4.

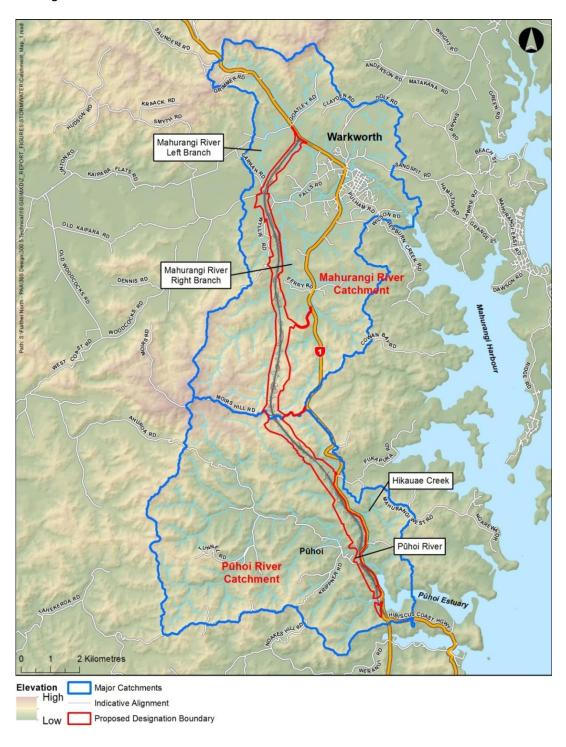


Figure 1: Mahurangi and Pūhoi River catchments



High level flood risk assessment

As part of our assessment of the Project, we undertook a high level flood risk assessment for the indicative Project alignment. Our flood risk assessment was for each crossing of the main stream branches. The flood risk at other minor stream crossings is dealt with through the design of culverts and the assessment of headwater extents, refer Water Factual Report 8: Cross Drainage and Stream Diversion Design and OWAR Section 6 (Cross drainage) and 8 (Assessment of effects).

Flooding is an existing issue in the lower Mahurangi catchment, including in parts of Warkworth. Auckland Council is developing flood management models for the Mahurangi and Warkworth area to define hazards and to plan for mitigation options. The flood hazard areas in the Mahurangi and Pūhoi catchments are shown in Figure 2 and Figure 3 respectively, for the existing 100 year ARI flood overlaid with the indicative Project alignment. The flood hazard areas are based on the Auckland Council rapid flood hazard models. Areas where we consider there to be potential for flooding caused by the Project are identified on the figures.

The locations identified on Figure 2 and Figure 3 are summarised in the flood risk assessment matrix in Table 1. The crossings at Carran Road (Ch 48300m) and Woodcocks Road (Ch 49220m) are high risk due to the flood flow, configuration of the indicative alignment relative to the floodplain and the presence of dwellings.

At two other locations, Chainage 49500 and 54720, fills are proposed within the floodplain and culverts proposed, but there are no dwellings in close proximity to the floodplain, so the risk is low.



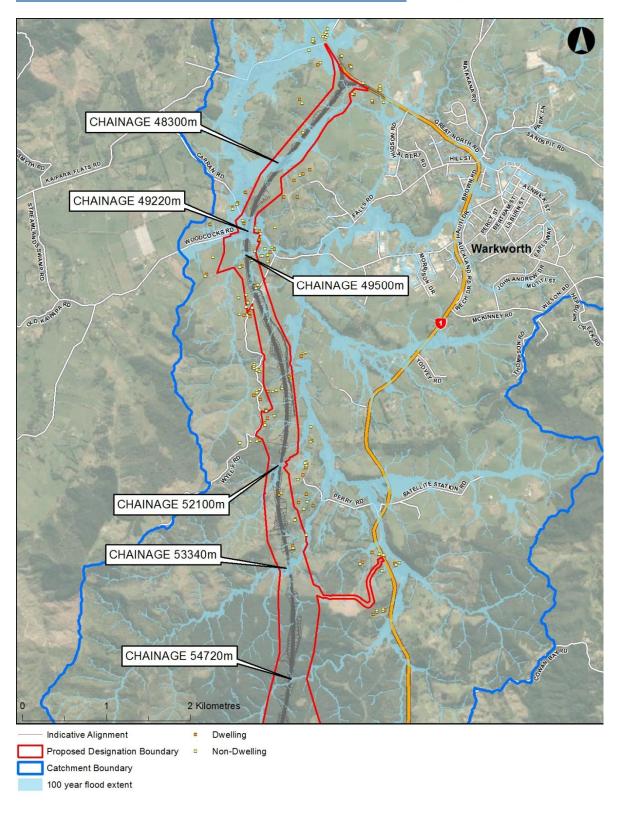


Figure 2: Significant alignment crossings in the Mahurangi catchment (100 year flood extent from Auckland Council rapid flood hazard model)



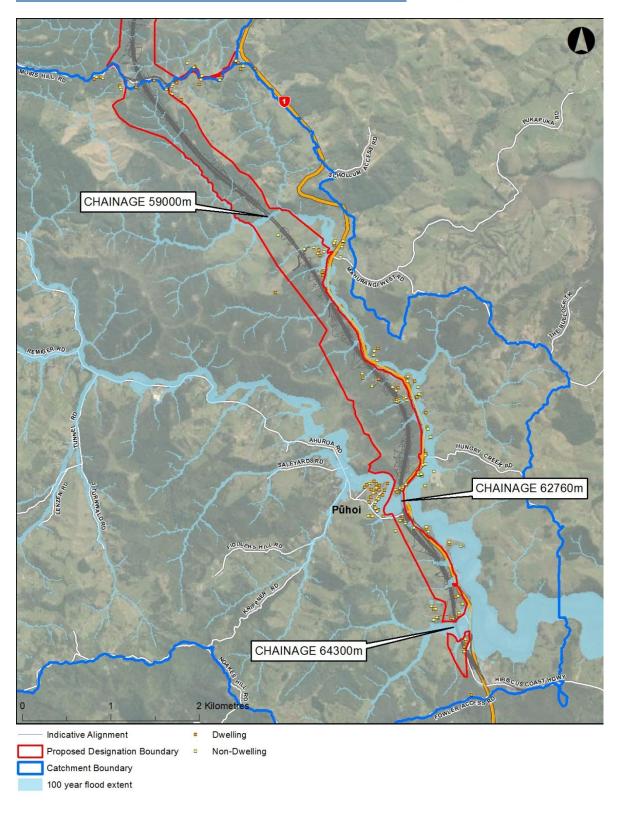


Figure 3: Significant alignment crossings in the Pūhoi catchment (100 year flood extent from Auckland Council rapid flood hazard model)



Table 1: High Level Flood risk assessment matrix

Approximate Chainage (m)	Significant stream crossing	Fill on the floodplain*	Diversion of secondary flow path	Potential significant impact on dwellings from flooding	Mitigation measure proposed	Risk
48300	No	Yes	Yes	Yes	Carran Road Flood Relief Bridge	High
49220	Yes	Yes	No	Yes	Woodcocks Road Viaduct	High
49500	Yes	Yes	No	No	Concrete arch culvert	Low
52100	Yes	No	No	No	Kauri Eco Viaduct	Negligible
53240	Yes	No	No	No	Perry Road Viaduct	Negligible
54720	Yes	Yes	No	No	Concrete arch culvert	Low
59000	Yes	No	No	No	Schedewys Viaduct	Negligible
62760	Yes	No	No	No	Pūhoi Viaduct	Negligible
64300	Yes	No	No	No	Okahu Viaduct	Negligible

^{*1.} Please refer to drawings SW-100 to 115.



4. Hydraulic modelling of high risk areas

We undertook hydraulic modelling to predict the impact of the Project on the high risk areas identified in Table 1. The high risk areas are in the vicinity of Carran and Woodcocks Road where there is potential high risk to dwellings from flooding.

Auckland Council has a rapid flood hazard model built using InfoWorks ICM software, which was supplied for our flood risk assessment. The rapid flood hazard tool is a high level type model used to screen for flood hazard issues. Auckland Council is developing a more detailed flood model for the Warkworth township, but this model will not be ready prior to the Project applications being lodged.

This ICM model uses a rainfall on grid approach with a 100 year ARI rainfall event. The ICM model uses a digital elevation model (DEM) with flexible mesh sizes ranging from 2 to 100 m^2 . Flood zones have a high resolution mesh range down to 2 m^2 (with an average mesh size of 12.8 m^2). A low resolution mesh size of up to 100 m^2 was used for elevated areas. The ICM model included the existing State Highway 1 alignment and the building footprints.

We undertook our own review of the AC rapid flood hazard models. We consider the Auckland Council models to be of relevance and of sufficient accuracy for our assessment of the Project effects, as these models provide the relative difference (the change) between existing and post-development flood levels. In our experience however, these types of models are often conservative and over predict flows and water depth, which is why they are used to develop an understanding of flooding issues prior to development of more accurate models. We acknowledge that more detailed modelling and calibration of the model would more accurately define peak flood levels and recommend such a model be prepared as part of the Project's detailed design when prediction of absolute levels is more important. This will confirm that consent conditions are met.

We updated the existing Auckland Council model mesh with the Project indicative alignment and ran the model to investigate the effects generated from the implementation of the Project. Only the motorway embankments associated with the Project alignment that encroaches into the floodplain of the Mahurangi Left Branch in the vicinity of Carran and Woodcocks Road were added to the model. All model input parameters (such as boundary conditions, modelling time step, initial conditions and surface roughness) were kept the same as those provided by Auckland Council.

We modelled physical gaps in the motorway embankments to represent the opening of the Carran Road Flood Relief Bridge and Woodcocks Road Viaduct. The Woodcocks Road Viaduct had a 280m span. Other aspects of the alignment including associated culverts were not modelled as they would artificially detain runoff in these areas and distort the predicted flow rates in the lower Mahurangi River. The Carran Road Flood Relief Bridge was sized to reduce flood effects as detailed in subsequent sections.

A high level review of our model was undertaken by Auckland Council in June 2013 (refer Appendix A). The review checked elements of the model that were important for an appropriate assessment of the flooding effects to be carried out. Auckland Council's review was not an assessment of the effects of the results from the model.



The review recommends more detailed modelling at the detailed design stage, which we support. Finally the review questions the accuracy of predicted flood level increases downstream of the Woodcocks Road Viaduct. We consider these simulated increases to be real due to the predicted increase in flows in the Mahurangi Left Branch (refer Sections 4.1 and 4.2).

4.1 Hydraulic Modelling Results

The Carran Road Flood Relief Bridge spans the secondary flow path from the Mahurangi Left Branch. It was initially modelled with a span of 28m.

The pre and post-development scenarios were run for a 100 year ARI rainfall, including allowance for the effects of climate change.

The resultant model hydrographs, showing both the pre and post-development flows at both Carran Road Flood Relief Bridge and at Woodcocks Road Viaduct are shown in Figure 4 and Figure 5 respectively.

Figure 4 shows that a 28 m span Carran Road Flood Relief Bridge passes the secondary flow but with a reduction in peak flow from 90 m 3 /s to 60 m 3 /s. Figure 5 shows a corresponding increase of peak flow from approximately 110 m 3 /s to 135 m 3 /s at Woodcocks Road Viaduct. These changes are caused by the 28m span Carran Road Flood Relief Bridge restricting flow through the secondary flow path causing more flow to stay in the Mahurangi Left Branch.

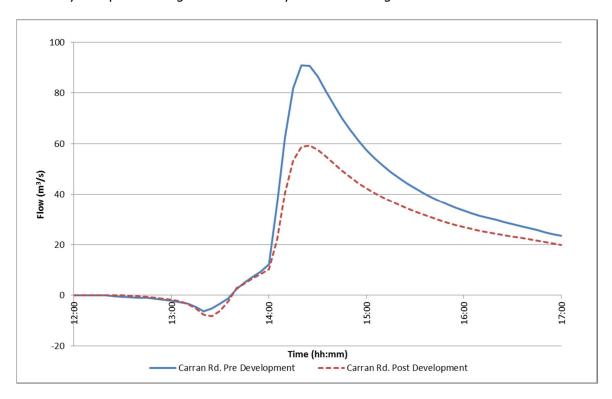


Figure 4: Comparison of flow for the 100 year ARI storm event at Carran Road Flood Relief Bridge (28 m Carran Road Bridge span)



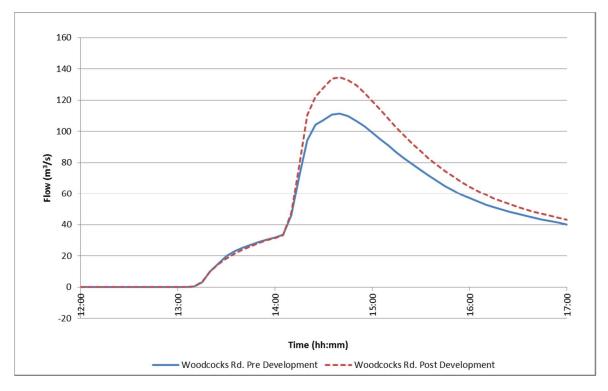


Figure 5: Comparison of flow for the 100 year ARI flood event at Woodcocks Road Viaduct (28 m Carran Road Bridge span)

The impact of the change in floodplain conveyance by the Project can be seen in Figure 6, which presents a comparison of the pre-development and the post-development condition in the form of the difference in flood depth.

The 28 m span bridge results in an afflux of up to 250 mm upstream of the bridge. These increases in flood levels occur along the Mahurangi Left Branch until the Falls Road area. Along the secondary flow path downstream of the Carran Road Flood Relief Bridge the flood levels decrease. The Woodcocks Road Viaduct may also result in an increase in flood depth upstream of the viaduct, although the greater impact is considered to come from the increase in flow in the Mahurangi Left Branch resulting in the reduction in capacity of the secondary flow path.



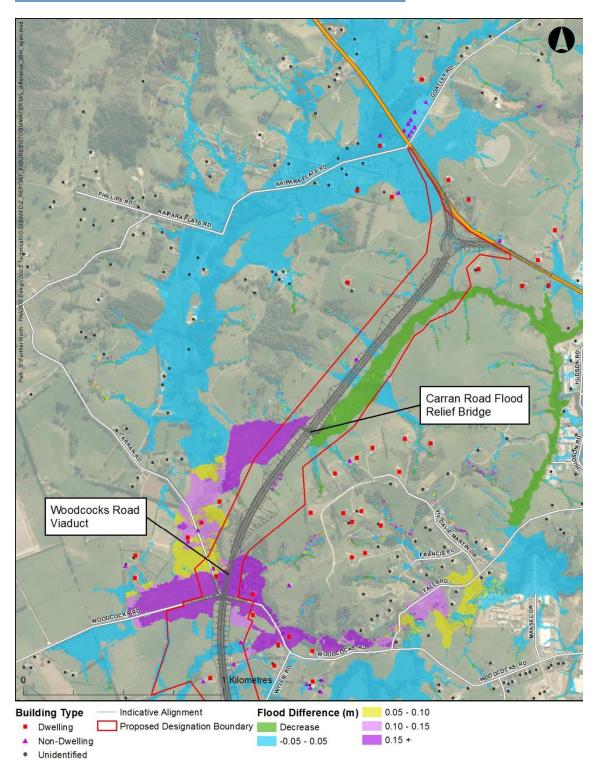


Figure 6: Carran Road sector water level difference for 100 year ARI (28m Carran Road Bridge Span)



4.2 60m span Carran Road Flood Relief Bridge

To achieve a higher level of mitigation by a greater reduction of afflux, we increased the bridge span at the Carran Road Flood Relief Bridge to 60 m. Figure 7 and Figure 8 show pre and post-development flood flows for the Carran Road Flood Relief Bridge and at Woodcocks Road Viaduct respectively. The hydrograph for the 28 m span Carran Road Flood Relief Bridge is also shown in Figure 7 for comparison.

Figure 7 shows a $10~\text{m}^3/\text{s}$ reduction in flow at the Carran Road Flood Relief Bridge for the 60m span, compared to pre-development conditions.

Figure 8 indicates that flows at Woodcocks Road Viaduct are almost identical for pre-development and post-development scenarios.

The differences between pre and post-development flood levels for the Carran Road Flood Relief Bridge with a 60 m span are shown in Figure 9. With the 60 m span, the Carran Road Flood Relief Bridge can convey the secondary flow with an afflux of less than 100 mm.

The increase in water levels still has potential to cause adverse flooding effects to dwellings. This is discussed in Section 5 of this report.

The hydraulic sizing of both the Carran Road Flood Relief Bridge and the Woodcocks Road Viaduct will be refined during detailed design when further hydraulic modelling will be carried out.

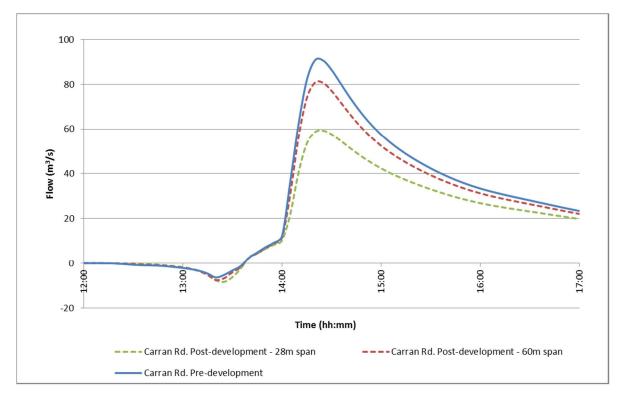


Figure 7: Comparison of flow for the 100 year rainfall event at Carran Road Flood Relief Bridge (60 m Carran Road Bridge Span)



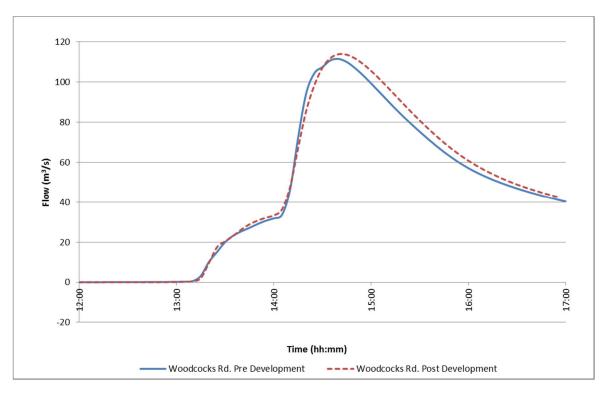


Figure 8: Comparison of flow for the 100 year rainfall event at Woodcocks Road Viaduct (60 m Carran Road Bridge Span)



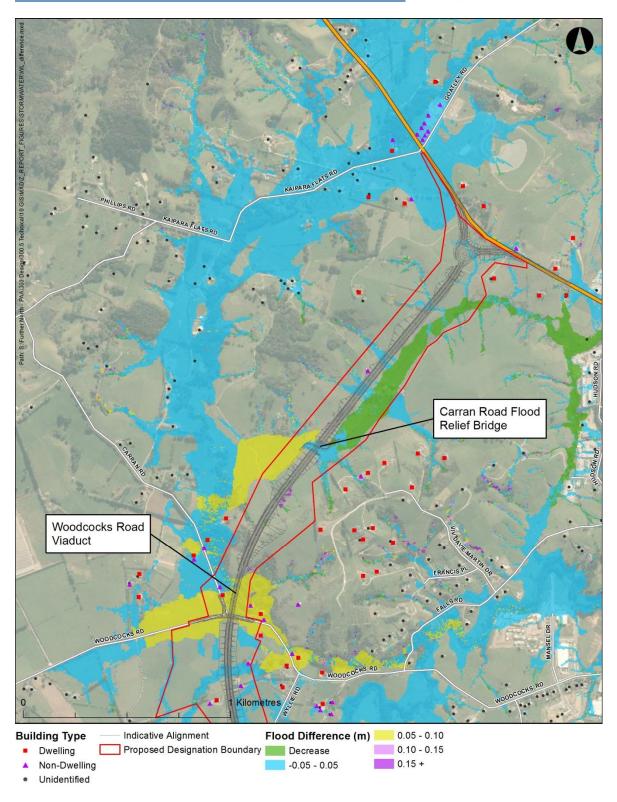


Figure 9: Carran Road sector water level difference for 100 year ARI (60m Carran Road Bridge Span)



5. Potential dwellings affected by flooding

For the 60 m span Carran Road Flood Relief Bridge there are four dwellings located beyond the Project designation within areas where a 50-100 mm increase in flood levels is predicted for the 100 year ARI storm event. These dwellings are shown in Figure 10. An increase in flood level / depth ranging from 30 mm to 80 mm is predicted at the four dwellings.

To enable the effect of flooding on these four dwellings to be assessed in the OWAR, we surveyed the lowest habitable floor levels. Table 2 compares the surveyed floor levels with pre and post development flood levels.



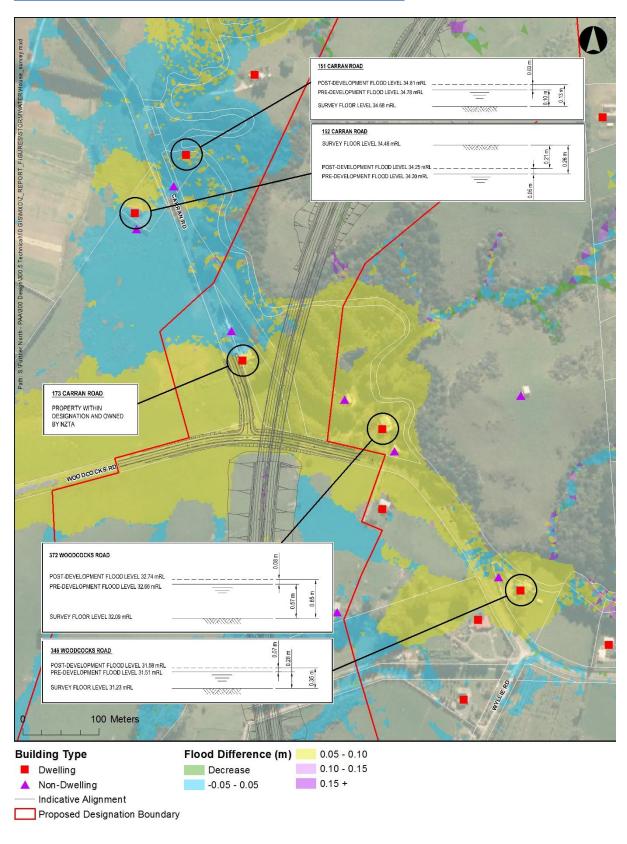


Figure 10: Dwelling floor and flood levels



Table 2: Dwellings affected by flooding for 100 year ARI event

		Pi	re-developme	nt	Post-development		
Street Address of Dwelling Affected	Lowest Habitable Floor Level *1 (mRL)	Flood Level (mRL)	Flood Depth (m)	Flood Depth Above Floor Level (m)	Flood Level (mRL)	Flood Depth Above Floor Level (m)	Project Increase in Flood Depth (m)
151 Carran Road	34.68	34.781	1.779	0.101	34.813	0.133	0.03
152 Carran Road	34.46	34.200	0.404	-0.260 ^{*2}	34.249	-0.211 ^{*2}	0.05
346 Woodcocks Road	31.23	31.508	0.967	0.278	31.578	0.348	0.07
372 Woodcocks Road	32.09	32.661	1.510	0.571	32.736	0.646	0.08

^{*1} Floor level surveyed is lowest habitable floor level constructed or consented on or before Friday 28 June 2013.

The results in Table 2 show that the dwelling floor levels at No. 151 Carran Road and No's 346 and 372 Woodcocks Road are below the pre-development flood level. The dwellings' flood pre-development and the flood level increases by only 30 mm, 70 mm and 80 mm respectively post-development.

At No. 152 Carran Road, the dwelling floor level is 260 mm above the pre-development flood level. The Project increases this flood level by only 50 mm therefore the flood level remains 211 mm below the floor level of the dwelling.

The effects of the Project on flooding are assessed in Section 8 of the Operational Water Assessment Report.

Appropriate consent conditions and recommendations regarding change in flood levels caused by the Project are discussed in Section 9 of the Operational Water Assessment Report.

^{*2} A (-) ve reduced level means this reduced is below the lowest habitable floor level.



Appendix A – High level review of RFHM by Auckland Council

Comments on Mahurangi Catchment Rapid Flood Hazard Assessment Alignment Option model - high level review only

Model Created By (Person/Organisation): Wolfram Schluter - SKM

Date: 21 June 2013

General Information

Items	Findings
Model Version	Infoworks ICM 3.0
Model file names	WarkworthRFH.icmm
Other file names	rastert_60m_ope4.asc, Structural drawings of Woodcocks road viaduct and Carran road flood relief bridge (PDF files)
Report file name	N/A
Purpose of model	To assess effects of proposed Puhoi to Warkworth motorway. The alignment crosses the primary floodplain of the Mahurangi River (left branch) over the primary flood plain (the Woodcocks Rd Viaduct) and a flood relief bridge (the Carran Road Flood Relief Bridge) to convey the secondary flood plain.
Base model used	Auckland Council Mahurangi catchment RFHA model, the base model used was agreed by Tim Fisher (FNA) and Nick Brown (AC)

Rating at right of each table below: 0 – Not an issue 3 – Major Issue will effect model output

RFHA Option Model

Item Checked	Findings & Comments	Rating
RFHA Model bathymetry and mesh size check.	The DEM used in the model in the subjected locations - (the Woodcocks Rd Viaduct) and a flood relief bridge (the Carran Road Flood Relief Bridge) is based on Council provided existing model, the average mesh size is 12.8m2. the mesh size can be reduced for option study. The impact of mesh size of 12.8m2 for the option of 60m wide flood relief bridge is acceptable for a high level study. The mesh size won't impact the wood cocks Rd Viaduct.	1
Structure for the Woodcocks Rd Viaduct	The proposed Woodcocks Rd Viaduct has 280m of overall length of deck control line supported by 8 piers, it covers primary floodplain of Mahurangi River. The 8 piers is not modelled for this high level study which is fine. It is suggested to have a proper cross section surveyed for this location and modelled the bridge structure at detailed design stage.	1
Carran Road Flood Relief Bridge	The Carran Road flood relief bridge is modelled in 2D, there are no head losses being modelled. It is suggested to model the bridge structure and survey the surround ground levels at detailed design stage.	1
Results Check	Model can be run and results are fine for the existing scenario.	0

Item Checked	Findings & Comments	Rating
Summary	The modelling work is very high level. None of proposed structures modelled. At detailed design stage when the structures are mode increase in flood level upstream of the structures above what is currently predicted will occur. At the detailed design stage the briopenings and piers may need to be adjusted to achieve change upstream flood level it becomes necessary.	elled an
	Conveyance of floodwaters outside of these 2 locations across to proposed highway has not been assessed in the model, many triuling will be impacted by the proposed highway alignment and each read detailed assessment.	butary
	The water level difference plot in the provided hardcopy is probal accurate as it shows a flood level increase d/s of Woodcocks Ro Viaduct where the bridge will decrease conveyance.	•