15 NOR 10 – Upgrade to Wainui Road

15.1 Assessment Features

This NOR allows for an upgrade to the existing Wainui Road as shown in Figure 15-1 with the predicted flooding extents for the 1% AEP future with 2.1° climate change base case shown in Figure 16-2.

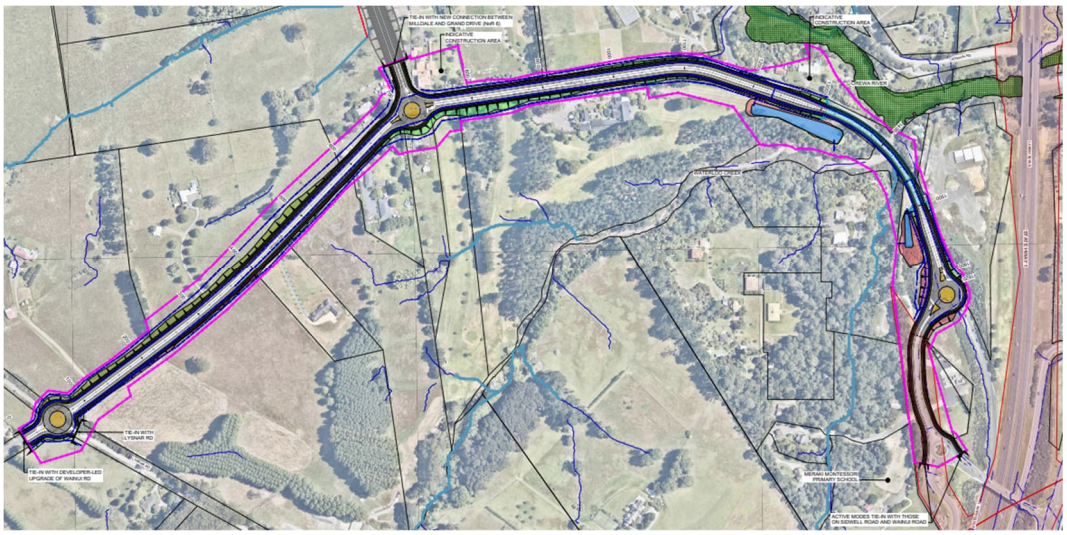


Figure 15-1: NOR10 Wainui Rd upgrade

Figure 15-2: NOR10 Wainui Rd upgrade 1% AEP future base case flood extent

The potential flood effects for this NOR relate to the earthworks, minor stream diversion, flood storage volume loss, construction of bridges over the stream and formation / wetland construction adjacent or within the flood plain.

15.2 Positive Flooding and stormwater effects

The positive flooding effect relates to the new widened formation and new bridge being constructed above the predicted flood plain.

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

15.3 Assessment of construction effects

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

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

15.4 Recommended measures to avoid, remedy or mitigate construction effects

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

15.5 Assessment of operational effects

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

- lengthening existing culverts could create upstream flooding due to increased inlet levels and greater pipe friction losses which will drive up the upstream water level
- bridge crossings over the streams will need to be sized to optimise upstream and downstream water levels to within NOR conditions
- minor length reduction of an open permanent stream through lengthened existing culverts
- construction of new road formation reduces flood storage volume, which could increase water levels.

15.6 Recommended measures to avoid, remedy or mitigate operational effects

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

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

15.7 Summary and Conclusions

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

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

16 NOR 11 –Connection from Dairy Flat Highway to Wilks Road

16.1 Assessment Features

The concept design for this NOR shown in Figure 16-1allows for a new road connection between Wilks Rd and Dairy Flat Highway with a new intersection at Kahikatea Flat Rd / Dairy Flat Highway. Figure 16-2 shows the predicted flooding extents for the 1% AEP future with 2.1° climate change base case.

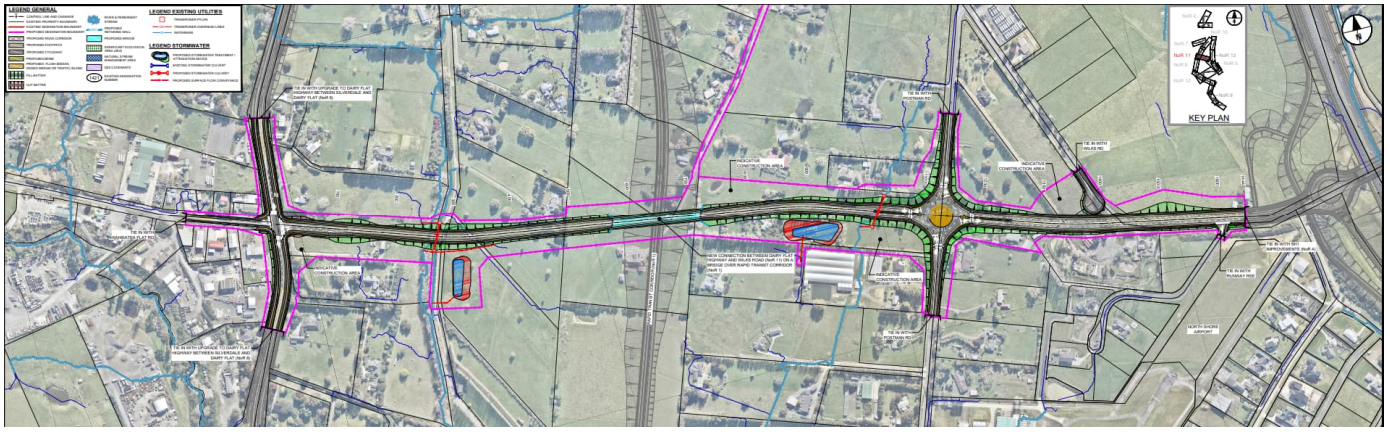


Figure 16-1: NOR11 Connection from Wilks to Dairy Flay Highway

Figure 16-2: NOR11 Wilks Rd connection predicted future pre-SGA 1% AEP flooding extent

The potential flood effects for this NOR relate to the earthworks, minor stream diversion, flood storage volume loss, construction of culverts over existing streams and formation / wetland construction adjacent or within the flood plain.

Proposed culverts under the road formation have relatively small upstream catchments (50Ha western culvert) and 26Ha (eastern culvert near Postman Rd) based on AC Geomaps.

16.2 Positive Flooding and stormwater effects

The positive flooding effect relates to the new widened formation being constructed above the predicted flood plain.

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

16.3 Assessment of construction effects

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

- Construction of new culverts over existing streams which could create flooding impacts by restricting flows - dependent on the construction method, particularly if large storms are predicted

- 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 allow materials or debris to float and block drainage and create flooding
- Embankments over overland flow paths/flood plains which can create flooding issues due to formation work during heavy rainfall periods
- Bulk earthworks to complete the formations require a dry works area and can alter overland flow paths or generate erosion and sediment effects and flooding impacts

16.4 Recommended measures to avoid, remedy or mitigate construction effects

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

16.5 Assessment of operational effects

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

- minor length reduction of open permanent stream through new culverts
- wetland by Postman Rd intersection built adjacent to a flood plain
- construction of new road formation reduces flood storage volume, which could increase water levels.

16.6 Recommended measures to avoid, remedy or mitigate operational effects

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

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

16.7 Summary and Conclusions

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

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

17 NOR 12 – Upgrade and Extension to Bawden Road

17.1 Assessment Features

This NOR allows for upgrade and extension to the existing Bawden Rd as shown in Figure 17-1 with the predicted flooding extents for the 1% AEP future with 2.1° climate change base case shown in Figure 17-2. Figure 17-3 shows more detail of the proposed bridge crossing over the Dairy Stream tributary.

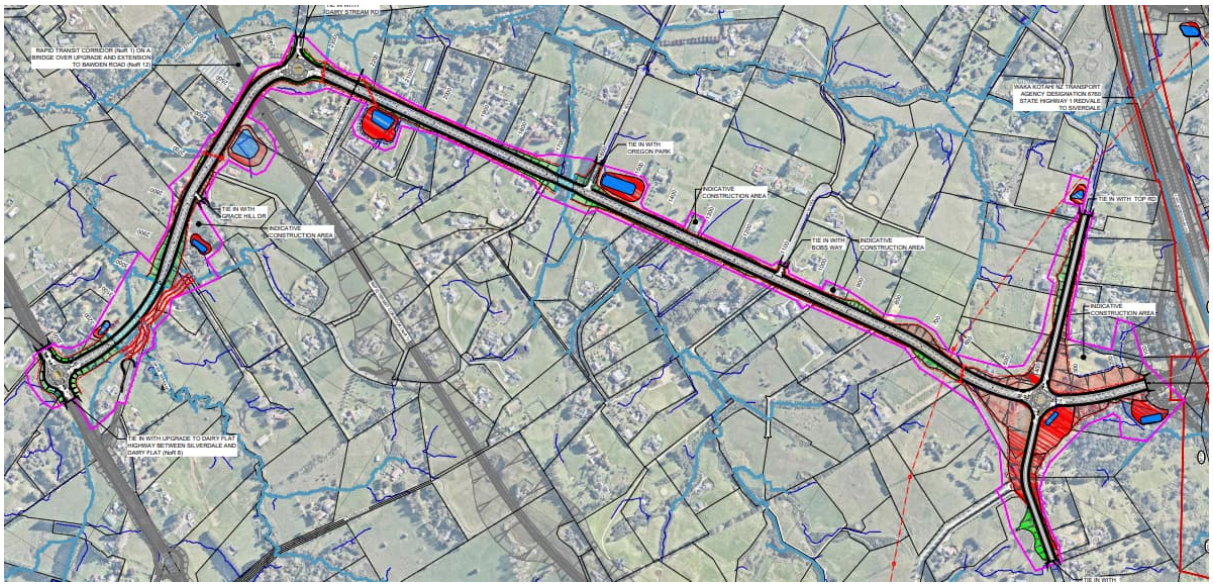


Figure 17-1: NOR12 Bawden Rd upgrade

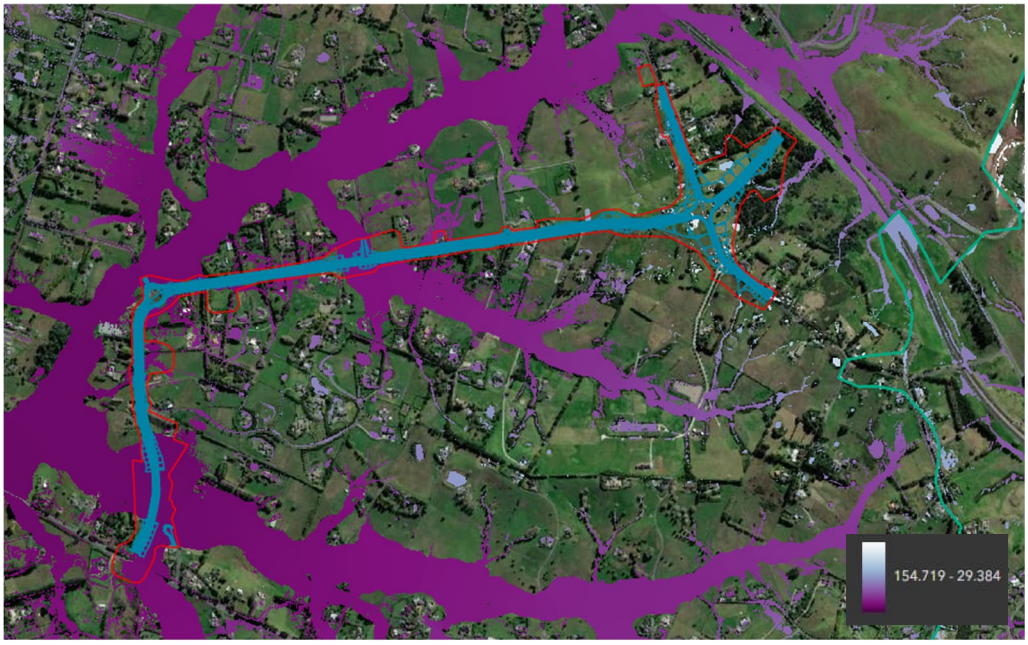


Figure 17-2: NOR12 Bawden Rd upgrade 1% AEP future base case flood extents

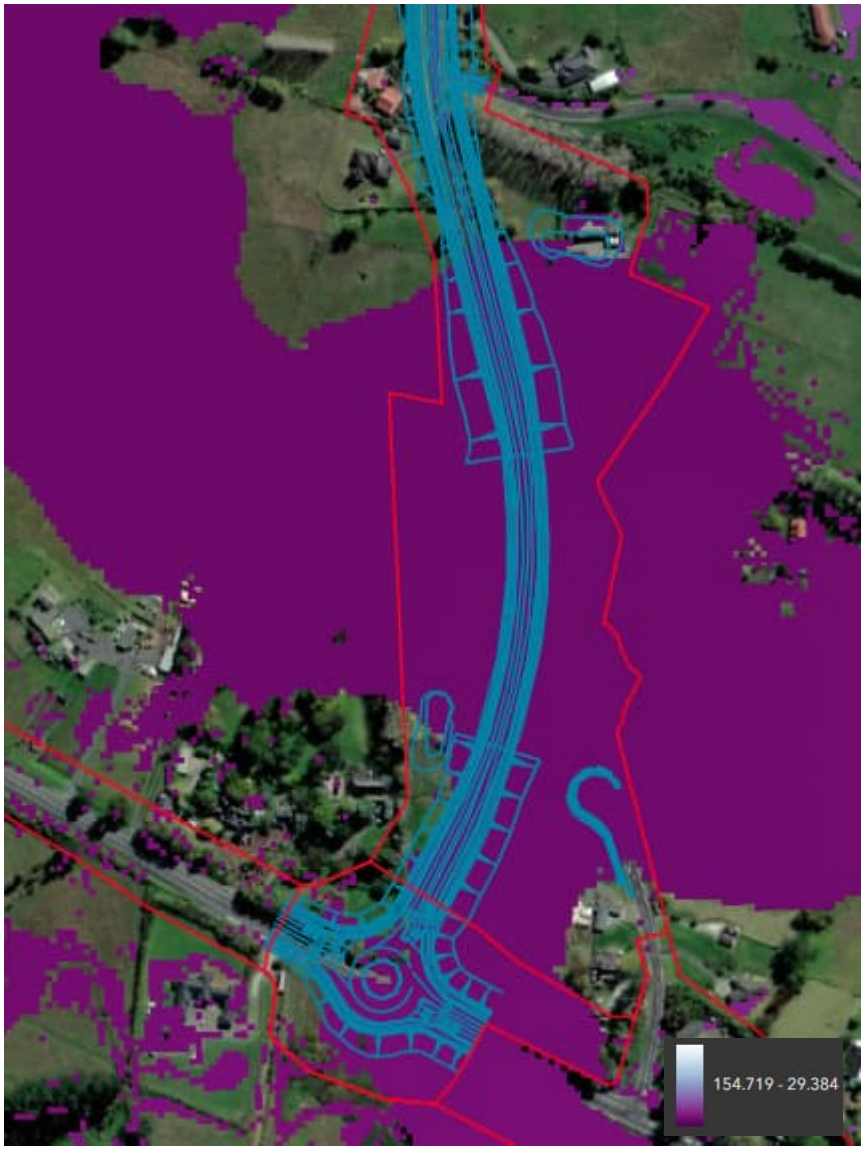


Figure 17-3: Bawden Rd bridge over Dairy Stream tributary

The potential flooding effects for this NOR relate to the earthworks, minor stream diversion, flood storage volume loss, construction of bridges / culverts over the streams and formation / wetland construction adjacent or within the flood plain.

The main concern is the proposed Bawden Rd intersection with Dairy Flat Highway (DFH) where flooding is predicted to overtop the existing road and the concept design proposes raising DFH plus adding a larger DFH bridge. As discussed under NOR8, additional modelling was completed to assess the impact of raising DFH and the proposed Bawden Rd bridge. As noted in the memo attached under Appendix 2, including the small section of land between the old / proposed Bawden Roads and DFH within the designation boundary will provide opportunity for added ground recontouring adjacent to the existing stream to reduce water levels in the area and both upstream and downstream of that area.

The results showed that with refinements, the designation conditions were very close to being achieved, and with future refinements available (such as recontouring adjacent to the existing stream), the flood hazard risk can be further improved to within the outcomes sought in the designation conditions.

17.2 Positive Flooding and stormwater effects

The positive flooding effects relate to the widened road formation and new bridge being constructed above the predicted flood plain.

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

17.3 Assessment of construction effects

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

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

17.4 Recommended measures to avoid, remedy or mitigate construction effects

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

17.5 Assessment of operational effects

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

- lengthening existing culverts could create upstream flooding due to increased inlet levels and greater pipe friction losses which will increase the upstream water level
- bridge crossings over the streams will need to be sized to optimise upstream and downstream water levels to within conditions; particularly the Bawden Rd bridge near the Dairy Flat Highway intersection
- the proposed cul-de-sac on the existing Bawden Rd (Figure 16-3) will reduce the waterway between the embankment and cul-de-sac and may require modifications at detailed design stage
- minor length reduction of open permanent stream through lengthened existing culverts
- construction of new road formation reduces flood storage volume, which could increase water levels.

17.6 Recommended measures to avoid, remedy or mitigate operational effects

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

- Later detailed modelling and design to assess and minimise the impacts of flood levels / extent / depth due to the culvert extensions and flood storage volume loss
- Bridge length, waterway opening and ground recontouring to be optimised with the aim to achieve flood designation conditions. Recent modelling of the concept Bawden Rd bridge design (over the Huruhuru tributary) has shown that the bridge opening needs to be widened further and ground recontouring is needed in the block between the new and old Bawden Rd alignments and Dairy Flat Highway to achieve the conditions. This will be refined in the later design and modelling stages to optimise the design to meet the flood hazard designation conditions.

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

17.7 Summary and Conclusions

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

The main issue that needs to be resolved is the span of the Bawden Rd bridge over the Huruhuru tributary and the waterway between the proposed cul-de-sac head and the proposed Bawden Rd embankment. This will be refined in the later design and modelling stages to optimise the design to meet the flood hazard designation conditions.

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

18 NOR 13 – Upgrade to East Coast Road between Silverdale and Ō Mahurangi Penlink (Redvale) Interchange

18.1 Assessment Features

The concept design for the upgrade to East Coast Road (ECR) and predicted flooding extents for the 1% AEP future with 2.1° climate change base case are shown in Figure 18-1. The majority of this NOR is on a ridgeline; therefore flood effects are non-existent except for the southern end of the alignment. Figure 18-2 shows details of the predicted flooding at the southern end of the proposed ECR upgrade by SH1 crossing Huruhuru (Dairy Flat) Stream.

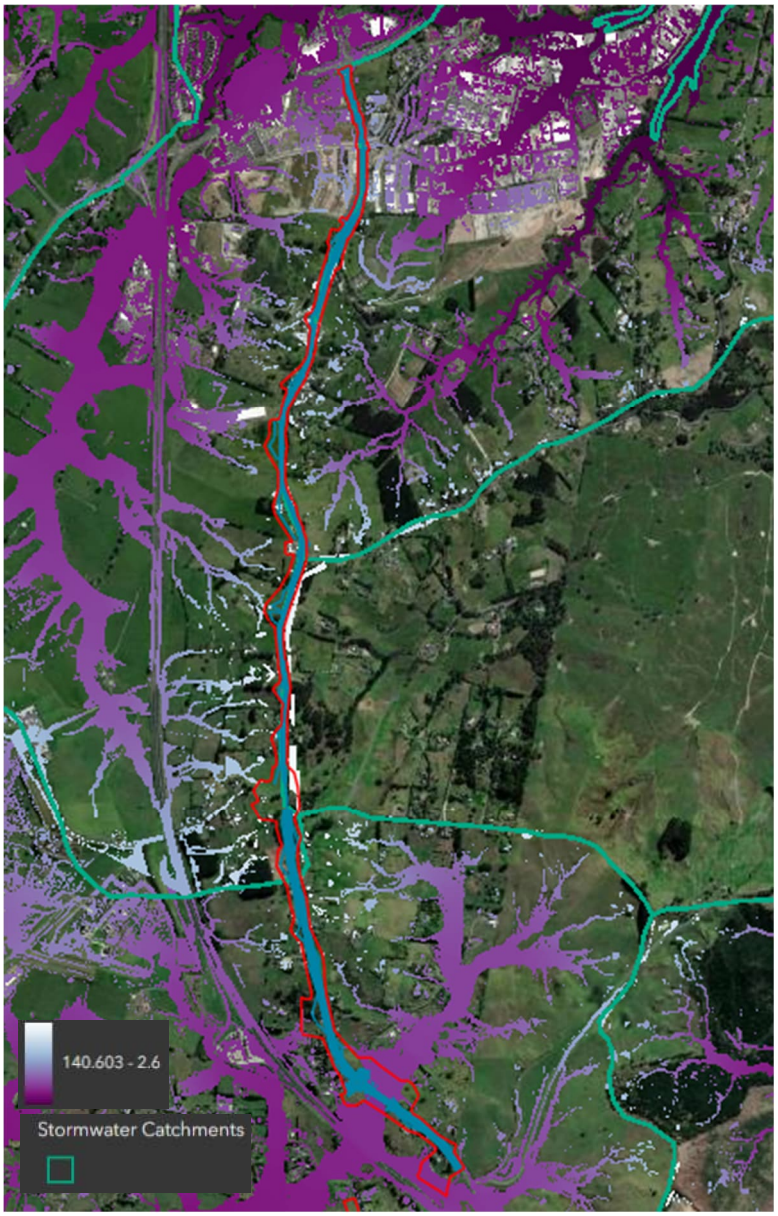


Figure 18-1: NOR13 East Coast Rd upgrade 1% AEP base case flood extents

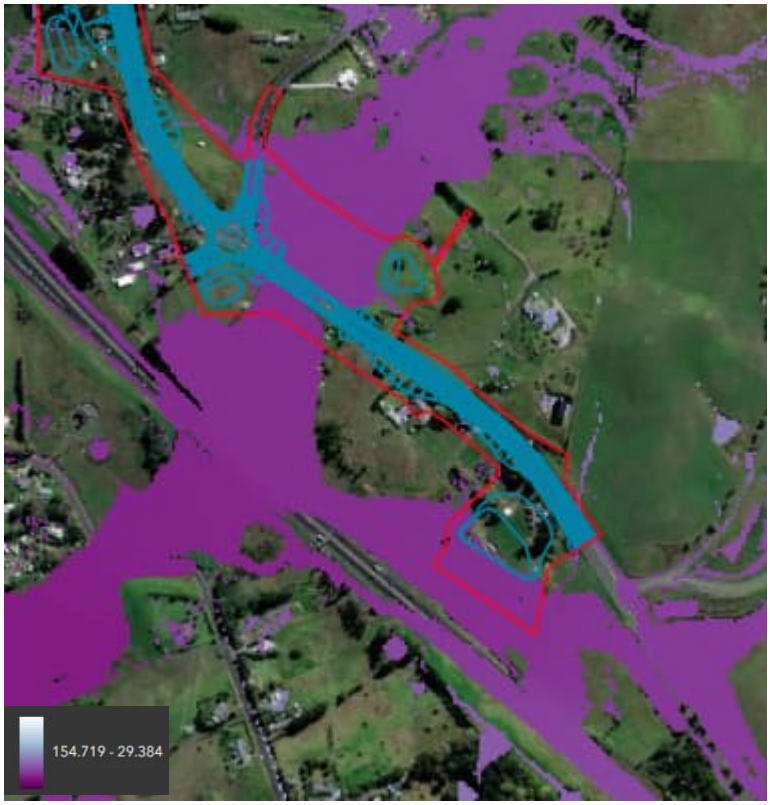


Figure 18-2: NOR13 East Coast Rd upgrade 1% AEP base case flood extents by SH1

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

18.2 Positive Flooding and stormwater effects

The positive flooding effect relates to the new widened road formation being constructed above the predicted flood plain.

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

18.3 Assessment of construction effects

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

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

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

18.4 Recommended measures to avoid, remedy or mitigate construction effects

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

18.5 Assessment of operational effects

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

- bridge crossings over the Huruhuru Stream which need to be sized to optimise upstream and downstream water levels to achieve NOR conditions in the later design and modelling stage. This potential effect is considered to be low risk as there is sufficient room available within the designation to design a solution to achieve the flooding conditions.
- The new road formation would reduce flood storage volume, which relates to the need for bridge opening optimisation.

18.6 Recommended measures to avoid, remedy or mitigate operational effects

The operational measures proposed in Section 5.6 apply to this NOR with the main one being later detailed modelling and design to assess and minimise the impacts of flood levels / extent / depth due to the bridge widening and flood storage volume loss. Optimising the bridge waterway to achieve the conditions will be the objective at that stage.

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

18.7 Summary and Conclusions

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

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

19 Conclusions

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

Flooding is a natural hazard and has therefore been considered as part of the North NORs to assess if the Te Tupu Ngātahi proposals will impact that flooding (using the models that were recently updated by Te Tupu Ngātahi to understand the existing flood risks).

The four (4) Te Tupu Ngātahi base case (pre-Projects) catchment models were sent to AC Healthy Waters (AC HW) for review in Sept 2020 and the AC HW review responses were addressed by either updating the models or providing commentary on our approach.

The flood extent results have been compared to those published on the AC Geomaps site, particularly the latest 2023 version, and the results are comparable as the modelling approaches both follow the AC Healthy Waters rapid flood hazard approach.

The proposed NORs have not yet been modelled to assess the impacts of the post- development scenario as this is proposed to occur during later design and modelling stages.

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

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

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

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

Assessment undertaken

The assessment of flooding effects has involved the following steps:

- Desktop assessment to identify potential flooding locations
- Modelling of the pre-development terrain scenario without the North Projects
- Producing flood maps for the pre-development scenario to show the flood levels and extents (greater than 50mm deep) that need to be considered
- Inspection and review of flood maps at key locations such as proposed bridges, culverts, wetlands and major earthworks.
- Modelling of the concept design for areas that are identified as having the greatest flood hazard risk i.e. the predicted overtopping of Dairy Flat Highway (NoR 8) to the west of the

existing Bawden Road intersection and both sides of the Green Road intersection, along with the realigned Bawden Road and bridge (NoR 12) were considered sufficient to warrant modelling of the post Project case.

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

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

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

The assessment focuses on flooding effects as this is a district plan matter under the AUP:OP that requires assessment for the purposes of an NOR.

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

Results of assessment and recommended measures

The main positive effects associated with the North Project NOR are:

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

Construction effects

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

The management and mitigation measures for construction effects are:

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

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

- Operational effects

The potential operational effects are:

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

Mitigation measures which may be implemented include:

- Detailed flood modelling of the detailed final corridor design during the later design stage to meet NOR condition requirements and optimise bridges, culverts and wetlands will be needed to assess cumulative effects of upstream NOR on downstream NOR
- Designing culvert sizes so that the upstream and downstream water level differences achieve the NOR flooding conditions. culverts will be designed for the 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 Practice (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 new flood prone areas
- Installing drains at the toe of the embankment sloping towards the culverts can also provide additional storage to decrease the velocity and peak flow through the culvert crossings
- Installing drains at the top of cuttings to reduce water entering the cutting and thus need conveying through the cutting. This can also be improved using benches in deep cuttings to further reduce the flow entering the cutting base drain
- Providing space for wetlands for treatment and attenuation as needed.

A Flood Hazard condition is proposed which will require the future detailed design of the transport corridors to be designed to achieve specific flood risk outcomes. The condition includes flood modelling of the pre-Project and post-Project 1% AEP flood levels (for Maximum Probable Development land use and including climate change). The following table indicates the significant flooding issues that are predicted in each NOR along with recommendations to reduce the risk. 1% AEP including climate change allowance of 2.1° temperature increase. Note in the table below: Y = Yes, it is applicable to that particular NOR and N = No, it is not applicable to that particular NOR.

Effect category	Potential flooding effects	Recommendations	Relevant to which NORs											
			1	2	3	4	5	6	7	8	9	10	11	12	13
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.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Laydown and construction areas can block flow paths and create upstream flooding if not managed	Increased risk of construction site and upstream flooding	Laydown and construction areas outside of predicted flood plains. Construction methodology needs to be developed and followed to reduce the risk of construction related flooding. Also ties in with construction contingency planning for larger events with rainfall monitoring as part of the plan.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
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.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Very large upstream catchments (>200Ha) can create large flows (>40m^3/s). New bridges and piers must be built over existing river and will therefore be exposed to the flood risk	Large flows passing through the bridge construction site could cause scour and temporary works to be washed away or could be obstructed by temporary works and cause upstream flooding. Major diversions are not feasible. Works	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.	Y	N	N	Y	Y	Y	N	Y	N	Y	N	Y	N

Effect category	Potential flooding effects	Recommendations	Relevant to which NORs											
	require controls to reduce the risk.													
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 optimised	Detailed modelling and detailed design phase to assess best option to meet Flood Hazard condition requirements for upstream and downstream water levels.	Y	N	N	Y	Y	Y	Y	Y	N	Y	N	X	N
Raising existing roads above the predicted 1% AEP 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 and design to achieve flood hazard conditions.	Y	N	N	N	N	N	Y	Y	N	Y	N	N	N
Wetlands for treatment only will reduce footprint needs	Downstream wetlands could be water quality only (GD01) as opposed to treatment and attenuation	Detailed modelling to show attenuation not needed during later design stages.	N	Y	Y	Y	Y	Y	Y	N	N	Y	N	N	N
Bridge and culverts over existing stream could create upstream and downstream flood water level increase	Bridge opening and culvert size needs to be optimised to meet conditions	Detailed modelling of the bridge, culvert and associated formation design during later design stages to meet conditions	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

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

The positive flooding effects are primarily associated with raising existing roads out of the flood plain that are currently predicted to flood in the future 1% AEP events plus treatment of existing roads that are widened.

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

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

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

20 References

Auckland Council GD01

Auckland Council Geomaps

Auckland Council Healthy Waters Rapid Flood Hazard Approach modelling

Auckland Council Healthy Waters Modelling memo dated Sept 2019

Auckland Council Code of Practice

Te Tupu Ngātahi North base case modelling

Te Tupu Ngātahi Rev B drawings

Te Tupu Ngātahi North Specialist Briefing Pack

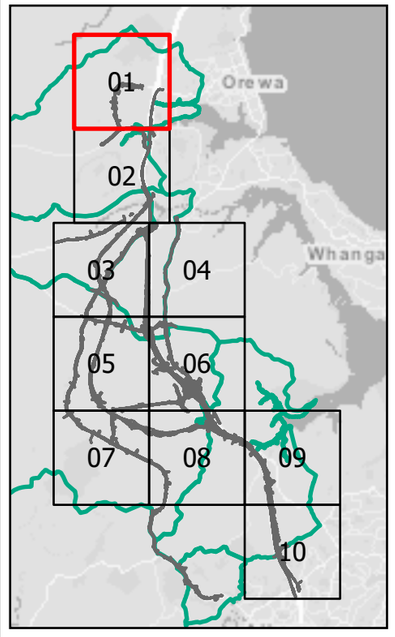
1 Appendix 1 Water level comparisons for the pre-Project 1% AEP rainfall with the 2.1 and 3.8° climate change scenarios.

ID	100yr 2.1CC Water Level	100yr 3.8CC Water Level
75	15.20	15.24
76	15.15	15.20
77	14.32	14.39
78	12.27	13.00
79	10.92	11.73
80	19.46	19.90
81	19.07	19.48
82	22.98	23.03
83	25.25	25.46
85	7.69	7.74

Supporting Growth
SGA North pre Project
(base case) future
100yr predicted water levels

Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery

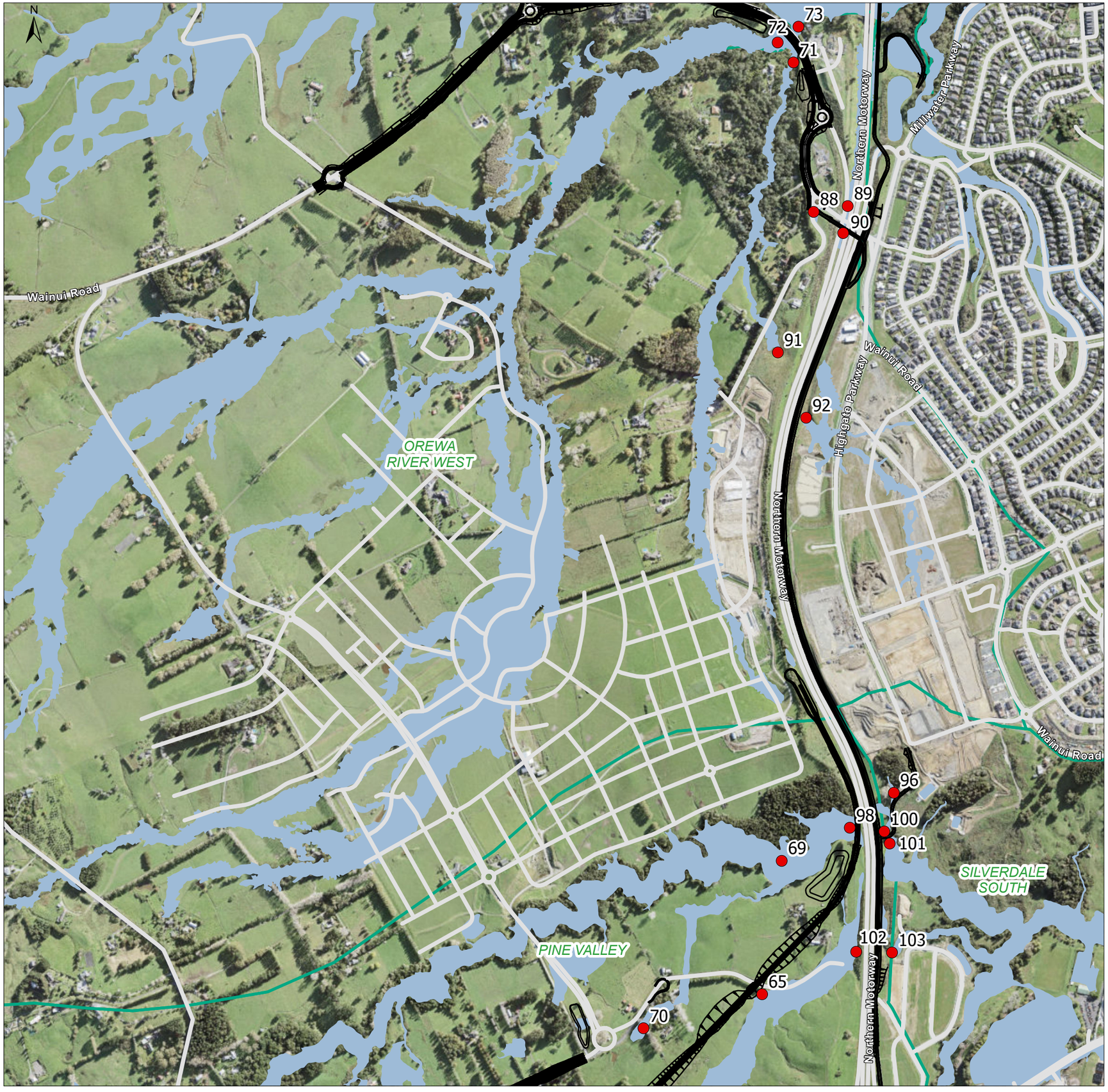


Map Scale @ A3:1:10,000

Project:	Drawing No:
Flood Hazard Mapping - North	**SGA-FL-N-001**

TE TUPU NGĀTAHI SUPPORTING GROWTH
WAKA KOTAHI NZ TRANSPORT AGENCY

Path: C:\Users\bryantm\Documents\ArcGIS\Projects\60558831_SGA\SGA_FHM_North\SGA_FHM_North.aprx Name: SGA_FHM_North

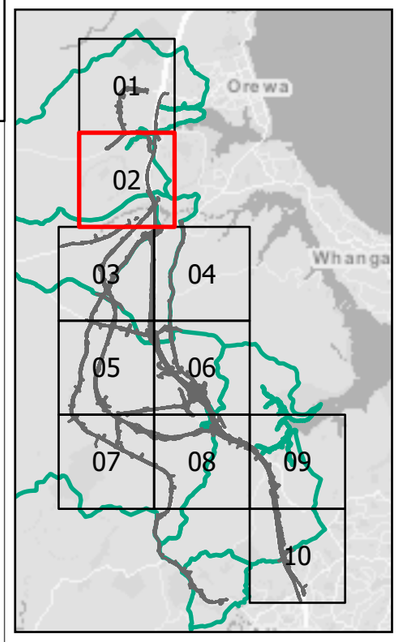


ID	100yr 2.1CC Water Level	100yr 3.8CC Water Level
65	15.13	15.24
69	14.21	15.75
70	24.65	24.68
71	5.71	6.31
72	5.71	6.30
73	5.50	6.16
88	20.59	20.60
89	16.26	16.31
90	18.12	18.16
91	17.75	17.80
92	22.32	23.47
96	17.06	17.12
98	14.11	15.70
100	9.87	9.97
101	9.47	9.80
102	14.23	15.20
103	9.92	10.02

Supporting Growth
SGA North pre Project
(base case) future
100yr predicted water levels

Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery



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Project:	Drawing No:
Flood Hazard Mapping - North	**SGA-FL-N-002**

TE TUPU NGĀTAHI SUPPORTING GROWTH
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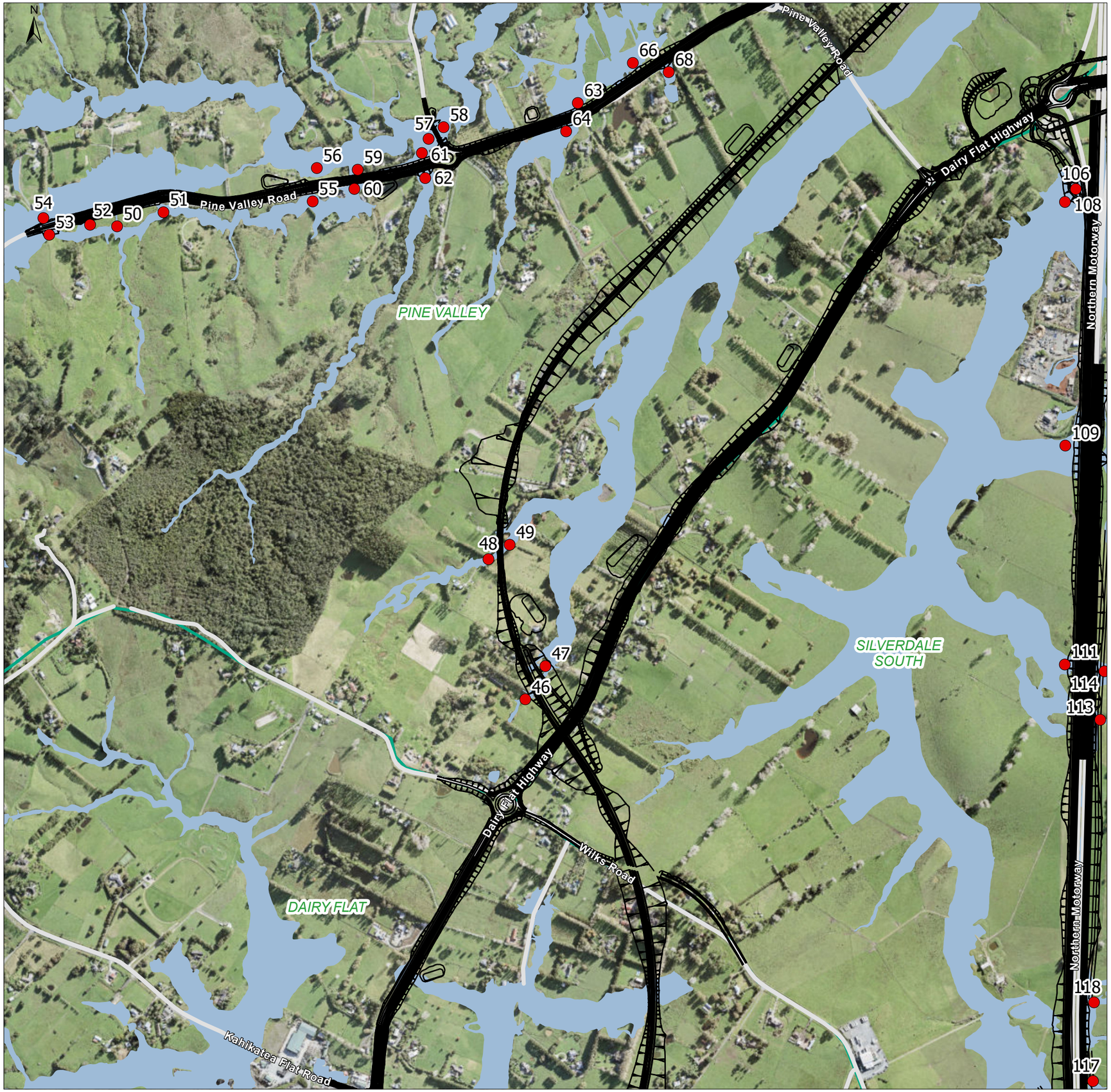

ID	100yr 2.1CC Water Level	100yr 3.8CC Water Level
46	53.24	53.30
47	48.69	48.73
48	45.06	45.14
49	42.94	43.02
50	30.93	31.11
51	29.45	29.75
52	32.21	32.29
53	32.76	32.92
54	33.24	33.29
55	27.27	27.44
56	25.30	25.77
57	24.66	24.94
58	23.41	23.99
59	25.19	25.64
60	27.23	27.36
61	24.78	25.10
62	26.17	26.30
63	24.54	24.64
64	25.32	25.39
66	24.17	24.22
68	27.39	27.43
106	17.65	18.34
108	17.69	18.38
109	19.97	20.11
111	27.51	27.53
113	33.93	34.22
114	31.41	32.05
117	45.29	45.49
118	43.37	43.63

Supporting Growth
SGA North pre Project
(base case) future
100yr predicted water levels

Legend

- Pre Project flood level location
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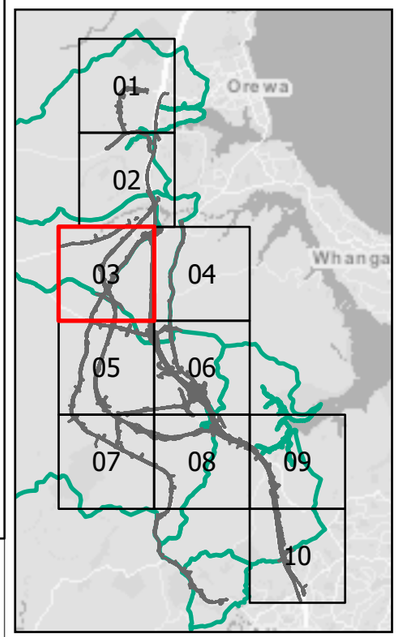
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery



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Project:	Drawing No:
Flood Hazard Mapping - North	SGA-FL-N-003

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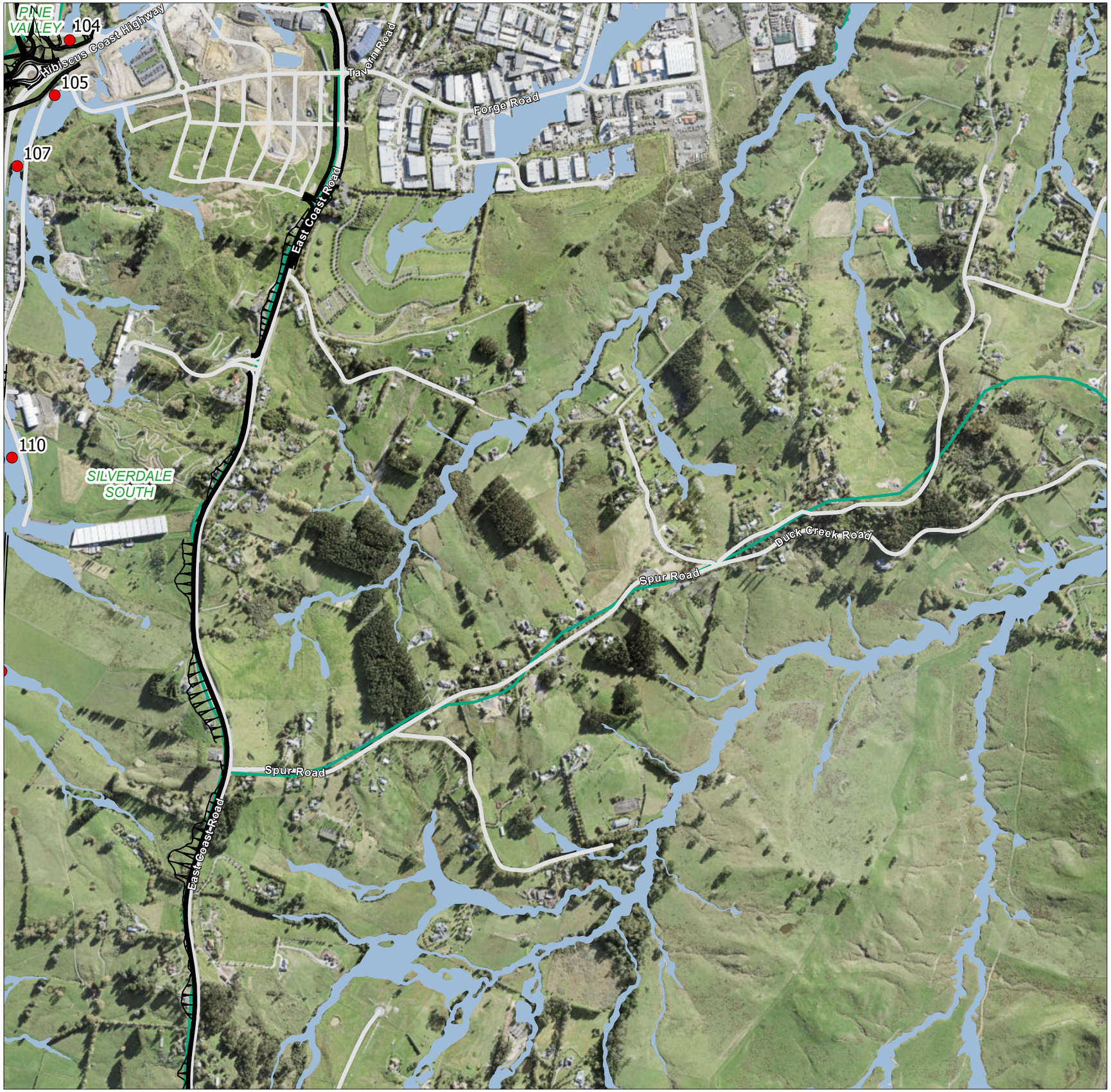

ID	100yr 2.1CC Water Level	100yr 3.8CC Water Level
104	10.08	10.37
105	14.32	15.56
107	14.72	15.68
110	22.75	23.36
114	31.41	32.05

Supporting Growth
SGA North pre Project
(base case) future
100yr predicted water levels

Legend

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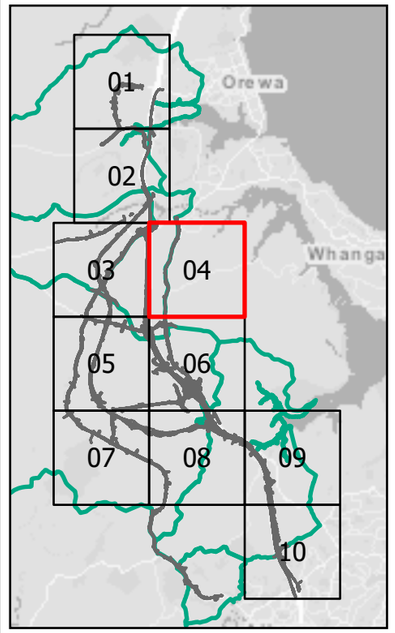
- New Zealand Imagery



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Project:	Drawing No:
Flood Hazard Mapping - North	**SGA-FL-N-004**

TE TUPU NGĀTAHI SUPPORTING GROWTH
WAKA KOTAHI NZ TRANSPORT AGENCY

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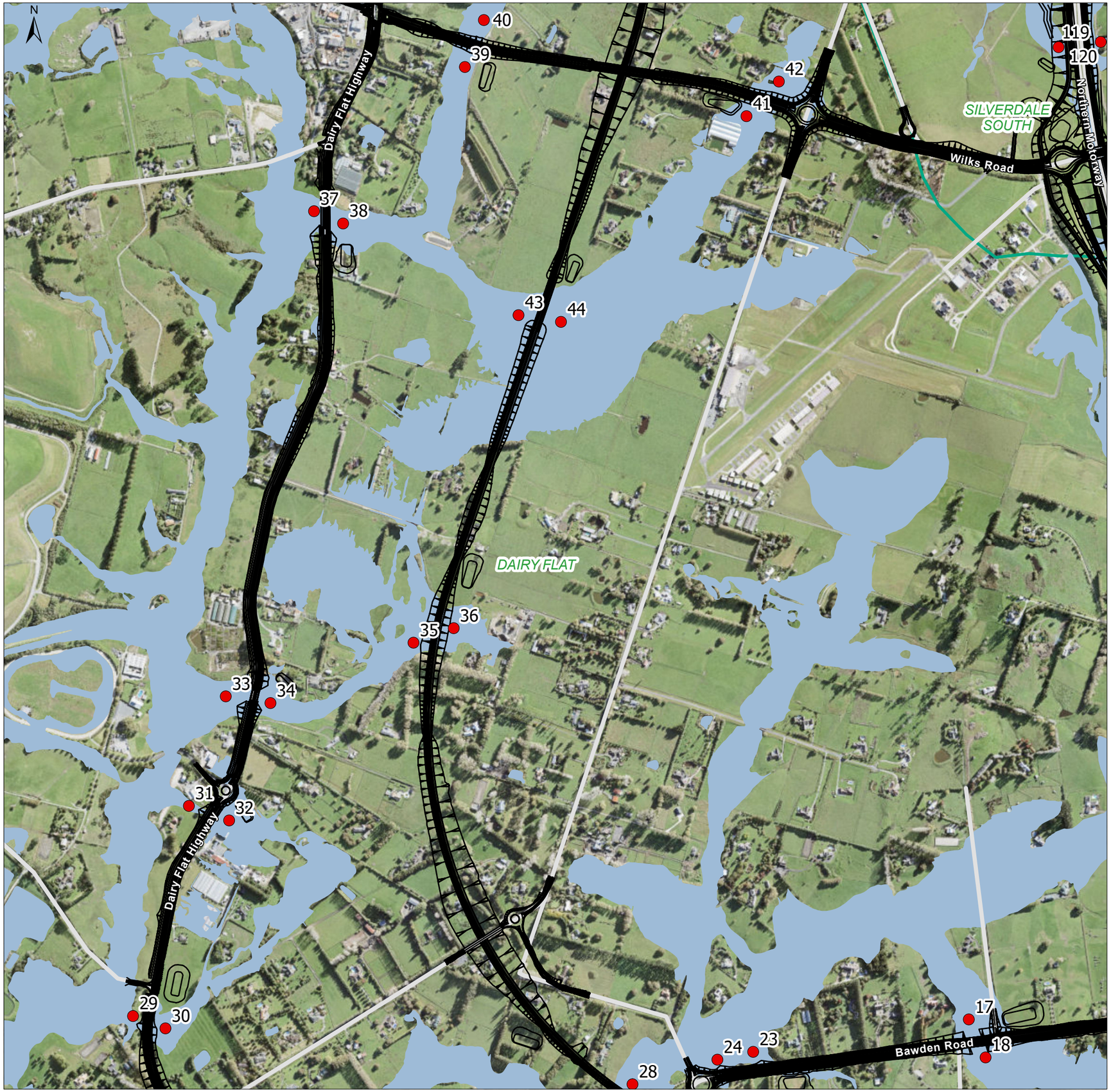

ID	100yr 2.1CC Water Level	100yr 3.8CC Water Level
17	39.26	39.42
18	39.87	39.96
23	36.94	37.24
24	36.91	37.19
28	35.94	36.37
29	44.40	44.69
30	46.28	46.45
31	46.73	47.11
32	49.49	49.60
33	47.98	48.54
34	48.25	48.56
35	49.89	49.99
36	50.30	50.38
37	52.00	52.45
38	53.29	53.39
39	53.68	53.84
40	54.32	54.42
41	58.25	58.33
42	58.83	58.88
43	53.96	54.08
44	53.99	54.12
119	41.07	41.11
120	47.20	47.25

Supporting Growth
SGA North pre Project
(base case) future
100yr predicted water levels

Legend

- Pre Project flood level location
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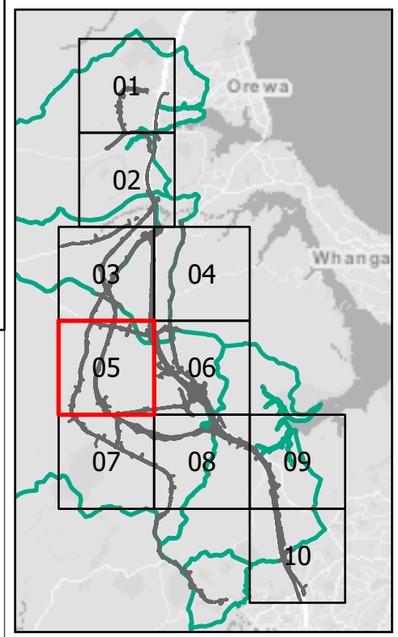
- Stormwater Catchments
- New Zealand Imagery



Map Scale @ A3:1:10,000

Project:	Drawing No:
Flood Hazard Mapping - North	SGA-FL-N-005

TE TUPU NGĀTAHI SUPPORTING GROWTH
WAKA KOTAHI NZ TRANSPORT AGENCY

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