To

Auckland Council
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From

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W-REF: P16-335
25 March 2020

Response to Auckland Council Further Information Request on Stormwater Matters for Drury East

This memo has been written to summarise the additional stormwater assessments undertaken in response to the Further Information Request (FIR) from Auckland Council for the Drury East Plan Change requests.

The structure of the memo is as follows:

- Stormwater management
- Hydrological mitigation
- Flood management

How the response relates to the Auckland Council FIR table is summarised in Appendix A.

1. Stormwater management

A matrix of stormwater management outcomes and tools for different land use zones is presented in Table 1 to demonstrate that an integrated stormwater management approach will be implemented across all three Plan Change Areas (Kiwi Property, Fulton Hogan and Oyster Property). The matrix is compiled from the current Stormwater Management Plans (SMP) for each Plan Change and will form part of the updated SMP. It shows alignment of stormwater quality, hydrological mitigation and flood attenuation approaches across the three Plan Change Areas. An ecological assessment will be provided to address potential impacts on the Significant Ecological Area.

In addition, a broad range of Best Practicable Options (BPOs) for mitigating effects and/or achieving these outcomes are listed for the corresponding land-use. This toolbox will be used to develop each development's stormwater management approach, though different devices and/or combinations may be adopted across the three Plan Change Areas to achieve the outcomes.

Feedback from Auckland Council at our update meeting of 19 February 2020 was that the performance standards should be as consistent as possible across the three Plan Change Areas, and the stormwater management toolbox as broad as possible to have flexibility of implementation.

Table 1: Stormwater Management Toolbox

Zone	Land Use	Performance Outcomes				Best Practicable Options	Notes
		Water Quality	**Hydrological Mitigation**	**Flood Attenuation**	**Water Sensitivity Design [1]**		[1] The proposed stormwater management options adopt a Blue Green Corridor approach that includes other devices or measures which are not listed in this table i.e. filter strips, green outfalls (where practicable), streams protected and enhanced with riparian buffer and re-vegetation planting. The need for bank stabilisation/instream works to be determined by stream erosion assessments.
Performance standard		GD01[2]	AUP:OP SMAF 1[3]	1% AEP: $Q_{pre} = Q_{post}$[4]			[2] Stormwater Management Devices in the Auckland Region –Guideline Document 20017/001 (GD01). (December 2017). Auckland Council
Mixed use Metropolitan Centre	Roads	✓	✓	X	✓	**Bio-retention devices including:** • Raingardens • Tree pits • Vegetated swales	[3] Auckland Unitary Plan –Operative in Part (AUP:OP). Auckland Council
	Non Roads	✓	✓	X	✓	Inert Building materials Rainwater tanks for re-use of roof runoff Permeable pavements for public realm areas Communal detention devices **Bio-retention devices including:** • Raingardens • Tree pits • Vegetated swales	The Plan Change Area does not fall within a Stormwater Management Area - Flow 1 (SMAF 1) overlay but this will be adopted as the minimum requirement across all three sites. This stormwater management approach is consistent with Policy E1.3.10. The minimum hydrological mitigation requirements proposed are as follows: • Retention (volume reduction) of at least 5mm of runoff depth from impervious surfaces • Detention of the 95th percentile event for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24 hour rainfall event minus the achieved retention volume. Exceptions for providing retention can be made in cases where soil infiltration rates preclude disposal to ground and rainwater reuse is not possible. It is noted that if retention cannot be met, devices are to be lined with the retention volume being treated as a detention through bioretention devices. An erosion assessment is to be carried out to determine if additional measures (such as additional detention requirements) are required to mitigate the hydrological impacts of development.
Mixed Housing – Urban Mixed Housing – Suburban Terraced Housing Apartment Buildings	Roads	✓	✓	X✓[6,7]	✓	Communal devices[5] Offline Wetlands/Dry Basins[5] **Bio-retention devices including:** • Raingardens[4] • Tree pits • Vegetated swales	[4] Post-development peak flows to match pre-development peak flows for the 1 % Annual Exceedance Event (AEP).
	Carparks > 30 Vehicles	✓[5]	✓	X✓[6,7]	✓	Inert Building materials Rainwater tanks for re-use of roof runoff Permeable pavements for driveways or laneways Communal devices[5]	[5] Devices will be provided and sized for WQ treatment for carparks (greater than 30 vehicles) only for the Residential Zones.
	Roofs, JOALS, driveways, gardens/landscaping	X✓[8]	✓	✓	✓	**Bio-retention devices including:** • Communal detention devices • Living Roofs • Raingardens • Vegetated swales	[6] Includes the option for large communal devices to provide treatment and hydrology mitigation to public roads and impervious areas. Gross Pollutant Traps (GPT) or alternative proprietary devices will be installed upstream of communal devices. The communal devices may be dual-purpose as they could also provide flood attenuation, if required. [7] Flood attenuation for Oyster Southern Zone. [8] Hydrology mitigation will be provided for these impervious areas; the use of devices such as bio-retention for mitigation will also provide WQ treatment.

2. Hydrological Mitigation

2.1 Stormwater management

Hydrological mitigation controls should be applied within the Plan Change Area as it is located upstream of a Stormwater Management Area control - Flow 1 (SMAF 1) and is a greenfield development where Policy E1.3.8 requires "*…minimising or mitigating changes in hydrology…*" and effects on rivers and streams.

The proposed Drury East (three Plan Change Areas) approach to hydrological mitigation and addressing stream erosion risk is to provide a minimum of SMAF 1 hydrological mitigation (detention and retention) for all impervious surfaces . The minimum hydrological mitigation requirements proposed are as follows:

- Retention (volume reduction) of at least 5mm of runoff depth from impervious surfaces where possible (refer Table E10.6.3.1.1)
- Detention of the 95th percentile event for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24 hour rainfall event minus the achieved retention volume.

A stream erosion assessment (refer Section 2.2) is to be carried out to identify high risk areas and determine if additional measures (such as additional detention requirements) are required to mitigate the hydrological impacts of development.

Exceptions for providing retention can be made in cases where soil infiltration rates preclude disposal to ground and rainwater reuse is not possible. It is noted that if retention cannot be met, devices are to be lined with the retention volume being treated as a detention through bioretention devices.

For roads and car-parks within the Plan Change Area, hydrological mitigation can be achieved through vegetated bio-retention devices such as raingardens, tree pits and swales. These devices generally provide multiple functions: retention/detention, visual amenity and water quality treatment close to the source.

For residential lots within the Plan Change Area, hydrological mitigation of roof runoff may be achieved through rainwater tanks. Rainwater tanks promote the recycling and re-use of rainwater, while mitigating stormwater runoff at source. Stormwater runoff from other impervious surfaces within residential lots could be managed within permeable pavements on private or shared driveways. If this is not practicable, communal underground detention tanks could be utilised to minimise the land take required whilst achieving the required detention volume.

Within the Metropolitan Centre, rainwater tanks, communal detention devices and/or permeable pavements could be used to achieve hydrological mitigation. Rainwater tanks will only be utilised where there is sufficient demand for water reuse. Where practicable, raingardens can also be used to achieve hydrological mitigation alongside water quality mitigation e.g. for roads and carparks and surrounding public spaces where practicable.

2.2 Stream erosion

The extend and effects of stream erosion on the streams and Drury Creek are described in the Drury East Plan Change – Ecology Response (19 March).

All stream tributaries within the Plan Change Area are highly eroded and degraded. This is attributed to a combination of poor bank stability, unrestricted stock access leading to ongoing agricultural related nutrient inputs, instream channel disturbance, minimal stream channel shading and bare or sparsely vegetated riparian vegetation within the catchment.

Drury East Plan Change – Ecology Response (19 March) has identified the follow mitigation measures as being those which will aid in the management of erosion and sedimentation in the Plan Change aArea:

- Removal of stock from the site and therefore avoiding active bank de-stabilisation through stock access and pugging.

- Incorporation of green spaces adjacent to stream networks to provide for planting of riparian margins to improve bank stability and reduce erosion potential.
- Modification of hydrograph mitigated through stormwater retention/detention (SMAF 1 hydrological mitigation) measures which will slow flows.
- Remediation or removal of existing in-stream structures (culverts, inlets/outlets) which are currently identified as having erosion issues.
- Realignment of streams which have been channelised to a more natural alignment.
- Incorporation of erosion and scour protection measures at all outfalls to minimise erosion at new structures.
- Targeted in-stream erosion protection measures may be required within the Hingaia Stream and other larger streams.

While the effectiveness of these measures cannot be quantified at this stage, these are still considered to provide some benefit to erosion and sediment generation from stream channels affected by the change in hydrology within the Plan Change Area.

This proposed approach to addressing stream erosion risk recognises that there are several mitigating factors including the fact that Plan Change Area is proportionally a very small part of the overall Hingaia Catchment and is towards the bottom of the catchment so instream works are likely to be the best way to address locally derived erosion risk. Also, that the proposed urban land use has typically a lower sediment load than for rural land.

2.3 Stream erosion risk assessment

The Auckland Council Stream Erosion Risk Tool was investigated as a mechanism to analyse stream erosion resulting from the development. We have encountered issues with the simplistic tool, that means this assessment cannot be completed within the timeframes of the FIR response.

The issues and our next steps are summarised below:

#	Issue	Next step
1	TP108 hydrology is too coarse for a large catchment such as the Hingaia where a refined hydraulic model is available	Use hydrographs from the flood model. Rebuild Stream Erosion Risk Tool to allow this.
2	Hydraulic shear stress is very sensitive to Slope (S) and thalweg/bed levels are too variable and result in non-sensible results	Use bed shear stress calculated by the hydraulic model at all locations and at all time steps. Rebuild the Stream Erosion Risk Tool to allow for these inputs.
3	Simplification of channel cross-sections to a trapezoid is too coarse	
4	Critical shear stress cannot be determined from the geotechnical testing already done for the site.	Estimate this from Auckland Council databases in the Stream Erosion Risk Tool.
5	Quantification of change in exceedance of critical shear stress will only indicate a change in erosion potential. It will not quantify how much extra erosion and what the change in sediment load will be to the receiving environment, so it cannot be used to assess effects.	Auckland Council to advise how they see this working. The tool will identify areas with increased erosion risk and where extra mitigation measures should be applied.

The technology and understanding in this area are evolving but is not ready yet. We will work with Council to complete this assessment for the hearing stage of the Plan Change.

3. Flood Management

Additional flood modelling was undertaken to assess the potential flooding mechanisms and effects caused by a "development only flood' scenario. This scenario assumes extreme rainfall (2, 10, 100 year ARI rainfall) in the lower catchment only (over existing Drury and Plan Change Areas). A proposed flood modelling methodology was outlined in the memo *Drury East (Kiwi and Fulton Hogan) flood modelling – response to Auckland Council Modelling requests* prepared by Tonkin + Taylor to Auckland Council on 10 and 19 February 2020, and accepted as a part of the lodgement of Plan Changes for Drury East by Fulton Hogan and Kiwi Property in the FIR from Auckland Council.

The proposed steps outlined in the memo were:

1 *For 10-year and 100-year ARI model runs (pre-development and post development) map the buildings with floors at risk from flooding. This is the "full catchment flood scenario". Shape file with building extents and floor levels to be supplied by Auckland Council. Use T+T/Woods current models as they are (model version, Drury South included and impervious assumptions).*

2 *Simulate the potential flooding caused by development of the lower catchment. This is the "development only flood scenario". Reconfigure the post development models to:*
   - *apply 10-year and 100-year ARI rainfall to the lower catchment including existing Drury Township and the developed Future Urban areas inclusive of developments (e.g. MPD in the FU areas)*
   - *Allow for nominal "fresh" flow of 50 m3/s from the upper catchment*
   - *Map the buildings that flood*

3 *Compare the flood extents and buildings that flood for full catchment flood scenario (pre and post) to development only flood scenario*

4 *Assess the impacts on existing Drury due to the developments from both the flood for full catchment flood scenario and development only flood scenario*

3.1 Model build and updates

These model scenarios were based on the Drury South Precinct Plan Change model that has been reviewed and signed off by Auckland Council as a part of the Drury South Precinct Plan Change application. Previous changes to the model have been documented in the D*rury Town Centre - Kiwi Property - Model Build* Memo prepared by Tonkin +Taylor to Auckland Council on 17 June 2019, and includes changes to the Hingaia Stream catchment model representing the pre- and post-development catchment scenarios supplied by Fulton Hogan and Kiwi Property for the Drury East Plan Change applications.

Any additional changes to the models are captured in Tables 2 and 3 below, which outline the catchment and development only model matrices agreed with Auckland Council as a part of this request. Associated supporting information will be supplied to Auckland Council for review of the flood model build/changes.

3.1.1 Post Development Model Structures

A plan showing the structures that have been "opened" or modified is available in Appendix B; a summary of this is as follows:

- Great South Road Culvert, Railway Culvert, Flanagan Road Culvert –Supplemented with 2mx2.5m box culvert
- Off Flanagan Rd (Private Bridge) - Opened
- Fitzgerald Culvert - Opened
- Field Road Culvert - Opened
- Cossey Road Culvert - Opened
- Fitzgerald Road Culvert (off – Fielding Road) - Opened
- Fitzgerald Road Culvert (off – Cossey Road) - Opene

Table 2: Model matrix – Catchment Models

Scenario	Baseline Model (and key assumptions)	Great South Road tributary culvert status	Land use outside Fulton Hogan and Kiwi Property Plan Change Area	Land use within Fulton Hogan and Kiwi Property Plan Change Area	Model ID	Event	Climate Change	Model Changes
Pre-Development Model	Drury South Precinct Plan Change model *(post development impervious and landforms)*	Existing Culverts	10% Imperviousness within FUZ; Drury South - Post Development; Upstream rural zonings at 10% imperviousness	10% Imperviousness within FUZ (including PCA)	01	2yr	Yes	- Hydrology updated to use 2yr Future Rainfall using Model 02 - No other changes
					02	10yr		- Model developed as a part of preparing Stormwater Management Plan for Drury East Plan Change Area for Fulton Hogan and Kiwi Properties
					03	100yr		- Model developed as a part of preparing Stormwater Management Plan for Drury East Plan Change Area for Fulton Hogan and Kiwi Properties
Post-Development Model	Drury South Precinct Plan Change model *(post development impervious and landforms)*	Culverts open with post development landforms within Plan Change areas (these culverts will be designed for 100yr conveyance capacity based on pass flows forward approach)	10% Imperviousness within FUZ; Drury South - Post Development; Upstream rural zonings at 10% imperviousness	Imperviousness for Metropolitan Centre = 100% Imperviousness for Kiwi Property land = 70% Imperviousness for Fulton Hogan land = 65% Future Urban Zone outside of Plan Change Area = 60%	04	2yr	yes	- Hydrology updated to use 2yr Future Rainfall using Model 05 - No other changes
					05	10yr		- Model developed as a part of preparing Stormwater Management Plan for Drury East Plan Change Area for Fulton Hogan and Kiwi Properties
					06	100yr		- Model developed as a part of preparing Stormwater Management Plan for Drury East Plan Change Area for Fulton Hogan and Kiwi Properties
					07	2yr	No	- Hydrology updated to use 2yr Existing Rainfall using Model 01 - No other changes

Table 3: Model matrix – Development Only Models

Scenario	Model ID	Event	Climate Change	Model Changes

Pre-Development Model	08	10yr	Yes	- Mike 11 network model updated using Model 02
				- Hingaia Stream river branch was disconnected at chainage 14723 to a dummy outlet
				  o Dummy outlet was modelled with dummy river branch and wide cross sections
				  o Channel bed of dummy branch was set equal to the channel bed on Hingaia Stream branch at chainage 14723
				  o Q-h relationship was set as a boundary condition to discharge unrestricted flows out of the system
				- Hingaia Stream river branch was modelled with inflows of $30m^3/s$ and $50m^3/s$ are applied for 10yr and 100yr scenarios respectively along Hingaia Stream at upstream chainage of 14724
				- No other changes

	09	100yr		

Post-Development Model	10	10yr	Yes	- Mike 11 network model updated using Model 05
				- Hingaia Stream river branch was disconnected at chainage 14723 to a dummy outlet
				  o Dummy outlet was modelled with dummy river branch and wide cross sections
				  o Channel bed of dummy branch was set equal to the channel bed on Hingaia Stream branch at chainage 14723
				  o Q-h relationship was set as a boundary condition to discharge unrestricted flows out of the system
				- Hingaia Stream river branch was modelled with inflows of $30m^3/s$ and $50m^3/s$ are applied for 10yr and 100yr scenarios respectively along Hingaia Stream at upstream chainage of 14724
				- No other changes

	11	100yr		

3.2 Results analysis

Model results were analysed for flood extents, peak water levels and flood depths for all building footprints for each scenario to understand the flood risk for the pre and post development scenarios. Analysis was limited to the building footprints within Drury Township (excludes existing building footprints within the Plan Change Areas) and covers the area encompassed by –

- Southern Motorway bridge to the north
- Southern Motorway to the west
- Great South Road to the east
- Flanagan Road to the south.

This is shown as 'Area of interest' on the flood maps provided in Appendix B.

The intention of this assessment was to understand if there is any increase in flood risk to properties downstream of the Plan Change Areas with the increases in flows associated with higher imperviousness within these developments. This area of analysis is shown in figures (provided in Appendix B) and all flood results outside this extent as less reliable with the model setup.

3.3 Building Flood Risk

The approach identified for understanding Flood Risk for buildings was as below –

- Peak modelled Flood levels were extracted for buildings footprints where floor levels were available
- Peak Flood Depths were extracted for buildings footprints where floor levels were not available and habitable floor level was assumed to be 150mm above the respective ground levels
- Flood maps were generated for all scenarios (provided in Appendix B) to understand the differences.

A total of 81 buildings footprints within the 'Area of interest' were analysed based on the above approach and tabulated in Table 4 below.

The 'Development only' models were run for the 10yr and 100yr scenarios and Catchment models were run for the 2yr scenario with and without climate change.

The 2yr model Catchment model results were analysed in addition to agreed scenarios to understand if there are any adverse flood risks with the proposed development for smaller rainfall events.

The analysis shows that the total number of properties flooded are unchanged, for the 'Development only' as well as Catchment models for the scenarios analysed. This confirms there is no additional flood risk to habitable floor or properties with the proposed development in place.

Table 4: Building footprints at Flood Risk

Scenario	Flood Risk	Development only Model		Catchment Model	
	Building Flooding	Pre - Development Model	Post - Development Model	Pre - Development Model	Post - Development Model
2yr without Climate Change	Above Floor Level	n/a	n/a	-	-
	Below Floor Level	n/a	n/a	1	1
	Flood Depth > 0.15m	n/a	n/a	-	-
	Flood Depth < 0.15m	n/a	n/a	1	1
	Total Flooded properties	**n/a**	**n/a**	2	**2**
2yr with Climate Change	Above Floor Level	n/a	n/a	-	-
	Below Floor Level	n/a	n/a	1	1
	Flood Depth > 0.15m	n/a	n/a	-	-
	Flood Depth < 0.15m	n/a	n/a	1	1
	Total Flooded properties	**n/a**	**n/a**	**2**	**2**
10yr with Climate Change	Above Floor Level	-	-	n/a	n/a
	Below Floor Level	4	4	n/a	n/a
	Flood Depth > 0.15m	1	1	n/a	n/a
	Flood Depth < 0.15m	1	1	n/a	n/a
	Total Flooded properties	**6**	**6**	**n/a**	**n/a**
100yr with Climate Change	Above Floor Level[1]	2	1	n/a	n/a
	Below Floor Level[1]	10	12	n/a	n/a
	Flood Depth > 0.15m[2]	5	4	n/a	n/a
	Flood Depth < 0.15m[2]	1	1	n/a	n/a
	Total Flooded properties	**18**	**18**	**n/a**	**n/a**

1 Above Floor level: Model water level > Building Floor Levels (provided by Auckland Council
Below Floor level: Model water level < Building Floor Levels (provided by Auckland Council)
2 Flood Depth > 0.15m: Model flood depth > 0.15m at building where floor level is not available
Flood Depth < 0.15m: Model flood depth < 0.15m at building where floor level is not available.

The number of buildings attributed for 100yr with Climate Change scenario for 'Development only' is denoted in grey to indicate differences in the results as the total number of flooded properties are overall unchanged but there is an improvement with one property which flooded above floor level, floods below floor level for the post development scenario.

3.4 Flow and peak time comparisons

Flows were extracted for the 10yr and 100yr scenarios to understand the differences between the pre and post development scenarios for the 'Development only'. The post development flows are peakier when compared to the pre-development scenario but have shorter time to peak with no lag as seen in Figure 1 and 2 below.

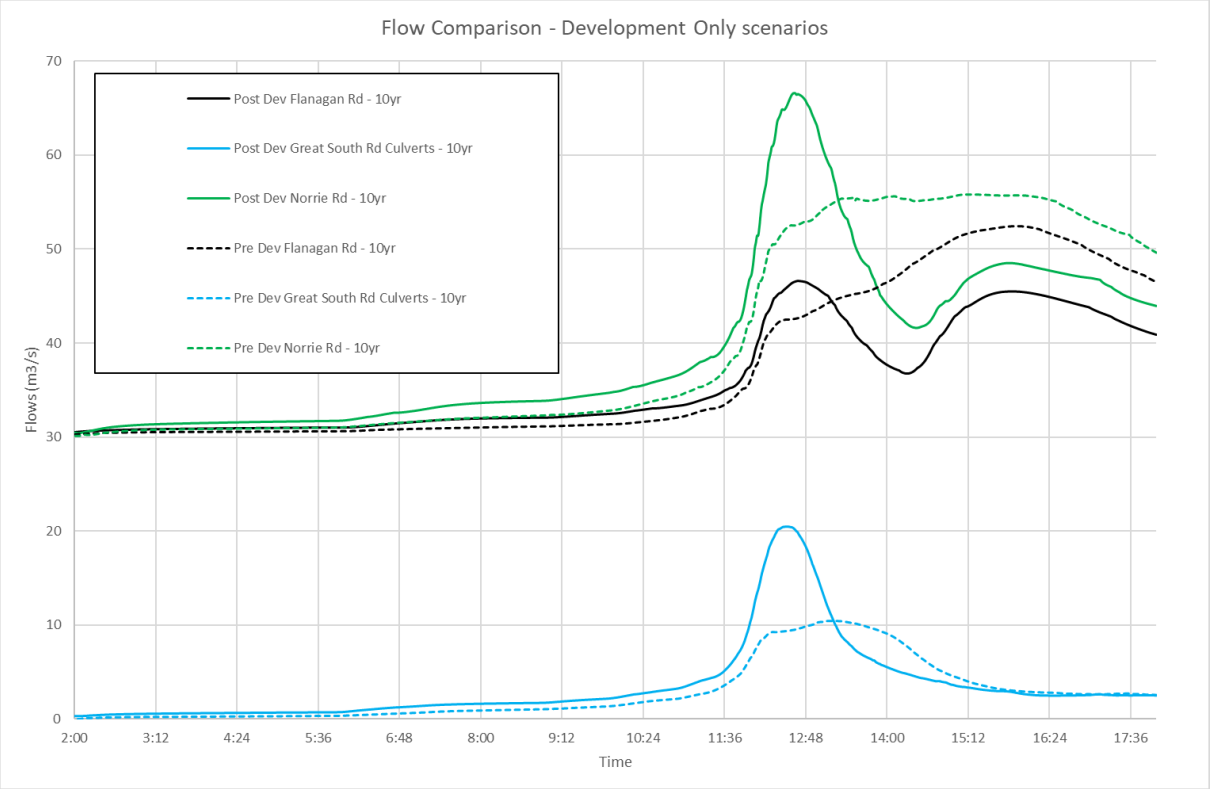


Figure 1: Flow comparison – 10yr

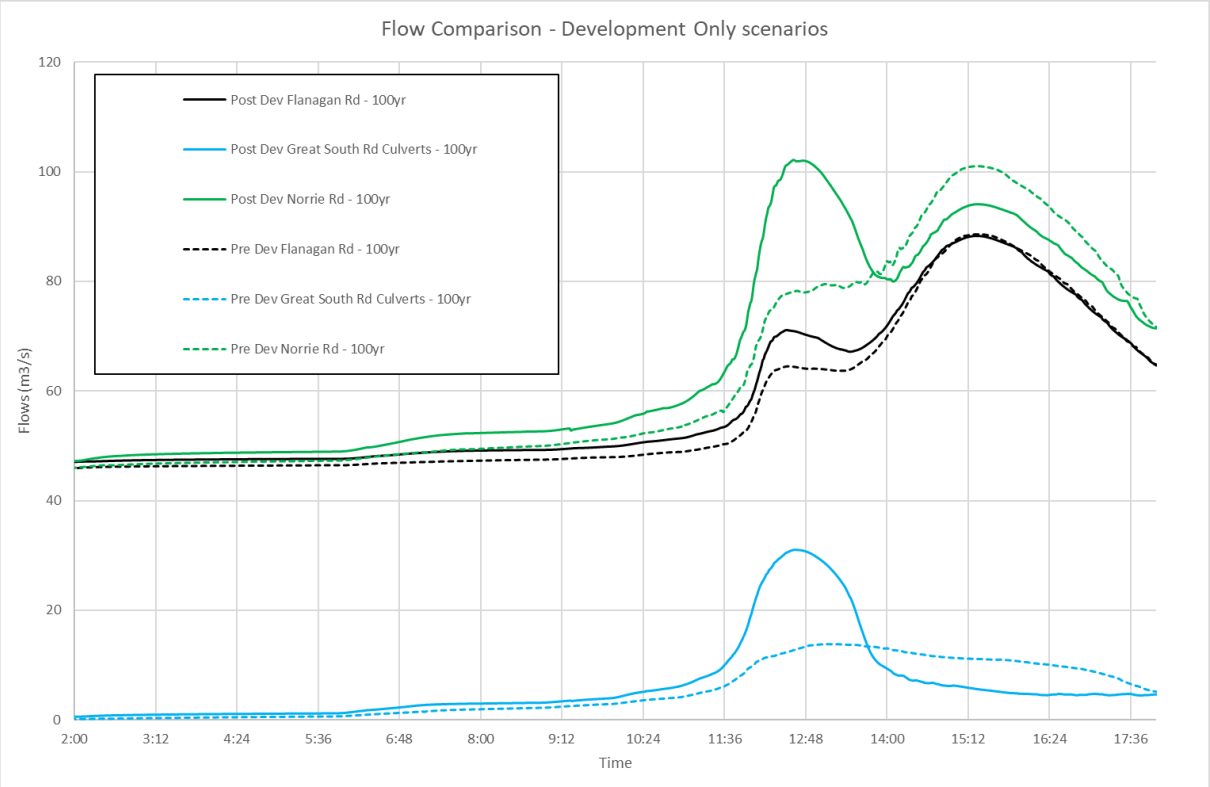


Figure 2: Flow comparison – 100yr

The 10yr flows at Norrie Road bridge were compared for the catchment and 'Development only' models flows which confirm that a 'pass flows' forward approach works better for the proposed development to discharge majority of the flows before the peak of the upstream flows reach Drury township.

This is supported by the building floor risk analysis which shows no increased flood risk to buildings/habitable floors with the 'pass flows forward' approach.

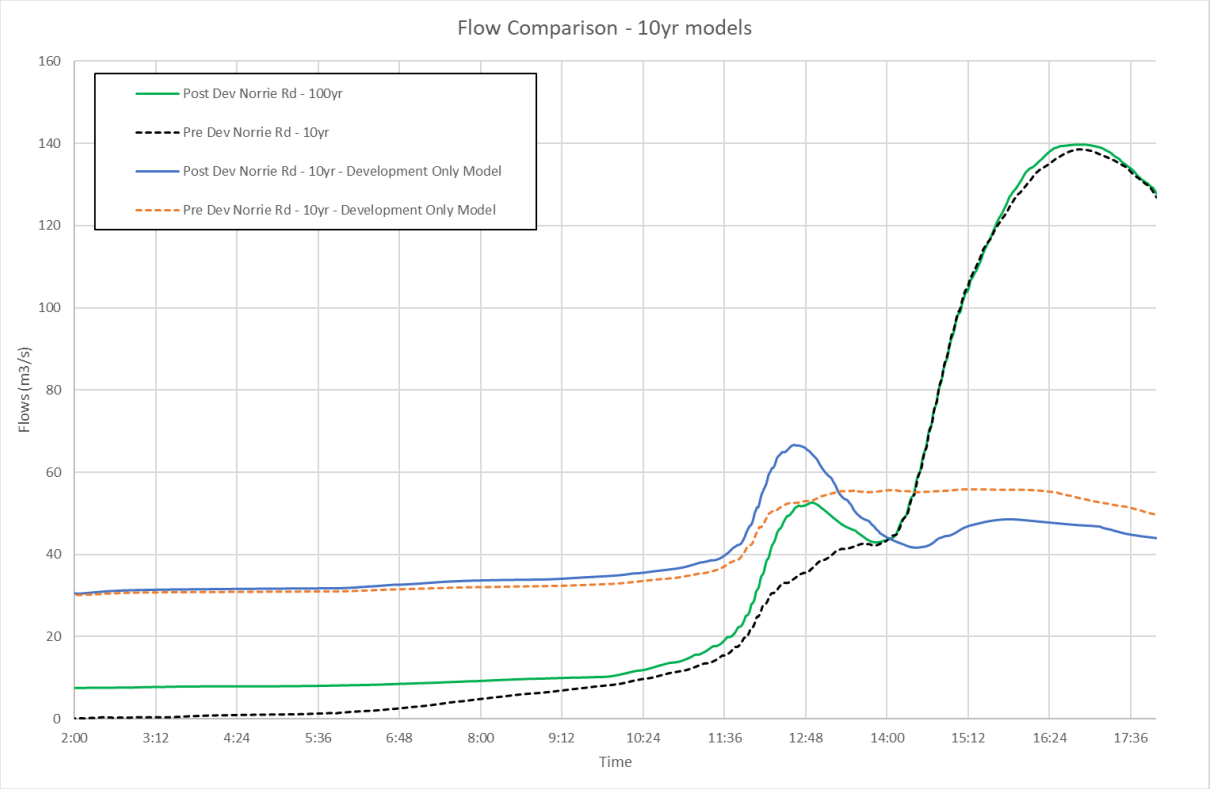


Figure 3: 10yr Flow comparison

APPENDIX A: Technical Memos

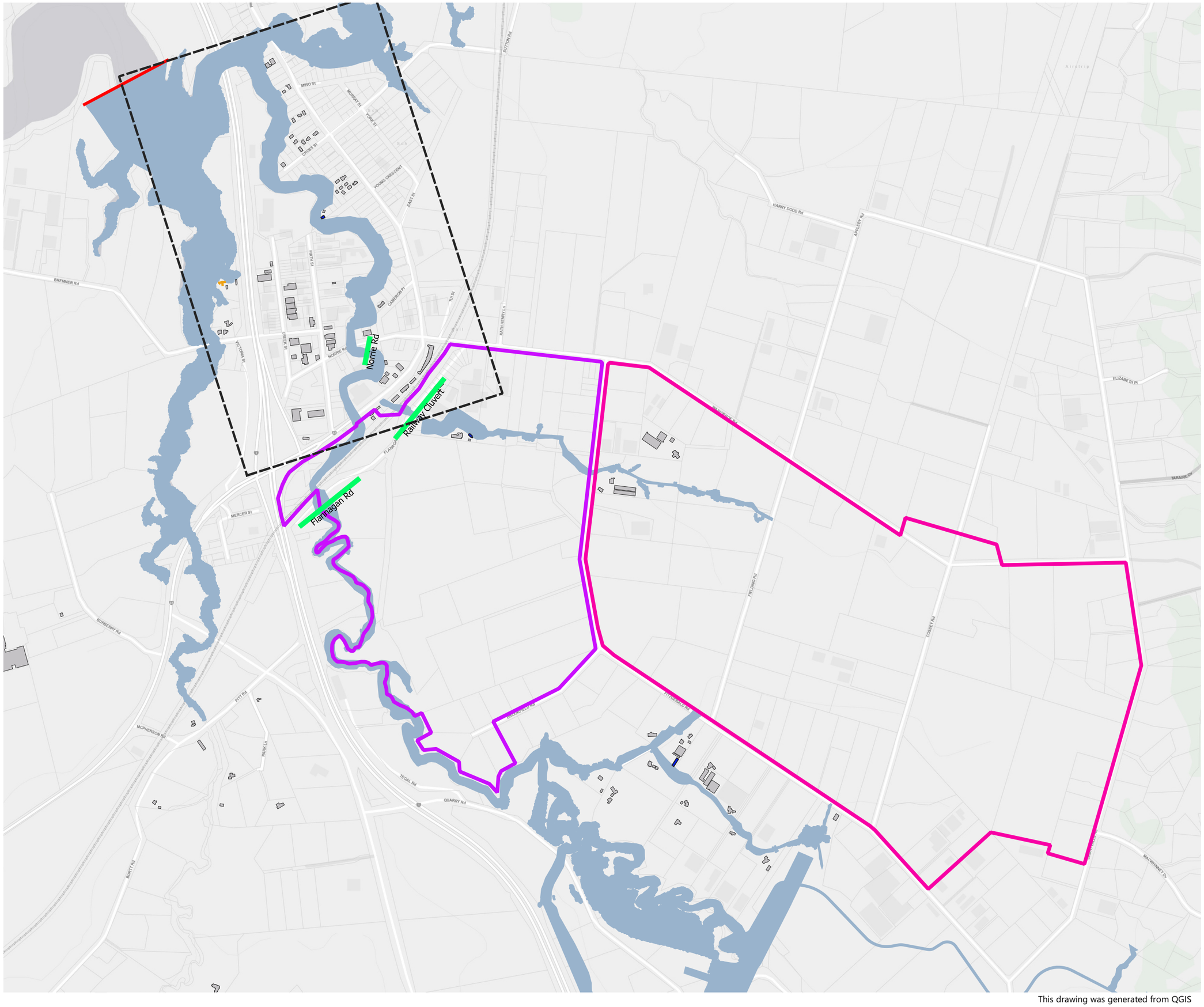
Assessment category		Comments /requests	Reason for comments/requests	Responses
No	Category			
01	Stormwater Planning	Please provide an assessment of how the proposed plan changes meet the outcomes of the NPS-FM and the related matters in the AUP Regional Policy Statement. How does the s32 report acknowledge and address methods to meet regional policy statement objectives that are relevant to the plan change areas, including B7.3 E1.3.8 and E1.310? Please update if necessary.	The policy framework acknowledged in the s32 reports primarily addresses matters relating to urban development and the provision of land for urban growth. While there is some acknowledgement of the NPS-FM, this appears to be limited to how streams and other natural hydrological features are recognized in the proposed plan changes. NPS-FM Objectives and Policies relating to water quality; and Regional Policy Statement objectives and policies for water quality and integrated stormwater management do not appear to be addressed. The process and outcome of urbanising land has significant environmental effects both immediately and into the future. There appears to be little acknowledgement of these effects on the receiving environment (which the NPS and RPS objectives and policies refer to) or adequate demonstration of how these effects will be mitigated through the proposed precinct plan provisions and proposed stormwater management plan.	Refer to Planning and Ecology Response
02	Stormwater quality	Please clarify how objectives in the AUP for water quality will be met. The Planning report (pg46) emphasises that high contaminant generating roads and carparks will be treated (treatment of these roads is covered by region wide rules in Chapter E9 AUP). However, it is unclear how many roads are anticipated to meet the thresholds to trigger E9 rules and if additional roads should be treated to meet the proposed objective. There is also reference in the Drury East – Fulton Hogan request (page 46) to a treatment train approach and secondary treatment but it is unclear if this is part of the approach to treat high contaminant generating roads or is an additional response applied to all roads to meet objectives E1.3.8 and E1.3.8 and meet Schedule 4 NDC requirements greenfield developments.	AUP E1.3.8 directs to avoid as far as practicable the adverse effects of development on water quality. AUP Objective E1.2.3 and Policies 1.3.2 and 1.3.3 directly implements the NPS-FM 2017. Avoiding adverse effects on water quality should be demonstrated in the planning report and SMP. The creation of adverse effects on water quality due to contaminants in runoff from impervious surfaces is an effect of urban land use. Therefore, this should be part of the S32 report and AEE. Reliance on region wide rules in the AUP may not sufficient to meet AUP policies for this plan change area and for the associated receiving environment which is a Significant Ecological Area; some of which (such as Drury Creek Islands) have further restoration and enhancement underway. Additional detail on the methods for treating stormwater to avoid adverse effects may also be sought prior to notification of this plan change as part of the SMP in support of stormwater discharge authorisation.	Refer to Section 1: Stormwater management of Memo P16-335.

		A matrix showing what tools will be used in what proposed land use zone to avoid any adverse effects on water quality should be included in the SMPs as part of identifying how adverse effects will be mitigated and how these achieve AUP policies for water quality.		
03	Water quality	Please more fully describe how the water quality policies in E1 will be achieved, and what options have been considered to meet the policies.	The current descriptions in the SMPs are confusing and appear to rely solely on the region wide rules. Given the AUP policy directives for greenfield development and the sensitivity of the receiving environment, additional treatment (such as a treatment train approach) may be justified.	Refer to Planning and Ecology Response
04	Hydrology Mitigation	Please provide an assessment of the degree to which SMAF1 avoids or remedies changes in hydrology which will result from the urban land uses proposed in the plan changes. A Regional Erosion Threshold Metric risk assessment identifies areas at risk of erosion and provides some quantification of the amount of erosion caused, however it does not address how effects will be avoided, remedied or mitigated. Identification of measures to avoid effects and mitigate should also be made and the BSTEM model is appropriate for this task. More detail on this tool is being supplied to the applicants.	The AUP states that for greenfield areas adverse effects of development shall be avoided as far as practicable or otherwise remedied or mitigated and this includes changes in hydrology (Policy E1.3.8). No SMAF controls were applied to greenfield areas in the AUP as it was expected that an assessment on what hydrological mitigation is required, would be undertaken as part of plan change process. The Drury-Opaheke Structure Plan SMP also identified that hydrological mitigation and erosion assessments should be completed at the scale of the plan changes so that the particular effects of proposed land uses would be identified, and mitigation measures would be determined, at scale proportionate to the proposed activities and effects.	Refer to Section 2: Hydrological Mitigation of Memo P16-335.
05	Flooding	Please address the matters identified and discussed in the memo to Healthy Waters from Tonkin and Taylor dated 19 Feb 2020. We note that all applicants need to explain what the effect cumulatively across developments will be on the Drury township flooding and parts of the catchment that interact with the Slippery Creek floodplain.	Flooding in the Hingaia catchment is complex and needs to be considered in conjunction with other plan changes proposed for the area; acknowledge any interactions with other catchments and the cumulative impact of potential development in the surrounding areas and the point of discharge downstream. Understanding the impact of development on the flood plain within the plan change sites and impacts downstream is necessary to evaluate the plan change proposal and ensure any potential flood effects are avoided or mitigated. Several discussions between Healthy Waters and the applicant's planners have occurred on the best way to approach flood	Refer to Section 3: Flooding of Memo P16-335.

			modelling and the memo from T&T dated 19 Feb 2020 reflects our agreement with regards to flooding matters.	
06	Riparian Margins	Please explain why a 10m wide riparian margin is proposed when the Drury-Opaheke Structure Plan Stormwater Management Plan identified a 20m riparian margin as being appropriate. No evaluation of these two options is provided including their consistency with the objectives and policies of the AUP.	A 20m wide riparian margin was consulted on as part of the Drury-Opaheke Structure Plan 'Blue Green Network' and associated the Stormwater Management Plan. The purpose of the wide margin is to provide an ecological corridor and provide a buffer for the stream noting that stream meander may occur due to erosion. These benefits support achievement of AUP objectives and policies. A rationale for a lesser width margin is not provided in the s32 report.	Refer to Planning and Ecology Response
07	Ecological corridors and blue green network.	Please clarify what the ecological corridors are and how they contribute to meeting objectives and policies of the AUP. They are mentioned briefly but there is no description on how these align to the Blue-Green network identified in the Drury-Opaheke Structure Plan, nor are the streams or corridors noted specifically in the precinct plan or stormwater management plan. Planning provisions to enable the ecological corridor are not provided in the precinct plan nor is an assessment given in s32 assessment reports.	A blue green network utilising the natural hydrological features of existing streams was identified as part of Auckland Council's Drury-Opaheke Structure Plan. If and how streams are used in this way has implications in relation to: • Identifying the impact of urban development on streams (if they are intended to be retained or not); • Keeping flood conveyance channels available as part of the 'pass-it-forward' approach outlined in the Drury-Opaheke Structure Plan • Mitigation of effects anticipated by urban development, including hydrology mitigation. The precinct plan and stormwater management plan lack information on the ecological corridors making their purpose for achieving AUP objectives and policies or as part of effects mitigation unclear. We note public access such as walkways/cycle network need to be located outside riparian setbacks and the minimum width required to accommodate water sensitive devices.	Refer to Planning and Ecology Response
08	Development staging	Please explain if and how the precinct plan is to manage flood risks (such as staging of development in conjunction with flood mitigation measures). Flood attenuation is proposed in the SMP but there are no precinct plan provisions to ensure that flood attenuation is provided or when it	The plan change areas are areas of significant flood hazard and developing the plan change areas could increase the flooding downstream in the existing Drury township. Fulton Hogan, in their SMP page 6 propose as part of their flood management approach for Zone A to provide: *Temporary flood attenuation to pre-develop flow – to enable development in advance of culvert upgrades*	With respect to Fulton Hogan and their proposed attenuation, this will be provided once more clarity around development and staging is available. The SMP was alluding to the potential for development to occur prior to upgrade of

		would be appropriate to not have flood attenuation.	There is no indication in their SMP or precinct plan of when this would be provided or when it will not be provided. The attenuation relates to current culvert capacity at Great South Rd and Flannagan Rd. These culverts will likely need upgrading in the future when road upgrades are done but this requirement is not linked to transport infrastructure upgrades or backed up by analysis of culvert capacity.	downstream assets i.e. railway culverts. A staging plan will be provided upon finalization of approach which won't be available until resource consent stage.

APPENDIX B: Flood Maps



Tonkin+Taylor

WOODS Est.1970

LEGEND

- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flow Cross Sections
- Area of Interest

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	17/03/2020

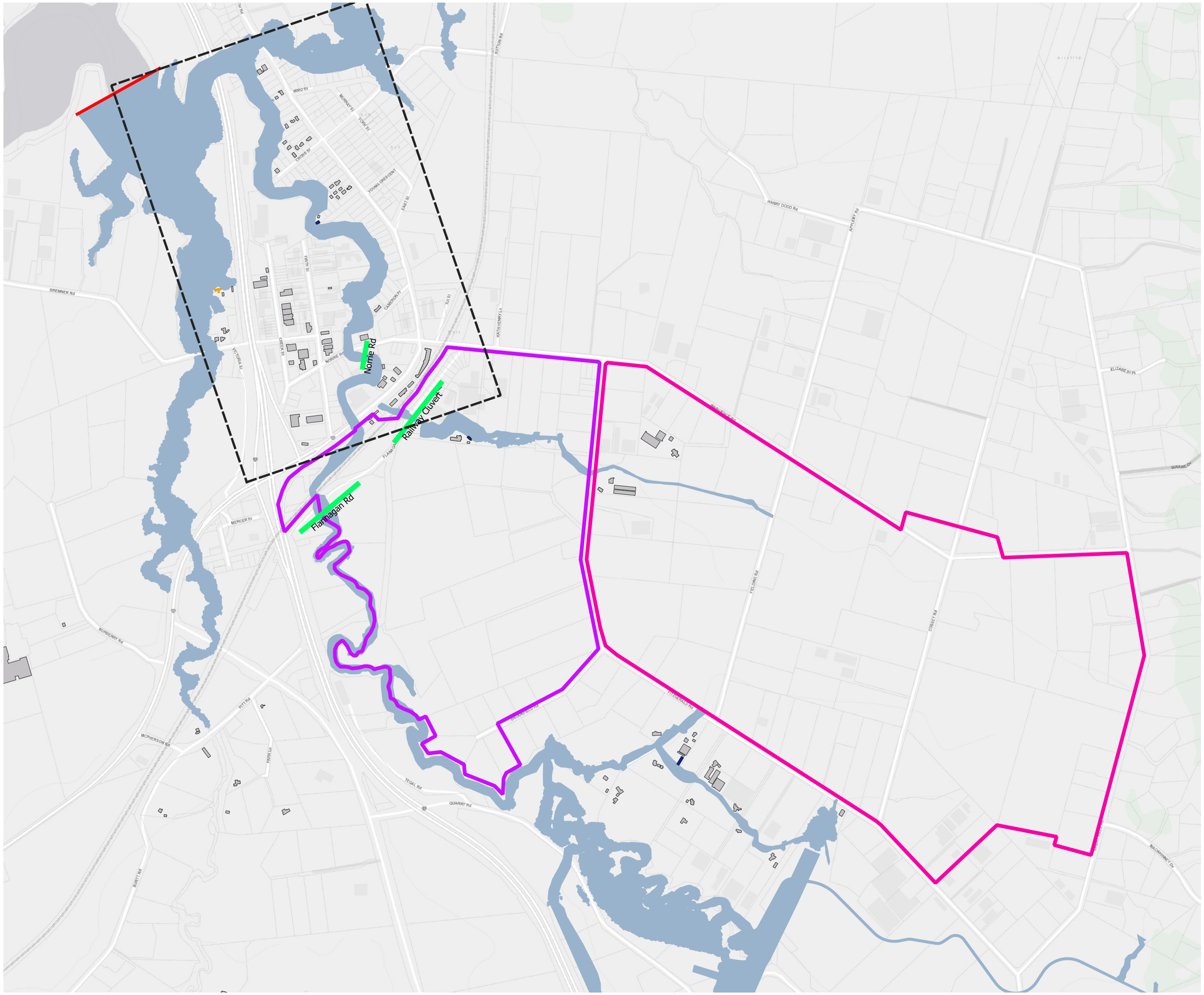
SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

Pre Development 2 Year MPD Flood Assessment
Catchment Model
Climate Change - YES

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0003	

This drawing was generated from QGIS



LEGEND

- Flood Extent

Buildings

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- Flood level > 0.15m
- Flood Model Boundary
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- Kiwi Property Plan Change (Feb 2019)
- Flow Cross Sections
- Area of Interest

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	17/03/2020

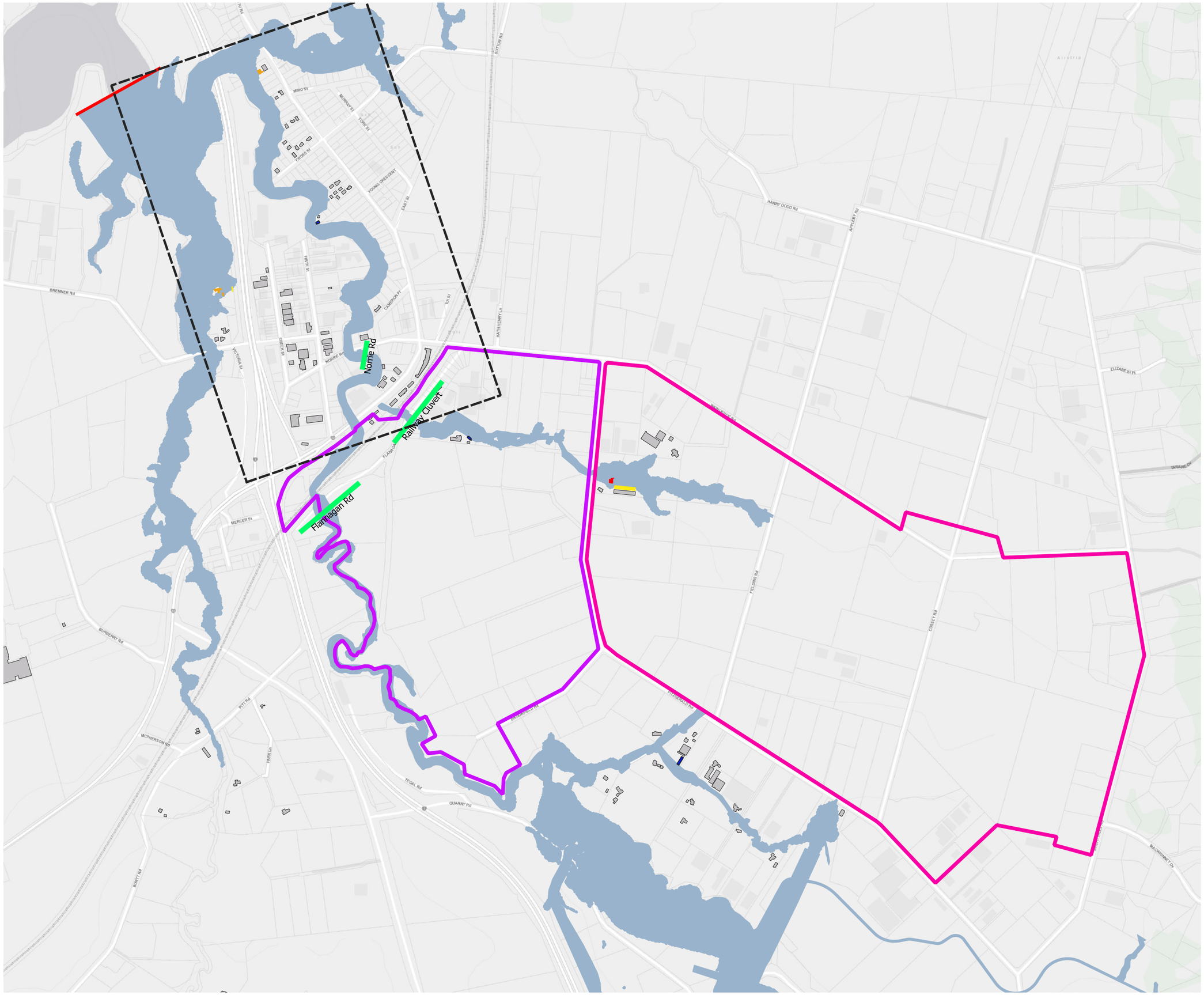
SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

Post Development 2 Year MPD Flood Assessment
Catchment Model
Climate Change - YES

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0004	

This drawing was generated from QGIS



Tonkin+Taylor

WOODS Est.1970

LEGEND

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REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	17/03/2020

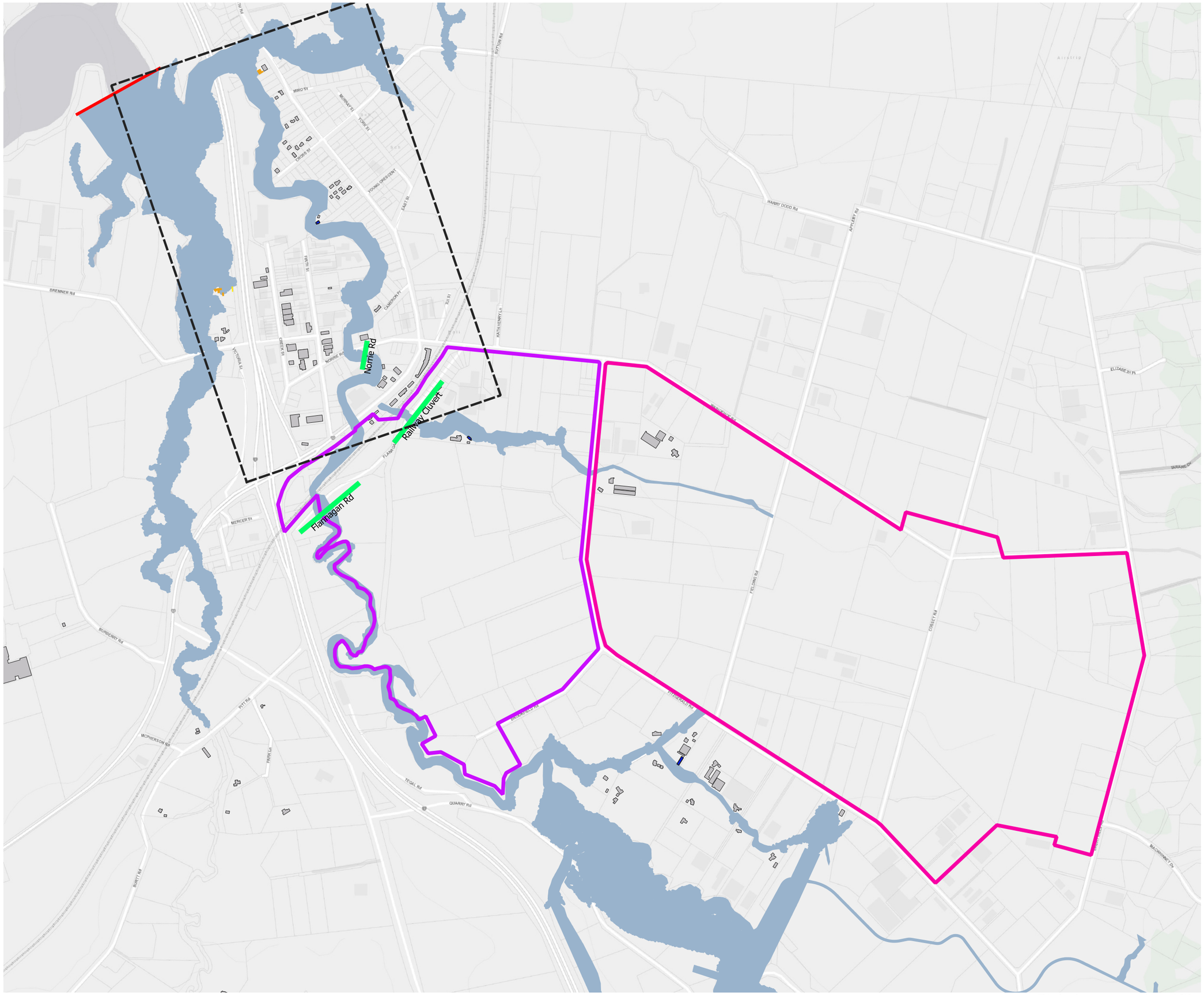
SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

Pre Development 10 Year MPD Flood Assessment
Development Model
Climate Change - YES

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0007	

This drawing was generated from QGIS



Tonkin+Taylor

WOODS EST.1970

LEGEND

- Flood Extent

Buildings

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- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m
- Flood Model Boundary
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- Kiwi Property Plan Change (Feb 2019)
- Flow Cross Sections
- Area of Interest

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	17/03/2020

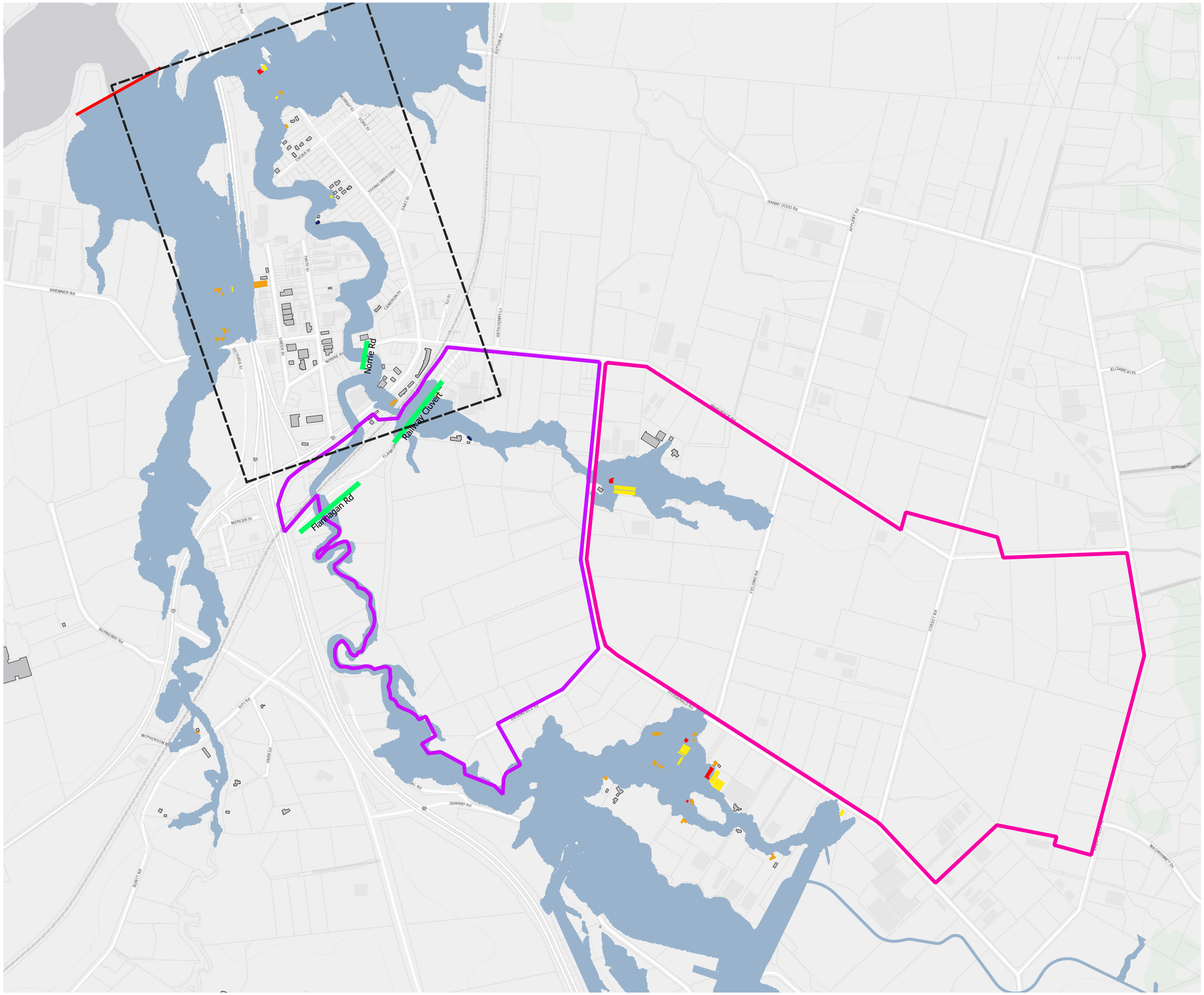
SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

Post Development 10 Year MPD Flood Assessment
Development Model
Climate Change - YES

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0008	

This drawing was generated from QGIS



Tonkin+Taylor

WOODS Est.1970

LEGEND

- Flood Extent

Buildings

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- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flow Cross Sections
- Area of Interest

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	17/03/2020

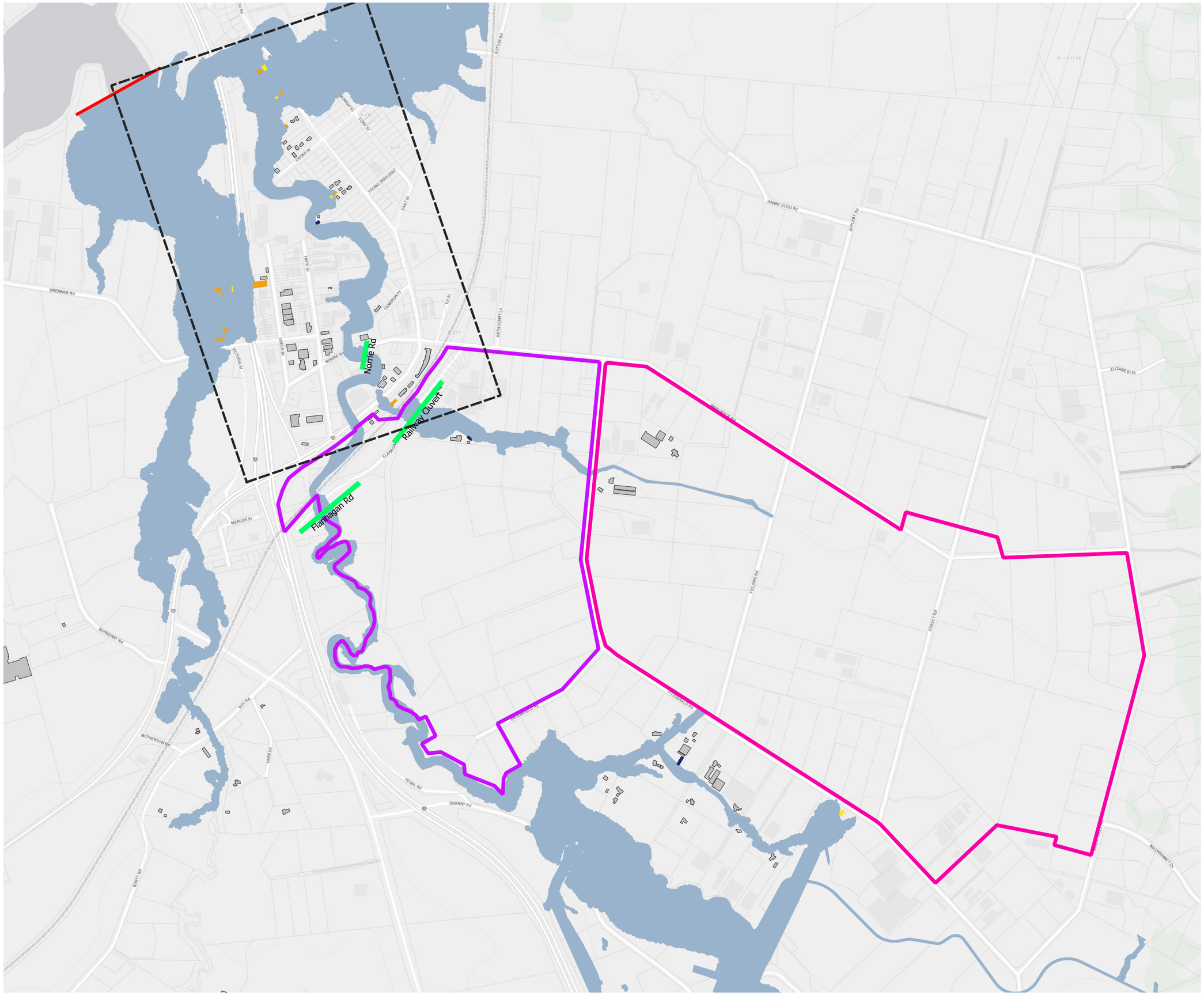
SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

Pre Development 100 Year MPD Flood Assessment
Development Model
Climate Change - YES

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0011	

This drawing was generated from QGIS



Tonkin+Taylor

WOODS EST.1970

LEGEND

- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flow Cross Sections
- Area of Interest

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	17/03/2020

SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

Post Development 100 Year MPD
Flood Assessment
Development Model
Climate Change - YES

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0012	

This drawing was generated from QGIS