Memorandum

To: Shalini Sanjeshi, Xenia Meier

From: Charlotte Duke
Reviewed: Kristin Stokes, Tess Gillham, Julian Hogg

CC: Emma Broadbent

Subject: Hydraulic Modelling Updates for May Road Proposed Ecological Enhancements

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1 Introduction

Previous baseline modelling (discussed in the Jacobs report JNZ-WSL-CIP-RT-0000014) determined that the proposed May Road stormwater pond will provide sufficient volume to attenuate the 10-year Average Return Interval (ARI) and 100-year ARI storm events to pre-development levels after the construction of the May Road shaft platform as part of the Watercare Central Interceptor Project (CI). For final reinstatement, Watercare wish to undertake ecological enhancements within the May Road Pond. Hydraulic modelling has been conducted to assess the impact of the proposed ecological enhancements on the surrounding area.

Jacobs New Zealand Ltd have been engaged to review the impacts of the updated design to the stormwater conveyance at the May Road site as a part of the Central Interceptor Project using the updated model previously provided by Auckland Council and since modified by Jacobs for the purpose of other hydraulic modelling assessments. The purpose of this memorandum is to outline the hydraulic modelling assessments to support the resource consent application for the May Road Stream Ecological Enhancements.

This memorandum presents the results for four model scenarios. Previous modelling undertaken by Jacobs (JNZ-WSL-CIP-RT-0000014) developed a pre-development scenario and a post-development scenario with the May Road Pond, shaft, Roma Road culvert and raised accessway to the new development at the adjacent property (105 May Road). This memorandum describes the addition to the post-development scenario of the future Goodman's site and the May Road Stream Ecological Enhancements. These scenarios are referred to as Model 1 to Model 4, as described in Table 3.

1.1 Previous Modelling

For the previous assessment, the Oakley Creek Catchment model developed for the Maximum Probable Development (MPD) scenario was adopted as the pre-development model; the post-development model has the addition of the May Road Pond, shaft and the raised accessway to the ground model, as well as the proposed Roma Road culvert. Full details of these models are provided in JNZ-WSL-CIP-RT-0000014. In this memorandum, these models are referred to as Model 1A (pre-development) and Model 1B (post-development).

1.2 Climate Change Considerations

Both the Goodman's Future Development model and the proposed stream enhancements model were run using three rainfall scenarios, as shown in Table 1. These models include allowances for 2.1°C of warming from 1990 to 2090 to account for climate change (CC), in accordance with the Auckland Council's Stormwater Flood Modelling Specifications (November 2011).

Table 1. Percentage increase in 24-hour Design Rainfall Depth

Average Return Interval (ARI)	Percentage Increase in 24-hour Design Rainfall Depth Due to Future Climate Change (2.1°C Increase in Temperature)
2-year	9.0%
10-year	13.2%
100-year	16.8%

2 Hydraulic Model

2.1 Previous Modelling

This assessment used the hydraulic model described in JNZ-WSL-CIP-RT-0000014. The model is an integrated 1D-2D coupled hydrodynamic model developed by AECOM using InfoWorks ICM v2021.7 modelling software (Oakley Creek Catchment Stormwater Modelling – Model Build and Validation Report, January 2022). In this model, Oakley Creek and the Watercare site area are included in the 2D Zone mesh which uses a maximum triangle area of $10m^2$ and a minimum element area of $4m^2$.

2.2 Goodman's Development Model

Previous hydraulic modelling showed that overland flow entered the Central Interceptor site from the neighbouring property (Goodman's Development). However, during a site inspection in July 2023, it seemed likely that overland flow would now be directed away from the Central Interceptor site due to the changes within the Goodman's Future Development. Furthermore, the Stormwater Management Plan for the Goodman's Future Development indicated that flow should also be directed away from the Central Interceptor site which aligns with the site inspection findings.

The previous hydraulic model (JNZ-WSL-CIP-RT-0000014) did not include the Goodman's Future Development. It was therefore concluded that the post-development overland flow may be significantly lower than what was shown in the previous modelling. These discrepancies were raised with Watercare and it was confirmed to design the stream enhancements to a 10-year event using the most realistic information available. The post-development model (Model 1B, described in JNZ-WSL-CIP-RT-0000014) was amended to include the Goodman's Future Development to confirm the overland flow direction and whether implementation of overflow points is required within the stream. Table 3 defines the Goodman's Future Development model as Model 2.

The following changes, as shown in Figure 1, were implemented into Model 2:

- An updated ground model incorporating the Goodman's Future Development topography (provided by GHD in August 2023).
- A concrete channel along the western side of the Goodman's Future Development
- A grass swale along the southern side of the Goodman's Future Development.
- A revised alignment of the existing DN 1800 stormwater pipe.
- A DN1200 pipe that joins the network at the existing DN 1800 stormwater pipe.

The results of the Goodman's Future Development modelling showed that overland flow is directed away from the CI site, aligning with onsite observations and the Goodman's Future Development Stormwater Management Plan. Therefore, it was not necessary to design the stream specifically to account for incoming flow from the Goodman's Development, such as overflow points into the stormwater pond.

Figure 1. Model updates to reflect Goodman's Future developments.

2.3 May Road Stream Ecological Enhancements Model

Concept options investigated for the proposed ecological enhancements included the creation of a wetland, the creation of a stream diversion or enhancement of the existing stream corridor. The preferred concept option to be taken to the next stage of design is for the enhancement of the existing stream corridor. This is investigated in Model 3 and Model 4.

The proposed stream enhancements, shown in Figure 2 consist of the following:

- Recontouring the southern and eastern bunds to reduce soil heights.
- Implementing benches that undulate in width alongside the existing stream channel to establish habitat pool and planting diversity.
- Implementing a meandering low-flow channel to maintain in-stream habitat and create variable flow patterns for a range of microhabitats.
- Retaining existing trees where possible.

Five proposed planting zones were provided by Beca in October 2023. These zones, as indicated in Figure 2, required roughness zones to be defined in the hydraulic model. Appropriate roughness values were determined using Auckland Council's Stormwater Flood Modelling Specifications (November 2011).

The model was updated to represent these changes by:

- Updating the ground model to represent the channel and bund recontouring.
- Changing the 2D roughness to reflect the proposed planting adjacent to the channel.
- Reducing the Roma Road culvert inlet and outlet mesh zone maximum area to ensure that the 2D ground level at the inlet and outlet matches the as-built levels.

The Roma Road access road design has been updated based on requirements of the lease agreement with the neighbouring property 105 May Road (MRP). The design changes include widening of the access road from 4m to 6m and changing the surface roughness to reflect the sealed surface. The updated access road design was also incorporated within the ground model for Model 3 and Model 4.

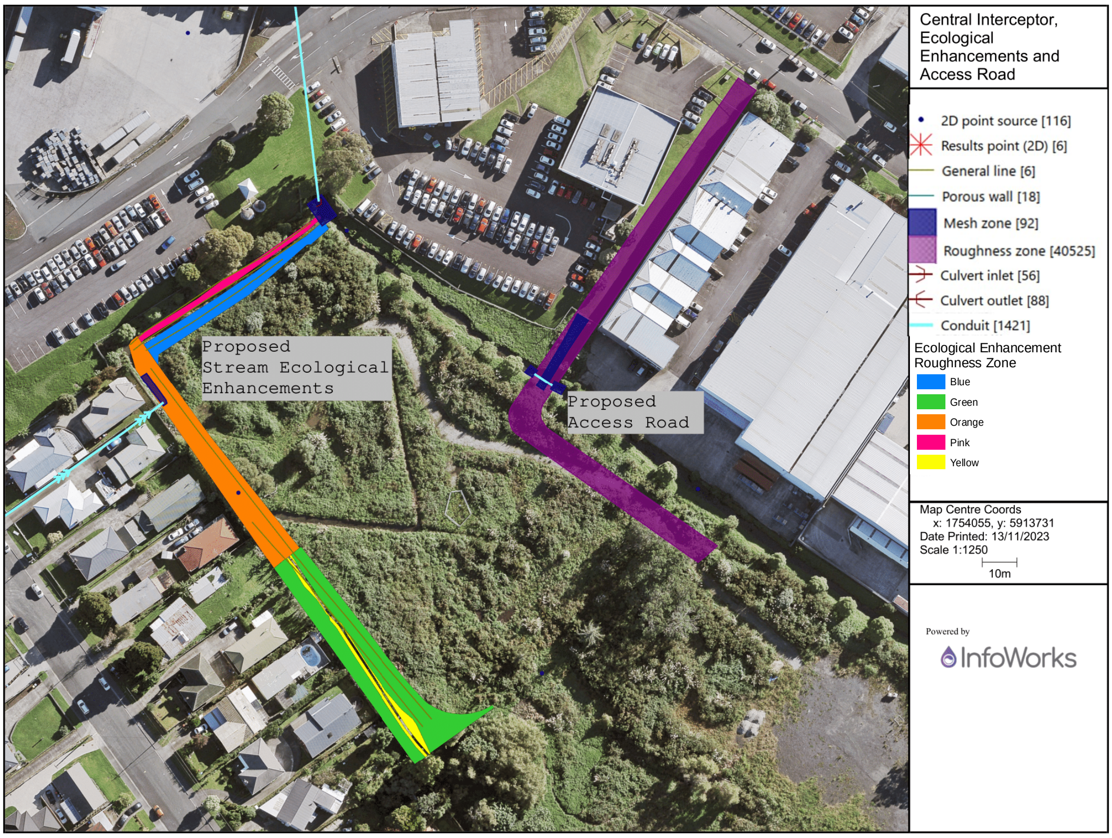

Figure 2. Model updates to reflect proposed ecological enhancements and access road developments.

Table 2: Manning's *n* roughness for ecological enhancement zones

Name	Proposed planting design	Manning's *n* roughness
Pink	Existing vegetation, weeds removed and replaced with native grasses, planted at 3-4 per m^2	0.12
Blue	Pockets of native grasses, planted at 3-4 per m^2	0.09
Orange	Native grasses and reeds, planted at 3-4 per m^2	0.09
Green	Native grasses, planted at 3-4 per m^2 Small shrubs at 1-1.5m spacing	0.12
Yellow	Native grasses and reeds, planted at 3-4 per m^2	0.09

2.4 Modelling Scenarios

The hydraulic performance of the proposed ecological enhancements at the Watercare site was compared to the previous pre-development Jacobs model (discussed in the Jacobs report JNZ-WSL-CIP-RT-0000014). This was done to ensure that the proposed ecological enhancements did not increase flood impacts to the surrounding area. The models used in this analysis are in Table 3 below.

Table 3. Modelling scenarios

Number	Name	Description	Rainfall
Model 1A	Pre-development	- No changes to the original model	2-year ARI + CC 10-year ARI + CC 100-year ARI + CC
Model 1B	Post-development	- Original model - May Road shaft platform, stormwater pond and Roma Road culvert and raised accessway	2-year ARI + CC 10-year ARI + CC 100-year ARI + CC
Model 2	Post-development with Goodman's Future Development	- Model 1B including May Road shaft platform, stormwater pond and Roma Road culvert and raised accessway - Goodman's Future Development surface and stormwater network	2-year ARI + CC 10-year ARI + CC 100-year ARI + CC
Model 3	Post-development with Goodman's Future Development and Ecological Enhancements	- Model 2 including May Road shaft platform, stormwater pond and Roma Road culvert and raised accessway - Goodman's Future Development - Proposed stream ecological enhancements - Updated surface for the proposed Roma Road access road	2-year ARI + CC 10-year ARI + CC 100-year ARI + CC
Model 4	Post-development with Ecological Enhancements	- Model 1B including May Road shaft platform, stormwater pond and Roma Road culvert and raised accessway - Proposed stream ecological enhancements - Updated surface for the proposed Roma Road access road	100-year ARI + CC

3 Results

The post development hydraulic modelling results (Model 3 and Model 4) were assessed against the pre-development model (Model 1A), as outlined above in Table 3. Peak water levels were extracted from 6 points (shown in Figure 3 and Figure 4), in line with the results discussed in the Jacobs report JNZ-WSL-CIP-RT-0000014.

Figure 3. Point and inlet locations for Model 2 and Model 3.

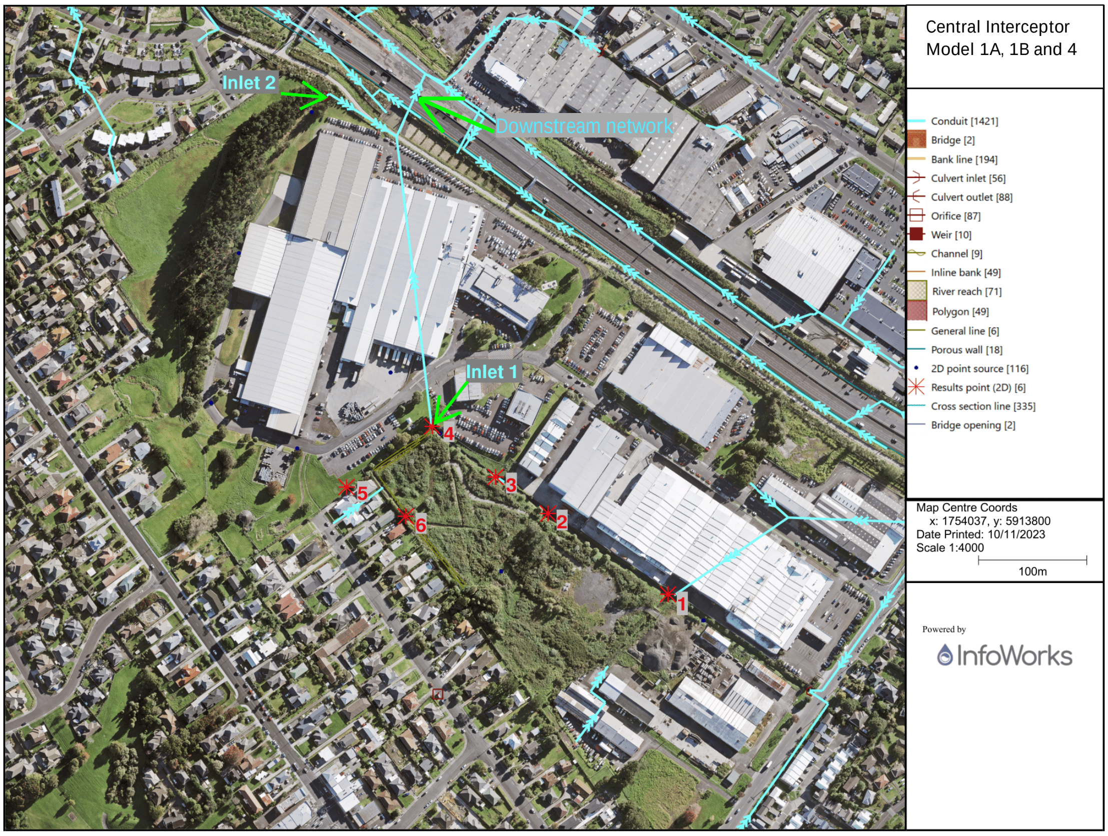

Figure 4. Point and inlet locations for Model 1A, Model 1B and Model 4.

The peak water levels at location 1 to 6, shown in Table 4, and the difference in peak water level, shown in Table 5, indicate the following:

- 2-year ARI + CC
  - Locations 2 to 6 show a decrease in peak water level with the addition of the stream enhancements (Model 1A to Model 3).
  - Location 1 shows no change to the peak water level from Model 1A to Model 3.
- 10-year ARI + CC
  - Locations 1 to 6 show a decrease in peak water level with the addition of the stream enhancements (Model 1A to Model 3).
- 100-year ARI + CC
  - Locations 1 to 6 show a decrease in peak water level with the addition of the stream enhancements (Model 1A to Model 3) and (Model 1A to Model 4).

The hydraulic flood modelling in JNZ-WSL-CIP-RT-0000014 represented the proposed Roma Road access road as a raised 2D mesh zone. The updated design of the Roma Road access road has been incorporated into the ground model of the hydraulic model as this is more representative of the proposed road geometry. The results show that location 1 and location 2 have decreased peak water levels, indicating that the updated road geometry does not increase flooding to the surrounding area.

Table 4. Peak Water Levels at points 1 to 6 (mRL)

Location			1	2	3	4	5	6
Peak Water Levels (mRL)	Model 1A – Pre-development	2-year ARI + CC	49.59	48.82	48.79	47.73	48.60	48.60
		10-year ARI + CC	49.75	49.03	49.01	48.27	48.93	48.94
		100-year ARI + CC	50.00	49.50	49.49	49.26	49.47	49.48
	Model 1B - Post-development	2-year ARI + CC	49.59	48.65	48.60	47.77	48.45	48.11
		10-year ARI + CC	49.74	48.95	48.78	48.31	48.54	48.51
		100-year ARI + CC	50.00	49.57	49.45	49.20	49.32	49.32
	Model 2 – Post-development with Goodman's Future Development	2-year ARI + CC	49.59	49.09	48.56	47.35	47.61	48.03
		10-year ARI + CC	49.78	49.33	48.78	47.96	48.16	48.27
		100-year ARI + CC	50.07	49.82	49.27	49.02	49.12	49.13
	Model 3 – Post-development with Goodman's Future Development and Ecological Enhancements	2-year ARI + CC	49.59	48.53	48.54	47.38	47.65	48.00
		10-year ARI + CC	49.73	48.76	48.75	48.03	48.21	48.29
		100-year ARI + CC	49.96	49.35	49.32	49.14	49.24	49.24
	Model 4 – Post-development with Ecological Enhancements	100-year ARI + CC	49.97	49.48	49.41	49.22	49.34	49.34

Table 5. Difference in Peak Water Levels at points 1 to 6 (m)

Location			1	2	3	4	5	6
2-year ARI + CC	Model 1A vs	Model 3	0.00	-0.29	-0.25	-0.35	-0.95	-0.60
10-year ARI + CC			-0.02	-0.27	-0.26	-0.24	-0.72	-0.65
100-year ARI + CC			-0.04	-0.15	-0.17	-0.12	-0.23	-0.24
100-year ARI + CC	Model 1A vs	Model 4	-0.03	-0.02	-0.08	-0.04	-0.13	-0.14

The peak flow and total volume through three inlets, sized 1800 mm, 750 mm and 1200 mm respectively (shown in Figure 3 and Figure 4 above) were reviewed, in line with the results discussed in the Jacobs report JNZ-WSL-CIP-RT-0000014. Inlet 3 is proposed as part of the Goodman's Future Development. These results, shown in Table 6, and the differences in peak flow and volume, shown in Table 7 indicate the following:

- 2-year ARI + CC

  - Inlets 1 and 2 show a decrease in peak flow and volume with the addition of the stream enhancements (Model 1A to Model 3).
- 10-year ARI + CC
  - Inlets 1 and 2 show a decrease in peak flow and volume with the addition of the stream enhancements (Model 1A to Model 3).
- 100-year ARI + CC:
  - Inlet 1 shows a decrease in peak flow and volume with the addition of the stream enhancements and Goodman's Future Development (Model 1A to Model 3).
  - Inlet 1 shows a decrease in peak flow with the addition of the stream enhancements (Model 1A to Model 4). There is an increase in volume which was also 3seen in the previous post development modelling (Model 1B) and is likely related to the attenuation caused by the pond. This effect is dampened by the Goodman's Future Development which diverts flow to Inlet 3 instead.
  - Inlet 2 shows an increase in peak flow and decrease in volume with the addition of the Goodman Future Development and stream enhancements (Model 1A to Model 3). The increase in peak flow is likely related to the improved model representation of the channel in the section of stream that runs along the southwest boundary of the site, allowing a slightly increased flow towards the Goodman property, much of this flow enters the Goodman Inlet 3, however once the concrete channel reaches capacity the overflow enters Inlet 2. The Goodman's Future Development changes the timing of the peak flows: the initial peak from the local catchment adjacent to Inlet 2 is much reduced as the flow enters the channel and flows towards inlet 3. A second peak where overland flows through the May Road site enter the Goodman property and the concrete channel reaches capacity reach Inlet 2 with a peak flow larger than the pre-development 'second peak'.
  - Inlet 2 shows an increase in peak flow and a decrease in volume with the addition of the stream enhancements (Model 1A to Model 4). This is partly offset by a decrease in flow through Inlet 1, resulting in an overall increase in flow to the existing stormwater network of 0.09 m^3/s. The increase is likely related to the improved representation of the channel in the section of stream that runs along the southwest boundary of the site channelling a slightly increased flow towards the Goodman property.
  - Inlet 2 shows a decrease in both peak flow and total volume from Model 2 and Model 3 to Model 1A and Model 1B. This is likely due to the concrete channel which is part of the Goodman's Future Development which diverts flow away from Inlet 2 into Inlet 3, as shown in Figure 5.

Table 6. Peak flow and total volume at inlets 1, 2 and 3

Scenarios	Storm Events					
	2 Year + CC		10 Year + CC		100 Year + CC	
	Peak Flow (m^3/s)	Total Volume (m^3)	Peak Flow (m^3/s)	Total Volume (m^3)	Peak Flow (m^3/s)	Total Volume (m^3)
Inlet 1 (1800mm diameter pipe)						
Model 1A	3.80	54630.00	6.00	98962.00	8.00	159108.00
Model 1B	3.90	55692.00	6.20	100101.00	8.00	162054.00
Model 2	2.26	35641.89	4.65	64069.46	5.94	107638.26
Model 3	2.36	39739.96	4.83	71222.69	5.97	115110.31
Model 4	-	-	-	-	7.88	161697.30
Inlet 2 (750mm diameter pipe)						
Model 1A	0.40	2315.00	0.70	4220.00	0.90	10455.00
Model 1B	0.40	2322.00	0.70	4271.00	0.60	8562.00
Model 2	0.01	8.58	0.03	9.60	0.74	2712.84
Model 3	0.01	4.81	0.05	32.25	1.05	4248.90
Model 4	-	-	-	-	1.11	8585.61
Inlet 3 (1200mm diameter pipe)						
Model 2	1.97	22881.50	2.16	40382.98	2.53	60826.15
Model 3	1.97	18964.38	2.18	33775.93	2.23	52166.58
Overall (downstream network)						
Model 1A	-	-	-	-	8.83	169,485.11
Model 1B	-	-	-	-	8.60	170471.13
Model 2	-	-	-	-	8.54	170535.99
Model 3	-	-	-	-	8.89	171226.28
Model 4	-	-	-	-	8.65	169968.43

Overall Increase to Existing Stormwater System (total peak flows)

- The network downstream of both the Goodman Future Development and May Road shows a 0.29m^3/s decrease in peak flow and increase in volume with the addition of the Goodman Future Development and without ecological enhancements (Model 1A to Model 2).
- The network downstream of both the Goodman Future Development and May Road shows an increase in peak flow of 0.06m^3/s and an increase in volume with the addition of the Goodman Future Development and ecological enhancements (Model

1A to Model 3). This is a less than 1% increase in flow and is considered less than minor.

- The network downstream of both the Goodman Future Development and May Road shows a decrease in peak flow of 0.18 m3/s and an increase in volume with the addition of the ecological enhancements (Model 1A to Model 4).

Table 7. Difference in Peak flow (m^3/s) and total volume (m^3) at inlets 1 and 2

Inlet 1 (1800mm diameter pipe)							
		Peak Flow (m^3/s)	Total Volume (m^3)	Peak Flow (m^3/s)	Total Volume (m^3)	Peak Flow (m^3/s)	Total Volume (m^3)
		2 Year + CC		10 Year + CC		100 Year + CC	
Model 1A vs	Model 3	-1.45	-14890.00	-1.18	-27739.31	-2.03	-43997.69
	Model 4					-0.12	+2589.30
Inlet 2 (750mm diameter pipe)							
Model 1A vs	Model 3	-0.39	-2310.19	-0.65	-4187.75	+0.15	-6206.10
	Model 4					+0.22	-1869.39

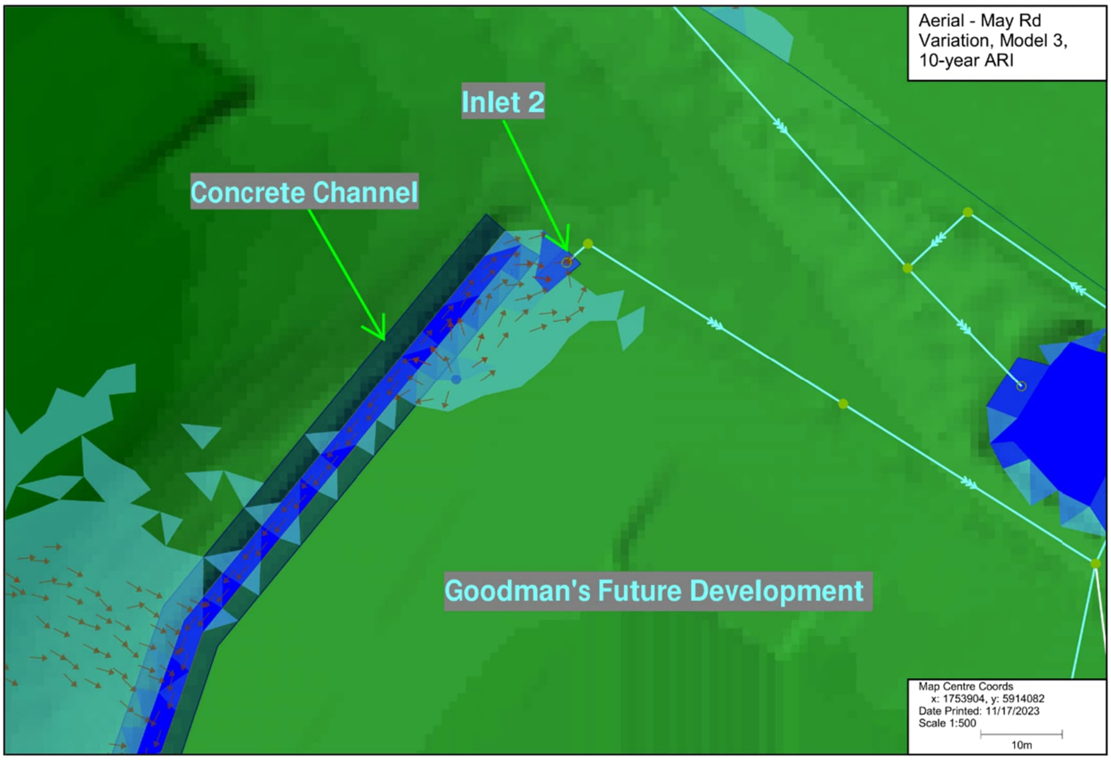

Figure 5. Flow through concrete channel away from Inlet 2

4 Conclusions and Recommendations

- The proposed stream ecological enhancements decrease the peak water levels at locations 1 to 6 for all return periods. This indicates that the proposed stream ecological enhancements do not worsen flooding in these areas. In particular, the Marion Ave properties will experience less flooding.
- For the 2-year ARI and 10-year ARI event the flow through Inlet 1 and Inlet 2 decreases with the proposed stream ecological enhancements.
- For the 100-year event, the flow through the Inlet 1 decreases with the proposed stream enhancements.
- For the 100-year event, the flow through Inlet 2 increases with the proposed stream enhancements. This is a result of an improved representation of the channel in the section of stream that runs along the southwest boundary of the site channelling a slightly increased flow towards the Goodman property. However, the volume is decreasing which reflects the change in timing of peak flows indicating that flow is attenuated within the pond. Flows in the downstream pipe are similar between pre-development and post development; the balance of flow between Inlets 1 and 2 is altered but the total downstream peak flow is less altered. Some further refinement of the stream design could be undertaken at the detailed design stage to re balance the flows through Inlet 1 and Inlet 2 to align with the pre-development levels if required.
- The stream ecological enhancements have a less than minor effect on the overall flow to the downstream stormwater. This represents that flow is being attenuated to pre-development levels.