14. Project risks

A number of risks have been identified in the design of the Awakeri Wetlands. These risks sit within the design, construction and operation phases of the project and are outlined in Table 26 below with the proposed management strategies for each risk.

Table 26 has been provided at the end of the design phase and addresses identified design risks and anticipated construction risks. It is expected that these would be incorporated into a risk register and updated as new risks are identified. At the completion of the construction phase it is expected that the risk register will be managed by Auckland Council as asset owner.

Table 26 Project risks

Risk	Description	Management
Design risks		
Flooding	Flooding risks are possible if the channel is planted with excessive planting which could reduce the capacity of the channel.	Low height shrubs and native grasses than can lay flat during storm events are proposed for the channel planting. Landscaping designer has been made aware of these constraints.
Service crossings	Channel could create a barrier to services in the area.	A typical detail has been provided to allow services to cross at the weir locations (upstream of the weirs at the channel invert level). Auckland Council should guide developers to implement this detail where required.
Stormwater connections to channel	Poor choice of stormwater connection locations can have an adverse effect on the channel visually and/or in terms of erosion.	The design recommends stormwater connections to enter channel immediately downstream of the weirs and a typical detail has been provided. Auckland Council should guide developers to implement this detail where required.
Settlement of weirs	Settlement of the weirs could alter the permanent water level in the channel, potentially resulting in groundwater drawdown induced settlement or drying out of the wetland areas.	Considered in design of the weirs. Using sheet piles reduces this risk. The top of the sheet pile can be retrofitted to readjust the top level if future settlement is encountered.
Scour and erosion	Risk of undercutting structures or de-stabilising channel banks and channel invert due to scour and erosion.	Managed through implementing protection measures in critical areas and recommending monitoring and maintenance to promptly address problem areas.
Culvert blockages	There is a risk of culvert blockages and potential upstream flooding as a result.	Managed through design of the culverts as discussed in Section 10. Culverts are typically outlet controlled up until 40% blockage, which is considered an unlikely scenario for this size of the culverts and considering the culverts typically have two barrels.
Culvert settlement	Risk of culvert settlement and damage to services.	Managed through design of culverts and protection of services as discussed in Section 10.

Risk	Description	Management
Culvert floatation	Risk of culvert flotation and damage to adjacent services.	Managed through design of culverts. Suitable factor of safety has been achieved.
Construction risks		
Soft ground	Potential for soft ground.	Contractor's safety plan to include risk of soft ground and management options. Contingency plan to allow remediation if ground is softer than assumed.
Obstructions	Chance of hitting buried tree trunks / logs as observed in the area.	Contractor to allow for contingency plan if obstructions are encountered. Designer has considered this risk and have contingency measures to manage this this outcome.
Flooding	Risk of heavy rainfall event during construction and excavation flooding	Contractor to include a contingency plan in their construction management plan on how to address risk of flooding during excavation. Erosion and Sediment Control plan includes a bund around the excavation to mitigate this.
Access	Construction access issues	Contractor to liaise with Auckland Council regarding access, to understand the access constraints and include in their methodology how these will be considered.
Operation risks		
Safety	A number of safety risks exist within the Awakeri Wetlands corridor – open water, trips and fall hazards.	Mitigated through design as per Section 13 and proposed corridor maintenance as part of the O&M.
Flooding	Flooding risks are possible if the channel planting is not maintained; as overgrown vegetation can reduce the capacity of the channel.	Include regular maintenance of plants within the Operation and Maintenance Plan.
Culvert blockage	Risk of culverts blocking.	The culverts should be inspected and maintained in accordance with Auckland Council's Operation and Maintenance schedule to remove any small blockages or material deposited within the culvert that could accumulate and increase the blockage potential compared to the design assumptions.
Channel scour and erosion	There is a risk of scour and erosion in the channel, undercutting of structures and instability of slopes.	Managed through a risk based approach and monitoring as discussed in Section 6.
Long term settlement	Effect of settlement upon structures, adjacent land, property and buildings.	Risk of settlement post construction due to groundwater dewatering has been considered as part of the Awakeri Wetlands Northern Extension resource consent application. This considers long-term groundwater dewatering as part of the overall scheme. Monitoring and mitigation if required will be carried out in accordance with the GSMCP.

Risk	Description	Management
Water balance	Risk of no flow through fish passage and water level dropping during extended dry periods.	On-going monitoring of water levels, especially during dry periods. Make up water can be designed to recharge the system if required.

15. Conclusion and monitoring

The proposed Stage 1 Awakeri Wetlands will extend from 181 Walters Road in the north to 91 Grove Road in the south (Northern channel), and includes part of the main channel between Cosgrave Road and Grove Road.

In general the conveyance channel will provide stormwater servicing for future development of Areas 2A, 2B and part of Area 4 (2B4) of the Takanini Structure Plan and the Mill Road Block area. At present the area is significantly impacted by the 1% AEP (Annual Exceedance Probability) floodplain, restricting development of the area. The Awakeri Wetlands will reduce the extent of the floodplain within the Awakeri Wetlands catchment to facilitate development of the land.

Development of the Awakeri Wetlands catchment area will increase peak flows from the catchment. The proposed Awakeri Wetlands will direct the increased flows up to the 1% AEP event to the discharge location at the proposed Grove Road Box Culvert.

Stage 1 of the Awakeri Wetlands will consist of:

- 1.2 km of open waterway.
- Depth of 1.9 m to 4.0 m below ground level.
- Notional overall gradient of the channel invert of approximately 0.2%.
- Overall total width (of the 1% AEP level) ranging from 13 m to 39 m.
- 1.3 km of footpath.
- 290 m of boardwalk.

The channel is designed with a meandering low flow series of discrete water bodies or wetlands with a permanent water depth of about 0.2-1.2 m controlled by sheet pile weirs at notional 100 m centres longitudinally along the base of the channel. These provide an ecological benefit and limit the ground water drawdown. Generally the low flow channel will have a of 3-6 m wide base with slope batters 2H:1V, with an intermediate wetland bench and upper 4H:1V riparian planted slopes.

There are two existing future crossings included:

- Twin 3 m x 2 m box culverts on the Northern Channel at Chainage 300.
- Twin 2 m x 1.5 m box culverts on the Northern Channel at Chainage 700.

The proposed Awakeri Wetlands will provide an effective drainage solution for the Awakeri Wetlands catchment.

15.1 Monitoring

The following recommendations are proposed.

Table 27 outlines the monitoring recommendations for the Awakeri Wetlands.

Table 27 Monitoring recommendations

Monitoring	Details	Frequency
Scour and erosion	Monitoring of the channel banks during construction to determine areas of fibrous peat or particularly soft areas within the 10% AEP extent. Scour protection as per the typical details on drawing 51-33411-C216 should be installed in these areas during construction.	On-going during construction.
	Monitoring of the channel banks post-construction, particularly around the edges of the low flow channel should be carried out to determine whether any areas are degrading over time. If scour is observed, then these areas should be remediated with the typical details on drawing 51-33411-C216. Budget should be allowed for retrofitting some areas of the channel.	6 monthly following construction of the channel for 5 years and after storm events, then on-going as part of the standard channel maintenance as per the O&M Manual.
Water level monitoring	Monitoring of the low flow water level in the channel. The water level in the channel should be maintained at the weir level to provide a healthy environment for wetland plants, aquatic life and to control groundwater levels.	On-going as part of the standard channel maintenance as per the O&M Manual.
Water chemistry	The water chemistry of the channel should be monitored as per the Acid Sulphate Soils (ASS) Management Plan.	As per the ASS management plan.
Groundwater and settlement	Groundwater and settlement monitoring should be carried out in accordance with the GSMCP before, during and after construction.	As per the GSMCP.

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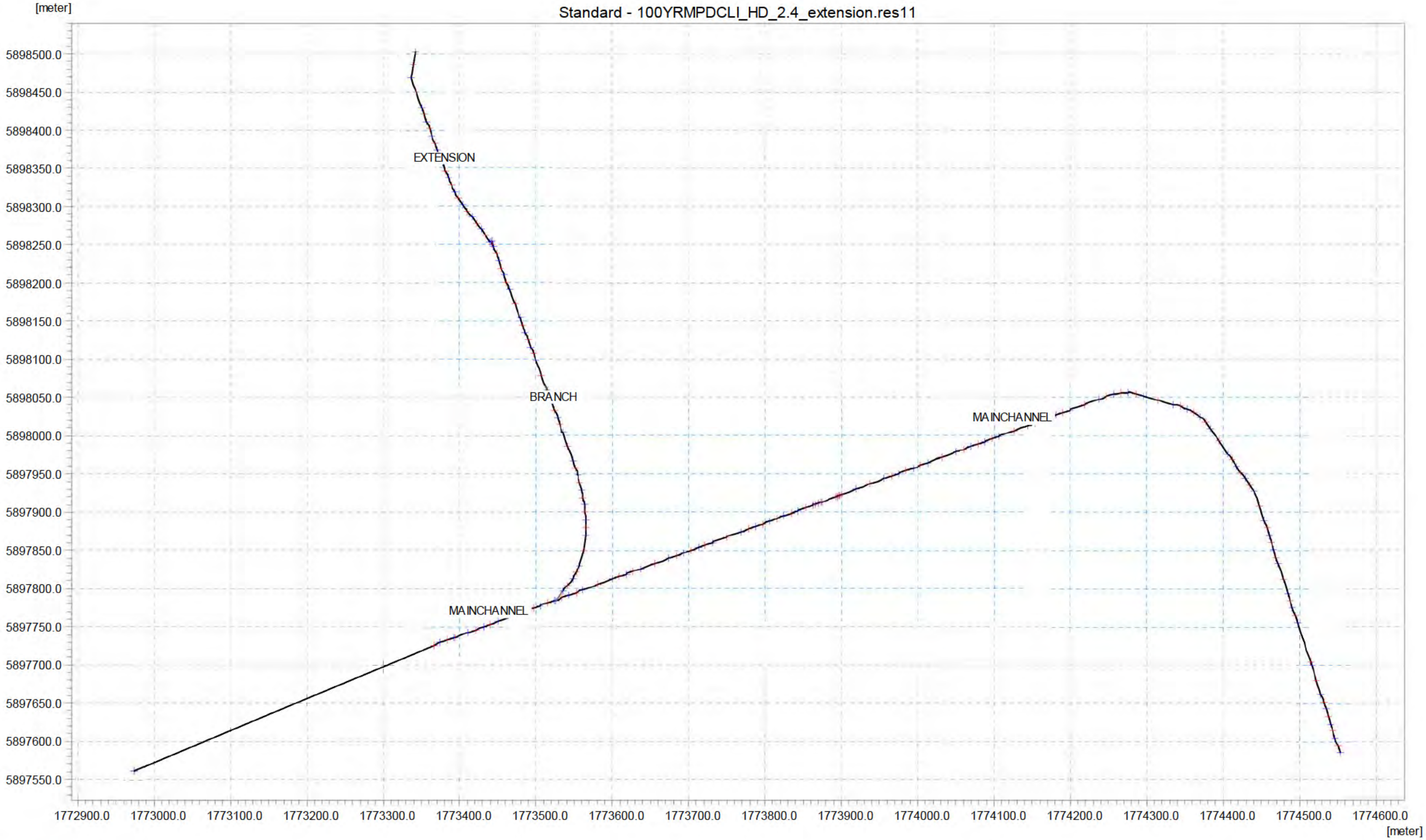
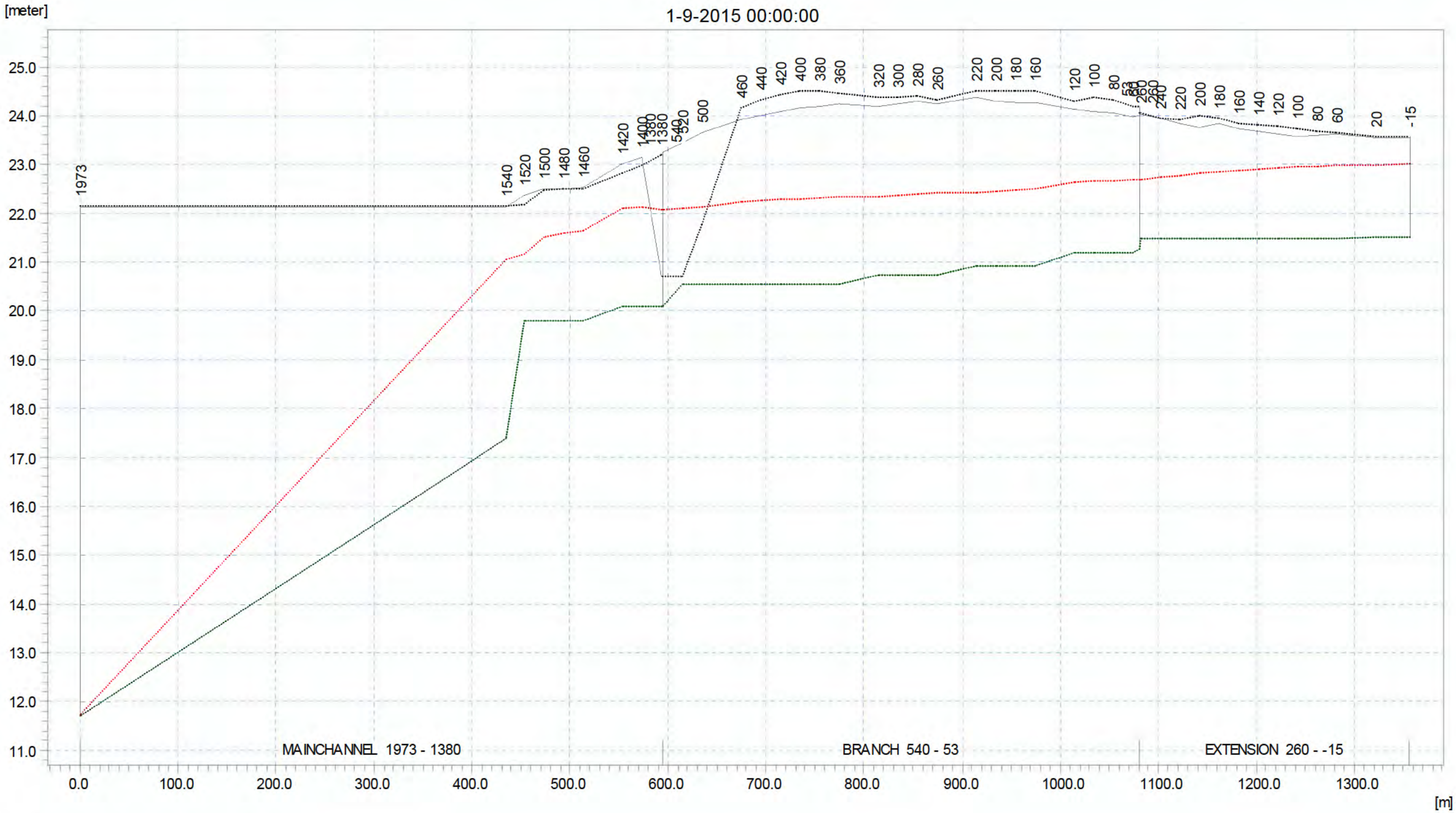
Appendices

Appendix A - (MIKE11 Model)



MIKE11 Model alignment



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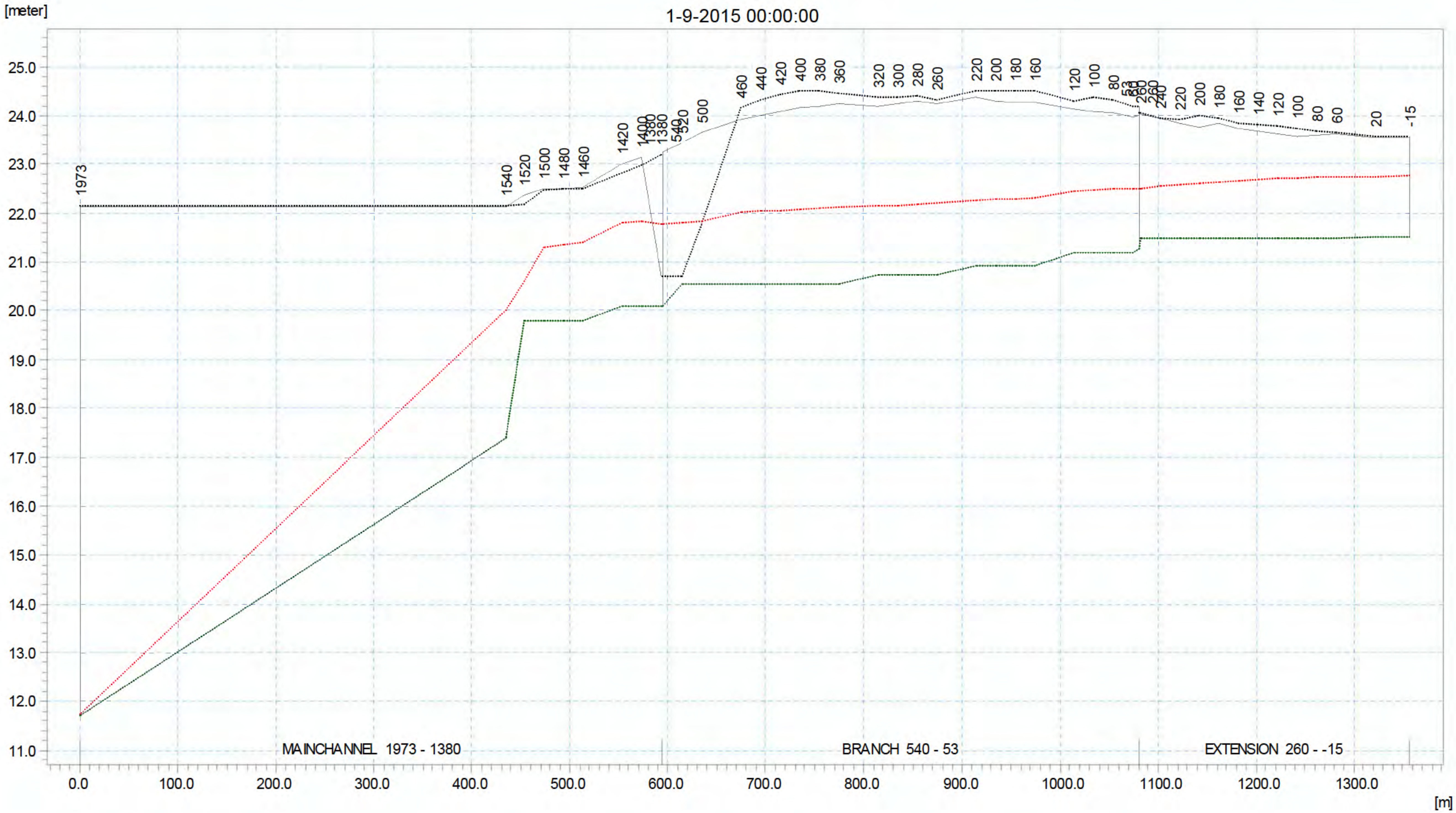
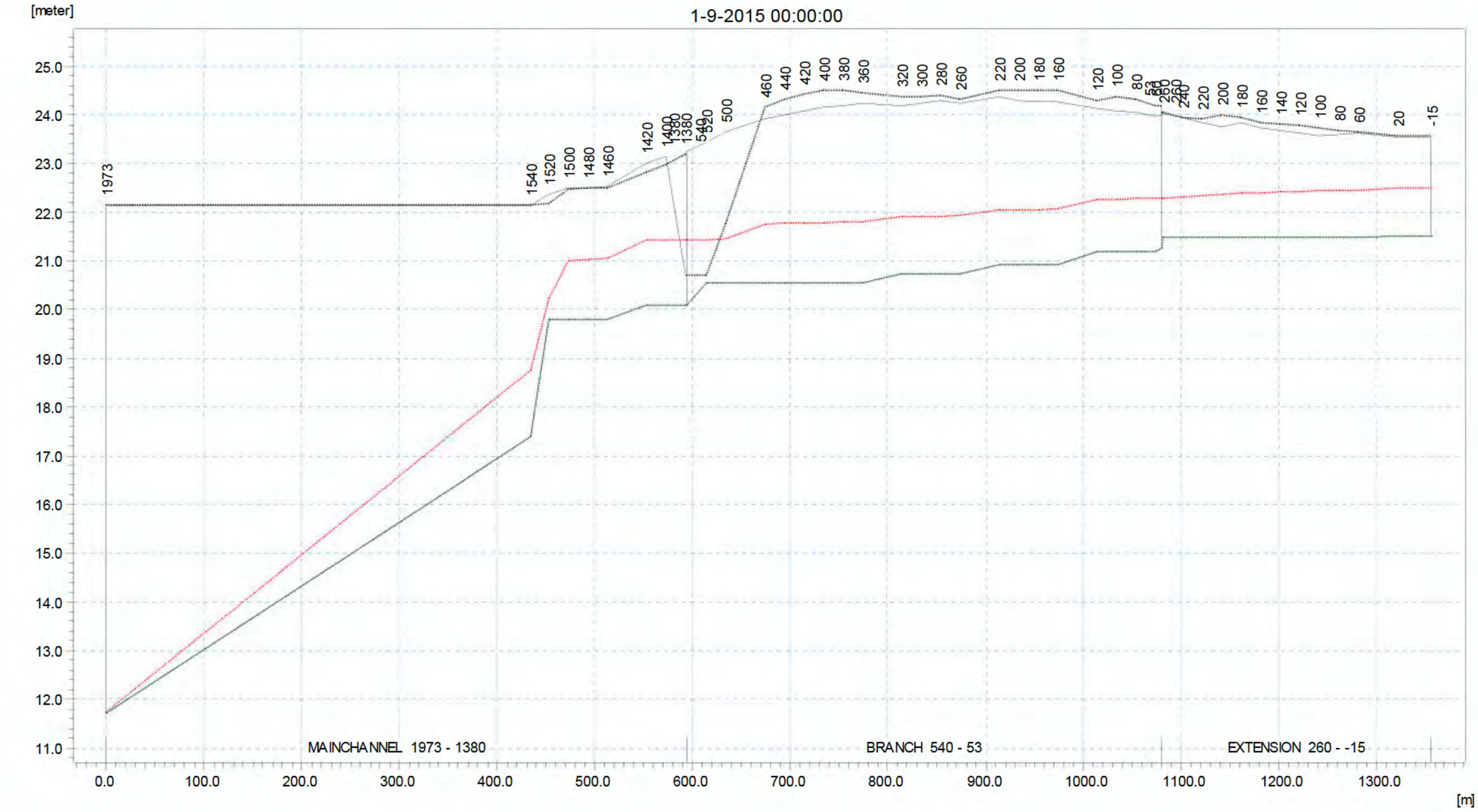
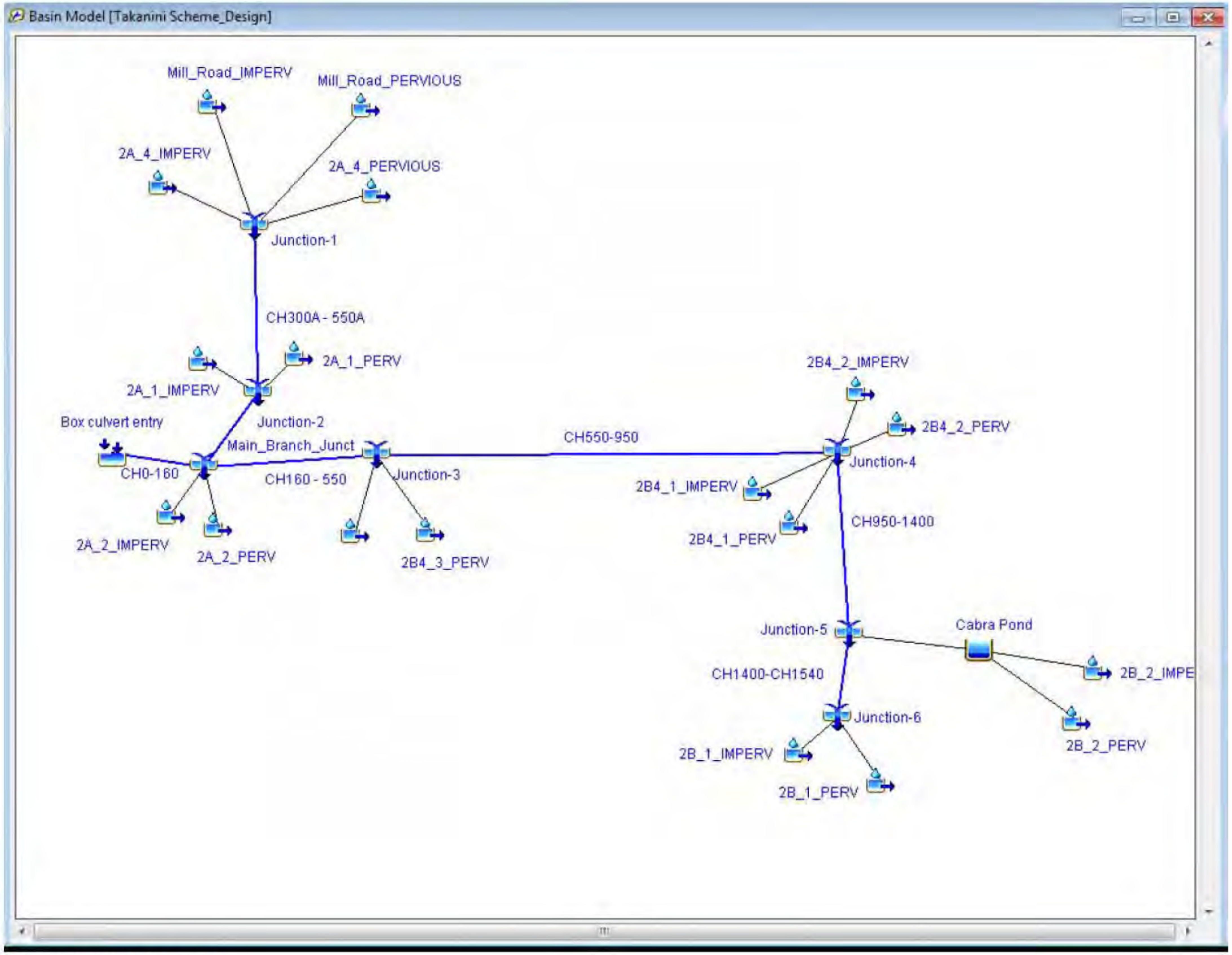


10% AEP – Northern Branch and Extension



50% AEP – Northern Branch and Extension

Appendix B - (HEC-HMS Model)



HEC-HMS – Model Alignment

Global Summary Results for Run "Run 1"

Project: Takanini - Northern Extensi   Simulation Run: Run 1

Start of Run: 01Jan2000, 00:00   Basin Model: Takanini Scheme_Design
End of Run: 02Jan2000, 00:00   Meteorologic Model: Met 1_100yr
Compute Time: 27Nov2016, 18:30:32   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: MM / 1000 M3   Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
2B_2_IMPERV	0.1245000	4.8	01Jan2000, 12:05	255.73
2B_2_PERV	0.0939550	2.4	01Jan2000, 12:11	182.36
Cabra Pond	0.2184550	3.5	01Jan2000, 12:25	199.11
2B_1_IMPERV	0.0948250	3.5	01Jan2000, 12:06	255.62
2B_1_PERV	0.0556910	1.4	01Jan2000, 12:13	184.25
Junction-6	0.1505160	4.7	01Jan2000, 12:07	229.21
CH1400-CH1540	0.1505160	4.7	01Jan2000, 12:11	228.97
Junction-5	0.3689710	8.1	01Jan2000, 12:11	211.29
CH950-1400	0.3689710	8.1	01Jan2000, 12:20	210.67
2B4_2_IMPERV	0.1806022	6.3	01Jan2000, 12:08	255.46
2B4_2_PERV	0.1060700	2.4	01Jan2000, 12:16	183.98
2B4_1_IMPERV	0.0506018	2.0	01Jan2000, 12:05	255.76
2B4_1_PERV	0.0337345	0.9	01Jan2000, 12:10	184.50
Junction-4	0.7399795	17.3	01Jan2000, 12:13	219.67
CH550-950	0.7399795	17.3	01Jan2000, 12:19	219.27
2B4_3_IMPERV	0.1249192	4.6	01Jan2000, 12:06	255.63
2B4_3_PERV	0.0733652	1.8	01Jan2000, 12:13	184.27
Junction-3	0.9382639	21.8	01Jan2000, 12:18	221.37
CH160 - 550	0.9382639	21.8	01Jan2000, 12:24	220.97
Mill_Road_IMPERV	0.1143000	3.5	01Jan2000, 12:12	255.03
2A_4_IMPERV	0.0694320	2.5	01Jan2000, 12:07	255.54
Mill_Road_PERVIOUS	0.0490000	1.1	01Jan2000, 12:18	183.84
2A_4_PERVIOUS	0.0297560	0.7	01Jan2000, 12:15	184.09
Junction-1	0.2624880	7.4	01Jan2000, 12:11	233.83
CH300A - 550A	0.2624880	7.4	01Jan2000, 12:15	233.57
2A_1_IMPERV	0.2058660	7.3	01Jan2000, 12:07	255.52
2A_1_PERV	0.0882280	2.1	01Jan2000, 12:15	184.08
Junction-2	0.5565820	16.0	01Jan2000, 12:11	233.85
CH0A-CH300A	0.5565820	16.0	01Jan2000, 12:17	233.45
2A_2_IMPERV	0.0724208	3.0	01Jan2000, 12:03	255.84
2A_2_PERV	0.0389958	1.1	01Jan2000, 12:08	184.67
Main_Branch_Junct	1.6062625	39.1	01Jan2000, 12:18	225.98
CH0-160	1.6062625	39.1	01Jan2000, 12:19	225.92
Box culvert entry	1.6062625	39.1	01Jan2000, 12:19	225.92

HEC-HMS results – 1% AEP event

APPENDIX 12 – Auckland Council 2019 McLennan Wetland Spillway Assessment

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Official Height Standard Change

From 1 July 2024, Auckland Council adopts the official height standard for New Zealand called New Zealand Vertical Datum 2016 (NZVD2016).

This model was carried out prior to the height standard change.

All levels included in this modelling report are in Auckland Vertical Datum 1946 (AUK1946/AVD1946).

Levels in this report can be transformed from Auckland Vertical Datum 1946 into New Zealand Vertical Datum 2016 by applying an offset value of 0.282 m.

For example:

$$H_{NZVD2016} = H_{AVD1946} - \text{Offset Value}$$

A single offset value for the catchment has been taken from the Land Information New Zealand (LINZ) Auckland 1946 to NZVD2016 Conversion Raster therefore this offset should be taken as an approximation only for the catchment.

A more accurate height transformation value can be derived by downloading the conversion raster available on the LINZ website below:

https://data.linz.govt.nz/layer/103953-auckland-1946-to-nzvd2016-conversion-raster/

REPORT

McLennan wetland spillway options modelling

Prepared for
Auckland Council
Prepared by
Tonkin & Taylor Ltd
Date
June 2021
Job Number
1012030.1040

Exceptional thinking together
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Document Control

Title: McLennan wetland spillway options modelling					
Date	Version	Description	Prepared by:	Reviewed by:	Authorised by:
03.06.2021	1	DRAFT report	JMOR	SGB	-
29.06.2021	2	Final report	JMOR	SGB	TSRF

Distribution:

Auckland Council 1 electronic copy

Tonkin & Taylor Ltd (FILE) 1 electronic copy

Table of contents

1 Introduction and background

Tonkin & Taylor Ltd (T+T) was engaged by Auckland Council to identify an optimum spillway level at McLennan wetland, to enable the Artillery Drive Stormwater Tunnel (ADST) to perform as per design. The McLennan wetland spillway in this study refers to the above ground spillway from the upper to the lower wetland. The McLennan wetland sub-catchment is located within the Pahurehure inlet stormwater administrative catchment.

The ADST was built in 2017 to facilitate growth in the catchment upstream of McLennan wetland without increased flood risk to downstream properties. One of the design objectives of the ADST was to prevent the spillway from the upper McLennan wetland storage area being activated in a 1% Annual Exceedance Probability (AEP) rainfall event, including allowance for climate change (CC) and Maximum Probable Development (MPD)[1]. The ADST was designed assuming a wetland spillway level of 15.4 m RL, but the current crest level of the spillway is 15.1 to 15.2 m RL[2].

All levels reported (RL) in this study are in terms of Auckland Vertical Datum 1946.

1.1 Study objectives and scope

The objective of this study is to inform the required upper McLennan wetland spillway height and the resulting flood effects from any raising of the spillway.

The scope of this study was as follows:

- Build a flood model of the McLennan wetland sub-catchment, to an appropriate level of detail to meet the study objective. Representing an MPD scenario in the catchment, incorporating best available data on constructed and planned upstream works (conveyance structures and future land use).
- Assess the MPD baseline scenario at the McLennan wetland including sensitivity analysis on two hydraulic parameters.
- Determine an appropriate upper McLennan wetland spillway height including assessment of flood effects associated with raising the spillway.

1.2 Background

1.2.1 Catchment

A catchment map is presented in Figure Appendix A.1. The catchment upstream of Grove Road is zoned 'Residential – mixed housing suburban zone', 'Future Urban Zone' and 'Residential – Single House Zone'[3]. To facilitate the anticipated growth in these areas numerous stormwater infrastructure projects have been completed or are being designed including the Awakeri wetland conveyance channels, The Grove Road Culvert, and the ADST and associated works at McLennan wetland.

The catchment topography is very flat, particularly upstream of McLennan wetland and therefore raising of the spillway at the wetland has potential to incur backwater flood effects.

1.2.2 McLennan wetland

Figure 1.1 shows the layout of McLennan wetland and the key hydraulic structures. Flows are discharged to the wetland through numerous stormwater pipes, the largest being the Grove Road

[1] Artillery Drive Stormwater Tunnel, Detail design report for client review. Jacobs. 14 November 2014.
[2] McLennan Dam Survey crest levels "topo160517_nztm.shp", Provided by Auckland Council.
[3] Auckland Unitary Plan Operative in part (15 November 2016) Update 9 April 2021 planning maps viewer. https://unitaryplanmaps.aucklandcouncil.govt.nz/upviewer/

culvert which discharges flows from the Awakeri wetland conveyance channels in the upstream catchment.

The upper McLennan wetland is connected to the lower wetland by a 1350 mm diameter pipe. It is understood from discussion with Auckland Council that the existing 950 mm orifice at this pipe will be further throttled to a 200 mm orifice, with the permanent water level in the pond being maintained at 11.30 m RL.

Flood flows are attenuated within the upper wetland and drained by the ADST which has two inlet structures[4]:

- A low-flow 1050 mm diameter scruffy dome at 11.7 m RL. Connected to the ADST with a 450 mm diameter 3.5 m length pipe.
- A bellmouth weir scruffy dome at 12.7 m RL into the 2500 mm diameter tunnel.

At 14.2 m RL flood flows spill into the adjacent sports field which provides further attenuation volume to the upper wetland. The spillway conveys any flows exceeding the total storage volume of the upper wetland and sports field to the lower wetland. The lower wetland is drained by two 900 mm diameter pipes.

Figure 1.1: McLennan wetland key hydraulic structures

1.2.2.1 McLennan spillway and embankment

Figure 1.2 shows the surveyed crest levels[5] of the spillway and embankment at McLennan wetland. The crest levels can be divided into three distinct sections:

[4] Artillery Drive Stormwater Tunnel: Operations and Maintenance Manual. Auckland Council Healthy Waters Design Office. Final Version 1.0. 19/07/2019.

[5] McLennan Dam Survey crest levels "topo160517_nztm.shp". Provided by Auckland Council.

1 The McLennan wetland spillway: Elevations across the spillway range from 15.07 to 15.39 m RL and then tie into the high ground at 15.7 m RL to the west of the spillway.

2 Embankment along Artillery Drive: Elevations range from 15.98 to 16.31 m RL.

3 Dip in Embankment / overland flowpath into the wetland at the junction of Artillery Drive and Maadi Place: Elevations range from 15.68 to 16.28 m RL.

Figure 1.2: McLennan wetland spillway and embankment crest levels

2 Methodology

2.1 Flood model

A flood model of the catchment was built in Mike Flood (Mike Urban, Mike 21, Mike 11)[6]. Details of the flood model build, and input data are recorded in the model review documentation in Appendix B. An ArcGIS map package is also provided with the flood model deliverables which contains the model schematisation and data record.

The flood model was reviewed by Auckland Council and approved for the purposes of this study after the initial review comments were addressed.

2.1.1 Boundary conditions

The hydrological inflows to the flood model are derived using the TP108 methodology. All simulations in this study include Maximum Probable Development (MPD) within the catchment and climate change (CC) applied to rainfall, as per the Stormwater Code of Practice[7]. The MPD impervious coverages were assigned using the latest Auckland Council modelling recommendations[8] and the Auckland Unitary Plan Operative in part[9].

[6] Model built and simulated in DHI software 2017 release.

[7] Auckland Council, November 2015. Code of Practice for Land Development and subdivision. Chapter 4 – Stormwater.

[8] Land use Zone Imperviousness for Hydraulic Modelling based on the Auckland Unitary Plan Operative in Part (AUP OiP), Auckland Council Memorandum 04/09/2019.

[9] Auckland Unitary Plan Operative in part (15 November 2016) Update 9 April 2021 planning maps viewer. https://unitaryplanmaps.aucklandcouncil.govt.nz/upviewer/

A constant downstream boundary of 2.34 m RL has been applied as requested by Auckland Council. This is the Highest Astronomical Tide (HAT) condition used in the design of the ADST[10].

2.1.2 Flood model assumptions and limitations

All model build assumptions are recorded in the review documentation in Appendix B and the ArcGIS map package. The main assumptions of note are:

- The flood model has been built as per the Auckland Council modelling specification where applicable, but it is not a detailed catchment model appropriate for floodplain mapping. The model has been schematised to represent an appropriate flood hydrograph and hydraulic detail at McLennan wetland to assess local flood effects. Therefore, the model only includes the primary trunklines of the stormwater network in the upper catchment.
- Hydrological soil groups D and C have been used to derive the pervious area curve numbers in the catchment. Auckland Council requested these soil groups were applied with regards to the high soil moisture content and peat.
- Soakage is present within the catchment but has not been included in the flood model following agreement with Auckland Council. It is understood that soakage in the catchment is primarily for peat recharge purposes, and it does not provide mitigation in high magnitude flood events.
- The proposed 200 mm orifice throttle on the 1350 mm diameter pipe connecting the upper and lower wetland has been included in the model as requested by Auckland Council during the peer review process.
- Assumptions associated with the representation of the ADST structures, as described in section 2.1.2.1 below.
- No debris blockage has been included in the upstream catchment stormwater system or the ADST structures. Debris blockage at the ADST has potential to reduce the efficiency of the structure and increase water levels in the upper Wetland.

A limitation of the flood model is that the majority of overland flowpaths are modelled using the 2016 LiDAR (unless specified) and these ground levels are subject to change as development in the catchment occurs. Modification to overland flowpaths in the catchment could impact the timing and shape of the flood hydrograph at McLennan wetland.

2.1.2.1 Artillery Drive Stormwater Tunnel representation

The ADST and inlet structures have been modelled using a discharge-stage (QH) relationship derived using spreadsheet calculations. The QH includes allowances for the tailwater condition and hydraulic losses at the inlets, outlet, pipe bends and roughness. A new QH relationship has been developed due to the following differences observed between the ADST as-built[11] and design drawings:

- The as-built drawings show that a 2500 mm internal diameter tunnel has been installed. The detailed design report, drawings, and calculations showed a 2470 mm internal diameter. The as-built tunnel therefore has an increased capacity compared with design.
- The as-built drawings and photos show that a low flow 1050 mm diameter scruffy dome has been installed at 11.7 m RL instead of the designed low flow slot in the main inlet structure, as shown in Figure 2.1.

[10] Artillery Drive Stormwater Tunnel, Detail design report for client review. Jacobs. 14 November 2014

[11] Artillery Drive Stormwater Tunnel: Operations and Maintenance Manual. Auckland Council Healthy Waters Design Office. Final Version 1.0. 19/07/2019

- The as-built drawings show that four 250 mm wide raised separator blocks are included on the bellmouth weir structure at 12.7 m RL (assumed to be for structural reasons). These separators impact the effective weir length of the structure, as shown in Figure 2.1.

Figure 2.1: ADST inlet structures. Images from Artillery Drive Stormwater Tunnel: Operations and Maintenance Manual.

Figure 2.2 shows the new QH relationship curve derived, and the QH curve from the previous 2016 assessment of the McLennan wetland[12]. The previous curve was based on dimensions in the design drawings.

The updated QH curve includes the low flow scruffy dome at 11.7 m RL and is shown to be more efficient (conveys more flow) at water levels greater than 13.75 m RL where the capacity of the tunnel dominates over the weir control at the inlet. The main reason for this improved efficiency is the increased internal diameter size (2470 to 2500 mm) of the 1.1 km length tunnel. The key stages of the baseline QH curve are described in Table 2.1

Ideally the hydraulics of the ADST would be verified through computational fluid dynamic (CFD) or physical modelling as they are complex, but this was not within the scope of this work. Sensitivity scenarios have been undertaken on the structures, as described in section 2.2.1.

[12] Assessment of McLennan Upper Wetland and Artillery Drive Tunnel Design Performance, 2016-09-21, Auckland Council.

Table 2.1: Key stages of the updated QH curve for the ADST and inlet structures

Water level / H (m RL)	Hydraulics / Q
11.3 – 11.7	No flow entering ADST
11.7 – 12.7	Flow entering ADST through low flow scruffy dome only (Weir control up to 11.94, then pipe control)
12.7 -13.8	Flow enters ADST via Bellmouth weir and low flow scruffy dome (both under Weir control). The as-built drawings of the ADST show that four 250 mm wide raised separator blocks are included on the bellmouth weir structure at 12.7 m RL (as shown in Figure 2.1). These separators reduce the effective weir length of the structure. The separators have been included at all elevations above 12.7 m RL (where weir control is dominant) in the QH. In reality the hydraulics become very complex when the water level exceeds the top of the separators (13.0 m RL) as multiple weir structures of different type, crest level, and orientation will become active. A sensitivity scenario was set up with the separators completely removed from the structure (sensitivity scenario 1), as described in section 2.2.1.
13.8 – 13.91	At 13.8 m RL the low flow scruffy dome and connection is fully drowned and becomes ineffective / negligible. The bellmouth weir remains under weir control.
13.91 – 15.6	The capacity of the ADST becomes the dominant control. The bellmouth weir is transitioning from weir to orifice control.
15.6 >	The bellmouth weir inlet structure is under full orifice flow conditions. The hydraulic losses at the inlet are adjusted accordingly to account for orifice flow throttling and an additional bend loss under orifice conditions.

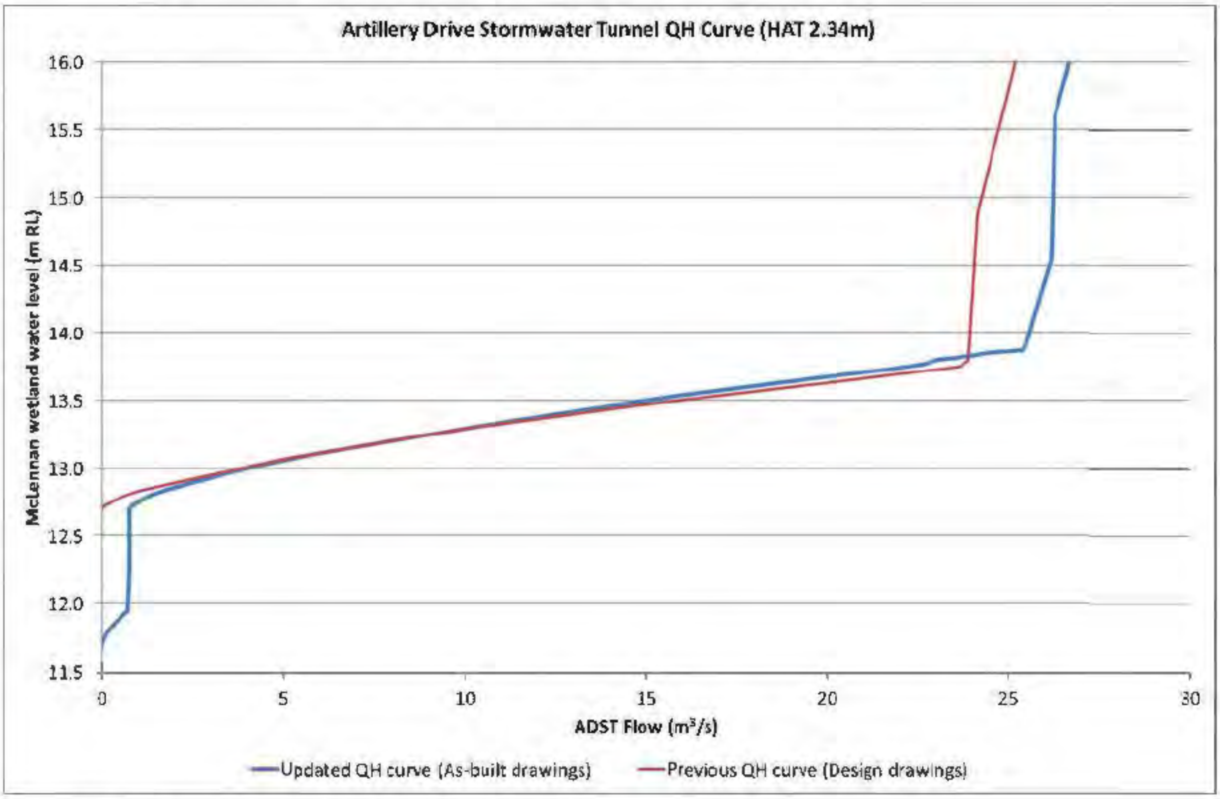


Figure 2.2: Updated and previous QH curves for ADST and inlet structures.

2.2 Scenarios modelled

2.2.1 Baseline and sensitivity

Baseline scenarios were modelled for the 10 and 100 year ARI MPD CC events. Sensitivity scenarios on the ADST and the wetland spillway are described in Table 2.2 below. Sensitivity scenarios 1 and 2 impact the QH curve used to represent the ADST, as shown in Figure 2.3.

Table 2.2: Sensitivity scenarios modelled

Scenario	Description
1	Removal of 250 mm separator structures from Bellmouth weir structure: The as-built drawings show that four 250 mm wide raised separator blocks are included on the bellmouth weir structure at 12.7 m RL. These separators reduce the effective weir length of the structure. The hydraulics are complex when the water level exceeds the top of the separators (13.0 m RL) as multiple weir structures of different type, crest level, and orientation will become active. In the updated baseline QH curve the separators are included at all elevations above 12.7 m RL (where weir control is dominant). A sensitivity analysis has therefore been completed on the QH curve where these separator structures are fully removed (full diameter of bellmouth at 12.7 m RL is used in weir equation) to understand the uncertainty of the complex hydraulics described above.
2	Manning's roughness of Artillery tunnel increased from 0.012 to 0.015. Deterioration of pipe wall roughness values can occur overtime due to slime/grime growth, barnacles, sedimentation, weathering, and debris accumulation.
3	Weir coefficient on McLennan spillway reduced to 1.28 (20% reduction to 1.6 value used in baseline).
4	Weir coefficient on McLennan spillway increased to 1.92 (20% increase to 1.6 value used in baseline).

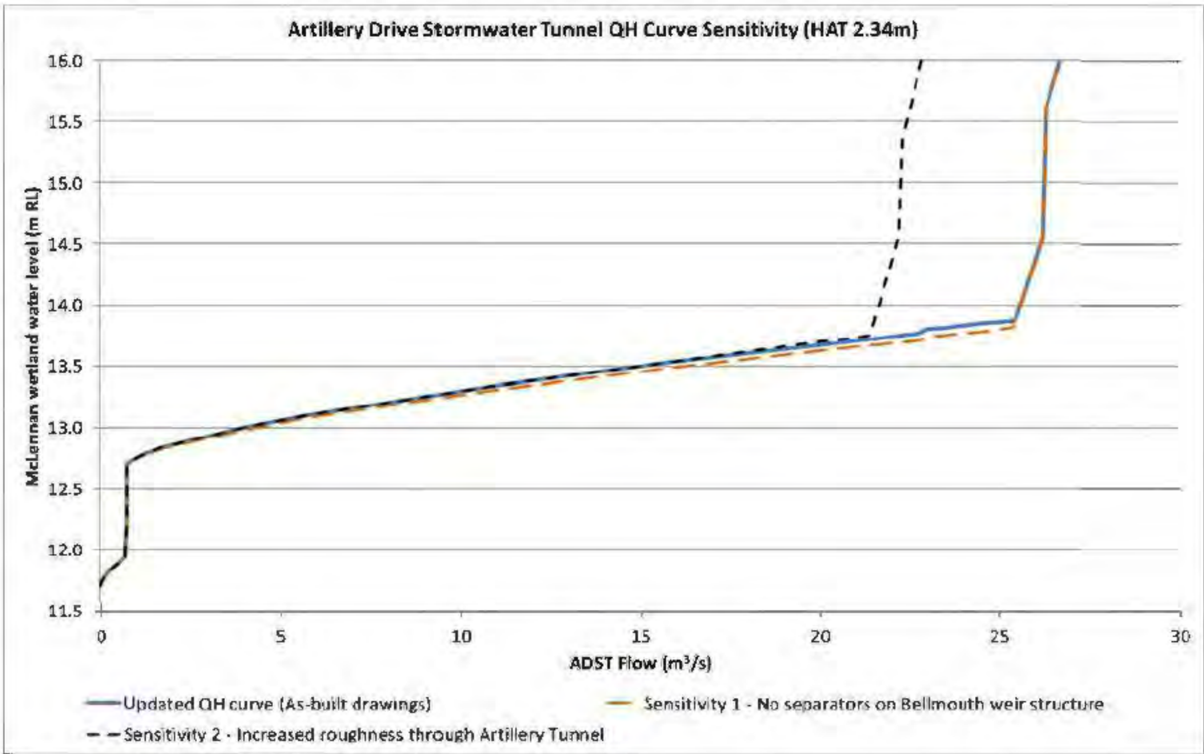


Figure 2.3: QH curves for ADST: sensitivity scenarios 1 and 2.

2.2.2 Options

Raised spillway options modelled are described in Table 2.3.

Table 2.3: Option scenarios modelled

Option scenario	Description
1	All three sections of the spillway and embankment shown in Figure 1.2 raised to a high value of 25 m RL. This is a 'modelled elevation' rather than a proposed spillway height, to establish the peak water level within the wetland when flow over the spillway and embankment is restricted.
1b	Option scenario 1 described above with sensitivity scenario 2 applied (Manning's roughness of Artillery tunnel increased from 0.012 to 0.015).
2	Crest levels raised to 15.68 m RL at the spillway. This is the maximum level the spillway could be raised to without causing an obstruction or backwater effects to the overland flowpath into the wetland at the junction of Artillery Drive and Maadi Place (section 3 in Figure 1.2).
2b	Option scenario 2 described above with sensitivity scenario 2 applied (Manning's roughness of Artillery tunnel increased from 0.012 to 0.015).

3 Results

Results are summarised in Table 3.1. Flood extent figures are shown in Appendix C. Time series of modelled water levels in the upper McLennan wetland are shown in Figure 3.1 and Figure 3.2.

Baseline results show that 0.48 m^3/s overtops the spillway in the 100 year ARI event (no freeboard to the existing spillway level). The ADST inlet structure and spillway coefficient sensitivity (scenarios 1, 3, and 4) resulted in only minor differences in water level in the upper wetland (≤ 0.01 m).

The performance of the ADST is shown to be sensitive to hydraulic roughness (sensitivity scenario 2) and this highlights the importance of regular maintenance of this asset to ensure good hydraulic conditions are retained. Figure Appendix C.3 shows increased flood levels occur in McLennan Park and on the Artillery Drive road, but no increases in flood level > 0.05 m are observed on private properties.

The overland flowpath into the wetland at the junction of Artillery Drive and Maadi Place has a peak flow of 2.1 m^3/s and 1.1 m^3/s in the 100 and 10 year ARI events respectively. In option scenario 1 this overland flowpath is obstructed by the raised embankment. The obstruction to this flowpath results in a lower peak water level (compared to baseline) of 15.06 m RL in the upper wetland as approximately 8,300 m^3 volume of flow cannot discharge into the wetland. The obstruction to the flowpath results in negative flood effects to properties on Artillery Drive and Old Wairoa Road, as shown in Figure Appendix C.4.

Option scenario 2 shows that raising the spillway to 15.68 m RL does not have a negative flood effect as the peak water level increase in the wetland is < 0.01 m. With option scenario 2b (includes increased roughness in the ADST) the peak water level in the wetland of 15.48 is below the 15.68 m RL. Appendix Figures C.5 to C.7 show that option scenario 2 does not increase flood levels outside of McLennan Park, even with increased roughness applied to the ADST.

Table 3.1: Summary of modelled results

Event (ARI MPD CC)	100 year									10 year
Scenario	Baseline	Baseline Sensitivity				Option Scenario				Baseline
		1	2	3	4	1	1b	2	2b	
Peak water level in upper McLennan wetland (m RL)	15.17	15.16	15.36	15.17	15.17	15.06	15.36	15.17	15.48	14.36
Freeboard to current spillway level (15.07 m RL)	-0.10	-0.09	-0.29	-0.10	-0.10	0.01	-0.29	-0.10	-0.41	0.71
Peak flow Artillery Drive Stormwater Tunnel (m^3/s)	26.26	26.26	22.30	26.26	26.26	26.25	22.30	26.26	22.41	26.00
Peak flow over spillway (m^3/s)	0.48	0.32	6.04	0.50	0.50	0.00	0.00	0.00	0.00	0.00
Duration for water level above existing spillway level* (hours:minutes)	0:52	0:47	1:44	0:53	0:52	0:00	1:54	0:53	2:14	0:00

**Duration reported as time water level exceeds 15.07 m RL (lowest crest level of existing spillway). In the option scenarios, where the water level exceeds 15.07 m RL there is no flow over the spillway as it has been raised.*

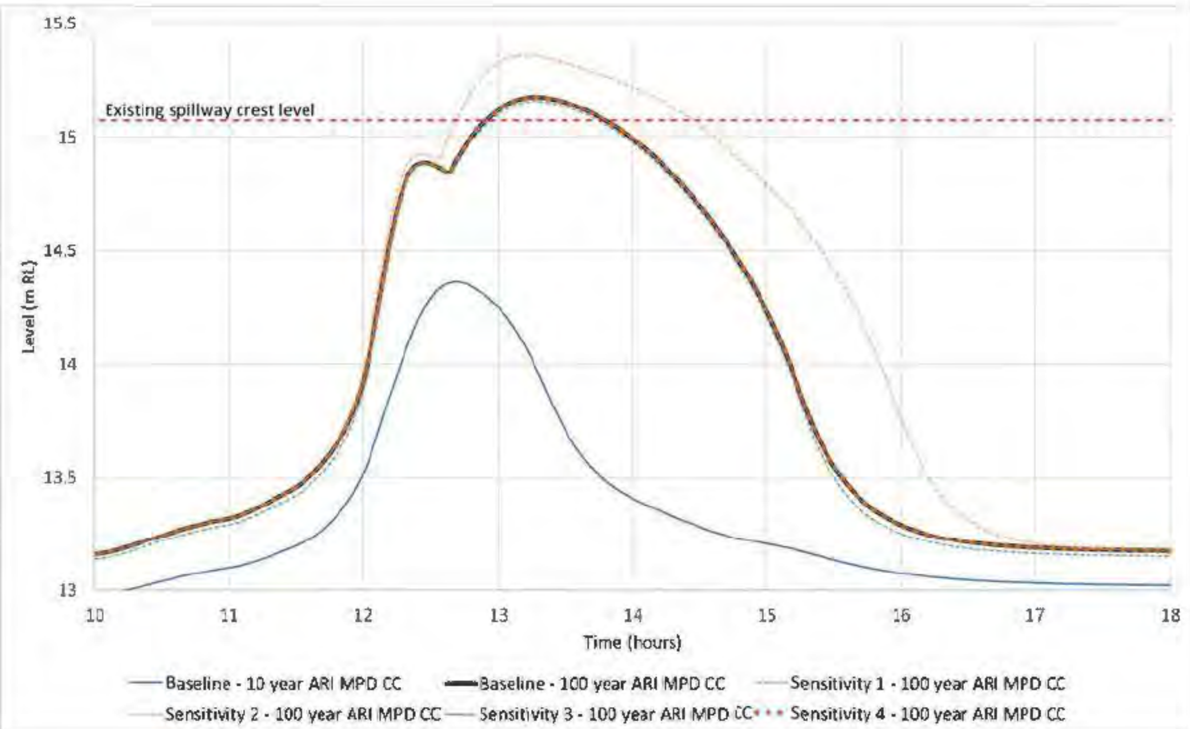


Figure 3.1: Water level in upper McLennan wetland. Baseline and sensitivity scenarios.

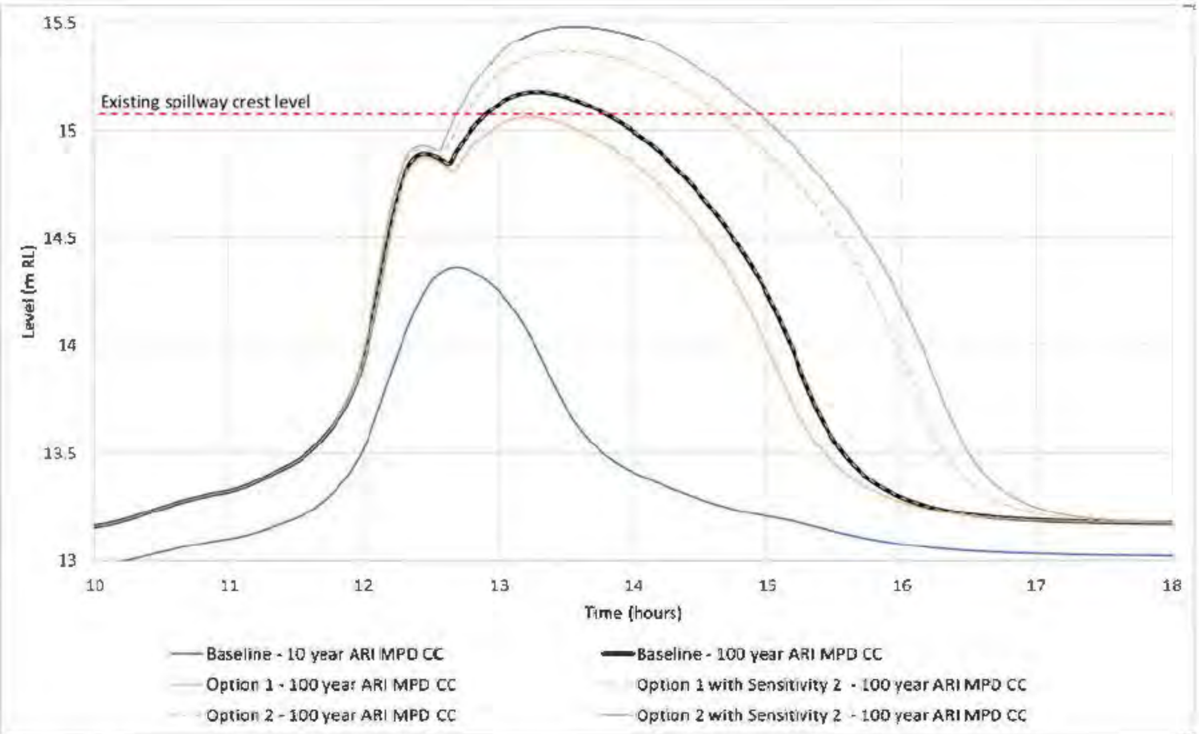


Figure 3.2: Water level in upper McLennan wetland. Option scenarios.

4 Conclusions and recommendations

A flood model has been built using the latest available survey and design data to represent an appropriate flood hydrograph and hydraulic detail at McLennan wetland to assess flood effects associated with potential raising of the spillway.

Results from the study show:

- In the 100 year ARI MPD CC rainfall event the peak water level in the upper wetland is 15.17 m RL which is 100 mm above the lowest crest level of the existing spillway. Potential deterioration of the ADST pipe wall overtime means that hydraulic roughness values could increase this peak level to 15.36 m RL.
- Raising the spillway and embankment above 15.68 m RL has negative flood effects as an overland flowpath into the wetland at Maadi Place becomes obstructed preventing flood flows from entering the wetland and causes flooding in areas not flooded previously.
- Raising the spillway and embankment up to a level of 15.68 m RL does not result in increased flood levels (greater than 0.05 m) outside of McLennan Park, even with an increased roughness applied to the ADST.

Recommendations from this study are:

- The spillway is raised to a minimum level of 15.48 m RL. The spillway could be raised to a lower level of 15.17 m RL provided that the existing pipe wall roughness of the ADST is retained through regular inspection and maintenance. The operations and maintenance manual for the ADST[13] does not currently specify a maintenance plan for this.
- Raising the spillway above 15.68 m RL is not recommended as this will cause backwater effects and/or obstruction to the flowpath into the wetland at Maadi Place. Alternatively, the

[13] Artillery Drive Stormwater Tunnel: Operations and Maintenance Manual. Auckland Council Healthy Waters Design Office. Final Version 1.0. 19/07/2019.

overland flowpath could be diverted away from the wetland and managed with upgrade works to the stormwater network or flowpaths to the east of the wetland. This scenario has not been assessed.

- The required freeboard and any modifications to the wetland structures should be in accordance with the latest New Zealand Society on Large Dams (NZSOLD) and other relevant guidelines.
- This study is a hydraulic / flood assessment only and other potential effects associated with raising the spillway (structural, aesthetic, public access impacts for example) have not been considered.
- Computational fluid dynamic (CFD) or physical modelling of the ADST and associated inlet structures would verify the accuracy of the estimated capacity of the structures. In particular at the stages where complex hydraulics occur at the bellmouth (spilling over the four separator blocks in the structure) and when the inlet structure transitions from weir to orifice control.
- The majority of overland flowpaths in the flood model use 2016 LiDAR (unless otherwise specified) and these ground levels are subject to change as development in the catchment occurs. It is recommended that any proposed modification to overland flowpaths in the catchment are assessed (or implemented into the flood model) to ensure the impact on the timing and shape of the flood hydrograph at McLennan wetland is realised. Alternatively, a future terrain model scenario can be developed to represent development ground levels and any resulting impacts on flood hydrograph timing and shape.

5 Applicability

This report has been prepared for the exclusive use of our client Auckland Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:	Report reviewed by:
....	....
James Mogridge	Sarah Basheer
Water engineer and modeller	Project Manager

Authorised for Tonkin & Taylor Ltd by:

....

Tim Fisher

Project Director

JMOR
p:\1012030\1012030.1040 mclennan wetland spillway\issueddocuments\2021-06-30 final report\1012030.1040-rpt-mclennan_wetland_spillway_options-2021-06-30.docx

Appendix A: Catchment background

Figure Appendix A.1: Catchment map MPD

NOTES:
Basemap: Land use map created using Auckland Unitary Plan
This figure has been prepared for Auckland Council with respect to the particular brief given to Tonkin + Taylor for the study. The supporting information, methodology and assumptions adopted in the development of the figures can be found in the McLennan wetland spillway options report (2021). Auckland Council and Tonkin + Taylor do not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	JMOR	SGB	25/05/21

LOCATION PLAN

PROJECT No. 1012030.1040
DESIGNED JMOR JUN.21
DRAWN JMOR JUN.21
CHECKED SGB JUN.21
APPROVED DATE

CLIENT AUCKLAND COUNCIL
PROJECT MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING
TITLE CATCHMENT MAP (MPD)
SCALE (A3) 1:12,500 FIG No. FIGURE A.1 REV 0

Appendix B: Flood Model Review

- Auckland council model review documentation

Auckland Council Model Review

Section 1 - Model Metadata

General Model Info	
Main Consolidated SW Catchment:	**Pahurehure Inlet**
Council Project Manager	Carmel O'Sullivan / Danny Curtis
Other SW Catchment within Model Extent:	-
Other relevant SW Catchment for model inputs:	-
Model Name:	McLennan spillway options - baseline MPD model
Model Horizon ID:	
Model Software, AND Version:	DHI 2017 (Mike Urban, Mike 21, Mike 11)
Type of Model:	Framework Model (FWM)
Model Created By	James Mogridge (Tonkin and Taylor)
Is this model an update based on a previous model?	No
Is the model built as per the SW Modelling Specs?	NO
Model Description:	Model has been schematised to represent an appropriate flood hydrograph at McLennan Wetland with an appropriate level of detail around the wetland to assess flood effects following potential spillway raising options. Refer to the model purpose and objectives below. The model therefore only includes the primary pipe trunklines (generally these are pipes greater than or equal to 900mm in diameter), key connectivity pipes and pipes that may affect hydraulics at the McLennan wetland. The model has been built as per the SW modelling specs where appropriate, noting that some elements of the spec are not applicable to this model (including all pipes >=300mm, maximum sub-catchment size etc.) The flood model topography, assets and hydrology represent a 'future base scenario' MPD, incorporating the design of the upstream works (where as-built or design topo is known/available) related to conveyance channels (Awakeri wetlands and Kauri Flats conveyance channels/wetlands) and future land use as per the Unitary Plan.
Model Purpose / Objectives:	Options models to identify an optimum spillway level to enable the Artillery Tunnel to perform as per design. Model to identify resulting flood effects and hydraulics from a raised spillway level. This project is required to facilitate the continued upstream development of the Takanini area in line with the Healthy Waters preferred stormwater management approach. Currently the McLennan wetland spillway is set too low to allow for the effective operation of the constructed Artillery Drive Tunnel. As a response there is increased flood risk to properties downstream of the wetland during a high return period event.
Limitations specific to this model:	There are areas of development which post-date the 2016 LiDAR topography on the floodplain. Where required and agreed these have been rectified with topography created through interpolation of the manhole lid levels within the new developments.
Is this model fit for producing floodplain for publication?	NO
If answered "NO" for the above question, why not?	refer to model and project purpose. Model is not detailed in upper catchment as this is not required for purpose of model.

Model Files and Documentation	
File directory for model deliverables (MUST COMPLETE): (All model deliverables are to be stored at respective catchment folder(s) under "U:\COO\IES \StormWaterModels\00 Model DELIVERABLES\...")	U:\COO\IES\StormWaterModels\00 Model DELIVERABLES\Manukau Harbour\Pahurehure Inlet\McLennan Wetland Model 2021

Auckland Council Model Review

Section 1 - Model Metadata

Is model report supplied (must have, but can be draft):	NO
Is model extent polygon supplied (must have):	YES
Is model schematisation map supplied (must have):	YES
Is model data flag file supplied:	NO
Are model results supplied:	YES
List out all scenarios modelled (design storm events, validation events, sensitivity analysis runs, etc.)	100yr MPD CC
List relevant input/calculation files supplied:	Hydrology spreadsheet Artillery Tunnel head losses QH calculation spreadsheet
Is WaterRIDE file supplied (only at FINAL delivery):	NO
Model Metadata	
Any DEM modifications? If yes, describe in more detail.	The following DEM modifications (to the 2016 LiDAR DEM) are included. The extent of these modifications are shown in the model schematisation map package provided. **Awakeri Wetlands stage 1:** As-built survey data 2D surface (Surveyworx 2020) **Awakeri Wetlands stage 2 and 3:** 2D surface from Awakeri HEC-RAS model (Awakeri_HECRAS_Rev3) **Grove Road outlet:** 2D surface around Grove Road Culvert outlet (McLennan wetland) derived from drawing provided by AC (*117177-9-1-C GROVE ROAD OUTLET AREA ASBUILT PLAN.dwg*). **McLennan wetland -** 2017 survey contours (SW POND SURVEY AC-HWD-PIN_4417) **Kauri Flats channels:** 2D surface of channels/wetlands created from topography in drawings provided by AC (*117107 - 820-STG5_Stormwater_Rev G.dwg and 117107-101-1-J Asbuilt Plan - Stormwater.dwg*). **Artistry lane and Swamp Kauri developments:** There were significant differences observed at these developments between manhole lid levels and the 2016 LiDAR (the 2016 LiDAR appears to have been captured during earthworks of the development). A 2D surface has been created through interpolation of the manhole lid levels as these are more representative of the developed ground level. There are likely to be uncertainties in the overland flowpaths through these areas and it is recommended that the model is updated with surveyed ground levels/new LiDAR when available. **2d mesh modifications shapefile:** shapefile shows location and elevation of localised modifications to the mesh. These are primarily minor ground level changes at culvert inlets/outlets (to match mesh with invert levels) and to remove blockages caused by footbridges in the Awakeri Wetlands 2D surface.
Mesh Type	Flexible Triangular Mesh
Mesh Size	Maximum element areas have been defined as follows: 1m2 around smaller stormwater channels/roadside drains, 2m2 in and around the Awakeri wetland channels and McLennan wetlands. 4m2 top 6m2 on floodplain. 10m2 -20m2 in areas outside catchment/areas of interest
Soakage representation	Soakage is present in catchment but thought not to perform well in winter months especially during high magnitude flood events. It agreed during model schematisation workshop with AC (15/01/2021) to not be included as effects on flooding likely to be minimal. soakage in the catchment is primarily for peat recharge.
Pipe network modelled (e.g. all pipes >=300mm, etc.)	primary pipe trunklines (generally these are pipes greater than or equal to 900mm in diameter), key connectivity pipes and pipes that may affect hydraulics at the McLennan wetland.

Auckland Council Model Review

Section 1 - Model Metadata

Key structures modelled? Describe type and number	Artillery Drive Tunnel - The previous Q-H relationship (HAT 2.34) used in the "Assessment of McLennan Upper Wetland and Artillery Drive Tunnel Design Performance, AC 2016) has been updated. This Q-H relationship was derived using spreadsheet calculations and included all hydraulic losses such as the bell-mouth inlet, the outlet and various horizontal /vertical bends. The calculations were based on Jacobs design of the structure. A new QH has been developed due to the following considerations.... • The As-built drawings in the Artillery Drive Stormwater Tunnel Operations and Maintenance manual show that a 2500 mm internal diameter tunnel has been installed. The detailed design report, drawings, and calculations showed a 2470 mm internal diameter. The as built tunnel therefore has an increased capacity compared with design. • The As-built drawings in the Artillery Drive Stormwater Tunnel Operations and Maintenance manual (and recent photos of the McLennan wetland) show that a low flow 1050 mm scruffy dome has been installed at 11.7 mRL instead of a low flow slot in the main structure from intended design. • The As-built drawings in the Artillery Drive Stormwater Tunnel Operations and Maintenance manual (and recent photos of the McLennan wetland) show that 4x250mm wide raised separator blocks are included on the bellmouth weir structure (assumed to be for structural reasons). These separators reduce the effective weir length of the structure at 12.7 mRL. The hydraulics are complex when the waterlevel exceeds the top of the separators (13.0 mRL) as multiple weirs structures of different type, crest level, and orientation will be active. In the baseline QH curve the separators are included at all elevations (where weir control is dominant). A sensitivity analysis has therefore been completed on the QH curve where these separator structures are fully removed (full diameter of bellmouth at 12.7 mRL is used in weir equation) to understand the uncertainty of the complex hydraulics described above.
	As a QH relationship has been used, Losses have therefore not been included at the tunnel shafts/bends within the model, to avoid double counting the losses (incorporated into the Q-H relationship). Grove Road Culvert - modelled in Mike11. Energy losses have been modelled as follows: Inlet - 0.26 (rectangular culvert, flared wingwalls /top edge bevelled /single barrel) Total bend loss of 0.3 (12 degree bend 0.05 and 60 degree bend 0.25) M21 Dike structures (weirs/spillways) - M21 Dike structures have been used to define the crest level of the McLennan wetland spillway (2017 survey data). The north and south spillway crests have a coefficient of 1.6 (grass embankments) and the broad crested rock armoured spillway has a coefficient of 1.2. The weir structure just upstream of the Grove Road Culvert inlet fish ladder has also been incorporated as a M21 dike structure with a coefficient of 1.6. The fish ladder weirs and the low flow weirs through the Awakeri wetlands are not modelled (other than being within the 2d mesh DEM) as they are deemed to have a negligible impact in high magnitude flood events. sensitivity analysis is proposed for the Q-H relationship at artillery drive tunnel (as shown in calculation spreadsheet) and the spillway coefficient use
Open channel / stream representation description	Open channels are represented in 2D.
MPD representation (Unitary Plan, District Plan, etc.)	Unitary Plan. MPD impervious as per modelling recommendations in AC memo *(AUP Imperviousness for Hydraulic Modelling 2019-09-04)*
Climate change allowances	2.1 degree Celsius
Tide Boundary Level (current and future)	Artillery Drive Tunnel Design highest astronomical tide level of 2.34mRL. Boundary level requested by AC.
Simulation Duration (24hrs, etc.)	24 hours
Simulation Timesteps	M21FM timestep of 0.25 (0.05-0.25 solution technique)
Model Run Time (How long did it take to run)	The model takes approximately 8 hours to simulate 24 hours on a standard GPU machine

Auckland Council Model Review

Section 2 Review Summary

Review Summary	
Reviewed By (Person/Organisation):	Jahangir Islam, Auckland Council
Type of Review (Standard Review or Partial Review)	Partial review on specifics (describe scope below)
Review Scope Description:	Review of model built for development purposes only, i.e. not a catchment wide model
Summarise Key Findings of the Review:	1. Initial conditions at McLennan upper and lower ponds are not appropriate. 2. Some invert levels and pipe diameter are different from the pond survey data. 3. Artillery Drive Tunnel inlets are not modelled according to as-built plans. 4. Box culverts under Battalion Drive need to be included in the model. **2nd Review: All modelling issues are fixed.**

Document Control

Model Revision	Delivery Date	Review Version	Review Date	Review Completed By, Company
1st version	2021	1st review	1/04/2021	Jahangir Islam, AC
2nd version	23/04/2021	2nd review	30/04/2021	Jahangir Islam, AC

Overview of Review Findings

Traffic Light Rating Scores (0 - no issue, 3 - major issue)

0 - No issue found

1 - Minor issue or non-standard approach, but unlikely to significantly impact on objectives of the study

2 - Some concerns, likely to have an impact on model results

3 - Concerns that may have a significant impact on model results and not meeting the study objectives

Review Section	Traffic Light	Comments
A - Overview		
A:1 Deliverables	0	
A:2 Previous Review Comments	0	
A:3 Model Speed and Stability	0	
B - Detailed Model Review		
B:1 Model Boundary Conditions	2	Initial conditions issue at McLennan ponds
B:2 Model Catchments	0	
B:3 Pipe Networks	3	Pipe diameter and invert levels issue
B:4 Channel / Stream Networks	0	
B:5 Hydraulic Structures and Control Elements	3	Artillery Drive Tunnel inlets modelling issue
B:6 Other Asset Features	0	
B:7 1D Overland Flow Paths	0	
B:8 2D Model Components	3	Box culverts under Battalion Drive missing
C - Model Results Review		
C:1 Model Results Check	0	
C:2 Model Validation	0	
D - Additional Checks		
D:1 Additional Check Items	0	

Auckland Council Model Review

Section 3 Review Details

Instruction Notes:

1. About FIGURES *– Please note figures should be clearly* ***labelled*** *and included the FIGURES tab and* ***referenced*** *in the review comments.*

2. Traffic Light Rating Scores *(0 - no issue, 3 - major issue)*

0 - No issue found

1 - Minor issue or non-standard approach, but unlikely to significantly impact on objectives of the study

2 – Some concerns, likely to have an impact on model results

3 – Concerns that may have a significant impact on model results and not meeting the study objectives

A - General Information Review

A:1 - Deliverables

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
A:1.1	Is tab "Section 1 - Model Metadata" filled in and does it provide an accurate summary of the supplied model data.	0	Tab 1 completed. Arcmap MPK of model schematisation provided. The GIS layers in this MPK include comments within attribute tables detailing asset data sources and any assumptions.	Yes	-	
A:1.2	Have all agreed deliverables been provided – Reporting, Model Database, Survey etc.	0	Options and assessment and reporting programmed for completion after review of baseline model.	Yes	-	
A:1.3	Is the model delivered in the required software version?	0	Model has been built and run with DHI 2017	Yes	-	
A:1.4	Are all associated model input files supplied in specified format, i.e. as part of the icmt file or in folders with appropriate naming conversion if using other software.	0	model files provided	Yes	-	
A:1.5	Are all required modelled scenarios included in the deliverable? Does the model database include result files for all the scenarios?	0	100 year MPD baseline scenarios provided for initial review. Options assessment programmed for completion after review of baseline model.	Yes	-	

A:2 - Previous Review Comments

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
A:2.1	Confirm that all previous review comments have been incorporated or resolved, if any (such as MEDAR recommendations, etc.). List any that have not, and comment on impact to model usability.	0	No previous review. Notes/agreed actions from model schematisation workshop on 15/01/2021 attached with model. This includes instruction from AC on soil type to adopt for the catchment pervious areas.	N/A	-	
A:2.2	Assess model against any other review recommendations produced during the model development. If there was no formal process for resolving the reviewers comments, then each item should be listed below and a comment made as to whether or not the issue has been resolved, and if it has significant impacts.	0	see comment above	N/A	-	
A:2.3	Identify and document any agreed divergence from spec and adopted model build process	0	no divergence from model approach outlined in project scope	None	-	

A:3 - Model Speed and Stability

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
A:3.1	Check model simulation period and time steps, including result time steps.	0	24 hour simulation. 0.25 second timestep. Mike urban results - 1 min output interval Mike 21 2D results - 5 minute output interval	OK	-	
A:3.2	Comment on run time expected in terms of the catchment size and complexity.	0	The model takes approximately 8 hours to simulate 24 hours on a standard GPU machine	OK	-	
A:3.3	Check model validation errors and warning messages.	0	MU warnings include manhole sizes (smaller than connected links), short pipe lengths (minimum 10m pipe length applied) and negative pipe grades (see B.3.11)	OK	-	
A:3.4	Assess model stability i.e. identify time step critical locations. Any apparent issues in model results caused by model instabilities? Is peak impacted by instabilities?	0	some instabilities at pipe 3000059640 (MU) and AWACUL1&2 (M11) but these do not affect hydrograph peak. The Walters Road Culvert (WALCUL) and culvert immediately downstream (AWACUL3&4) have not been coupled as numerous stability issues were encountered at these locations during the model build despite a range of tests (coupling parameters, MU and M11 representation, invert levels). The culvert openings are currently modelled in 2D only (topographical opening in the mesh). The upstream water level does not reach the soffit level of the culverts and these culverts are sufficiently far upstream of McLennan wetland to have a minimal impact on results.	OK	-	

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
A:3.5	Review mass balance (<1%, if more than 1%, find out why & whether improvements should be made, discuss with AC if mass balance error cannot be reduced)	0	Mass balance calculated at 0.4%	OK	-	

Review Hold Point – if there is any corrective action required as a result of the above – the review is to be halted until the issue is resolved to the satisfaction of the appointed reviewer and Auckland Council

B - Detailed Model Review

B:1 - Model Boundary Conditions

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:1.1	Confirm rainfall values and profiles used are appropriate, and that modelled values are equivalent to what is included in the associated reporting.	0	TP108/SW code of practice rainfall profiles and climate change applied. 24 hour rainfall depths extracted at McLennan wetland upstream catchment centroid (1773870, 5897860) - 10 year ARI 140mm, 100 year ARI 222mm.	OK	-	
B:1.2	Assess downstream water levels with reference to coastal marine boundary or other software	0	Artillery Drive Tunnel Design highest astronomical tide level of 2.34mRL. Boundary level requested by AC. Note: NIWA MHWS10%ile +1m SLR is 3.13m RL but the Artillery tunnel was designed with a HAT tidal condition	OK	-	
B:1.3	Describe and review any inflow boundary conditions	0	Hydrological inflows modelled in Mike Urban and loaded to pipe network or M21 following AC modelling spec approach. In Time of concentration calcs, slopes less than 0.005 (0.5%) have been changed to 0.005. to prevent long lag times	OK	-	
B:1.4	Check how model initial conditions are applied for both 1D and 2D. The use of model features such as initial condition zone for tidal areas and ponds, etc.	2	Initial conditions applied in 2D model at following locations: elevations below 2.34mRL (downstream boundary water level) - IWL set at 2.34mRL McLennan wetland upper wetland - IWL of 11.5mRL - reported permanent water level in artillery tunnel detailed design report McLennan wetland lower wetland - IWL of 8.4mRL - surveyed water level in McLennan wetland 2006 as built drawings	The initial conditions used in the model at McLennan wetland upper and lower ponds are not appropriate, should be based on the normal water level shown in the 2017 McLennan Reserve pond survey plans.	The initial conditions at the McLennan Wetlands have updated using 2017 survey plans.	Model updated.
B:1.5	Check time varying inputs and make sure their start and finish time aligns with simulation setting.	0	checked	OK	-	
B:1.6	How is climate change applied? Check rainfall and tide boundary	0	TP108/SW code of practice rainfall profiles and climate change applied. no climate change applied to downstream boundary	OK	-	

B:2 - Model Catchments

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:2.1	Review modelled catchment extent. Confirm that it follows contours, and incorporates or excludes any additional primary network which is not consistent with the contours. Any flow transfers across catchment boundaries?	0	Glasswalling occurs along the northern boundary of the model. This is as per schematisation agreement (assume Bruce pullman park subcatchments flow towards the wetland)/administrative catchment of McLennan wetland whereby future developments may contour flowpaths to flow towards the wetland (despite the 2016 LiDAR suggesting that overland flows currently go north - away from the wetland)	OK	-	
B:2.2	Subcatchment extents and sizes. Comment on methodology used for subcatchments delineation – is it appropriate, are there any limitations? Comment on subcatchment size. Any impact on model usefulness.	0	Subcatchments have been delineated using: 2016 LiDAR Existing stormwater network Anticipated future stormwater upgrades (discharge to Awakeri Wetlands), Unitary Plan and previous reporting/scheme catchment for Artillery Tunnel. 3 sub-catchments were added following the model schematisation workshop (rural1, rural2 and rural3) due to uncertainty in direction of the 2016 lidar overland flowpaths. These catchments have been loaded to the 2D model grid to ensure any flows that do enter the McLennan catchment from these areas are captured.	OK	-	
B:2.3	Spot check subcatchment loading nodes are assigned properly.	0	Hydrological inflows modelled in Mike Urban and loaded to pipe network or M21 following AC modelling spec approach	OK	-	

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:2.4	Check hydrological method used	0	UHM - SCS dimensionless hydrograph approach, SCS generalised loss method	OK	-	
B:2.5	Identify the curve numbers used in the model. Compare to Auckland Council Soil Maps to confirm appropriate use of curve number for pervious land use.	0	CN 98 for impervious. Pervious CN values assigned as urban good condition grass cover soil types D and C, as per AC instruction relating to the high soil moisture content and peat soils. Shapefile provided by AC (see arcmap MPK) of where to apply soil group D (CN 80), with soil group C (CN 74) to be applied elsewhere. A weighted pervious CN has been applied in the subcatchments that cover/overlap both the soil group D and C extents	OK	-	
B:2.6	Check impervious coverage and compare numbers extracted from model with reported figures. Spot check ED imperviousness using existing impervious layers and aerial photographs – include a screen dump of any issues identified. Review approach for defining MPD.	0	MPD impervious as per modelling recommendations in AC memo (AUP Imperviousness for Hydraulic Modelling 2019-09-04). No ED scenario.	OK	-	
B:2.7	Spot check and document time of concentration for catchments, comparing to TP108 graphical calculations.	0	TP108 graphical method used to derive subcatchment TOC/lag times. Minimum subcatchment slope of 0.5% applied (e.g. 0.5% used if subcatchment slope less than 0.5%) to prevent unrealistically long lag times	OK	-	
B:2.8	Check initial abstraction (Ia) ranges in existing / future scenarios.	0	Initial abstraction of 5mm applied in pervious and 0mm applied in impervious areas. Approach agreed during model schematisation workshop 15/01/21	OK	-	
B:2.9	Check catchment length, slope and Tc are correctly assigned.	3	TP108 graphical method used to derive subcatchment TOC/lag times. Minimum subcatchment slope of 0.5% applied (e.g. 0.5% used if subcatchment slope less than 0.5%) to prevent unrealistically long lag times	The lag times used in the model are not appropriate. Subcatchment lengths should be estimated as the furthest upstream point to the loading nodes. The channelisation factor should be 0.6 for both impervious and pervious areas if subcatchment drained by piped network systems and 0.8 if drained by engineered grass channels.	Flowpath lengths and slopes have been updated to loading node points. A channelisation factor of 0.6 has been applied to all pervious and impervious catchments as agreed at model review meeting. The updated lag times have been added to the model and new hydrology generated.	Model updated.

B:3 - Pipe Networks

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:3.1	Confirm all critical network and structures are included in model (trunk network, known flooding points, key structures, etc.)	0	all key structures that affect flow/level at McLennan wetland are included	Yes	-	
B:3.2	Check if the model extent is suitable for generating floodplains, i.e. does it extend far enough upstream and include all flood prone areas.	0	model not for floodplain mapping	Model extent is appropriate.	-	
B:3.3	Check asset naming convention. Can model ID be linked to assets in the GIS	0	SAPID's have been used on all assets where available.	OK	-	
B:3.4	Confirm node/manhole data source flagging and if it is documented for attributes such as lid level, invert level, shaft area, flood type, etc.	0	Lid, invert and diameter source flags have been added to the Mike Urban model	OK	-	
B:3.5	Confirm pipe asset data source flagging and if it is documented for attributes like shape, diameter / width/ height, material, upstream and downstream inverts, etc.	0	pipe diameter and invert data flags have been added to the Mike Urban model	OK	-	
B:3.6	Spot check data entry of asset inspection/survey records for 5 locations	3	checked	Invert levels of the lower pond outlet pipes and some other incoming pipes to the pond do not match with the 2017 McLennan Reserve pond survey data.	Pipe inverts around the McLennan Wetland have been updated using the 2017 survey data	Model updated.
B:3.7	Spot check node attributes (diameter, shaft area, invert level and lid level) match asset data or are interpolated appropriately.	0	checked	OK	-	

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:3.8	Compare node lid levels to LiDAR	0	Artistry lane and Swamp Kauri developments: There were significant differences observed at these developments between manhole lid levels and the 2016 LiDAR (the 2016 LiDAR appears to have been captured during earthworks of the development). A 2D surface has been created through interpolation of the manhole lid levels as these are more representative of the developed ground level. There are likely to be uncertainties in the overland flowpaths through these areas and it is recommended that the model is updated with surveyed ground levels/new LiDAR when available.	OK	-	
B:3.9	Check cover types are appropriate i.e. sealed, stored, 2D, etc.	0	Normal manholes: set to 'normal' Loading nodes: set to 'sealed' Dummy loading nodes: set to 'normal' (so can spill to M21) Assumed manholes/connection nodes added at pipe ends (missing asset data): set to 'sealed'. Shafts and bends in Artillery Tunnel and Grove Culvert set to sealed.	OK	-	
B:3.10	Check pipe attributes (diameter, shape, length, material, invert levels) match asset data or are interpolated sensibly	3	checked	The diameter of the culvert connecting upper pond to lower pond should be 1350mm (not 200mm used in the model). The invert levels should also need to be updated based on the 2017 McLennan Reserve pond survey data.	Following discussion and instruction from AC in model review meeting the 1350mm pipe has been fitted with a 200mm orifice plate.	Model updated as per discussion in model review meeting.
B:3.11	Check pipe long section and gradient for steep, zero and negative grades.	0	Following pipes have negative grades, these have currently been left as negative as inverts are based on AC asset data with no further info available. 2001050139 2001072375 2001095319 AC invert data shows increase from 6.04 to 6.08 - left as negative grade as no further info available. 2001072529 AC invert data shows increase from 6.87 to 6.98 - pipe amalgamated with downstream pipe to remove short pipe length and negative grade (improved model stability). 2001094097 PIPE635211 Unknown pipe direction - AC data invert levels of 20.05 at southern end and 20.51 at northern end. left as negative grade as no further info available and pipe could be flowing in north to south direction. 2001054451 AC invert data shows increase from 20.95 to 21.07 - left as negative grade as no further info available. 2000073244 AC data in nodes and pipes shows negative grade - pipe amalgamated with downstream pipe to remove short pipe length and negative grade (improved model stability).	OK	-	
B:3.12	Check if continuation pipe is matched using soffit levels	0	checks made	OK	-	
B:3.13	Ground cover. Identify pipes that have insufficient cover – less than 300mm.	0	Pipe 3000023255 sits above ground level but this is an outlet from a stormwater pond in the upstream catchment. All others have >300mm ground cover.	OK	-	
B:3.14	Identify any network which has decreasing diameters in a down-stream direction.	0	Pipes downstream of the following nodes are recorded as reducing in diameter - these diameters are as per the asset data provided and shown on Geomaps: 2001077219, 2001070994, 2001064948, CONNECT1, LATERAL12, LATERAL14, CONNECT12	OK	-	
B:3.15	Check pipe lengths less than 10m, and if any actions required.	0	A minimum pipe length of 10m has been applied for improved model stability	OK	-	

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:3.16	Check pipe roughness assumptions appropriate for material and condition	0	All pipes and culverts assigned as concrete normal (n 0.013) apart from: 3 existing pipe assets with unknown material type - assumed to be concrete normal (n 0.013) 2 pipes material "Brick". Roughness assigned as concrete rough (n 0.015) at SW_LINE12 a roughness value of 0.011 has been applied due to lining, following confirmation with AC. At SW_LINE11 (arched armco pipe) the manning's roughness is currently set to concrete. The dimensions and roughness of this arched pipe require confirmation with AC. Unlikely to have an impact on this assessment but should be incorporated in any future model updates.	OK	-	
B:3.17	Check manhole head losses in the model.	0	Manholes - Km 0.3 mean energy approach Inlets to pipes and culverts - Total HLC 0.5 Outlets from pipes/culverts - Total HLC 1.0 For connection nodes added (no asset data) Km 0.3 mean energy approach has been applied at pipe junctions (3 or more pipes) and 'no cross section changes' applied at pipe joins (2 pipes).	OK	-	
B:3.18	Check entry and exit losses of pipes and any minor losses caused by bends, side connections or joint defects, etc.	0	Standard culvert inlet (0.5) and outlet (1.0) HLC's have been applied apart from the Grove Road Culvert. The Grove Road culvert energy losses have been modelled as follows: Inlet - 0.26 (rectangular culvert, flared wingwalls /top edge bevelled /single barrel) Total bend loss of 0.3 (12 degree bend 0.05 and 60 degree bend 0.25)	OK	-	
B:3.19	Check natural depression areas or dry pond are modelled with proper outlet configuration i.e. it drains properly after flooding.	0	Drainage from sports field adjacent to McLennan wetland to be added to model (200mm pipe to lower wetland). Ponding on upstream side of railway near Ingram Street - no obvious outlets from this area other than pipe network already modelled. This is also outside of study area of interest	OK	Drainage from the sports field adjacent to McLennan wetland has been added to model. Using 2017 survey data and a 200mm pipe to the lower wetland shown in AC_Data.	OK
B:3.20	How is storage compensation applied to any trimmed network.	0	no specific compensation has been applied. The extent of upstream pipe networks in currently undeveloped areas is unknown. The low flow/permanent water level in the Awakeri wetland channels is not included and this compensates the trimmed network storage to an extent.	OK		

B:4 - Channel/Stream Networks

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:4.1	Are channels modelled appropriately? (in 2D or as 1D river reaches)	0	Awakeri wetlands/conveyance channels and Kauri Flats channel topography represented in 2D. Roadside drains LiDAR 2016. All open channels are modelled with 1m2 resolution (highest resolution used in the 2D mesh)	OK	-	
B:4.2	In case of burning surveyed cross-sections in 2D, spot check cross-sections from 2D bathymetry compared to the surveyed cross-sections.	0	checks made	OK	-	
B:4.3	Spot check modelled cross-sections and banklines with LiDAR	0	Awakeri wetland channels do not tie in with LiDAR at numerous locations (due to recent development), but the flow remains in bank in the 100 year MPD	OK	-	
B:4.4	Is location and spacing between cross sections appropriate? (e.g. maximum dx in MIKE11)	0	n/a - no 1D channel model	N/A		
B:4.5	Spot check of modelled cross-sections whether it includes low flow channel.	0	n/a - no 1D channel model	N/A		
B:4.6	Spot check data entry of survey records for 5 locations	0	No surveyed cross sections. 2D surfaces from TIN's/dwg's or existing HEC-RAS 2D surface.	N/A		
B:4.7	Identify any topography which may cause instabilities – such as flat sections.	0	majority of catchment is of very flat topography including through the culvert structures of the Awakeri Wetlands	OK		
B:4.8	Review the use of "channel markers" or "new panels".	0	n/a - no 1D channel model	N/A		

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:4.9	Identify if cross sections are drawn properly: - check length and extents sufficient to cover flood flows - any sections which are not perpendicular to the direction of flow. - are sections straight lines? Comment on the impact to the conveyance, and to the model results.	0	n/a - no 1D channel model	N/A	-	
B:4.10	Check locations where flooding extends from the channel to the 2D mesh – comment on merging of 1D/2D representation.	0	n/a - no 1D channel model	N/A	-	
B:4.11	Comment on application of roughness values.	0	a roughness value of n 0.04 has been applied to the Awakeri wetlands/channels. This is to account for vegetation, scour protection, logs etc within the channels. Bend/losses around structures in the the wetlands is accounted for by using 2D modelling approach.	OK	-	
B:4.12	Identify any double counting of volumes, in overland flow paths basins other cross sections	0	n/a - no 1D channel model or basins	N/A	-	
B:4.13	Check gradient for steep, zero and negative grades.	0	n/a - no 1D channel model	N/A	-	
B:4.14	Confirm no double counting of flood storage volumes, at locations such as basins or connection nodes at the ends of channels, , etc.	0	n/a - no 1D channel model or basins	N/A	-	

B:5 - Hydraulic Structures and Control Elements

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:5.1	Are inlets represented correctly? Do they align with surrounding terrain and have correct inlet control/headloss parameters?	0	Standard culvert inlet (0.5) and outlet (1.0) HLC's have been applied apart from the Grove Road Culvert.	OK	-	
B:5.2	Check outlet and/or outfall representations. Do they align with surrounding terrain or connect appropriately with downstream features?	0	minor changes to the 2D mesh have been made to ensure outlet levels match the 2D topography.	OK	-	
B:5.3	Check representation of culverts. Shape, number of barrows, inlet/outlet losses, roughness, gradient, etc.	0	The Grove Road culvert energy losses have been modelled as follows: Inlet - 0.26 (rectangular culvert, flared wingwalls /top edge bevelled /single barrel) Total bend loss of 0.3 (12 degree bend 0.05 and 60 degree bend 0.25)	OK	-	
B:5.4	Review bridges representation: - cross sections - contraction and expansion losses - bridge deck, profile and coefficients - bridge skew - bridge opening, gradient, inlet and outlet losses - bridge piers or other obstructions	0	No bridges modelled - footbridges in Awakeri Wetland assumed to have minimal impact on flows at McLennan wetland (i.e. considered negligible with regards to the purpose of this project).	N/A	-	
B:5.5	Check representation of storages, depressions, dams or constructed ponds: - stage storage relationship - any controls - inlets and outlets - initial or permanent water levels - overtopping arrangements (single level or irregular shape; weir coefficients; 2D mesh / breaklines);	3	Artillery Drive Tunnel - The previous Q-H relationship (HAT 2.34) used in the "Assessment of McLennan Upper Wetland and Artillery Drive Tunnel Design Performance, AC 2016) has been used. This Q-H relationship was derived using spreadsheet calculations and included all hydraulic losses such as the bell-mouth inlet, the outlet and various horizontal /vertical bends. The calculations are based on Jacobs design of the structure. Losses have therefore not been included at the tunnel shafts/bends within the model, to avoid double counting the losses (incorporated into the Q-H relationship).	The inlets of the Artillery Drive Tunnel (two scruffy domes) should be modelled based on as-built plans - see Figure 1.	A new QH relationship has been developed based on the as-builts. Refer to description in metadata tab and provided spreadsheet. The Inlet structure is modelled as an outlet for stability, with QH control from spreadsheet in pipe. ILOL54728 is used as the control node for QH as MU does not allow outlet nodes for control. ILOL54728 has consistent WL with M21 across the wetland. It was found that modelling the Artillery inlet as a manhole did not cause the QH to work as intended (water level in dam used as H) due to a drop in WL within the manhole structure.	Model updated as per discussion in model review meeting.

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:5.6	Check pump configurations. On/off levels, pump type, pump curve, pump controls, etc.	0	no pumps in the catchment/modelled	N/A	-	

B:6 - Other Asset Features

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:6.1	Soakage modelling methods and representation in the model.	0	Soakage is present in catchment but thought not to perform well in winter months especially during high magnitude flood events. It agreed during model schematisation workshop with AC (15/01/2021) to not be included as effects on flooding likely to be minimal. soakage in the catchment is primarily for peat recharge.	N/A	-	
B:6.2	How is the soakage outlet capacity modelled. The assumptions, e.g. ARIs, etc.	0	soakage not included (refer to above comment)	N/A	-	
B:6.3	Review the use of weir units in the model. Comment on the weir representation and coefficients used	0	M21 Dike structures (weirs/spillways) - M21 Dike structures have been used to define the crest level of the McLennan wetland spillway (2017 survey data). The north and south spillway crests have a coefficient of 1.6 (grass embankments) and the broad crested rock armoured spillway has a coefficient of 1.2. The weir structure just upstream of the Grove Road Culvert inlet fish ladder has also been incorporated as a M21 dike structure with a coefficient of 1.6 The fish ladder weirs and the low flow weirs through the Awakeri wetlands are not modelled (other than being within the 2d mesh DEM) as they are deemed to have a negligible impact in high magnitude flood events.	OK	-	
B:6.4	Review the use of orifice units in the model, comment on the associated coefficients applied.	0	no orifice units used in model	N/A	-	
B:6.5	Check representation of tunnels/underpasses	0	Artillery Drive Tunnel - The previous Q-H relationship (HAT 2.34) used in the "Assessment of McLennan Upper Wetland and Artillery Drive Tunnel Design Performance, AC 2016) has been used. This Q-H relationship was derived using spreadsheet calculations and included all hydraulic losses such as the bell-mouth inlet, the outlet and various horizontal /vertical bends. The calculations are based on Jacobs design of the structure. Losses have therefore not been included at the tunnel shafts/bends within the model, to avoid double counting the losses (incorporated into the Q-H relationship).	OK	-	

B:7 - 1D Overland Flow Paths

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	
B:7.1	Modelled overland flow paths locations and downstream connectivity.	0	n/a - no overland 1D model	N/A	-	
B:7.2	Comment on application of roughness values applied to 1D overland flow paths.	0	n/a - no overland 1D model	N/A	-	
B:7.3	Review section shape for 1D overland flow paths	0	n/a - no overland 1D model	N/A	-	
B:7.4	Check OLFP gradient and levels	0	n/a - no overland 1D model	N/A	-	

B:8 - 2D Model Components

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:8.1	Review 2D extent and mesh sizes (any terrain sensitive meshing, and no extremely large or small meshes) Are mesh sizes appropriate at inlets and outlets.	0	1m2 in and around channels and wetlands, 4m2 on floodplain. 10m2 in areas outside catchment/areas of interest	OK		
B:8.2	How have building footprints been represented	0	No changes to 2016 LIDAR DEM at buildings. 2D roughness of n 0.35 applied at existing building footprints	OK		
B:8.3	Review DEM and identify if any errors in DEM, e.g. around buildings	0	Model DEM at swamp Kauri development (see FIGURES tab)	OK		
B:8.4	Check representation of any key obstructions	3	culvert/pipe asset data required at Battalion Drive see FIGURES tab)	Box culverts under Battalion Drive need to be included in the model. AC Project Manager will provide the available data.	The structure has been added using HNZ as-built provided (DWG 125173-AB3B-420)	Model updated.
B:8.5	Check roughness zones and values	0	Roughness shapefile with land use attributes included in ArcMap MPK. Values were defined using Unitary plan, roads, building footprints and wetland extents used to define values. Concrete paths and vegetation around McLennan wetland digitised manually using aerials	OK	-	

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
B:8.6	Review and check double counting between 1D and 2D model components. For example 2D cells not blocked out where flow is represented in 1D	0	no 1D channels	N/A	-	
B:8.7	Check 1D/2D interface and coupling method is appropriate. Check appropriate 1D/2D connections are applied at 2D nodes, inline banks, river reach banks, etc. E.g. appropriate Qmax at 2D manhole, RESERVOIRHEIGHT= 100m, M21_AS_GROUNDLEVEL=0 in dhiapp.in file	0	RESERVOIRHEIGHT= 100m, M21_AS_GROUNDLEVEL=0 in dhiapp.in file	OK	-	

C - Model Results Review

C:1 - Model Results Check

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
C:1.1	Have all events been simulated and results provided?	0	100 year MPD provided for initial review before options are modelled	100yr ARI MPD CC	-	
C:1.2	All correct input data assigned to the run file for each simulation? and check simulation start and stop times.	0	checked	OK	-	
C:1.3	Check if flow, level and velocity are within reasonable range for pipes. - Identify Pipes with velocities >6m/s; - Check if inlet control should be included.	0	checks made - no pipes with velocity over 6m/s	OK	-	
C:1.4	Check if flow, level and velocities are within reasonable range for overland flow paths, open channels and floodplain	0	checks made	OK	-	
C:1.5	Is there any depression area or ponding not drained at the end of simulation? Check outlet configuration for depression.	0	Drainage from sports field adjacent to McLennan wetland to be added to model (200mm pipe to lower wetland). Ponding on upstream side of railway near Ingram Street - no obvious outlets from this area other than pipe network already modelled. This is also outside of study area of interest	OK	Drainage from the sports field adjacent to McLennan wetland has been added to model. Using 2017 survey data and a 200mm pipe to the lower wetland shown in AC_Data.	OK
C:1.6	Are predicted losses at manhole and pipe connections within reasonable range and as expected?	0	checked	OK	-	
C:1.7	Are predicted losses at inlet and outlet within reasonable range and as expected?	0	checked	OK	-	
C:1.8	Culvert Performance: - Is culvert operating as expected? Head losses within reasonable range. - Is flow limiting observed for 1D/2D connection at inlet/outlet? - Spot Check with HY8 and manuals calcs at least 2 locations, more maybe required if model includes large number of culverts.	0	Grove road culvert performing as expected. some instabilities at AWACUL1&2 (M11) but these do not affect hydrograph peak. The Walters Road Culvert (WALCUL) and culvert immediately downstream (AWACUL3&4) have not been coupled as numerous stability issues were encountered at these locations during the model build despite a range of tests (coupling parameters, MU and M11 representation, invert levels). The culvert openings are currently modelled in 2D only (topographical opening in the mesh). The upstream water level does not reach the soffit level of the culverts and these culverts are sufficiently far upstream of McLennan wetland to have a minimal impact on results.	OK	-	
C:1.9	Bridge Performance: - Is bridge operating as expected? - Are contraction and expansion losses within reasonable range.	0	n/a - no bridges in model	N/A	-	
C:1.10	Check if 1D / 2D flow transfers as expected. Any location with significant instabilities	0		OK	-	
C:1.11	Check if pump operation as expected	0	n/a - no pumps modelled	N/A	-	

C:2 - Model Validation

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)

Auckland Council Model Review

Section 3 Review Details

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
C:2.1	Compare TP108 graphical and modelled peak flows at a range of key locations, comment on any significant differences, and the impact on model predicted flows.	0	UHM and graphical method compared. No major differences in peak flow observed. Largest difference occurred at the impervious area of subcatchment AWA_SC3_Imp. The UHM method gives a flow of 2.91 whereas the tp108 graphical method gives a flow of 2.83 (UHM flow increased by 3%)	OK	echecked with updated hydrology and no major differences in peak flow observed	
C:2.2	Check if overall flood extent sensible. Compare new flood extent with any previous floodplains	0	flood extents in area of interest deemed sensible	Overall flood extent are reasonable.	-	
C:2.3	Validation against RFS records, anecdotal evidence?	0	validation not part of scope. Model is MPD future base scenario terrain, channels and land use so RFS records not applicable in area of interest	N/A	-	
C:2.4	Validation against gauged data or flood surveys?	0	as per comment above	N/A	-	

D - Additional Checks

D:1 - Additional Check Items

Item	Description	Rating Score	Modeller's Initial Notes	Reviewer's Comments	Modellers Response	Reviewer's Comments (2nd)
D:1.1	Does the model report provides adequate documentation on: - project objectives and purpose; - data analysis and model schematisation; - modelling methodology for key model components - assumptions and limitations.	0	report and options assessment programmed for after baseline model review	In future stage	-	
D:1.2	If applicable, are options represented adequately with appropriate levels of details? Comment on confidence level based on both model setup and model results.	0	report and options assessment programmed for after baseline model review	In future stage	-	
D:1.3	Should any aspects of the model be refined or redone in order to further investigate flooding effects?	0	model topography should be updated with new terrain of developments if smaller pipe networks are modelled	OK	-	
D:1.4	Which scenarios are modelled? Comment on the adequacy of scenarios modelled for achieving the project objectives	0	100 year MPD provided for initial review before options are modelled	100yr ARI MPD CC	-	
D:1.5	Any other assumptions used in the model that may have an impact on the overall model performance and meeting project objectives?	0	Model DEM at swamp Kauri development (see FIGURES tab) and culvert/pipe asset data required at Battalion Drive see FIGURES tab)	AC Project Manager will provide the available data.	The Battalion drive culvert has been added but the DEM at the developments has not been provided. The mesh has been updated at the edge of the developments to interpolate/smooth edges and remove the vertical drops previously experienced.	OK
D:1.6	Describe any additional checks or issues to raise	0	More recent survey (2017) of the McLennan wetland was recently provided in PDF format. If the survey is available in dwg format then the contours should be updated in the model (if required)	AC Project Manager will provide the available data.	The 2D mesh has been updated with 2017 survey data at McLennan wetland.	OK

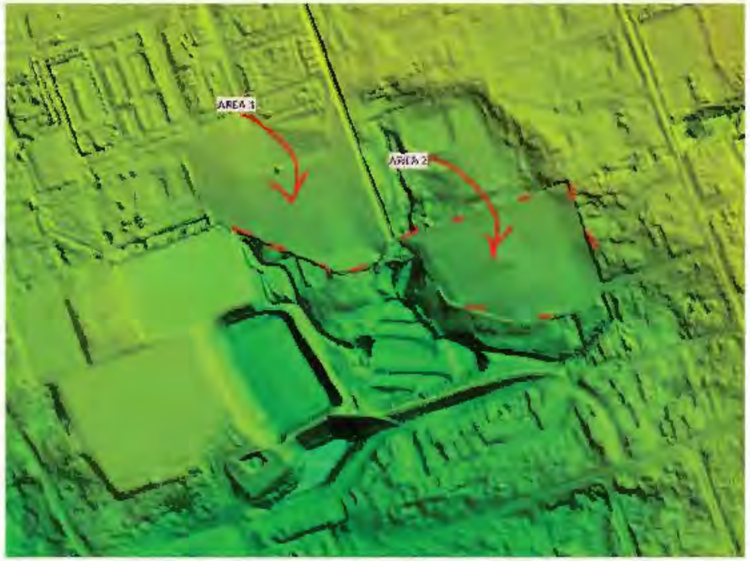
Artistry lane and Swamp Kauri developments:

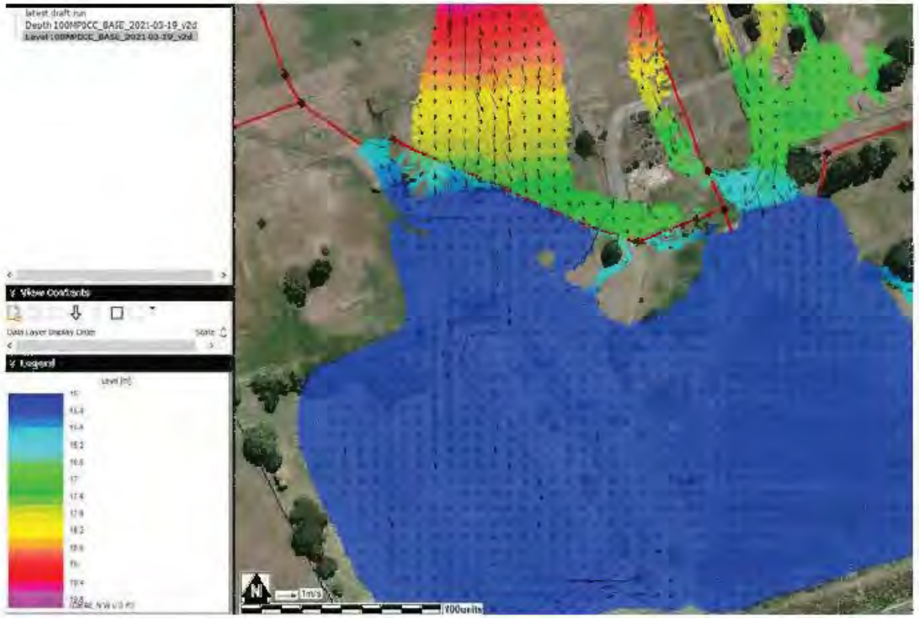
There were significant differences observed at these developments between manhole lid levels and the 2016 LiDAR (the 2016 LiDAR appears to have been captured during earthworks of the development). A 2D surface has been created through interpolation of the manhole lid levels as these are more representative of the developed ground level. There are likely to be uncertainties in the overland flowpaths through these areas and it is recommended that the model is updated with surveyed ground levels/new LiDAR when available.

The model results show a sudden drop in terrain and water level at the Swamp Kauri development (area 1 in figures below) where the terrain created from the Lid levels does not tie in well with the LiDAR. The exact slope to the developed ground level is unknown.

UPDATE:

The steep drops between the development DEM's and the LiDAR/2017 survey contours have been smoothed through interpolation between the datasets.





asset data required for culvert/pipe discharging to wetland from Military camp

UPDATE: Data received and structures have been added to the model

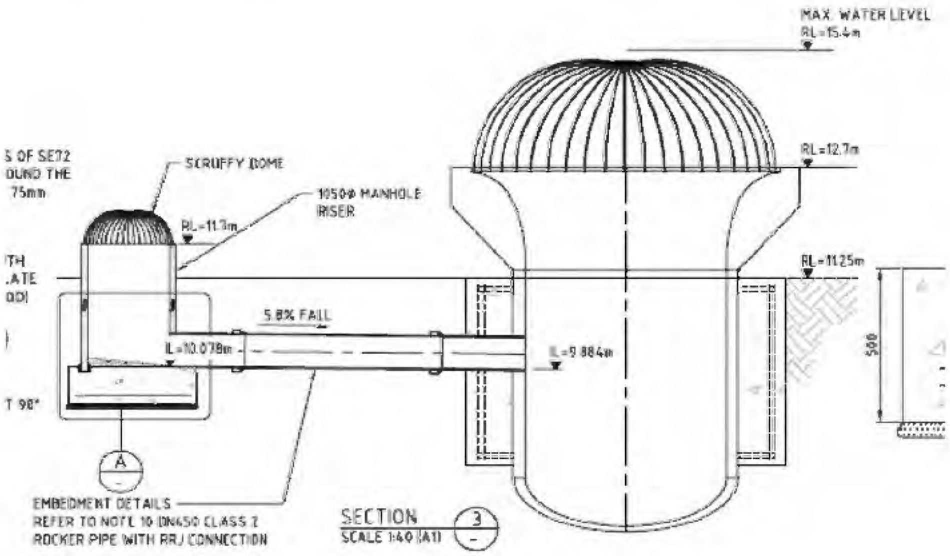

MAX. WATER LEVEL
RL=15.4m
RL=12.7m
SCRUFFY DOME
1050Φ MANHOLE RISER
RL=11.3m
RL=11.25m
5.8% FALL
IL=10.078m
IL=9.884m
500
EMBEDMENT DETAILS
REFER TO NOTE 10 DN450 CLASS 2
ROCKER PIPE WITH RRJ CONNECTION
SECTION
SCALE 1:40 (A1)

Figure 1


Scruffy Dome

Appendix C: Flood extent figures

Figure Appendix C.1: Flood extent – 100 year ARI MPD CC Baseline

Figure Appendix C.2: Flood extent – 10 year ARI MPD CC Baseline

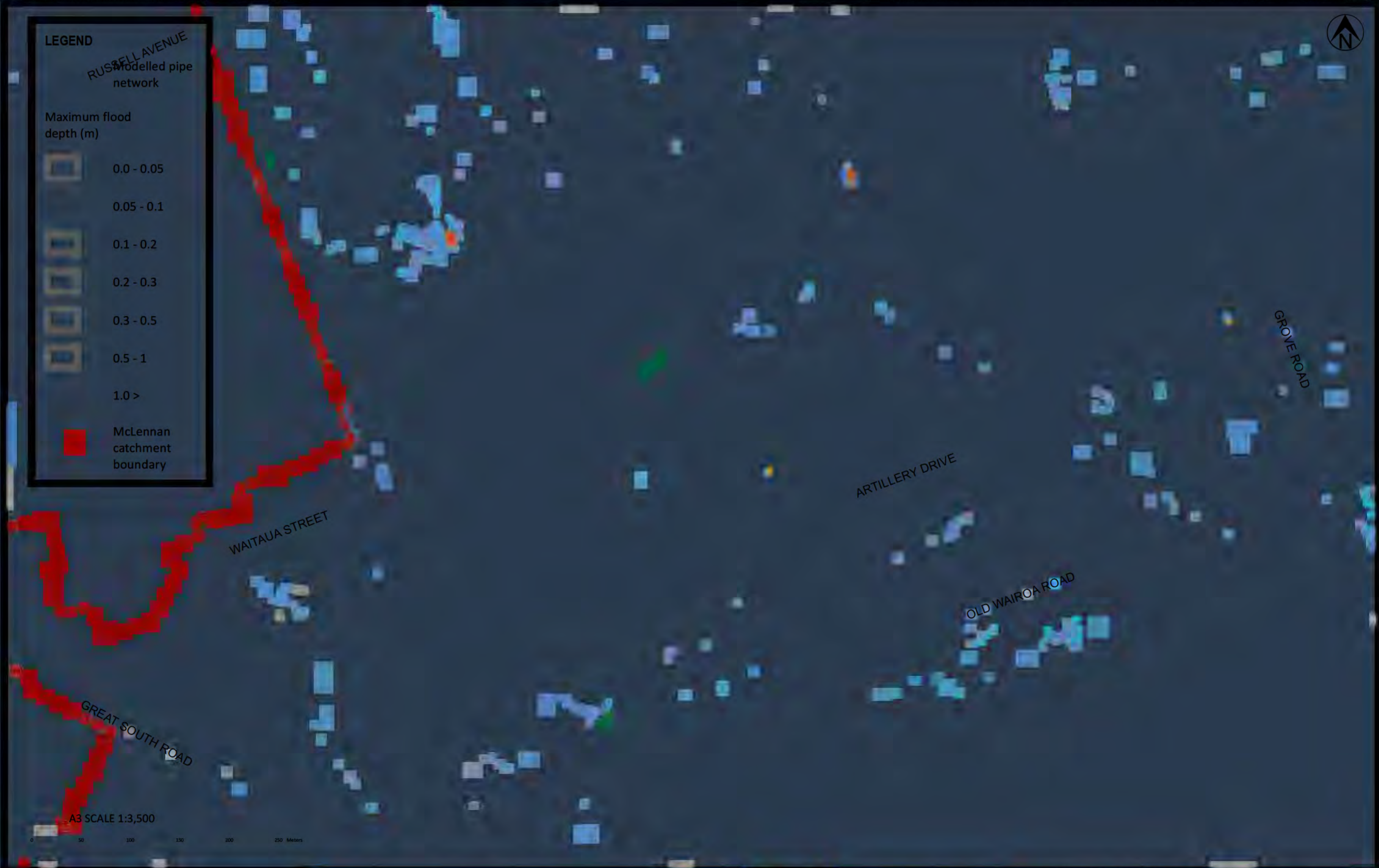
Figure Appendix C.3: Flood extent – 100 year ARI MPD CC Sensitivity scenario 2

Figure Appendix C.4: Flood extent – 100 year ARI MPD CC Option scenario 1

Figure Appendix C.5: Flood extent – 100 year ARI MPD CC Option scenario 2

Figure Appendix C.6: Flood extent – 100 year ARI MPD CC Option scenario 2 and sensitivity scenario 2 (compared to baseline)

Figure Appendix C.7: Flood extent – 100 year ARI MPD CC Option scenario 2 and sensitivity scenario 2 (compared to sensitivity scenario 2)



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REV	DESCRIPTION	GIS	CHK	DATE
0	First version	JMOR	SGB	25/05/21

LOCATION PLAN

PROJECT No.	1012030.1040	
DESIGNED	JMOR	JUN.21
DRAWN	JMOR	JUN.21
CHECKED	SGB	JUN.21
APPROVED		DATE

CLIENT: AUCKLAND COUNCIL
PROJECT: MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING
TITLE: FLOOD EXTENT - 100 YEAR ARI MPD CC BASELINE
SCALE (A3): 1:3,500 FIG No. FIGURE C.1 REV 0

NOTES:
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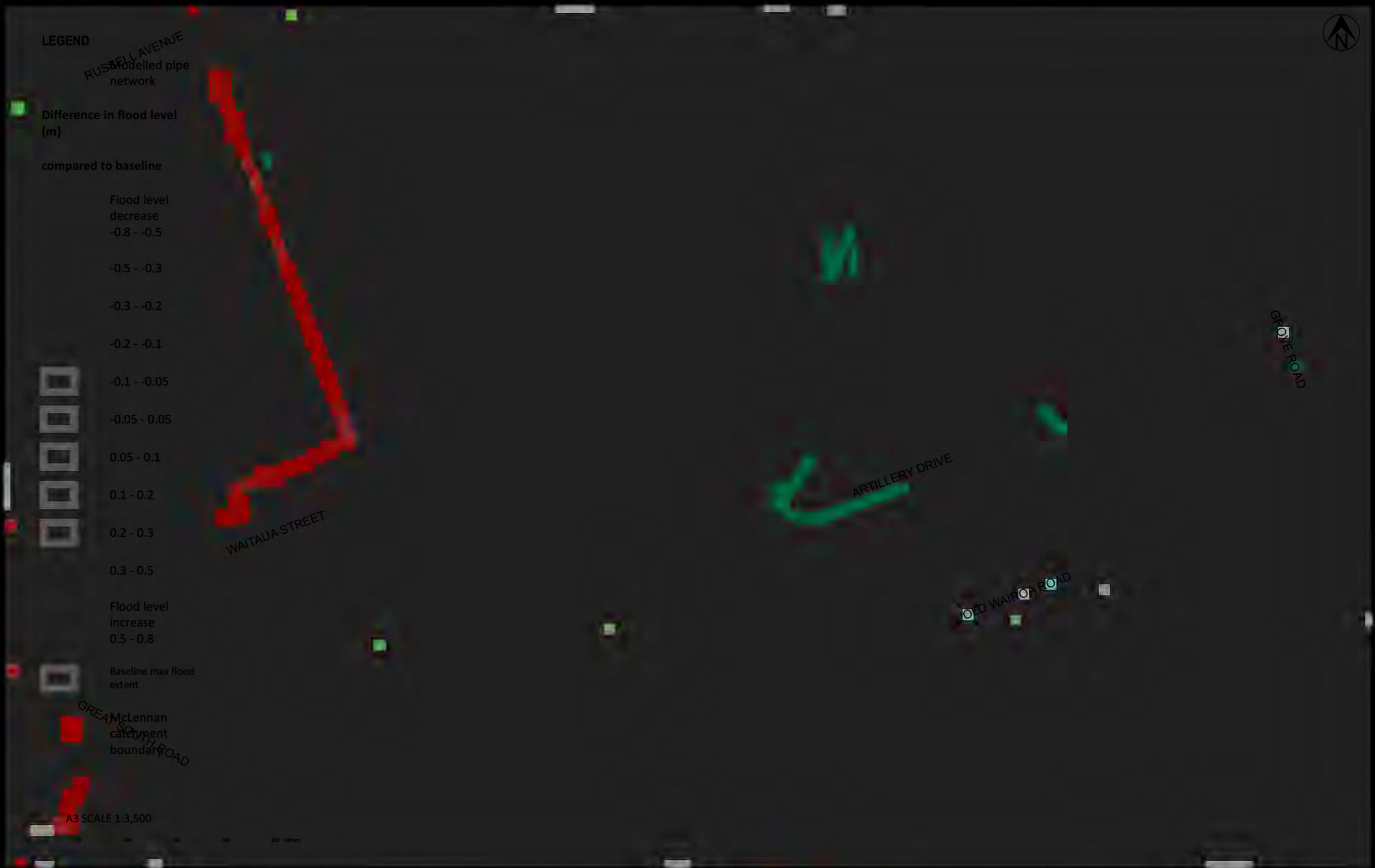
APPROVED		DATE

CLIENT AUCKLAND COUNCIL
PROJECT MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING
TITLE FLOOD EXTENT - 10 YEAR ARI MPD CC BASELINE
SCALE (A3) 1:3,500   FIG No. FIGURE C.2   REV 0



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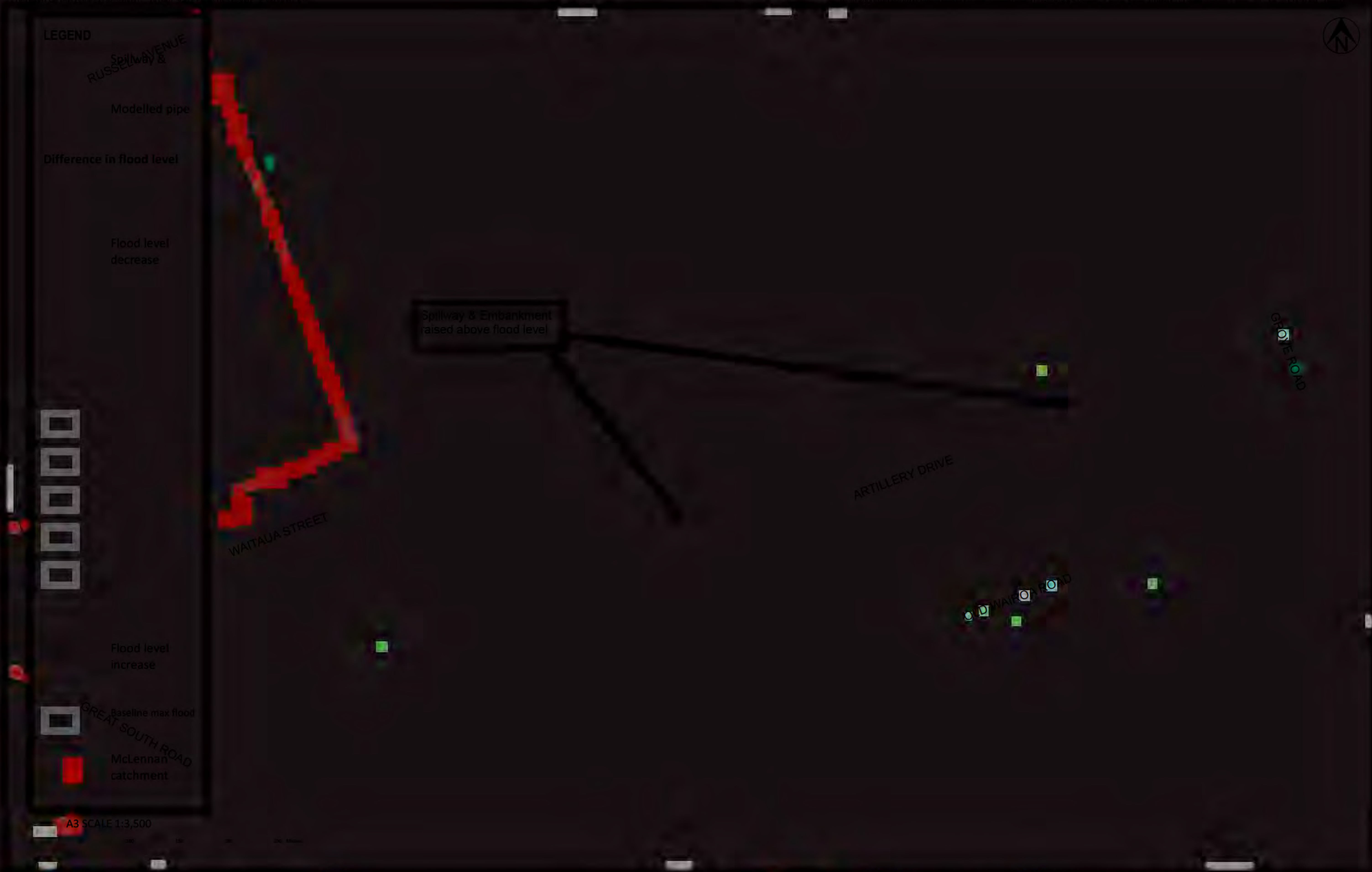
APPROVED		DATE

CLIENT **AUCKLAND COUNCIL**

PROJECT **MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING**

TITLE FLOOD EXTENT - 100 YEAR ARI MPD CC
SENSITIVITY SCENARIO 2 (ADST ROUGHNESS INCREASE)

SCALE (A3) 1:3,500 FIG No. FIGURE C.3 REV 0



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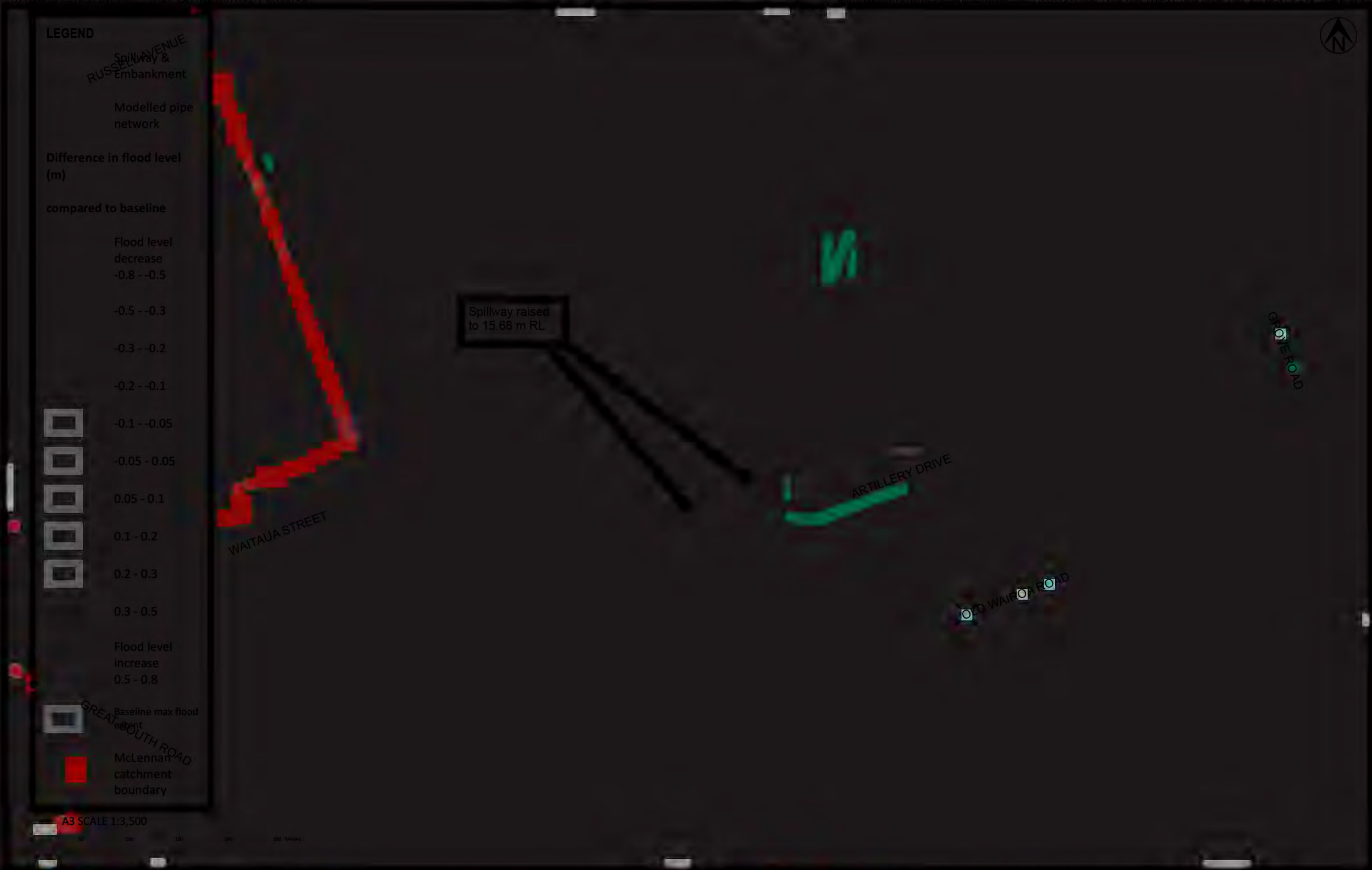
APPROVED		DATE

CLIENT: AUCKLAND COUNCIL

PROJECT: MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING

TITLE: FLOOD EXTENT - 100 YEAR ARI MPD CC OPTION SCENARIO 1

SCALE (A3): 1:3,500 FIG No. FIGURE C.4 REV 0



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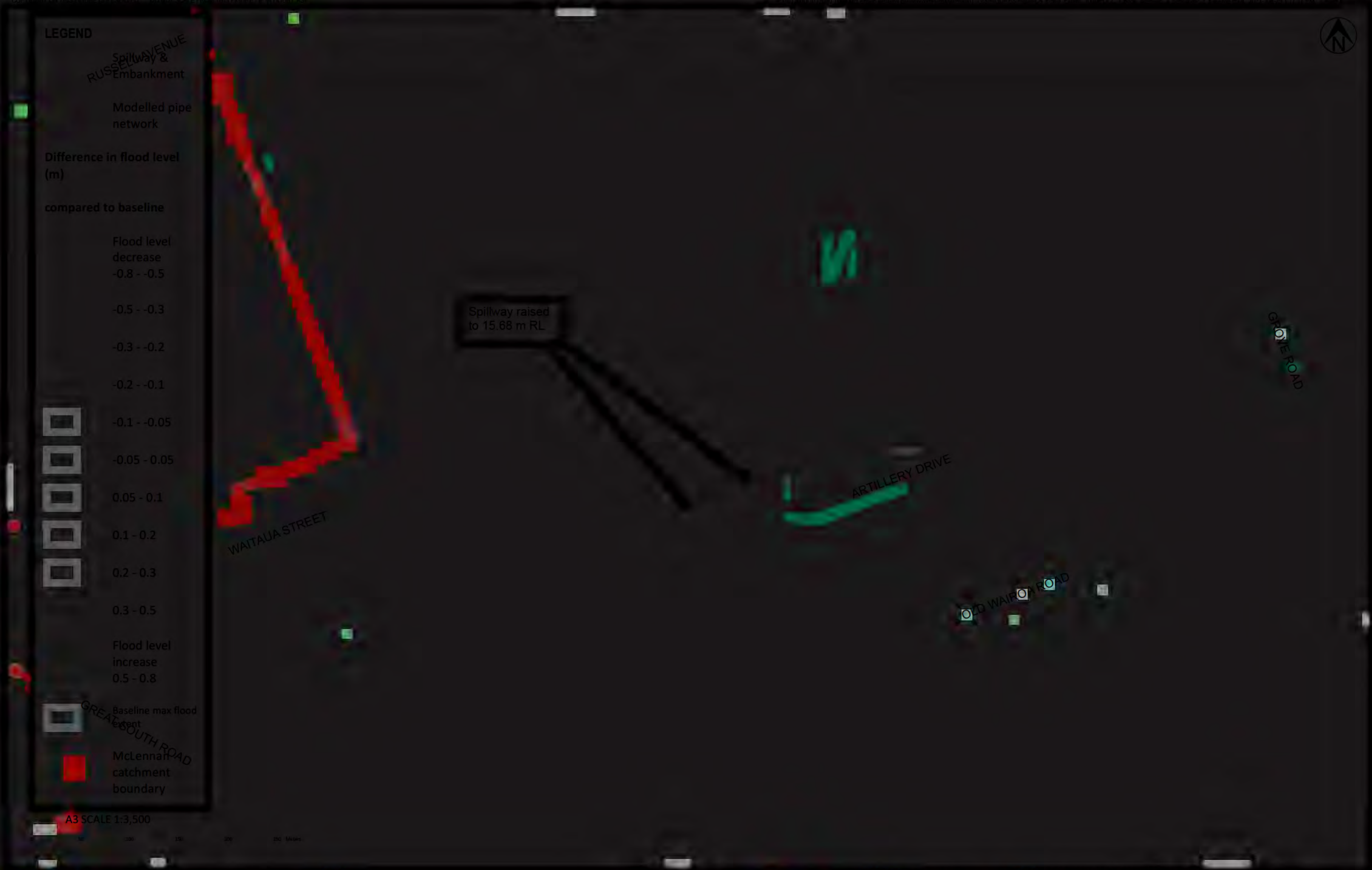
CLIENT AUCKLAND COUNCIL
PROJECT MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING
TITLE FLOOD EXTENT - 100 YEAR ARI MPD CC OPTION SCENARIO 2

SCALE (A3) 1:3,500 FIG No. FIGURE C.5 REV 0



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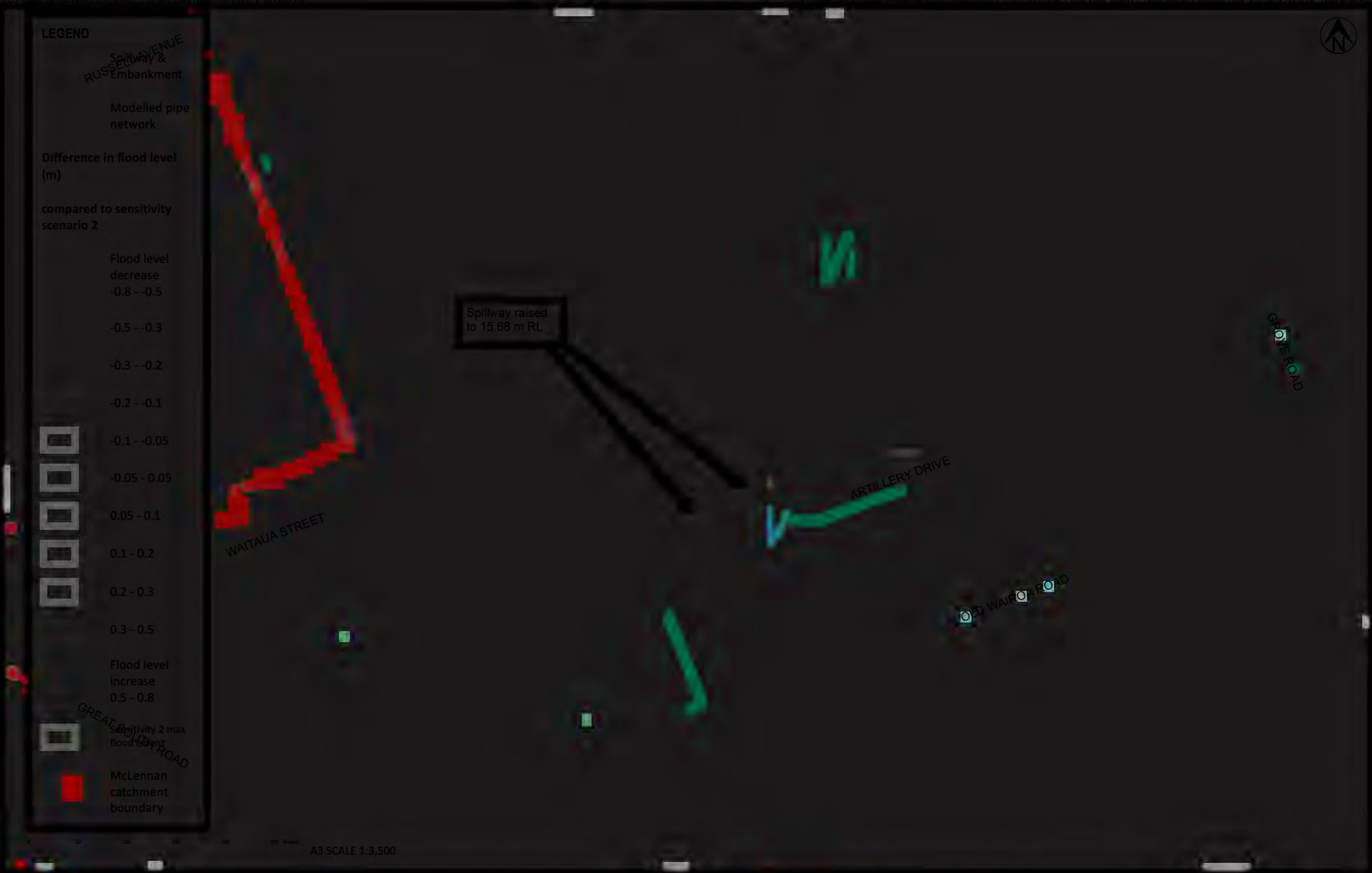
CLIENT **AUCKLAND COUNCIL**

PROJECT **MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING**

TITLE FLOOD EXTENT - 100 YEAR ARI MPD CC
OPTION SCENARIO 2 & SENSITIVITY SCENARIO 2
(COMPARED TO BASELINE)

SCALE (A3) 1:3,500 FIG No. FIGURE C.6 REV 0



NOTES:

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APPROVED DATE

CLIENT AUCKLAND COUNCIL
PROJECT MCLENNAN WETLAND SPILLWAY OPTIONS MODELLING
TITLE FLOOD EXTENT - 100 YEAR ARI MPD CC
OPTION SCENARIO 2 & SENSITIVITY SCENARIO 2
(COMPARED TO SENSITIVITY SCENARIO 2)
SCALE (A3) 1:3,500
FIG No. FIGURE C.7
REV 0

APPENDIX 13 – Auckland Council 2016 TSWCC – Stormwater Report

Takanini Stormwater Conveyance Channel

Volume Two

Appendix A – Stormwater Report

Prepared by Hill Young Cooper Limited

April 2016

Auckland Council

Takanini Stormwater Conveyance Channel

Stormwater Report

Technical Report A

April 2016

Table of contents

Table index

Figure index

Appendices

1. Introduction

The Takanini Stormwater Conveyance Channel forms the fourth stage of a greater scheme to provide stormwater servicing for the Takanini south-east area. The Takanini Stormwater Conveyance Channel will pass forward flows from Old Wairoa Road, Cosgrave Road, Walters Road and Grove Road, for which there is currently no formal drainage system, to a proposed box culvert at Grove Road. The Grove Road Box Culvert conveys flows from the Takanini Stormwater Conveyance Channel to the McLennan wetland. During large storm events, flow is attenuated in the McLennan wetland before being discharged to the Pahurehure inlet via the proposed Artillery Drive tunnel. Refer to Drawing *51-3217404-C001* for an overview of the greater scheme.

The conveyance channel will consist of approximately 2.1 km of open waterway that will contain the existing 1% AEP floodplain allowing the surrounding land to be comprehensively developed. It is anticipated that the channel construction will take approximately 2-3 years to complete.

A Notice of Requirement was lodged in July 2014 for the designation of land to allow the development of the channel. The project is currently at the scheme design stage. The designation corridor will allow for the channel extents to convey both low flows and the full 1% AEP flows with both wetland and riparian planting. It will deliver an open public space with the provision for cycleways and footpaths that will increase the connectivity between new urban areas and allow for the development of the Special Housing Takanini Strategic Areas (including Special Housing Areas 2A, 2B and Wallace) and area 2B4 which is currently zoned rural.

1.1 Purpose

An Infrastructure Report was prepared in 2014 to assist Auckland Council process and lodge a Notice of Requirement (NoR) to designate the land required for the permanent works associated with the proposed stormwater conveyance channel. This report builds upon the 2014 Infrastructure Report and refines the stormwater effects to reflect the additional designs and investigations undertaken during scheme design.

Changes to this Stormwater Report compared to the NoR lodgement include:

- Further development of the scheme design of the Takanini Stormwater Conveyance Channel.
- Further geotechnical analysis, based on additional groundwater monitoring, as part of the scheme design of the Takanini Stormwater Conveyance Channel.
- Early construction of some sections of the channel by developers as temporary stormwater ponds. Refer to the Section 1.3.

The purpose of this report is to:

- Provide details relating to the Scheme design of the stormwater conveyance channel.
- Discuss the benefits and drainage related effects of the proposed channel, both short and long-term.
- Outline mitigation measures that will be employed by Council to minimise any adverse effects.
- Outline the updated design from the time of the Notice of Requirement.

1.2 Scope

The scope of this report is to:

- Detail the stormwater scheme design of the Takanini Conveyance Channel.
- Document the design philosophy and design practices relating the Scheme design that further advance the concept design outlined in the *Takanini Stormwater Conveyance Channel, Infrastructure Report, GHD July 2014.*
- Provide a record of any key decisions.
- Identify any further investigations or management plans required for detailed design, or prior to construction.

1.3 Assumptions and limitations

The following information and assumptions were used in the development of this Stormwater Report:

- This report has been prepared in conjunction with the other technical reports that make up the AEE; including Technical Reports A – M.
- That the proposed Grove Road Box Culvert will have been constructed and in place prior to the construction of the Takanini Stormwater Conveyance Channel.
- The channel between 989-999 Papakura-Clevedon Road and 55 Cosgrave Road (CH1250 m to 1540 m) has been constructed by developers to serve as a temporary stormwater pond. This section will require reshaping only to finished design levels. Note that the Old Wairoa Road culvert has been constructed as part of these developer works and consequently a reduction in the earthworks volumes for the formation of the Takanini Stormwater Conveyance Channel has been considered at this location.
- Auckland Council has an agreement in place with the developers of 94, 74, 64 and 54 Cosgrave Road who propose to construct part of the channel at 84 Cosgrave Road (CH275 m to 500 m) and consequently a reduction in the earthworks volumes for the formation of the Takanini Stormwater Conveyance Channel has been considered at this location. Construction is planned for October 2016.

2. Project Overview

2.1 Takanini Stormwater Conveyance Channel

The proposed Takanini Stormwater Conveyance Channel will extend from 989-999 Papakura-Clevedon Road in the south-east to 91 Grove Road in the west. A northern branch will extend northwards towards Walters Road.

In general the conveyance channel will provide stormwater servicing for future development of Areas 2A, 2B and part of Area 4 (2B4) of the Takanini Structure Plan. At present the area is significantly impacted by the 1% AEP (Annual Exceedance Probability) floodplain, restricting development of the area.

The proposed channel will:

- Provide for the full 1% AEP flows, effectively removing the floodplain from surrounding land.
- Offer an ecological corridor (both terrestrial and aquatic) that would otherwise not be provided.
- Deliver stormwater servicing for development within the catchment area that is not currently presented.
- Afford an open space with significant amenity value and the provision for pedestrian linkages and cycleways.

The Takanini Stormwater Conveyance Channel consists of two main branch channels; the main channel and the northern branch channel.

- **Main channel**

  The main channel has a length of 1.55 km of open waterway, ranging in depth between 2 m and 4 m below ground level. The channel has an approximate gradient of 0.28% and a total width (at the 1% AEP water level) ranging from 20 m to 37 m.

- **Northern branch**

  The northern branch channel has a length of 0.55 km of open waterway, ranging in depth between 2.4 m and 3.8 m below ground level. The channel has an approximate gradient of 0.24% and a total width (at the 1% AEP water level) of approximately 25 m.

The Takanini Stormwater Conveyance Channel is designed with a meandering low flow series of discrete water bodies or wetlands with a permanent water depth of about 0.8 m controlled by rock weirs at 100 m centres longitudinally along the base of the channel. These provide an ecological benefit and limit groundwater drawdown. Generally the low flow channel will have a 3.6 m wide base with slope batters 2H:1V, with an intermediate flat wetland bench. Above the wetland bench are riparian planted channel banks with slope batters 4H:1V and a grassed floodplain.

2.2 Catchment area

The Takanini 2A2B stormwater catchment (shown in Figure 1) represents the area to be serviced by the proposed stormwater conveyance channel.

The area is approximately 155 hectares (ha) and consists of areas 2A (50.3 ha), 'Wallace' (9.1 ha), 2B4 (57.3 ha), 2B (38.0 ha) as shown as a dotted purple line in Figure 1 (referred to as the Takanini 2A2B catchment herein.

This catchment is within the Central Papakura Integrated Catchment Management Plan (ICMP) area. The sub-catchments are similar to those in the ICMP and Old Wairoa Road Catchment Management Plan, with the exception of area 2B4 which, in the ICMP and Old Wairoa Road Catchment Management Plan, excludes a small triangular shaped area at the end of Pukeroa Place. The size of this area is approximately 1 hectare and is included in the catchment area of the proposed Takanini Stormwater Conveyance Channel.

Figure 1 Takanini 2A2B catchment

2.3 Takanini Stormwater Scheme

The Takanini Stormwater Conveyance Channel is part of a greater stormwater scheme (refer Drawing *51-3217404-C001*) to reduce flooding in the 1% AEP and provide servicing for the greater Old Wairoa Road catchment. The Takanini Stormwater Scheme is comprised of four sections including:

Part 1 - Artillery Drive Tunnel

A new 2.5 m diameter tunnel that will extend over approximately 1.1 km from the McLennan wetland to the Pahurehure Inlet. This effectively forms the downstream outlet for the stormwater scheme.

Part 2 - McLennan wetland

Constructed in 2002, this wetland already receives stormwater from the Housing New Zealand development and Papakura Military Camp through to Bruce Pulman Park in the north; and Willis Road and Clevedon Road to the south. The wetland provides attenuation and treatment for the greater catchment before discharge. Currently the wetland passes forward flows to the Gills Road pond and will continue to do so in the future with only high flows being conveyed through the new Artillery Drive tunnel.

The McLennan wetland is designed to accept flows from the Old Wairoa Road catchment, which includes the catchment area of the Takanini Stormwater Conveyance Channel. The wetland has been included in a hydrological model held by Auckland Council, which confirms that there is enough storage to attenuate flows to an acceptable level of which the Artillery Drive Tunnel has been designed in accordance with.

Part 3 - Grove Road Culvert

A new culvert that will convey flows from the Takanini 2A2B catchment to the McLennan wetland.

The location of the Grove Road Culvert was altered from the location shown in the Grove Road Structure Plan. The structure plan showed the channel running through the middle of 61 Grove Road and connecting to the proposed Grove Road Culvert at Matheson Street.

The property at 61 Grove Road has subdivision consent and physical works on site are near completion for Stage 1 of their development. As a consequence; the route defined in the Structure Plan is no longer viable. The optimal location for the box culvert connection is therefore to the north of the northern boundary of 61 Grove Road. This allows minimal dissection of private properties and optimises drainage potential of the surrounding land.

The Grove Road Culvert is being designed by Jacobs and is a separate project to the Takanini Stormwater Conveyance Channel.

Construction is anticipated in 2016/2017.

Part 4 - Takanini Stormwater Conveyance Channel

As outlined in this report, a new 2.1 km open channel that will convey flows from part of the Old Wairoa Road catchment (Old Wairoa Road in the south-west to Walters Road in the north) to the Grove Road Culvert. Construction of the conveyance channel cannot occur until the Grove Road Culvert is completed. It is expected that construction of the channel will take 2-3 years.

2.4 Zoning and Special Housing Areas

The zoning of the catchment is based on the Unitary Plan zoning within the special housing areas (Areas 2A, 2B and Wallace). Area 2B4 is not part of the SHA and is currently zoned rural. Refer to the Assessment of Environmental Effects Vol 1 and Drawing *51-3217404-C005* for more details on zoning.

2.5 Network Discharge Consent

The Old Wairoa Road CMP (2004) defines the catchment boundary for the McLennan wetland. In 2010 the boundary shown in the CMP increased to include part of the Takanini South Catchment through CMP Variation 33738 (2010). This additional area is shown as the 'Wallace' area.

A "trunk stormwater conveyance system to serve areas 2A, 2B and 2B4" is consented under the NDC. The Takanini Stormwater Conveyance Channel is the proposed infrastructure for servicing these areas and the Wallace area to the north.

2.6 Draft Central Papakura ICMP

The Draft Central Papakura ICMP (October 2007) documents the overarching stormwater conveyance approach for the catchment. The ICMP outlines a potential alignment for the Takanini Stormwater Conveyance Channel.

The ICMP alignment is similar to the main channel alignment proposed in this report; with the main difference at the eastern end where the ICMP alignment splits into two channels. The ICMP channel excludes the proposed Northern Branch channel and services part of the 2A catchment using a piped stormwater system.

2.1 Concept design

The concept design was developed by GHD in July 2014 as part of the Notice of Requirement process and is described in the *Takanini Stormwater Conveyance Channel Infrastructure Report (GHD, 2014)*. The Concept Design concluded that a conveyance channel was the most beneficial and recommended stormwater solution for the catchment, compared to a piped solution, or piped / pond hybrid system.

Refer to the Plan amendment 48 – Takanini stormwater conveyance corridor (Auckland Council, 2014) for more detail.

3. Existing Environment

3.1 Site setting

3.1.1 Land use

The majority of land use within the conveyance catchment is currently pastoral although of a relatively low intensive nature.

Consents have already been obtained for development of sites within the catchment subject to temporary stormwater solutions on the proviso that once the channel is built, these sites will be connected to it. These include:

- The Grove at 61 Grove Road (Equinox Group).
- Twin Parks Estate at 989 to 999 Papakura-Clevedon Road (Cappella Papakura Developments Ltd).
- Papakura Residential at 965 Old Wairoa Road and 965 to 973 Papakura-Clevedon Road (Cabra Investments Ltd).
- Part of Montgomery at 881 to 899 Papakura-Clevedon Road.

All of their sites are currently undergoing bulk earthworks with houses currently being established at 61 Grove Road (The Grove) and sale of design-build packages being promoted for the Cappella development (Twin Parks Estate).

The developments above are shown on drawing *51-3217404-C006*.

Planned development

There are 7 sites in the catchment currently subject to subdivision consent.

A proposed school site has been designated at 181 and 191 Walters Road at the north eastern end of Area 2A.

3.1.2 Temporary Stormwater

The Equinox and Cappella application's for consent included temporary stormwater attenuation. It should be noted that these properties are an anomaly to those remaining sites within the catchment as they have the ability to convey flows to adjacent catchments, albeit on a temporary basis.

The Cabra application for consent included a permanent attenuation pond. The pond has been flow routed and included in the MIKE11 catchment model discussed in Section 4.2.3.

3.1.3 Topography

The catchment is essentially flat in nature; except for the eastern portion where it falls from approximately 67 m over a distance of 0.8 km to 26 m; with an average slope of about 3 %.

From here; the catchment falls from an RL of 26 m over 1.7 km to an RL of 22 m at Grove Road. This provides an average slope for the flat portion of about 0.24 %.

3.1.4 Existing stormwater and features

There is no formalised drainage across the catchment with small dissected channels and farm drains connecting to roadside table drains. The existing natural streams in the region are very short and have little to nil baseflow during the summer months (Draft Central Papakura ICMP, 2007).

The roadside table drains along Cosgrave Road collect overland flow and have limited conveyance capability. These roadside drains are deeply incised, up to about 2 to 2.5 m in depth. Generally, the roadside drains store water and discharge to ground soakage when water tables are low over summer. Figure 2 shows the table drain on Cosgrave Road.

Figure 2 Cosgrave Road table drain

To the west of Grove Road and south of Fernaig Street and Pukeroa Place stormwater is reticulated. Most of these flows are directed to the wetland located in McLennan Park. This wetland (the McLennan wetland) is designed to attenuate and treat flows from the Old Wairoa Road catchment before discharge via Gills Pond to the Pahurehure Inlet and is discussed further in Section 5.4.

Figure 3 McLennan wetland

3.1.5 Existing flooding

The vast majority of the Takanini 2A2B area and a portion of the Takanini South catchment to the north-west are predicted to be inundated in a 1% AEP storm event to a depth of 300 to

500 mm. Extensive ponding has been observed during rainfall events, particularly in winter when the groundwater table is high. This is primarily a result of ineffective stormwater drainage but also due to flat topography, high groundwater tables and limited soakage capacity of the peat fields.

3.1.6 Geological setting and extent of peat

The geotechnical investigation confirms that the ground beneath the Takanini Stormwater Conveyance Channel is predominantly made up of peats, organic silts and sands.

The peat is shown to extend throughout Areas 2A, part of 2B4 but does not extend significantly into Area 2B.

The geotechnical investigations carried out by GHD confirm the extent of peat, which matches very closely to the predictions in the Papakura District Peat Area Stormwater Discharge Review (PDP, 2006). Refer to Drawing *51-3217404-Q073* for GHD's mapped peat extent.

The Takanini Stormwater Conveyance Channel is within the inferred peat zone.

3.1.7 Surface water and discharge to ground

The majority of stormwater in the undeveloped areas of the Takanini 2A2B and surrounding rural areas enters the ground via direct infiltration. Impervious surfaces in areas designated as rural discharge to ground soakage or open channels. Soakage test results indicate some of the highest soakage rates were found within peat areas. However, sample testing indicated the peat also had low permeability.

The Takanini area is known to be underlain by a significant peat aquifer.

Geological units described generally as peat in this area consist of a material that ranges from humic, fibrous peat to amorphous organic clay and are generally horizontally stratified, somewhat explaining the variance in permeability. This is further discussed in the Geotechnical Investigations Report (Technical Report C).

3.1.8 Groundwater

Groundwater level monitoring data has been collected over the past 12 months to establish seasonal variation in groundwater levels. These data are included in Geotechnical Investigation Report (Technical Report C).

Depths to groundwater in the shallow unconfined aquifer system range from 0.0 m in the eastern part of the subject site to 1.0 m to 1.5 m near Cosgrove Road and are >1.5 m depth in the south western part of the site near Grove Road.

3.1.9 Design for ground conditions

Development in this area requires specific design and within sub-precincts D and E, the PAUP (Auckland Council, 2013) stipulates that specific consideration must be given to consolidation settlement, differential settlement and foundation bearing pressure (Part 3, Chapter K, Section 6.25, Rules 8, 10 and 11).

The Papakura District Plan also requires specific geotechnical design for this area (Section 3, Part 16.2.3.5.1). All applications for subdivision in the 2A or 2B area require a Geotechnical Report that assesses consolidation settlement, differential settlement and foundation bearing pressure.

3.1.10 Existing utilities

Existing services are outlined in Drawing *51-3217404-C008* which include:

Stormwater

As already noted, the Takanini 2A2B area is not serviced by a formal stormwater network, instead water is collected in roadside table drains and conveyed to the Papakura Stream (Stream No. 438810) to the north with a small portion of the catchment discharging to Slippery Creek in the south. A short length of reticulation on Grove Road drains a roadside swale to the McLennan wetland. The remaining table drains do not discharge and instead are subject to seasonal groundwater fluctuations.

Water

Watercare Services Limited (WSL) through Veolia Water provides reticulated drinking water to residential properties within the Takanini 2A2B area along Cosgrave Road and Grove Road.

Wastewater

There is no existing wastewater servicing for the undeveloped areas within the catchment. As development of the catchment commences, wastewater servicing is being constructed by developers. The wastewater will be owned and operated by Veolia.

Currently, rising mains from the 61 Grove Road development, the Cappella development, and the Cabra development are being constructed to service their sites. The proposed connection for future wastewater is to the north at Walters Road.

The residential areas adjacent to the catchment are reticulated with both services. Refer to Drawing *51-3217404-C008*.

Waikato No. 1 trunk watermain

A 1,200 mm diameter watermain owned by WSL runs along the western side of Cosgrave Road and has an estimated depth to invert varying between approximately 2.5 m to 3.0 m. This is considered a strategic main, supplying the bulk of potable water to east Auckland.

There is a fibre optic cable above the watermain for communication purposes.

Gas

A 356 OD PE Vector high pressure gas transmission pipeline traverses through areas 2B and 2B4 with an average depth of cover of 900 mm and a 12 m wide designation. The gas main travels in a north-south direction between Settlement Road and Hamlin Road, as shown in Drawing *51-3217404-C008*.

Power

Power is transmitted in overhead lines. There are no significant high voltage feeds in this area.

Telecom and Vodafone

There are existing Telecom and Vodafone services along Cosgrave Road, Grove Road and the local roads adjacent to the Takanini 2A2B catchment.

Rural Land Private Services

The rural zoned farm area bounded by Cosgrave and Old Wairoa Roads has a small diameter water supply for stock and a power feed for electrification of stock fences.

3.1.11 Planned future services

Mill Road corridor

Auckland Transport has indicated that the proposed Mill Road Corridor is likely to traverse areas 2B4 and 2B; however the exact alignment has not been finalised. It is possible that transport corridors will run perpendicular to the channel.

[redacted]

3.2 McLennan wetland

Existing and consented wetland

[redacted]

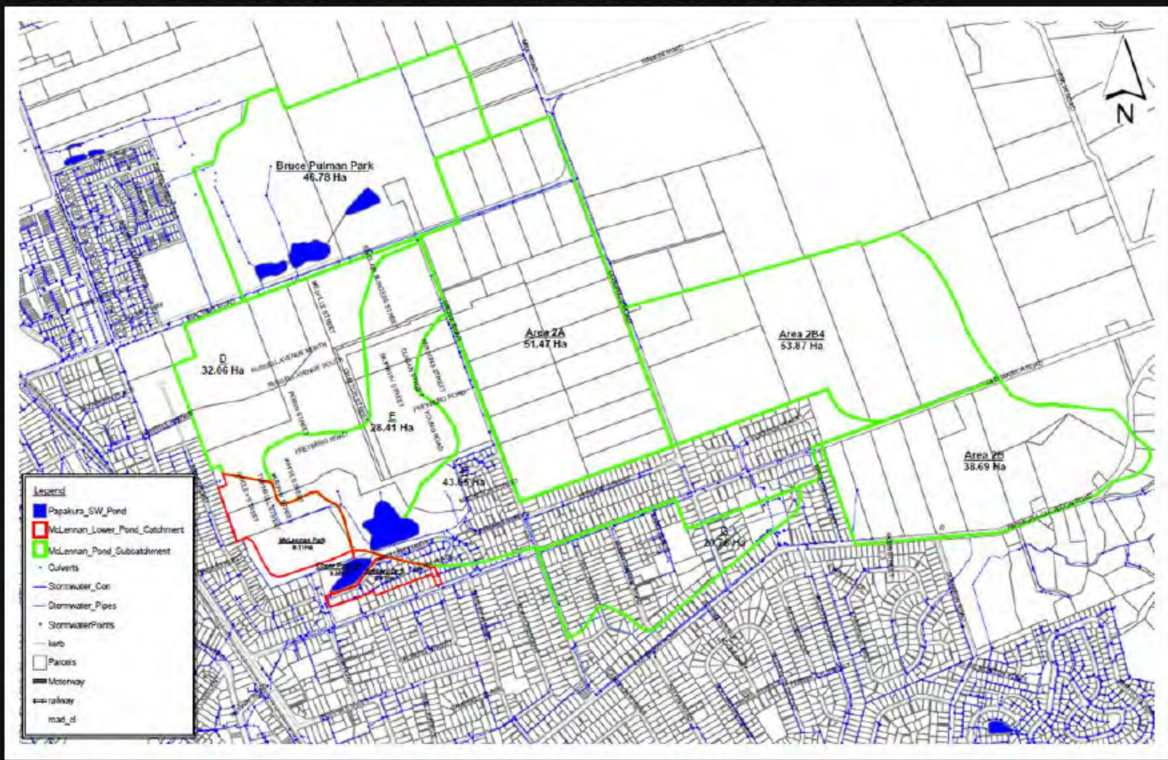

Figure 4 McLennan wetland sub-catchment map (Old Wairoa Road CMP Variations, 2009)

[redacted]

- [redacted]

3.3 Documented / observed flooding

[redacted]

3.4 Water quality

For the pre-developed scenario, during the Water Quality rainfall event (1/3 50% AEP event), rainfall onto Takanini 2A2B catchment is expected to soak through the soil, with little runoff being produced.

For the developed areas adjacent to the proposed Takanini 2A2B catchment; water quality treatment is provided by the McLennan upper wetland discussed in Section 3.2. The efficiency of the upper McLennan wetland is estimated at 72%.

There is another stormwater treatment pond at the downstream end of the Old Wairoa Road catchment; the Gills Road Pond. The Gills Road Pond provides stormwater treatment for the Old Wairoa Road catchment prior to discharging to the Pahurehure Inlet.

There is a requirement for developments in the area to discharge stormwater into soakage devices.

4. Methodology and Design Parameters

4.1 Design requirements

The Takanini Stormwater Conveyance Channel has been designed to accommodate the following elements:

1. Convey the 1% AEP wholly within the channel extent and subsequently within the designation.
2. Provide a permanent water level to support the development of a natural aquatic ecosystem.
3. Provide low flow operation levels of the channel at a suitable depth to allow piped flow from adjacent catchment areas to flow with a free discharge at low flows (not drowned) where practical.
4. Provide suitable 1% AEP flow levels in the channel to allow properties at the catchment extents to design overland flow paths with sufficient capacity and grade to discharge to the channel.
5. Provide a safe environment for the community and for those staff undertaking the operation and maintenance of the channel.
6. Provide for additional amenity value within the designated area where possible.
7. Make provision of the development of footpaths and cycleways.

4.1.1 Design standards

The design requirements and considerations have been compiled from the Auckland Council Stormwater Code of Practice (CoP), relevant planning documents and consents. These are summarised in Table 1 below.

Note that some of these are development criteria, and cannot be directly controlled in the design of the Takanini Stormwater Conveyance Channel. However, provision can and has been made in the design of the channel to aid developers in achieving these criteria. Appendix G provides a more detailed table which outlines how these have been met / considered.

Table 1 Design requirements and considerations

	Criteria Summary	Reference Document
Flooding	Conveyance of up to the 10% AEP event through a primary stormwater system. The location of the primary system should align with the natural flow path as far as possible	Stormwater CoP
	Conveyance of up to the 1% AEP event flow through a secondary stormwater system assuming the primary system is completely blocked	Stormwater CoP, ICMP
	Provide sufficient freeboard to allow future development with habitable floor levels to be constructed at least 500mm above the 1% AEP event flood level (300mm in the Old Wairoa Road NDC)	Unitary Plan, Stormwater CoP
	Minimise infilling of the 1% AEP floodplain	ICMP
	Secondary flow path design for culverts shall assume culvert blockage of 50% for pipes larger than 1500 mm diameter. This criteria assumes that culverts are designed for the 10% AEP with a secondary overland flowpath available. In this case, culverts will be designed for the 1% AEP, and therefore it has been agreed with Auckland Council that lower blockage scenarios can be considered.	Stormwater CoP, Auckland Council
Ecological	Provision for climbing fish passage shall be made at the McLennan wetland, and shall also be provided in any other works within the bed of a watercourse	NDC
	Protection of the stream riparian margin	ICMP
Planning	If practicable, provide centralised community stormwater management devices to avoid ineffective, often expensive, piecemeal stormwater treatment solutions	ICMP
Cultural	Involve local iwi groups in the stormwater management process and incorporate iwi philosophy in the stormwater design where possible	ICMP

Note: refer to Appendix G for a table of how these criteria and considerations have been met

4.2 Hydrological parameters

The following section outlines the hydrological parameters assumed for the catchment.

4.2.1 Prescribed catchment

The proposed catchment area outlines the area that the stormwater conveyance channel can service for the 1% AEP event. This is controlled by the channel depth, capacity and the topography of the catchment.

The area is approximately 155 hectares (ha) and consists of areas 2A (50.3 ha), 'Wallace' (9.1 ha), 2B4 (57.3 ha), 2B (38.0 ha), as shown as a dotted purple line in Figure 1.

A large portion of the Takanini 2A2B catchment does not currently drain naturally to the McLennan wetland but will be picked up by the proposed stormwater conveyance system including:

- The eastern part of 2B and 2B4 currently drains north towards the Papakura Stream (Stream No. 438810).

- The topography of western portion of area 2B currently falls to the north, before being intercepted by a farm drain which discharges to the south-west to the Slippery Creek catchment.
- The Wallace area and the northern portion of 2A currently drain north to Takanini South catchment.

The intention is to drain these areas to the proposed stormwater conveyance system. Accommodating flows from the eastern portion of Area 2B and the Wallace area, that normally drain to adjacent catchments, will reduce downstream capacity and flooding issues in the Takanini South and Slippery Creek catchments.

4.2.2 Design rainfall and climate change

24 hour rainfall

For this project the design rainfall has been derived from Auckland Council's TP108 with a 24-hour storm profile. The 24-hour total rainfall for each of the design storms without climate change allowances are presented in Table 2 below:

Table 2 Design rainfall

Rainfall event	24 hr rainfall
1% AEP	220 mm
2% AEP	200 mm
5% AEP	165 mm
10% AEP	140 mm
20% AEP	110 mm
50% AEP	70 mm

Climate change

The adopted climate change scenario for this project is to year 2090, as per the AC COP. The MfE Guidance for local government recommends a warming value of 2.1°C for the 2090 A1B mid range scenario.

Based upon a 24-hour storm, the effect on rainfall per degree rise is set out in Table 3: (source MfE Preparing for Climate Change – A Guide for Local Government, 2008 Table 7).

Table 3 Adopted climate change scenarios

Rainfall event	Percentage increase in rainfall
1% AEP	8.0 % increase per 1°C rise
2% AEP	8.0 % increase per 1°C rise
5% AEP	7.2 % increase per 1°C rise
10% AEP	6.3 % increase per 1°C rise
20% AEP	5.4 % increase per 1°C rise
50% AEP	4.3 % increase per 1°C rise

Design rainfall values

The adopted 24-hour design rainfall with climate change to 2090 used in the design is as shown in Table 4 below:

Table 4 Adopted design rainfall

Rainfall event	Pre-development rainfall (not including climate change) (mm)	Adopted design rainfall after climate change (mm)
1% AEP	220	256
2% AEP	200	234
5% AEP	165	190
10% AEP	140	158
20% AEP	110	122
50% AEP	70	76

4.2.3 Modelling and hydrological parameters

Impervious areas

The Proposed Auckland Unitary Plan allows for 60% maximum impervious area in catchment 2A and 2B. Area 2B4 is currently zoned rural in the Proposed Auckland Unitary Plan, however it is expected that this land will be rezoned following the construction of the Mill Road Corridor.

The impervious areas noted in the ICMP are generally equal to or greater than the maximum allowable in the Proposed Auckland Unitary Plan zoning. The impervious areas in the ICMP have therefore been used as a base, from which they have been adjusted to account for additional impervious area from the Mill Road Block, as discussed below.

The Mill Road Corridor is proposed to run through areas 2B and 2B4, as shown in Figure 5. The alignment and size of the Mill Road Corridor has not been confirmed; however, for the purpose of this report, a possible route has been assumed which allows for a corridor approximately 1 km long, 20 m wide and 100% impervious. This additional impervious area will slightly increase the maximum impervious area (MPD) scenario as per the values in Figure 5. The three sub-catchments that Mill Road runs through will have impervious areas increased from 60% to 63%.

A sensitivity analysis was carried out on the impervious area assumptions for the catchment. The 1% AEP model was run using a base of 70% impervious area for each sub-catchment, adjusted further as above for the Mill Road Corridor (+3% for the three sub-catchment s that Mill Road runs through). This resulted in an increase in flow of approximately 1 m^3/s for the 1% AEP event (37.9 m^3/s). This is expected to have a negligible effect on the water level in the channel, and therefore the values in Figure 5 are considered reasonable.

Figure 5 Impervious areas

Design curve numbers

An SCS Curve Number (CN) of 74 has been used for peat soils for the predevelopment scenario as per the Papakura ICMP. The post-developed scenario also uses a CN of 74 for pervious areas based on likely imported fill characteristics or existing peat soils as per above.

This aligns with the curve numbers being used by developers in the catchment.

Geotechnical observations indicate that the top crust of the soil can harden when exposed to oxygen and sheds water. This gives further evidence to using a curve number of 74.

An SCS Curve Number (CN) of 98 has been used for impervious areas as per the Papakura ICMP, this aligns with TP108 and other industry standards.

Channelisation factor

Channelisation factors as per Table 5 below were used.

Table 5 Channelisation factors

Surface	Factor	
Impervious areas	0.8	This is considered appropriate due to the fact that developers are required to implement recharge pits which will increase the time of concentration as water needs to pass through the granular material before discharging through a pipe. In addition, the catchment is very flat and overland flow to the channel for events greater than the 10% AEP event does not follow direct routes to the channel. Overland flow is expected to pass through "green corridors" in some areas.
Pervious areas	1.0	This is considered appropriate as the pervious areas in the catchment are expected to sheet flow onto the impervious areas once saturated with no formalised drainage pathways. In small events, water will likely soak into the ground before reaching the impervious areas. In larger events, the water will be slowed by grass / vegetation before sheet flowing onto the impervious areas.

The channelization factors in Table 5 were used for the 50%, 10% and 1% AEP events. A sensitivity check was carried out by changing the Channelisation factor for impervious areas to 0.6 for the 10% AEP model. This resulted in an increase in flow of less than 1 m^3/s in the 10% AEP (22.1 m^3/s). This is expected to have a negligible effect on the water level in the channel, and therefore using a Channelisation factor of 0.8 for impervious areas for all storm events has been considered reasonable; given the flat catchment, possible use of open stormwater systems for some areas of the catchment and recharge pits / soakage devices.

Time of concentration

The values for flow length and time of peak flow have been derived from calculations based on the TP108 methodology. The slopes and catchment lengths consider the developed slopes of the catchment draining to the proposed channel and therefore in some cases are slightly steeper than the existing gradient. These consider:

- Channel flow in the main channel.
- Pervious and impervious flow over the reduced length.

The effect of recharge pits on time of concentration has generally been ignored as the recharge pits are designed for small rainfall events (15 mm); whereas the smallest event modelled is the 50% AEP event (70 mm).

Catchment roughness

Catchment roughness has been determined based on the type of land use as shown in Table 6.

The Manning's numbers align with the Auckland Council modelling guidelines (Auckland Council, 2011).

Table 6 Manning's numbers for catchment surface

Surface type	Manning's number (n)	Inverse of Manning's number input for model (M)
Pre-development (ED)		
Roads	0.018	55
Buildings	0.200	5
Other	0.040	25
Maximum Probable Development (MPD)		
Developed catchment (all surfaces)	0.050	20

Depression storage

The significant area of flat land within the catchment area currently has the ability to store significant volumes of runoff.

Post development with the Takanini conveyance channel in place, the flow path lengths and depression storage will be significantly reduced due to filling and grading of the land. GHD has used reduced channel lengths to reflect the geometric layout of the proposed conveyance channel layout within the catchment.

For impervious and pervious areas; depression storage of 0 and 5 mm respectively, has been used. These are the recommended values in Auckland Council's TP108.

The development controls have a requirement for storage and soakage to ground for the first 15 mm of rainfall. Although this is acknowledged, we consider that the soakage will have negligible effect on the peak flows from larger events such as the 50%, 10% and 1% AEP events (which have been modelled). Therefore the 15mm soakage criteria has not been explicitly considered in the model, however, some representation is present in the consideration of Channelization factors. The presence of soakage devices has only been considered in the model for selection of Channelisation factors to account for drainage pathways.

Attenuation

Generally there is limited attenuation in the catchment, as the proposed Takanini Stormwater Conveyance Channel will convey post-development flows.

The exception is for the sub-catchment which is currently under development by Cabra Investments Ltd (refer to Figure 6). A permanent stormwater pond has been consented to attenuate flows from the Cabra development up to the 1% AEP event to pre-development levels.

The pond has been flow routed by GHD and incorporated into the model. The peak discharge from the pond in the 1% AEP event has been modelled as 3.6 m^3/s.

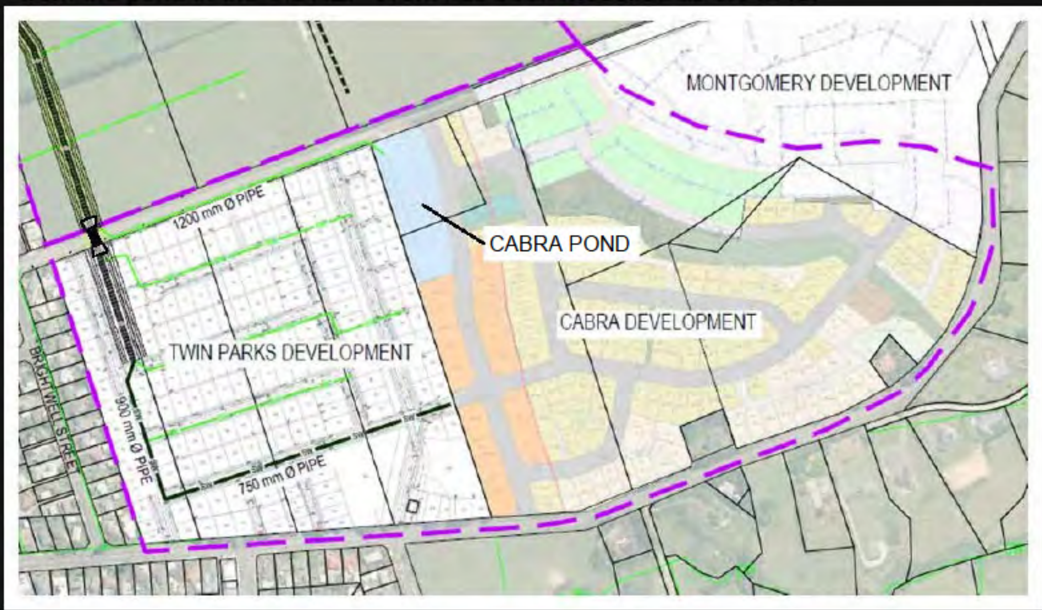

Figure 6 Cabra development and attenuation pond

4.3 Design flows

4.3.1 GHD 1D / 2D coupled model

The catchment and scheme design channel have been modelled in a 1D / 2D coupled model to determine peak flow in the catchment and flood levels within the catchment and channel. The channels were modelled using MIKE11 (1D model) and the surface has been modelled in MIKE 21 (2D model).

The sub-catchment runoff was computed by the model; using the parameters outlined in Section 4.2.

The model predicts a peak flow at the downstream end of the conveyance channel of 37.9 m^3/s for the 1% AEP storm event.

Sub-catchment loading

The sub-catchments were loaded into the Takanini Stormwater Conveyance Channel in the GHD model as per Table 7 below (refer to Figure 5 for sub-catchment boundaries).

Table 7 Loading of sub-catchments

Sub - catchment	Loading	Explanation
2B4_1	Distributed load along the channel.	Represents multiple incoming pipes and overland flow paths as per the expected development.
2B4_2	Point load at CH 950.	Represents an incoming pipe or open channel connection. This sub-catchment is large and it is expected that the developer will need to construct an open channel to service their development which will connect into the Takanini Stormwater Conveyance Channel at CH 950.
2B_2	Point load downstream of the Old Wairoa Road Culvert.	Represent the proposed connection location of the Cabra Pond discharge pipe.
2B_1	Point load at top (upstream end) of the main channel.	Assumes the development discharge to the top of the channel via a pipe or overland flowpath.
2A_1	Distributed load along the northern branch channel.	Represents multiple incoming pipes and overland flow paths as per the expected development.
2A_2	Distributed load along the main channel.	Represents multiple incoming pipes and overland flow paths as per the expected development.
2B4_3	Distributed load along the main channel.	Represents multiple incoming pipes and overland flow paths as per the expected development.
2A_3	Point load at top of northern branch channel.	The Wallace Block is expected to discharge to the top of the branch channel via an 1800 mm diameter pipe.

The modelled flow and hydraulic grade line are plotted on the channel longsection and cross sections in the respective drawings *51-3217404-C121-C127* and *51-3217404-C131-170*.

MIKE11 model outputs

Drawing *51-3217404-C002* shows the modelled Takanini Stormwater Conveyance Channel and the chainage along the channel. Refer to Table 8 for MIKE11 model outputs.

Table 8 Scheme design peak flows

	MIKE11 modelled peak flow (m^3/s)		
Chainage (m)	Q2	Q10	Q100
Main Channel			
0	8.7	22.1	37.9
100	8.6	21.9	37.6
150	8.6	21.8	37.4
200	5.3	14.0	24.2
300	5.1	13.7	23.6
400	5.0	13.4	23.2
500	4.9	13.1	22.7
600	4.8	12.9	22.3
700	4.5	12.2	21.0
800	4.3	11.5	19.8
900	4.0	10.7	18.5
950	3.9	10.5	17.9
1000	1.7	5.9	9.6
1100	1.6	5.7	9.2
1200	1.5	5.4	8.7
1300	1.4	5.1	8.2
1400	1.3	5.0	7.9
1500	1.2	2.8	4.7
Northern Branch			
60A	3.5	8.0	13.2
200A	2.9	6.7	11.1
300A	2.2	4.5	10.3
400A	1.4	3.2	5.4
500A	0.6	1.5	2.5
550A	0.6	1.4	2.4

4.3.2 HEC-HMS model

A HEC-HMS model was prepared by GHD to compare and confirm the predicted flows from the MIKE11 modelling. The peak flow predicted by the HEC-HMS model in the Takanini Stormwater Conveyance Channel at Grove Road is 36.9 m^3/s.

The channel was represented in HEC-HMS as a series of reaches linked together with junctions. Lag time for each reach was based on expected flow velocities along the length of each reach. Velocities and corresponding lag times for each reach have been assumed as per Table 9.

Table 9 Lag times and flow velocity

Reach	Velocity (m/s)	Lag time (min)
Main channel		
CH 0 - 160	1.50	1.8
CH 160 - 550	1.00	6.5
CH 550 - 950	1.00	6.7
CH 950 - 1400	0.80	9.4
CH 1400 - 1540	0.50	4.7
Northern branch		
CH 0 - 300	0.75	6.7
CH 300 - 550	0.90	4.6

The catchment was represented by a series of sub-catchments which were split into separate impervious and pervious catchments, with the catchment parameters as per Section 4.2. Each sub-catchment was loaded into the channel at junction points. This is expected to give a good representation of the flow at each junction. However between junctions the flow is unknown.

The Cabra pond has been represented in HEC-HMS by a reservoir linked to an Elevation-Area Function and an Elevation-Discharge Function which was derived from the pond routing carried out by GHD.

The flow predicted by the HEC-HMS model matches the MIKE11 modelling and confirms that the peak flow predictions are valid.

Refer to Appendix B for HEC-HMS model outputs.

4.4 Channel design

4.4.1 Design basis

The design of the Takanini Stormwater Conveyance Channel has been driven by a number of factors. These are recorded below along with a brief commentary of the effects of each on other aspects of the design.

- The design philosophy in having weirs along the channel length is to maintain low flow water as high as is practical in order to limit the groundwater drawdown and provide for the development of aquatic habitats.
- A second parameter is that the weirs should not cause more than a modest rise in the 1% AEP flow profile.
- The design has considered the ability to drain all of the catchment with minimal site filling to maintain minimum freeboard to habitable floor levels.
- The setting of the 1% AEP flood level has been determined at sufficient depth to allow the channel to operate as an open waterway whilst minimising the overall depth.
- During low flow there will be a series of discrete water bodies or wetlands. Each water body will be nominally 100 m long and be separated by a weir structure to maintain a permanent water surface.
- The wetland bench channel is important for flow, ecological, aesthetic and safety reasons. The wetland bench will contain plants, whereas the low flow channel will be deep enough to prevent or limit plant growth.

4.4.2 Channel alignment

The overall floodplain extent is linear. However the low flow channel would generally meander along the length of the channel. An asymmetric alignment along the main 1% AEP channel has been allowed for this. Refer to Drawing *51-3217404-C181* for a typical section of the channel.

The meander is gradual and velocities in the channel are low, therefore the meander is expected to cause minimal scour within the low flow channel.

4.4.3 Channel bed slope

The overall gradient of the main channel from Old Wairoa Road at IL 23.97 m at the top of the channel falls to IL 19.80 m at Grove Road over a distance of approximately 1.55 km. This is an approximate gradient of 0.28%.

The overall gradient of the northern branch channel from 131 Grove Road at IL 21.45 m at the top of the channel falls to IL 20.10 m at the junction with the main branch over a distance of approximately 0.55 km. This is an approximate gradient of 0.24%.

4.4.4 Channel geometry

Defined zones

The channel has been designed to allow for the following zones:

1. **Low flow channel**

   A meandering low flow channel with a permanent water depth of about 0.8 m controlled by the weirs at 100 m centres longitudinally along the base of the channel. The base of the low flow channel is typically 3.6 m wide with slope batters 2H:1V.

2. **Wetland bench**

   A slightly meandering wetland bench above the low flow channel that varies in width as the low flow channel meanders within it. The wetland bench is part of the permanent flow channel and the intention is for this zone to be within the permanent water level provided for by the weirs. The wetland bench will be planted with wetland species, is nominally flat and has a permanent water depth of 0.2 m.

3. **10% AEP water level**

   The channel bank is battered at 4H: 1V or flatter to a height between 0.70 m and 1.5 m to allow for conveyance of the 10% AEP. The batters will incorporate riparian planting, as per the planting plan in the Urban and Landscape Design Analysis Report (GHD, 2014). Generally, native grass species that would lay flat during large flow events have been proposed. Tree species will have most of their mass above the 1% AEP event and therefore would not have a significant impact on the channel roughness. These include cabbage tree and kahikatea.

4. **1% AEP water level**

   The channel above the 10% AEP water level continues at a gradient of 33H:1V to allow for conveyance of the 1% AEP. This portion of the channel will be grassed with amenity and has provision for footpaths and cycleways.

Side slopes / channel batters

Generally, slope batters have been designed at 4H:1V or flatter, as per the recommendations from the Geotechnical Investigations Report (Technical Report C). Steeper batters (2H:1V) in the low flow channel have been considered suitable as these will be fully submerged, and are a maximum of 0.6 m high. The channel sections have been modelled in the Geotechnical Investigations Report (Technical Report C).

Overall depth and width

The main channel ranges in depth from between 1.9 m to 4.0 m bgl to the base of the channel. The overall total width of the main channel at the 1% AEP water level ranges from 13 m to 39 m.

The northern branch channel ranges in depth between 2.4 m to 3.8 m bgl to the base of the channel. The total overall width of the northern branch channel at the 1% AEP level ranges from 12 m to 27 m.

Rock weirs

In order to maintain a permanent waterbody within the wetland channel, a series of rock weirs at notional 100 m centres will be used to maintain this body of water. The depth of water behind each weir is 800 mm with a depth of 200 mm along the wetland bench. As well as providing for aquatic habitat, the permanent water level will assist in reducing groundwater drawdown and related potential settlement.

The top surface of the weir is 14 m across at the largest section. The width of the low flow channel is approximately 6 m wide at the largest section.

The step between each weir varies from 0.18 m to 0.45 m to give an overall average gradient along the full channel length. At high flows these weirs will be totally drowned. The depth of the 1% AEP event flow above the top of the weir level has been calculated at about 1 m deep.

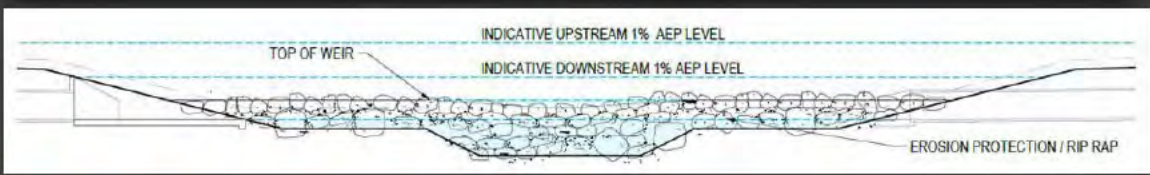

Figure 7 Rock weir cross section detail

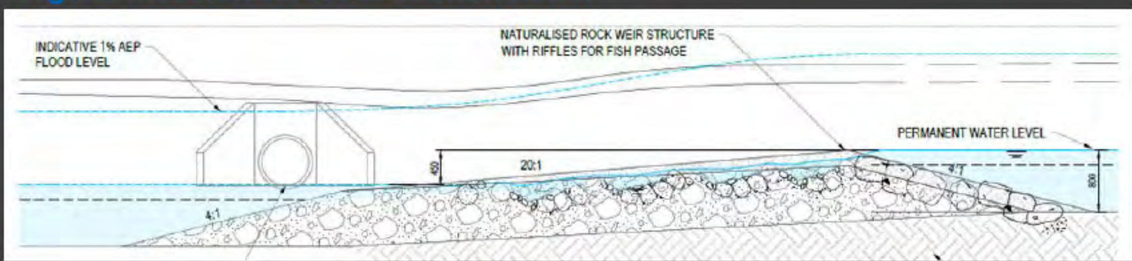

Figure 8 Rock weir longsection detail

As the flow increases (during a flood event) the flow over the weir increases and the flow in the channel downstream of the weir raises at a faster rate until the weir is almost drowned. Prior to the weir being drowned the flow becomes critical over the weir and the velocities will increase. The extent of increase will depend on the difference in water level above and below the weir. The design of the weirs will be further refined in detailed design to include energy dissipation to reduce the velocities back to subcritical flow downstream of the weir.

Operational water levels

The permanent water level in the channel is consistent throughout its length with a depth of 800 mm. The operational water levels for the 10% AEP and 1% AEP flows vary along the channel but typically are in the order of those shown in Table 10.

Table 10 Operational water levels

Channel zone	Typical water level above channel invert (m)
Low flow	0.80
10% AEP	1.40
1% AEP	1.70

Low flow channel

The low flow channel depth has been selected based on a combination of water quality, flow characteristics, safety and industry guidelines.

The low flow channel depth of 0.8 m helps to achieve:

- Sufficient flow capacity contributing to conveyance of large events
- Low velocities during low flow to minimise erosion
- A suitable volume of water to control temperature fluctuations
- Safe water depth and velocity in case of person entry

No design recommendations for low flow channel depths or widths have been found in any Auckland Council or New Zealand design standards for similar channel designs. The Queensland Urban Drainage Manual (Department of Energy and Water Supply, 2013) recommends a depth of 0.45 m for a low flow channel with a base width of 2.0 m.

The base width of the proposed Takanini Stormwater Conveyance Channel for the majority of its length is 3.6 m; a depth of 0.8 m for this width achieves a similar width/depth ratio as per the Queensland Channel Design Guideline. The width of the channel is based on allowing shading of the low flow channel, low velocities and reduced scour, and sufficient conveyance capacity for the 10% AEP event.

It is expected that the wetland grasses in the wetland bench adjacent to the low flow channel, and some of the larger plant and tree species in the riparian margin (cabbage tree, kahikatea) will provide shading to the stream. This will also help control temperature and provide additional ecological benefit. As discussed in Section 4.4.4, the tree species have been selected to have most of their mass above the 1% AEP event, and the larger plant species have been selected to lay flat during large storm events.

4.4.5 Channel hydraulics

Manning's numbers

The adopted Manning's numbers for the Takanini Stormwater Conveyance Channel align with the recommended values in *Christchurch City Council's Waterways, Wetlands and Drainage Guide* (Christchurch City Council, 2003). The above publication was used as it contains Manning's numbers for stream surfaces that are similar to the proposed vegetation and channel profiles of the proposed Takanini Stormwater Conveyance Channel. No local (Auckland) publications were found with Manning's numbers for similar surface types.

No channel example case studies with assessment Manning's numbers were found in local (Auckland or New Zealand) publications, however, example case studies are given in the *Natural Channel Design Guidelines (Brisbane City Council, 2003)*. Figure 9 outlines a channel with similar features to the proposed stormwater channel.

Figure 9 Similar channel with an average bankfull n = 0.035

The example channel is described as having mown grass banks, unmaintained wetland plants on bed, regular cross section, and a very slight meander. This example has no riparian margin.

The wetland plants in the Takanini Stormwater Conveyance Channel would ideally be maintained and would have a lower roughness coefficient than the example above. The Takanini Stormwater Conveyance Channel has riparian planting as per Section 4.4.4 which transitions into a mown grassed floodplain.

Overall the proposed conveyance channel is expected to have a similar or slightly higher average roughness coefficient as the example channel.

Adopted Manning's n numbers

The following Manning's numbers have been used for the hydraulic analysis. These have been selected assuming:

1. The low flow channel is maintained to keep clear obstructions and prevent excessive weed growth. n = 0.030
2. The wetland plants are lay flat species and will flatten during flood events. n = 0.045
3. The flax and native grasses on the channel bank are maintained to keep clear of excessive weeds. The plant species are assumed as a mixture of those that can flatten during flood events with some heavier shrubs less than 1 m tall. n = 0.060
4. The grass is maintained at a short length and specimen trees are scattered throughout the floodplain. n = 0.045

Table 11 Manning's numbers for conveyance channel design

Section	Surface Cover	Manning's number (n)
Low flow channel	Naturalised channel with pools and slight channel meander	0.030
Wetland bench	Wetland grasses	0.045
Channel bank	Flax and native grasses (<1 m tall)	0.060
Floodplain	Mowed grass with footpath and specimen trees	0.045

4.4.6 Grove Road Culvert Inlet

The Grove Road Box Culvert and the inlet structure are being designed by Jacobs, who have provided an invert level of the culvert of 17.5 m. The culvert entry has a tapered mouth to provide more efficient inlet conditions. The mouth has an invert level of 17.6 m. The mouth transitions into an apron which slopes up to RL19.6 m.

The downstream weir of the Takanini Stormwater Conveyance Channel has an RL of 20.6 m. Therefore a 1 m vertical transition is required between the inlet structure/apron and the last weir of the Takanini Stormwater Conveyance Channel. This section outlines the concept design of this transition. Drawing 51-3217404-C192 outlines the concept.

Design principle

The key considerations for the design of the transition between the Takanini Stormwater Conveyance Channel and the Grove Road Box Culvert inlet structure include:

- Low velocities to control erosion / scour
- Flood level to achieve suitable freeboard for Grove Road
- Fish passage
- Controlling groundwater drawdown

The key design features include a series of three concrete pools with small low flow weirs/riffles which spill/cascade into one another. The average longitudinal slope between the pools is approximately 12H:1V. The concrete pools will have rocks within them to provide ecological benefits and energy dissipation. Rocks will also be incorporated around the pools to control erosion and scour as flows approach the pools. The average cross sectional slope heading towards the low flow pools and riffles is approximately 5H:1V. Planting will be incorporated along the slopes and around the rock pools to provide shading and aesthetics.

The last weir of the Takanini Stormwater Conveyance Channel is located at the top of the slope and is approximately 35 m long with an RL of 20.6 m. This level sets the permanent water level in the channel, which has been maintained to control the groundwater level. A groundwater cut-off barrier is proposed underneath this weir to minimise any groundwater drawdown caused by the cut below this level to create the transition to the Grove Road Culvert Inlet.

Velocities

High flow events such as the 1% AEP event are not expected to produce the highest velocities, as the flow will be drowned out at the culvert entry; rather, the smaller events will produce the critical velocities for erosion and scour. Velocities are expected to reach up to 3-4 m/s for the critical storm events. These velocities are expected to be acceptable for planting and will be dissipated using rip rap / rocks and the concrete pools. Some sacrificial planting near the pools may be lost, which is acceptable.

Groundwater drawdown

The weir at the top of the slope will maintain the permanent water level in the channel. Downstream of this weir, the proposed ground level will drop into the Grove Road Culvert Inlet. To prevent groundwater drawdown due to the deeper cut; a physical groundwater cut-off barrier is proposed at RL 20.6 m and will surround the entire inlet structure, as per Drawing 51-3217404-C192. The barrier will be designed during detailed design, however it is expected to be up to 7 m deep below the existing ground surface.

A similar barrier has been modelled upstream near Cosgrave Road to mitigate groundwater drawdown due to the deep cut of the channel. This modelling will be updated during detailed design to confirm the required depth and properties of the cut-off wall for the Grove Road Box Culvert inlet.

4.4.7 Crossings

Watercare Waikato No.1 Watermain crossing

Description

The Waikato No.1 Watermain conveys potable water from the Waikato Water Treatment Plant to the Redoubt Road Reservoir and runs along Cosgrave Road.

The as-built drawings (dated 2006) show this section of pipe is a 1200 mm CLS (concrete lined steel) pipe with 9.5 mm thick steel and 16 mm concrete lining. Depth to invert is approximately 2.5 m. The pipe was laid on granular backfill and although not specified on the as-built drawings, Watercare have indicated that this is likely to be 19 mm aggregate.

There is an existing fibre optic cable which run on top of the Watercare pipeline. This link provides control of the Waikato and Ardmore Water Treatment Plants as well as the pipeline from the Watercare main control room.

Through consultation with Watercare, they have advised that they require a minimum separation between the base of their 1200 mm pipe and any new structure of 500 mm.

Proposed Cosgrave Road Culvert

The proposed Cosgrave Road Culvert has been designed for:

- Free water surface at low flow.
- The design 1% AEP event of 22.7 m^3/s flow with minimal head loss.

These criteria can be met with twin 3 m wide by 2 m deep culverts. The design involves head walls upstream and downstream to support the Cosgrave Road carriageway. The culvert invert will be approximately 1 m below the adjacent channel bed level, creating a drowned culvert. Refer to drawing *51-3217404-C192* for the preliminary design of the Cosgrave Road Culvert.

Culvert blockage

Two high level blockage scenarios for the Cosgrave Road Culvert have been considered to determine the effect of blockage on the inlet capacity of the culvert and the performance of the conveyance channel. The scenarios considered include:

- 10% blockage
- 20% blockage

The culvert is outlet controlled and therefore 10% blockage and 20% blockage have a negligible effect on the performance of the Cosgrave Road box culvert and the Takanini Stormwater Conveyance Channel. Refer to Appendix E for the blockage assessment.

Using twin culverts provides protection against significant blockage. Each culvert has an inlet area of 6 m^2, giving a total inlet area of 12 m^2. Significant blockage of such an area is unlikely, as most objects will be passed through the culvert.

Old Wairoa Road crossing

The proposed Takanini Stormwater Channel crosses Old Wairoa Road at the boundary of 999 Papakura-Clevedon Road. The upstream catchment drained by the proposed culvert is approximately 15 hectares and is being developed by Cappella Papakura Developments Ltd. The upstream catchment is expected to generate a peak flow of 4.3 m^3/s during the 1% AEP event.

Twin 1500 mm diameter culverts are proposed to drain the Cappella development with a 1200 mm diameter pipe draining the 11.1 ha Cabra development further upstream. The proposed 1200 mm diameter pipe will connect into the downstream headwall of the Old Wairoa Road Culvert.

This sizing and headwall design provides an acceptable freeboard during the 1% AEP event for Old Wairoa Road.

Detailed design for the Old Wairoa Road Culvert has been undertaken by MSC Consulting Group Ltd. on behalf of Cappella Papakura Developments Ltd. The detailed design is based on the levels from the GHD scheme design. The culvert has been consented and constructed by the developer.

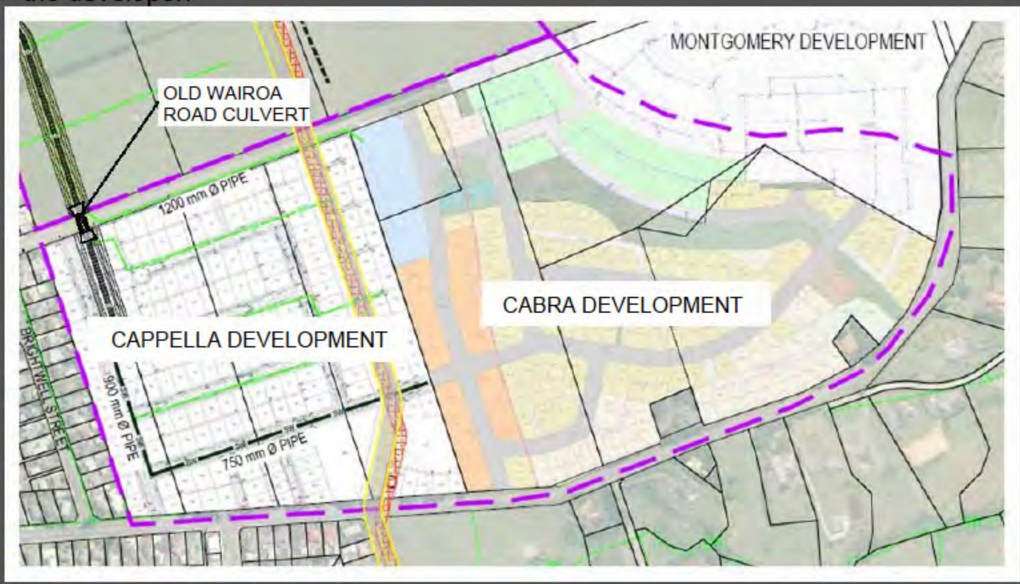

Figure 10 Old Wairoa Road Culvert location plan (Drawing 51-3217404-C310)

The Old Wairoa Culvert will be partially submerged with a permanent water level approximately 600 mm to 800 m deep.

Figure 11 Old Wairoa Road Culvert longsection (MSC, October 2015)

4.5 Hydraulics and flooding

The Takanini Stormwater Conveyance Channel Scheme design was modelled in MIKE11 to determine the hydraulic grade line in the channel for the 50%, 10% and 1% AEP events. The model was checked using spreadsheet calculations based on Bernoulli's energy principle and Manning's flow equation (using Flowmaster).

4.5.1 1D/2D coupled flood model

To calculate the hydraulic grade line for the channel; the catchment and channel were modelled using MIKE11 and MIKE21. Channel cross sections were input into the model at 20 m spacing. Channel cross sections, roughness, culverts and catchment parameters were used to match the values described in Section 4.2 and 4.4 of this report.

The model confirms that the channel design is adequate for conveying the 1% AEP event with adequate freeboard. In addition, the hydraulic grade line is maintained at a low enough level to provide drainage of the surrounding land developments; this is further discussed in section 5.3.1. Refer to Drawing *51-3217404-C121-C127.*

Refer to Appendix A for the MIKE11 model outputs.

4.6 Safety in design

Safety has been considered throughout the design process. Each component of the Takanini Stormwater Conveyance Channel has been designed with safety as a key consideration.

The following section provides a summary of the safety considerations for the channel design.

4.6.1 Low flow channel

The low flow channel has been designed with a maximum permanent water level 0.8 m deep. Channel banks that are permanently underwater will have side slopes of 2:1.

The low flow has been designed to discourage entry by the public. If someone were to enter the low flow channel, the key features discussed below would mitigate the safety risk:

- Low velocity
- Shallow depth maintained by weirs (0.8 m)
- 2:1 side slopes constructed from granular material. As such, the ability for someone to walk up this drowned slope without slipping is enhanced
- Wetland bench provides warning of imposing deep water. The wetland bench also acts as a safety bench to assist anyone climbing out of the channel and reduces the chance of people falling into the deeper section.
- Riparian margin creates barrier to entry

4.6.2 Cosgrave Road box culvert

The proposed Cosgrave Road box culvert will be permanently drowned with a permanent water depth of approximately 1.7 m. At the upstream end, there is approximately 0.3 m between the roof of the box culvert and the permanent water level. At the downstream end there is a 0.25 m air pocket between the roof of the culvert and the permanent water level.

The velocity and turbulence in the culvert during low flow conditions will be low and would allow a person to swim through. The person will be able to escape the culvert at each end where the channel bed grades up to a shallower depth.

Key features include:

- Low velocity and turbulence during low flow conditions.
- Channel bed sloped at each end to provide a ramp up to shallower water.
- Entry into the culvert is discouraged by planting in the channel at each end and a permanent water level that is continuous between the channel and the culvert.

4.6.3 Old Wairoa Road box culvert

The Old Wairoa Road box culvert has been designed by Cappella's development engineers. Auckland Council Stormwater Operations have reviewed the design and have approved the twin 1.5 m diameter culvert size.

GHD have peer reviewed the structure. A brief assessment of safety is outlined below.

The proposed Old Wairoa Road Culvert is a twin 1.5 m diameter culvert and will have a permanent water level of 0.8 m at the downstream end and 0.54 m at the upstream end. At low flow, while discouraged, an adult would be able to safely walk through the culvert. During high flows, the culvert will be fully drowned, and entry into the culvert at this time is not expected. Key features include:

- Low velocity during low flow conditions.
- Shallow depth during low flow.
- Entry into the culvert is discouraged by planting in the channel at each end and a permanent water level that is continuous between the channel and the culvert.

5. Effects Assessment

5.1 Effects overview

The channel will have an overall positive effect on the community and environment. There is no existing drainage infrastructure for the catchment area, and therefore the land cannot be comprehensively developed. The construction of the Takanini Stormwater Conveyance Channel will provide a drainage pathway, which reduces the extent of the existing floodplain and thus allow development of the adjacent land.

Without the channel, there is no stormwater infrastructure for developers to connect into. To develop the land without the channel, houses would need to be raised above the existing floodplain and developers would need to attenuate flows to predevelopment levels (subject to approval from Auckland Council). The area of land required to attenuate flows in stormwater ponds would significantly reduce the area of developable land in the catchment and would be expensive. The implementation of the Takanini Stormwater Conveyance Channel provides a significant benefit for the landowners in the catchment.

The Takanini Conveyance Stormwater Conveyance channel will provide an ecological link through the existing area and future development area. The current environment has little ecological value, as discussed in Ecological Report (Technical Report J). The Takanini Stormwater Conveyance Channel will provide an opportunity to increase wildlife in the area by providing a potential habitat for aquatic life, birds, lizards and other wildlife. Native plant species can be incorporated into the riparian margins, wetland bench and floodplain areas of the channel.

The channel and designation area will also provide public space to provide amenity to the future communities in the area. The floodplain area can incorporate a footpath, cycleway and public recreational space.

5.2 Reduced flooding

The construction of the Takanini Stormwater Conveyance Channel will provide a drainage pathway. This allows for development of the site by reducing the floodplain to allow development of their land.

Overland flow from the adjacent developments is expected to be conveyed along roads and drainage corridors within the development to the Takanini Stormwater Conveyance Channel where flow will be contained within the designation area.

The capacity of the channel is adequate to convey the 1% AEP flow at a level that is reasonable for adjacent land developers to grade their overland flow paths towards. This is further discussed in Section 5.3.

5.3 Servicing development

5.3.1 Development connections to channel

The channel has been designed with a shallow depth to reduce potential for groundwater drawdown and ground settlement. The channel therefore requires a wide, shallow flow depth to allow connections for servicing the 10% AEP. Swales or multiple small diameter shallow pipes would be favourable for draining the catchment once developed due to the shallow channel.

Lateral connections to allow properties to drain have been assumed as piped flow, where practical, for events up to the 10% AEP. Overland flow paths will be required to convey flows up to the 1% AEP event (refer to Section 5.3.2).

Drawing *51-32174-C310* shows an indicative drainage configuration with pipe sizing (refer to Appendix F for pipe sizing calculations).

Piped connections to the channel will typically enter at the permanent water level. Piped connections are expected to discharge at the base of the 4H:1V channel banks downstream of the proposed weirs. Figure 12 and Figure 13 show a typical detail for connections.

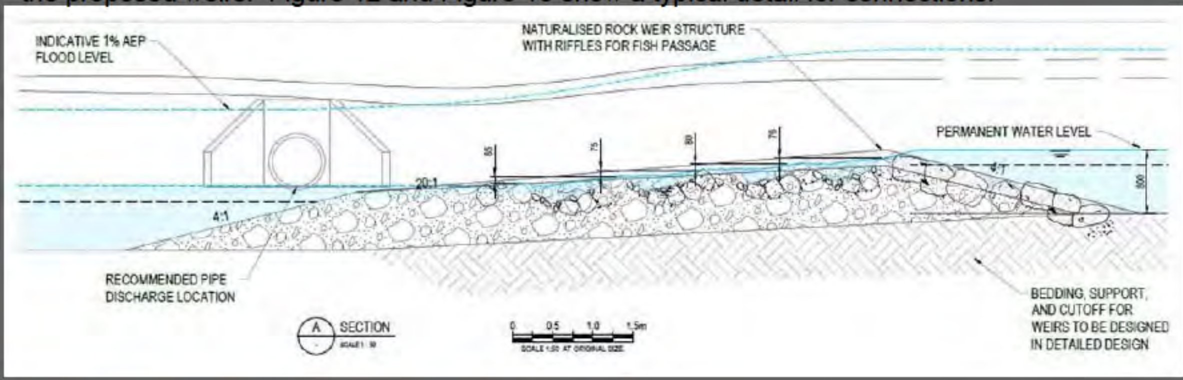

Figure 12 Typical connection longsection

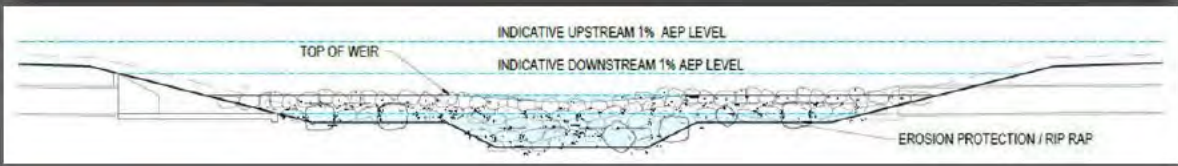

Figure 13 Typical connection cross section

Key benefits of discharging downstream of the weir locations are:

- Limit outlet structures and associated energy dissipation to areas where energy dissipation is already required to control flow from the weirs.
- Allows maximum steepness of the hydraulic gradient of the piped flow and as such limiting pipe sizes to their respective minimum size.
- Increased cover over the discharging pipe.
- Visually less prominent within the riparian and wetland planting.

Each connection will be designed and constructed by the developer.

5.3.2 Overland flow

Overland flow will need to be conveyed to the channel via secondary overland flow paths from development within the adjacent land. The design of these flow paths will be undertaken by the developers of the land. Overland flow paths for developments are usually designed along walkways or roads. This will be done by individual developers as and when infrastructure for particular development is implemented.

The channel has been designed with a depth to allow sufficient hydraulic grade from the furthermost extent of the catchment to the channel. Some areas will require fill by the developer due to the existing topography sloping away from the catchment. Refer to drawing *51-3217404-C311-C312* for long sections showing a possible drainage solution for the catchment. The possible drainage solution considered uses pipes to convey the primary flow (10% AEP) and is not the optimal solution, ideally, developers would use swales and low impact design rather than piped networks.

5.4 Downstream effects

Downstream of the Takanini Stormwater Conveyance Channel is the Grove Road Box Culvert which discharges to the McLennan wetland. The McLennan wetland is to be drained by the proposed Artillery Drive Tunnel, which has been designed to convey the attenuated flows from the wetland. The overall drainage scheme which includes this infrastructure is discussed in Section 2.3.

Grove Road Box Culvert

The Grove Road Box Culvert is hydraulically steep and is being designed to convey the 1% AEP event without tail water effects on the conveyance channel. The culvert is currently being designed by Jacobs and construction is anticipated in 2016/2017. This will provide infrastructure for the Takanini Stormwater Conveyance Channel to discharge into.

McLennan wetland

The McLennan wetland was included in a previous model held by Auckland Council. This model includes the proposed Takanini Stormwater Conveyance Channel scheme design, the Grove Road Box Culvert and the proposed Artillery Drive Tunnel and is therefore considered a good representation of the downstream conditions.

The McLennan wetland was modelled with:

- Top of bund RL 16.40 m
- Emergency spillway RL 15.40 m
- Artillery Drive Tunnel outlet at RL 11.50 m
- Low flow outlet pipe IL 10.04 m

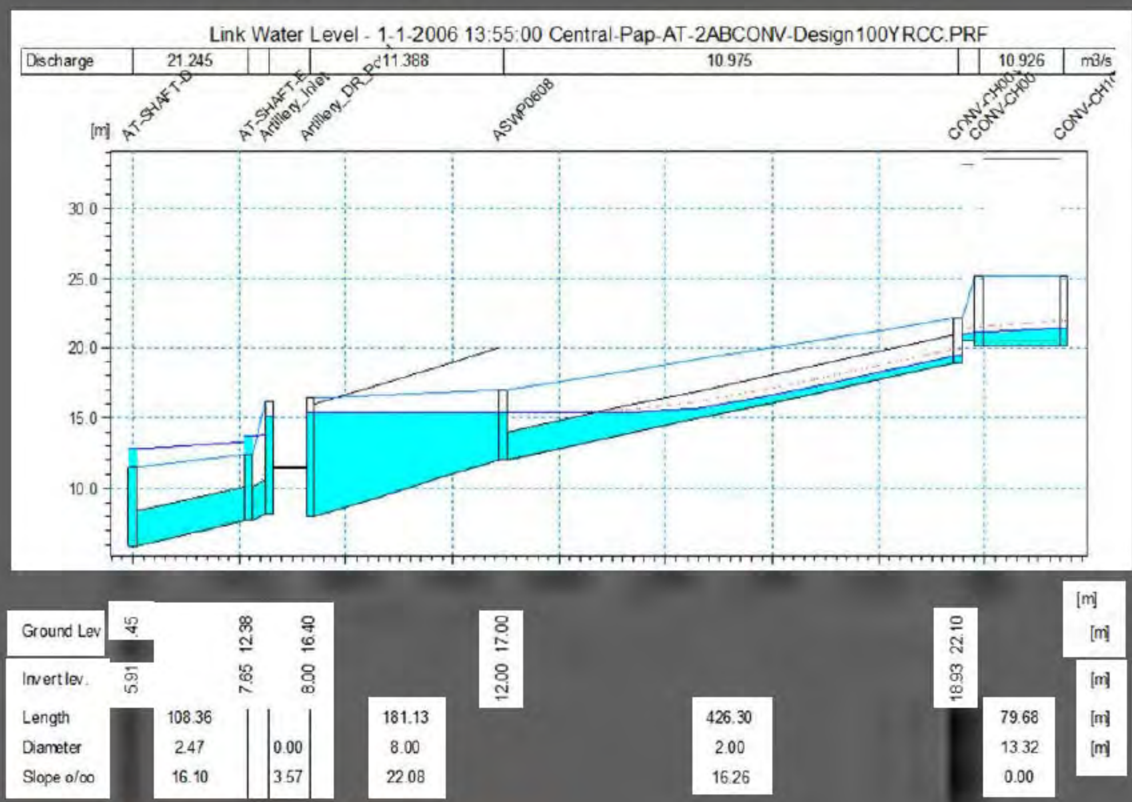

Figure 14 McLennan wetland model

As discussed in Section 3.2 the model indicates that following modification of the embankment, overflow levels and construction of the Artillery Drive Tunnel, there is sufficient storage in the wetland to accommodate the expected flow from the Old Wairoa Road catchment, as per the Draft Papakura Central ICMP.

The maximum flood level in the McLennan wetland during the 1% AEP event is RL 15.40 m.

5.5 Sediment deposition

5.5.1 Typical Auckland catchment

The typical runoff from a developed Auckland catchment will be in the order of 0.5 t/ha/annum. This is based on soil types generally consisting of Waitemata clays and would occur when all bulk earthwork development has been completed and individual housing sites are developed. In the case of this development there is expected to be areas of recent peat alluvium as per the existing soils, in addition, there is expected to be imported fill from developers. Slopes in this catchment are very flat and therefore it is expected that the runoff will be towards the lower range of any variance around 0.5 t/ha/annum. The steep portion of the 2B catchment will drain to a stormwater pond at the Cabra Development site, and therefore sediment removal is expected for this area.

We can also expect that a portion of sediment will be entrained and passed through the system down to the McLennan wetland and Pahurehure Inlet during high flow events. We therefore expect the residual sediment deposition in the channel to be in the order of 0.25 t/ha/annum. If this deposition is evenly distributed along the channel, then the catchment area/channel length (155 ha / 2100 m = 0.74 ha / lineal meter) relates to an annual deposition of 18 kg per lineal meter of channel per annum. We would expect some of this to be deposited below the permanent water level.

The annual estimated deposition rate is between 1.0 - 1.5 mm/annum. At this rate, it would take between 60-100 years for 100 mm of sediment to build up along the channel. This may not be distributed evenly, and would likely be distributed along the wetland planting area, the main low flow channel and behind the weirs. It is expected that maintenance to remove sediment would be required approximately every 20-50 years.

5.6 Scour and erosion potential

Scour and erosion potential is an important consideration for the design of the Takanini Stormwater Conveyance Channel. Scour and erosion of the channel could potentially result in poor amenity, discharge of sediment into the downstream receiving environment and bank stability issues for adjacent structures.

5.6.1 Channel velocities

Potentially high velocities in the channel pose the biggest risk of scour and erosion to the channel banks. Velocities are expected to be low during small rainfall events and scour and erosion is not considered to be an issue. In larger events, such as the 1% and 10% AEP, velocities are higher and scour and erosion protection has been incorporated in the design to address this.

The peak 1% AEP flow velocity is approximately 1.3 m/s just upstream of Grove Road (Refer to Table 12. This reduces to approximately 1.0 m/s above Cosgrave Road. This excludes water flowing over the weir sections, where there is an expected increase in velocity.

Average velocities have been calculated along the channel and are noted in Table 12.

Table 12 Average channel velocities

	10% AEP		1% AEP	
Chainage (m)	Q (m^3/s)	V (m/s)	Q (m^3/s)	V (m/s)
Main Channel				
100	21.9	1.06	37.6	1.31
150	21.8	0.96	37.4	1.25
200	14	0.63	24.2	0.81
300	13.7	0.74	23.6	0.93
400	13.4	0.77	23.2	0.96
500	13.1	0.72	22.7	0.94
600	12.9	0.82	22.3	0.92
700	12.2	0.66	21	0.79
800	11.5	0.62	19.8	0.79
900	10.7	0.59	18.5	0.76
1000	5.9	0.55	9.6	0.64
1100	5.7	0.54	9.2	0.66
1200	5.4	0.50	8.7	0.63
1300	5.1	0.42	8.2	0.52
1500	2.8	0.23	4.7	0.25
Northern Branch				
60A	8	0.87	13.2	0.90
200A	6.7	0.57	11.1	0.63
300A	4.5	0.45	10.3	0.68
400A	3.2	0.40	5.4	0.48
500A	1.5	0.24	2.5	0.32
550A	1.4	0.26	2.4	0.37

The velocities in Table 12 represent the average velocities over the full cross sectional flow area. These velocities are low and are generally less than 1 m/s. In storm events smaller than the 1% and 10% AEP, velocities are expected to be lower.

It is estimated that the velocity at the downstream end of the main channel is approximately 0.6 m/s in the 50% AEP and 0.3 m/s in the 100% AEP. These velocities are low and not expected to cause significant scour or erosion in the channel. A more detailed assessment of the velocity profile will be undertaken in detailed design to account for the variation in velocity across the channel section.

In reality, the velocity across each channel section is expected to vary vertically depending on surface cover and depth. A typical velocity profile is shown in Figure 15.

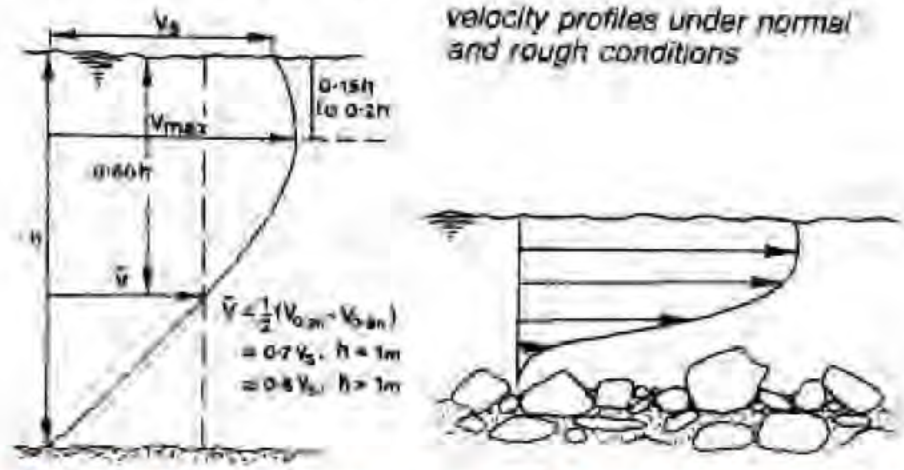

Figure 15 Typical velocity vertical profile (Australian Groundwater Research, 2013)

The velocity profile illustrates that velocities are expected to be moderately lower at the base of the channel.

5.6.2 Scour and erosion

The surface cover of different zones within the channel provides varying levels of resistance against scour and erosion. Table 13 outlines the surface cover types and the expected performance in regards to scour and erosion due to flow in the channel.

Table 13 Scour and erosion risk for channel zones

Zone	Surface Cover	Risk of scour / erosion	Possible protection measures
Low Flow Channel	Naturalised channel with pools and slight channel meander	High susceptibility to scour and erosion. However velocities are expected to be lower at the base of the channel.	To be further assessed in detailed design. Possible options include: • Rip rap. • Coir matting.
Wetland Bench	Wetland grasses	Low risk. Wetland grasses will slow velocities and roots will strengthen soils.	No additional protection required.

Channel bank	Flax and native grasses. Small unrestrictive trees with mass of branches above 1% AEP.	Low risk. Roots of grasses and trees will strengthen channel banks.	No additional protection required.
Floodplain	Mowed grass with footpath and specimen trees	Low risk. Grass will naturally protect from scour and erosion.	No additional protection required.

Table 13 identifies the low flow channel as the key area susceptible to scour and erosion. This is because there will likely be soils directly exposed to channel flow. The risk is reduced by having a large cross sectional area of permanent water, which will reduce velocities in the low flow channel. In addition, the expected velocity profile is expected to produce lower velocities at the base and slopes of the low flow channel.

The base of the low flow channel will not be lined to allow naturalisation of the channel over time. Subject to further assessment during detailed design, rip-rap may be required along the low flow channel to provide additional resting places for fish and reduced erosion and scour of the low flow channel.

Further assessment during detailed design will refine the velocities that the low flow channel will be subject to. This will determine whether rip rap at the base of the channel is suitable and the required size of rip rap or whether additional protection is required.

Edge protection at the point of potential wave action

Along the low flow portion of the channel, there is a need to prevent the peats from day to day erosion at the point of wave action as can be observed in the Bruce Pulman Park ponds. The channel is planted with wetland planting at this location, which will provide erosion mitigation.

Subject to further assessment during detailed design, additional mitigation may be required along the batter of the wetland bench. This requirement and the type of scour protection will be determined at detailed design. Figure 16 outlines the possible location of additional scour protection if required.

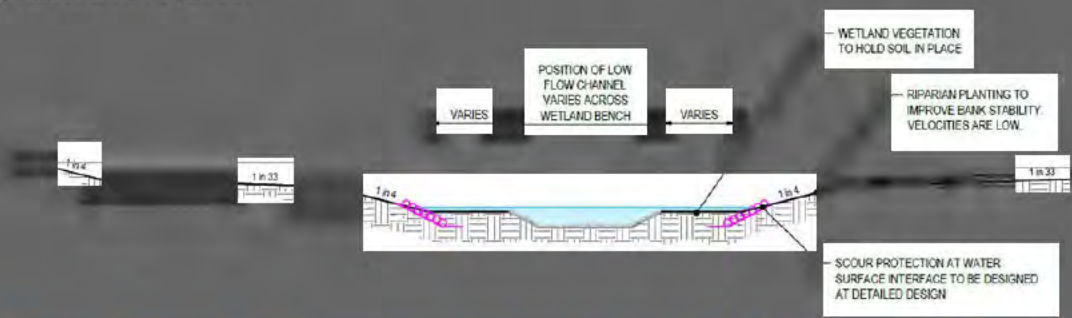

Figure 16 Possible channel erosion protection to be implemented if required

Planting

Wetland plants, flax, native grasses and small trees have an ability to withstand the expected velocities (<1.4 m/s) without adverse effect. The planting of the channel will provide stability to the soils to resist against scour and erosion. Treatment of the soil may be required to aid the growth of plants if the acidity of the soils increases significantly after construction of the channel.

Full development of the catchment is not expected to be completed for some years after the construction of the channel. As such peak flow rates will be less than the MPD scenario. This will allow time for the wetland plants to become established and grow.

Channel bend (Ch 1000)

In terms of the main alignment around chainage 1000, there is a gradual 90 degree bend. The channel bend is of such a large radius, that scour on the outside of the bend is anticipated to be negligible. The flow is less than 0.7 m/s in the 1% AEP event and less than 0.6 m/s in the 10% AEP event, therefore there is no need for additional protection on the outside of the bend.

Confluence main channel and northern branch (Ch 200)

The main channel at the confluence has a peak flow of 24.2 m^3/s in the 1% AEP event. The northern branch has a peak flow of 13.2 m^3/s in the 1% AEP event. Specific design measures will be undertaken for the confluence to control flow at the bend by strategic use of blown soil bags. This will be designed at the detailed design stage.

6. Conclusion

The proposed Takanini Stormwater Conveyance Channel will extend from 989-999 Papakura-Clevedon Road in the south-east to Grove Road in the west. A northern branch will extend northwards towards Walters Road.

In general the conveyance channel will provide stormwater servicing for future development of Areas 2A, 2B and part of Area 4 (2B4) of the Takanini Structure Plan and the Wallace area. At present the area is significantly impacted by the 1% AEP (Annual Exceedance Probability) floodplain, restricting development of the area. The Takanini Stormwater Conveyance Channel will reduce the extent of the floodplain within the Takanini 2A2B catchment to facilitate development of the land.

Development of the Takanini 2A2B area will increase peak flows from the catchment. The proposed Takanini Stormwater Conveyance Channel will direct the increased flows up to the 1% AEP event to the discharge location at the proposed Grove Road Box Culvert.

The main conveyance channel will consist of:

- 1.55 km of open waterway.
- Depth of 1.9 m to 4.0 m below ground level.
- Notional overall gradient of the channel invert 0.28%.
- Overall total width (of the 1% AEP level) ranging from 13 m to 39 m.

The northern branch channel will consist of:

- 0.55 km of open waterway.
- Depth of 2.4 m to 3.8 m below ground level.
- Notional overall gradient of the channel invert 0.24%.
- Overall total width (of the 1% AEP level) ranging from 12 m to 27 m.

The channel is designed with a meandering low flow series of discrete water bodies or wetlands with a permanent water depth of about 0.8 m controlled by rock weirs at 100 m centres longitudinally along the base of the channel. These provide an ecological benefit and limit the ground water drawdown. Generally the low flow channel will have a 3.6 m wide base with slope batters 2H:1V, with an intermediate wetland bench and upper 4H:1V riparian planted slopes.

There are two existing road crossings included:

- Twin 3 m x 2 m box culverts at Cosgrave Road.
- Twin 1.5 m diameter culverts at Old Wairoa Road.

The proposed Takanini Stormwater Conveyance Channel will provide an effective drainage solution for the Takanini 2A2B catchment.

7. References

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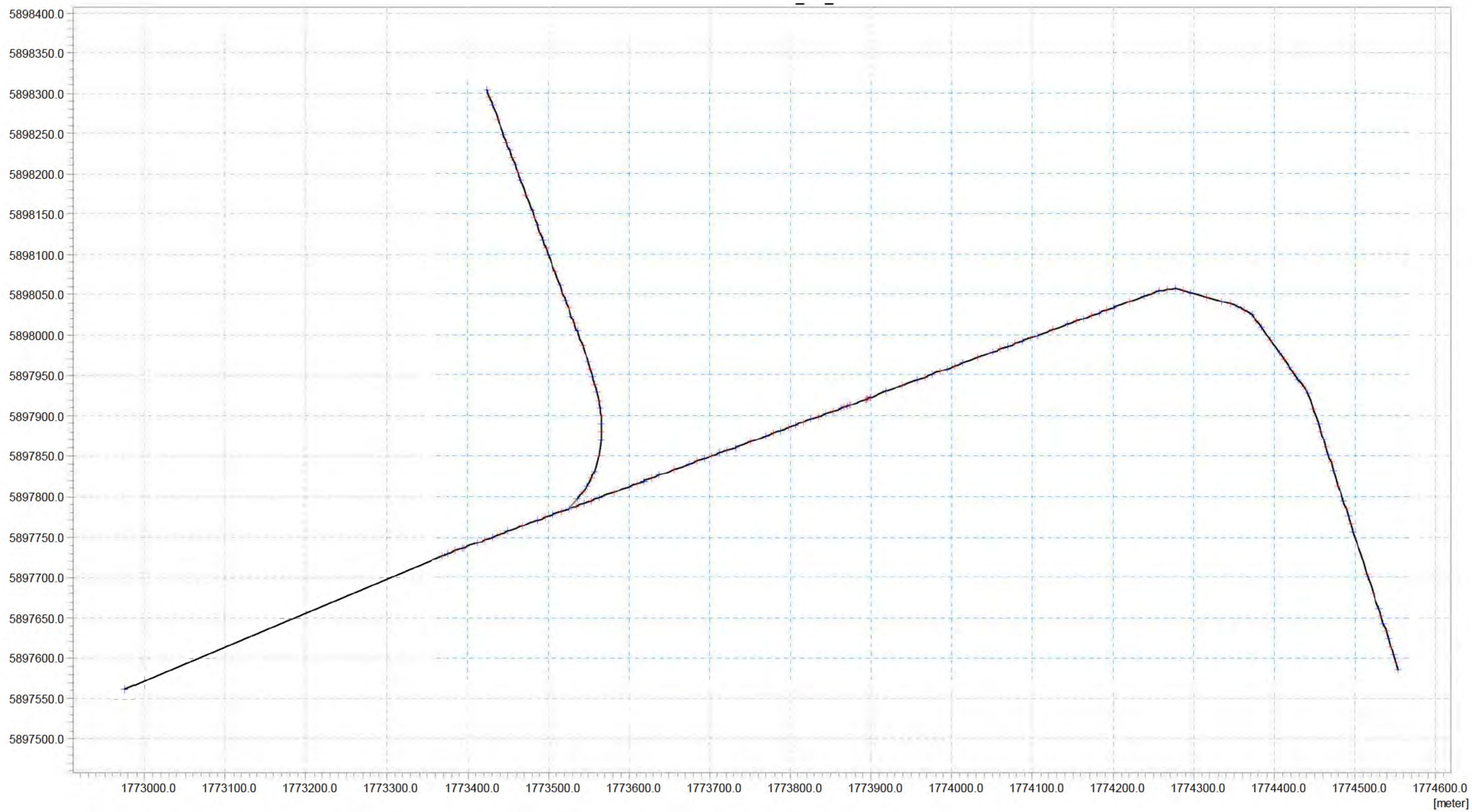
Appendices

Appendix A - (GHD MIKE11 modelling)

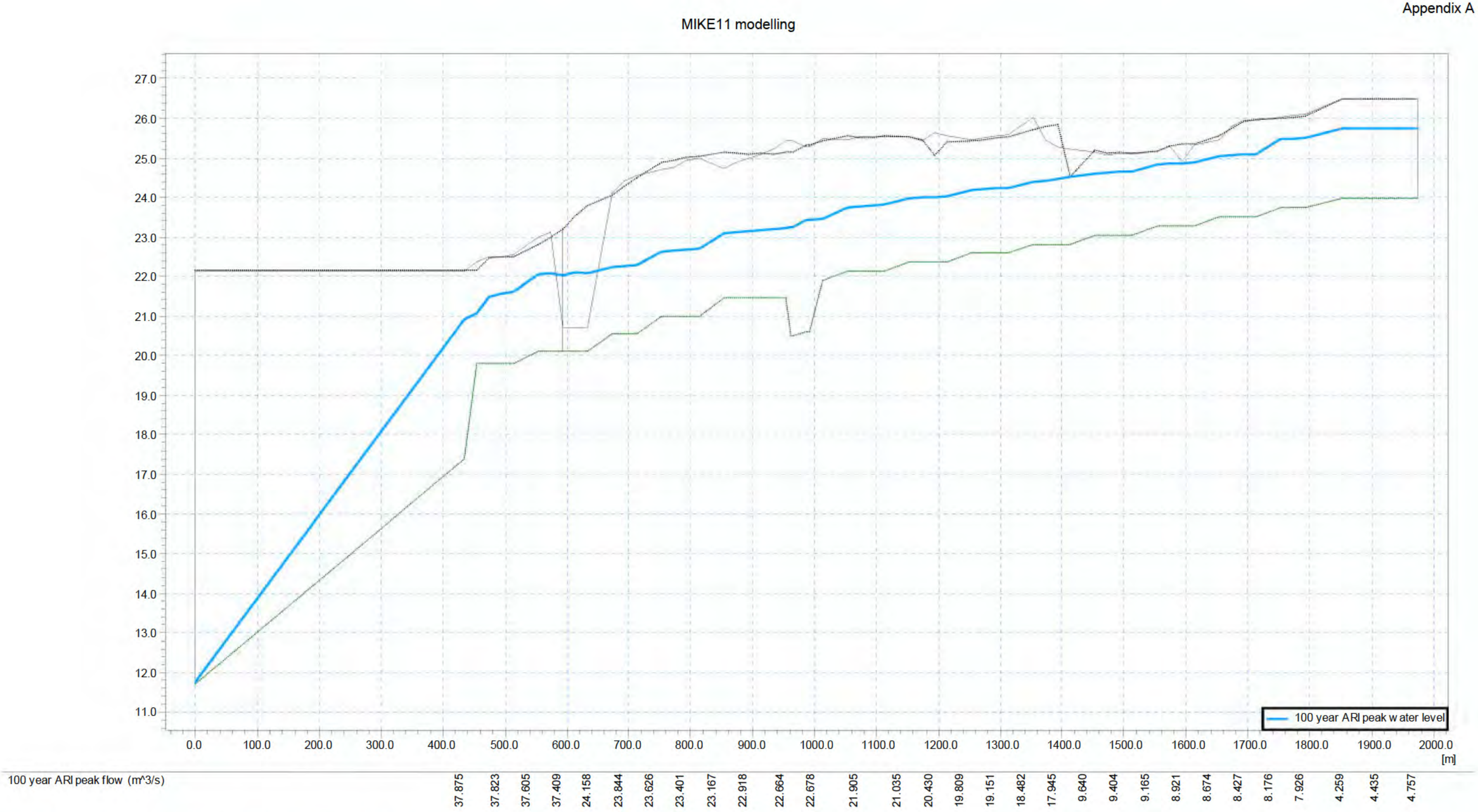
- MIKE11 model plan
- MIKE11 model long sections

Name	Area _Ha	Weighted CN	Channelisation factor	length (m)	slope (m/m)	tc (hr)	tp (hrs)	tp (min)	Design tp (min)	TP (hrs)	
2B4_1_IMP	5.060	98	0.80	250	0.0047	0.229	0.153	9.2	10.0	0.167	
2B4_1_PRV	3.373	74	1.00	250	0.0047	0.375	0.250	15.0	15.0	0.250	
2B4_2_IMP	18.060	98	0.80	700	0.0140	0.326	0.217	13.0	13.0	0.217	
2B4_2_PRV	10.607	74	1.00	700	0.0140	0.534	0.356	21.3	21.3	0.356	
2B_2_IMP	12.455	98	0.80	687	0.0370	0.240	0.160	9.6	10.0	0.167	Prior to pond routing
2B_2_PRV	9.396	74	1.00	687	0.0370	0.394	0.262	15.7	15.7	0.262	Prior to pond routing
2B_1_IMP	9.483	98	0.80	400	0.0070	0.277	0.184	11.1	11.1	0.184	
2B_1_PRV	5.569	74	1.00	400	0.0070	0.453	0.302	18.1	18.1	0.302	
2A_1_IMP	25.522	98	0.80	400	0.0050	0.307	0.204	12.3	12.3	0.204	
2A_1_PRV	13.742	74	1.00	400	0.0050	0.503	0.335	20.1	20.1	0.335	
2A_2_IMP	7.242	98	0.80	250	0.0078	0.197	0.131	7.9	10.0	0.167	
2A_2_PRV	3.900	74	1.00	250	0.0078	0.322	0.215	12.9	12.9	0.215	
2B4_3_IMP	12.492	98	0.80	400	0.0075	0.271	0.181	10.9	10.9	0.181	
2B4_3_PRV	7.337	74	1.00	400	0.0075	0.445	0.296	17.8	17.8	0.296	
2A_3_IMP	5.959	98	0.80	700	0.0050	0.443	0.296	17.7	17.7	0.296	
2A_3_PRV	3.208	74	1.00	700	0.0050	0.727	0.484	29.1	29.1	0.484	

MIKE11 modelling

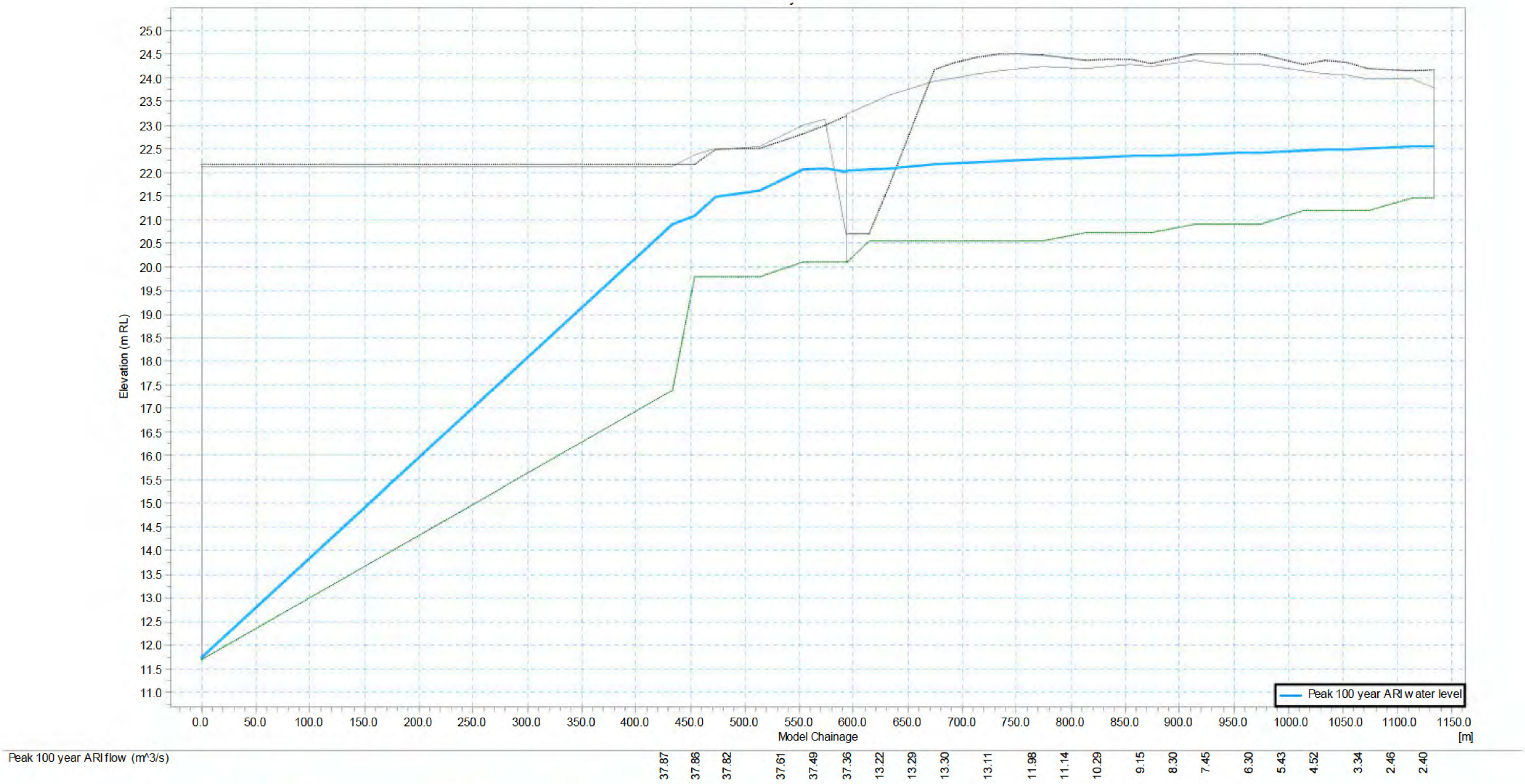


MIKE11 model plan



MIKE11 model long section – 1% AEP event + CC – MPD Scenario – Main Channel

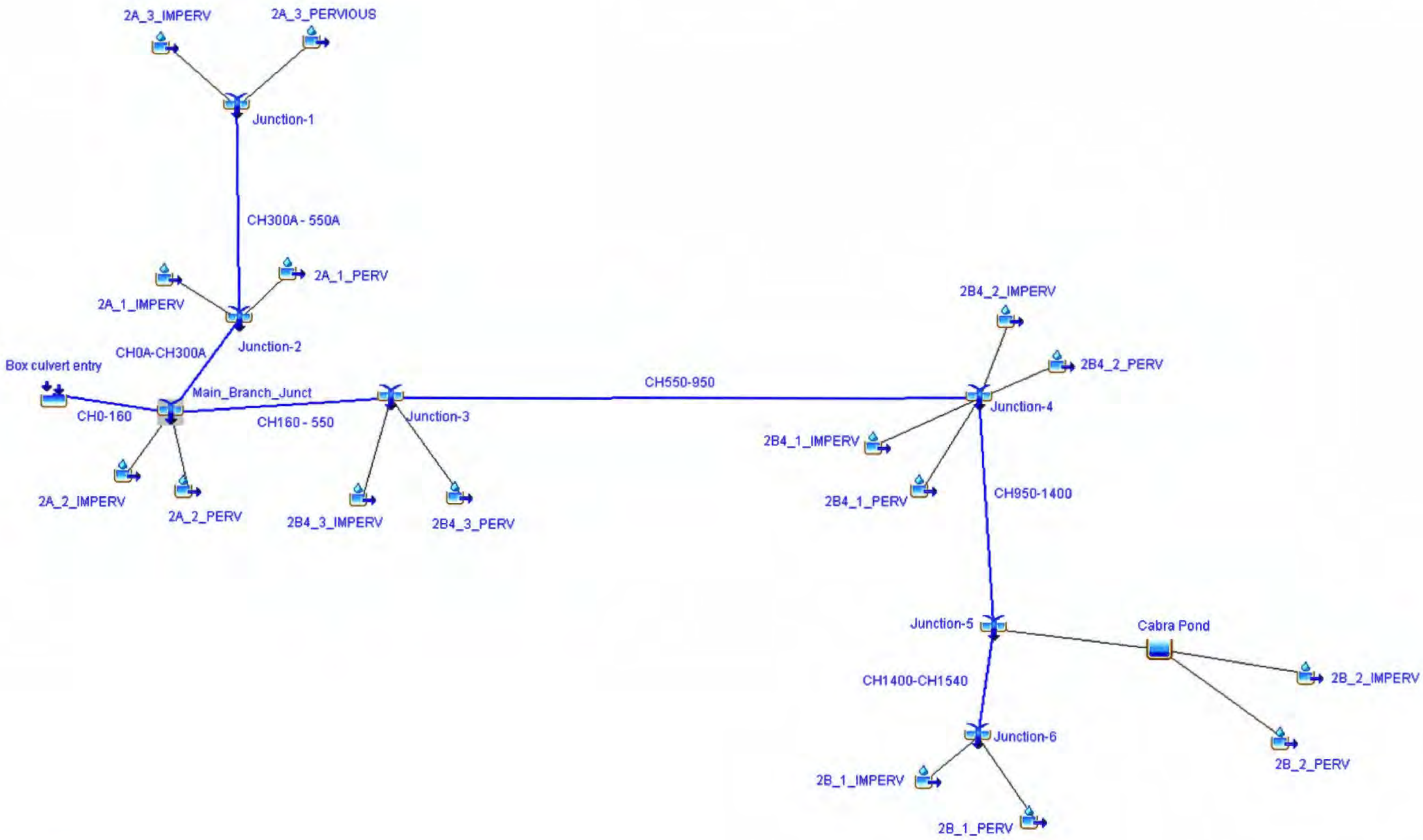
MIKE11 modelling



MIKE11 model long section – 1% AEP event + CC – MPD Scenario – Branch Channel

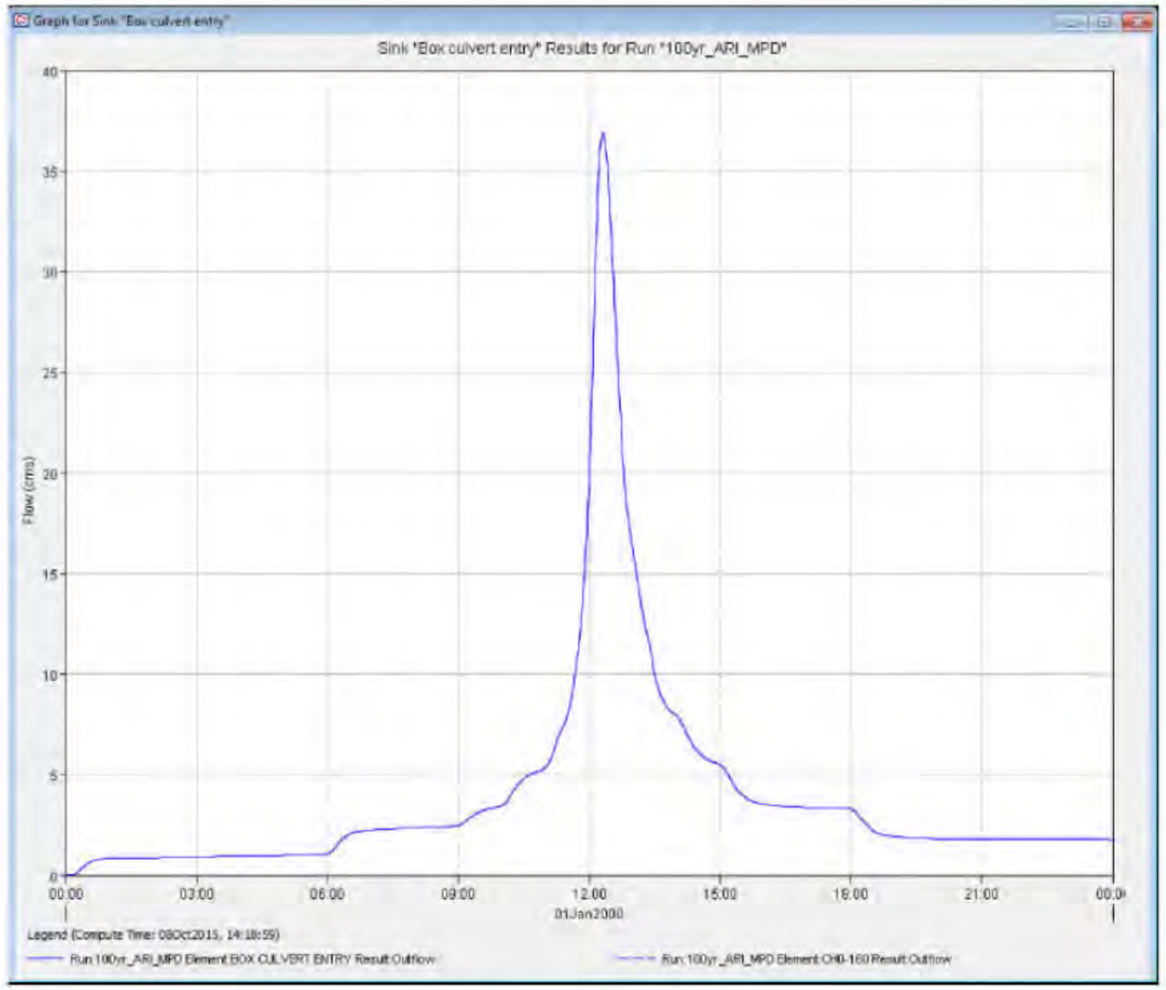
Appendix B - (HEC-HMS modelling)

- HEC-HMS model plan
- HEC-HMS global summary table



HEC-HMS model plan

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
2B_2_IMPERV	0.1245	4.8	01Jan2000, 12:05	31.8
2B_2_PERV	0.093955	2.4	01Jan2000, 12:11	17.1
Cabra Pond	0.218455	3.5	01Jan2000, 12:26	43.5
2B_1_IMPERV	0.094825	3.5	01Jan2000, 12:06	24. 2
2B_1_PERV	0.055691	1.4	01Jan2000, 12:13	10.3
Junction-6	0.150516	4.7	01Jan2000, 12:07	34.5
CH1400-CH1540	0.150516	4.7	01Jan2000, 12:11	34.5
Junction-5	0.368971	8.1	01Jan2000, 12:11	78
CH950-1400	0.368971	8.1	01Jan2000, 12:20	77.7
2B4_2_IMPERV	0.1806022	6.3	01Jan2000, 12:08	46.1
2B4_2_PERV	0.10607	2.4	01Jan2000, 12:16	19.5
2B4_1_IMPERV	0.0506018	1.9	01Jan2000, 12:05	12.9
2B4_1_PERV	0.0337345	0.9	01Jan2000, 12:10	6.2
Junction-4	0.7399795	17.4	01Jan2000, 12:13	162.5
CH550-950	0.7399795	17.4	01Jan2000, 12:19	162.2
2B4_3_IMPERV	0.1249192	4.6	01Jan2000, 12:06	31.9
2B4_3_PERV	0.0733652	1.8	01Jan2000, 12:13	13.5
Junction-3	0.9382639	21.7	01Jan2000, 12:18	207.7
CH160 - 550	0.9382639	21.7	01Jan2000, 12:24	207.3
2A_1_IMPERV	0.2552177	9.1	01Jan2000, 12:07	65.2
2A_1_PERV	0.1374249	3.2	01Jan2000, 12:15	25.3
2A_3_IMPERV	0.0595864	1.8	01Jan2000, 12:12	15.2
2A_3_PERVIOUS	0.032085	0.6	01Jan2000, 12:25	5.9
Junction-1	0.0916714	2.4	01Jan2000, 12:14	21.1
CH300A - 550A	0.0916714	2.4	01Jan2000, 12:18	21.1
Junction-2	0.484314	13.9	01Jan2000, 12:09	111.6
CH0A-CH300A	0.484314	13.9	01Jan2000, 12:15	111.4
2A_2_IMPERV	0.0724208	2.8	01Jan2000, 12:05	18.5
2A_2_PERV	0.0389958	1.1	01Jan2000, 12:08	7.2
Main_Branch_Junct	1.5339945	36.9	01Jan2000, 12:18	344.4
CH0-160	1.5339945	36.9	01Jan2000, 12:19	344.3
Box culvert entry	1.5339945	36.9	01Jan2000, 12:19	344.3



HEC-HMS global summary table – 1% AEP event + CC

Appendix C - (TP108 sub-catchment calculations)

	MPD Peak flow (m^3/s) 1% AEP event + CC		MPD Peak flow (m^3/s) 10% AEP event + CC	
Sub-catchment	TP108 calcs	GHD Model flows	TP108 calcs	GHD Model flows
2B4_1	2.88	2.83	1.68	1.66
2B4_2	8.72	8.57	5.09	5.05
2B_2	7.27	7.15	4.22	4.18
2B_1	4.86	4.82	2.84	2.84
2A_1	12.30	12.15	7.20	7.19
2A_2	4.06	3.92	2.38	2.31
2B4_3	6.45	6.39	3.77	3.77
2A_3	2.48	2.41	1.45	1.43

TP108 Large Catchment
2B4_1

Data entry cells	
Result cells	
Drop down menu	

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	5.06	5.06	5.06	5.06	5.06	5.06
Pervious Area	ha	3.37	3.37	3.37	3.37	3.37	3.37
Total area	ha	8.434	8.434	8.434	8.434	8.434	8.434
% Impervious		60%	60%	60%	60%	60%	60%
Catchment Slope (S_c)	m/m	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
Catchment Length (l)	km	0.250	0.250	0.250	0.250	0.250	0.250
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		88.40	88.40	88.40	88.40	88.40	88.40
Initial Abstraction (Ia) weighted	mm	2.00	2.00	2.00	2.00	2.00	2.00
t_c	hours	0.25	0.25	0.25	0.25	0.25	0.25
t_p	hours	0.17	0.17	0.17	0.17	0.17	0.17
Storage (S)	mm	33	33	33	33	33	33
c*=(P24-2Ia)/(P24-2Ia+2S)		0.519	0.635	0.698	0.791	0.242	0.314
q* (from TP108 Fig. 6.1)	Approx!!	0.108	0.120	0.126	0.133	0.066	0.080
Peak Flowrate (q_p)	m^3/s	0.69	1.22	1.68	2.88	0.141	0.232
24 hour rainfall depth (Q_{24})	mm	51.0	92.0	128.5	224.5	9.6	16.0
24 hour runoff volume (V_{24})	m^3	4303	7760	10840	18937	810	1353

TP108 Large Catchment
2B4_2

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	18.06	18.06	18.06	18.06	18.06	18.06
Pervious Area	ha	10.61	10.61	10.61	10.61	10.61	10.61
Total area	ha	28.667	28.667	28.667	28.667	28.667	28.667
% Impervious		63%	63%	63%	63%	63%	63%
Catchment Slope (S_c)	m/m	0.014	0.014	0.014	0.014	0.014	0.014
Catchment Length (l)	km	0.700	0.700	0.700	0.700	0.700	0.700
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		89.12	89.12	89.12	89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85	1.85	1.85	1.85
t_c	hours	0.36	0.36	0.36	0.36	0.36	0.36
t_p	hours	0.24	0.24	0.24	0.24	0.24	0.24
Storage (S)	mm	31	31	31	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.652	0.713	0.803	0.259	0.332
q* (from TP108 Fig. 6.1)	Approx!!	0.098	0.108	0.112	0.119	0.061	0.073
Peak Flowrate (q_p)	m^3/s	2.13	3.70	5.09	8.72	0.445	0.724
24 hour rainfall depth (Q_{24})	mm	52.3	93.6	130.3	226.5	10.1	16.7
24 hour runoff volume (V_{24})	m^3	14989	26829	37347	64935	2901	4801

TP108 Large Catchment
2B_2

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	12.45	12.45	12.45	12.45	12.45	12.45
Pervious Area	ha	9.40	9.40	9.40	9.40	9.40	9.40
Total area	ha	21.850	21.850	21.850	21.850	21.850	21.850
% Impervious		57%	57%	57%	57%	57%	57%
Catchment Slope (S_c)	m/m	0.037	0.037	0.037	0.037	0.037	0.037
Catchment Length (l)	km	0.687	0.687	0.687	0.687	0.687	0.687
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		87.68	87.68	87.68	87.68	87.68	87.68
Initial Abstraction (Ia) weighted	mm	2.15	2.15	2.15	2.15	2.15	2.15
t_c	hours	0.269	0.269	0.269	0.269	0.269	0.269
t_p	hours	0.180	0.180	0.180	0.180	0.180	0.180
Storage (S)	mm	36	36	36	36	36	36
c*=(P24-2Ia)/(P24-2Ia+2S)		0.501	0.618	0.683	0.779	0.228	0.297
q* (from TP108 Fig. 6.1)	Approx!!	0.104	0.116	0.122	0.130	0.062	0.075
Peak Flowrate (q_p)	m^3/s	1.73	3.05	4.22	7.27	0.341	0.568
24 hour rainfall depth (Q_{24})	mm	49.8	90.5	126.8	222.6	9.1	15.4
24 hour runoff volume (V_{24})	m^3	10879	19765	27708	48629	1995	3361

TP108 Large Catchment
2B_1

Data entry cells	(green)
Result cells	(orange)
Drop down menu	(yellow)

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	9.48	9.48	9.48	9.48	9.48	9.48
Pervious Area	ha	5.57	5.57	5.57	5.57	5.57	5.57
Total area	ha	15.052	15.052	15.052	15.052	15.052	15.052
% Impervious		63%	63%	63%	63%	63%	63%
Catchment Slope (S_c)	m/m	0.007	0.007	0.007	0.007	0.007	0.007
Catchment Length (l)	km	0.400	0.400	0.400	0.400	0.400	0.400
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		89.12	89.12	89.12	89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85	1.85	1.85	1.85
t_c	hours	0.31	0.31	0.31	0.31	0.31	0.31
t_p	hours	0.20	0.20	0.20	0.20	0.20	0.20
Storage (S)	mm	31	31	31	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.652	0.713	0.803	0.259	0.332
q* (from TP108 Fig. 6.1)	Approx!!	0.104	0.114	0.119	0.126	0.065	0.078
Peak Flowrate (q_p)	m^3/s	1.18	2.06	2.84	4.86	0.248	0.403
24 hour rainfall depth (Q_{24})	mm	52.3	93.6	130.3	226.5	10.1	16.7
24 hour runoff volume (V_{24})	m^3	7870	14087	19609	34094	1523	2521

TP108 Large Catchment
2A_1

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	25.52	25.52	25.52	25.52	25.52	25.52
Pervious Area	ha	13.74	13.74	13.74	13.74	13.74	13.74
Total area	ha	39.264	39.264	39.264	39.264	39.264	39.264
% Impervious		65%	65%	65%	65%	65%	65%
Catchment Slope (S_c)	m/m	0.005	0.005	0.005	0.005	0.005	0.005
Catchment Length (l)	km	0.400	0.400	0.400	0.400	0.400	0.400
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		89.60	89.60	89.60	89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75	1.75	1.75	1.75
t_c	hours	0.34	0.34	0.34	0.34	0.34	0.34
t_p	hours	0.22	0.22	0.22	0.22	0.22	0.22
Storage (S)	mm	29	29	29	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.664	0.724	0.811	0.270	0.345
q* (from TP108 Fig. 6.1)	Approx!!	0.101	0.111	0.116	0.122	0.065	0.077
Peak Flowrate (q_p)	m^3/s	3.02	5.25	7.20	12.30	0.646	1.041
24 hour rainfall depth (Q_{24})	mm	53.1	94.7	131.4	227.8	10.5	17.2
24 hour runoff volume (V_{24})	m^3	20868	37164	51612	89456	4115	6767

TP108 Large Catchment
2A_2

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	7.24	7.24	7.24	7.24	7.24	7.24
Pervious Area	ha	3.90	3.90	3.90	3.90	3.90	3.90
Total area	ha	11.142	11.142	11.142	11.142	11.142	11.142
% Impervious		65%	65%	65%	65%	65%	65%
Catchment Slope (S_c)	m/m	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078
Catchment Length (l)	km	0.250	0.250	0.250	0.250	0.250	0.250
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		89.60	89.60	89.60	89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75	1.75	1.75	1.75
t_c	hours	0.22	0.22	0.22	0.22	0.22	0.22
t_p	hours	0.14	0.14	0.14	0.14	0.14	0.14
Storage (S)	mm	29	29	29	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.664	0.724	0.811	0.270	0.345
q* (from TP108 Fig. 6.1)	Approx!!	0.118	0.130	0.135	0.142	0.076	0.090
Peak Flowrate (q_p)	m^3/s	1.00	1.73	2.38	4.06	0.213	0.344
24 hour rainfall depth (Q_{24})	mm	53.1	94.7	131.4	227.8	10.5	17.2
24 hour runoff volume (V_{24})	m^3	5921	10546	14645	25384	1168	1920

TP108 Large Catchment
2B4_3

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	12.49	12.49	12.49	12.49	12.49	12.49
Pervious Area	ha	7.34	7.34	7.34	7.34	7.34	7.34
Total area	ha	19.828	19.828	19.828	19.828	19.828	19.828
% Impervious		63%	63%	63%	63%	63%	63%
Catchment Slope (S_c)	m/m	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Catchment Length (l)	km	0.400	0.400	0.400	0.400	0.400	0.400
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		89.12	89.12	89.12	89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85	1.85	1.85	1.85
t_c	hours	0.30	0.30	0.30	0.30	0.30	0.30
t_p	hours	0.20	0.20	0.20	0.20	0.20	0.20
Storage (S)	mm	31	31	31	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.652	0.713	0.803	0.259	0.332
q* (from TP108 Fig. 6.1)	Approx!!	0.104	0.115	0.120	0.127	0.066	0.078
Peak Flowrate (q_p)	m^3/s	1.57	2.74	3.77	6.45	0.329	0.535
24 hour rainfall depth (Q_{24})	mm	52.3	93.6	130.3	226.5	10.1	16.7
24 hour runoff volume (V_{24})	m^3	10367	18557	25832	44914	2007	3320

TP108 Large Catchment
2A_3

Project	51-32174 TAKANINI SCHEME DESIGN
Designer	Jesse Peeters
Consultant	GHD
Date	8/10/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

		50% AEP + CC	20% AEP + CC	10% AEP + CC	1% AEP + CC	WQ Event	34.5mm
Impervious Area	ha	5.96	5.96	5.96	5.96	5.96	5.96
Pervious Area	ha	3.21	3.21	3.21	3.21	3.21	3.21
Total area	ha	9.167	9.167	9.167	9.167	9.167	9.167
% Impervious		65%	65%	65%	65%	65%	65%
Catchment Slope (S_c)	m/m	0.005	0.005	0.005	0.005	0.005	0.005
Catchment Length (l)	km	0.700	0.700	0.700	0.700	0.700	0.700
Channelisation Factor (C)		0.8	0.8	0.8	0.8	0.8	g
SCS Curve Number (CN)		74	74	74	74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	120	158	256	25.33	34.5
Weighted Curve Number		89.60	89.60	89.60	89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75	1.75	1.75	1.75
t_c	hours	0.49	0.49	0.49	0.49	0.49	0.49
t_p	hours	0.32	0.32	0.32	0.32	0.32	0.32
Storage (S)	mm	29	29	29	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.664	0.724	0.811	0.270	0.345
q* (from TP108 Fig. 6.1)	Approx!!	0.087	0.096	0.100	0.106	0.056	0.066
Peak Flowrate (q_p)	m^3/s	0.61	1.06	1.45	2.48	0.130	0.210
24 hour rainfall depth (Q_{24})	mm	53.1	94.7	131.4	227.8	10.5	17.2
24 hour runoff volume (V_{24})	m^3	4872	8677	12050	20886	961	1580

Appendix D - (Culvert calculations)

Cosgrave Road Culvert losses calculation

Twin 3x2m box culverts	D/S channel			Culvert			U/S channel	
	1% AEP EVENT	10% AEP		1% AEP EVENT	10% AEP		1% AEP EVENT	10% AEP
Q (m^3/s)	22.7	13.1	Q (m^3/s)	22.7	13.1	Q (m^3/s)	22.7	13.1
A (m^2)	34	28.25	A (m^2)	12	12	A (m^2)	33.71	27.3
v_d= Q/A	0.668	0.464	v= Q/A	1.892	1.092	v_u= Q/A	0.673	0.480
$v_d^2/2g$	0.023	0.011	$v^2/2g$	0.182	0.061	$v_u^2/2g$	0.023	0.012
Expansion	0.352941176	0.424779				Contraction	0.356	0.440
k_e	0.5	0.36	$Sf = 10.3 \times n^2 \times d^{-\frac{16}{3}} \times Q^2$	0.010	0.003	k_c	0.28	0.31
$Ho = ke\left[\frac{v^2}{2g}\right]$	0.091	0.022	L (m)	20	20	$Ho = ke\left[\frac{v^2}{2g}\right]$	0.051	0.019
			H_f (m)	0.195	0.065			

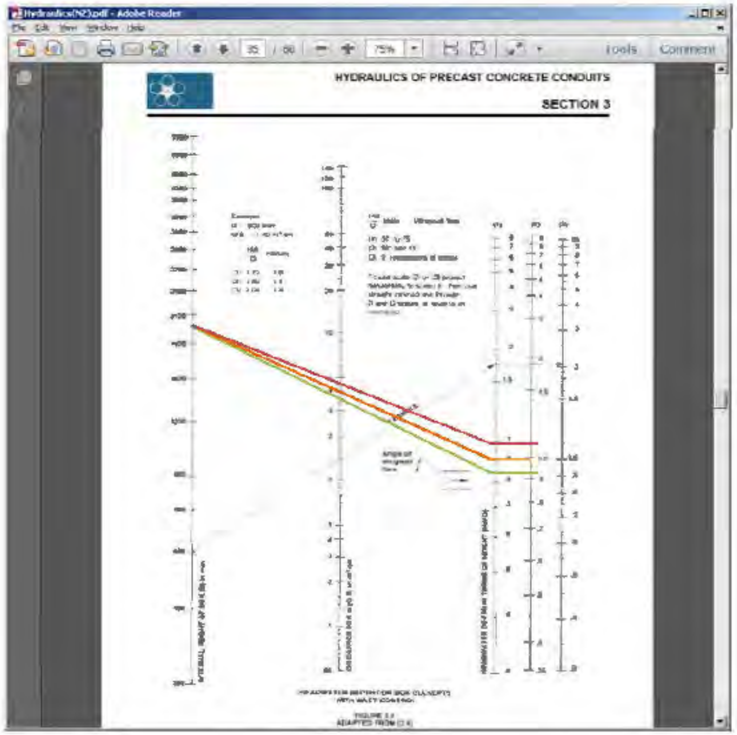
	d/s channel water level	d/s culvert water level	u/s culvert water level	u/s channel water level
1% AEP + CC	23.20	23.29	23.49	23.54
10% AEP + CC	22.95	22.97	23.04	23.06

Old Wairoa Road Culvert losses calculation

Twin 1.5m diameter culverts	D/S channel			Culvert			U/S channel	
	1% AEP EVENT	10% AEP		1% AEP EVENT	10% AEP		1% AEP EVENT	10% AEP
Q (m^3/s)	7.9	5	Q (m^3/s)	4.7	2.5	Q (m^3/s)	4.7	2.5
A (m^2)	14.2	11	A (m^2)	3.5	3.5	A (m^2)	16.16	9.05
v_d= Q/A	0.556	0.455	v= Q/A	1.343	0.714	v_u= Q/A	0.291	0.276
$v_d^2/2g$	0.016	0.011	$v^2/2g$	0.092	0.026	$v_u^2/2g$	0.004	0.004
Expansion	0.246478873	0.318182				Contraction	0.217	0.387
k_e	0.57	0.5	$Sf = 10.3 \times n^2 \times d^{-\frac{16}{3}} \times Q^2$	0.0013	0.0004	k_c	0.37	0.25
$Ho = ke \left[\frac{v^2}{2g}\right]$	0.052	0.013	L (m)	49.18	49.18	$Ho = ke \left[\frac{v^2}{2g}\right]$	0.034	0.007
			H_f (m)	0.063	0.018			

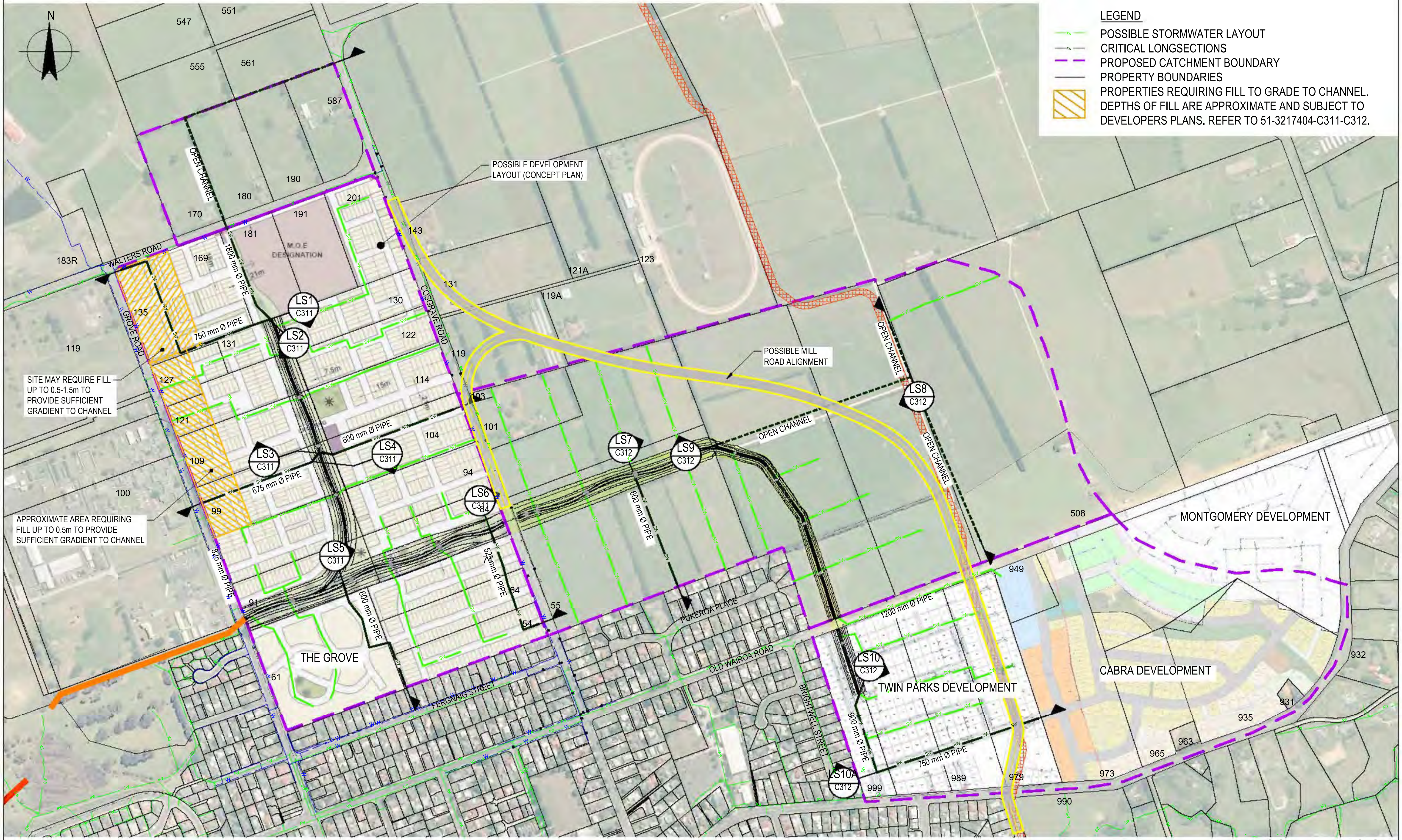
	d/s channel water level	d/s culvert water level	u/s culvert water level	u/s channel water level
1% AEP + CC	25.49	25.54	25.61	25.64
10% AEP + CC	25.32	25.33	25.35	25.36

Appendix E - (Cosgrave Road Culvert blockage)



Box Culvert Summary	TWIN 3m x 2m box		
Blockage scenario	0% blockage	10% blockage	20% blockage
Flow (m^3/s)	22.7	22.7	22.7
D (m)	2	2	2
B (m)	6	5.4	4.8
Q/B	3.78	4.20	4.73
HW/D	0.93	1	1.1
HW (m)	1.86	2	2.2
RL 100yr (inlet) - if inlet control assumed	22.46	22.6	22.8
RL 100yr (inlet) - if outlet control assumed (see Appendix D)	23.54	23.54	23.54
Control	Downstream controlled	Downstream controlled	Downstream controlled

Appendix F - (Development connection calculations)



No	Revision		Drawn	Job Manager	Project Director	Date
B	RESOURCE CONSENT		JP			03/16
A	SCHEME DESIGN		D X			12/14

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 100 200 300m
SCALE 1:10,000 AT ORIGINAL SIZE

Auckland Council

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DO NOT SCALE

Drawn D XIE
Designer J PEETERS
Drafting Check
Design Check
Approved (Project Director)
Date
Scale 1:10000
This Drawing must not be used for Construction unless signed as Approved

Client **AUCKLAND COUNCIL**
Project **TAKANINI STORMWATER CONVEYANCE CHANNEL**
Title **POSSIBLE FUTURE CONNECTIONS TO CHANNEL PLAN**

Original Size A3 Drawing No: **51-3217404-C310** Rev: B

Plot Date: 18 March 2016 - 5:35 p.m. Plotted By: Jesse Peeters Cad File No: G:\51\32174\03 Takanini\14 CAD\Drawings\51-3217404-C310.dwg

Connection	Area (m^2)	Impervious	Length (m)	Slope	10% AEP + CC flow (m^3/s)	1% AEP + CC flow (m^3/s)	Pipe size (mm)
LS1	39787	65%	408	0.50%	0.80	1.37	750 mm dia. Pipe
LS2	91134	65%	531	0.12%	1.47	2.51	12m wide swale and 1800mm dia pipe
LS3	26767	65%	326	0.78%	0.59	1.01	600 mm dia. Pipe
LS4	26780	65%	300	0.50%	0.58	0.99	675 mm dia. Pipe
LS5	21101	65%	250	0.68%	0.49	0.83	600 mm dia. Pipe
LS6	15382	65%	230	0.83%	0.37	0.63	525 mm dia. Pipe
LS7	22440	63%	260	0.65%	0.51	0.87	600 mm dia. Pipe
LS8	66597	63%	778	2.30%	1.35	2.31	10m wide swale
LS9	283422	63%	980	0.80%	4.82	8.25	15m wide swale
LS10	69783	63%	557	0.50%	1.30	2.23	900 mm dia. Pipe
LS10A	41583	63%	387	1.10%	0.91	1.56	750 mm dia. Pipe

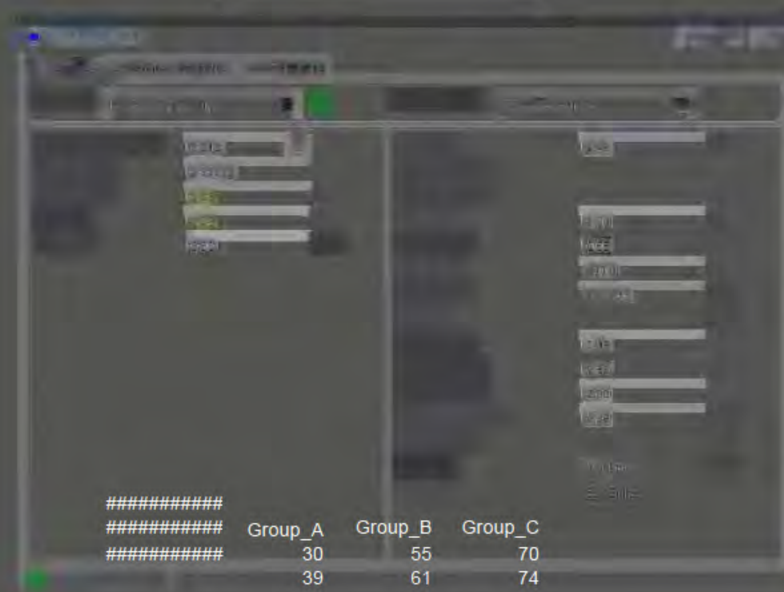
LS1

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

Select appropriate design storm	[redacted]	50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	2.586155	2.586155	2.586155
Pervious Area	ha	1.392545	1.392545	1.392545
total area	ha	3.9787		
% Impervious		65%	65%	65%
Catchment Slope (S_c)	m/m	0.005	0.005	0.005
Catchment Length (l)	km	0.408	0.408	0.408
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75
t_c	hours	0.26	0.26	0.26
t_p	hours	0.17	0.17	0.17
Storage (S)	mm	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.724	0.811
q* (from Fig. 6.1)	Approx!!	0.112	0.128	0.135
Peak Flowrate (q_p)	m^3/s	0.34	0.80	1.37
24 hour rainfall depth (Q_{24})	mm	53.1	131.4	227.8
24 hour runoff volume (V_{24})	m^3	2115	5230	9065



	Group_A	Group_B	Group_C
###########			
###########			
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

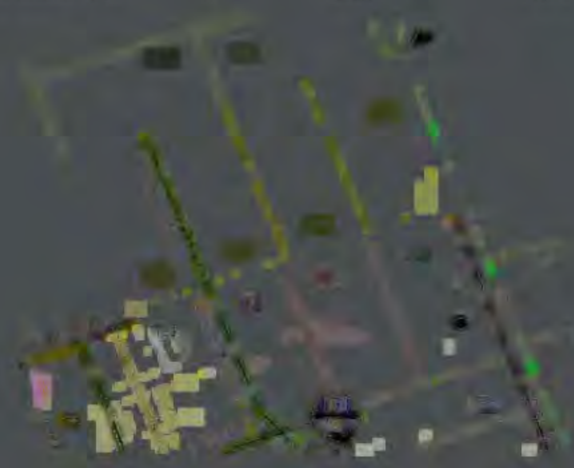
LS2

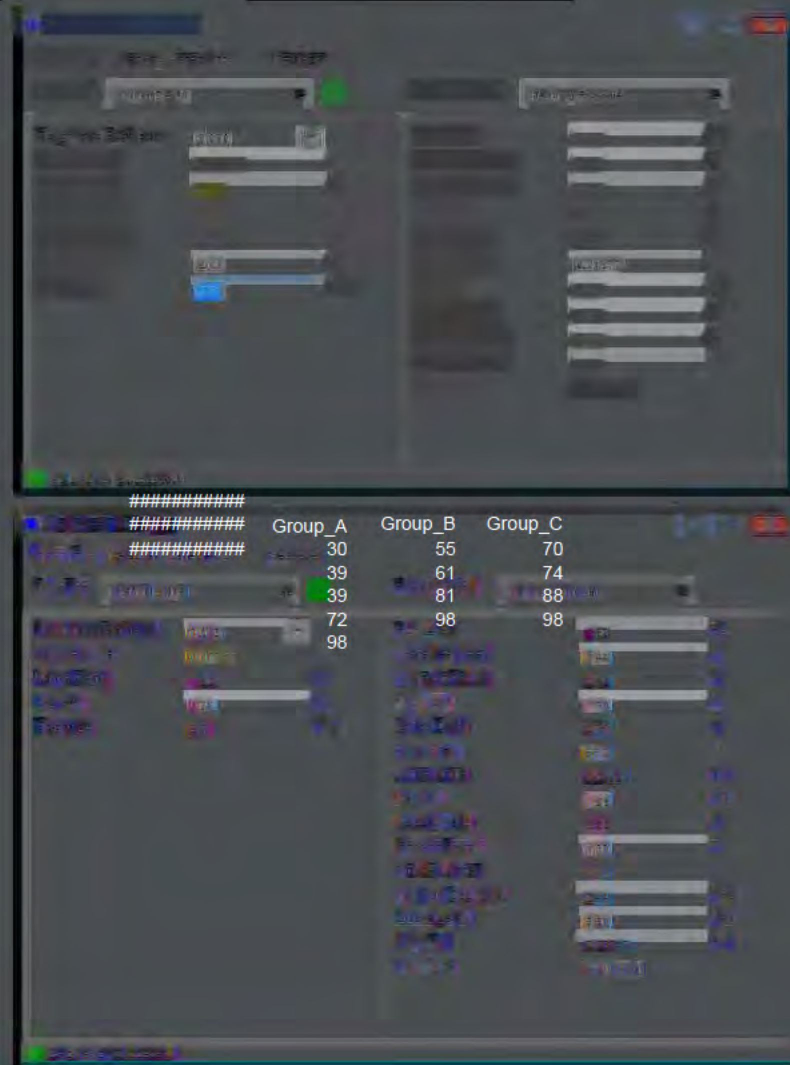
Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

Select appropriate design storm		50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	5.92371	5.92371	5.92371
Pervious Area	ha	3.18969	3.18969	3.18969
total area	ha	9.1134		
% Impervious		65%	65%	65%
Catchment Slope (S_c)	m/m	0.0012	0.0012	0.0012
Catchment Length (l)	km	0.531	0.531	0.531
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75
t_c	hours	0.47	0.47	0.47
t_p	hours	0.31	0.31	0.31
Storage (S)	mm	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.724	0.811
q* (from Fig. 6.1)	Approx!!	0.089	0.102	0.108
Peak Flowrate (q_p)	m^3/s	0.62	1.47	2.51
24 hour rainfall depth (Q_{24})	mm	53.1	131.4	227.8
24 hour runoff volume (V_{24})	m^3	4844	11979	20763





	Group_A	Group_B	Group_C
###########			
###########			
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

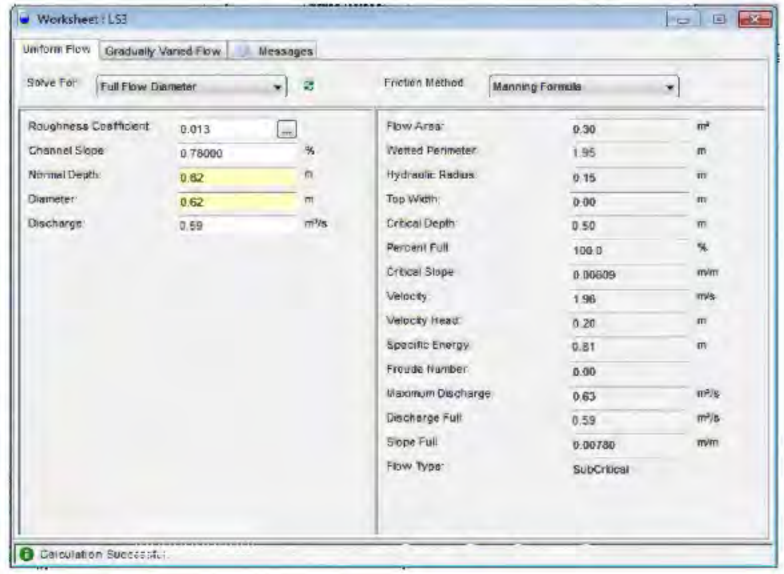
LS3

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

Select appropriate design storm	→	50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	1.739855	1.739855	1.739855
Pervious Area	ha	0.936845	0.936845	0.936845
total area	ha	2.6767		
% Impervious		65%	65%	65%
Catchment Slope (S_c)	m/m	0.0078	0.0078	0.0078
Catchment Length (l)	km	0.326	0.326	0.326
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75
t_c	hours	0.19	0.19	0.19
t_p	hours	0.13	0.13	0.13
Storage (S)	mm	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.724	0.811
q* (from Fig. 6.1)	Approx!!	0.122	0.140	0.148
Peak Flowrate (q_p)	m^3/s	0.25	0.59	1.01
24 hour rainfall depth (Q_{24})	mm	53.1	131.4	227.8
24 hour runoff volume (V_{24})	m^3	1423	3518	6098



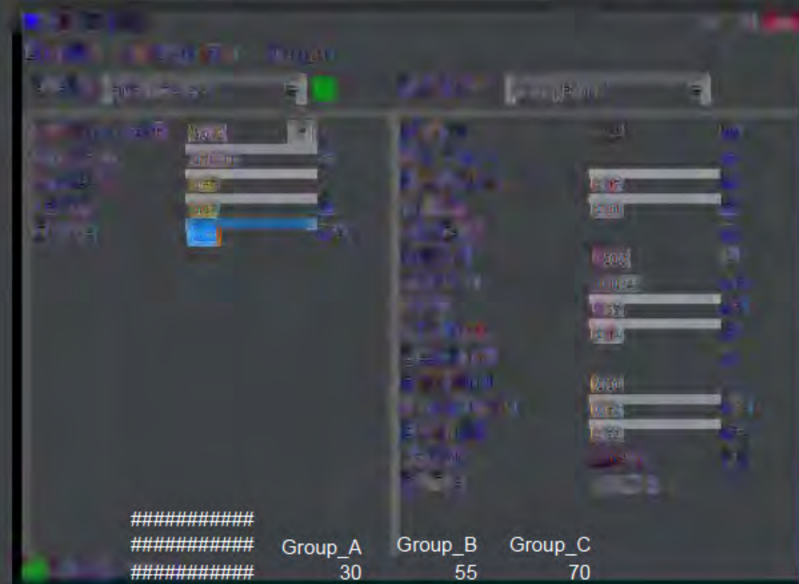
LS4

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

Select appropriate design storm		50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	1.7407	1.7407	1.7407
Pervious Area	ha	0.9373	0.9373	0.9373
total area	ha	2.678		
% Impervious		65%	65%	65%
Catchment Slope (S_c)	m/m	0.005	0.005	0.005
Catchment Length (l)	km	0.3	0.3	0.3
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75
t_c	hours	0.21	0.21	0.21
t_p	hours	0.14	0.14	0.14
Storage (S)	mm	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.724	0.811
q* (from Fig. 6.1)	Approx!!	0.119	0.137	0.144
Peak Flowrate (q_p)	m^3/s	0.24	0.58	0.99
24 hour rainfall depth (Q_{24})	mm	53.1	131.4	227.8
24 hour runoff volume (V_{24})	m^3	1423	3520	6101



###########
###########
###########

Group_A	Group_B	Group_C
30	55	70
39	61	74
39	81	88
72	98	98
98		

LS5

Data entry cells
Result cells
Drop down menu

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

DEVELOPED CATCHMENT

Select appropriate design storm		50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	1.371565	1.371565	1.371565
Pervious Area	ha	0.738535	0.738535	0.738535
total area	ha	2.1101		
% Impervious		65%	65%	65%
Catchment Slope (S_c)	m/m	0.0068	0.0068	0.0068
Catchment Length (l)	km	0.25	0.25	0.25
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75
t_c	hours	0.17	0.17	0.17
t_p	hours	0.11	0.11	0.11
Storage (S)	mm	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.724	0.811
q* (from Fig. 6.1)	Approx!!	0.127	0.146	0.154
Peak Flowrate (q_p)	m^3/s	0.20	0.49	0.83
24 hour rainfall depth (Q_{24})	mm	53.1	131.4	227.8
24 hour runoff volume (V_{24})	m^3	1121	2774	4807

	Group_A	Group_B	Group_C
###########			
###########			
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

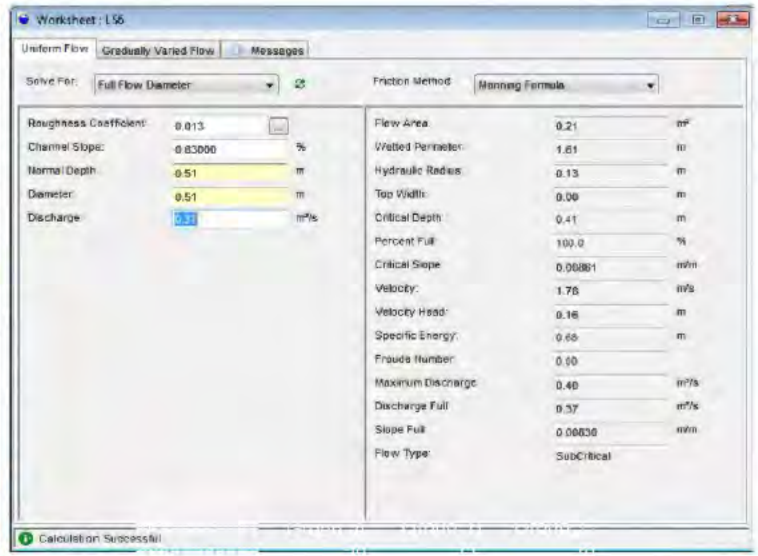
LS6

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells	
Result cells	
Drop down menu	

DEVELOPED CATCHMENT

Select appropriate design storm	→	50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	0.99983	0.99983	0.99983
Pervious Area	ha	0.53837	0.53837	0.53837
total area	ha	1.5382		
% Impervious		65%	65%	65%
Catchment Slope (S_c)	m/m	0.0083	0.0083	0.0083
Catchment Length (l)	km	0.23	0.23	0.23
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.60	89.60	89.60
Initial Abstraction (Ia) weighted	mm	1.75	1.75	1.75
t_c	hours	0.15	0.15	0.15
t_p	hours	0.10	0.10	0.10
Storage (S)	mm	29	29	29
c*=(P24-2Ia)/(P24-2Ia+2S)		0.551	0.724	0.811
q* (from Fig. 6.1)	Approx!!	0.132	0.151	0.159
Peak Flowrate (q_p)	m^3/s	0.15	0.37	0.63
24 hour rainfall depth (Q_{24})	mm	53.1	131.4	227.8
24 hour runoff volume (V_{24})	m^3	818	2022	3505



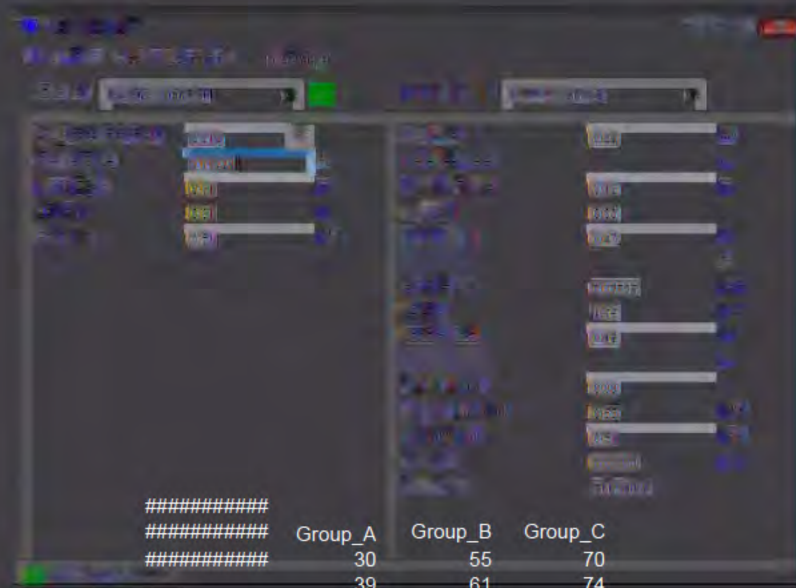
LS7

Data entry cells
Result cells
Drop down menu

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

DEVELOPED CATCHMENT

Select appropriate design storm	[redacted]	**50% AEP + CC**	**10% AEP + CC**	**1% AEP + CC**
Impervious Area	ha	1.41372	1.41372	1.41372
Pervious Area	ha	0.83028	0.83028	0.83028
total area	ha	2.244		
% Impervious		63%	63%	63%
Catchment Slope (S_c)	m/m	0.0065	0.0065	0.0065
Catchment Length (l)	km	0.26	0.26	0.26
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85
t_c	hours	0.18	0.18	0.18
t_p	hours	0.12	0.12	0.12
Storage (S)	mm	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.713	0.803
q* (from Fig. 6.1)	Approx!!	0.124	0.143	0.151
Peak Flowrate (q_p)	m^3/s	0.21	0.51	0.87
24 hour rainfall depth (Q_{24})	mm	52.3	130.3	226.5
24 hour runoff volume (V_{24})	m^3	1173	2923	5083



	Group_A	Group_B	Group_C
###########			
###########			
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

LS8

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

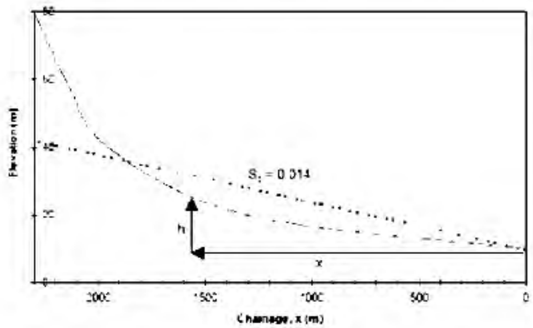
Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

Select appropriate design storm		50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	4.195611	4.195611	4.195611
Pervious Area	ha	2.464089	2.464089	2.464089
total area	ha	6.6597		
% Impervious		63%	63%	63%
Catchment Slope (S_c)	m/m	0.023	0.023	0.023
Catchment Length (l)	km	0.778	0.778	0.778
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85
t_c	hours	0.25	0.25	0.25
t_p	hours	0.17	0.17	0.17
Storage (S)	mm	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.713	0.803
q* (from Fig. 6.1)	Approx!!	0.111	0.128	0.135
Peak Flowrate (q_p)	m^3/s	0.56	1.35	2.31
24 hour rainfall depth (Q_{24})	mm	52.3	130.3	226.5
24 hour runoff volume (V_{24})	m^3	3482	8676	15085

###########			
###########	Group_A	Group_B	Group_C
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

LS8 Catchment Slope **(Calculating the Slope (Sc) using the equal area method)**



Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

$$S_c = \frac{2A}{L^2}$$

Data Entry Cells (green)
Result cells (orange)

Pre-development

Survey Point	Elevation RL (m)	h (m)	x (m)	Δx(m)	$\bar{h}$ (m)	$\Delta A(=\bar{h}\Delta x)$
1	26.2	0	0	0		
2	26.2	0	110	110	0	0
3	32.4	6.2	316.7	206.7	3.1	640.77
4	43.8	17.6	516.7	200	11.9	2380
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	516.7	TOTAL =	3020.77

S_c 0.023

		h	x	Δx	$\bar{h}$	$\Delta A(=\bar{h}\Delta x)$

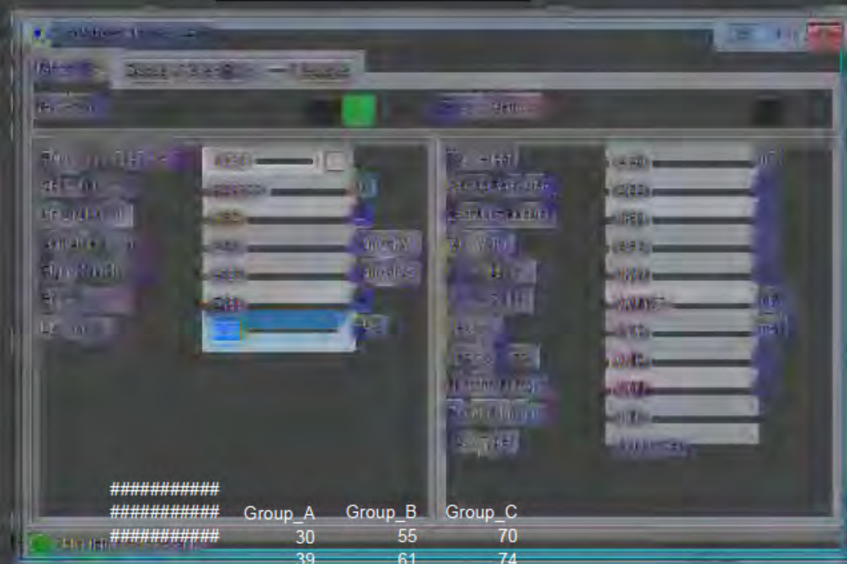
LS9

Data entry cells [redacted]
Result cells
Drop down menu

[redacted]

DEVELOPED CATCHMENT

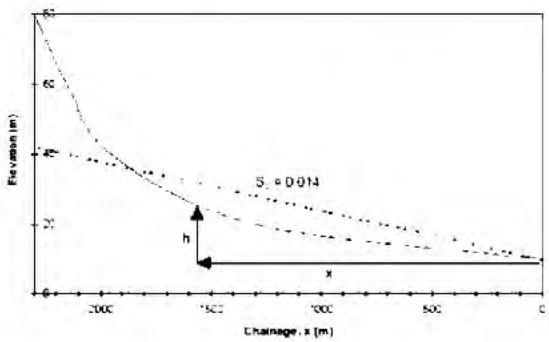
Select appropriate design storm	[redacted]	[redacted]
Impervious Area	ha	[redacted]
Pervious Area	ha	[redacted]
total area	ha	[redacted]
% Impervious		[redacted]
Catchment Slope (S_c)	m/m	[redacted]
Catchment Length (l)	km	[redacted]
Channelisation Factor (C)		[redacted]
Hydrological Soil Group		[redacted]
SCS Curve Number (CN)		[redacted]
24-Hour Rainfall Depth (P_{24})	mm	[redacted]
Weighted Curve Number		[redacted]
Initial Abstraction (Ia) weighted	mm	[redacted]
t_c	hours	[redacted]
t_p	hours	[redacted]
Storage (S)	mm	[redacted]
c*=(P24-2Ia)/(P24-2Ia+2S)		[redacted]
q* (from Fig. 6.1)	Approx!!	[redacted]
Peak Flowrate (q_p)	m^3/s	[redacted]
24 hour rainfall depth (Q_{24})	mm	[redacted]
24 hour runoff volume (V_{24})	m^3	[redacted]



###########			
###########	Group_A	Group_B	Group_C
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

LS9 Catchment Slope

(Calculating the Slope (Sc) using the equal area method)



Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

$$S_c = \frac{2A}{L^2}$$

Data Entry Cells

Result cells

Pre-development

Survey Point	Elevation RL (m)	h (m)	x (m)	Δx(m)	$\bar{h}$ (m)	$\Delta A(=\bar{h}\Delta x)$
1	25	0	0	0		
2	27	2	770	770	1	770
3	53	28	996	226	15	3390
4		0		0	0	0
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	996	TOTAL =	4160

S_c 0.008

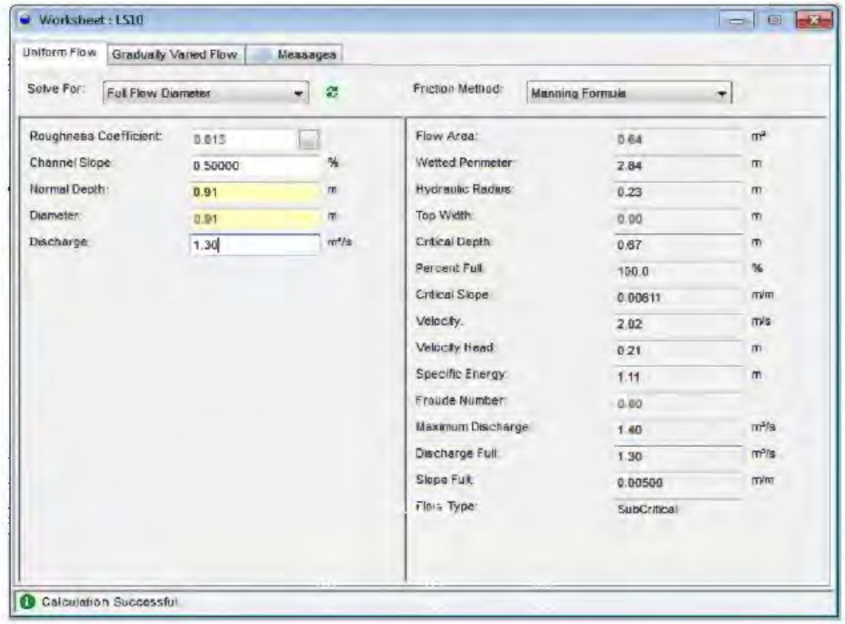
LS10

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells	
Result cells	
Drop down menu	

DEVELOPED CATCHMENT

Select appropriate design storm →		50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	4.396329	4.396329	4.396329
Pervious Area	ha	2.581971	2.581971	2.581971
total area	ha	6.9783		
% Impervious		63%	63%	63%
Catchment Slope (S_c)	m/m	0.005	0.005	0.005
Catchment Length (l)	km	0.557	0.557	0.557
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85
t_c	hours	0.32	0.32	0.32
t_p	hours	0.21	0.21	0.21
Storage (S)	mm	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.713	0.803
q* (from Fig. 6.1)	Approx!!	0.102	0.118	0.125
Peak Flowrate (q_p)	m^3/s	0.54	1.30	2.23
24 hour rainfall depth (Q_{24})	mm	52.3	130.3	226.5
24 hour runoff volume (V_{24})	m^3	3649	9091	15807



Worksheet : LS10

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Full Flow Diameter — Friction Method: Manning Formula

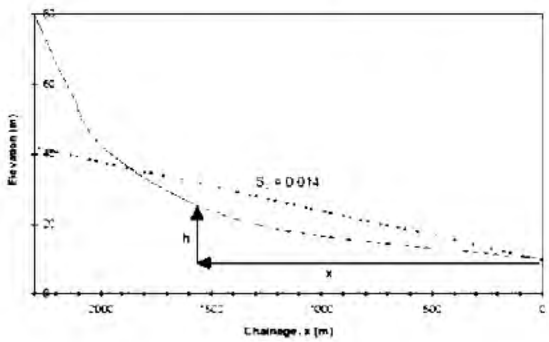
Roughness Coefficient:	0.013	
Channel Slope:	0.50000	%
Normal Depth:	0.91	m
Diameter:	0.91	m
Discharge:	1.30	m^3/s

Flow Area:	0.64	m^2
Wetted Perimeter:	2.84	m
Hydraulic Radius:	0.23	m
Top Width:	0.00	m
Critical Depth:	0.67	m
Percent Full:	100.0	%
Critical Slope:	0.00611	m/m
Velocity:	2.02	m/s
Velocity Head:	0.21	m
Specific Energy:	1.11	m
Froude Number:	0.00	
Maximum Discharge:	1.40	m^3/s
Discharge Full:	1.30	m^3/s
Slope Full:	0.00500	m/m
Flow Type:	SubCritical	

Calculation Successful

LS10 - Catchment Slope

(Calculating the Slope (Sc) using the equal area method)



Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

$$S_c = \frac{2A}{L^2}$$

Data Entry Cells

Result cells

Survey Point	Elevation RL (m)	h (m)	x (m)	Δx(m)	$\bar{h}$ (m)	$\Delta A(=\bar{h}\Delta x)$
1	26.5	0	0	0		
2	26.5	0	190	190	0	0
3	28.5	2	379	189	1	189
4	31.5	5	557	178	3.5	623
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	557	TOTAL =	812

S_c 0.005

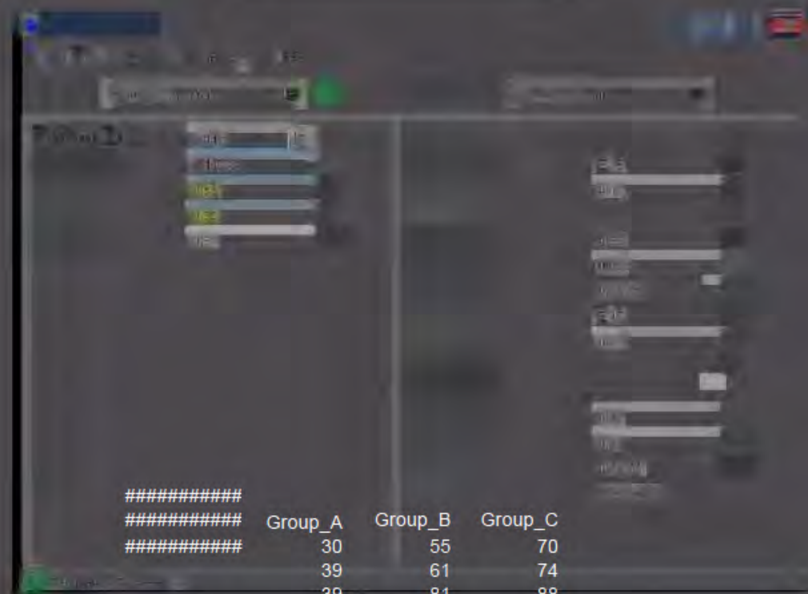
LS10A

Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

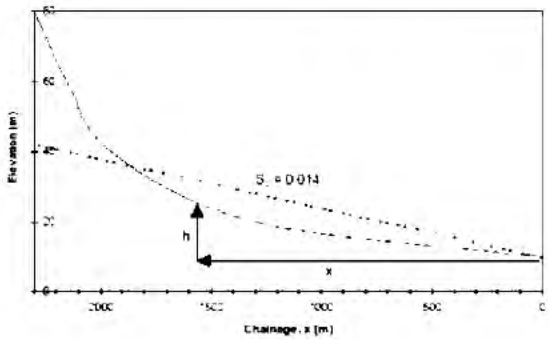
Select appropriate design storm		50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	2.619729	2.619729	2.619729
Pervious Area	ha	1.538571	1.538571	1.538571
total area	ha	4.1583		
% Impervious		63%	63%	63%
Catchment Slope (S_c)	m/m	0.011	0.011	0.011
Catchment Length (l)	km	0.387	0.387	0.387
Channelisation Factor (C)		0.6	0.6	0.6
Hydrological Soil Group		Group_C	Group_C	Group_C
SCS Curve Number (CN)		74	74	74
24-Hour Rainfall Depth (P_{24})	mm	76	158	256
Weighted Curve Number		89.12	89.12	89.12
Initial Abstraction (Ia) weighted	mm	1.85	1.85	1.85
t_c	hours	0.20	0.20	0.20
t_p	hours	0.13	0.13	0.13
Storage (S)	mm	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.713	0.803
q* (from Fig. 6.1)	Approx!!	0.120	0.138	0.146
Peak Flowrate (q_p)	m^3/s	0.38	0.91	1.56
24 hour rainfall depth (Q_{24})	mm	52.3	130.3	226.5
24 hour runoff volume (V_{24})	m^3	2174	5417	9419



	Group_A	Group_B	Group_C
###########			
###########			
###########	30	55	70
	39	61	74
	39	81	88
	72	98	98
	98		

LS10A - Catchment Slope

(Calculating the Slope (Sc) using the equal area method)



Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

$$S_c = \frac{2A}{L^2}$$

Data Entry Cells

Result cells

Survey Point	Elevation RL (m)	h (m)	x (m)	Δx(m)	$\overline{h}$ (m)	$\Delta A (= \overline{h}\Delta x)$
1	26.5	0	0	0		
2	28.75	2.25	238	238	1.125	267.75
3	31.5	5	387	149	3.625	540.125
4		0		0	0	0
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	387	TOTAL =	807.875

S_c	0.011

Appendix G - (Design summary table)

	Criteria Summary	Reference Document	Proposed design to meet criteria
Flooding	Conveyance of up to the 10% AEP event through a primary stormwater system. The location of the primary system should align with the natural flow path as far as possible	Stormwater CoP	10% AEP flow channel for primary drainage.
	Conveyance of up to the 1% AEP event flow through a secondary stormwater system assuming the primary system is completely blocked	Stormwater CoP, ICMP	1% AEP floodplain within designation for secondary stormwater flows.
	Provide sufficient freeboard to allow future development habitable floor levels to be constructed at least 500mm above the 1% AEP event flood level (300mm in the Old Wairoa Road NDC)	Unitary Plan, Stormwater CoP	Sufficient depth and capacity for developers to connect to with minimum filling of their sites to achieve required freeboard.
	Minimise infilling of the 1% AEP floodplain	ICMP	Construction of channel allows floodplain to be reduced / contained within designation.
	Secondary flow path design for culverts shall assume culvert blockage of 50% for pipes larger than 1500 mm diameter. This criteria assumes that culverts are designed for the 10% AEP with a secondary overland flowpath available. In this case, culverts will be designed for the 1% AEP, and therefore it has been agreed with Auckland Council that lower blockage scenarios can be considered.	ICMP	Blockage assessment of 10% and 20% culvert blockage.
Ecological	Provision for climbing fish passage shall be made at the McLennan wetland, and shall also be provided in any other works within the bed of a watercourse	NDC	Fish passage to be designed in detailed design. Provision for fish passage has been allowed within the weir and culvert designs.
	Protection of the stream riparian margin	ICMP	Plants selected to withstand channel flows
Planning	If practicable, provide centralised community stormwater management devices to avoid ineffective, often expensive, piecemeal stormwater treatment solutions	ICMP	Implementation of the Takanini Stormwater Conveyance Channel achieves this
Cultural	Involve local iwi groups in the stormwater management process and incorporate iwi philosophy in the stormwater design where possible	ICMP	Iwi to be consulted and involved in detailed design.

GHD

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N:\NZ\Auckland\Projects\51\32174\03 Takanini\04 Scheme Design\09 Report\Takanini Stormwater Conveyance Channel - Stormwater Scheme Design Report 2015-11-10.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	Jesse Peeters	Tony Miller	Tony Miller	Edward Reid	[signature]	29/01/16
2	Jesse Peeters	Tony Miller	Tony Miller	Edward Reid	[signature]	07/04/16

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APPENDIX 14 – Auckland Unitary Plan E36 ASSESSMENT

AUP E36 Objective Assessment Table 1

E36 Objective	Related Policy	Assessment
1) Subdivision, use and development outside urban areas does not occur unless the risk of adverse effects to people, property, infrastructure and the environment from natural hazards has been assessed and significant adverse effects are avoided, taking into account the likely long-term effects of climate change.	Policy 1 (E36.3.1), Policy 17 (E36.3.17)	An assessment has been completed as per AUP36.3 in table 2 and 3 below. Flood modelling was completed taking into account climate change. All natural hazards have been assessed, and adverse effects have been avoided
2) Subdivision, use and development, including redevelopment in urban areas, only occurs where the risks of adverse effects from natural hazards to people, buildings, infrastructure and the environment are not increased overall and where practicable are reduced, taking into account the likely long-term effects of climate change.	Policy 21 (E36.3.21)	Flood modelling supports that there will be no increase in risks in the downstream urban environment.
3) Subdivision, use and development on rural land for rural uses is managed to ensure that the risks of adverse effects from natural hazards are not increased and where practicable are reduced.	Policy 1 (E36.3.1), Policy 17 (E36.3.17)	Not applicable for this application.
4) Where infrastructure has a functional or operational need to locate in a natural hazard area, the risk of adverse effects to other people, property, and the environment shall be assessed and significant adverse effects are sought first to be avoided or, if avoidance is not able to be totally achieved, the residual effects are otherwise mitigated to the extent practicable.	Policy 4 (E35.3.4)	The risk assessment has been completed in table 2 and 3below. where possible avoidance of hazards where infrastructure is needed has been sought. Where this is not possible the hazards have been mitigated.
5) Subdivision, use and development including redevelopment, is managed to safely maintain the conveyance function of floodplains and overland flow paths.	Policy 20 (E36.3.20), Policy 29 (E36.3.29), Policy 30 (E36.3.30)	The flood modelling assessment takes into account climate change assesses conveyance functions of flood plains and overland flow paths and has provided these are safely managed.
6) Where appropriate, natural features and buffers are used in preference to hard protection structures to manage natural hazards.	Policy 1 (E36.3.1), Policy 17 (E36.3.17)	Where practicable natural features and buffers are proposed to manage natural hazards.

E36 Natural Hazards Flood Risk Assessment Table 2

E36.3 Policy Assessment	Assessment
a) The type, frequency and scale of the natural hazard and whether adverse effects on the development will be temporary or permanent;	The main risk to the development is flooding in the 1%AEP storm event. The 1% AEP+CC design storm event is very infrequent, with associated flooding effects being temporary in nature. Although this will be mitigated onsite it won't remove the hazard completely from the site, but the flooding with be controlled through onsite channels and ponds/wetlands. All lots will have no flooding issues.
b) The type of activity being undertaken and its vulnerability to natural hazard events;	Master planned development. Habitable spaces, Community Facilities and Commercials spaces are vulnerable to natural hazards without appropriate mitigation.
c) The consequences of a natural hazard event in relation to the proposed activity;	The consequences would be flooding and potential loss of property unless proper mitigations are provided.
d) The potential effects on public safety and other property;	Flooding could be a risk to public safety by restricting movement and damaging property.
e) Any exacerbation of an existing natural hazard risk or the emergence of natural hazard risks that previously were not present at the location;	<u>Western Catchment</u> Flood modelling shows peak water levels and peak flow in the TSWCC (Takanini Stormwater Conveyance Channel) to remain unchanged or decrease for the modelled 50%, 10% and 1% AEP storms. Flow across the McLennan wetland spillway has a minor decrease post development. Flow and loading on the Artillery Driveway Tunnel remain unchanged. Flood levels in the McLennan wetland downstream also remain unchanged. There will be no exacerbation of existing natural hazards onsite or within the surrounding catchment areas, no new hazards will be created. <u>Eastern Catchment</u> Flood modelling shows water levels and peak flow downstream of the eastern catchment to remain unchanged or decrease for the modelled 50%, 10% and 1% AEP storms. Flood levels in the Papakura Stream downstream also remain unchanged. There will be no exacerbation of existing natural hazards onsite or within the surrounding catchment areas, no new hazards will be created.
f) whether any building, structure or activity located on land subject to natural hazards near the coast can be relocated in the event of severe coastal erosion, inundation or shoreline retreat;	There are no coastal areas within the site.

g) The ability to use non-structural solutions, such as planting or the retention or enhancement of natural landform buffers to avoid, remedy or mitigate hazards, rather than hard protection structures;	Hazard mitigation onsite will be completed though groundwater recharge (retention), onsite attenuation using ponds (wet/dry), swales and wetlands(detention) or passing through the upstream catchment (diversion). Western Catchment specifics Peak flow attenuation is provided to the Western catchment via stormwater pond 4. The pond's flow attenuation results in slight reduction in peak flows and water levels downstream of the site (including the TSWCC and McLennan wetland) during the 50%, 10% and 1% AEP storms. Eastern Catchment specifics A stormwater swale network within the site allows flow from Catchment B to be passed forward and discharged across Northern outflow 1. Flows from catchment D1 and D2 are attenuated via stormwater pond 2 and 3 respectively. Upstream flows from the east of the site are conveyed around the site perimeter via a diversion channel. Stormwater pond 1 provides flood storage for peak flow diversion. Stormwater management results in peak flows and water levels downstream of the site (including within the Papakura Stream) during the 50%, 10% and 1% AEP storms to remain unchanged.
h) The design and construction of buildings and structures to mitigate the effects of natural hazards;	No buildings will be proposed to mitigate the flooding hazard.
i) The effect of structures used to mitigate hazards on landscape values and public access;	The use of wetlands and dry ponds promotes landscape values given the natural forms which become amenity areas for public use.
j) Site layout and management to avoid or mitigate the adverse effects of natural hazards, including access and exit during a natural hazard event.	The design of the development aligns with the council code of practise which stipulates egress routes, flow depths, flow velocities and freeboard requirements.
k) The duration of consent and how this may limit the exposure for more or less vulnerable activities to the effects of natural hazards including the likely effects of climate change.	The consent will be for staged construction and will have no adverse effect on the hazards. The effects of climate change have been included in the assessment.

APPENDIX C – STORMWATER CACULATIONS

	Maven Associates	Job Number	Sheet	Rev
		140005	1	A
Job Title	Ardmore Block, Takanini	**Author**	**Date**	**Checked**
Calc Title	Recharge Pit Design	JP	31/03/2021	WM

As per PDC SW - 21 & 22

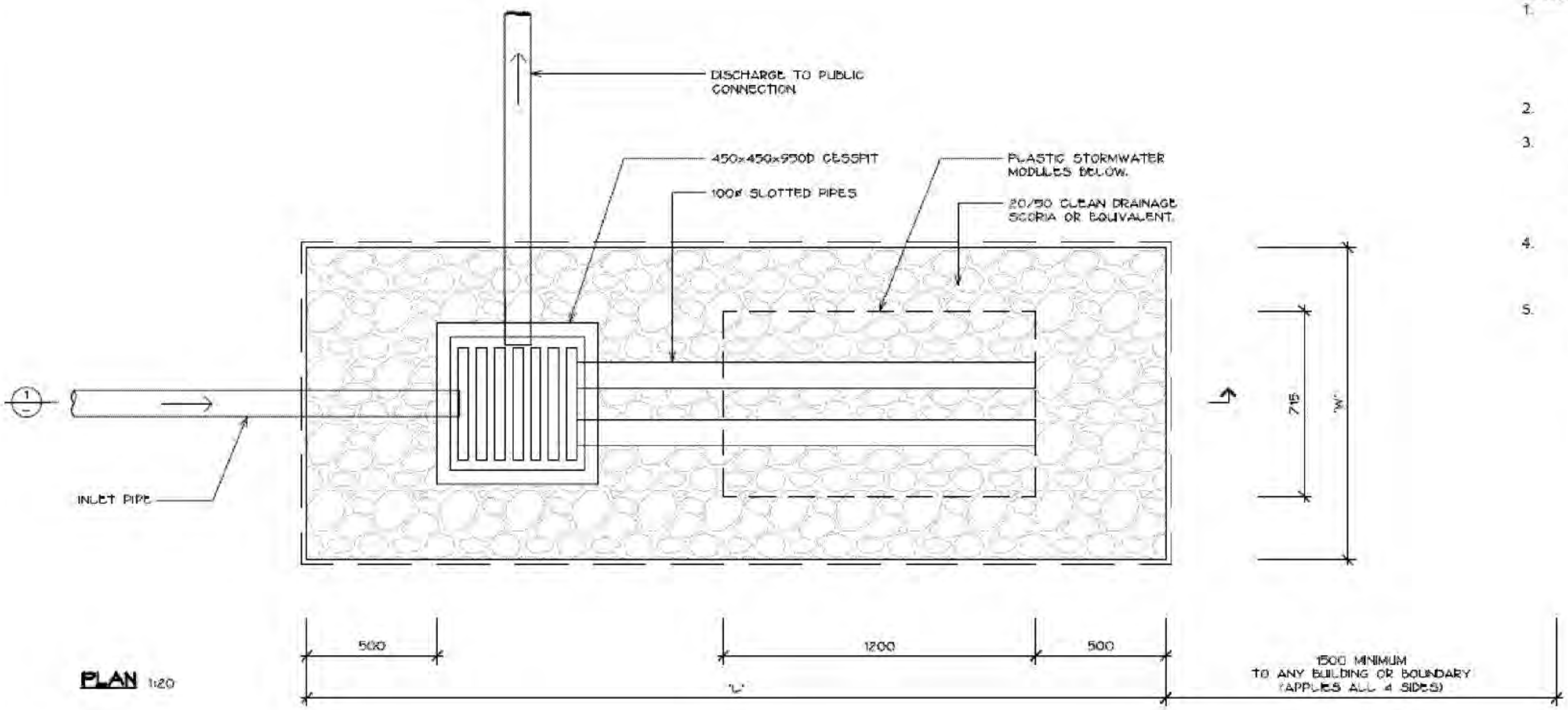
X= IMPERVIOUS AREA (m^2)

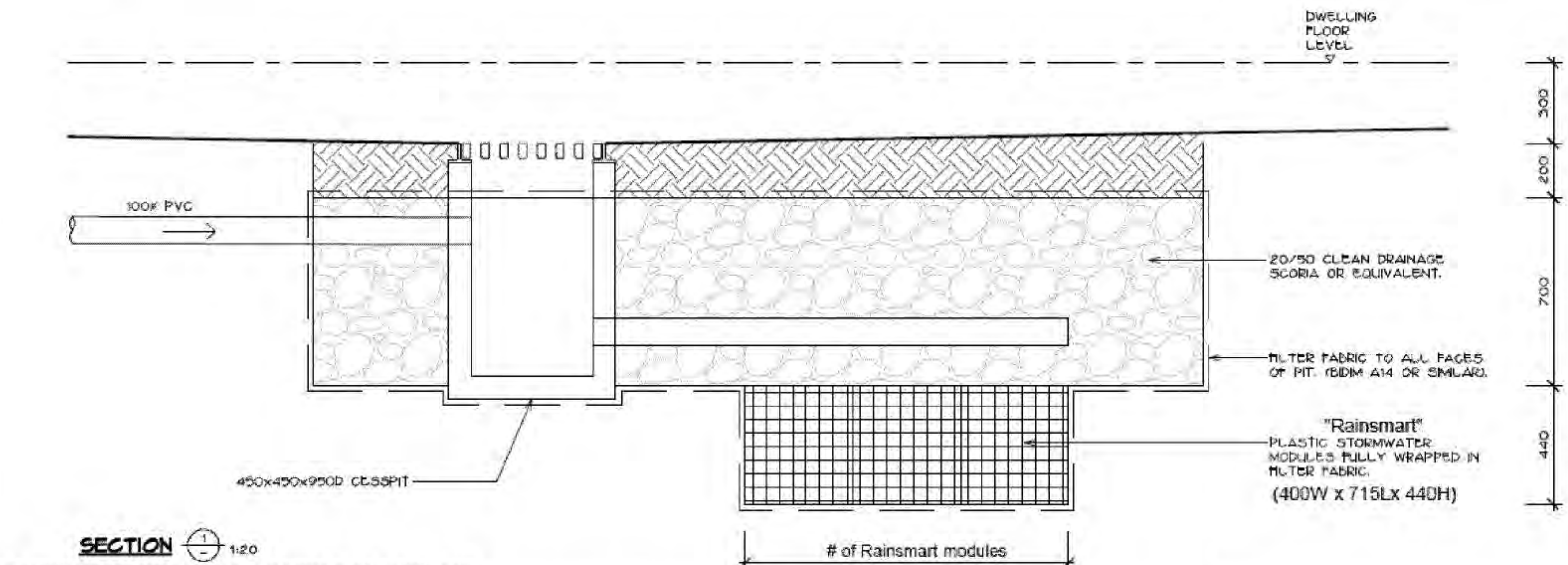
PIT WIDTH(m) = $0.091X^{.5423}$

PIT LENGTH(m) = $0.2275X^{.5423}$

85% Impervious Area

RECHARGE PIT	IMPERVIOUS AREA (m2)	REQUIRED PIT WIDTH (m)	PIT LENGTH(m)	MINIMUM PIT AREA (m2)	PROP PIT WIDTH (m)	PROP PIT LENGTH(m)
RP 1-0A	150	1.4	3.4	4.7	1.1	4.3





Base Drawing Source: Geotek Service Limited detail, as supplied to us by Auckland Council

CONSTRUCTION NOTES:

1. All pits must not be positioned any closer than 1.5m from buildings and boundaries UNLESS specific assessment is undertaken by a Geo-Professional confirming a setback of no less than 1.0m will not adversely affect adjacent buildings and/or structures. We recommend registered survey undertake both the setout and as-built survey location of the pit.
2. All pits must be fully lined with geotextile.
3. Dimensions 'L' & 'W' may be altered (provided 'W' ≥ 0.8m) to suit site constraints, provided that the plan area of the drainage pit is maintained. No other alterations whatsoever shall be made to the design and detailing on these plans unless written instruction is received from the designer. This includes, but is not limited to, setout, depth & material selections.
4. Any discrepancy or request for clarification shall be immediately brought to the designer's attention. Work requiring clarification shall not proceed under any circumstances without the designer's further written instruction.
5. All construction shall be subject to appropriate construction quality monitoring in order that a Producer Statement - Construction Review (PS4) can be issued to confirm that the recharge device meets the specific design requirements.

See Note 3.

Impervious Area (m^2)	Minimum Pit Area (m^2)	Pit Length L (m)	Pit Width W (m)	Internal Pit # Rainsmart Modules
50	1.4	1.9	0.8	1
60	1.8	2.1	0.8	1
70	2.1	2.3	0.9	2
80	2.4	2.4	1.0	2
90	2.7	2.6	1.0	2
100	3.1	2.8	1.1	2
110	2.4	2.9	1.2	2
120	3.7	3.1	1.2	3
130	4.1	3.2	1.3	2
140	4.4	3.3	1.3	3
150	4.7	3.4	1.4	3
160	5.1	3.6	1.4	3
170	5.4	3.7	1.5	4
180	5.8	3.8	1.5	4
190	6.1	3.9	1.6	4
200	6.5	4.0	1.6	4

Minimum Width 0.8m

OPERATION & MAINTENANCE NOTES:

1. **Maintenance of flow to and through the recharge pit**

   A monthly and/or severe storm event inspection is to be carried out that covers the following;

   - Visual overall inspection, with particular attention to surface ponding
   - Clearing of flow paths leading to the surcharge pit
   - Clearing of inlet to uPVC stubs, including filter sock, of any debris that may inhibit recharge through to the scoria pit
   - Inlet and outlet cleared of debris that may impair flow

2. **Removal of accumulated sediments**

   A monthly and/or after a severe storm event inspection is to be carried out to ensure that there is no accumulation of sediments within the recharge pit that would inhibit the pre-treatment of the stormwater runoff from the site or recharge through the scoria pit.

   If sediment removal is required the following should be carried out;

   - Removal of sediment and disposal to an approved receiving environment

3. **Debris removal**

   Monthly inspection and removal of debris from the recharge pit shall occur. This will ensure optimum operation of the recharge pit.

revision	description	drawn	approved	date

drawn	CE
approved	sgl
date	9 July 2020
scale	NTS
original size	A3

LANDER geotechnical

client:

project:

title: **Typical Residential Stormwater Recharge Pit Detail**

project no: **J01331** figure no: **01**

Template revision: 1:100 (10/12/14)

RainSmart

Modular Tank System

TECHNICAL DATA SHEET	TDS G 001 019
ISSUE NUMBER	05
DATE	OCTOBER 2016

DESCRIPTION

Modular tank systems designed for inground water storage and or water detention for peak flow events. Ellipse modular tanks can be designed to conform to most shapes and sizes to suit site conditions, and are simply stacked into a matrix of cells to create the desired storage volume.

APPLICATION

Application includes inground water storage and water flow detention.

TYPICAL PROPERTIES – TANK DIMENSIONS

MODULE (UNITS)	WIDTH (MM)	LENGTH (MM)	HEIGHT (MM)	TYPICAL TANK VOLUME (LITRES)	TYPICAL WATER STORAGE VOLUME (LITRES)
Single (1)	400	715	440	125.77	119.47
Double (2)	400	715	860	245.94	233.64
Triple (3)	400	715	1280	366.08	347.77
Quad (4)	400	715	1700	486.29	461.97
Pent (5)	400	715	2120	606.32	576.00

INTERNAL VOID RATIO	95% void
MATERIAL	85% Recycled Polypropylene + 15% Proprietary Mix
BIOLOGICAL & CHEMICAL RESISTANCE	Unaffected by moulds and algae, soil borne chemicals, bacteria and bitumen.
SERVICE TEMPERATURE	-10°C to 75°C
FLOW RATE	0.040 m^3/sec
Ultimate Load / Unconfined Crush Testing: *(Results for standard units with 4 Large & 4 Small plate tanks, also 4 large & 5 small plate tanks)*	Crush Load – 4 Plate Module : > 22.88 t/m^2 **Crush Load – 5 Plate Module:** > 26.16 t/m^2 **Temperature**: 21-27°C

- RainSmart Modular Tank is a design registered or design registered pending system of RainSmart Ply Ltd.
- Suitably qualified designers should apply the appropriate reduction factors for load based on the application.

Maven Associates	Job Number	Sheet	Rev	SUNFIELD	Author	Date	Checked
	215010	1	A	STAGE 5 SW Network Pipe Capacity Check	IZ	8/01/2025	AC

Rainfall Depth		ARI 10YR (mm)
TP108 rainfall data		145
Climate change Increase		170

(assuming 2.1C increase in temperature)

Pipe ks factor = 0.9

	CN Number		CN Number	
Impervious area	98	Public Road/JOAL	94.4	Equivalent CN - (85% impervious coverage, 15% pervious coverage)
Pervious	74	Industrial area	95.6	Equivalent CN - (90% impervious coverage, 10% pervious coverage)
		Residential lot	90.8	Equivalent CN - (70% impervious coverage, 30% pervious coverage)

Pipe Line *number*	Catchment *letter*	Catchment Area *m2*	CN	Peak Flow rate - 10YR ARI *l/s*	Cum. Flow *l/s*	Pipe dia *m*	Gradient *%*	Capacity *l/s*	Velocity *m/s*	Check OK
	lot 3, 26, 51	1620.0	90.8	42.91	42.91					
S5-MH 1-5 TO S5-MH 1-4	*road 84*	315.0	94.4	8.66	51.58					
					51.58	0.300	0.40	66.98	0.95	OK
	lot 7, 26	1199.0	90.8	31.76	83.34					
S5-MH 1-4 TO S5-MH 1-3	*road 87*	430.0	94.4	11.83	95.16					
					95.16	0.375	0.40	120.69	1.09	OK
	lot 27	1012.0	90.8	26.81	26.81					
S5-MH 1-3-1-2 TO S5-MH 1-3-1-1	*road*	0.0	94.4	0.00	26.81					
					26.81	0.225	0.40	31.30	0.79	OK
	lot	0.0	90.8	0.00	26.81					
S5-MH 1-3-1-1 TO S5-MH 1-3-1	*road 114, 105*	706.0	94.4	19.42	46.23					
					46.23	0.300	0.40	66.98	0.95	OK
	lot 23	1632.0	90.8	43.23	43.23					
S5-MH 1-3-3 TO S5-MH 1-3-2	*road*	0.0	94.4	0.00	43.23					
					43.23	0.300	0.25	52.94	0.75	OK
	lot	0.0	90.8	0.00	43.23					
S5-MH 1-3-2 TO S5-MH 1-3-1	*road 112, 113*	696.0	94.4	19.14	62.37					
					62.37	0.375	0.40	120.69	1.09	OK
	lot 5, 6, 25, 33	2819.0	90.8	74.67	183.27					
S5-MH 1-3-1 TO S5-MH 1-3	*road 97, 115*	778.0	94.4	21.40	204.67					
					204.67	0.525	0.40	292.76	1.35	OK
	lot	0.0	90.8	0.00	204.67					
S5-MH 1-3 TO S5-MH 1-2	*road 89, 90*	806.0	94.4	22.17	226.84					
					322.00	0.600	0.40	415.92	1.47	OK
	lot 31, 32	1934.0	90.8	51.23	51.23					
S5-MH 1-2-2 TO S5-MH 1-2-1	*road 94*	264.0	94.4	7.26	58.49					
					58.49	0.300	0.40	66.98	0.95	OK
	lot 34	923.0	90.8	24.45	24.45					
S5-MH 1-2-1-1 TO S5-MH 1-2-1	*road 92*	375.0	94.4	10.31	34.76					
					34.76	0.300	0.40	66.98	0.95	OK
	lot 30	329.0	90.8	8.71	101.97					
S5-MH 1-2-1 TO S5-MH 1-2	*road 93, 96*	554.0	94.4	15.24	117.21					
					117.21	0.375	0.40	120.69	1.09	OK
	lot	0.0	90.8	0.00	0.00					
S5-MH 1-2 TO S5-OUTLET 1-1	*road 91*	377.0	94.4	10.37	449.58					
					449.58	0.675	0.40	566.77	1.58	OK

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	215010	1	A	STAGE 5 SW Network Pipe Capacity Check	IZ	8/01/2025	AC

Rainfall Depth		ARI 10YR (mm)
TP108 rainfall data		145
Climate change Increase		170

(assuming 2.1C increase in temperature)

Pipe ks factor = 0.9

	CN Number		CN Number	
Impervious area	98	Public Road/JOAL	94.4	Equivalent CN - (85% impervious coverage, 15% pervious coverage)
Pervious	74	Industrial area	95.6	Equivalent CN - (90% impervious coverage, 10% pervious coverage)
		Residential lot	90.8	Equivalent CN - (70% impervious coverage, 30% pervious coverage)

Pipe Line *number*	Catchment *letter*	Catchment Area *m2*	CN	Peak Flow rate - 10YR ARI *l/s*	Cum. Flow *l/s*	Pipe dia *m*	Gradient *%*	Capacity *l/s*	Velocity *m/s*	Check OK
	lot 28, 29	2023.0	90.8	53.59	53.59					
S5-MH 2-4 TO S5-MH 2-3	*road*	0.0	94.4	0.00	53.59					
					53.59	0.300	0.40	66.98	0.95	OK
	lot 2	692.0	90.8	18.33	18.33					
S5-MH 2-3-2 TO S5-MH 2-3-1	*road 104, 110*	1174.0	94.4	32.29	50.62					
					50.62	0.300	0.40	66.98	0.95	OK
	lot	0.0	90.8	0.00	0.00					
S5-MH 2-3-1-1 TO S5-MH 2-3-1	*road 100*	247.0	94.4	6.79	6.79					
					6.79	0.225	0.40	31.30	0.79	OK
	lot 195	624.0	90.8	16.53	73.94					
S5-MH 2-3-1 TO S5-MH 2-3	*road*	0.0	94.4	0.00	73.94					
					73.94	0.375	0.40	120.69	1.09	OK
	lot 1, 4, 50	1535.0	90.8	40.66	168.19					
S5-MH 2-3 TO S5-MH 2-2	*road 88*	386.0	94.4	10.62	178.81					
					178.81	0.450	0.40	195.12	1.23	OK
	lot 52	952.0	90.8	25.22	25.22					
S5-MH 2-2-1 TO S5-MH 2-2	*road 85*	428.0	94.4	11.77	36.99					
					36.99	0.300	0.40	66.98	0.95	OK
	lot 8	484.0	90.8	12.82	228.62					
S5-MH 2-2 TO S5-OUTLET 2-1	*road*	0.0	94.4	0.00	228.62					
					228.62	0.525	0.40	292.76	1.35	OK

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	215010	1	A	STAGE 5 SW Network Pipe Capacity Check	IZ	8/01/2025	AC

Rainfall Depth		ARI 10YR (mm)
TP108 rainfall data		145
Climate change Increase		170

(assuming 2.1C increase in temperature)

Pipe ks factor = 0.9

	CN Number		CN Number	
Impervious area	98	Public Road/JOAL	94.4	Equivalent CN - (85% impervious coverage, 15% pervious coverage)
Pervious	74	Industrial area	95.6	Equivalent CN - (90% impervious coverage, 10% pervious coverage)
		Residential lot	90.8	Equivalent CN - (70% impervious coverage, 30% pervious coverage)

Pipe Line *number*	Catchment *letter*	Catchment Area *m2*	CN	Peak Flow rate - 10YR ARI *l/s*	Cum. Flow *l/s*	Pipe dia *m*	Gradient *%*	Capacity *l/s*	Velocity *m/s*	Check OK
	Lot 176, 196	925.0	90.8	24.50	24.50					
S5-MH 3-11 TO S5-MH 3-10	*road 67*	909.0	94.4	25.00	49.50					
					49.50	0.300	0.40	66.98	0.95	OK
	Lot 19	488.0	90.8	12.93	62.43					
S5-MH 3-10 TO S5-MH 3-9	*road 118*	687.0	94.4	18.90	81.33					
					81.33	0.375	0.40	120.69	1.09	OK
	lot 22, 56	1703.0	90.8	45.11	45.11					
S5-MH 3-9-2 TO S5-MH 3-9-1	*road 98*	293.0	94.4	8.06	53.17					
					53.17	0.300	0.40	66.98	0.95	OK
	lot 59	971.0	90.8	25.72	78.89					
S5-MH 3-9-1 TO S5-MH 3-9	*road*	0.0	94.4	0.00	78.89					
					78.89	0.375	0.40	120.69	1.09	OK
	Lot 197	314.0	90.8	8.32	168.54					
S5-MH 3-9 TO S5-MH 3-8	*road*	0.0	94.4	0.00	168.54					
					168.54	0.450	0.40	195.12	1.23	OK
	lot 62	958.0	90.8	25.38	193.91					
S5-MH 3-8 TO S5-MH 3-7	*road 121*	623.0	94.4	17.14	211.05					
					211.05	0.525	0.40	292.76	1.35	OK
	lot 54	968.0	90.8	25.64	236.69					
S5-MH 3-7 TO S5-MH 3-6	*road 123*	806.0	94.4	22.17	258.86					
					258.86	0.525	0.40	292.76	1.35	OK
	lot 68	1195.0	90.8	31.65	31.65					
S5-MH 3-5-3 TO S5-MH 3-5-2	*road 101*	302.0	94.4	8.31	39.96					
					39.96	0.300	0.40	66.98	0.95	OK
	lot 63, 66	1628.0	90.8	43.12	43.12					
S5-MH 3-5-2-1 TO S5-MH 3-5-2	*road 102*	222.0	94.4	6.11	49.23					
					49.23	0.300	0.40	66.98	0.95	OK
	lot 170	967.0	90.8	25.61	114.81					
S5-MH 3-5-2 TO S5-MH 3-5-1	*road*	0.0	94.4	0.00	114.81					
					114.81	0.375	0.40	120.69	1.09	OK
	lot 64	814.0	90.8	21.56	136.37					
S5-MH 3-5-1 TO S5-MH 3-5	*road 103*	313.0	94.4	8.61	144.98					
					144.98	0.450	0.40	195.12	1.23	OK
	lot	0.0	90.8	0.00	403.84					
S5-MH 3-6 TO S5-MH 3-5	*road 130*	473.0	94.4	13.01	416.85					
					416.85	0.675	0.40	566.77	1.58	OK
	lot 61	387.0	90.8	10.25	10.25					

S5-MH 3-4-2TO S5-MH 3-4-1	*road 106, 107*	994.0	94.4	27.34	37.59					
					37.59	0.300	0.40	66.98	0.95	OK
	lot 61	0.0	90.8	0.00	0.00					
S5-MH 3-4-1 TO S5-MH 3-4	*road 106, 107*	0.0	94.4	0.00	0.00					
					37.59	0.300	0.40	66.98	0.95	OK
	lot 35	717.0	90.8	18.99	473.43					
S5-MH 3-4 TO S5-MH 3-3	*road*	0.0	94.4	0.00	473.43					
					473.43	0.675	0.40	566.77	1.58	OK
	lot	0.0	90.8	0.00	473.43					
S5-MH 3-3 TO S5-MH 3-2	*road 128*	686.0	94.4	18.87	492.30					
					492.30	0.675	0.40	566.77	1.58	OK
	lot 198	264.0	90.8	6.99	499.29					
S5-MH 3-2 TO S5-OUTLET 3-1	*road 117*	738.0	94.4	20.30	519.59					
					519.59	0.675	0.40	566.77	1.58	OK

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Rainfall Depth	ARI 10YR (mm)
TP108 rainfall data	145
Climate change Increase	170 (assuming 2.1C increase in temperature)

Pipe ks factor = 0.9

	CN Number
Impervious area	98
Pervious	74

	CN Number	
Public Road/JOAL	94.4	Equivalent CN - (85% impervious coverage, 15% pervious coverage)
Industrial area	95.6	Equivalent CN - (90% impervious coverage, 10% pervious coverage)
Residential lot	90.8	Equivalent CN - (70% impervious coverage, 30% pervious coverage)

Pipe Line *number*	Catchment *letter*	Catchment Area *m2*	CN	Peak Flow rate - 10YR ARI *l/s*	Cum. Flow *l/s*	Pipe dia *m*	Gradient *%*	Capacity *l/s*	Velocity *m/s*	Check OK
S5-MH 4-7 TO S5-MH 4-6B	*Lot 79, 178*	518.0	90.8	13.72	13.72					
	road	0.0	94.4	0.00	13.72					
					13.72	0.225	0.40	31.30	0.79	OK
S5-MH 4-6B TO S5-MH 4-6A	*Lot 44*	1115.0	90.8	29.54	43.26					
	road 127	625.0	94.4	17.19	60.45					
					60.45	0.300	0.40	66.98	0.95	OK
S5-MH 4-6A TO S5-MH 4-6	*Lot 202*	464.0	90.8	12.29	72.74					
	road 119	707.0	94.4	19.45	92.18					
					92.18	0.375	0.40	120.69	1.09	OK
S5-MH 4-6-4 TO S5-MH 4-6-3	*lot 14, 17, 39, 40*	2442.0	90.8	64.69	64.69					
	road 142	340.0	94.4	9.35	74.04					
					74.04	0.375	0.40	120.69	1.09	OK
S5-MH 4-6-3 TO S5-MH 4-6-2	*lot 78, 80*	1808.0	90.8	47.89	121.93					
	road	0.0	94.4	0.00	121.93					
					121.93	0.450	0.40	195.12	1.23	OK
S5-MH 4-6-2 TO S5-MH 4-6-1	*lot*	0.0	90.8	0.00	121.93					
	road 143	243.0	94.4	6.68	128.61					
					128.61	0.450	0.40	195.12	1.23	OK
S5-MH 4-6-1-3 TO S5-MH 4-6-1-2	*lot 38*	766.0	90.8	20.29	20.29					
	road	0.0	94.4	0.00	20.29					
					20.29	0.225	0.40	31.30	0.79	OK
S5-MH 4-6-1-2 TO S5-MH 4-6-1-1	*lot*	0.0	90.8	0.00	20.29					
	road 144	261.0	94.4	7.18	27.47					
					27.47	0.225	0.40	31.30	0.79	OK
S5-MH 4-6-1-1 TO S5-MH 4-6-1	*lot 43, 45*	2477.0	90.8	65.61	93.08					
	road 146	249.0	94.4	6.85	99.93					
					99.93	0.375	0.40	120.69	1.09	OK
S5-MH 4-6-1 TO S5-MH 4-6	*lot*	0.0	90.8	0.00	228.55					
	road 145	286.0	94.4	7.87	236.41					
					236.41	0.525	0.40	292.76	1.35	OK
S5-MH 4-6 TO S5-MH 4-5A	*lot 201*	345.0	90.8	9.14	337.74					
	road	0.0	94.4	0.00	337.74					
					337.74	0.600	0.40	415.92	1.47	OK
S5-MH 4-5B TO S5-MH 4-5A	*Lot 42*	569.0	90.8	15.07	352.81					
	road 120	684.0	94.4	18.81	371.62					
					371.62	0.675	0.40	566.77	1.58	OK
S5-MH 4-5-2-2 TO S5-MH 4-5-2-1	*lot 172*	370.0	90.8	9.80	9.80					
	road	0.0	94.4	0.00	9.80					
					9.80	0.225	0.40	31.30	0.79	OK
S5-MH 4-5-2-1 TO S5-MH 4-5-2	*lot 173*	269.0	90.8	7.13	16.93					
	road 147	308.0	94.4	8.47	25.40					
					25.40	0.225	0.40	31.30	0.79	OK

	lot 16	729.0	90.8	19.31	19.31					
S5-MH 4-5-3 TO S5-MH 4-5-2	*road*	0.0	94.4	0.00	19.31					
					19.31	0.225	0.40	31.30	0.79	OK
	lot	0.0	90.8	0.00	44.71					
S5-MH 4-5-2 TO S5-MH 4-5-1	*road 148*	338.0	94.4	9.30	54.01					
					54.01	0.300	0.40	66.98	0.95	OK
	lot 70	1616.0	90.8	42.81	96.81					
S5-MH 4-5-1 TO S5-MH 4-5	*road*	0.0	94.4	0.00	96.81					
					96.81	0.375	0.40	120.69	1.09	OK
	lot 200	345.0	90.8	9.14	477.57					
S5-MH 4-5A TO S5-MH 4-5	*road 150*	259.0	94.4	7.12	484.70					
					484.70	0.675	0.40	566.77	1.58	OK
	lot 199	650.0	90.8	17.22	501.91					
S5-MH 4-5 TO S5-MH 4-4	*road 122*	694.0	94.4	19.09	521.00					
					521.00	0.750	0.40	747.39	1.69	OK
	lot 74	865.0	90.8	22.91	543.91					
S5-MH 4-3C TO S5-MH 4-3B	*road 131*	829.0	94.4	22.80	566.72					
					566.72	0.750	0.40	747.39	1.69	OK
	lot	0.0	90.8	0.00	566.72					
S5-MH 4-3B TO S5-MH 4-3A	*road 129*	858.0	94.4	23.60	590.32					
					590.32	0.750	0.40	747.39	1.69	OK
	lot	0.0	90.8	0.00	590.32					
S5-MH 4-3A TO S5-MH 4-3	*road 126*	820.0	94.4	22.55	612.87					
					612.87	0.750	0.40	747.39	1.69	OK
	lot 37	859.0	90.8	22.75	22.75					
S5-MH 4-3-6 TO S5-MH 4-3-5	*road 151, 159, 160, 161*	1821.0	94.4	50.09	72.84					
					72.84	0.375	0.40	120.69	1.09	OK
	lot	0.0	90.8	0.00	72.84					
S5-MH 4-3-5 TO S5-MH 4-3-4	*road 77, 166*	980.0	94.4	26.95	99.80					
					99.80	0.375	0.40	120.69	1.09	OK
	lot 36, 46	3270.0	90.8	86.62	86.62					
S5-MH 4-3-4-1 TO S5-MH 4-3-4	*road*	0.0	94.4	0.00	86.62					
					86.62	0.450	0.40	195.12	1.23	OK
	lot	0.0	90.8	0.00	186.42					
S5-MH 4-3-4 TO S5-MH 4-3-3	*road 149, 194*	501.0	94.4	13.78	200.20					
					200.20	0.525	0.40	292.76	1.35	OK
	lot	0.0	90.8	0.00	200.20					
S5-MH 4-3-3 TO S5-MH 4-3-2B	*road 168, 169*	884.0	94.4	24.31	224.51					
					224.51	0.525	0.40	292.76	1.35	OK
	lot	0.0	90.8	0.00	224.51					
S5-MH 4-3-2B TO S5-MH 4-3-2A	*road 163, 164*	705.0	94.4	19.39	243.90					
					243.90	0.525	0.40	292.76	1.35	OK
	lot 203	705.0	90.8	18.67	18.67					
S5-MH 4-3-2A-3 TO S5-MH 4-3-2A-2	*road*	0.0	94.4	0.00	18.67					
					18.67	0.225	0.40	31.30	0.79	OK
	lot 75	1194.0	90.8	31.63	50.30					
S5-MH 4-3-2A-2 TO S5-MH 4-3-2A-1	*road 152, 153, 154, 155*	1534.0	94.4	42.19	92.50					
					92.50	0.375	0.40	120.69	1.09	OK
	lot	0.0	90.8	0.00	92.50					
S5-MH 4-3-2A-1 TO S5-MH 4-3-2A	*road 156, 157*	840.0	94.4	23.10	115.60					
					115.60	0.375	0.40	120.69	1.09	OK
	lot	0.0	90.8	0.00	359.50					
S5-MH 4-3-2A TO S5-MH 4-3-2	*road*	0.0	94.4	0.00	359.50					
					359.50	0.600	0.40	415.92	1.47	OK
	lot 174	1880.0	90.8	49.80	49.80					
S5-MH 4-3-2-1 TO S5-MH 4-3-2	*road*	0.0	94.4	0.00	49.80					
					49.80	0.375	0.40	120.69	1.09	OK
	lot	0.0	90.8	0.00	409.30					
S5-MH 4-3-2 TO S5-MH 4-3-1	*road*	0.0	94.4	0.00	409.30					

					409.30	0.600	0.40	415.92	1.47	OK
	lot 18	953.0	90.8	25.24	434.54					
S5-MH 4-3-1 TO S5-MH 4-3	*road*	0.0	94.4	0.00	434.54					
					434.54	0.675	0.40	566.77	1.58	OK
	lot	0.0	90.8	0.00	434.54					
S5-MH 4-3 TO S5-MH 4-2	*road 158*	278.0	94.4	7.65	442.19					
					1055.06	0.900	0.40	1205.80	1.90	OK
	lot	0.0	90.8	0.00	1055.06					
S5-MH 4-2 TO S5-OUTLET 4-1	*road*	0.0	94.4	0.00	1055.06					
					1055.06	0.900	0.40	1205.80	1.90	OK

Maven Associates	Job Number	Sheet	Rev	SUNFIELD	Author	Date	Checked
	215010	1	A	STAGE 5 SW Network Pipe Capacity Check	IZ	8/01/2025	AC

Rainfall Depth		ARI 10YR (mm)
TP108 rainfall data		145
Climate change Increase		170

(assuming 2.1C increase in temperature)

Pipe ks factor = 0.9

	CN Number		CN Number	
Impervious area	98	Public Road/JOAL	94.4	Equivalent CN - (85% impervious coverage, 15% pervious coverage)
Pervious	74	Industrial area	95.6	Equivalent CN - (90% impervious coverage, 10% pervious coverage)
		Residential lot	90.8	Equivalent CN - (70% impervious coverage, 30% pervious coverage)

Pipe Line number	Catchment letter	Catchment Area m2	CN	Peak Flow rate - 10YR ARI l/s	Cum. Flow l/s	Pipe dia m	Gradient %	Capacity l/s	Velocity m/s	Check OK
	lot 76	1498	90.8	39.68	39.68					
S5-MH 5-9 TO S5-MH 5-8	*road*	0	94.4	0.00	39.68					
					39.68	0.300	0.40	66.98	0.95	OK
	lot 204	1017	90.8	26.94	66.62					
S5-MH 5-8 TO S5-MH 5-7	*road 132, 133*	944	94.4	25.96	92.58					
					92.58	0.375	0.40	120.69	1.09	OK
	lot 175	892	90.8	23.63	116.21					
S5-MH 5-7 TO S5-MH 5-6	*road 135, 179*	850	94.4	23.38	139.59					
					139.59	0.450	0.40	195.12	1.23	OK
	lot 15	230	90.8	6.09	145.68					
S5-MH 5-6 TO S5-MH 5-5	*road 134, 135*	869	94.4	23.90	169.59					
					169.59	0.450	0.40	195.12	1.23	OK
	lot 11, 12	662	90.8	17.54	187.12					
S5-MH 5-5 TO S5-MH 5-4B	*road 181, 141*	875	94.4	24.07	211.19					
					211.19	0.525	0.40	292.76	1.35	OK
	lot 41	739	90.8	19.58	230.77					
S5-MH 5-4B TO S5-MH 5-4A	*road 182, 183*	833	94.4	22.91	253.68					
					253.68	0.525	0.40	292.76	1.35	OK
	lot 205	632	90.8	16.74	270.42					
S5-MH 5-4A TO S5-MH 5-4	*road 48, 82*	715	94.4	19.67	290.08					
					290.08	0.525	0.40	292.76	1.35	OK
	lot 10	1747	90.8	46.28	46.28					
S5-MH 5-4-2 TO S5-MH 5-4-1	*road*	0	94.4	0.00	46.28					
					46.28	0.300	0.40	66.98	0.95	OK
	lot	0	90.8	0.00	46.28					
S5-MH 5-4-1 TO S5-MH 5-4	*road 165, 167*	795	94.4	21.87	68.14					
					68.14	0.375	0.40	120.69	1.09	OK
	lot	0	90.8	0.00	358.23					
S5-MH 5-4 TO S5-MH 5-3	*road 188, 189*	667	94.4	18.35	376.57					
					376.57	0.600	0.40	415.92	1.47	OK
	lot	0	90.8	0.00	0.00					
S5-MH 5-3-3 TO S5-MH 5-3-2	*road 192, 193*	863	94.4	23.74	23.74					
					23.74	0.225	0.40	31.30	0.79	OK
	lot	0	90.8	0.00	23.74					
S5-MH 5-3-2 TO S5-MH 5-3-1	*road 136, 137*	752	94.4	20.68	44.42					

					44.42	0.300	0.40	66.98	0.95	OK
	lot	0	90.8	0.00	44.42					
S5-MH 5-3 TO S5-MH 5-3	*road 190, 191*	969	94.4	26.65	71.07					
					71.07	0.375	0.40	120.69	1.09	OK
	lot	0	90.8	0.00	447.65					
S5-MH 5-3 TO S5-MH 5-2	*road*	0	94.4	0.00	447.65					
					447.65	0.675	0.40	566.77	1.58	OK
	lot	0	90.8	0.00	447.65					
S5-MH 5-2 TO S5-OUTLET 5-1	*road*	0	94.4	0.00	447.65					
					447.65	0.675	0.40	566.77	1.58	OK

Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Stage 5 Calc Title: Recharge Pit Design	Author IZ	Date -	Checked AC

As per PDC SW - 21 & 22

X= IMPERVIOUS AREA (m^2)

PIT WIDTH(m) = $0.091X^{.5423}$

PIT LENGTH(m) = $0.2275X^{.5423}$

85% Impervious Area

RECHARGE PIT	CATCHMENT AREA (m2)	IMPERVIOUS AREA (m2)	REQUIRED PIT WIDTH (m)	PIT LENGTH(m)	MINIMUM PIT AREA (m2)	PROP PIT WIDTH (m)	PROP PIT LENGTH(m)
RCP S5-1-3-1-1	706	600	2.9	7.3	21.3	0.8	26.7
RCP S5-1-3-2A&B	696	592	2.9	7.2	21.0	0.8	26.3
RCP S5-1-3-2C&D	778	661	3.1	7.7	23.7	0.8	29.6
RCP S5-3-4-1	994	845	3.5	8.8	30.9	0.8	38.7
RCP S5-3-3A	686	583	2.9	7.2	20.7	0.8	25.9
RCP S5-3-3	738	627	3.0	7.5	22.4	0.8	28.0
RCP S5-4-3B	858	729	3.2	8.1	26.4	0.8	33.0
RCP S5-4-3A	820	697	3.2	7.9	25.1	0.8	31.4
RCP S5-4-3-3	884	751	3.3	8.3	27.2	0.8	34.0
RCP S5-4-3-2B	705	599	2.9	7.3	21.3	1.1	19.4

JOINTLY OWNED PRIVATE RECHARGE PITS

RECHARGE PIT	CATCHMENT AREA (m2)	IMPERVIOUS AREA (m2)	REQUIRED PIT WIDTH (m)	PIT LENGTH(m)	MINIMUM PIT AREA (m2)	PROP PIT WIDTH (m)	PROP PIT LENGTH(m)
RCP S5-1-4A	315	268	1.9	4.7	8.9	1.1	8.1
RCP S5-1-4B	430	366	2.2	5.6	12.5	1.1	11.3
RCP S5-1-3A	430	366	2.2	5.6	12.5	1.1	11.3
RCP S5-1-3B	429	365	2.2	5.6	12.4	1.1	11.3
RCP S5-1-3C	377	320	2.1	5.2	10.8	1.1	9.8
RCP S5-1-2A	377	320	2.1	5.2	10.8	1.1	9.8
RCP S5-1-2B	272	231	1.7	4.4	7.6	1.1	6.9
RCP S5-1-2C	282	240	1.8	4.4	7.9	1.1	7.2
RCP S5-1-2-1A	375	319	2.1	5.2	10.7	1.1	9.8
RCP S5-1-2-1B	264	224	1.7	4.3	7.3	1.1	6.7
RCP S5-3-2	142	121	1.2	3.1	3.7	1.1	3.4
RCP S5-2-3	386	328	2.1	5.3	11.1	1.1	10.1
RCP S5-3-5-1	313	266	1.9	4.7	8.8	1.1	8.0
RCP S5-4-3-1	278	236	1.8	4.4	7.8	1.1	7.1

Catchment	No.	Structure Name	Type	Barrels	Culvert Span (m)	Culvert Rise (m)	Design Rainfall	Scenario	Design Flow (m^3/s)	Control	Culvert Outlet Flow Depth (m)	Culvert Outlet Velocity (m/s)	Froude No.	Fr < 1.7	1.7 < Fr < 3	Fr > 3	Energy Dissipation
Western Catchment	1	Road 1 Culvert 1	Box Culvert	1	3.50	1.50	100 YR ARI	No Blockage	8.368	Inlet	0.73	3.27	1.22	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	2	Road 1 Culvert 2	Box Culvert	1	3.50	1.50	100 YR ARI	No Blockage	7.307	Inlet	0.43	4.28	2.08	No	Yes	No	Headwall and Apron (with Baffles) and Riprap Apron
	3	Road 1 Culvert 3	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	1.280	Inlet	0.38	2.25	1.17	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	4	Road 2 Culvert 1	Box Culvert	2	3.00	1.50	100 YR ARI	No Blockage	15.734	Outlet	1.5	1.75	0.46	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	5	Road 2 Culvert 2	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.757	Inlet	0.45	1.11	0.53	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	6	Road 3 Culvert 1	Box Culvert	1	2.50	1.50	100 YR ARI	No Blockage	5.29	Inlet	0.74	2.87	1.07	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	7	Road 4 Culvert 1	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.561	Outlet	0.24	1.54	1.00	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	8	Road 4 Culvert 2	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.890	Outlet	0.3	1.99	1.16	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	9	Road 9 Culvert 1	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.998	Inlet	0.33	1.99	1.11	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	10	Road 14 Culvert 1	Box Culvert	2	2.00	0.80	100 YR ARI	No Blockage	3.391	Outlet	0.61	1.39	0.57	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	11	Road 14 Culvert 2	Box Culvert	2	2.00	0.90	100 YR ARI	No Blockage	4.285	Outlet	0.69	1.55	0.60	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	12	Road 32 Culvert 1	Box Culvert	1	1.50	1.00	100 YR ARI	No Blockage	2.200	Outlet	0.77	1.91	0.69	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	13	Carpark Crossing Culvert 1	Box Culvert	1	3.50	1.50	100 YR ARI	No Blockage	8.379	Outlet	0.75	3.2	1.18	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
Eastern Catchment	14	Road 1 Culvert 4	Circular	1	0.53	0.53	100 YR ARI	No Blockage	1.11	Inlet	0.53	2.63	1.11	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	15	Road 5 Culvert 1	Box Culvert	1	2.00	0.90	100 YR ARI	No Blockage	2.174	Inlet	0.42	2.61	1.29	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	16	Road 5 Culvert 2	Box Culvert	1	1.50	1.00	100 YR ARI	No Blockage	1.333	Inlet	0.21	4.21	2.93	No	Yes	No	Headwall and Apron (with Baffles) and Riprap Apron
	17	Road 6 Culvert 1	Box Culvert	1	2.00	1.20	100 YR ARI	No Blockage	3.114	Outlet	0.9	1.73	0.59	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	18	Road 6 Culvert 2	Box Culvert	1	1.50	1.20	100 YR ARI	No Blockage	3.114	Outlet	0.78	1.61	0.58	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	19	Road 7 Culvert 1	Circular	1	0.53	0.53	100 YR ARI	No Blockage	2.32	Outlet	0.5	1.95	0.88	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	20	Road 19 Culvert 1	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.527	Outlet	0.42	0.83	0.41	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	21	Road 20 Culvert 1	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.251	Outlet	0.28	0.59	0.36	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	22	Road 21 Culvert 1	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.981	Outlet	0.58	1.12	0.47	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	23	Road 22 Culvert 1	Box Culvert	1	1.50	0.80	100 YR ARI	No Blockage	0.257	Outlet	0.31	0.55	0.32	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	24	Road 25 Culvert 1	Box Culvert	1	2.50	1.50	100 YR ARI	No Blockage	5.025	Outlet	0.88	2.34	0.81	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	25	Road 26 Culvert 1	Box Culvert	1	3.00	1.50	100 YR ARI	No Blockage	7.948	Outlet	1.02	2.6	0.82	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent
	26	Road 31 Culvert 1	Box Culvert	1	2.50	1.00	100 YR ARI	No Blockage	2.62	Inlet	1	0.53	0.17	Yes	No	No	Headwall and Apron with erosion control lining 'Enkamat 7018'or equivalent

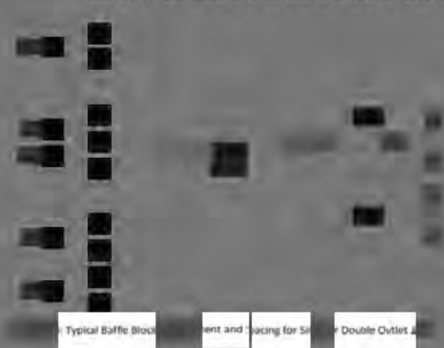
MAVEN ASSOCIATES

Job Number	Sheet	Rev
215010	2	A

		Author	Date	Checked
Job Title	Sunfield Development			
Calc Title	Outlet Structures Design Road 1 Culvert 2 - Outlet	OQ	7/02/2025	LC

Culvert Type	Box	
No. Barrels =	1	
Culvert Span =	3.500	m
Culvert Rise =	1.500	m
Pipe gradient =	0.015	m/m
1% AEP Flow depth =	0.43	m
Velocity =	4.28	m/s
Froude Number Fo =	2.08	

BAFFLE BLOCK ARRANGEMENT (ENERGY DISSIPATORS)



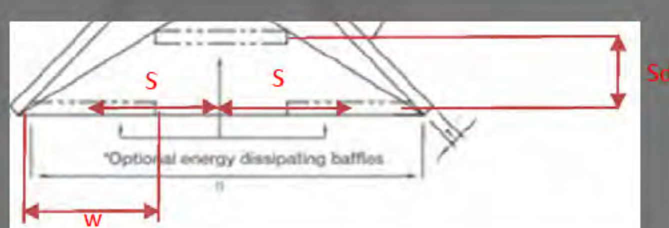
Typical Baffle Block ... ent and ... pacing for Si... Double Outlet

Block width

Where;

R = hydraulic radius of the culvert, in full pipe flow = ¼ diameter of the pipe, m
w = baffle block width, m
d = theoretical baffle block depth, equal to the height of the outlet, m.
= spacing of two consecutive rows of blocks, Figure 24, m.
= spacing between two impact blocks in different but consecutive rows, Figu
Excludes the first row, where spacing is determined by the spacing of the approaching jets.

Flow Cross sectional Area=	1.505	m^2
Wetted Perimeter=	4.36	m
Rh	0.35	m
w	3.500	m
d	1.500	m
Row Spacing Sd=	2.88	m
Block Width Sw=	2.44	m
Block Height=	0.75	



OUTLET STRUCTURE 14-12-1 (RIP RAP APRONS AFTER ENERGY DISSIPATORS)

10.3 RIPRAP APRONS AFTER ENERGY DISSIPATORS

Some energy dissipators provide exit conditions, velocity and depth, near critical. This flow condition rapidly adjusts to the downstream or natural channel regime; however, critical velocity may be sufficient to cause erosion problems requiring protection adjacent to the energy dissipator. Equation 10.6 provides the riprap size recommended for use downstream of energy dissipators. This relationship is from Searcy (1967) and is the same equation used in HEC 11 (Brown and Clyde, 1989) for riprap protection around bridge piers.

$$D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right) \quad (10.6)$$

whe[redacted]

= median rock size, m (ft)
= velocity at the exit of the dissipator, [redacted]/s (ft[redacted]
= riprap specific gravity

The length of protection can be judged based on the magnitude of the exit velocity compared with the natural channel velocity. The greater this difference, the longer will be the length required for the exit flow to adjust to the natural channel condition. A filter blanket should also be provided as described in HEC 11 (Brown and Clyde, 1989).

V	1.5 m/s		(assumed velocity at the exit of the baffle dissipator to target channel flow as per GD01 specification, m/s)
S	2.5 unitless		rip rap specific gravity
g	9.8 m/s²		
D50	0.053 m		
	53.0 mm		

Table 10.1. E[redacted]ample Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
[redacted]	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	[redacted]			
[redacted]				
5	500	[redacted]		$2.0D_{50}$
6	550	[redacted]		$2.0D_{50}$

[1]D is the culvert rise

Example of Apron dimensions extrapolation

Estimate apron dimensions.
From Table 10.1 for riprap class 2,
Length, L = 4D = 4(5) = 20 ft
Depth = $3.3D_{50}$ = 3.3 (6) = 19.8 in = 1.65 ft
Width (at apron end) = 3D + (2/3)L = 3(5) + [redacted]2/3)(20) = 28.3 ft

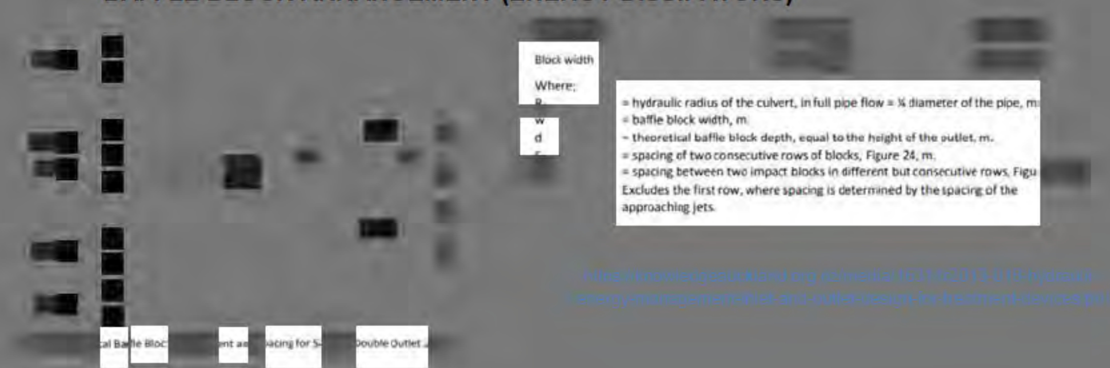
Apron length after energy dissipator =	6.00 m	=> Use	**6.00** m (min)
Apron width after energy dissipator =	8.50 m	=> Use	**8.50** m (min)
Apron depth after energy dissipator =	0.19 m	=> Use	**0.25** m (min)

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	4	A

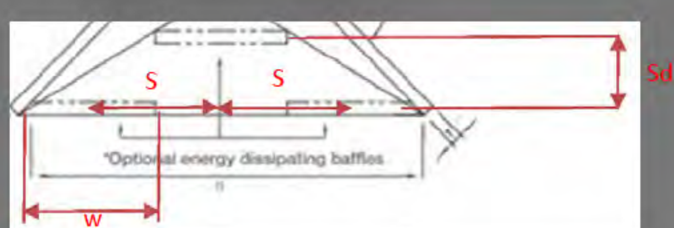
		Author	Date	Checked
Job Title	Sunfield Development			
Calc Title	Outlet Structures Design Road 5 Culvert 2 - Outlet	OQ	7/02/2025	LC

Culvert Type	Box	
No. Barrels =	1	
Culvert Span =	1.500	m
Culvert Rise =	1.000	m
Pipe gradient =	0.033	m/m
1% AEP Flow depth =	0.12	m
Velocity =	4.21	m/s
Froude Number Fo =	2.92	

BAFFLE BLOCK ARRANGEMENT (ENERGY DISSIPATORS)



Flow Cross sectional Area=	0.18	m^2
Wetted Perimeter=	1.74	m
Rh	0.10	m
w	1.500	m
d	1.000	m
Row Spacing Sd=	1.41	m
Block Width Sw=	0.96	m
Block Height=	0.5	



OUTLET STRUCTURE 14-12-1 (RIP RAP APRONS AFTER ENERGY DISSIPATORS)

10.3 RIPRAP APRONS AFTER ENERGY DISSIPATORS

Some energy dissipators provide exit conditions, velocity and depth, near critical. This flow condition rapidly adjusts to the downstream or natural channel regime; however, critical velocity may be sufficient to cause erosion problems requiring protection adjacent to the energy dissipator. Equation 10.6 provides the riprap size recommended for use downstream of energy dissipators. This relationship is from Searcy (1967) and is the same equation used in HEC 11 (Brown and Clyde, 1989) for riprap protection around bridge piers.

$$D_{50} = \frac{0.692}{S-1}\left(\frac{V^2}{2g}\right) \quad (10.6)$$

whe[redacted]
= median rock size, m (ft)
= velocity at the exit of the dissipator, [redacted]/s (ft[redacted]
= riprap specific gravity

The length of protection can be judged based on the magnitude of the exit velocity compared with the natural channel velocity. The greater this difference, the longer will be the length required for the exit flow to adjust to the natural channel condition. A filter blanket should also be provided as described in HEC 11 (Brown and Clyde, 1989).

V	1.5	m/s	(assumed velocity at the exit of the baffle dissipator to target channel flow as per GD01 specification, m/s)
S	2.5	unitless	rip rap specific gravity
g	9.8	m/s^2	
D50	0.053	m	
	53.0	mm	

Table 10.1. E[redacted]ample Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
[redacted]	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	[redacted]			
[redacted]				
5	500	[redacted]		$2.0D_{50}$
6	550	[redacted]		$2.0D_{50}$

[1]D is the culvert rise

Example of Apron dimensions extrapolation

Estimate apron dimensions.
From Table 10.1 for riprap class 2,
Length, L = 4D = 4(5) = 20 ft
Depth = $3.3D_{50}$ = 3.3 (6) = 19.8 in = 1.65 ft
Width (at apron end) = 3D + (2/3)L = 3(5) + [redacted]2/3)(20) = 28.3 ft

Apron length after energy dissipator =	4.00 m	=> Use	**4.00** m (min)
Apron width after energy dissipator =	5.67 m	=> Use	**5.80** m (min)
Apron depth after energy dissipator =	0.17 m	=> Use	**0.25** m (min)

MAVEN ASSOCIATES	Job Number	Sheet	Job Title: Sunfield Development Calc Title: Culvert Design Summary	Rev	Author	Date	Checked
	215010	1		A	OQ	7/02/2025	LC

	No.	Structure Name	Type	Barrels	Culvert Span (m)	Culvert Rise (m)	Thickness (m)	US Invert (mRL)	DS Invert (mRL)	Length (m)	Top of Upstream Bank Elevation (mRL)	Edge of Seal Elevation (mRL)	Design Rainfall	Scenario	Design Flow (m^3)	Headwater Elevation (m)	Tailwater Depth (m)	Tailwater Elevation (mRL)	10 Yr flow below Culvert Soffit	Freeboard (m)
Western Catchment	1	Road 1 Culvert 1	Box Culvert	1	3.50	1.50	0.20	25.07	24.88	41.66	29.15	28.91	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	4.783 8.388	26.05 27.76	0.68 0.87	25.56 25.75	Yes	1.39
	2	Road 1 Culvert 2	Box Culvert	1	3.50	1.50	0.20	27.75	26.92	51.5	30.66	30.44	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	4.200 7.307	28.56 30.10	0.59 0.76	27.51 27.68	Yes	0.56
	3	Road 1 Culvert 3	Box Culvert	1	1.50	0.80	0.20	26.96	26.81	27.58	29.24	29	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.703 1.280	27.44 28.27	0.28 0.38	27.09 27.19	Yes	0.97
	4	Road 2 Culvert 1	Box Culvert	2	3.00	1.50	0.20	23.00	22.80	35.83	26.95	26.64	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	8.480 15.734	24.45 26.19	1.56 2.09	24.36 24.89	Yes	0.76
	5	Road 2 Culvert 2	Box Culvert	1	1.50	0.80	0.20	25.31	25.17	27.61	27.6	27.35	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.420 0.757	25.74 26.23	0.35 0.45	25.52 25.62	Yes	1.37
	6	Road 3 Culvert 1	Box Culvert	1	2.50	1.50	0.20	23.04	22.81	59.47	26.15	25.84	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	2.855 5.29	23.91 25.43	0.39 0.55	23.20 23.36	Yes	0.72
	7	Road 4 Culvert 1	Box Culvert	1	1.50	0.80	0.20	25.25	25.12	26.05	27.51	27.41	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.314 0.561	25.97 26.07	0.19 0.26	25.31 25.38	Yes	1.44
	8	Road 4 Culvert 2	Box Culvert	1	1.50	0.80	0.20	25.31	25.16	28.81	27.88	27.46	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.485 0.890	25.69 26.31	0.24 0.33	25.40 25.49	Yes	1.57
	9	Road 9 Culvert 1	Box Culvert	1	1.50	0.80	0.20	24.87	24.76	23.47	27.1	26.83	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.555 0.998	25.28 25.95	0.25 0.34	25.01 25.10	Yes	1.15
	10	Road 14 Culvert 1	Box Culvert	**2**	**2.00**	0.80	**0.20**	26.02	25.90	22.53	28.28	28.06	10 Yr ARI 100 YR ARI	**No Blockage** **50% Blockage**	1.858 3.391	26.50 27.33	**0.52** **0.69**	**26.42** **26.59**	**Yes**	0.95
	11	Road 14 Culvert 2	Box Culvert	**2**	**2.00**	0.90	**0.20**	25.62	25.51	22.72	28.03	27.76	10 Yr ARI 100 YR ARI	**No Blockage** **50% Blockage**	2.343 4.285	26.18 27.17	**0.52** **0.69**	**26.03** **26.20**	**Yes**	0.86
	11	Road 32 Culvert 1	Box Culvert	1	1.50	1.00	0.20	25.16	25.08	27.93	28.83	28.56	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	1.263 2.200	25.89 27.20	0.61 0.77	25.69 25.85	Yes	1.63
	12	Carpark Crossing Culvert 1	Box Culvert	1	3.50	1.50	0.20	24.77	24.68	19.71	28.57	28.31	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	4.801 8.379	25.75 27.46	0.68 0.87	25.36 25.55	Yes	1.11
Eastern Catchment	13	Road 1 Culvert 4	Circular	1	0.525	0.525	0.12	20.41	20.35	23.57	21.58	21.56	10 Yr ARI 100 YR ARI	No Blockage No Blockage	0.7 1.11	21.63 21.68	0.44 0.52	20.79 20.87	No	-0.10
	14	Road 5 Culvert 1	Box Culvert	1	2.00	0.90	0.20	22.23	21.98	41.83	24.69	24.29	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	1.352 2.174	22.84 23.80	0.29 0.37	22.27 22.35	Yes	0.89
	15	Road 5 Culvert 2	Box Culvert	1	1.50	1.00	0.20	23.93	22.25	51.11	26.15	25.83	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.41 1.333	24.34 25.23	0.32 0.56	22.57 22.81	Yes	0.92
	16	Road 6 Culvert 1	Box Culvert	1	2.00	1.20	0.20	22.14	22.06	40.23	25.07	24.81	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	1.186 3.114	22.76 24.10	0.59 0.90	22.65 22.96	Yes	0.97
	17	Road 6 Culvert 2	Box Culvert	1	1.50	1.20	0.20	21.65	21.60	39.07	24.45	24.23	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.589 1.892	22.15 23.35	0.46 0.78	22.06 22.38	Yes	1.10
	18	Road 7 Culvert 1	Circular	1	0.525	0.525	0.12	24.90	24.89	22.4	26.07	25.8	10 Yr ARI 100 YR ARI	No Blockage No Blockage	1.05 2.32	26.18 26.30	0.67 0.89	25.56 25.78	No	-0.23
	19	Road 19 Culvert 1	Box Culvert	1	1.50	0.80	0.20	23.60	23.56	24.45	25.86	25.65	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.199 0.527	23.81 24.40	0.26 0.42	23.82 23.98	Yes	1.46
	20	Road 20 Culvert 1	Box Culvert	1	1.50	0.80	0.20	23.78	23.73	23.92	26.21	25.99	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.096 0.251	23.93 24.42	0.17 0.28	23.90 24.01	Yes	1.79
	21	Road 21 Culvert 1	Box Culvert	1	1.50	0.80	0.20	24.02	23.99	24.35	26.42	26.16	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.293 0.981	24.36 25.10	0.33 0.58	24.32 24.57	Yes	1.32
	22	Road 22 Culvert 1	Box Culvert	1	1.50	0.80	0.20	24.12	24.08	26.12	26.71	26.5	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	0.065 0.257	24.25 24.77	0.15 0.31	24.23 24.39	Yes	1.94
	23	Road 25 Culvert 1	Box Culvert	1	2.50	1.50	0.20	21.73	21.68	25.3	24.77	24.55	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	2.296 5.025	22.49 24.01	0.52 0.80	22.20 22.48	Yes	0.76
	24	Road 26 Culvert 1	Box Culvert	1	3.00	1.50	0.20	21.38	21.33	27.29	24.98	24.71	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	4.018 7.948	22.36 24.38	0.72 1.02	22.05 22.35	Yes	0.60
	25	Road 31 Culvert 1	Box Culvert	1	2.50	1.00	0.20	23.71	19.90	261.43	25.73	-	10 Yr ARI 100 YR ARI	No Blockage 50% Blockage	1.77 2.62	24.33 25.18	1.5 1.5	21.40 21.40	Yes	0.55

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 1 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 1 Culvert 1

Crossing Properties

Name: Road 1 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	5.000	_:1
Channel Slope	0.0050	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	24.880	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	17.000	m
Crest Elevation	29.150	m
Roadway Surface	Paved	
Top Width	32.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	3500.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	25.070	m
Outlet Station	41.660	m
Outlet Elevation	24.880	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 1 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
26.05	10 year	4.78	4.78	0.00	1
26.48	100 year	8.39	8.39	0.00	1
29.15	Overtopping	24.58	24.58	0.00	Overtopping

Display

- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation: 25.07 m
Outlet Elevation: 24.88 m
Culvert Length: 41.66 m
Culvert Slope: 0.0046
Culvert Rise: 1.50 m
Culvert Span: 3.50 m

Outlet Control: Profiles

Plot

Crossing Rating Curve | Culvert Performance Curve | Selected Water Profile | Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 1 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 1 Culvert 2 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 1 Culvert 2

Crossing Properties

Name: Road 1 Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.300	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0190	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	26.960	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	31.000	m
Crest Elevation	30.840	m
Roadway Surface	Paved	
Top Width	36.000	m

Culvert Properties

Culvert 2

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 2	
Shape	Concrete Box	
Material	Concrete	
Span	4000.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90°) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	27.750	m
Outlet Station	51.500	m
Outlet Elevation	26.960	m
Number of Barrels	1	

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HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 1 Culvert 2

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 2 Discharge (cms)	Roadway Discharge (cms)	Iterations
28.56	10 year	4.20	4.20	0.00	1
28.92	100 year	7.31	7.31	0.00	1
30.84	Overtopping	22.94	22.94	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 2
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	27.75 m
Outlet Elevation:	26.96 m
Culvert Length:	51.51 m
Culvert Slope:	0.0153
Culvert Rise:	1.50 m
Culvert Span:	4.00 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 1 Culvert 2 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 1 Culvert 3 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 1 Culvert 3

Crossing Properties

Name: Road 1 Culvert 3

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0050	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	26.810	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	8.000	m
Crest Elevation	29.240	m
Roadway Surface	Paved	
Top Width	20.000	m

Culvert Properties

Culvert 3

Add Culvert · Duplicate Culvert · Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 3	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	26.960	m
Outlet Station	27.580	m
Outlet Elevation	26.810	m
Number of Barrels	1	

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HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 1 Culvert 3

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 3 Discharge (cms)	Roadway Discharge (cms)	Iterations
27.44	10 year	0.70	0.70	0.00	1
27.67	100 year	1.28	1.28	0.00	1
29.24	Overtopping	4.24	4.24	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 3
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 26.96 m
- Outlet Elevation: 26.81 m
- Culvert Length: 27.58 m
- Culvert Slope: 0.0054
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help · Flow Types... · Edit Input Data... · Energy Dissipation... · AOP... · Low Flow... · Export Report · MS Word (*.docx) · Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 1 Culvert 3 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Development Culvert Design Road 2 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 2 Culvert 1

Crossing Properties

Name: Road 2 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	4.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0010	m/m
Manning's n (channel)	0.050	
Channel Invert Elevation	22.800	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	26.000	m
Crest Elevation	26.950	m
Roadway Surface	Paved	
Top Width	20.000	m

Culvert Properties

Culvert 1

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	3000.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	23.000	m
Outlet Station	35.830	m
Outlet Elevation	22.800	m
Number of Barrels	2	

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HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 2 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
24.45	10 year	8.48	8.48	0.00	1
25.17	100 year	15.73	15.73	0.00	1
26.95	Overtopping	33.00	33.00	0.00	Overtopping

Display

- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	23.00 m
Outlet Elevation:	22.80 m
Culvert Length:	35.83 m
Culvert Slope:	0.0056
Culvert Rise:	1.50 m
Culvert Span:	3.00 m
Outlet Control:	Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

		Job Number	Sheet	Rev
	MAVEN ASSOCIATES	215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 2 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 2 Culvert 2 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 2 Culvert 2

Crossing Properties

Name: Road 2 Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0050	m/m
Manning's n (channel)	0.050	
Channel Invert Elevation	25.170	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	9.000	m
Crest Elevation	27.600	m
Roadway Surface	Paved	
Top Width	20.000	m

Culvert Properties

Culvert 2

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 2	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	25.400	m
Outlet Station	27.610	m
Outlet Elevation	25.170	m
Number of Barrels	1	

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HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 2 Culvert 2

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 2 Discharge (cms)	Roadway Discharge (cms)	Iterations
25.74	10 year	0.42	0.42	0.00	1
25.90	100 year	0.76	0.76	0.00	1
27.60	Overtopping	4.14	4.14	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 2
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 25.40 m
- Outlet Elevation: 25.17 m
- Culvert Length: 27.61 m
- Culvert Slope: 0.0083
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

		Author	Date	Checked
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 2 Culvert 2 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design Road 3 Culvert 1 - No Blockage	OQ	7/02/2025	LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 3 Culvert 1

Crossing Properties

Name: Road 3 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	6.000	m
Side Slope (H:V)	5.000	_:1
Channel Slope	0.0036	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	22.810	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	30.000	m
Crest Elevation	26.150	m
Roadway Surface	Paved	
Top Width	45.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	2500.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90°) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	23.040	m
Outlet Station	59.490	m
Outlet Elevation	22.810	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 3 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
23.91	10 year	2.85	2.85	0.00	1
24.34	100 year	5.29	5.29	0.00	1
26.15	Overtopping	14.38	14.38	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 23.04 m
- Outlet Elevation: 22.81 m
- Culvert Length: 59.49 m
- Culvert Slope: 0.0039
- Culvert Rise: 1.50 m
- Culvert Span: 2.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 3 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 4 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 4 Culvert 1

Crossing Properties

Name: Road 4 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0040	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	25.150	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	9.000	m
Crest Elevation	27.510	m
Roadway Surface	Paved	
Top Width	13.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	400.000	mm
Manning's n (Top/Sides)	0.013	
Manning's n (Bottom)	0.035	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	25.250	m
Outlet Station	26.050	m
Outlet Elevation	25.150	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 4 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
25.97	10 year	0.31	0.31	0.00	1
26.11	100 year	0.56	0.56	0.00	1
27.51	Overtopping	1.31	1.31	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 25.65 m
- Outlet Elevation: 25.55 m
- Culvert Length: 26.05 m
- Culvert Slope: 0.0038
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design Road 4 Culvert 1 - 50% Blockage	OQ	7/02/2025	LC

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 4 Culvert 2 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 4 Culvert 2

Crossing Properties

Name: Road 4 Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0040	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	25.160	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	9.000	m
Crest Elevation	27.880	m
Roadway Surface	Paved	
Top Width	13.000	m

Culvert Properties

Culvert 2

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 2	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	25.310	m
Outlet Station	28.810	m
Outlet Elevation	25.160	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 4 Culvert 2

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 2 Discharge (cms)	Roadway Discharge (cms)	Iterations
25.69	10 year	0.48	0.48	0.00	1
25.87	100 year	0.89	0.89	0.00	1
27.88	Overtopping	4.57	4.57	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 2
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 25.31 m
- Outlet Elevation: 25.16 m
- Culvert Length: 28.81 m
- Culvert Slope: 0.0052
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

		Job Number	Sheet	Rev
	MAVEN ASSOCIATES	215010	1	A

		Author	Date	Checked
Job Title	Sunfield Development			
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 4 Culvert 2 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 9 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 9 Culvert 1

Crossing Properties

Name: Road 9 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0048	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	24.760	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	9.000	m
Crest Elevation	27.100	m
Roadway Surface	Paved	
Top Width	13.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	24.870	m
Outlet Station	23.470	m
Outlet Elevation	24.760	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 9 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
25.28	10 year	0.55	0.55	0.00	1
25.47	100 year	1.00	1.00	0.00	1
27.10	Overtopping	4.17	4.17	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 24.87 m
- Outlet Elevation: 24.76 m
- Culvert Length: 23.47 m
- Culvert Slope: 0.0047
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

	MAVEN ASSOCIATES	**Job Number**	**Sheet**	**Rev**
		215010	1	A
Job Title	**Sunfield Development**	**Author**	**Date**	**Checked**
Calc Title	**Culvert Design**	OQ	7/02/2025	LC
	Road 9 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 14 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 14 Culvert 1

Crossing Properties

Name: Road 14 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0050	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	25.900	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	8.000	m
Crest Elevation	28.280	m
Roadway Surface	Paved	
Top Width	20.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	2000.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	26.020	m
Outlet Station	22.530	m
Outlet Elevation	25.900	m
Number of Barrels	2	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 14 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
26.50	10 year	1.86	1.86	0.00	1
26.74	100 year	3.39	3.39	0.00	1
28.28	Overtopping	11.23	11.23	0.00	Overtopping

Display

- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

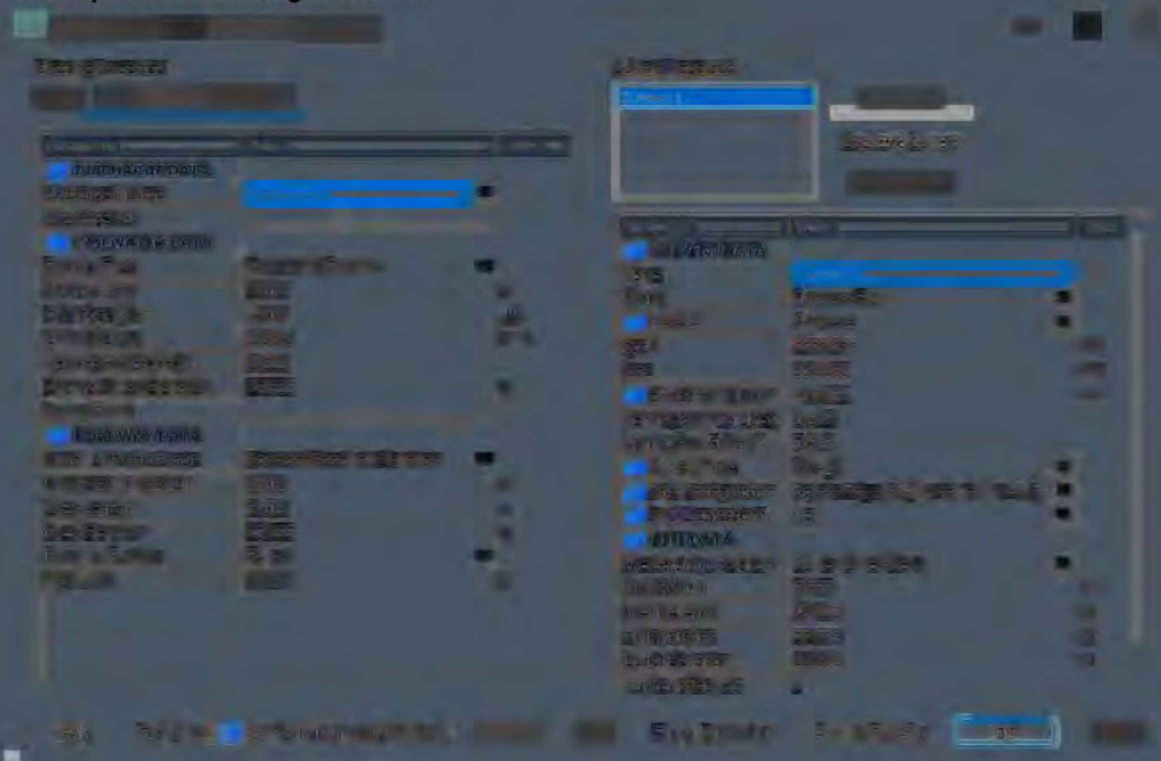
Inlet Elevation:	26.02 m
Outlet Elevation:	25.90 m
Culvert Length:	22.53 m
Culvert Slope:	0.0053
Culvert Rise:	0.80 m
Culvert Span:	2.00 m
Outlet Control:	Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

HY-8 Input - 50% Blockage Scenario



HY-8 Results - 50% Blockage Scenario

HY-8 Input - No Blockage Scenario

Crossing Data - Road 14 Culvert 2

Crossing Properties

Name: Road 14 Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	4.000	_:1
Channel Slope	0.0048	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	25.510	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	10.000	m
Crest Elevation	28.030	m
Roadway Surface	Paved	
Top Width	20.000	m

Culvert Properties

Culvert 2

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 2	
Shape	Concrete Box	
Material	Concrete	
Span	2000.000	mm
Rise	900.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	25.620	m
Outlet Station	22.720	m
Outlet Elevation	25.510	m
Number of Barrels	2	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 14 Culvert 2

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 2 Discharge (cms)	Roadway Discharge (cms)	Iterations
26.18	10 year	2.34	2.34	0.00	1
26.46	100 year	4.29	4.29	0.00	1
28.03	Overtopping	12.92	12.92	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 2
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	25.62 m
Outlet Elevation:	25.51 m
Culvert Length:	22.72 m
Culvert Slope:	0.0048
Culvert Rise:	0.90 m
Culvert Span:	2.00 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 14 Culvert 2 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 32 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 32 Culvert 1

Crossing Properties

Name: Road 32 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	5.000	_:1
Channel Slope	0.0010	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	25.080	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	9.000	m
Crest Elevation	28.830	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert · Duplicate Culvert · Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	1000.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90°) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	25.160	m
Outlet Station	27.930	m
Outlet Elevation	25.080	m
Number of Barrels	1	

Help · Click on any icon for help on a specific topic · Low Flow · AOP · Energy Dissipation · Analyze Crossing · OK · Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 32 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
25.89	10 year	1.26	1.26	0.00	1
26.20	100 year	2.20	2.20	0.00	1
28.83	Overtopping	6.90	6.90	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 25.16 m
- Outlet Elevation: 25.08 m
- Culvert Length: 27.93 m
- Culvert Slope: 0.0029
- Culvert Rise: 1.00 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help · Flow Types... · Edit Input Data... · Energy Dissipation... · AOP... · Low Flow... · Export Report · MS Word (*.docx) · Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 32 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Carpark Crossing Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Carpark Crossing Culvert

Crossing Properties

Name: Carpark Crossing Culvert

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	2.000	m
Side Slope (H:V)	5.000	_:1
Channel Slope	0.0050	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	24.680	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	9.000	m
Crest Elevation	28.570	m
Roadway Surface	Paved	
Top Width	10.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	3500.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90°) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	24.770	m
Outlet Station	19.710	m
Outlet Elevation	24.680	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Carpark Crossing Culvert

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
25.75	10 year	4.80	4.80	0.00	1
26.18	100 year	8.38	8.38	0.00	1
28.57	Overtopping	23.39	23.39	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

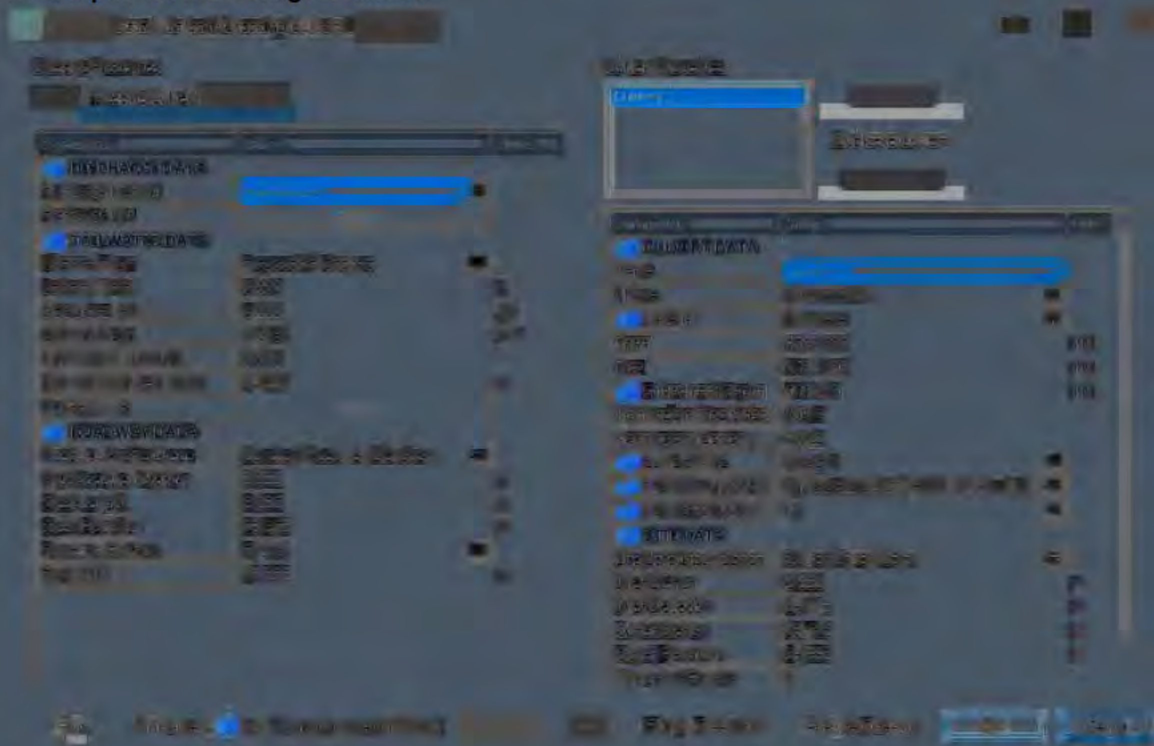
Inlet Elevation:	24.77 m
Outlet Elevation:	24.68 m
Culvert Length:	19.71 m
Culvert Slope:	0.0046
Culvert Rise:	1.50 m
Culvert Span:	3.50 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

		Job Number	Sheet	Rev
	MAVEN ASSOCIATES	215010	1	A
Job Title	Sunfield Development	**Author**	**Date**	**Checked**
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Carpark Crossing Culvert 1 - 50% Blockage			

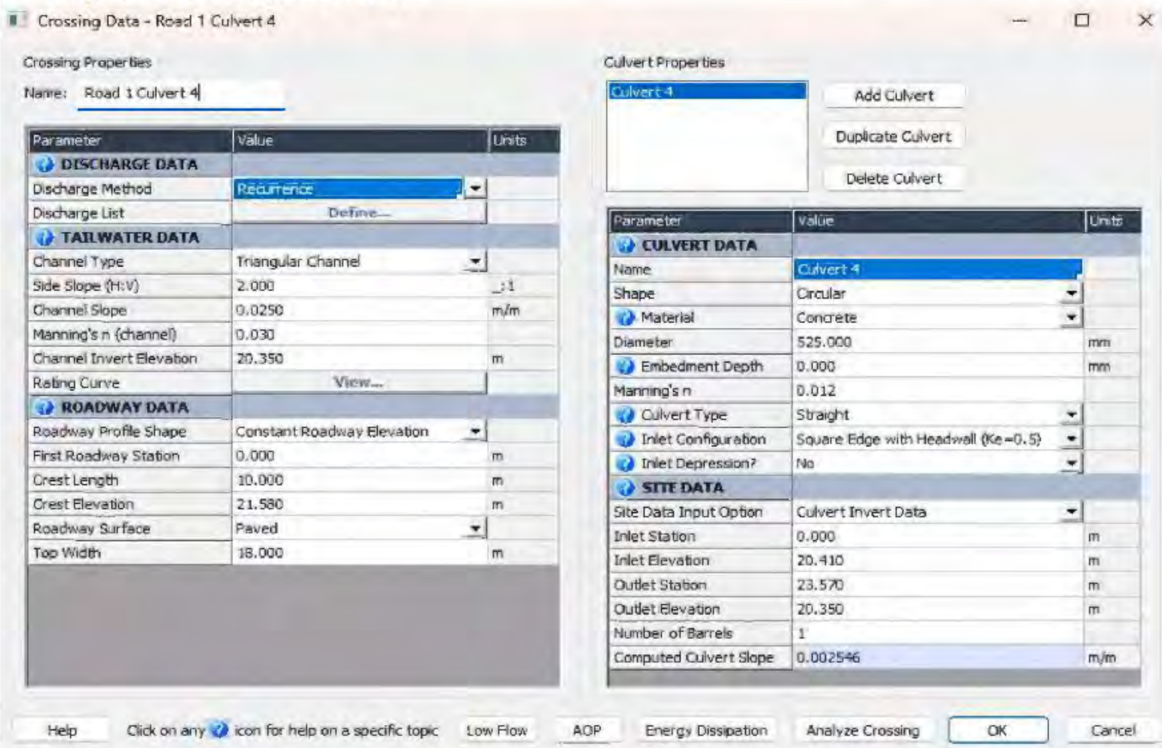
HY-8 Input - 50% Blockage Scenario



HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design Road 1 Culvert 4 - No Blockage	OQ	7/02/2025	LC

HY-8 Input - No Blockage Scenario



Crossing Data - Road 1 Culvert 4

Crossing Properties

Name: Road 1 Culvert 4

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Triangular Channel	
Side Slope (H:V)	2.000	_:1
Channel Slope	0.0250	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	20.350	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	10.000	m
Crest Elevation	21.580	m
Roadway Surface	Paved	
Top Width	18.000	m

Culvert Properties

Culvert 4

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 4	
Shape	Circular	
Material	Concrete	
Diameter	525.000	mm
Embedment Depth	0.000	mm
Manning's n	0.012	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	20.410	m
Outlet Station	23.570	m
Outlet Elevation	20.350	m
Number of Barrels	1	
Computed Culvert Slope	0.002546	m/m

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 1 Culvert 4

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 4 Discharge (cms)	Roadway Discharge (cms)	Iterations
21.63	10 year	0.70	0.53	0.17	11
21.68	100 year	1.10	0.55	0.55	5
21.58	Overtopping	0.52	0.52	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 4
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 20.41 m
- Outlet Elevation: 20.35 m
- Culvert Length: 23.57 m
- Culvert Slope: 0.0025
- Culvert Rise: 0.53 m
- Culvert Span: 0.53 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 5 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 5 Culvert 1

Crossing Properties

Name: Road 5 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	4.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0057	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	21.980	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.000	m
Crest Elevation	24.690	m
Roadway Surface	Paved	
Top Width	32.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	2000.000	mm
Rise	900.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	22.230	m
Outlet Station	41.830	m
Outlet Elevation	21.980	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 5 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
22.84	10 year	1.35	1.35	0.00	1
23.06	100 year	2.17	2.17	0.00	1
24.69	Overtopping	6.55	6.55	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table (Culvert 1)
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table (Options...)

Geometry

Inlet Elevation:	22.23 m
Outlet Elevation:	21.98 m
Culvert Length:	41.83 m
Culvert Slope:	0.0060
Culvert Rise:	0.90 m
Culvert Span:	2.00 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 5 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 5 Culvert 2 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 5 Culvert 2

Crossing Properties

Name: Road 5 Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0030	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	22.250	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.000	m
Crest Elevation	26.150	m
Roadway Surface	Paved	
Top Width	32.000	m

Culvert Properties

Culvert 2

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 2	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	1000.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	23.930	m
Outlet Station	51.110	m
Outlet Elevation	22.250	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 5 Culvert 2

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 2 Discharge (cms)	Roadway Discharge (cms)	Iterations
24.26	10 year	0.41	0.41	0.00	1
24.65	100 year	1.33	1.33	0.00	1
26.15	Overtopping	4.98	4.98	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 2
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

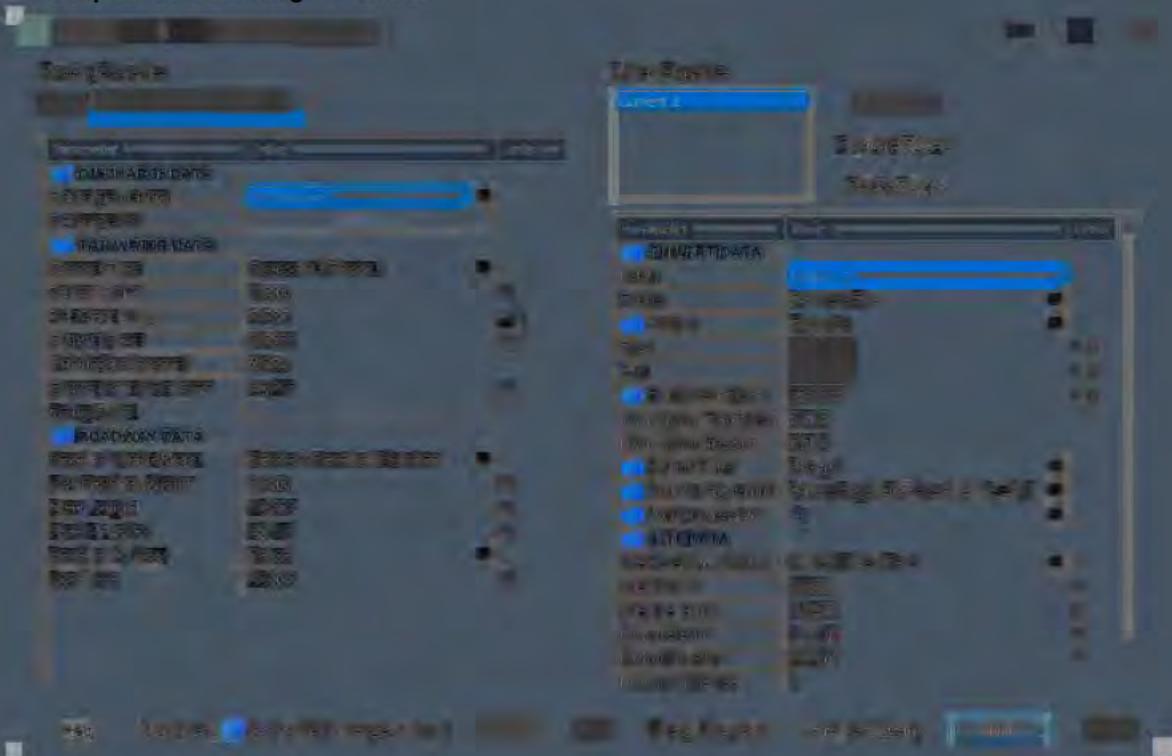
Inlet Elevation:	23.93 m
Outlet Elevation:	22.25 m
Culvert Length:	51.14 m
Culvert Slope:	0.0329
Culvert Rise:	1.00 m
Culvert Span:	1.50 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 5 Culvert 2 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario



HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 6 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 6 Culvert 1

Crossing Properties

Name: Road 6 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0020	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	22.060	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.700	m
Crest Elevation	25.070	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert · Duplicate Culvert · Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	2000.000	mm
Rise	1200.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	22.140	m
Outlet Station	40.230	m
Outlet Elevation	22.060	m
Number of Barrels	1	

Help · Click on any icon for help on a specific topic · Low Flow · AOP · Energy Dissipation · Analyze Crossing · OK · Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 6 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
22.76	10 year	1.19	1.19	0.00	1
23.25	100 year	3.11	3.11	0.00	1
25.07	Overtopping	9.31	9.31	0.00	Overtopping

Display

- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	22.14 m
Outlet Elevation:	22.06 m
Culvert Length:	40.23 m
Culvert Slope:	0.0020
Culvert Rise:	1.20 m
Culvert Span:	2.00 m
Outlet Control:	Profiles

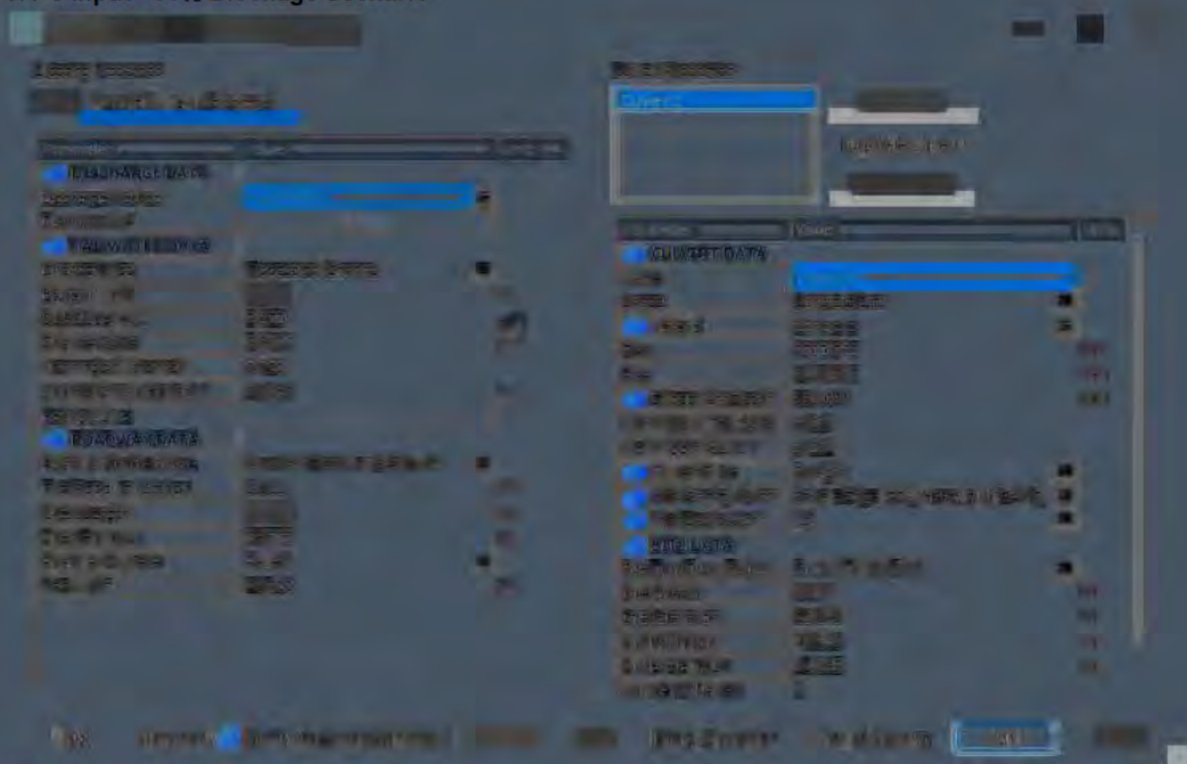
Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help · Flow Types... · Edit Input Data... · Energy Dissipation... · AOP... · Low Flow... · Export Report · MS Word (*.docx) · Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 6 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario



HY-8 Results - 50% Blockage Scenario

HY-8 Input - No Blockage Scenario

Crossing Data - Road 6 Culvert 2

Crossing Properties

Name: Road 6 Culvert 2

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0014	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	21.600	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.700	m
Crest Elevation	24.450	m
Roadway Surface	Paved	
Top Width	32.000	m

Culvert Properties

Culvert 2

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 2	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	1200.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	21.650	m
Outlet Station	39.070	m
Outlet Elevation	21.600	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 6 Culvert 2

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 2 Discharge (cms)	Roadway Discharge (cms)	Iterations
22.15	10 year	0.59	0.59	0.00	1
22.64	100 year	1.89	1.89	0.00	1
24.45	Overtopping	6.75	6.75	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 2
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 21.65 m
- Outlet Elevation: 21.60 m
- Culvert Length: 39.07 m
- Culvert Slope: 0.0013
- Culvert Rise: 1.20 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

	MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 6 Culvert 2 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 7 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 7 Culvert 1

Crossing Properties

Name: Road 7 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Triangular Channel	
Side Slope (H:V)	2.000	_:1
Channel Slope	0.0045	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	24.870	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	10.000	m
Crest Elevation	26.070	m
Roadway Surface	Paved	
Top Width	20.000	m

Culvert Properties

Culvert 1

Add Culvert · Duplicate Culvert · Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.012	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	24.900	m
Outlet Station	22.400	m
Outlet Elevation	24.890	m
Number of Barrels	1	
Computed Culvert Slope	0.000446	m/m

Help · Click on any icon for help on a specific topic · Low Flow · AOP · Energy Dissipation · Analyze Crossing · OK · Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 7 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
26.18	10 year	1.05	0.43	0.62	5
26.30	100 year	2.23	0.38	1.85	4
26.07	Overtopping	0.45	0.45	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 24.90 m
- Outlet Elevation: 24.89 m
- Culvert Length: 22.40 m
- Culvert Slope: 0.0004
- Culvert Rise: 0.50 m
- Culvert Span: 0.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help · Flow Types... · Edit Input Data... · Energy Dissipation... · AOP... · Low Flow... · Export Report · MS Word (*.docx) · Close

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Development Culvert Design Road 19 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 19 Culvert 1

Crossing Properties

Name: Road 19 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0016	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	23.560	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.000	m
Crest Elevation	25.860	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	23.600	m
Outlet Station	24.450	m
Outlet Elevation	23.560	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 19 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
23.86	10 year	0.20	0.20	0.00	1
24.06	100 year	0.53	0.53	0.00	1
25.86	Overtopping	4.18	4.18	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	23.60 m
Outlet Elevation:	23.56 m
Culvert Length:	24.45 m
Culvert Slope:	0.0016
Culvert Rise:	0.80 m
Culvert Span:	1.50 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

	MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design Road 19 Culvert 1 - 50% Blockage	OQ	7/02/2025	LC

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 20 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 20 Culvert 1

Crossing Properties

Name: Road 20 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0019	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	23.730	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.000	m
Crest Elevation	26.210	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1 — Add Culvert / Duplicate Culvert / Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	23.780	m
Outlet Station	23.920	m
Outlet Elevation	23.730	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 20 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
23.93	10 year	0.10	0.10	0.00	1
24.06	100 year	0.25	0.25	0.00	1
26.21	Overtopping	4.41	4.41	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 23.78 m
- Outlet Elevation: 23.73 m
- Culvert Length: 23.92 m
- Culvert Slope: 0.0021
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 20 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Development Culvert Design Road 21 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 21 Culvert 1

Crossing Properties

Name: Road 21 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0014	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	23.990	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	10.000	m
Crest Elevation	26.420	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	24.020	m
Outlet Station	24.350	m
Outlet Elevation	23.990	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 21 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
24.36	10 year	0.29	0.29	0.00	1
24.69	100 year	0.98	0.98	0.00	1
26.42	Overtopping	4.33	4.33	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 24.02 m
- Outlet Elevation: 23.99 m
- Culvert Length: 24.35 m
- Culvert Slope: 0.0012
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 21 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Development Culvert Design Road 22 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 22 Culvert 1

Crossing Properties

Name: Road 22 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	1.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0014	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	24.080	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	10.000	m
Crest Elevation	26.710	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	1500.000	mm
Rise	800.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	24.120	m
Outlet Station	26.120	m
Outlet Elevation	24.080	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 22 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
24.25	10 year	0.06	0.06	0.00	1
24.43	100 year	0.26	0.26	0.00	1
26.71	Overtopping	4.57	4.57	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 24.12 m
- Outlet Elevation: 24.08 m
- Culvert Length: 26.12 m
- Culvert Slope: 0.0015
- Culvert Rise: 0.80 m
- Culvert Span: 1.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 22 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 25 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 25 Culvert 1

Crossing Properties

Name: Road 25 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	4.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0014	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	21.680	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.000	m
Crest Elevation	24.770	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	2500.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	21.730	m
Outlet Station	25.300	m
Outlet Elevation	21.680	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 25 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
22.49	10 year	2.30	2.30	0.00	1
23.01	100 year	5.02	5.02	0.00	1
24.77	Overtopping	14.11	14.11	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	21.73 m
Outlet Elevation:	21.68 m
Culvert Length:	25.30 m
Culvert Slope:	0.0020
Culvert Rise:	1.50 m
Culvert Span:	2.50 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES	Job Number	Sheet	Rev
	215010	1	A

Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 25 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Development Culvert Design Road 26 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 26 Culvert 1

Crossing Properties

Name: Road 26 Culvert 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Trapezoidal Channel	
Bottom Width	4.000	m
Side Slope (H:V)	3.000	_:1
Channel Slope	0.0018	m/m
Manning's n (channel)	0.030	
Channel Invert Elevation	21.330	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	13.000	m
Crest Elevation	24.980	m
Roadway Surface	Paved	
Top Width	16.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	3000.000	mm
Rise	1500.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90°) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	21.380	m
Outlet Station	27.290	m
Outlet Elevation	21.330	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 26 Culvert 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
22.36	10 year	4.02	4.02	0.00	1
22.92	100 year	7.95	7.95	0.00	1
24.98	Overtopping	19.28	19.28	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	21.38 m
Outlet Elevation:	21.33 m
Culvert Length:	27.29 m
Culvert Slope:	0.0018
Culvert Rise:	1.50 m
Culvert Span:	3.00 m
Outlet Control:	Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

	MAVEN ASSOCIATES	Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 26 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Development Calc Title: Culvert Design Road 31 Culvert 1 - No Blockage	Author OQ	Date 7/02/2025	Checked LC

HY-8 Input - No Blockage Scenario

Crossing Data - Road 31 Pipe 1

Crossing Properties

Name: Road 31 Pipe 1

Parameter	Value	Units
DISCHARGE DATA		
Discharge Method	Recurrence	
Discharge List	Define...	
TAILWATER DATA		
Channel Type	Enter Constant Tailwater Elevation	
Channel Invert Elevation	19.900	m
Constant Tailwater Elevation	21.400	m
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	m
Crest Length	10.000	m
Crest Elevation	25.730	m
Roadway Surface	Paved	
Top Width	200.000	m

Culvert Properties

Culvert 1

Add Culvert | Duplicate Culvert | Delete Culvert

Parameter	Value	Unit
CULVERT DATA		
Name	Culvert 1	
Shape	Concrete Box	
Material	Concrete	
Span	2500.000	mm
Rise	1000.000	mm
Embedment Depth	0.000	mm
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge (90º) Headwall (Ke=0.5)	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	m
Inlet Elevation	23.710	m
Outlet Station	261.430	m
Outlet Elevation	19.900	m
Number of Barrels	1	

Help | Click on any icon for help on a specific topic | Low Flow | AOP | Energy Dissipation | Analyze Crossing | OK | Cancel

HY-8 Results - No Blockage Scenario

Summary of Flows at Crossing - Road 31 Pipe 1

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert 1 Discharge (cms)	Roadway Discharge (cms)	Iterations
24.33	10 year	1.77	1.77	0.00	1
24.52	100 year	2.63	2.63	0.00	1
25.73	Overtopping	7.68	7.68	0.00	Overtopping

Display
- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry
- Inlet Elevation: 23.71 m
- Outlet Elevation: 19.90 m
- Culvert Length: 261.46 m
- Culvert Slope: 0.0146
- Culvert Rise: 1.00 m
- Culvert Span: 2.50 m

Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | MS Word (*.docx) | Close

MAVEN ASSOCIATES		Job Number	Sheet	Rev
		215010	1	A
Job Title	Sunfield Development	Author	Date	Checked
Calc Title	Culvert Design	OQ	7/02/2025	LC
	Road 31 Culvert 1 - 50% Blockage			

HY-8 Input - 50% Blockage Scenario

HY-8 Results - 50% Blockage Scenario

MAVEN
Ref: 215010

7nd February 2025

Wetland 1 Design Memo for Proposed Sunfield FAA Application

- **Background**

Wetland design is required by Heathy Water to demonstrate the proposed wetland space is adequate to provide the required mitigation volumes. Wetland 1. This memo, as a supplement to the SMP, details the Wetland 1 design principles and sizing method.

- **Catchment and Storm Intensities**

As shown on civil drawing M-C480 Catchment Plan set, the total catchment for Wetland 1 is 639,656m^2. The pre-development and post-development catchment areas are summarised in Table 1 below.

Table 1 – Wetland 1 Catchment Summary

Total Catchment Area	639,656m^2		
Pre-Dev Pervious Area	639,656m^2 (100%)	CN=74	ToC = 0.44hr
Post-Dev Pervious Area	189,517m^2 (30%)	CN=74	ToC = 0.167hr
Post-Dev Impervious Area	450,139m^2 (70%)	CN=98	ToC = 0.167hr

The following storm intensities have been applied based on TP108 and SWCoP Revision 4 requirements, see Tabel 2.

Table 2 – Storm Intensities

Design Storm	Rainfall Across 24hr (mm) – TP108	Climate allowance as per SWCoP Rev 4	Rainfall+CC (mm)
90th	25	-	-
95th	33	-	-
50%AEP	75	15.10%	86
10%AEP	145	17%	170
1%AEP	225	32.70%	298

- **Design Principles**

As stated in the SMP and flood report regarding flooding management of the Eastern Catchment Outflow 1, a pass forward flow strategy is proposed, it is recommended not to provide attenuation for 10-year and 100-year storm event. In this case, Wetland 1 has been designed to provide treatment and partial mitigation for SMAF 1 only (with some of the SMAF volume being provided in the sites swale network). It is anticipated the wetland is to be used as peak a peak flow diversion basin during 2yr, 50yr and 100-year.

- **Hydrologic Calculations**

TP108 has been utilized to conduct the hydrologic calculations. The results are summarized in Table 3 below. Hydraulic modelling was undertaken in HEC RAS and results may be found in Stormwater Modelling Report.

Table 3 – Hydrologic Calculations Results

Item	Value
PWV -	7,673 m^3
Minimum Forebay Volume (15% of PWV)	1,150 m^3
Sediment Drying Area (10% of PWV)	767 m^2
Detention Volume for SMAF	9,828 m^3

Table 4 – Elevation-Storage Relationship

Water Level (m, RL)	Storage Volume (m^3)
20.7	0
21.0	11,000
21.5	31,150
22.0	52,420
22.5	75,700
23.0	100,000

Note: An additional 76,000 m3 flood storage is available below water level 23.0. This is only used for 100yr flood storage with a spillway RL 22.57

Table 6: Wetland Design Summary

ITEM	COMMENTS
Permanent Water Level (PWL) Proposed	RL20.70m
Standard PWV Required (Table 3 above)	7,673 m^3
Minimum PWV Required When Stream Protection is provided As per GD01 C8.2.3.1	3,836m^3 (50% of Standard PWV)
PWV Provided	4,683m^3 (>50% of Standard PWV)
Wetland Length to Width Raito	Approximately 4:1
Forebay Volume Proposed	575m^3, 12% of PWV
Forebay Depth	1.4m
Shallow Marsh Zone Depth	0.1m
Deep Marsh Zone Depth	0.4m
Deep Pool Depth	1.4m
Slope	Internal wetland banks below the PWL: 1V:4H Internal side slope above the PWL: 1V: 3H Forebay bund slope: 1V:3H External side slope: 1V:3H
Maintenance Access	Provided, 3.5m wide, maximum gradient 1 in 8.
Sediment Drying Area	Provided, 468m^2, >10% of PWV
Safety Bench	Provided, 3m wide, maximum water depth 300mm below PWL
Emergency Spillway	Provided
Overland Flow into Wetland	Yes, for peak flow diversion of Swale
Flooding Risk	Wetland is designed for 100yr ARI storm event flood storage.
Inlet and Outlet	Inlet is sized to convey WQF WQF peak flow of 1,142l/s Outlet is sized to drain down flood storage after storm event 750mm SW pipe Orifice at outlet manhole: SMAF 1 release: 344mm diameter at RL20.70 (invert level) Across Norther Outflow 1 spillway bund Reno Mattress or Rock Riprap has been proposed for erosion protection and velocity control

Please do not hesitate to contact me should you have any queries.

Kind regards,

Designed By:

Yotsak Wansong
Civil Engineer
Maven Associates Limited

Appendices:

- **Appendix 1** – Calculations

Appendix 1 – Calculation

TP108 Calculations

			10	100
			140	228
0.08	0.11		0.42	0.55
0.020	0.028		0.090	0.110
0.320	**0.591**	n	**8.060**	**16.043**
			81.3	159.3
			51986.98	101873.94

MAVEN

[redacted]

		10	100
		140	228
		17.0	32.7
		163.8	302.556
0.08	0.11	0.46	0.62
0.170	0.170	0.170	0.170
0.805	**1.063**	**5.277**	**9.748**
		101.7	228.9
		19267.29	43380.93

MAVEN ASSOCIATES	Job Number 215010	Sheet 5	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Post Development Wetland 1 - Impervious	Author AO	Date 19/12/2024	Checked 0

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2=1 ha	Product of CN x area
C	Urban-commercial and bussiness	98		0.00
C	Road pavement	98	45.0139	4411.37
C	Berms + Footpath	85		0.00
C	Open space (Pervious)	74		0.00
* from Appendix B		Totals =	45.0139	4411.37

CN (weighted) = total product / total area = 4411.37 / 45.014 = 98.0   23.7400

Ia (average) = 5 x pervious area / total area = 5 x 0.0000 / 45.014   0.0 mm

2. Time of Concentration

Channelisation factor   C = 0.6 (From Table 4.2)

Catchment length   L = 1.2 km (along drainage path)

Catchment Slope   Sc= 0.010 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 98.0 / (200- 98.0) = 0.96

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14   0.6   1.13   1.02   3.98   = 0.17 hrs
10.0

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.11 hrs
6.71 mins

NO GOOD
use
0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 215010	Sheet 6	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Post Development Wetland 1 - Impervious	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area	A=	0.45014	km2(100ha =1km2)			
Runoff curve number	CN=	98.0	(from worksheet 1)			
Initial abstraction	Ia=	0.0	mm (from worksheet 1)			
Time of concentration	tc=	0.17	hrs (from worksheet 1)			

2. Calculate storage, S =(1000/CN - 10)25.4 = 5.2 mm

	PWV - SMA	SMAF1	Design	Excess	
3. Average recurrence interval, ARI	90th %	95th %			(yr)
4. 24 hour rainfall depth	25	33			(mm)
Percentage Increase					(%)
4. 24 hour rainfall depth, P24	25	33			(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.71	0.76			
6. Specific peak flow rate q*	0.170	0.170			
7. Peak flow rate, q_p=q*A*P_{24}	**1.913**	**2.525**			m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	20.7	28.5			mm
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	9320.84	12837.99			(m3)
10 Retention volume, imp*5mm	2251				m³
Combined v24	10015	14105.28			
Post V24- Pre V24	**7673**	**9828**			m³
Detention volume	5422				m³
50% PWV - Live storage provided	3836		**4,961.0**	*1,124.69*	m³
Ponding Depth Coefficient	0.5				m
Minimum Wetland Area	7673		**9,798.8**	*2,126.20*	m²
Forebay volume	575		**1,143.6**	*568.19*	m²
Live Storage Required		**9828**			m²

Length	200	Ratio 1:	3.960396
Width	**50.50**	Area	**10100.00**

Worksheet 2: Graphical Peak Flow Rate

Transverse Deep Pools	432.96		
	956.68	Outlet	1389.64
Forebay Area	1260		13% >10%
"wetland area""	8538.83		
Percentatge of transverse deep poc	16%		<20% excl forebay

MAVEN ASSOCIATES	Job Number 215010	Sheet 7	Rev A
Job Title: Sunfield FAA Calc Title: Catchment Summary for Wetland Design 1	Author AO	Date 19/12/2024	Checked 0

Total Area (ha)	Pervious (ha)	%	Impervious (ha)	%
Pre Developmnet	63.9655904	100%	0	0%
Post Development	18.95165079	30%	45.01393961	70%

	Runoff Volume V24 (m3)		Peak Flow Rate (m3/s)		Volume Required
	Pre	Post	Pre	Post	
90th %	2342	10015	0.32	2.72	7672.6
95th %	4277	14105	0.59	1.06	9827.9

MAVEN

SMAF Orifice Sizing Calculation

engineering new zealand

Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield FAA Calc Title: SW Pond 1 SMAF Orifice Size Calc	Author YW	Date 13/01/2025	Checked

Detention Volume

12121.00 m^3 *(See SMAF Summary)*

Flow Rate (Q_p) if released over 24 hours

0.14029 m^3/sec (Average Discharge Flow-Rate)

Tank Details

Tank Height 0.450 m
Orifice Height 0.000 m (Above tank base)

Orifice Sizing (to atmo)

$Q_P=0.62*A*(2*G*H_{2/3})^{1/2}$

Q_P	0.14029	m^3/sec (Peak Discharge Flow-Rate)
G=	9.810	m^2/sec
H_T=	0.450	m (Height of water above Discharge Point)
$H_{2/3}$=	0.300	m (Average Head of Water in pond = Two-Thirds of H_T)
A=	0.0932659	m^2 (Cross-Sectional of the Discharge Pipe)

Circular Area Formula

$A=(\pi*D^2)/4$

A= 0.0932659 m^2 (Cross-Sectional of the Discharge Pipe)
D= 0.344601 m (Diameter of Discharge Pipe)

Use 10mm Orifice (minimum size)

344.60098 (Diameter of Discharge Orifice in mm)

Qmax =	0.2806	m^3/sec
Qi (265mm)	0.0830	m^3/sec

Post Storm Draindown Orifice Sizing Calculation

Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Calc Title: SW Pond 1 Post 1%AEP Draindown Orifice Size Calc	Author YW	Date 13/01/2025	Checked

Detention Volume

129000.00 m^3 *(1%AEP Flood Storage)*

Flow Rate (Q_p) if released over 30 hours

1.19444 m^3/sec (Average Discharge Flow-Rate)

Tank Details

Tank Height 1.600 m
Orifice Height 0.000 m (Above tank base)

Orifice Sizing (to atmo)

$Q_P = 0.62 * A * (2 * G * H_{2/3})^{1/2}$

Q_P 1.19444 m^3/sec (Peak Discharge Flow-Rate)
G= 9.810 m^2/sec
H_T= 1.600 m (Height of water above Discharge Point)
$H_{2/3}$= 1.067 m (Average Head of Water in pond = Two-Thirds of H_T)

A= 0.4211244 m^2 (Cross-Sectional of the Discharge Pipe)

Circular Area Formula

$A = (\pi * D^2)/4$

A= 0.4211244 m^2 (Cross-Sectional of the Discharge Pipe)
D= 0.7322515 m (Diameter of Discharge Pipe)

Use 10mm Orifice (minimum size)

732.25148 (Diameter of Discharge Orifice in mm)

Qmax = 2.3889 m^3/sec
Qi (265mm) 0.1564 m^3/sec

7th February 2025

Wetland 2 Design Memo for Proposed Sunfield FAA Application

- **Background**

Wetland design is required by Heathy Water to demonstrate the proposed wetland space is adequate to provide the required mitigation volumes. Wetland 2. This memo, as a supplement to the SMP, details the Wetland 2 design principles and sizing method.

- **Catchment and Storm Intensities**

As shown on civil drawing M-C480 Catchment Plan set, the total catchment for Wetland 2 is 152,738 m^2. The pre-development and post-development catchment areas are summarised in Table 1 below.

Table 1 – Wetland 2 Catchment Summary

Total Catchment Area	152,738 m^2		
Pre-Dev Pervious Area	152,738 m^2 (100%)	CN=74	ToC = 0.44hr
Post-Dev Pervious Area	32,297m^2 (21%)	CN=74	ToC = 0.167hr
Post-Dev Impervious Area	120,441m^2 (79%)	CN=98	ToC = 0.167hr

The following storm intensities have been applied based on TP108 and SWCoP Revision 4 requirements, see Tabel 2.

Table 2 – Storm Intensities

Design Storm	Rainfall Across 24hr (mm) – TP108	Climate allowance as per SWCoP Rev 4	Rainfall+CC (mm)
90th	25	-	-
95th	33	-	-
50%AEP	75	15.10%	86
10%AEP	145	17%	170
1%AEP	225	32.70%	298

- **Design Principles**

As stated in the SMP and flood report regarding flooding management of the Eastern Catchment Outflow 2, it is recommended to provide attenuation for 2-year, 10-year and 100-year storm event. In this case, Wetland 2 has been designed to provide treatment and live storage for SMAF 1, 2yr, 10yr and 100yr peak flow attenuation.

Hydrologic Calculations

TP108 and HEC-HMS has been utilized to conduct the hydrologic calculations. The results are summarized in Table 3 below.

Table 3 – Hydrologic Calculations Results

Item	Value
PWV -	2,053 m^3
Minimum Forebay Volume (15% of PWV)	308 m^3
Sediment Drying Area (10% of PWV)	205 m^2
Detention Volume for SMAF	2,629 m^3

Hydraulic Calculations and Wetland Design Summary

Autodesk Civil 3D software has been used to build the Wetland 2 3D model and Elevation-Storage relationship (Table 4) has been extracted from the Wetland 2 3D model contours for HEC-HMS hydraulic calculation.

The final Wetland 2 design is summarised in Table 5 below.

Table 4 – Elevation-Storage Relationship

Water Level (m, RL)	Storage Volume (m^3)
19.4	0
20.0	6,085
21.0	17,415
22.0	30,300

Table 6: Wetland Design Summary

ITEM	COMMENTS
Permanent Water Level (PWL) Proposed	RL19.40m
PWV - (Table 3 above)	2,053 m^3
Minimum PWV Required When Stream Protection is provided As per GD01 C8.2.3.1	1,026m^3 (50% of Standard PWV)
PWV Provided	2,629m^3 (>50% of Standard PWV)
Wetland Length to Width Raito	Approximately 3.6:1
Forebay Volume Proposed	154m^3, 15% of PWV
Forebay Depth	1.75m
Shallow Marsh Zone Depth	0.2m
Deep Marsh Zone Depth	0.5m
Deep Pool Depth	1.2m
Slope	Internal wetland banks below the PWL: 1V:4H Internal side slope above the PWL: 1V: 3H Forebay bund slope: 1V:3H External side slope: 1V:3H
Maintenance Access	Provided, 3.5m wide, maximum gradient 1 in 8.
Sediment Drying Area	Provided, 1,200m^2, >10% of PWV
Safety Bench	Provided, 3m wide, maximum water depth 300mm below PWL
Emergency Spillway	Provided
Overland Flow into Wetland	Yes
Flooding Risk	Wetland is designed for 100yr ARI storm event flood attenuation
Inlet and Outlet	Inlet is sized to convey pre-mitigation 10yr peak flow of 4,182l/s Outlet is sized to convey post-dev mitigated 2yr peak flow of 60l/s mitigated 10yr peak flow of 639l/s mitigated 100yr peak flow of 4,142l/s 2m manhole cutout at RL20.40 Orifice at outlet manhole: SMAF 1 release: 180mm diameter at RL19.40 (invert level) Reno Mattress or Rock Riprap has been proposed for erosion protection and velocity control

Designed By:

Yotsak Wansong
Civil Engineer
Maven Associates Limited

Appendices:

- **Appendix 1** — Calculations

Appendix 1 – Calculation

TP108 Calculations

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Pre-Development Wetland 2	Author AO	Date 19/12/2024	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Residential lots	89.6		0.00
C	Road pavement	98		0.00
C	Carpark	98		0.00
C	Open space (Pervious)	74	15.2738	1130.26
* from Appendix B		Totals =	15.2738	1130.26

CN (weighted) = total product / total area = 1130.26 / 15.274 = 74.0

Ia (average) = 5 x pervious area / total area = 5 x 15.2738 / 15.274 = 5.0 mm

2. Time of Concentration

Contours level in meters — High Level — Lower level

Channelisation factor — C = 1 (From Table 4.2)

Catchment length — L = 0.5 km (along drainage path)

Catchment Slope — Sc= 0.016 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.0 / (200- 74.0) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14   1   0.63   1.34   3.48 = 0.17 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.11 hrs

6.71 mins

NO GOOD

use

0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 215010	Sheet 2	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Pre-Development Wetland 2	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area A= 0.15274 km2(100ha =1km2)

Runoff curve number CN= 74.0 (from worksheet 1)

Initial abstraction Ia= 5.0 mm (from worksheet 1)

Time of concentration tc= 0.17 hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 89.2 mm

3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	86	170	298	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.08	0.11	0.30	0.47	0.62	
6. Specific peak flow rate q*	0.020	0.028	0.065	0.090	0.110	
7. Peak flow rate, q_p=q*A*P_{24}	0.076	0.141	0.854	2.337	5.007	m3/s
8. Runoff depth, Q_{24} = $(P_{24}-Ia)^2/(P_{24}-Ia)+S$	3.7	6.7	38.5	107.1	224.6	mm
9. Runoff volume, V_{24} = 1000xQ_{24}A	559.26	1021.35	5886.37	16355.58	34303.86	(m3)

MAVEN

MAVEN ASSOCIATES	Job Number 215010	Sheet 4	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Post Development Wetland 2 - Pervious	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area	A=	0.03230	km2(100ha =1km2)
Runoff curve number	CN=	74.0	(from worksheet 1)
Initial abstraction	Ia=	5.0	mm (from worksheet 1)
Time of concentration	tc=	0.17	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 89.2 mm

	PWV	SMAF				
3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	86	170	298	(mm)
Percentage Increase			15.1	17.0	32.7	(%)
4. 24 hour rainfall depth, P24	25	33	98.986	198.9	395.446	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.08	0.11	0.33	0.51	0.68	
6. Specific peak flow rate q*	0.170	0.170	0.170	0.170	0.170	
7. Peak flow rate, q_p=q*A*P_{24}	0.137	0.181	0.543	1.092	2.171	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	3.7	6.7	48.2	132.8	317.8	mm
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	118.26	215.97	1557.02	4288.56	10264.18	(m3)
10. Retention volume, imp*5mm	0	0				m^3

MAVEN ASSOCIATES	Job Number 215010	Sheet 5	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Post Development Wetland 2 - Impervious	Author AO	Date 19/12/2024	Checked 0

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2=1 ha	Product of CN x area
C	Urban-commercial and bussiness	98		0.00
C	Road pavement	98	12.0441	1180.32
C	Berms + Footpath	85		0.00
C	Open space (Pervious)	74		0.00
* from Appendix B		Totals =	12.0441	1180.32

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = $\frac{1180.32}{12.044}$ = 98.0 23.7400

Ia (average) = $\frac{\text{5 x pervious area}}{\text{total area}}$ = $\frac{5 \times 0.0000}{12.044}$ 0.0 mm

2. Time of Concentration

Channelisation factor C = 0.6 (From Table 4.2)

Catchment length L = 0.5 km (along drainage path)

Catchment Slope Sc= 0.016 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN}$ = $\frac{98.0}{200- 98.0}$ = 0.96

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 0.6 0.63 1.02 3.48 = 0.17 hrs

10.0

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.11 hrs

6.71 mins

NO GOOD

use

0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 215010	Sheet 6	Rev A
Job Title: Sunfeild FAA Calc Title: TP108 Calculation - Post Development Wetland 2 - Impervious	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area A= 0.12044 km2(100ha =1km2)

Runoff curve number CN= 98.0 (from worksheet 1)

Initial abstraction Ia= 0.0 mm (from worksheet 1)

Time of concentration tc= 0.17 hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 5.2 mm

	PWV - SMA	SMAF1				
3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	86	170	298	(mm)
Percentage Increase			15.1	17.0	32.7	(%)
4. 24 hour rainfall depth, P24	25	33	98.986	198.9	395.446	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.71	0.76	0.91	0.95	0.97	
6. Specific peak flow rate q*	0.170	0.170	0.170	0.170	0.170	
7. Peak flow rate, q_p=q*A*P_{24}	**0.512**	**0.676**	**2.027**	**4.072**	**8.097**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	20.7	28.5	94.1	193.8	390.3	mm
9. Runoff volume, V_{24} = 1000xQ_{24}A	2493.92	3434.99	11328.73	23347.28	47011.73	(m3)
10 Retention volume, imp*5mm	602					m³
Combined v24	2612	3650.96	12885.75	27635.84	57275.91	
Post V24- Pre V24	**2053**	**2630**	**6999**	**11280**	**22972**	m³
Detention volume	1451					m³
			Design	checks		
50% PWV - Live storage provided	1026		1261	234.54		m³
Ponding Depth Coefficient	0.5					m
Minimum Wetland Area	2053		2778.55	725.63		m^2
Forebay volume	154		499.00	345.03		m^2
Live Storage Required		**2630**				m^2

Length 100 Ratio 1: 3.5714286

Width **28.00** Area **2800.00**

Worksheet 2: Graphical Peak Flow Rate

Transverse Deep Pools 199.5

72 Outlet 271.5

Forebay Area 708 25% >10%

"wetland area"" 2070.55

Percentatge of transverse deep poc 13% <20% excl forebay

MAVEN ASSOCIATES	Job Number 215010	Sheet 7	Rev A
Job Title: Sunfeild FAA Calc Title: Catchment Summary for Wetland 2 Design	Author AO	Date 19/12/2024	Checked 0

Total Area (ha)	Pervious (ha)	%	Impervious (ha)	%
Pre Developmnet	15.2738169	100%	0	0%
Post Development	3.229699707	21%	12.04411719	79%

	Runoff Volume V24 (m3)		Peak Flow Rate (m3/s)		Volume Required
	Pre	Post	Pre	Post	
90th %	559	2612	0.08	0.65	2052.9
95th %	1021	3651	0.14	0.18	2629.6
2yr	5886	12886	0.85	0.54	6999.4
10yr	16356	27636	2.34	1.09	11280.3
100yr	34304	57276	5.01	2.17	22972.0

HEC-HMS Calculation Results

2YR PRE-DEV –Calculation Results

Summary Results for Subbasin "Subbasin-Outflow 2 Ex"

Project: FAB_Swale_Sizing   Simulation Run: 2yr_FAB v2
Subbasin: Subbasin-Outflow 2 Ex

Start of Run:	01Jan2000, 00:00	Basin Model:	2yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_2yr_86mm
Compute Time:	14Jan2025, 13:57:54	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Dischar...	0.82457 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:25
Precipitation Volu...	13.13564 (1000 M3)	Direct Runoff Volume:	5.88644 (1000 M3
Loss Volu...	7.24920 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3
Excess Volu...	5.88644 (1000 M3)	Discharge Volume:	5.88644 (1000 M3

2YR POST-DEV WITH WETLAND 2 –Calculation Results

Summary Results for Reservoir "Reservoir-SW_Pond_2"

Project: FAB_Swale_Sizing   Simulation Run: 2yr_FAB v2
Reservoir: Reservoir-SW_Pond_2

Start of Run:	01Jan2000, 00:00	Basin Model:	2yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_2yr_86mm
Compute Time:	DATA CHANGED, RECOMPUTE	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	2.01036 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:13
Peak Discharge:	0.05980 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 18:15
Inflow Volume:	11.01380 (1000 M3)	Peak Storage:	8.38783 (1000 M3)
Discharge Volume:	7.03886 (1000 M3)	Peak Elevation:	20.20325 (M)

10YR PRE-DEV –Calculation Results

Summary Results for Subbasin "Subbasin-Outflow 2 Ex"

Project: FAB_Swale_Sizing Simulation Run: 10yr_FAB v2
Subbasin: Subbasin-Outflow 2 Ex

Start of R...	01Jan2000, 00:00	Basin Model:	10yr_Pr v2
End of R...	03Jan2000, 00:00	Meteorologic Model:	TP108_10yr_170mm_CoPv4
Compute Ti...	14Jan2025, 14:00:31	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Disch...	2.34580 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:2
Precipitation Vol...	25.96580 (1000 M3)	Direct Runoff Volume:	16.35578 (1000
Loss Vol...	9.61002 (1000 M3)	Baseflow Volume:	0.00000 (1000 M
Excess Vol...	16.35578 (1000 M3)	Discharge Volume:	16.35578 (1000

10YR POST-DEV WITH WETLAND 2 –Calculation Results

Summary Results for Reservoir "Reservoir-SW_Pond_2"

Project: FAB_Swale_Sizing Simulation Run: 10yr_FAB v2
Reservoir: Reservoir-SW_Pond_2

Start of Run:	01Jan2000, 00:00	Basin Model:	10yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_10yr_170mm_CoPv4
Compute Time:	22Jan2025, 14:25:09	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	4.18201 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:13
Peak Discharge:	0.63895 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:10
Inflow Volume:	23.3276 (1000 M3)	Peak Storage:	13.5827 (1000 M3)
Discharge Volume:	17.3799 (1000 M3)	Peak Elevation:	20.66176 (M)

100YR PRE-DEV –Calculation Results

Summary Results for Subbasin "Subbasin-Outflow 2 Ex"

Project: FAB_Swale_Sizing Simulation Run: 100yr_FAB v2
Subbasin: Subbasin-Outflow 2 Ex

Start of Run:	01Jan2000, 00:00	Basin Model:	100yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_100yr_298mm
Compute Time:	14Jan2025, 14:01:39	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Disch...	4.17135 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:2ε
Precipitation Vol...	45.51652 (1000 M3)	Direct Runoff Volume:	34.30427 (1000 M
Loss Vol...	11.21225 (1000 M3)	Baseflow Volume:	0.00000 (1000 M
Excess Vol...	34.30427 (1000 M3)	Discharge Volume:	34.30427 (1000 M

100YR POST-DEV WITH WETLAND 2 –Calculation Results

Summary Results for Reservoir "Reservoir-SW_Pond_2"

Project: FAB_Swale_Sizing Simulation Run: 100yr_FAB v2
Reservoir: Reservoir-SW_Pond_2

Start of Run:	01Jan2000, 00:00	Basin Model:	100yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_100yr_298mm
Compute Time:	22Jan2025, 14:36:45	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	7.27751 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:14
Peak Discharge:	4.14206 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:28
Inflow Volume:	42.5314 (1000 M3)	Peak Storage:	22.2910 (1000 M3)
Discharge Volume:	33.6255 (1000 M3)	Peak Elevation:	21.37843 (M)

SMAF Detention Orifice Sizing Calculation

Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield Calc Title: SW Pond 2 SMAF Orifice Size Calc	Author YW	Date 13/01/2025	Checked

Detention Volume

2628.80 m^3 *(See SMAF Summary)*

Flow Rate (Q_p) if released over 24 hours

0.03043 m^3/sec (Average Discharge Flow-Rate)

Tank Details

Tank Height 0.280 m
Orifice Height 0.000 m (Above tank base)

Orifice Sizing (to atmo)

$Q_P=0.62*A*(2*G*H_{2/3})^{1/2}$

Q_P	0.03043	m^3/sec (Peak Discharge Flow-Rate)
G=	9.810	m^2/sec
H_T=	0.280	m (Height of water above Discharge Point)
$H_{2/3}$=	0.187	m (Average Head of Water in pond = Two-Thirds of H_T)
A=	0.025643	m^2 (Cross-Sectional of the Discharge Pipe)

Circular Area Formula

$A=(\pi*D^2)/4$

A= 0.025643 m^2 (Cross-Sectional of the Discharge Pipe)
D= 0.1806923 m (Diameter of Discharge Pipe)

Use 10mm Orifice (minimum size)

180.69231 (Diameter of Discharge Orifice in mm)

Qmax = 0.0609 m^3/sec
Qi (265mm) 0.0654 m^3/sec

Ref: 215010

7th February 2025

Wetland 3 Design Memo for Proposed Sunfield FAA Application

- **Background**

Wetland design is required by Heathy Water to demonstrate the proposed wetland space is adequate to provide the required mitigation volumes. Wetland 3. This memo, as a supplement to the SMP, details the Wetland 3 design principles and sizing method.

- **Catchment and Storm Intensities**

As shown on civil drawing M-C480 Catchment Plan set, the total catchment for Wetland 3 is 27,555m^2. The pre-development and post-development catchment areas are summarised in Table 1 below.

Table 1 – Wetland 3 Catchment Summary

Total Catchment Area	27,555m2m^2		
Pre-Dev Pervious Area	27,555m2 (100%)	CN=74	ToC = 0.44hr
Post-Dev Pervious Area	21,285m^2 (23%)	CN=74	ToC = 0.167hr
Post-Dev Impervious Area	6,269m^2 (77%)	CN=98	ToC = 0.167hr

The following storm intensities have been applied based on TP108 and SWCoP Revision 4 requirements, see Tabel 2.

Table 2 – Storm Intensities

Design Storm	Rainfall Across 24hr (mm) – TP108	Climate allowance as per SWCoP Rev 4	Rainfall+CC (mm)
90th	25	-	-
95th	33	-	-
50%AEP	75	15.10%	86
10%AEP	145	17%	170
1%AEP	225	32.70%	298

- **Design Principles**

As stated in the SMP and flood report regarding flooding management of the Eastern Catchment Outflow 3, it is recommended to provide attenuation for 2-year, 10-year and 100-year storm event. In this case, Wetland 3 has been designed to provide treatment and live storage for SMAF 1, 2yr, 10yr and 100yr peak flow attenuation.

- **Hydrologic Calculations**

TP108 and HEC-HMS has been utilized to conduct the hydrologic calculations. The results are summarized in Table 3 below.

Table 3 – Hydrologic Calculations Results

Item	Value
PWV -	363 m^3
Minimum Forebay Volume (15% of PWV)	54 m^3
Sediment Drying Area (10% of PWV)	36 m^2
Detention Volume for SMAF	465 m^3

- **Hydraulic Calculations and Wetland Design Summary**

Autodesk Civil 3D software has been used to build the Wetland 3 3D model and Elevation-Storage relationship (Table 4) has been extracted from the Wetland 3 3D model contours for HEC-HMS hydraulic calculation.

The final Wetland 3 design is summarised in Table 5 below.

Table 4 – Elevation-Storage Relationship

Water Level (m, RL)	Storage Volume (m^3)
25.4	0
26.0	630
27.0	2,010
27.7	3,250

Table 6: Wetland Design Summary

ITEM	COMMENTS
Permanent Water Level (PWL) Proposed	RL25.40m
PWV - (Table 3 above)	363 m^3
Minimum PWV Required When Stream Protection is provided As per GD01 C8.2.3.1	181m^3 (50% of Standard PWV)
PWV Provided	181m^3 (>50% of Standard PWV)
Wetland Length to Width Raito	Approximately 3:1
Forebay Volume Proposed	27m^3, 15% of PWV
Forebay Depth	1. 5m
Shallow Marsh Zone Depth	0.2m
Deep Marsh Zone Depth	0.5m
Deep Pool Depth	1.2m
Slope	Internal wetland banks below the PWL: 1V:4H Internal side slope above the PWL: 1V: 3H Forebay bund slope: 1V:3H External side slope: 1V:3H
Maintenance Access	Provided, 3.5m wide, maximum gradient 1 in 8.
Sediment Drying Area	Provided, 20m^2, >10% of PWV
Safety Bench	Provided, 3m wide, maximum water depth 300mm below PWL
Emergency Spillway	Provided
Overland Flow into Wetland	Yes
Flooding Risk	Wetland is designed for 100yr ARI storm event flood attenuation
Inlet and Outlet	Inlet is sized to convey pre-mitigation 10yr peak flow of 766l/s Outlet is sized to convey post-dev mitigated 2yr peak flow of 75l/s mitigated 10yr peak flow of487 l/s mitigated 100yr peak flow of 874l/s 0.7m manhole cutout at RL26.16 Orifice at outlet manhole: SMAF 1 release: 68mm diameter at RL25.40 (invert level) Reno Mattress or Rock Riprap has been proposed for erosion protection and velocity control

Please do not hesitate to contact me should you have any queries.

Kind regards,

Designed By:

Yotsak Wansong
Civil Engineer
Maven Associates Limited

Appendices:

- **Appendix 1**– Calculations

Appendix 1 – Calculation

TP108 Calculations

MAVEN ASSOCIATES		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield FAA TP108 Calculation - Pre-Development Wetland 4	Author AO	Date 19/12/2024	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Residential lots	89.6		0.00
C	Road pavement	98		0.00
C	Carpark	98		0.00
C	Open space (Pervious)	74	53.5004	3959.03
* from Appendix B		Totals =	53.5004	3959.03

CN (weighted) = total product / total area = 3959.03 / 53.500 = 74.0

Ia (average) = 5 x pervious area / total area = 5 x 53.5004 / 53.500 = 5.0 mm

2. Time of Concentration

Contours level in meters — High Level [illegible] Lower level [illegible]

Channelisation factor — C = 1 (From Table 4.2)

Catchment length — L = 0.1 km (along drainage path)

Catchment Slope — Sc= 0.016 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.0 / (200- 74.0) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14   1   0.22   1.34   3.48 = 0.17 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.11 hrs

6.71 mins

NO GOOD

use

0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 215010	Sheet 2	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Pre-Development Wetland 4	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area	A=	0.53500	km2(100ha =1km2)
Runoff curve number	CN=	74.0	(from worksheet 1)
Initial abstraction	Ia=	5.0	mm (from worksheet 1)
Time of concentration	tc=	0.17	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 89.2 mm

3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	80	140	228	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.08	0.11	0.28	0.42	0.55	
6. Specific peak flow rate q*	0.020	0.028	0.065	0.090	0.110	
7. Peak flow rate, q_p=q*A*P_{24}	0.268	0.494	2.782	6.741	13.418	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	3.7	6.7	34.2	81.3	159.3	mm
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1958.94	3577.54	18322.79	43481.53	85206.62	(m3)

MAVEN

MAVEN ASSOCIATES	Job Number 215010	Sheet 4	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Post Development Wetland 4 - Pervious	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area A= 0.07713 km2(100ha =1km2)

Runoff curve number CN= 74.0 (from worksheet 1)

Initial abstraction Ia= 5.0 mm (from worksheet 1)

Time of concentration tc= 0.17 hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 89.2 mm

	PWV	SMAF				
3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	80	140	228	(mm)
Percentage Increase			15.1	17.0	32.7	(%)
4. 24 hour rainfall depth, P24	25	33	92.08	163.8	302.556	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.08	0.11	0.32	0.46	0.62	
6. Specific peak flow rate q*	0.170	0.170	0.170	0.170	0.170	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**0.328**	**0.433**	**1.207**	**2.148**	**3.967**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	3.7	6.7	43.0	101.7	228.9	mm
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	282.42	515.78	3317.14	7841.69	17655.81	(m3)
10. Retention volume, imp*5mm	0	0				m^3

MAVEN ASSOCIATES	Job Number 215010	Sheet 5	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Post Development Wetland 4 - Impervious	Author AO	Date 19/12/2024	Checked 0

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2=1 ha	Product of CN x area
C	Urban-commercial and bussiness	98		0.00
C	Road pavement	98	45.7901	4487.43
C	Berms + Footpath	85		0.00
C	Open space (Pervious)	74		0.00
* from Appendix B		Totals =	45.7901	4487.43

CN (weighted) = total product / total area = 4487.43 / 45.790 = 98.0 23.7400

Ia (average) = 5 x pervious area / total area = 5 x 0.0000 / 45.790 0.0 mm

2. Time of Concentration

Channelisation factor C = 0.6 (From Table 4.2)

Catchment length L = 0.5 km (along drainage path)

Catchment Slope Sc= 0.016 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 98.0 / (200- 98.0) = 0.96

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 0.6 0.63 1.02 3.48 = 0.17 hrs

10.0

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.11 hrs

6.71 mins

NO GOOD

use

0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

0.71	0.76	0.90	0.94	0.97
0.170	0.170	0.170	0.170	0.170
1.946	**2.569**	**7.168**	**12.751**	**23.552**

MAVEN ASSOCIATES	Job Number 215010	Sheet 7	Rev A
Job Title: Sunfield Stage 2 Calc Title: Catchment Summary for Wetland Design 4	Author AO	Date 19/12/2024	Checked 0

Total Area (ha)	Pervious (ha)	%	Impervious (ha)	%
Pre Developmnet	53.5004	100%	0	0%
Post Development	7.7132	14%	45.7901	86%

	Runoff Volume V24 (m3)		Peak Flow Rate (m3/s)		Volume Required
	Pre	Post	Pre	Post	
90th %	1959	9764	0.27	2.27	7805.0
95th %	3578	13575	0.49	0.43	9997.6
2yr	18323	43234	2.78	1.21	24910.8
10yr	43482	80545	6.74	2.15	37063.6
100yr	85207	153863	13.42	3.97	68656.4

HEC-HMS Calculation Results

2YR PRE-DEV –Calculation Results

Summary Results for Subbasin "Subbasin-Outflow 3 Ex"

Project: FAB_Swale_Sizing Simulation Run: 2yr_FAB v2
Subbasin: Subbasin-Outflow 3 Ex

Start of Run:	01Jan2000, 00:00	Basin Model:	2yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_2yr_86mm
Compute Time:	14Jan2025, 15:24:24	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Discharge:	0.17724 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:18
Precipitation Volume:	2.36971 (1000 M3)	Direct Runoff Volume:	1.06193 (1000 M3
Loss Volume:	1.30778 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3
Excess Volume:	1.06193 (1000 M3)	Discharge Volume:	1.06193 (1000 M3

2YR POST-DEV WITH WETLAND 3 –Calculation Results

Summary Results for Reservoir "Reservoir-SW_Pond_3"

Project: FAB_Swale_Sizing Simulation Run: 2yr_FAB v2
Reservoir: Reservoir-SW_Pond_3

Start of Run:	01Jan2000, 00:00	Basin Model:	2yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_2yr_86mm
Compute Time:	14Jan2025, 15:24:24	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	0.36600 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:13
Peak Discharge:	0.07489 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:03
Inflow Volume:	1.96810 (1000 M3)	Peak Storage:	1.02456 (1000 M3)
Discharge Volume:	1.68934 (1000 M3)	Peak Elevation:	26.28592 (M)

10YR PRE-DEV –Calculation Results

Summary Results for Subbasin "Subbasin-Outflow 3 Ex

Project: FAB_Swale_Sizing Simulation Run: 10yr_FAB v2
Subbasin: Subbasin-Outflow 3 Ex

Start of Run:	01Jan2000, 00:00	Basin Model:	10yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_10yr_170mm_CoPv4
Compute Time:	14Jan2025, 15:23:16	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Discharge:	0.50244 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:18
Precipitation Volume:	4.68432 (1000 M3)	Direct Runoff Volume:	2.95064 (1000 M3)
Loss Volume:	1.73368 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3)
Excess Volume:	2.95064 (1000 M3)	Discharge Volume:	2.95064 (1000 M3)

10YR POST-DEV WITH WETLAND 3 –Calculation Results

Summary Results for Reservoir "Reservoir-SW_Pond_3"

Project: FAB_Swale_Sizing Simulation Run: 10yr_FAB v2
Reservoir: Reservoir-SW_Pond_3

Start of Run:	01Jan2000, 00:00	Basin Model:	10yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_10yr_170mm_CoPv4
Compute Time:	14Jan2025, 15:23:16	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	0.76620 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:13
Peak Discharge:	0.48687 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:21
Inflow Volume:	4.18280 (1000 M3)	Peak Storage:	1.50543 (1000 M3)
Discharge Volume:	3.79048 (1000 M3)	Peak Elevation:	26.63437 (M)

100YR PRE-DEV –Calculation Results

Summary Results for Subbasin "Subbasin-Outflow 3 Ex"

Project: FAB_Swale_Sizing   Simulation Run: 100yr_FAB v2
Subbasin: Subbasin-Outflow 3 Ex

Start of Run:	01Jan2000, 00:00	Basin Model:	100yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_100yr_298mm
Compute Time:	14Jan2025, 15:23:46	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Discharge:	0.90075 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:20
Precipitation Volume:	8.21133 (1000 M3)	Direct Runoff Volume:	6.18861 (1000 M3)
Loss Volume:	2.02273 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3)
Excess Volume:	6.18861 (1000 M3)	Discharge Volume:	6.18861 (1000 M3)

100YR POST-DEV WITH WETLAND 3 –Calculation Results

Summary Results for Reservoir "Reservoir-SW_Pond_3"

Project: FAB_Swale_Sizing   Simulation Run: 100yr_FAB v2
Reservoir: Reservoir-SW_Pond_3

Start of Run:	01Jan2000, 00:00	Basin Model:	100yr_Pr v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	TP108_100yr_298mm
Compute Time:	14Jan2025, 15:23:46	Control Specifications:	48hr

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	1.19668 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:15
Peak Discharge:	0.87376 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:23
Inflow Volume:	7.64268 (1000 M3)	Peak Storage:	1.82041 (1000 M3)
Discharge Volume:	7.26074 (1000 M3)	Peak Elevation:	26.86261 (M)

MAVEN

SMAF Detention Orifice Sizing Calculation

engineering new zealand

Maven Associates		Job Number 215010	Sheet 1	Rev A
Job Title	Sunfield	Author	Date	Checked
Calc Title	SW Pond 3 SMAF Orifice Size Calc	YW	13/01/2025	

Detention Volume

465.00 m^3 *(See SMAF Summary)*

Flow Rate (Q_p) if released over 24 hours

0.00538 m^3/sec (Average Discharge Flow-Rate)

Tank Details

Tank Height 0.460 m

Orifice Height 0.000 m (Above tank base)

Orifice Sizing (to atmo)

$Q_P=0.62*A*(2*G*H_{2/3})^{1/2}$

Q_P 0.00538 m^3/sec (Peak Discharge Flow-Rate)

G= 9.810 m^2/sec

H_T= 0.460 m (Height of water above Discharge Point)

$H_{2/3}$= 0.307 m (Average Head of Water in pond = Two-Thirds of H_T)

A= 0.0035389 m^2 (Cross-Sectional of the Discharge Pipe)

Circular Area Formula

$A=(\pi*D^2)/4$

A= 0.0035389 m^2 (Cross-Sectional of the Discharge Pipe)

D= 0.0671255 m (Diameter of Discharge Pipe)

Use 10mm Orifice (minimum size)

67.125483 (Diameter of Discharge Orifice in mm)

Qmax = 0.0108 m^3/sec

Qi (265mm) 0.0839 m^3/sec

Ref: 215010

7th February 2025

Heathy Water Department
Auckland Council

To whom it may concern,

Re: Wetland 4 Design Memo for Proposed Sunfield FAA Application

- **Background**

Wetland design is required by Heathy Water to demonstrate the proposed wetland space is adequate to provide the required mitigation volumes. Wetland 4. This memo, as a supplement to the SMP, details the Wetland 4 design principles and sizing method.

- **Catchment and Storm Intensities**

As shown on civil drawing M-C480 Catchment Plan set, the total catchment for Wetland 4 is 535,004m^2. The pre-development and post-development catchment areas are summarised in Table 1 below.

Table 1 – Wetland 4 Catchment Summary

Total Catchment Area	535,004m^2		
Pre-Dev Pervious Area	535,004m^2 (100%)	CN=74	ToC = 0.44hr
Post-Dev Pervious Area	77,132m^2 (14%)	CN=74	ToC = 0.167hr
Post-Dev Impervious Area	457,901m^2 (86%)	CN=98	ToC = 0.167hr

The following storm intensities have been applied based on TP108 and SWCoP Revision 4 requirements, see Tabel 2.

Table 2 – Storm Intensities

Design Storm	Rainfall Across 24hr (mm) – TP108	Climate allowance as per SWCoP Rev 4	Rainfall+CC (mm)
90th	25	-	-
95th	33	-	-
50%AEP	70	15.10%	76
10%AEP	140	17%	164
1%AEP	220	32.70%	292

- **Design Principles**

As stated in the SMP and flood report regarding flooding management of the Western Catchment, it is recommended to provide attenuation for 2-year, 10-year and 100-year storm event. In this case, Wetland 4 has been designed to provide treatment and live storage for SMAF 1, 2yr, 10yr and 100yr peak flow attenuation. All live storage has been modelled in the flood modelling report. Only treatment calculations are provided in this report.

- **Hydrologic Calculations**

TP108 has been utilized to conduct the hydrologic calculations. The results are summarized in Table 3 below. Hydraulic modelling was undertaken in HEC RAS and results may be found in Stormwater Modelling Report.

Table 3 – Hydrologic Calculations Results

Item	Value
PWV -	7,805 m^3
Minimum Forebay Volume (15% of PWV)	1,170 m^3
Sediment Drying Area (10% of PWV)	781 m^2
Detention Volume for SMAF	3,129 m^3

Table 4 – Elevation-Storage Relationship

Water Level (m, RL)	Storage Volume (m^3)
27.72	0
24.0	7,920
24.5	33,650
25.0	63,840
25.5	96,550
26.0	131,840

Table 6: Wetland Design Summary

ITEM	COMMENTS
Permanent Water Level (PWL) Proposed	RL23.72m
Standard PWV Required (Table 3 above)	7,805 m^3
Minimum PWV Required When Stream Protection is provided As per GD01 C8.2.3.1	3,903m^3 (50% of Standard PWV)
PWV Provided	4,968m^3 (>50% of Standard PWV)
Wetland Length to Width Raito	Approximately 5:1
Forebay Volume Proposed	1311m^3, 26% of PWV
Forebay Depth	1.5m
Shallow Marsh Zone Depth	0.2m
Deep Marsh Zone Depth	0.5m
Deep Pool Depth	2.0m
Slope	Internal wetland banks below the PWL: 1V:4H Internal side slope above the PWL: 1V: 3H Forebay bund slope: 1V:3H External side slope: 1V:3H
Maintenance Access	Provided, 3.5m wide, maximum gradient 1 in 8.
Sediment Drying Area	Provided, 500m^2, >10% of PWV
Safety Bench	Provided, 3m wide, maximum water depth 300mm below PWL
Emergency Spillway	Provided
Overland Flow into Wetland	Yes, for peak flow diversion of Swale
Flooding Risk	Wetland is designed for 100yr ARI storm event flood storage.
Inlet and Outlet	Inlet is Swale network conveying all storm events Outlet is a 1m x 1m box culvert (per flood modelling report) at RL23.80 Reno Mattress or Rock Riprap has been proposed for erosion protection and velocity control

Please do not hesitate to contact me should you have any queries.

Kind regards,

Designed By:

Yotsak Wansong
Civil Engineer
Maven Associates Limited

Appendices:

- **Appendix 1** – Calculations

Appendix 1 – Calculation

MAVEN

TP108 Calculations

engineering
new zealand

MAVEN ASSOCIATES	Job Number 215010	Sheet 1	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Pre-Development Wetland 4	Author AO	Date 19/12/2024	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Residential lots	89.6		0.00
C	Road pavement	98		0.00
C	Carpark	98		0.00
C	Open space (Pervious)	74	53.5004	3959.03
* from Appendix B		Totals =	53.5004	3959.03

CN (weighted) = total product / total area = 3959.03 / 53.500 = 74.0

Ia (average) = 5 x pervious area / total area = 5 x 53.5004 / 53.500 = 5.0 mm

2. Time of Concentration

Contours level in meters — High Level — Lower level

Channelisation factor — C = 1 (From Table 4.2)

Catchment length — L = 0.1 km (along drainage path)

Catchment Slope — Sc= 0.016 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.0 / (200- 74.0) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 0.22 1.34 3.48 = 0.17 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.11 hrs

6.71 mins

NO GOOD

use

0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 215010	Sheet 2	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Pre-Development Wetland 4	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area A= 0.53500 km2(100ha =1km2)

Runoff curve number CN= 74.0 (from worksheet 1)

Initial abstraction Ia= 5.0 mm (from worksheet 1)

Time of concentration tc= 0.17 hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 89.2 mm

3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	80	140	228	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.08	0.11	0.28	0.42	0.55	
6. Specific peak flow rate q*	0.020	0.028	0.065	0.090	0.110	
7. Peak flow rate, q_p=q*A*P_{24}	0.268	0.494	2.782	6.741	13.418	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	3.7	6.7	34.2	81.3	159.3	mm
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1958.94	3577.54	18322.79	43481.53	85206.62	(m3)

MAVEN

MAVEN ASSOCIATES	Job Number 215010	Sheet 4	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Post Development Wetland 4 - Pervious	Author AO	Date 19/12/2024	Checked 0

1. Data

Catchment Area	A=	0.07713	km2(100ha =1km2)
Runoff curve number	CN=	74.0	(from worksheet 1)
Initial abstraction	Ia=	5.0	mm (from worksheet 1)
Time of concentration	tc=	0.17	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 89.2 mm

	PWV	SMAF				
3. Average recurrence interval, ARI	90th %	95th %	2	10	100	(yr)
4. 24 hour rainfall depth	25	33	80	140	228	(mm)
Percentage Increase			15.1	17.0	32.7	(%)
4. 24 hour rainfall depth, P24	25	33	92.08	163.8	302.556	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.08	0.11	0.32	0.46	0.62	
6. Specific peak flow rate q*	0.170	0.170	0.170	0.170	0.170	
7. Peak flow rate, q_p=q*A*P_{24}	0.328	0.433	1.207	2.148	3.967	m3/s
8. Runoff depth, Q_{24} = $(P_{24}-Ia)^2/(P_{24}-Ia)+S$	3.7	6.7	43.0	101.7	228.9	mm
9. Runoff volume, V_{24} = 1000xQ_{24}A	282.42	515.78	3317.14	7841.69	17655.81	(m3)
10. Retention volume, imp*5mm	0	0				m^3

MAVEN ASSOCIATES	Job Number 215010	Sheet 5	Rev A
Job Title: Sunfield FAA Calc Title: TP108 Calculation - Post Development Wetland 4 - Impervious	Author AO	Date 19/12/2024	Checked 0

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2=1 ha	Product of CN x area
C	Urban-commercial and bussiness	98		0.00
C	Road pavement	98	45.7901	4487.43
C	Berms + Footpath	85		0.00
C	Open space (Pervious)	74		0.00
* from Appendix B		Totals =	45.7901	4487.43

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{4487.43}{45.790} = 98.0$ 23.7400

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 0.0000}{45.790}$ = 0.0 mm

2. Time of Concentration

Channelisation factor C = 0.6 (From Table 4.2)

Catchment length L = 0.5 km (along drainage path)

Catchment Slope Sc= 0.016 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{98.0}{200 - 98.0} = 0.96$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 0.6 0.63 1.02 3.48 = 0.17 hrs

10.0

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.11 hrs

6.71 mins

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0.17 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

0.71	0.76	0.90	0.94	0.97
0.170	0.170	0.170	0.170	0.170
1.946	**2.569**	**7.168**	**12.751**	**23.552**

MAVEN ASSOCIATES	Job Number 215010	Sheet 7	Rev A
Job Title: Sunfield Stage 2 Calc Title: Catchment Summary for Wetland Design 4	Author AO	Date 19/12/2024	Checked 0

Total Area (ha)	Pervious (ha)	%	Impervious (ha)	%
Pre Developmnet	53.5004	100%	0	0%
Post Development	7.7132	14%	45.7901	86%

	Runoff Volume V24 (m3)		Peak Flow Rate (m3/s)		Volume Required
	Pre	Post	Pre	Post	
90th %	1959	9764	0.27	2.27	7805.0
95th %	3578	13575	0.49	0.43	9997.6
2yr	18323	43234	2.78	1.21	24910.8
10yr	43482	80545	6.74	2.15	37063.6
100yr	85207	153863	13.42	3.97	68656.4

Maven Associates		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield SW Pond 4 SMAF Orifice Size Calc	Author YW	Date 13/01/2025	Checked

Detention Volume

3129.00 m^3 *(See SMAF Summary)*

Flow Rate (Q_p) if released over 24 hours

0.03622 m^3/sec (Average Discharge Flow-Rate)

Tank Details

Tank Height 0.130 m
Orifice Height 0.000 m (Above tank base)

Orifice Sizing (to atmo)

$Q_P=0.62*A*(2*G*H_{2/3})^{1/2}$

Q_P 0.03622 m^3/sec (Peak Discharge Flow-Rate)
G= 9.810 m^2/sec
H_T= 0.130 m (Height of water above Discharge Point)
$H_{2/3}$= 0.087 m (Average Head of Water in pond = Two-Thirds of H_T)

A= 0.0447945 m^2 (Cross-Sectional of the Discharge Pipe)

Circular Area Formula

$A=(\pi*D^2)/4$

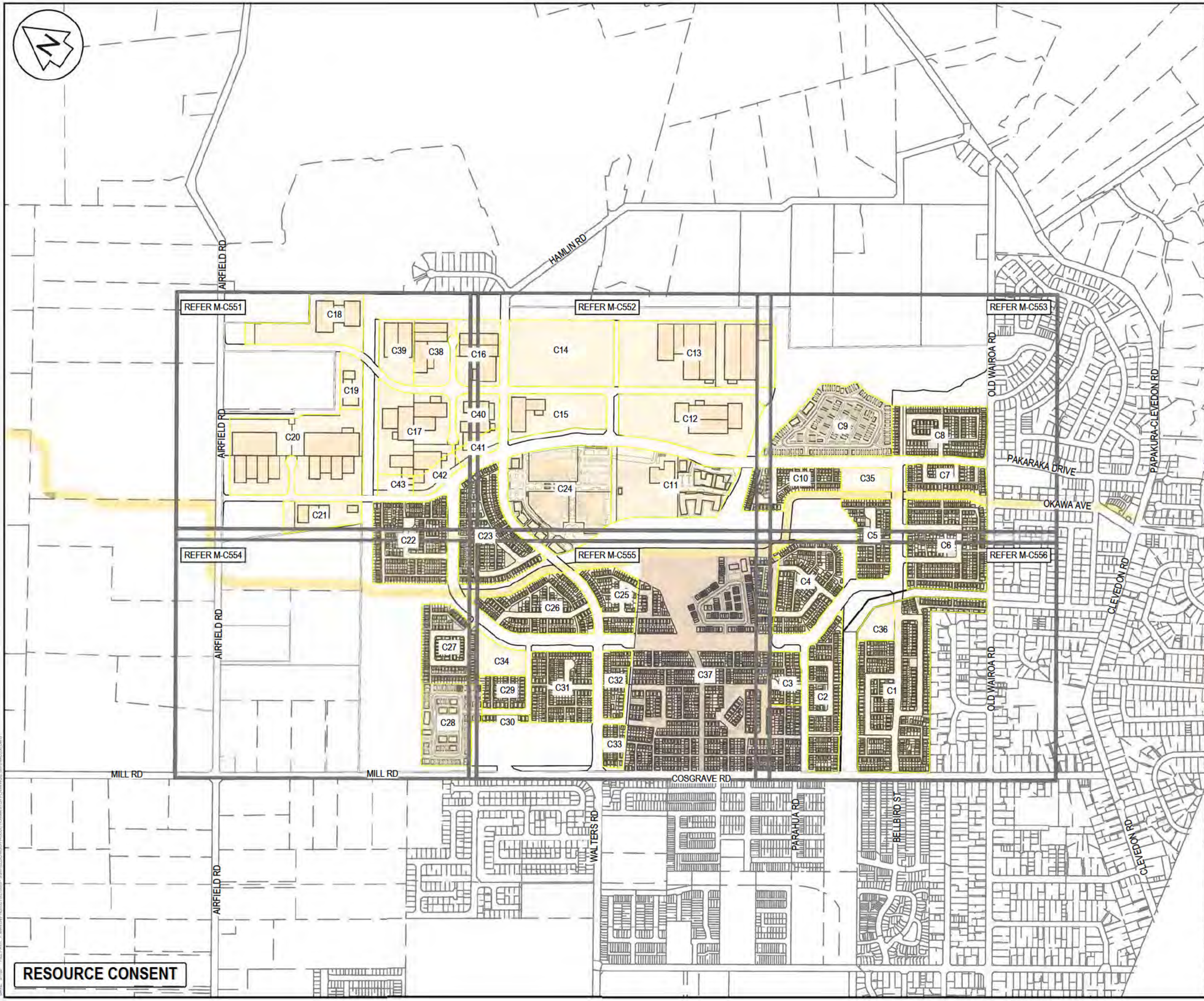
A= 0.0447945 m^2 (Cross-Sectional of the Discharge Pipe)
D= 0.2388182 m (Diameter of Discharge Pipe)

Use 10mm Orifice (minimum size)

238.81816 (Diameter of Discharge Orifice in mm)

Qmax = 0.0724 m^3/sec
Qi (265mm) 0.0446 m^3/sec

APPENDIX D – WASTEWATER DEMAND CALCULATIONS



WASTEWATER NOTES

1. ALL WORKS AND MATERIALS TO COMPLY WITH WATERCARE SERVICES LIMITED CODE OF PRACTICE.
2. ALL PRIVATE DRAINAGE WORKS TO COMPLY WITH THE NEW ZEALAND BUILDING CODE.
3. ALL DRAINAGE WORKS SHALL BE CARRIED OUT UNDER THE SUPERVISION OF A REGISTERED DRAIN LAYER AND IN ACCORDANCE WITH CURRENT HEALTH AND SAFETY PRACTICES. WHERE REQUIRED, DRAINAGE WORKS ARE TO BE UNDERTAKEN BY AN APPROVED LICENSED CONTRACTOR (A.L.C.)
4. ALL ORDINARY TRENCH BACKFILL SHALL COMPRISE SUITABLE EARTHFILL FREE OF TOPSOIL/ORGANICS AND SHALL BE WELL COMPACTED IN LAYERS NOT EXCEEDING 200mm TO ACHIEVE MINIMUM SHEAR STRENGTHS OF 100 kPa / MAX. 10% AIR VOIDS OR AS PER THE EARTHWORKS SPECIFICATION.
5. ALL PIPE CROSSINGS UNDER CARRIAGEWAYS/ TRAFFIC AREAS TO BE HARDFILL BACKFILLED WITH APPROVED GAP65 TO 1.0m BEYOND EXTENT CARRIAGEWAY. TRENCH HARDFILL BACKFILL TO BE WELL COMPACTED TO ACHIEVE MIN. CLEGG HAMMER CIV = 25.
6. COORDINATES IN TERMS OF NZ GEODETIC DATUM MT EDEN 2000. LEVELS IN TERMS OF THE NZVD 2016
7. IT IS THE CONTRACTORS RESPONSIBILITY TO LOCATE ALL SERVICES THAT MAY BE AFFECTED BY THEIR OPERATIONS.
8. PIPE BEDDING: 0 - 10% GRANULAR BEDDING,10 - 20% WEAK CONCRETE BEDDING,GREATER THAN 20% WEAK CONCRETE BEDDING (7MPA PLUS ANTI SCOUR BLOCKS AT 6M CRS).
9. EACH CONNECTION SHALL BE MARKED BY A 50MMX50MM TREATED PINE STAKE EXTENDING 600MM ABOVE GROUND LEVEL WITH THE TOP PAINTED. THIS MARKER POST SHALL BE PLACED ALONGSIDE A TIMBER MARKER INSTALLED AT THE TIME OF PIPELAYING AND EXTENDING FROM THE CONNECTION TO 150MM BELOW FINISHED GROUND LEVEL. CONNECTIONS SHALL BE ACCURATELY INDICATED ON "AS BUILT" PLANS.

LEGEND

- EX BDY
- PR BDY
- WASTEWATER CATCHMENT
- NEIGHBORING SITE WASTEWATER CATCHMENT

Rev	Description	By	Date
A	RESOURCE CONSENT	RK	02/2025

	By	Date
Survey	SURVEYWORX	02/2021
Design	CE	11/2024
Drawn	RK	01/2025
Checked	JP/LC	02/2025

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5 Owens Road, Epsom
Auckland 1023

Project

SUNFIELD DEVELOPMENT ARDMORE, AUCKLAND MASTERPLANNING FOR SUNFIELD DEVELOPMENTS LIMITED

Title

PROPOSED OVERVIEW WASTEWATER CACTHMENT PLAN

Project no.	215010
Scale	1:10000 @ A3
Cad file	215010-M-C550.DWG
Drawing no.	M-C550
Rev	A

	Maven Associates	Job Number	Sheet	Rev
		215010	1	A

		Author	Date	Checked
Job Title	SUNFEILD			
Calc Title	Wastewater Demand	RK	31/01/2025	JP

As per Watercare standards:

Residential

Discharge Rates — 3 people per dwelling
Average dry weather flow = 180 litres/person/day

Retail/ Retirement Village Office

Discharge Rates — Average dry weather flow = 1 litres/ha/sec

Industrial

Discharge Rates — Average dry weather flow = 4.5 litres/m2/day

Health Care and Towncentre

Discharge Rates — Average dry weather flow = 15.0 litres/day/m2

PWWF(1.2 LPS Peaking Factor)

CATCHMENT		DWELLINGS	PERSONS	AREA (Ha)	ADWF l/s	PWWF l/s	TOTAL PEAK FLOW FROM CATCHMENT l/s
SL1	Residential	350	1050		2.19	2.63	
	Retail hub			0.90	0.90	1.08	3.71
SL2	Residential	209	627		1.31	1.57	1.57
SL3	Residential	330	990		2.06	2.48	
	Retail Hub			0.95	0.95	1.14	3.62
SL4	Residential	96	288		0.60	0.72	0.72
SL5	Residential	164	492		1.03	1.23	1.23
SL6	Retriement village residential	221	663		1.38	1.66	
	Retriement village office			0.09	0.09	0.11	1.77
SL7	Health Care and Towncentre			4.02	6.98	8.38	8.38
SL8	Residential	203	609		1.27	1.52	1.52
SL9	Residential	219	657		1.37	1.64	1.64
SL10	Residential	150	450		0.94	1.13	1.13
SL11	Residential	344	1032		2.15	2.58	
	Retail Hub			1.27	1.27	1.53	4.11
SL12	Retriement village residential	89	267		0.56	0.67	
	Retriement village office			0.39	0.39	0.47	1.14
SL14	Residential	109	327		0.68	0.82	0.82
SL15	Residential	85	255		0.53	0.64	0.64
SL16	Industrial			2.03	1.06	1.27	1.27
SL17	Industrial			7.99	4.16	4.99	4.99
SL18	Industrial			0.93	0.48	0.58	0.58
SL19	Industrial			4.42	2.30	2.76	2.76
SL20	Industrial			2.87	1.50	1.80	1.80
SL21	Industrial			2.81	1.46	1.75	1.75
SL22	Residential	215	645		1.34	1.61	1.61
Neighbouring Site	Residential	1216	3648		7.60	9.12	
	Retail Hub			2.87	2.87	3.44	12.56
					Total Peak Flow from Site		**59.31**

APPENDIX E – LPS PRELIMINARY DESIGN REPORT

ecoflow

Preliminary Design Report

Project Name: ***Sunfield***
Prepared by: ***Jon McGettigan***
Date: ***16 December 2024***

e one
SEWER SYSTEMS

Attn: **Jignesh Patel**

Dear Jignesh,

Thank you for the opportunity to provide a preliminary design for the proposed low-pressure sewer (LPS) system at Sunfield. You will find included with this report, the Hydraulic calculations, Retention Times calculations and Layout drawings.

Network Design and Operation

This project consists of six phases with a mix of commercial and residential units. Flows per phase have been calculated based on the information provided. Each zone in the E/One hydraulic model has a portion of different phases, this is tabulated in the design section. This is a high-level design proving concept and indicating the pipe diameters for the main lines. Further detail is required for the smaller mains connecting the streets within each phase.

Design Parameters

The E/One Design Software is utilising the probability method was used in this preliminary design.

The following design parameters were adopted:

- Pump type = E/One Extreme series semi-positive displacement pump.
- Pump requirements = 230V, 50 Hz single phase
- Friction loss formula is Hazen-Williams with a C factor of 150
- Pipe type is Polyethylene, PE100, PN16, SDR 11 (All diameters measured OD)
- Minimum Scouring velocity of 0.6m/s

Please note the following is a "Preliminary" design report carried out in accordance with the Pressure Sewer Code of Practice WASA-07 (Water Services Association of Australia 2007) and the New Zealand Pressure Sewer National Guidelines.

Note: The following analysis is based specifically on the pump performance curve of the E/One semi positive displacement pump. The analysis does not apply where other pumps are substituted for this project.

Peak Flows

The Probability Method was developed and subsequently used to determine peak flow rates in pressure sewerage systems. This method was developed specifically for the E/One semi-positive displacement pump operating characteristics with their near vertical Head vs Quantity (HQ) performance curve.

Ecoflow determine the peak flow rate in each pipe segment and calculate the following:

- Friction head in each segment
- Static head for each pressure sewer unit
- Resulting total dynamic head for each pressure sewer unit

A key assumption in the recommended design procedure is Maximum Number of Pressure sewer unit Cores Operating Daily and the predicted maximum daily number of pumps running at once vs. the number of pumps connected.

As demonstrated in the hydraulic analysis outputs, the probability method determines a peak wastewater flow rate for the equivalent lots connected.

Maximum Desirable Total Dynamic Head

Design is integrally associated with knowledge of the pumps being used. The prime example of this is the maximum total dynamic head (TDH) that is chosen in the design process. Even though the E/One semi-positive displacement grinder pump can lift to over 100m, the total design dynamic head is limited to 56m TDH. This prolongs grinder pump life and enables known or unknown future connections into the network.

Infiltration Allowance

Infiltration factors are not normally used in the calculation of peak flow in a pressure sewerage system provided there is confidence of the water tightness of the house gravity wastewater pipe network.

The simultaneous pump operations method of determining peak flows does not include a component for excessive infiltration/inflow. It has been standard practice and recommendation, that proactive means be employed to eliminate the potential for significant Inflow and Infiltration. This has typically been accomplished by exercising control over the "water-tightness" of the private facilities. This would include inspecting the house plumbing at the time of house construction / connection and requiring that any faulty drainage works be rectified.

Because the Low-Pressure Sewer networks are constructed with sealed polyethylene PE pipe, and connections carried out with fusion welds, they are not susceptible for groundwater or surface drainage to creep in. Therefore, a completely pressurised collection system will, for all practical purposes, ignore infiltration flows and deliver only the intended wastewater stream to the treatment plant. Regardless, due to the hydraulic flexibility of the system and the design, pressure sewer systems can generally tolerate infiltration without impact to system performance.

Retention Time Analysis

Pipe diameters have been sized as small as possible to reduce volume and retention times. At full build out accumulated retention times for all zones are less than 1hr. This also increases the velocity which helps with self-scouring.

Flushing

Flushing may be required during initial build out. The worst case will be phase 2 commercial area, the main line passes through future phase 5 and 6 before the discharge point, the main has been sized to accommodate flows from phase 5 & 6. Depending on the timeframe for phase 5 & 6, it may be beneficial to install a dedicated main just for phase 2 and a redundant main for phase 5 & 6. This would mean zones 10, 12 and 14 can be sized smaller and reduce the requirement for flushing. Other phases operate efficiently once the phase is complete.

Air Management

Further analysis for air valves is required at the detailed design stage, but given the flat topography, air valves will be minimised.

Pipe Materials

Ecoflow recommend PE100 SDR11 PN16 for the low-pressure sewer mains. This is consistent with the New Zealand National Pressure Sewer Guidelines.

Isolation Valves

It is common practise for the contractor to follow the local guidelines with respect to material type as per the Council approved materials lists. Standard Low pressure Sewer options would recommend typical gate valve such as AVK or similar https://www.humes.co.nz/valves-and-fittings/resilient-seated-gate-valves/

Product Information

Grinder Pump

The E/One Extreme progressive cavity grinder pump is specifically designed for use in low-pressure sewer systems. The grinder pump is designed for reliability, ease of installation, and ease of serviceability. The grinder pump features integrated start controls and level sensing controls. This enables nearly all troubleshooting and repair to occur on the grinder pump itself. The entire unit can be quickly and easily exchanged in the event a fault cannot be quickly rectified on site. Full diagnostics and repair can occur at a service centre. The grinder pump has a large diameter grinding mechanism which creates low inlet velocity. Low inlet velocity contributes to the market leading grinder performance as demonstrated by the certification by NSF to the ANSI/NSF 46-2020 standard.

E/One Level Sensors

The E/One pump has all starting/stopping & alarm controls within the pump (core) unit to minimise on site fault finding, this also means there is nothing external to the pump which will require attention such as level switches/probes/transducers etc. This arrangement is specifically designed that way to ensure when there is an issue it is most likely within the pump (core), which is the easily replaceable component. All pumps within the system are interchangeable.

Control Panel

The E/One Sentry Protect Plus control panel is recommended to be used for the grinder pumps in this area.

Other features of the E/One Sentry Protect package include:

- Power-on delay to stagger starts following a power outage
- Trouble indication that shuts down the pump temporarily in the event of an unacceptable operating condition - brownout, system over-pressure and run-dry
- Predictive status display module
- Hour meter, cycle counter and alarm delay
- LCD display and user-friendly interface
- Inner cover (dead front)
- Contact group — dry, powered contacts for remote alarming/monitoring
- Audible and visual alarm including a silence button
- Generator port (optional)

- Remote monitoring (optional)

Pump Chamber

The pump chamber is made of high-density polyethylene of a grade selected for environmental stress cracking resistance. Tanks are manufactured to AS/NZS 1546.1.1998 and have been tested to twice the hydrostatic load that this specification requires. The tank provides 24hrs storage. Design life is 50 years.

Boundary Kit

The Boundary kits are constructed of 316 stainless steel and consist of an isolating ball valve, non-return valve and inspection tee all housed within polyethylene toby box. The E/One Boundary kit is pressure tested to 16Bar and is serialised for traceability. Ecoflow use stainless steel to polyethylene EF transition fitting to weld 40mm stubs at either end to simplify installation.

Operational Information

E/One Grinder Pump Maintenance

The E/One grinder pump has a design life of 25 years. Based on data from E/One's 850,000 unit install base there are many E/One grinder pumps still in operation after almost 50 years.

The E/One Extreme series grinder pump is designed as per any other home appliance, which is "run to failure". This means there is no requirement for annual inspections.
From previous operating data a mean time between service calls (MTBS) of 10 years can be expected.

$$MTBSC = \frac{Number\ of\ Grinder\ Pumps\ In\ Operation\ x\ Period\ of\ Time\ (years)}{Number\ of\ Service\ Calls\ During\ Period\ of\ Time}$$

For Example: With a 10 year MTBSC, a system with 100 E/One grinder pumps operating should experience approximately 10 service calls per year (not due to misuse, abuse, or installation defects)

The pump is strategically engineered to have low cost wearing components to ensure increased longevity of the operation. These components generally require replacement between 1,200 – 1,500 hours.

Please feel free to contact us if you have any queries relating to these preliminary designs or require any further information.

Kind Regards,

Jon McGettigan
Director

Calculations for daily flow per phase and the commercial/residential split per zone

Development Site using LPS				
Residential		Dwellings	People	
		3240	3	
Discharges		Persons	Rate l/p/day	Flow l/s
	ADWF	9720	180	20.25
Retirement		Dwellings	People	
		560	3	
Discharges		Persons	Rate l/p/day	Flow l/s
	ADWF	1680	180	3.50
Light Industrial		Ha		
GFA		22.92		
Discharges		Ha	Rate l/m2/day	Flow l/s
	ADWF	22.92	4.5	11.94
Retail, Town Centre & Health Care		Ha		
GFA		33.5		
Discharges		Ha	Rate l/ha/s	Flow l/s
	ADWF	33.52	1	33.52
Schools		Students	Rate l/person/day	
		2000	45	
Discharges		Persons	Rate l/person/day	Flow l/s
	ADWF	2000	45	1.04
	ADWF			70.25

Zone	Explanation	Number of Pumps	daily flow/pump (L/day)
1	50% of phase 4	238	6486
2	50% of phase 3	248	846
3	2/3 of phase 1	598	588
4	50% of phase 3 + 1/3 of phase 1	547	710
5	Assume no connections	0	0
6	50% of future portion	384	783
7	Assume no connections	0	0
8	100% of phase 2	107	6485
9	25% of phase 4	119	6501
10	25% of phase 4 + 1/3 of phase 5	257	3295
11	2/3 of phase 5	277	541
12	1/3 of phase 6	244	697
13	50% of future portion	384	1084
14	2/3 of phase 6	489	695
15		0	0

Note - For Commercial areas assume one pump does 6500l/day

Land Use	PHASE 1 - No. - GFA or Building Coverage	Phase 1 pumps (for commercial assume each pump does 6500l/day)	Daily flow phase 1 (L)	PHASE 2 - No. - GFA or Building Coverage	Phase 2 pumps (for commercial assume each pump does 6500l/day)	Daily flow phase 2
Residential	897 units	897	484380			
Aged Care						
Employment/Light Industrial (warehouse and office)				15.42 ha GFA	107	693900
Town Centre - Retail						
Education - School						
Local Hub - Retail	0 91ha site area - 0.5ha GFA	7	43200			
Health Centers						
Total Pumps		904	527580		107	693900

Land Use	PHASE 3 - No. - GFA or Building Coverage	Phase 3 pumps (for commercial assume each pump does 6500l/day)	Daily flow phase 3 (L)	PHASE 4 - No. - GFA or Building Coverage	Phase 4 pumps (for commercial assume each pump does 6500l/day)	Daily flow phase 4 (l)
Residential	476 units	476	257040			
Aged Care	227	19	122580			
Employment/Light Industrial (warehouse and office)				7.5ha GFA	52	337500
Town Centre - Retail				30 ha GFA	399	2592000
Education - School				1 unit/ 0.38 ha building coverage (2000 Students)	14	90000
Local Hub - Retail	0.94ha site area - 0.52ha GFA	7	44928			
Health Centers				5 units/ 0.79 ha GFA	11	68256
Total Pumps		502	424548		475	3087756

PHASE 5 - No. - GFA or Building Coverage	PHASE 6 - No. - GFA or Building Coverage	Phase 6 pumps (for commercial assume each pump does 6500l/day)	Daily flow phase 6	For portion outside our site but in master plan	Portion outside - pumps (for commercial assume each pump does 6500l/day)	Daily flow future portion
416 units	714 units	714	385560	737 units	737	397980
	133 units	11	71820	200 units	17	108000
	1.1ha site area - 0.61ha GF	8	52704	2ha site area - 1.1ha GFA	15	95040
		733	510084		768	601020

PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS

Prepared By:

Sunfield

December 17, 2024

Zone Number	Connects to Zone	Number of Pumps in Zone	Accum Pumps in Zone	Liters/Day per Pump	Max Flow Per Pump (lps)	Max Sim Ops	Max Flow (LPS)	Pipe Size (mm)	Max Velocity (MPS)	Length of Main this Zone	Friction Loss Factor (m/100m)	Friction Loss This Zone	Accum Fric Loss (meters)	Max Main Elevation	Minimum Pump Elevation	Static Head (meters)	Total Dynamic Head (m)
This spreadsheet was calculated using pipe diameters for: SDR11PE100										Friction loss calculations were based on a Constant for inside roughness "C" of: 150							
1.00	2.00	238	238	6500	.46	12	5.56	110.00	0.89	382.00	0.88	3.37	40.83	5.00	0.00	5.00	45.83
2.00	3.00	248	486	846	.49	20	9.52	125.00	1.19	553.00	1.29	7.13	37.46	5.00	0.00	5.00	42.46
3.00	5.00	598	1,084	588	.54	38	19.41	160.00	1.46	1,072.00	1.41	15.15	30.33	5.00	0.00	5.00	35.33
4.00	5.00	547	547	710	.53	22	11.67	125.00	1.46	880.00	1.88	16.55	31.73	5.00	0.00	5.00	36.73
5.00	7.00	0	1,631	540	.65	54	27.94	180.00	1.69	335.00	1.63	5.46	15.18	5.00	0.00	5.00	20.18
6.00	6.00	384	384	783	.67	17	11.44	110.00	1.84	350.00	3.35	11.73	11.73	5.00	0.00	5.00	16.73
7.00	15.00	0	1,631	540	.68	54	27.94	180.00	1.69	250.00	1.63	4.08	9.72	5.00	0.00	5.00	14.72
8.00	10.00	107	107	6500	.54	8	4.31	110.00	0.69	660.00	0.55	3.63	31.05	5.00	0.00	5.00	36.05
9.00	10.00	119	119	6500	.55	9	4.96	110.00	0.80	275.00	0.71	1.96	29.38	5.00	0.00	5.00	34.38
10.00	12.00	257	483	3295	.56	20	11.10	140.00	1.09	365.00	0.95	3.47	27.42	5.00	0.00	5.00	32.42
11.00	12.00	277	277	540	.53	13	6.90	110.00	1.11	630.00	1.32	8.29	32.24	5.00	0.00	5.00	37.24
12.00	14.00	244	1,004	697	.59	35	19.47	140.00	1.91	280.00	2.69	7.54	23.95	5.00	0.00	5.00	28.95
13.00	14.00	384	384	695	.58	17	9.84	110.00	1.58	350.00	2.54	8.88	25.29	5.00	0.00	5.00	30.29
14.00	15.00	489	1,877	695	.64	62	36.13	180.00	2.19	410.00	2.63	10.77	16.41	5.00	0.00	5.00	21.41
15.00	15.00	0	3,508	540	.71	111	61.31	250.00	1.89	415.00	1.36	5.64	5.64	5.00	0.00	5.00	10.64

Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One.

PRELIMINARY PRESSURE SEWER- ACCUMULATED RETENTION TIME(HR)

Prepared By:

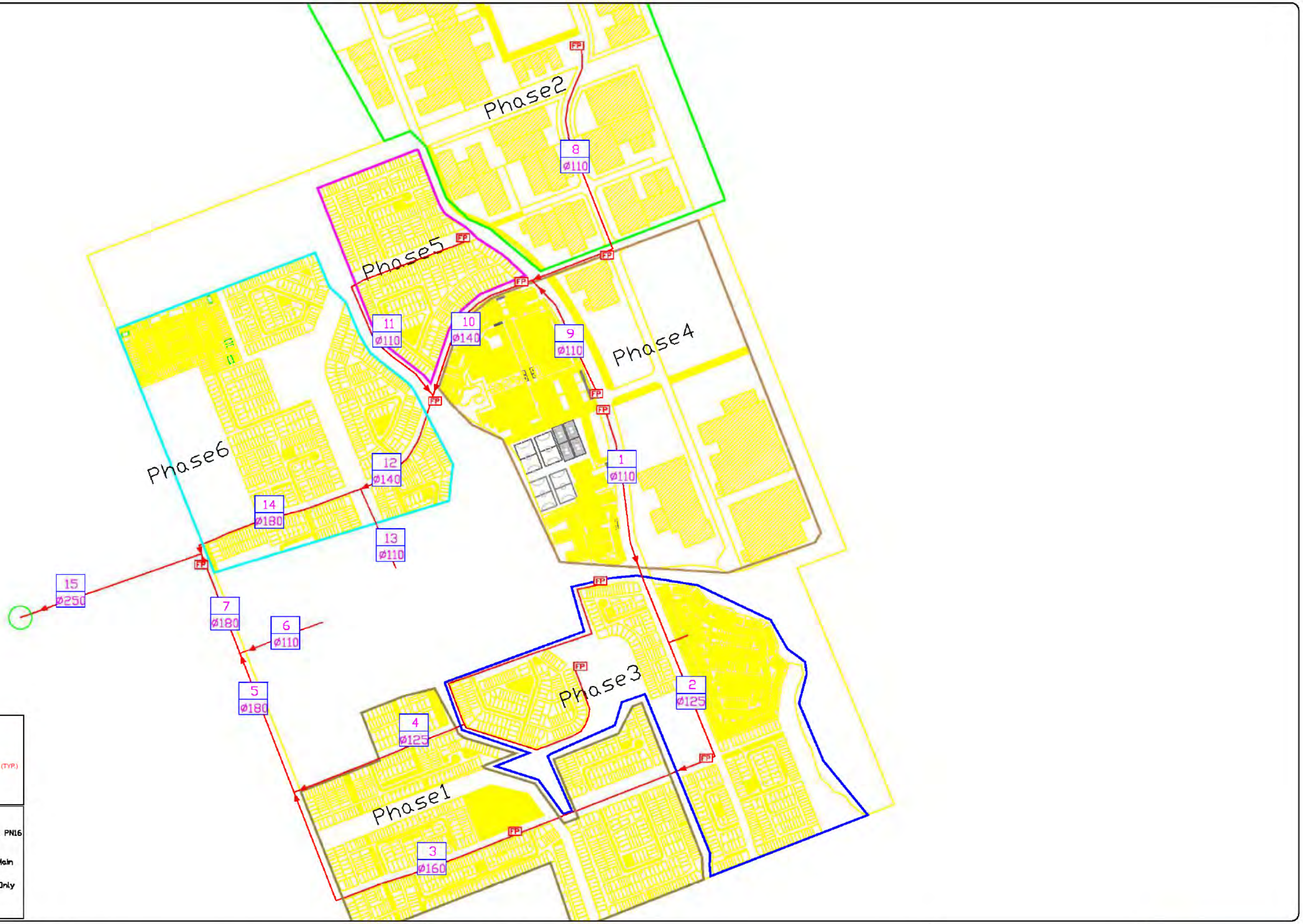
Sunfield

December 17, 2024

Zone Number	Connects to Zone	Accumulated Total of Pumps this Zone	Pipe Size (mm)	Liters per 100 lineal meters	Length of Zone	Capacity of Zone	Average Daily Flow	Average Fluid Changes per Day	Average Retention Time (Hr)	Accumulated Retention Time (Hr)
This spreadsheet was calculated using pipe diameters for: SDR11PE100								Liters per Day per Dwelling		650
1.00	2.00	238	110.00	622.11	382.00	2,376.48	1,547,000	650.96	0.04	0.41
2.00	3.00	486	125.00	801.18	553.00	4,430.55	1,756,808	396.52	0.06	0.37
3.00	5.00	1,084	160.00	1,327.32	1,072.00	14,228.90	2,108,432	148.18	0.16	0.31
4.00	5.00	547	125.00	801.18	880.00	7,050.42	388,370	55.08	0.44	0.58
5.00	7.00	1,631	180.00	1,651.30	335.00	5,531.85	2,496,802	451.35	0.05	0.15
6.00	6.00	384	110.00	622.11	350.00	2,177.40	300,672	138.09	0.17	0.17
7.00	15.00	1,631	180.00	1,651.30	250.00	4,128.25	2,496,802	604.81	0.04	0.10
8.00	10.00	107	110.00	622.11	660.00	4,105.95	695,500	169.39	0.14	0.31
9.00	10.00	119	110.00	622.11	275.00	1,710.81	773,500	452.12	0.05	0.22
10.00	12.00	483	140.00	1,020.70	365.00	3,725.57	2,315,815	621.60	0.04	0.17
11.00	12.00	277	110.00	622.11	630.00	3,919.32	149,580	38.16	0.63	0.76
12.00	14.00	1,004	140.00	1,020.70	280.00	2,857.97	2,635,463	922.15	0.03	0.13
13.00	14.00	384	110.00	622.11	350.00	2,177.40	266,880	122.57	0.20	0.30
14.00	15.00	1,877	180.00	1,651.30	410.00	6,770.33	3,242,198	478.88	0.05	0.11
15.00	15.00	3,508	250.00	3,236.55	415.00	13,431.67	5,739,000	427.27	0.06	0.06

Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One

C:\Users\JonMcGettiganEcoflow\Ecoflow Limited\Ecoflow - Quotes North Island and Pacific\Auckland\197 SUNFIELD 6000Lots\Hydraulic.EOne



PROPOSED LPS
E/ONE ZONE NUMBER (TYP.)
E/ONE ZONE DIVIDER/FLOW DIRECTION (TYP.)
ISOLATION VALVE
FP FLUSHING POINT
AV COMBINATION AIR/VACUUM VALVE

Notes:

- All LPS Pipes Shall Be PE100 SRD11 PN16
- All LPS Pipe Sizes Are OD
- LPS Laterals from LPS Tank to Main Shall Be 40mm OD
- This Plan is a Preliminary Design Only
- Locations Are Indicative Only

ecoflow
Sewer Made Simple

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CHRISTCHURCH
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Hornby, Christchurch
Ph (03)349-2506

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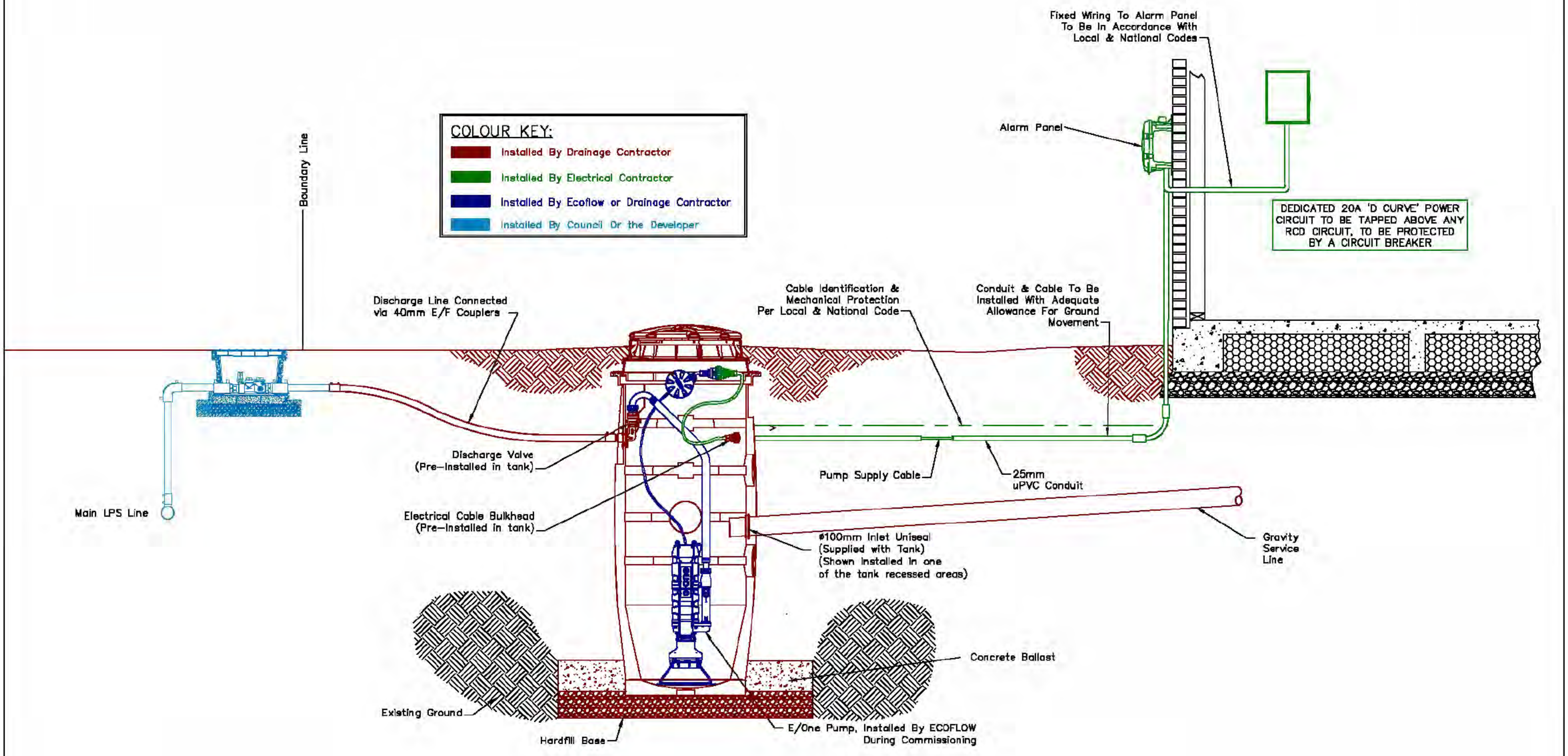
Email: info@ecoflow.co.nz

DRAWN	JM	13/12/24
CHECKED		
CLIENT APPROVED		
CLIENT	Maven	

TITLE
Sunfield
Low Pressure Sewer
Preliminary Design

Job		
REVISION	SCALE	Dwg No.
1	NTS AT	1

ENVIRONMENT ONE



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Sewer Made Simple

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CLIENT		

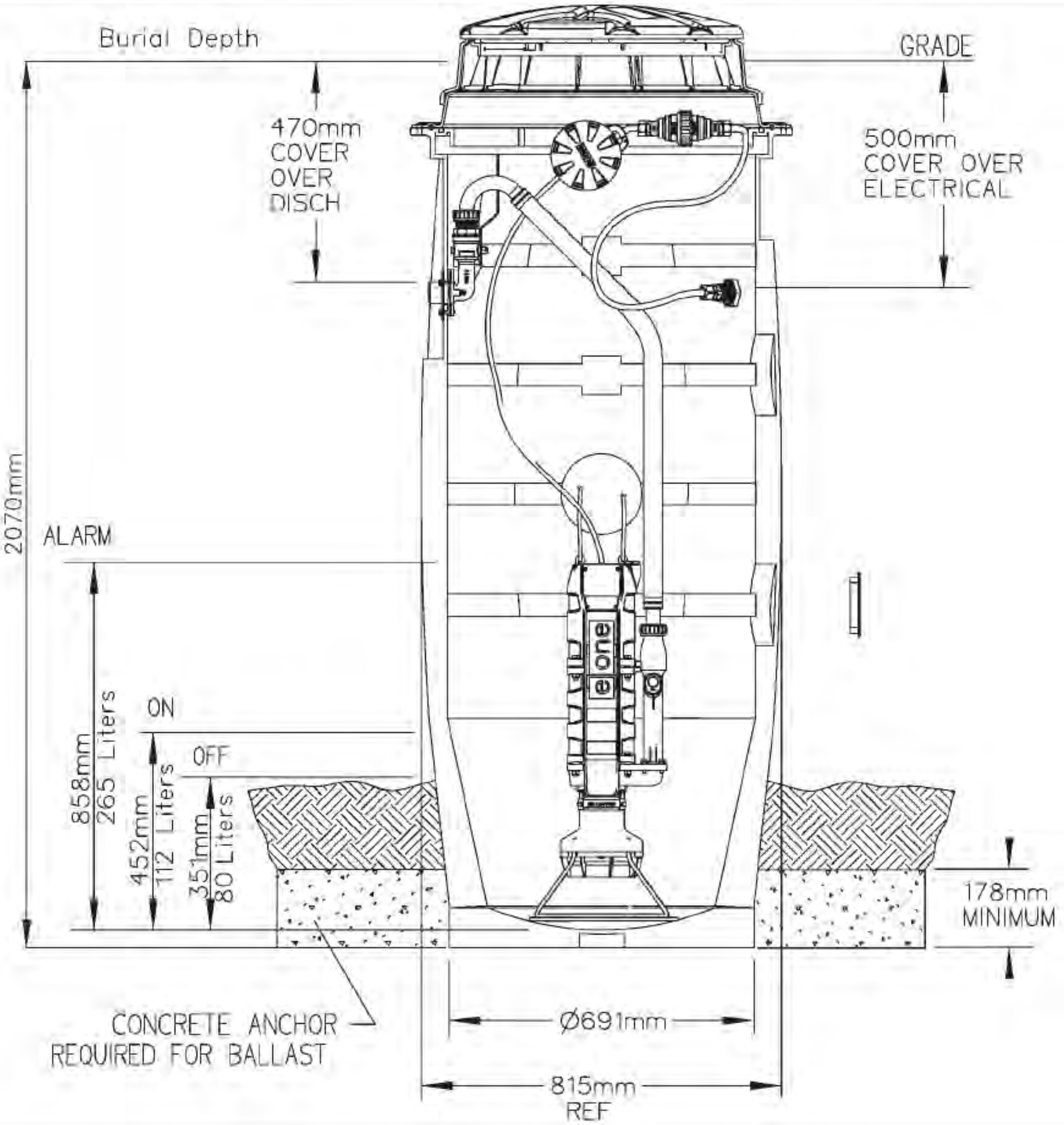
TITLE

System Layout

Environment One Simplex 2010iP

Job		
REVISION 1	SCALE NTS AT	Dwg No. 1

eone SEWER SYSTEMS



Pump	
Motor Type	Single Phase, 240V, 50Hz, 0.75kW
Standards	NSF46, AS/NZS 60335.2.41:2004
Pump Type	Helical Rotor, Semi-positive Displacement
Design Head	56m
Pump Flow	0.4 l/s @ 55m TDH 0.75 l/s @ 1m TDH
Speed	1450 rpm
Starting Current	26.4 Amps
Starting Torque	15.6 Nm
Check Valve	Proprietary Swing Check Valve
Anti-siphon Valve	Proprietary integral anti-siphon / Check Valve
Controls	Pressure Switch – On/Off & Alarm

Tank	
Material	High Density Polyethylene
Standards	As/NZS 1546.1:1998
Cover Loading	500kg Point Load in Centre of Lid
Capacity Total	720 Litres

Controller	
Rating	IP56
Audible Alarm	Yes
Visual Alarm	Yes
Protection	Low Voltage, Over Pressure and Dry Run
Information	Hours Run, Max/Min/Avg A, V, Run time

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16b Piermark Drive, North Harbour (NZ)
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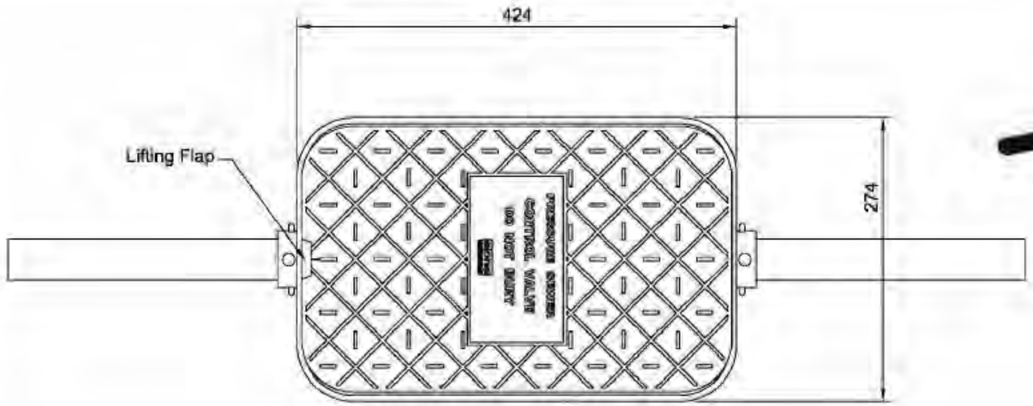
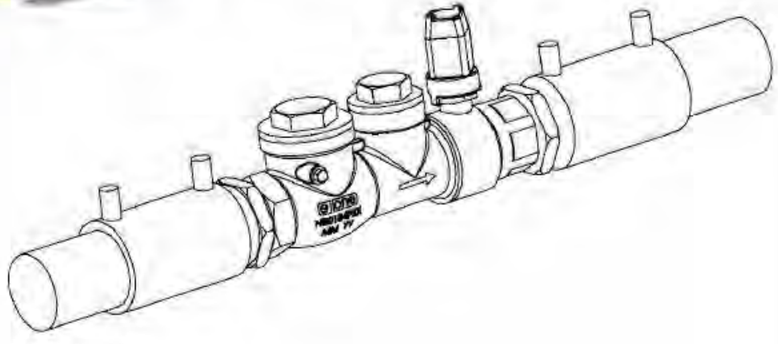
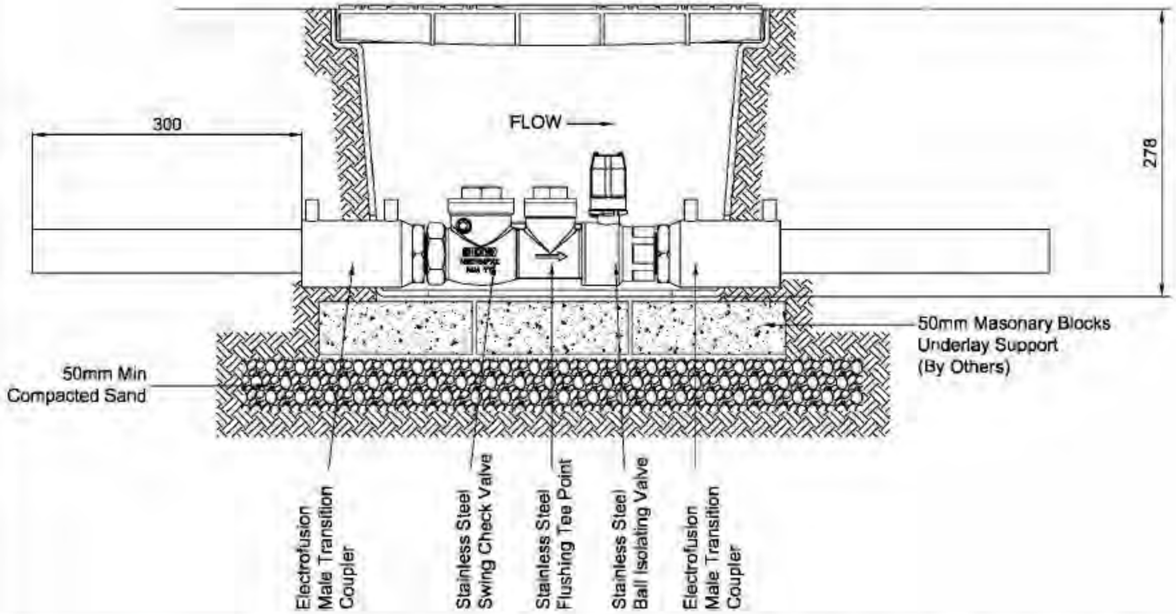
Environment One Simplex 800x2000iP

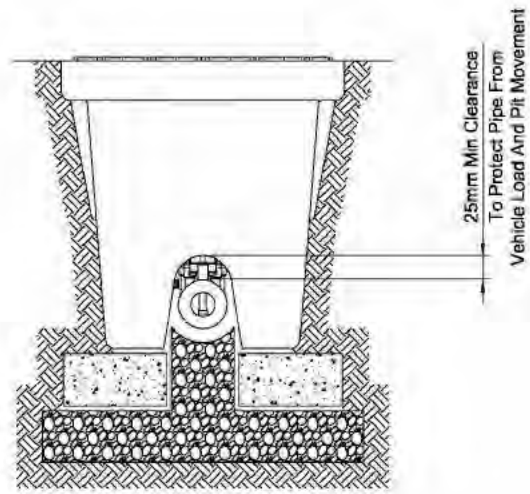
e one SEWER SYSTEMS





Each boundary kit supplied with
300mm length DN40 PE100 PN16 stubs
each end E/F welded and complete unit pressure
tested to 16 Bar by Ecoflow





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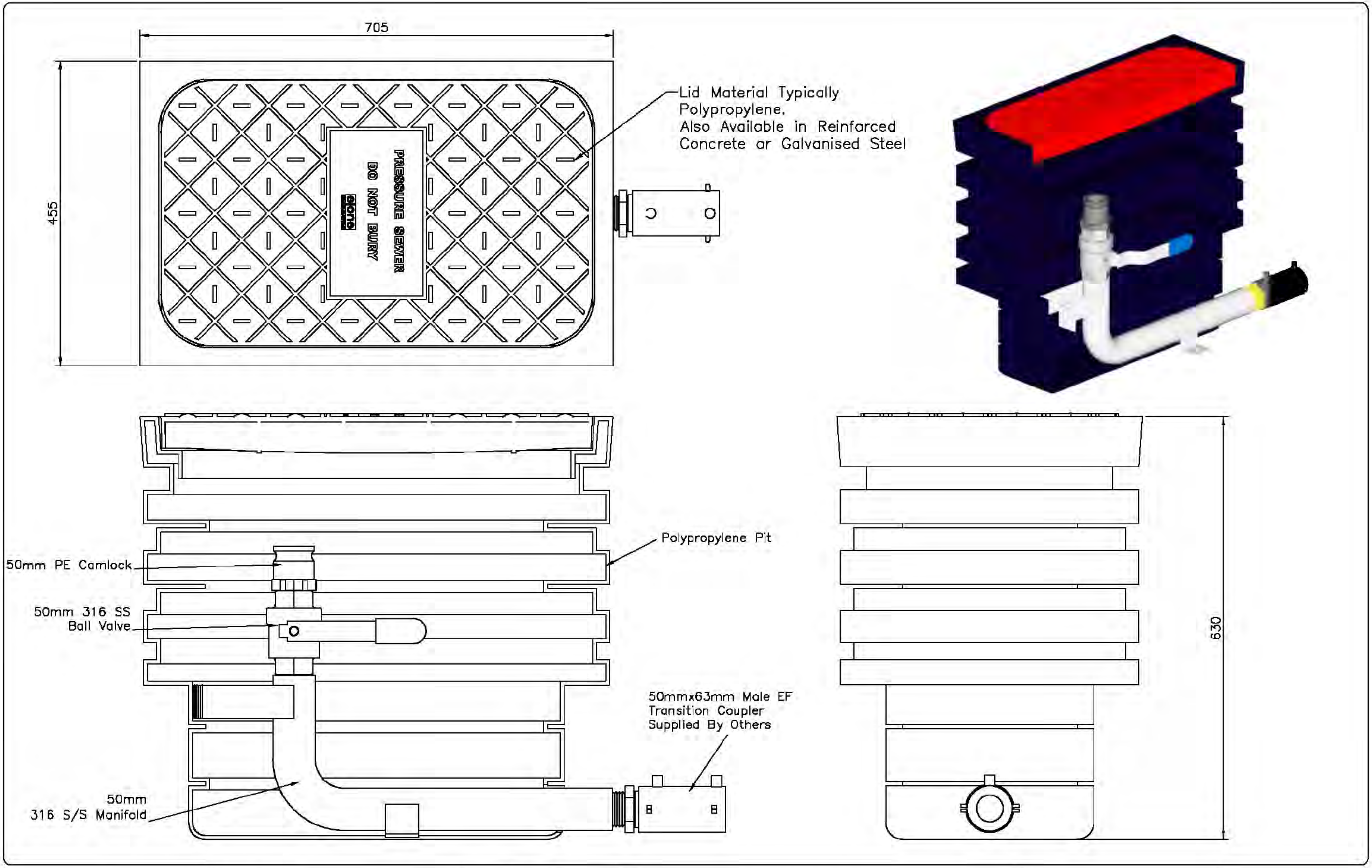
	BY	DATE
DRAWN	MC	17/1/13
CHECKED	JM	17/1/13
CLIENT APPROVED		

TITLE
Environment One - Boundary Kit
With Extended Stubs
New Zealand Standard

CLIENT

SCALE 1:20 AT A3

REVISION | Job | Dwg No.



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CLIENT	

TITLE

Environment One
Flushing Point
New Zealand Standard

Job			
REVISION	SCALE		Dwg No.
1	NTS	AT	1

eone SEWER SYSTEMS

ecoflow

SEWERS MADE SIMPLE

ENGINEERS | DEVELOPERS | COUNCILS

WHY ECOFLOW?

OUR TRACK RECORD

Over the last 15 years, Ecoflow has installed more than 20,000 E/One pressure sewer systems throughout New Zealand. We have helped engineers and councils design the pressure sewer systems found in many developments across the country.

WORLD-LEADING TECHNOLOGY

Ecoflow exclusively use E/One pumps, internationally recognised as the industry leader for pressure sewer systems.

TRUE SPECIALISTS

Ecoflow is a true specialist - pressure sewer systems are what we know and all we do. We get involved in every aspect of the implementation process, from community consultation, through to commissioning and ongoing support.

WE'RE DOWN-TO-EARTH

Ecoflow is a New Zealand-owned and operated company, with the original founders still working on every aspect of the business. Don't be surprised if you see them out in the field during an installation and talking with building company staff.

TOTAL RESPONSIBILITY

Being a small New Zealand-owned company, we're passionate, pro-active and supportive of every pressure system design and installation we do.

EXCELLENCE IN SERVICE

No matter where our customers are in New Zealand, Ecoflow is there to support them.

SERVICES

DESIGN

For your next project, Ecoflow can offer free hydraulic design, pipe layout and costings to assist with your option study.

AUDIT

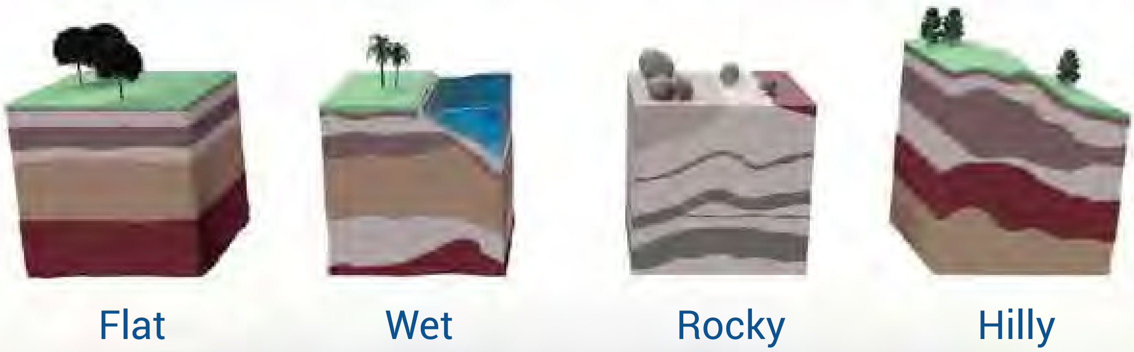
Ecoflow can monitor your existing pressure sewer network to give you a better idea of performance. From the data collected, we can confirm design assumptions, estimate additional capacity, assess how the network is operating in terms of self-scouring and now, with use of smart pump controllers, we can manipulate flows to achieve better efficiencies and weed out sources of infiltration.

MAINTENANCE

Ecoflow exclusively use E/One pumps, which are designed to last in excess of 25 years in a corrosive wastewater environment. With more than 650,000 grinder pumps operating in 40 countries, E/One pumps have an international reputation for being reliable and robust, with minimal maintenance needed. If a pump does need a service, no matter where in New Zealand, Ecoflow is there to provide the necessary support.

PROJECT MANAGEMENT

Ecoflow's in-house project managers can assist with the implementation of your pressure sewer network. Tap into our field experience to ensure your project is delivered without a hitch.



WHY CHOOSE PRESSURE SEWER OVER GRAVITY?

Wastewater treatment and infrastructure is an essential part of any community. However, traditional gravity sewer systems are not the most appropriate or cost-effective solution in difficult ground conditions. Fall requirements for adequate flow by gravity may require deep excavations in hilly or flat terrain and additional expensive pump stations may be needed.

On the other hand, a Pressure Sewer System consists of an E/One grinder pump at each property pumping into a network of small-diameter, heavy-duty polyethylene pipe, which can be installed shallow and follow the contours of the land. Because the network is sealed it eliminates inflow and infiltration. This means peak wet weather design flows can be reduced. The catchment will be less of a burden on downstream existing (often ageing) infrastructure. The network is also more resilient to ground movements and is easily accessible for maintenance.

Ecoflow is New Zealand's leading supplier of Pressure Sewer Systems. With an E/One grinder pump, Pressure Sewer Systems provide a far more reliable, controllable transfer of wastewater from the household to the treatment plant than conventional methods

Pressure Sewer Systems are becoming increasingly popular amongst council asset managers, engineering consultants and developers thanks to the advantages and cost savings they offer over traditional gravity systems.

Plus, upgrading to smart controllers that communicate via a cellular network to an online portal gives councils complete control of their pressure sewer networks. This means councils can monitor and control the network, reduce peak flows, hold back pumping during storm events and offer a higher level of service to the homeowner.

BENEFITS OF AN E/ONE PRESSURE SEWER SYSTEM

Sealed system, no infiltration – lower impact on treatment plant capacity

Minimal maintenance – no manholes or large public pump stations

More resilient to seismic activity such as ground movement and liquefaction

24 hours of storage for each home

Difficult ground conditions – a Pressure Sewer System is suitable for flat, wet, rocky and hilly conditions

Lower cost of reticulation – lower material costs and shallower trenching

e one
SEWER SYSTEMS

Dependable, reliable: over 650,000 units, 40 countries

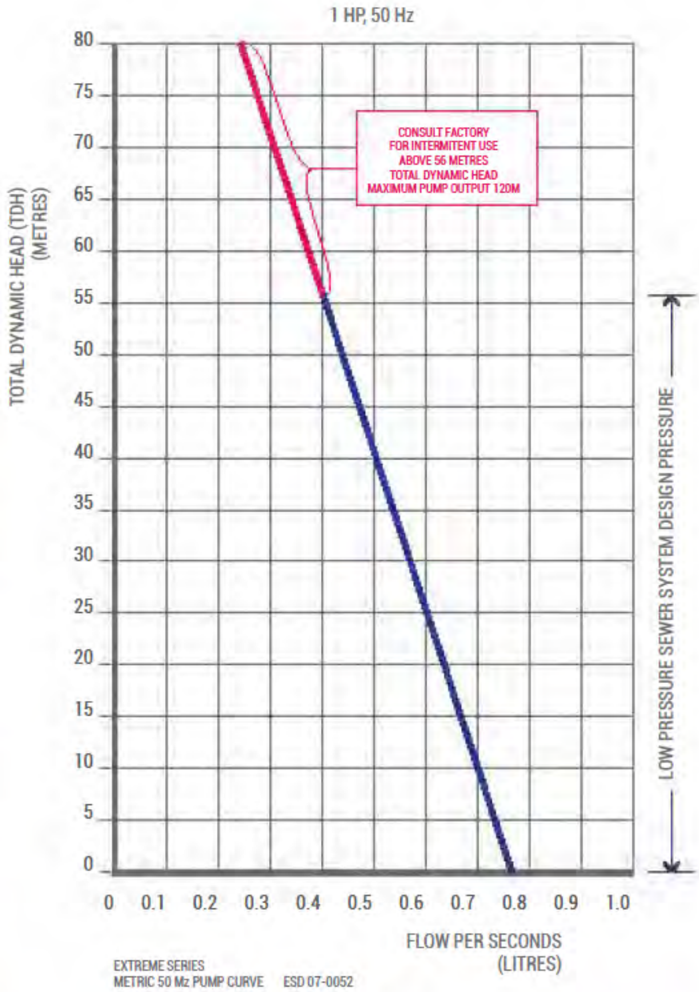
E/One's semi-positive displacement (SPD) grinder pump was developed specifically for pressure sewer systems. Its constant, predictable flowrate over a wide range of pressure provides the network designer with confidence, and the E/One pump's ability to pump at high head provides reserve hydraulic capacity and ultimately reduces design risk. It has benefited from nearly 50 years of fine-tuning and improvement. With over 650,000 units in 40 countries, the larger diameter, low velocity, high torque grinder offers market-leading reliability you can depend on.

How the E/One works

All household wastewater flows to the underground chamber, which is sized to include 24hrs emergency storage. At the heart of the station is the E/One grinder pump.

Pressure sensors in the head of the pump signal the controller to activate the pump at a predetermined level. E/One's low speed, high torque, 133mm cutter wheel has reduced inlet velocity, which slowly introduces the debris into the cutter and is less likely to jam, bind or suffocate.

Wastewater is then pumped via progressive cavity rotor and stator. The precision cast and polished stainless-steel rotor can pump many kilometres to the discharge point or treatment plant, reducing the need for lift stations.



Grinder Pump Performance Curve

PRODUCTS

CHAMBER OPTIONS

E/One Simplex 2010iP – single pump

Designed for residential dwellings.

- Standard storage flows
- Diameter (mm): 815
- Height (mm): 2130
- Weight (kg): 74
- Total Capacity (L): 718

E/One Duplex 2014iP – dual pump

Designed for commercial or industrial areas.

- Greater storage/flows
- Diameter (mm): 1140
- Height (mm): 2030
- Weight (kg): 132
- Total Capacity (L): 1337

Custom T Tank – multiple pump systems

Designed for commercial or industrial areas.

Custom design storage/flows

Ecoflow can design a system solution that meets your storage/ flow rate needs

INTELLIGENT PRESSURE SEWER

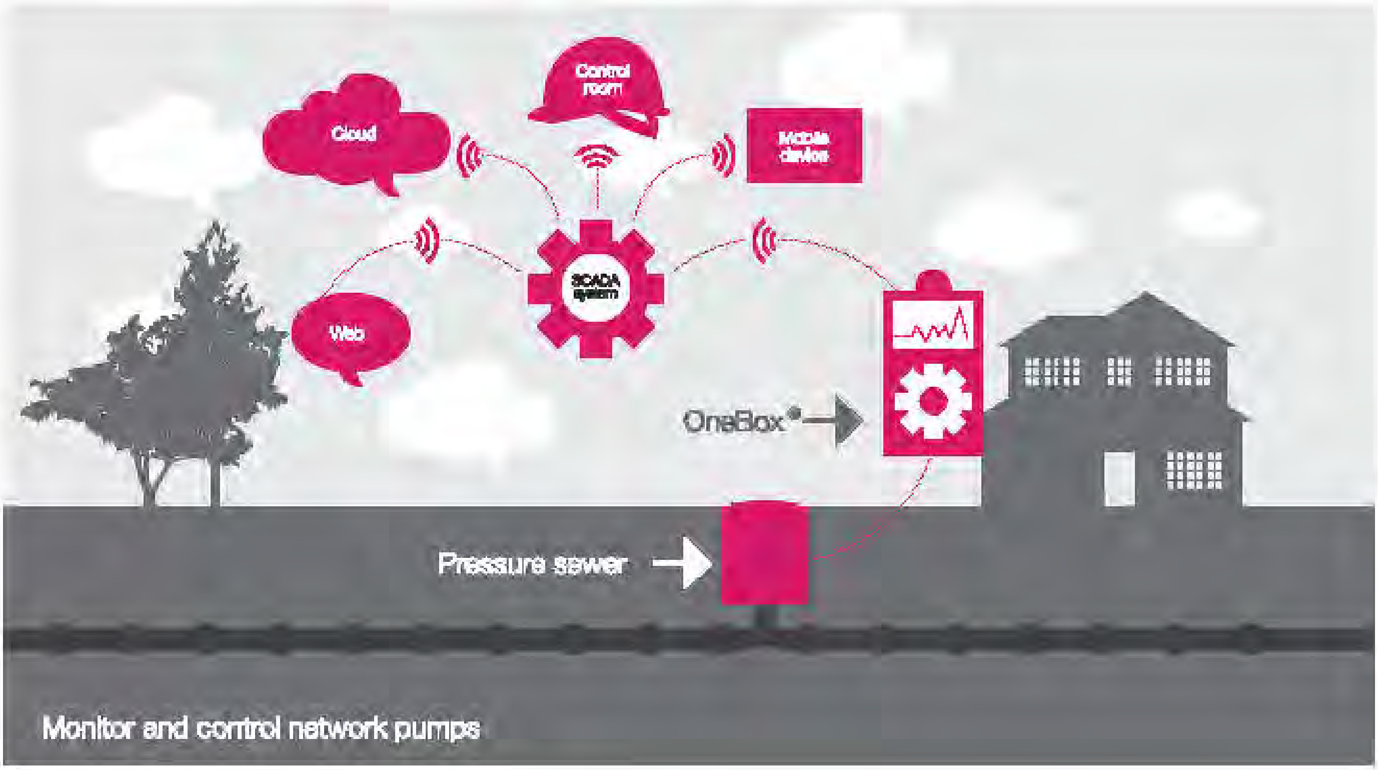
OneBox® iota.

Iota Onebox Controller

Monitor and control your low-pressure sewer system remotely and in real time.

With the Onebox Intelligent Sewer you can monitor the status of the sewer connection to regulate flows and remove peak volumes from the network. You can significantly reduce flows compared to gravity and uncontrolled pressure sewer systems, and also avoid exacerbating overflows downstream during storms.

OneBox Intelligent Sewer provides opportunities for significant savings in capital expenditure and allows growth with the least amount of impact on downstream infrastructure, minimising capacity constraints.



ACCESSORIES

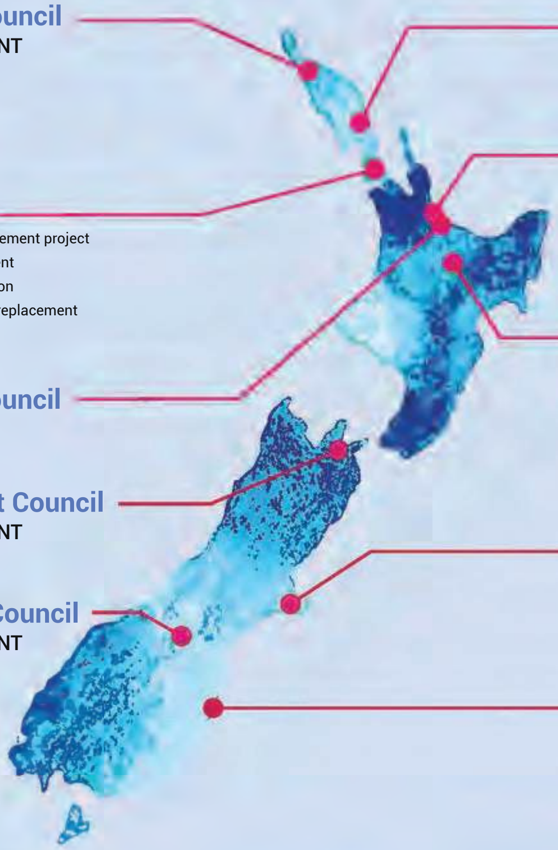
Boundary Kits

Provide a connection point for each individual house. These are especially useful for greenfield development as they eliminate the requirement for live tapings. Ecoflow's boundary kits come with polyethylene stubs pre-welded and pressure-tested to 16Bar.

Flushing Points

Provide an access point to the network for flushing or sucking if the downstream network is isolated. Ecoflow's Flushing point is pre-assembled, and pressure tested to 16Bar.

15 YEARS OF ECOFLOW
20,000 PRESSURE SEWER SYSTEMS INSTALLED



Far North District Council
SEPTIC TANK REPLACEMENT
2009 - Opua
2012 - Opua stage 2
2013 - Awanui
2017 - Kerikeri

Auckland Council
2008 - Point Wells septic tank replacement project
2009 - Failed step system replacement
2010 - Millwater greenfield subdivision
2010 - Huapai failed gravity system replacement
2012 - Matakana septic tank retrofit

Tauranga District Council
2018 - Mataphi (Smart Sewer)

Marlborough District Council
SEPTIC TANK REPLACEMENT
2009 - Grovetown

Mackenzie District Council
SEPTIC TANK REPLACEMENT
2010 - Fairley

Whangarei District Council
SEPTIC TANK REPLACEMENT
2012 - Ruakaka

Western Bay of Plenty District Council
SEPTIC TANK REPLACEMENT
2011 - Maketu
2017 - Te Puna (Smart Sewer)

Rotorua District Council
SEPTIC TANK REPLACEMENT
2007 - Hinemoa Point
2008 - Brunswick/Rotokawa
2010 - Okere Falls
2010 - Lake Okareka
2011 - Hamurana

Christchurch City Council
2011 - Rebuild, replacement of failing gravity system (post-earthquake)
2016 - Ongoing, greenfield development (Smart Sewer)

Dunedin City Council
SEPTIC TANK REPLACEMENT
2010 - Allanton

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SEWERS MADE SIMPLE

CONTACT US FOR A FREE CONSULTATION

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Fax: 09 447 3901

CHRISTCHURCH
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Phone: 03 349 2506

Email: info@ecoflow.co.nz
Website: www.ecoflow.co.nz

APPENDIX F – WATER DEMAND CALCULATIONS

Maven Associates		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Site Water Demand	Author ARVINDER S	Date 10/19/2025	Checked JP

Proposed Residential Development Site

Demand	Rate (L/p/d)
Average Daily Demand (AD)	220
Peak Day Demand (PF =1.5)	330
Peak Hourly Demand (PD) (PF =1.5x2)	825

Node	Catchment	Dwellings	Ocupancy	Average Daily Demand	Peak Day Demand	Peak Hourly Demand
1	1	10	30	0.0764	0.11	0.29
2	2	9	27	0.0688	0.10	0.26
3	3	49	147	0.3743	0.56	1.40
4	4-5	64	192	0.4889	0.73	1.83
5	6	51	153	0.3896	0.58	1.46
6	7-8	130	390	0.9931	1.49	3.72
7	9	6	18	0.0458	0.07	0.17
8	10-11	44	132	0.3361	0.50	1.26
9	12-13	66	198	0.5042	0.76	1.89
9A	14A	272	816	2.0778	3.12	7.79
10	14	18	54	0.1375	0.21	0.52
10A	15A	63	189	0.4813	0.72	1.80
11	15,13A	36	108	0.2750	0.41	1.03
12	16	219	657	1.6729	2.51	6.27
13	17,18	132	396	1.0083	1.51	3.78
14	19-20	95	285	0.7257	1.09	2.72
15	21-22	143	429	1.0924	1.64	4.10
16	23	24	72	0.1833	0.28	0.69
17	24	36	108	0.2750	0.41	1.03
18	25	10	30	0.0764	0.11	0.29
19	26	85	255	0.6493	0.97	2.43
20	27	64	192	0.4889	0.73	1.83
21	28	96	288	0.7333	1.10	2.75
22	29	221	663	1.6882	2.53	6.33
26	34	268	804	2.0472	3.07	7.68
27	35	48	144	0.3667	0.55	1.38
28	36	61	183	0.4660	0.70	1.75
29	37	96	288	0.7333	1.10	2.75
30	39	126	378	0.9625	1.44	3.61
31	40	77	231	0.5882	0.88	2.21
32	41	50	150	0.3819	0.57	1.43
33	42A	149	447	1.1382	1.71	4.27
34	42	233	699	1.7799	2.67	6.67
35	43	127	381	0.9701	1.46	3.64
35A	43A	219	657	1.6729	2.51	6.27
36	44	100	300	0.7639	1.15	2.86
39	45,50	53	159	0.4049	0.61	1.52

	Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Site Water Demand	Author ARVINDER S	Date 10/19/2025	Checked JP

LIGHT INDUSTRY

Catchment	AREA (ha)	Rate l/m2/day	Flow l/s
51	1.43	4.5	0.74
52	1.70	4.5	0.88
53	2.22	5.5	1.41
54A	4.08	4.5	2.12
54	0.60	4.5	0.31
55	1.15	4.5	0.60
56	0.78	4.5	0.40
57	2.40	4.5	1.25
58	0.35	4.5	0.18
59	1.66	4.5	0.86
60	0.93	4.5	0.49
Total Area	17.30		
Total Flow			9.27

RETAIL

Catchment	AREA (ha)	Rate l/ha/s	Flow l/s
43A	1.27	1	1.27
28A	0.95	1	0.95
18A	0.90	1	0.90
37	2.87	1	2.87
Total Area	6.00		
Total Flow			6.00

HEALTH CARE AND TOWNCENTER

Catchment	AREA (ha)	Rate l/m2/day	Flow l/s
31	1.14	15	1.98
32	0.38	16	0.70
33	2.88	15	5.00
Total Area	4.40		
Total Flow			7.68

RETIREMENT VILLAGE OFFICE

Catchment	AREA (ha)	Rate l/ha/s	Flow l/s
42	0.39	1	0.39
30	0.0929	1	0.09
Total Area	0.48		
Total Flow			0.48

	Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Site Water Demand	Author ARVINDER S	Date 10/19/2025	Checked JP

NODE	CATCHMENT	TOTAL (l/s)
1	1	0.08
2	2	0.07
3	3	0.37
4	4-5	0.49
5	6	0.39
6	7-8	0.99
7	9	0.05
8	10-11	0.34
9	12-13	0.50
9A	14A	2.08
10	14	0.14
10A	15A	0.48
11	15,13A	0.28
12	16	1.67
13	17,18,18A	1.91
14	19-20	0.73
15	21-22	1.09
16	23	0.18
17	24	0.28
18	25	0.08
19	26	1.55
20	27	0.49
21	28,28A	0.73
22	29,30	1.78
23	31	1.98
24	32	0.70
25	33	5.00
26	34	2.05
27	35	0.37
28	36	0.47
29	37	0.73
30	39	0.96
31	40	0.59
32	41	0.38
33	42A	1.14
34	42	2.17
35	43	2.24
35A	43A	1.67
36	44	0.76
37	47	0.49
38	48-49	0.86
39	45,50	0.74
40	51	0.74
41	52	0.88
42	53	1.41
43	54A	2.12
44	54	0.31
45	56	0.40
46	55	0.60
47	57	1.25
48	59	0.86
49	58	0.18
50	60	0.49
	Total Demand	49.3115

APPENDIX G – WATER SUPPLY MODELLING

WATER SUPPLY NETWORK MODELLING REPORT

SUNFIELD DEVELOPMENT, TAKANINI

MAVEN	Job Number 215010		Rev A
Job Title Sunfield development Takanini **Title** Water Supply Network Modelling Report	**Author** KNH/KH	**Date** 01/25	**Checked** JP

1. INTRODUCTION

The purpose of this report is to provide a hydraulic assessment for the proposed water supply network to service the Sunfield Development to meet domestic and industrial normal demands stated in Watercare Water Code of Practice and firefighting demands specified in SNZ PAS 4509.

1.1 PROJECT BACKGROUND

Sunfield Developments Limited (SDL) is seeking consent for a contiguous 244.5-hectare site to enable the development of a master-planned community, to be known as "Sunfield" (the Site).

The proposed development of Sunfield is a large-scale master-planned community, consisting of approximately 4,000 residential lots, and approximately 56.5ha of industrial/employment land. In addition to residential and industrial use, other uses to support a new community of this size are proposed, such as, a town centre, health care, aged care, local hub, a school, parks/open space, stormwater reserves and green connections/shared pathways.

The Site is located over several land tiles and is indicatively shown on the aerial photo below. The Site is bounded by Old Wairoa Road to the south, Cosgrave Road to the west and Airfield Road to the north.

Figure 1 – Aerial Photo (indicative extent of Sunfield Master plan shown in red outline)

1.2 LEGAL DESCRIPTION

The legal description and underlying zoning of the existing land parcels within the Site are shown below.

Address	Legal Description	Record of Title	Area (ha)	Underlying Zoning
55 Cosgrave Road, Papakura	Section 3-4 Survey Office Plan 495342	828127	9.2433	Future Urban

Old Wairoa Road, Papakura	Section 5-6 Survey Office Plan 495342	828128	11.8128	Future Urban
Old Wairoa Road, Papakura	Lot 1 Deposited Plan 55480	NA6C/1128	5.8014	Future Urban
Old Wairoa Road, Papakura	Lot 4 Deposited Plan 55480	NA6C/1131	10.3587	Future Urban
508 Old Wairoa Road, Ardmore	Deposited Plan 10383	NA258/245	23.6336	Future Urban & Rural
85 Hamlin Road, Ardmore	Lot 8 Deeds Plan Whau 38	NA778/296	22.5233	Rural
80 Hamlin Road, Ardmore	Part Lot 2 Deposited Plan 22141	NA1B/856	18.9937	Rural
80 Hamlin Road, Ardmore	Lot 2 Deposited Plan 21397	NA477/291	10.1171	Rural
80 Hamlin Road, Ardmore	Lot 1 Deposited Plan 21397	NA477/75	30.7192	Rural
80 Hamlin Road, Ardmore	Lot 5 Deposited Plan 12961	NA631/77	35.9057	Rural
80 Hamlin Road, Ardmore	Part Lot 4 Deposited Plan 12961	NA636/171	21.8505	Rural
279 Airfields Road, Ardmore	Lot 2 Deposited Plan 199521	NA128A/553	14.4224	Rural
92 Hamlin Road, Ardmore	Lot 1 Deposited Plan 46615	NA1666/17	0.0911	Rural
143 Cosgrave Road, Papakura	Lot 1 Deposited Plan 103787	NA57A/1149	3.0400	Rural
131 Cosgrave Road, Papakura	Lot 2 Deposited Plan 103787	NA57A/1150	3.0370	Rural
121A Cosgrave Road, Papakura	Lot 3 Deposited Plan 103787 and 1/3 Share in Lot 7 Deposited Plan 103787	NA57A/1151	3.0400	Rural
123 Cosgrave Road, Papakura	Lot 4 Deposited Plan 103787 and 1/3 Share in Lot 7 Deposited Plan	NA57A/1152	8.6325	Rural

	103787			
119A Cosgrave Road, Papakura	Lot 5 Deposited Plan 103787 and 1/3 Share in Lot 7 Deposited Plan 103787	NA61A/530	3.0370	Rural
119A, 121A and 123 Cosgrave Road, Papakura	Lot 7 Deposited Plan 103787		0.2417	Rural
119 Cosgrave Road, Papakura	Lot 6 Deposited Plan 103787	NA57A/1154	3.0360	Rural
101 Cosgrave Road, Papakura	Part Lot 1 Deposited Plan 45156	NA24C/216	1.9425	Future Urban
103 Cosgrave Road, Papakura	Lot 1 Deposited Plan 62629	NA18B/646	0.0809	Future Urban
55A Cosgrave Road, Papakura	Section 1-2 Survey Office Plan 495342	828126	2.9343	Future Urban
Total			244.4947	

Table 1- Legal Description & Existing Zoning Summary

1.3 EXISTING WATER SUPPLY NETWORK

There is an existing 150mm PE water supply located at the southwestern boundary of the site, as well as 100mm and 250mm PE water mains along Cosgrave Road. These local networks are potential options for supplying water to a portion of the site. Additionally, a 1200mm concrete-lined steel water transmission pipe (referred to as Waikato 1) runs along Cosgrave Road, and a 450mm asbestos cement transmission water pipe (referred to as Takanini 2) runs along Airfield Road. Takanini 2 connects to both Waikato 1 and a 760mm concrete-lined steel pipe (referred to as Hunua 1).

Given the scale of development proposed for Sunfield, the primary water supply is expected to be sourced from these water transmission networks rather than the local networks.

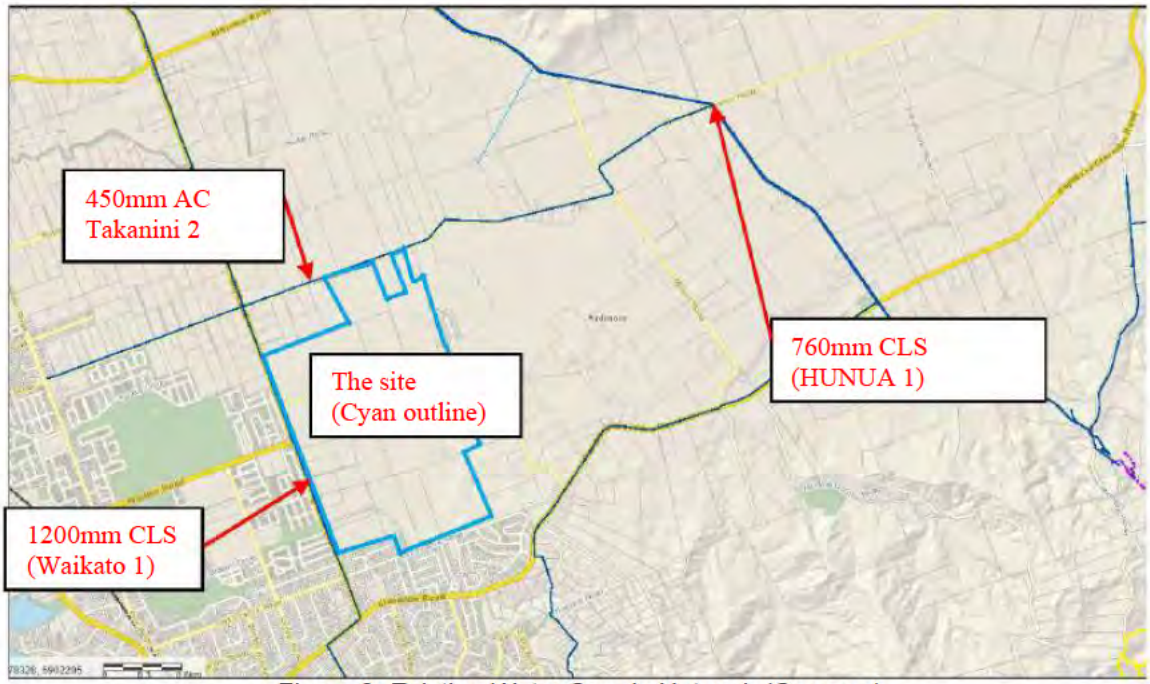

Figure 2: Existing Water Supply Network (Geomap)

2. PROPOSED WATER SUPPLY NETWORK

2.1 SUNFIELD WATER DEMAND

The water demand for Sunfield has been calculated in accordance with Watercare's Water Code of Practice. Assumptions have been made regarding the water demand rate for the industrial area, as clear data or details about future land use activities are not available at this stage. A summary of the water demand is provided in Table 2 below:

	Average Daily Demand (L/s)	Peak Daily Demand (L/s)	Peak Hourly Demand (L/s)
Residential Water Demand	27.11	40.67	101.69
Light Industrial Water Demand		9.27	
Retails Water demand		6	
Healthcare and Town center Water demand		7.68	
Retirement Village office water demand		0.48	
Total		64.1	

Table 2- Water Demand calculation

Given the differences in water demand calculations for industrial and commercial areas compared to residential zones, there is no clear guidance within Watercare's Code of Practice (COP) on converting peak daily demand for commercial/industrial areas into average daily demand. Consequently, the peak daily demand rate for the commercial/industrial area has been used as the average daily demand in the water supply modelling.

While this approach results in a higher estimated water take within the water supply model, it introduces a level of redundancy into the network. This redundancy safeguards against unforeseen water demands exceeding the assumptions, ensuring the model can accommodate potential variability in water usage.

Please refer to Appendix A for the Water demand Calculation.

2.2 PROPOSED WATER SUPPLY NETWORK LAYOUT

A local and transmission water supply network has been developed to service the Sunfield Development. A proposed 450mm PE water transmission loop, connected to the Takanini 2 transmission line, will provide the development with two bulk supply points.

From these bulk supply points, a network of 250mm water mains will deliver water to the development. Smaller water mains will branch off from the main distribution network to service individual areas within the site. Ultimately, this proposed networks will connect to an existing the existing local water main located along Cosgrave Road and old Wairoa Road for the securities of supply purposed.

For more details, refer to Figure 3 below.

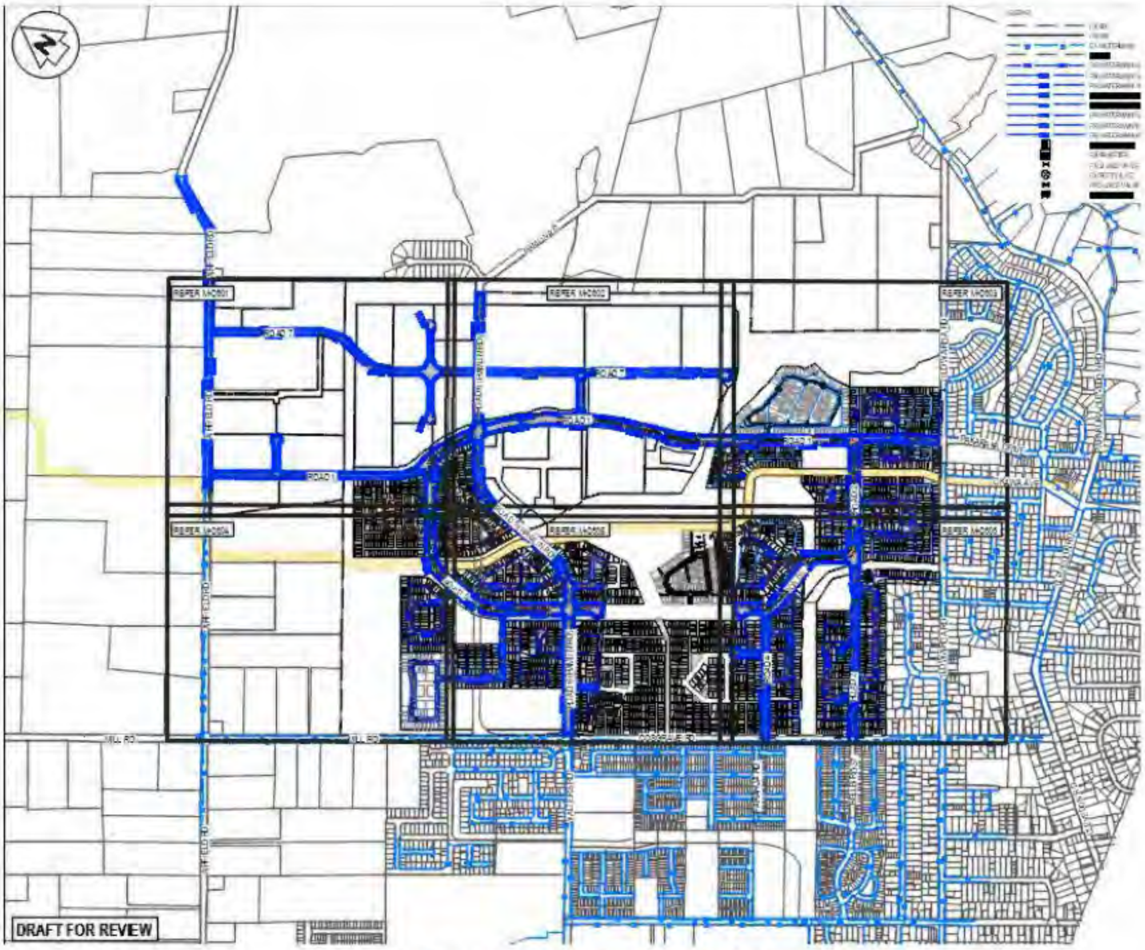

Figure 3: Proposed Water Supply Network

The proposed water supply network has been designed to accommodate domestic and industrial demands, as well as firefighting requirements. An overview of pipe sizing plans has been included in Appendix B of this report.

3. MIKE+ MODELLING

3.1 MIKE+ MODELLING PARAMETERS

Average Demand:

Residential base demand (average demand) is calculated as per Watercare Water Code of Practice as shown in Table 3:

Table 3-Residential Base Demand Calculation

Number of Occupancy	3 person/dwelling
Water Demand	220 Litre/Person/Day
Average Daily Demand	660 Litre/Day
Base Demand for Mike+ Model	0.0076 Litre/Sec/Dwelling

Commercial base demand (average demand) is calculated as per Watercare Water Code of Practice as shown in Table 4:

Table 4-Industrial/Commercial Demand Calculation

Commercial/ Industrial Gross area	28.18 Ha
Light Water usage (commercial + industrial)	4.5 L/m2/ Day
Peak Daily Demand	2024352 Litre/Day
Base Demand for mike+ Model	23.43 Litre/Sec

Normal Daily Demand Pattern

The Watercare 24hr domestic demand pattern is used to perform the simulation with the peak at 8am (Peak Multiplier = 2.27), see Figure 5 below.

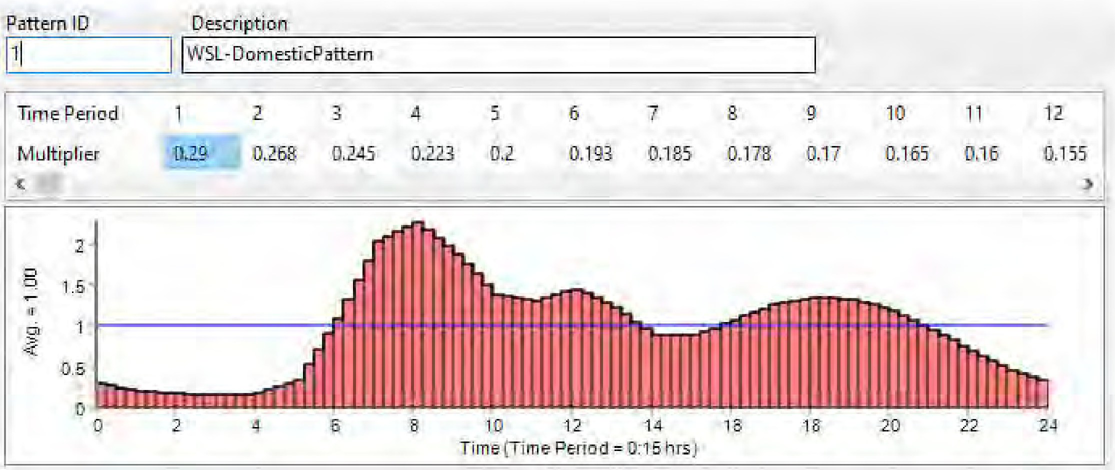

Figure 5. Watercare 24hr domestic demand pattern

Water Pipe Sizes

The following pipes are proposed and the settings in the model are listed in Table 3 below:

Table 5-Water Pipe Size Setting

Pipe	Mean Bore (mm)	Diameter used in Mike+ Model (mm)
63mm (OD) PE100 PN12.5	53.3	50

125mm (OD) PE100 PN12.5	106.1	100
180mm (OD) PE100 PN12.5	152.8	150
225mm (OD) PE100 PN12.5	191.1	191
250mm (OD) PE100 PN12.5	212.4	212
315mm (OD) PE100 PN12.5	267.6	267
355mm (OD) PE100 PN12.5	301.6	301
400mm (OD) PE100 PN12.5	339.9	339
450mm (OD) PE100 PN12.5	382.4	382

Model Reservoir Location and Head

As previously mentioned, the proposed 450mm PE loop will have two connections to the Takanini 2 transmission main. Since this network is part of a transmission system, pressure testing is not permitted by Watercare.

Given its primary role as a water transmission line and its proximity to the Drury Water Pump Station and the Hunua Water Reservoir, the pressure within this transmission network is expected to be relatively high, ranging between 250 kPa and 1200 kPa, in accordance with the Design Principles for Transmission Water and Wastewater Pipeline Systems (DP-07, Version 1.1).

For design purposes, an 500 kPa pressure is assumed at the connection points to the transmission network. The pressure drop caused by water draw from the proposed development is anticipated to be minimal due to the constant regulated pressure maintained by the Hunua 1 and Waikato 1 transmission mains. This pressure level has been adopted as the baseline for the proposed water main loop connections.

Firefighting Demand Model Setting

SNZ PAS 4509 recommends that the fire flows to be run at 60% of annual peak demand. Since the Watercare 24hr domestic demand pattern is used in the model, 60% of the 24hr demand pattern peak flow is used therefore the multiplier for firefighting scenario background consumer demand is around 1.362 (2.27*0.6), which is roughly at 10am.

According to SNZ PAS 4509 Appendix K, the hydraulic model settings should account for only one fire at a time. Considering the nature of the site, which includes a large industrial zone, a target fire water classification (FW4) has been adopted to assess the proposed water supply network.

To meet the FW3 fire water classification, a firefighting demand of 50 l/s has been modeled, split between two hydrants (25 l/s per hydrant). This demand is set to occur between 10:00 AM and 10:30 AM for a duration of 30 minutes.

Other General Model Setting

Table 6 below summaries the other general model settings:

Table 6-General Model Setting

Node Elevation Units	m
Pipe Diameter (mm)	Internal Diameter as per Table 3
Flow Units	Litre/Sec
Headloss Formula	Hazen-Williams Formula
Roughness Coefficient	130 (PE Pipe)*
Reservoir total head (m)	80m
Minor headloss	* 130 roughness Coefficient has been used instead of 140 for HDPE pipe as per Watercare COP to allowed for minor losses within the water supply networks

3.2 MIKE+ MODEL RESULTS

The results are summarized in Table 7 below.

Table 7-Model Results Summary

	Unit Head Loss: 5 m/km for DN ≤150; 3 m/km for DN >150	Design pressure: Between 250kPa and 800kPa (25 m to 80 m)	Firefighting Pressure at Hydrants Minimum 100kPa (10m)
Domestic Normal Demand	**Comply**	**Comply**	**N/A**
Firefighting Demand	**N/A**	**N/A**	**Comply**

Domestic Normal Demand model results are included in Appendix C
Fire fighting Demand model result are indlued in Appendix D

4. CONCLUSION

The model results confirm that the proposed water supply network can generally meet adequate service levels under both domestic normal demand and firefighting scenarios. However, the following issues have been identified:

Water Pressure at Bulk Supply Points

The water pressure head at the Takanini 2 water transmission network is currently based on a design assumption. Ongoing communication and consultation with Watercare are required to verify this assumption.

Demand Assumptions for Industrial and Commercial Use

The base demand assumption for industrial and commercial use is relatively high in this model. Once future industrial land-use activities are known, there may be an opportunity to reduce the pipe size for the development if the water mains have not yet been constructed.

Overall, the proposed water supply network is considered adequate for long-term requirements.

Appendix A – WATER DEMAND CALCULATION

Maven Associates		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Site Water Demand	Author ARVINDER S	Date 10/19/2025	Checked JP

Proposed Residential Development Site

Demand	Rate (L/p/d)
Average Daily Demand (AD)	220
Peak Day Demand (PF =1.5)	330
Peak Hourly Demand (PD) (PF =1.5x2)	825

Node	Catchment	Dwellings	Ocupancy	Average Daily Demand	Peak Day Demand	Peak Hourly Demand
1	1	10	30	0.0764	0.11	0.29
2	2	9	27	0.0688	0.10	0.26
3	3	49	147	0.3743	0.56	1.40
4	4-5	64	192	0.4889	0.73	1.83
5	6	51	153	0.3896	0.58	1.46
6	7-8	130	390	0.9931	1.49	3.72
7	9	6	18	0.0458	0.07	0.17
8	10-11	44	132	0.3361	0.50	1.26
9	12-13	66	198	0.5042	0.76	1.89
9A	14A	272	816	2.0778	3.12	7.79
10	14	18	54	0.1375	0.21	0.52
10A	15A	63	189	0.4813	0.72	1.80
11	15,13A	36	108	0.2750	0.41	1.03
12	16	219	657	1.6729	2.51	6.27
13	17,18	132	396	1.0083	1.51	3.78
14	19-20	95	285	0.7257	1.09	2.72
15	21-22	143	429	1.0924	1.64	4.10
16	23	24	72	0.1833	0.28	0.69
17	24	36	108	0.2750	0.41	1.03
18	25	10	30	0.0764	0.11	0.29
19	26	85	255	0.6493	0.97	2.43
20	27	64	192	0.4889	0.73	1.83
21	28	96	288	0.7333	1.10	2.75
22	29	221	663	1.6882	2.53	6.33
26	34	268	804	2.0472	3.07	7.68
27	35	48	144	0.3667	0.55	1.38
28	36	61	183	0.4660	0.70	1.75
29	37	96	288	0.7333	1.10	2.75
30	39	126	378	0.9625	1.44	3.61
31	40	77	231	0.5882	0.88	2.21
32	41	50	150	0.3819	0.57	1.43
33	42A	149	447	1.1382	1.71	4.27
34	42	233	699	1.7799	2.67	6.67
35	43	127	381	0.9701	1.46	3.64
35A	43A	219	657	1.6729	2.51	6.27
36	44	100	300	0.7639	1.15	2.86
39	45,50	53	159	0.4049	0.61	1.52

Maven Associates		Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Site Water Demand	Author ARVINDER S	Date 10/19/2025	Checked JP

LIGHT INDUSTRY

Catchment	AREA (ha)	Rate l/m2/day	Flow l/s
51	1.43	4.5	0.74
52	1.70	4.5	0.88
53	2.22	5.5	1.41
54A	4.08	4.5	2.12
54	0.60	4.5	0.31
55	1.15	4.5	0.60
56	0.78	4.5	0.40
57	2.40	4.5	1.25
58	0.35	4.5	0.18
59	1.66	4.5	0.86
60	0.93	4.5	0.49
Total Area	17.30		
Total Flow			9.27

RETAIL

Catchment	AREA (ha)	Rate l/ha/s	Flow l/s
43A	1.27	1	1.27
28A	0.95	1	0.95
18A	0.90	1	0.90
37	2.87	1	2.87
Total Area	6.00		
Total Flow			6.00

HEALTH CARE AND TOWNCENTER

Catchment	AREA (ha)	Rate l/m2/day	Flow l/s
31	1.14	15	1.98
32	0.38	16	0.70
33	2.88	15	5.00
Total Area	4.40		
Total Flow			7.68

RETIREMENT VILLAGE OFFICE

Catchment	AREA (ha)	Rate l/ha/s	Flow l/s
42	0.39	1	0.39
30	0.0929	1	0.09
Total Area	0.48		
Total Flow			0.48

	Maven Associates	Job Number 215010	Sheet 1	Rev A
Job Title Calc Title	Sunfield Site Water Demand	Author ARVINDER S	Date 10/19/2025	Checked JP

NODE	CATCHMENT	TOTAL (l/s)
1	1	0.08
2	2	0.07
3	3	0.37
4	4-5	0.49
5	6	0.39
6	7-8	0.99
7	9	0.05
8	10-11	0.34
9	12-13	0.50
9A	14A	2.08
10	14	0.14
10A	15A	0.48
11	15,13A	0.28
12	16	1.67
13	17,18,18A	1.91
14	19-20	0.73
15	21-22	1.09
16	23	0.18
17	24	0.28
18	25	0.08
19	26	1.55
20	27	0.49
21	28,28A	0.73
22	29,30	1.78
23	31	1.98
24	32	0.70
25	33	5.00
26	34	2.05
27	35	0.37
28	36	0.47
29	37	0.73
30	39	0.96
31	40	0.59
32	41	0.38
33	42A	1.14
34	42	2.17
35	43	2.24
35A	43A	1.67
36	44	0.76
37	47	0.49
38	48-49	0.86
39	45,50	0.74
40	51	0.74
41	52	0.88
42	53	1.41
43	54A	2.12
44	54	0.31
45	56	0.40
46	55	0.60
47	57	1.25
48	59	0.86
49	58	0.18
50	60	0.49
	Total Demand	49.3115

Attachment B – PROPOSED WATER SUPPLIED NETWORKS LAYOUT

Attachment C- MIKE+ MODEL RESULT OF THE NORMAL DOMESTIC DEMAND SCENARIO

ID	Type	Link Headloss Per 1000Unit [m]
50	Link	0
Pipe_1	Link	0
Pipe_108	Link	0
Pipe_127	Link	0
Pipe_128	Link	0
Pipe_130	Link	0
Pipe_144	Link	0
Pipe_145	Link	0
Pipe_146	Link	0
Pipe_15	Link	0
Pipe_31	Link	0
Pipe_63	Link	0
Pipe_64	Link	0
Pipe_95	Link	0
56	Link	0.0001
Pipe_76	Link	0.0002
Pipe_75	Link	0.0002
15	Link	0.0012
Pipe_47	Link	0.0016
Pipe_45	Link	0.0024
Pipe_8	Link	0.0025
29	Link	0.0032
Pipe_109	Link	0.0033
Pipe_22	Link	0.0033
Pipe_100	Link	0.0037
Pipe_38	Link	0.0059
16	Link	0.0068
Pipe_72	Link	0.0102
Pipe_39	Link	0.0105
Pipe_79	Link	0.0107
Pipe_68	Link	0.0117
Pipe_65	Link	0.0119
17	Link	0.0125
Pipe_20	Link	0.0139
Pipe_66	Link	0.0157
32	Link	0.0173
Pipe_132	Link	0.0178
Pipe_53	Link	0.0208
22	Link	0.024
Pipe_61	Link	0.0288
21	Link	0.0353
23	Link	0.038
Pipe_70	Link	0.0457
Pipe_80	Link	0.0461
Pipe_73	Link	0.0461
Pipe_81	Link	0.0461
Pipe_91	Link	0.0461
55	Link	0.049
Pipe_48	Link	0.05

Pipe_13	Link	0.0511
Pipe_101	Link	0.0526
Pipe_37	Link	0.067
Pipe_42	Link	0.0772
Pipe_59	Link	0.0815
18	Link	0.0846
Pipe_3	Link	0.0873
Pipe_40	Link	0.0971
31	Link	0.1065
Pipe_83	Link	0.1119
Pipe_28	Link	0.1126
33	Link	0.1184
Pipe_44	Link	0.1313
51	Link	0.1381
Pipe_19	Link	0.14
Pipe_23	Link	0.1427
Pipe_85	Link	0.1431
Pipe_33	Link	0.1532
Pipe_111	Link	0.1708
Pipe_26	Link	0.1722
Pipe_16	Link	0.176
Pipe_49	Link	0.1853
Pipe_35	Link	0.1853
Pipe_99	Link	0.1931
Pipe_96	Link	0.1967
Pipe_29	Link	0.206
Pipe_113	Link	0.2172
Pipe_115	Link	0.2189
Pipe_97	Link	0.223
Pipe_57	Link	0.2263
Pipe_94	Link	0.2267
Pipe_106	Link	0.2355
Pipe_27	Link	0.2423
10	Link	0.2651
9	Link	0.2717
Pipe_17	Link	0.2776
Pipe_126	Link	0.306
Pipe_120	Link	0.306
Pipe_118	Link	0.306
Pipe_4	Link	0.3089
Pipe_46	Link	0.3374
Pipe_60	Link	0.3427
Pipe_18	Link	0.3484
8	Link	0.3534
Pipe_82	Link	0.3584
28	Link	0.3666
19	Link	0.3871
Pipe_107	Link	0.3996
3	Link	0.4157
24	Link	0.4233

25	Link	0.4378
Pipe_43	Link	0.4523
Pipe_142	Link	0.4548
30	Link	0.4803
Pipe_90	Link	0.4847
Pipe_52	Link	0.4963
Pipe_114	Link	0.502
34	Link	0.5119
Pipe_137	Link	0.5352
Pipe_141	Link	0.5455
Pipe_62	Link	0.5488
Pipe_25	Link	0.5539
Pipe_112	Link	0.5942
52	Link	0.6138
Pipe_136	Link	0.6166
Pipe_67	Link	0.6397
Pipe_30	Link	0.6399
Pipe_117	Link	0.6812
Pipe_122	Link	0.7149
Pipe_71	Link	0.7192
Pipe_21	Link	0.7197
Pipe_138	Link	0.7423
Pipe_84	Link	0.7644
Pipe_139	Link	0.7814
Pipe_24	Link	0.7814
Pipe_110	Link	0.8682
Pipe_12	Link	0.8703
Pipe_32	Link	0.8741
Pipe_121	Link	0.8958
Pipe_119	Link	0.8993
Pipe_77	Link	0.9219
Pipe_74	Link	0.9223
Pipe_105	Link	0.9303
Pipe_34	Link	1.0017
Pipe_98	Link	1.1013
26	Link	1.1254
12	Link	1.1319
Pipe_10	Link	1.1892
Pipe_103	Link	1.231
Pipe_123	Link	1.2657
Pipe_150	Link	1.2657
Pipe_125	Link	1.266
Pipe_89	Link	1.2881
Pipe_92	Link	1.2887
7	Link	1.2958
53	Link	1.3181
Pipe_124	Link	1.325
Pipe_152	Link	1.3287
Pipe_151	Link	1.3287
6	Link	1.3292

Pipe_56	Link	1.4142
11	Link	1.4297
Pipe_102	Link	1.44
Pipe_88	Link	1.4419
Pipe_6	Link	1.5667
Pipe_134	Link	1.5827
Pipe_135	Link	1.5828
Pipe_104	Link	1.6103
Pipe_14	Link	1.6461
Pipe_55	Link	1.743
Pipe_54	Link	1.7433
Pipe_2	Link	1.7492
Pipe_87	Link	1.7833
Pipe_93	Link	1.7975
Pipe_50	Link	1.8838
Pipe_51	Link	1.8838
Pipe_86	Link	1.9225
4	Link	2.0009
Pipe_9	Link	2.0112
Pipe_11	Link	2.3642
54	Link	3.0964
Pipe_36	Link	4.1057
5	Link	4.2288
Pipe_41	Link	4.7484

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ID	Type	leadloss Per 1000Ur	Time Step
50	Link	0	at 8:00 am
Pipe_1	Link	0	at 8:00 am
Pipe_108	Link	0	at 8:00 am
Pipe_127	Link	0	at 8:00 am
Pipe_128	Link	0	at 8:00 am
Pipe_130	Link	0	at 8:00 am
Pipe_144	Link	0	at 8:00 am
Pipe_145	Link	0	at 8:00 am
Pipe_146	Link	0	at 8:00 am
Pipe_15	Link	0	at 8:00 am
Pipe_31	Link	0	at 8:00 am
Pipe_63	Link	0	at 8:00 am
Pipe_64	Link	0	at 8:00 am
Pipe_95	Link	0	at 8:00 am
56	Link	0.0001	at 8:00 am
Pipe_76	Link	0.0002	at 8:00 am
Pipe_75	Link	0.0002	at 8:00 am
15	Link	0.0012	at 8:00 am
Pipe_47	Link	0.0016	at 8:00 am
Pipe_45	Link	0.0024	at 8:00 am
Pipe_8	Link	0.0025	at 8:00 am
29	Link	0.0032	at 8:00 am
Pipe_109	Link	0.0033	at 8:00 am
Pipe_22	Link	0.0033	at 8:00 am
Pipe_100	Link	0.0037	at 8:00 am
Pipe_38	Link	0.0059	at 8:00 am
16	Link	0.0068	at 8:00 am
Pipe_72	Link	0.0102	at 8:00 am
Pipe_39	Link	0.0105	at 8:00 am
Pipe_79	Link	0.0107	at 8:00 am
Pipe_68	Link	0.0117	at 8:00 am
Pipe_65	Link	0.0119	at 8:00 am
17	Link	0.0125	at 8:00 am
Pipe_20	Link	0.0139	at 8:00 am
Pipe_66	Link	0.0157	at 8:00 am
32	Link	0.0173	at 8:00 am
Pipe_132	Link	0.0178	at 8:00 am
Pipe_53	Link	0.0208	at 8:00 am
22	Link	0.024	at 8:00 am
Pipe_61	Link	0.0288	at 8:00 am
21	Link	0.0353	at 8:00 am
23	Link	0.038	at 8:00 am
Pipe_70	Link	0.0457	at 8:00 am
Pipe_80	Link	0.0461	at 8:00 am
Pipe_73	Link	0.0461	at 8:00 am
Pipe_81	Link	0.0461	at 8:00 am
Pipe_91	Link	0.0461	at 8:00 am
55	Link	0.049	at 8:00 am
Pipe_48	Link	0.05	at 8:00 am

Pipe_13	Link	0.0511	at 8:00 am
Pipe_101	Link	0.0526	at 8:00 am
Pipe_37	Link	0.067	at 8:00 am
Pipe_42	Link	0.0772	at 8:00 am
Pipe_59	Link	0.0815	at 8:00 am
18	Link	0.0846	at 8:00 am
Pipe_3	Link	0.0873	at 8:00 am
Pipe_40	Link	0.0971	at 8:00 am
31	Link	0.1065	at 8:00 am
Pipe_83	Link	0.1119	at 8:00 am
Pipe_28	Link	0.1126	at 8:00 am
33	Link	0.1184	at 8:00 am
Pipe_44	Link	0.1313	at 8:00 am
51	Link	0.1381	at 8:00 am
Pipe_19	Link	0.14	at 8:00 am
Pipe_23	Link	0.1427	at 8:00 am
Pipe_85	Link	0.1431	at 8:00 am
Pipe_33	Link	0.1532	at 8:00 am
Pipe_111	Link	0.1708	at 8:00 am
Pipe_26	Link	0.1722	at 8:00 am
Pipe_16	Link	0.176	at 8:00 am
Pipe_49	Link	0.1853	at 8:00 am
Pipe_35	Link	0.1853	at 8:00 am
Pipe_99	Link	0.1931	at 8:00 am
Pipe_96	Link	0.1967	at 8:00 am
Pipe_29	Link	0.206	at 8:00 am
Pipe_113	Link	0.2172	at 8:00 am
Pipe_115	Link	0.2189	at 8:00 am
Pipe_97	Link	0.223	at 8:00 am
Pipe_57	Link	0.2263	at 8:00 am
Pipe_94	Link	0.2267	at 8:00 am
Pipe_106	Link	0.2355	at 8:00 am
Pipe_27	Link	0.2423	at 8:00 am
10	Link	0.2651	at 8:00 am
9	Link	0.2717	at 8:00 am
Pipe_17	Link	0.2776	at 8:00 am
Pipe_126	Link	0.306	at 8:00 am
Pipe_120	Link	0.306	at 8:00 am
Pipe_118	Link	0.306	at 8:00 am
Pipe_4	Link	0.3089	at 8:00 am
Pipe_46	Link	0.3374	at 8:00 am
Pipe_60	Link	0.3427	at 8:00 am
Pipe_18	Link	0.3484	at 8:00 am
8	Link	0.3534	at 8:00 am
Pipe_82	Link	0.3584	at 8:00 am
28	Link	0.3666	at 8:00 am
19	Link	0.3871	at 8:00 am
Pipe_107	Link	0.3996	at 8:00 am
3	Link	0.4157	at 8:00 am
24	Link	0.4233	at 8:00 am

25	Link	0.4378	at 8:00 am
Pipe_43	Link	0.4523	at 8:00 am
Pipe_142	Link	0.4548	at 8:00 am
30	Link	0.4803	at 8:00 am
Pipe_90	Link	0.4847	at 8:00 am
Pipe_52	Link	0.4963	at 8:00 am
Pipe_114	Link	0.502	at 8:00 am
34	Link	0.5119	at 8:00 am
Pipe_137	Link	0.5352	at 8:00 am
Pipe_141	Link	0.5455	at 8:00 am
Pipe_62	Link	0.5488	at 8:00 am
Pipe_25	Link	0.5539	at 8:00 am
Pipe_112	Link	0.5942	at 8:00 am
52	Link	0.6138	at 8:00 am
Pipe_136	Link	0.6166	at 8:00 am
Pipe_67	Link	0.6397	at 8:00 am
Pipe_30	Link	0.6399	at 8:00 am
Pipe_117	Link	0.6812	at 8:00 am
Pipe_122	Link	0.7149	at 8:00 am
Pipe_71	Link	0.7192	at 8:00 am
Pipe_21	Link	0.7197	at 8:00 am
Pipe_138	Link	0.7423	at 8:00 am
Pipe_84	Link	0.7644	at 8:00 am
Pipe_139	Link	0.7814	at 8:00 am
Pipe_24	Link	0.7814	at 8:00 am
Pipe_110	Link	0.8682	at 8:00 am
Pipe_12	Link	0.8703	at 8:00 am
Pipe_32	Link	0.8741	at 8:00 am
Pipe_121	Link	0.8958	at 8:00 am
Pipe_119	Link	0.8993	at 8:00 am
Pipe_77	Link	0.9219	at 8:00 am
Pipe_74	Link	0.9223	at 8:00 am
Pipe_105	Link	0.9303	at 8:00 am
Pipe_34	Link	1.0017	at 8:00 am
Pipe_98	Link	1.1013	at 8:00 am
26	Link	1.1254	at 8:00 am
12	Link	1.1319	at 8:00 am
Pipe_10	Link	1.1892	at 8:00 am
Pipe_103	Link	1.231	at 8:00 am
Pipe_123	Link	1.2657	at 8:00 am
Pipe_150	Link	1.2657	at 8:00 am
Pipe_125	Link	1.266	at 8:00 am
Pipe_89	Link	1.2881	at 8:00 am
Pipe_92	Link	1.2887	at 8:00 am
7	Link	1.2958	at 8:00 am
53	Link	1.3181	at 8:00 am
Pipe_124	Link	1.325	at 8:00 am
Pipe_152	Link	1.3287	at 8:00 am
Pipe_151	Link	1.3287	at 8:00 am
6	Link	1.3292	at 8:00 am

Pipe_56	Link	1.4142	at 8:00 am
11	Link	1.4297	at 8:00 am
Pipe_102	Link	1.44	at 8:00 am
Pipe_88	Link	1.4419	at 8:00 am
Pipe_6	Link	1.5667	at 8:00 am
Pipe_134	Link	1.5827	at 8:00 am
Pipe_135	Link	1.5828	at 8:00 am
Pipe_104	Link	1.6103	at 8:00 am
Pipe_14	Link	1.6461	at 8:00 am
Pipe_55	Link	1.743	at 8:00 am
Pipe_54	Link	1.7433	at 8:00 am
Pipe_2	Link	1.7492	at 8:00 am
Pipe_87	Link	1.7833	at 8:00 am
Pipe_93	Link	1.7975	at 8:00 am
Pipe_50	Link	1.8838	at 8:00 am
Pipe_51	Link	1.8838	at 8:00 am
Pipe_86	Link	1.9225	at 8:00 am
4	Link	2.0009	at 8:00 am
Pipe_9	Link	2.0112	at 8:00 am
Pipe_11	Link	2.3642	at 8:00 am
54	Link	3.0964	at 8:00 am
Pipe_36	Link	4.1057	at 8:00 am
5	Link	4.2288	at 8:00 am
Pipe_41	Link	4.7484	at 8:00 am

Attachment D- MIKE+ MODEL RESULT OF THE FIREFIGHTING DEMAND SCENARIO

ID	**Type**	**Link Headloss Per 1000Unit [m]**	Time Step
24	Link	0.0001	at 10:00 am
Pipe_48	Link	0.0002	at 10:00 am
18	Link	0.0007	at 10:00 am
Pipe_109	Link	0.0013	at 10:00 am
56	Link	0.0013	at 10:00 am
Pipe_82	Link	0.0017	at 10:00 am
Pipe_75	Link	0.0017	at 10:00 am
Pipe_76	Link	0.0018	at 10:00 am
Pipe_45	Link	0.0018	at 10:00 am
Pipe_53	Link	0.0022	at 10:00 am
Pipe_66	Link	0.0036	at 10:00 am
Pipe_18	Link	0.0045	at 10:00 am
Pipe_8	Link	0.0061	at 10:00 am
29	Link	0.0069	at 10:00 am
22	Link	0.0091	at 10:00 am
32	Link	0.0129	at 10:00 am
Pipe_23	Link	0.0132	at 10:00 am
Pipe_38	Link	0.0153	at 10:00 am
Pipe_68	Link	0.0181	at 10:00 am
Pipe_44	Link	0.0197	at 10:00 am
21	Link	0.0197	at 10:00 am
23	Link	0.0224	at 10:00 am
Pipe_62	Link	0.0254	at 10:00 am
Pipe_13	Link	0.0258	at 10:00 am
Pipe_47	Link	0.026	at 10:00 am
Pipe_99	Link	0.0262	at 10:00 am
Pipe_22	Link	0.0281	at 10:00 am
Pipe_57	Link	0.0288	at 10:00 am
Pipe_26	Link	0.0294	at 10:00 am
Pipe_96	Link	0.0303	at 10:00 am
Pipe_59	Link	0.0306	at 10:00 am
Pipe_113	Link	0.031	at 10:00 am
Pipe_100	Link	0.0348	at 10:00 am
Pipe_115	Link	0.0359	at 10:00 am
Pipe_19	Link	0.0367	at 10:00 am
Pipe_20	Link	0.0408	at 10:00 am
Pipe_4	Link	0.0469	at 10:00 am
Pipe_83	Link	0.0494	at 10:00 am
Pipe_77	Link	0.0495	at 10:00 am
Pipe_74	Link	0.0501	at 10:00 am
8	Link	0.0538	at 10:00 am
33	Link	0.0608	at 10:00 am
10	Link	0.0667	at 10:00 am
Pipe_111	Link	0.0683	at 10:00 am
Pipe_85	Link	0.0779	at 10:00 am
Pipe_16	Link	0.0785	at 10:00 am
Pipe_101	Link	0.0815	at 10:00 am
28	Link	0.0828	at 10:00 am
Pipe_28	Link	0.0955	at 10:00 am

Pipe_81	Link	0.0968	at 10:00 am
55	Link	0.1007	at 10:00 am
Pipe_70	Link	0.104	at 10:00 am
Pipe_91	Link	0.1073	at 10:00 am
Pipe_73	Link	0.1073	at 10:00 am
Pipe_80	Link	0.1073	at 10:00 am
31	Link	0.1247	at 10:00 am
Pipe_46	Link	0.1292	at 10:00 am
Pipe_3	Link	0.1398	at 10:00 am
Pipe_25	Link	0.1485	at 10:00 am
9	Link	0.1607	at 10:00 am
Pipe_97	Link	0.1633	at 10:00 am
Pipe_94	Link	0.1722	at 10:00 am
52	Link	0.1801	at 10:00 am
3	Link	0.1902	at 10:00 am
Pipe_42	Link	0.2003	at 10:00 am
Pipe_17	Link	0.2038	at 10:00 am
34	Link	0.2092	at 10:00 am
Pipe_65	Link	0.2333	at 10:00 am
Pipe_125	Link	0.236	at 10:00 am
Pipe_79	Link	0.2426	at 10:00 am
Pipe_39	Link	0.2452	at 10:00 am
Pipe_40	Link	0.2555	at 10:00 am
19	Link	0.2908	at 10:00 am
Pipe_61	Link	0.2928	at 10:00 am
Pipe_49	Link	0.3055	at 10:00 am
Pipe_35	Link	0.3055	at 10:00 am
Pipe_119	Link	0.3073	at 10:00 am
Pipe_98	Link	0.3118	at 10:00 am
Pipe_37	Link	0.3342	at 10:00 am
30	Link	0.3354	at 10:00 am
Pipe_27	Link	0.342	at 10:00 am
Pipe_110	Link	0.3488	at 10:00 am
Pipe_34	Link	0.3533	at 10:00 am
51	Link	0.3573	at 10:00 am
Pipe_33	Link	0.3773	at 10:00 am
12	Link	0.3866	at 10:00 am
Pipe_132	Link	0.39	at 10:00 am
Pipe_138	Link	0.4369	at 10:00 am
Pipe_52	Link	0.4453	at 10:00 am
Pipe_139	Link	0.4595	at 10:00 am
Pipe_24	Link	0.4596	at 10:00 am
Pipe_137	Link	0.4766	at 10:00 am
Pipe_29	Link	0.4793	at 10:00 am
Pipe_67	Link	0.495	at 10:00 am
Pipe_30	Link	0.495	at 10:00 am
Pipe_117	Link	0.5105	at 10:00 am
7	Link	0.5207	at 10:00 am
16	Link	0.5221	at 10:00 am
Pipe_136	Link	0.5324	at 10:00 am

6	Link	0.5377	at 10:00 am
Pipe_21	Link	0.5721	at 10:00 am
Pipe_72	Link	0.5763	at 10:00 am
Pipe_60	Link	0.5983	at 10:00 am
25	Link	0.619	at 10:00 am
Pipe_120	Link	0.623	at 10:00 am
Pipe_118	Link	0.623	at 10:00 am
Pipe_126	Link	0.623	at 10:00 am
11	Link	0.6595	at 10:00 am
Pipe_43	Link	0.6769	at 10:00 am
Pipe_142	Link	0.6935	at 10:00 am
Pipe_106	Link	0.7054	at 10:00 am
Pipe_141	Link	0.7445	at 10:00 am
Pipe_90	Link	0.7654	at 10:00 am
Pipe_135	Link	0.8171	at 10:00 am
Pipe_134	Link	0.8171	at 10:00 am
Pipe_107	Link	0.8585	at 10:00 am
Pipe_12	Link	0.8777	at 10:00 am
Pipe_32	Link	0.9642	at 10:00 am
Pipe_71	Link	1.0266	at 10:00 am
Pipe_105	Link	1.0315	at 10:00 am
26	Link	1.061	at 10:00 am
Pipe_103	Link	1.0755	at 10:00 am
Pipe_10	Link	1.1146	at 10:00 am
53	Link	1.1417	at 10:00 am
Pipe_56	Link	1.1772	at 10:00 am
Pipe_102	Link	1.1943	at 10:00 am
Pipe_6	Link	1.2824	at 10:00 am
Pipe_92	Link	1.2871	at 10:00 am
Pipe_14	Link	1.3276	at 10:00 am
Pipe_89	Link	1.3457	at 10:00 am
Pipe_122	Link	1.3554	at 10:00 am
Pipe_54	Link	1.3799	at 10:00 am
Pipe_55	Link	1.3801	at 10:00 am
Pipe_88	Link	1.4408	at 10:00 am
Pipe_104	Link	1.4451	at 10:00 am
Pipe_50	Link	1.4567	at 10:00 am
Pipe_51	Link	1.4571	at 10:00 am
4	Link	1.469	at 10:00 am
Pipe_150	Link	1.4955	at 10:00 am
Pipe_9	Link	1.5272	at 10:00 am
Pipe_93	Link	1.5893	at 10:00 am
Pipe_87	Link	1.6278	at 10:00 am
Pipe_86	Link	1.709	at 10:00 am
Pipe_121	Link	1.7701	at 10:00 am
Pipe_151	Link	1.8194	at 10:00 am
Pipe_152	Link	1.8194	at 10:00 am
Pipe_11	Link	1.9806	at 10:00 am
Pipe_2	Link	2.1079	at 10:00 am
Pipe_84	Link	2.2889	at 10:00 am

Pipe_15	Link	2.6752	at 10:00 am
Pipe_31	Link	2.6752	at 10:00 am
5	Link	3.0204	at 10:00 am
54	Link	3.2039	at 10:00 am
Pipe_36	Link	3.4882	at 10:00 am
Pipe_41	Link	3.5993	at 10:00 am
Pipe_123	Link	4.1625	at 10:00 am
Pipe_124	Link	4.2248	at 10:00 am

ID	Type	Link Headloss Per 1000Unit [m]	Time Step
24	Link	0.0001	at 10:00 am
Pipe_48	Link	0.0002	at 10:00 am
18	Link	0.0007	at 10:00 am
Pipe_109	Link	0.0013	at 10:00 am
56	Link	0.0013	at 10:00 am
Pipe_82	Link	0.0017	at 10:00 am
Pipe_75	Link	0.0017	at 10:00 am
Pipe_76	Link	0.0018	at 10:00 am
Pipe_45	Link	0.0018	at 10:00 am
Pipe_53	Link	0.0022	at 10:00 am
Pipe_66	Link	0.0036	at 10:00 am
Pipe_18	Link	0.0045	at 10:00 am
Pipe_8	Link	0.0061	at 10:00 am
29	Link	0.0069	at 10:00 am
22	Link	0.0091	at 10:00 am
32	Link	0.0129	at 10:00 am
Pipe_23	Link	0.0132	at 10:00 am
Pipe_38	Link	0.0153	at 10:00 am
Pipe_68	Link	0.0181	at 10:00 am
Pipe_44	Link	0.0197	at 10:00 am
21	Link	0.0197	at 10:00 am
23	Link	0.0224	at 10:00 am
Pipe_62	Link	0.0254	at 10:00 am
Pipe_13	Link	0.0258	at 10:00 am
Pipe_47	Link	0.026	at 10:00 am
Pipe_99	Link	0.0262	at 10:00 am
Pipe_22	Link	0.0281	at 10:00 am
Pipe_57	Link	0.0288	at 10:00 am
Pipe_26	Link	0.0294	at 10:00 am
Pipe_96	Link	0.0303	at 10:00 am
Pipe_59	Link	0.0306	at 10:00 am
Pipe_113	Link	0.031	at 10:00 am
Pipe_100	Link	0.0348	at 10:00 am
Pipe_115	Link	0.0359	at 10:00 am
Pipe_19	Link	0.0367	at 10:00 am
Pipe_20	Link	0.0408	at 10:00 am
Pipe_4	Link	0.0469	at 10:00 am
Pipe_83	Link	0.0494	at 10:00 am
Pipe_77	Link	0.0495	at 10:00 am
Pipe_74	Link	0.0501	at 10:00 am
8	Link	0.0538	at 10:00 am
33	Link	0.0608	at 10:00 am
10	Link	0.0667	at 10:00 am
Pipe_111	Link	0.0683	at 10:00 am
Pipe_85	Link	0.0779	at 10:00 am
Pipe_16	Link	0.0785	at 10:00 am
Pipe_101	Link	0.0815	at 10:00 am
28	Link	0.0828	at 10:00 am
Pipe_28	Link	0.0955	at 10:00 am

Pipe_81	Link	0.0968	at 10:00 am
55	Link	0.1007	at 10:00 am
Pipe_70	Link	0.104	at 10:00 am
Pipe_91	Link	0.1073	at 10:00 am
Pipe_73	Link	0.1073	at 10:00 am
Pipe_80	Link	0.1073	at 10:00 am
31	Link	0.1247	at 10:00 am
Pipe_46	Link	0.1292	at 10:00 am
Pipe_3	Link	0.1398	at 10:00 am
Pipe_25	Link	0.1485	at 10:00 am
9	Link	0.1607	at 10:00 am
Pipe_97	Link	0.1633	at 10:00 am
Pipe_94	Link	0.1722	at 10:00 am
52	Link	0.1801	at 10:00 am
3	Link	0.1902	at 10:00 am
Pipe_42	Link	0.2003	at 10:00 am
Pipe_17	Link	0.2038	at 10:00 am
34	Link	0.2092	at 10:00 am
Pipe_65	Link	0.2333	at 10:00 am
Pipe_125	Link	0.236	at 10:00 am
Pipe_79	Link	0.2426	at 10:00 am
Pipe_39	Link	0.2452	at 10:00 am
Pipe_40	Link	0.2555	at 10:00 am
19	Link	0.2908	at 10:00 am
Pipe_61	Link	0.2928	at 10:00 am
Pipe_49	Link	0.3055	at 10:00 am
Pipe_35	Link	0.3055	at 10:00 am
Pipe_119	Link	0.3073	at 10:00 am
Pipe_98	Link	0.3118	at 10:00 am
Pipe_37	Link	0.3342	at 10:00 am
30	Link	0.3354	at 10:00 am
Pipe_27	Link	0.342	at 10:00 am
Pipe_110	Link	0.3488	at 10:00 am
Pipe_34	Link	0.3533	at 10:00 am
51	Link	0.3573	at 10:00 am
Pipe_33	Link	0.3773	at 10:00 am
12	Link	0.3866	at 10:00 am
Pipe_132	Link	0.39	at 10:00 am
Pipe_138	Link	0.4369	at 10:00 am
Pipe_52	Link	0.4453	at 10:00 am
Pipe_139	Link	0.4595	at 10:00 am
Pipe_24	Link	0.4596	at 10:00 am
Pipe_137	Link	0.4766	at 10:00 am
Pipe_29	Link	0.4793	at 10:00 am
Pipe_67	Link	0.495	at 10:00 am
Pipe_30	Link	0.495	at 10:00 am
Pipe_117	Link	0.5105	at 10:00 am
7	Link	0.5207	at 10:00 am
16	Link	0.5221	at 10:00 am
Pipe_136	Link	0.5324	at 10:00 am

6	Link	0.5377	at 10:00 am
Pipe_21	Link	0.5721	at 10:00 am
Pipe_72	Link	0.5763	at 10:00 am
Pipe_60	Link	0.5983	at 10:00 am
25	Link	0.619	at 10:00 am
Pipe_120	Link	0.623	at 10:00 am
Pipe_118	Link	0.623	at 10:00 am
Pipe_126	Link	0.623	at 10:00 am
11	Link	0.6595	at 10:00 am
Pipe_43	Link	0.6769	at 10:00 am
Pipe_142	Link	0.6935	at 10:00 am
Pipe_106	Link	0.7054	at 10:00 am
Pipe_141	Link	0.7445	at 10:00 am
Pipe_90	Link	0.7654	at 10:00 am
Pipe_135	Link	0.8171	at 10:00 am
Pipe_134	Link	0.8171	at 10:00 am
Pipe_107	Link	0.8585	at 10:00 am
Pipe_12	Link	0.8777	at 10:00 am
Pipe_32	Link	0.9642	at 10:00 am
Pipe_71	Link	1.0266	at 10:00 am
Pipe_105	Link	1.0315	at 10:00 am
26	Link	1.061	at 10:00 am
Pipe_103	Link	1.0755	at 10:00 am
Pipe_10	Link	1.1146	at 10:00 am
53	Link	1.1417	at 10:00 am
Pipe_56	Link	1.1772	at 10:00 am
Pipe_102	Link	1.1943	at 10:00 am
Pipe_6	Link	1.2824	at 10:00 am
Pipe_92	Link	1.2871	at 10:00 am
Pipe_14	Link	1.3276	at 10:00 am
Pipe_89	Link	1.3457	at 10:00 am
Pipe_122	Link	1.3554	at 10:00 am
Pipe_54	Link	1.3799	at 10:00 am
Pipe_55	Link	1.3801	at 10:00 am
Pipe_88	Link	1.4408	at 10:00 am
Pipe_104	Link	1.4451	at 10:00 am
Pipe_50	Link	1.4567	at 10:00 am
Pipe_51	Link	1.4571	at 10:00 am
4	Link	1.469	at 10:00 am
Pipe_150	Link	1.4955	at 10:00 am
Pipe_9	Link	1.5272	at 10:00 am
Pipe_93	Link	1.5893	at 10:00 am
Pipe_87	Link	1.6278	at 10:00 am
Pipe_86	Link	1.709	at 10:00 am
Pipe_121	Link	1.7701	at 10:00 am
Pipe_151	Link	1.8194	at 10:00 am
Pipe_152	Link	1.8194	at 10:00 am
Pipe_11	Link	1.9806	at 10:00 am
Pipe_2	Link	2.1079	at 10:00 am
Pipe_84	Link	2.2889	at 10:00 am