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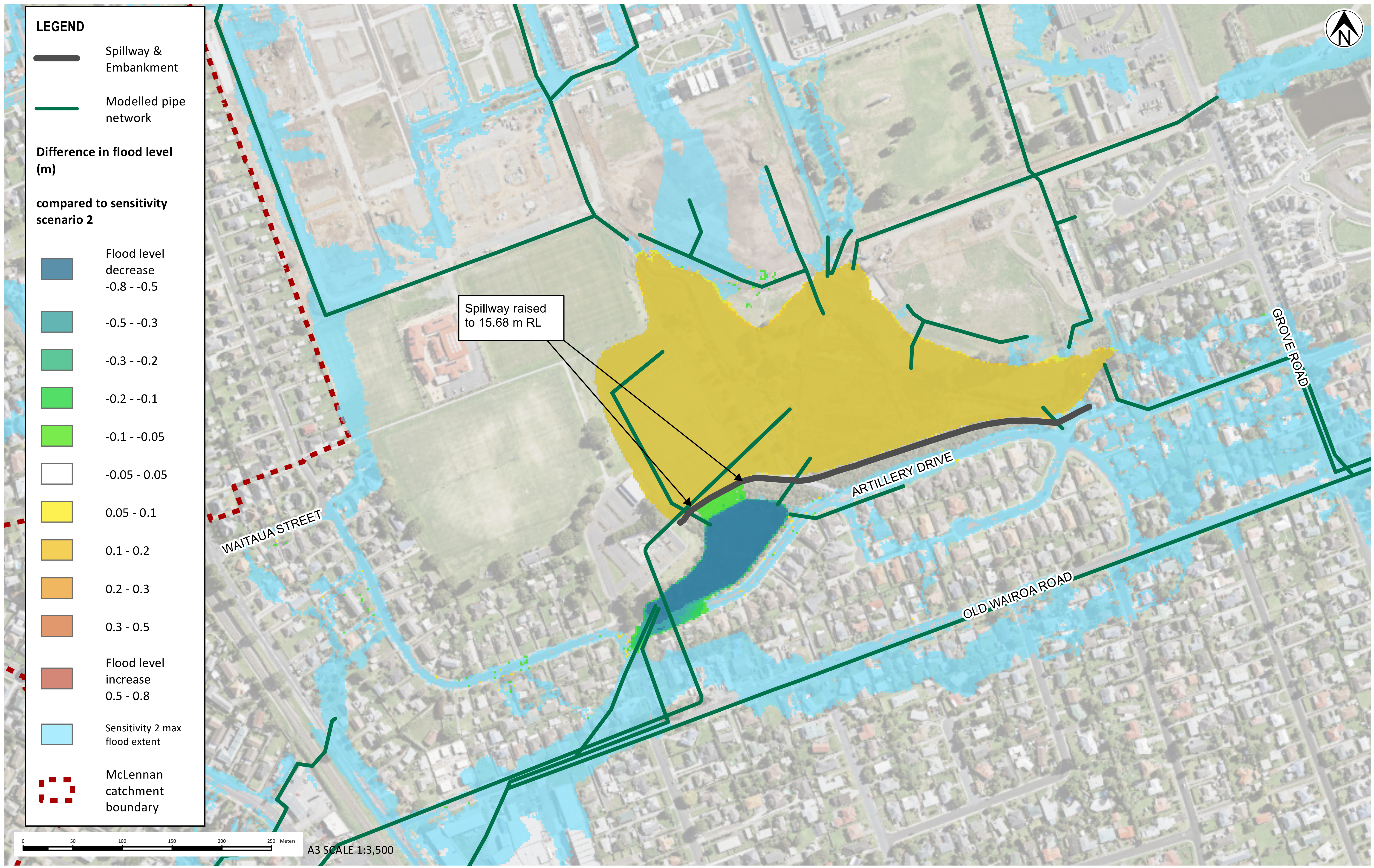

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REV	DESCRIPTION	GIS	CHK	DATE
0	First version	JMOR	SGB	25/05/21

LOCATION PLAN

PROJECT No.	1012030.1040	
DESIGNED	JMOR	JUN.21
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CHECKED	SGB	JUN.21

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

e n v i r o n m e n t s   r e s o u r c e s   f u t u r e s

Auckland Council

Takanini Stormwater Conveyance Channel

Stormwater Report

Technical Report A

April 2016

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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.

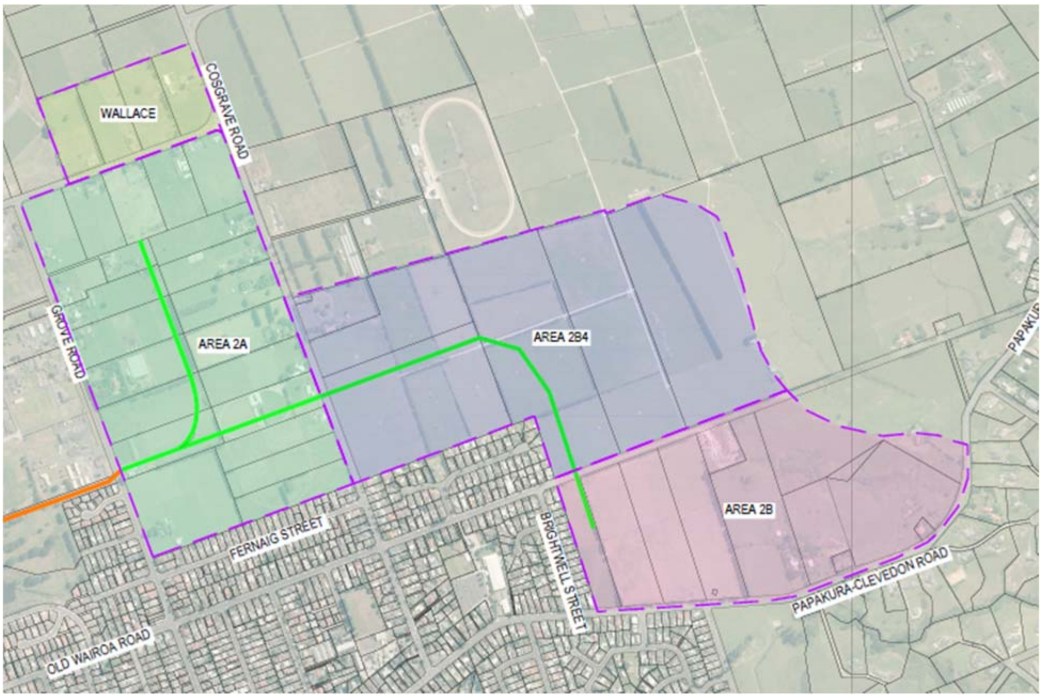

Figure 1 Takanini 2A2B catchment

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.

It was confirmed by Auckland Transport in November 2013 that the Mill Road alignment will likely not be finalised until after the Takanini 2A2B catchment conveyance system has been designated. For this reason, specific interconnection cannot currently be assessed.

It is expected that the Mill Road Corridor will run through 989 Papakura-Clevedon Road and 55 Cosgrave Road before connecting to either Cosgrave Road or Mill Road in the north. Auckland Transport has advised that the Mill Road extension is likely to be 10 to 15 years away.

3.2 McLennan wetland

Existing and consented wetland

The McLennan wetland was 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 of the Old Wairoa Road catchment as per Figure 4.

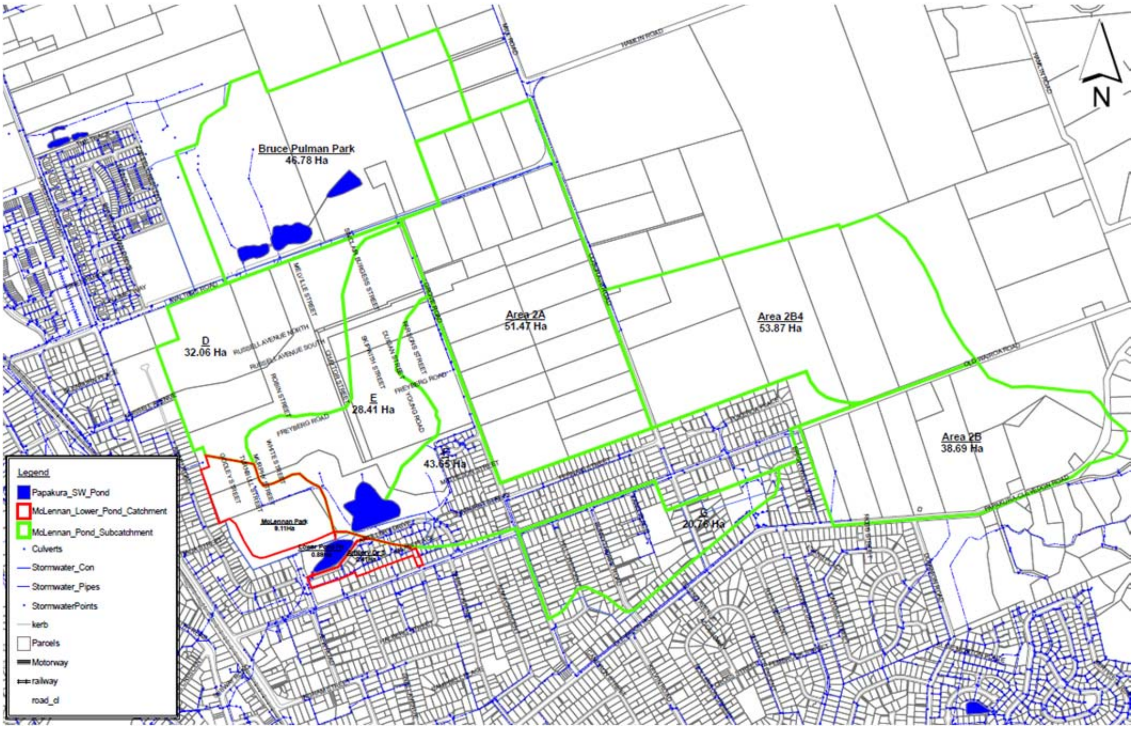

Figure 4 McLennan wetland sub-catchment map (Old Wairoa Road CMP Variations, 2009)

The wetland currently has an embankment top level of RL 16.00 m and an emergency spillway level of RL 15.1 m.

Network Discharge Consent 37205, 33738 and 33538 specify that prior to any further development commencing in areas 2A, 2B or 2B4 (ie. The construction of the Takanini Stormwater Conveyance Channel) the following works will be undertaken:

- Increase of embankment level from RL 16.0 m to RL 16.2 m
- Increase of spillway level from RL 15.1 m to RL 15.4 m

3.3 Documented / observed flooding

A 1% AEP surface flooding area with a maximum 0.5 m flood depth is noted across the Takanini 2A2B area in the ICMP. This floodplain is based on observational data. There have also been reports of historical flooding across the paddocks from landowners.

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^{o}C rise
2% AEP	8.0 % increase per 1^{o}C rise
5% AEP	7.2 % increase per 1^{o}C rise
10% AEP	6.3 % increase per 1^{o}C rise
20% AEP	5.4 % increase per 1^{o}C rise
50% AEP	4.3 % increase per 1^{o}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.

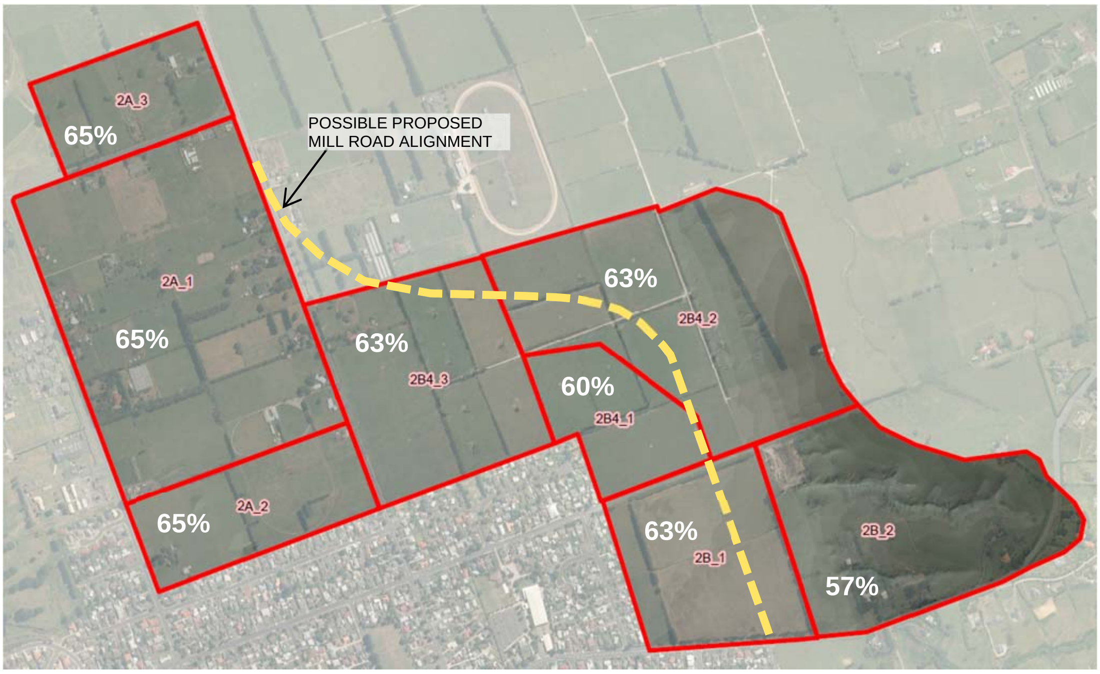

Figure 5 Impervious areas

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.

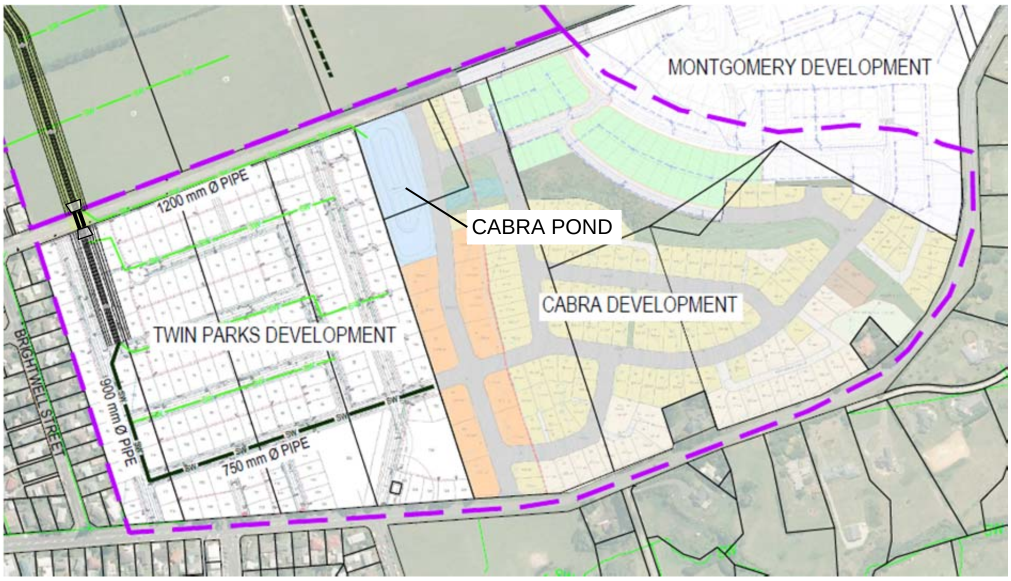

Figure 6 Cabra development and attenuation pond

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.

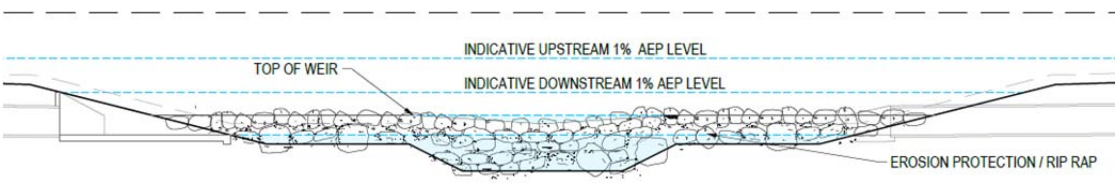

Figure 7 Rock weir cross section detail

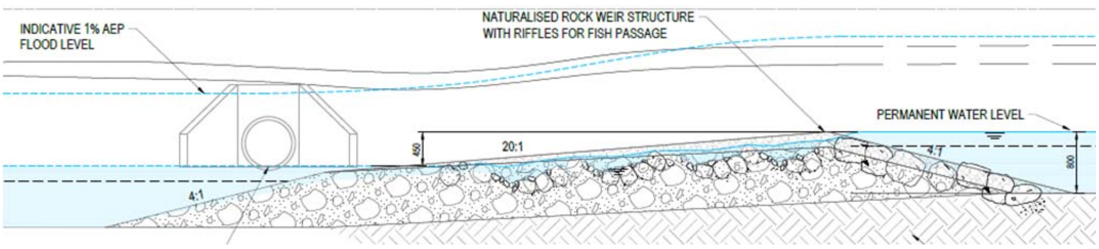

Figure 8 Rock weir longsection detail

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.

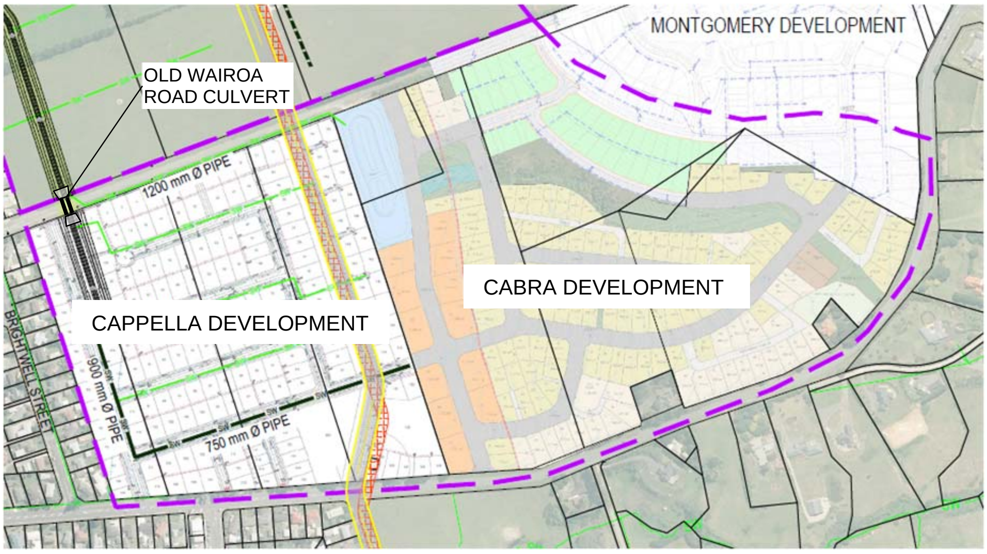

Figure 10 Old Wairoa Road Culvert location plan (Drawing 51-3217404-C310)

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

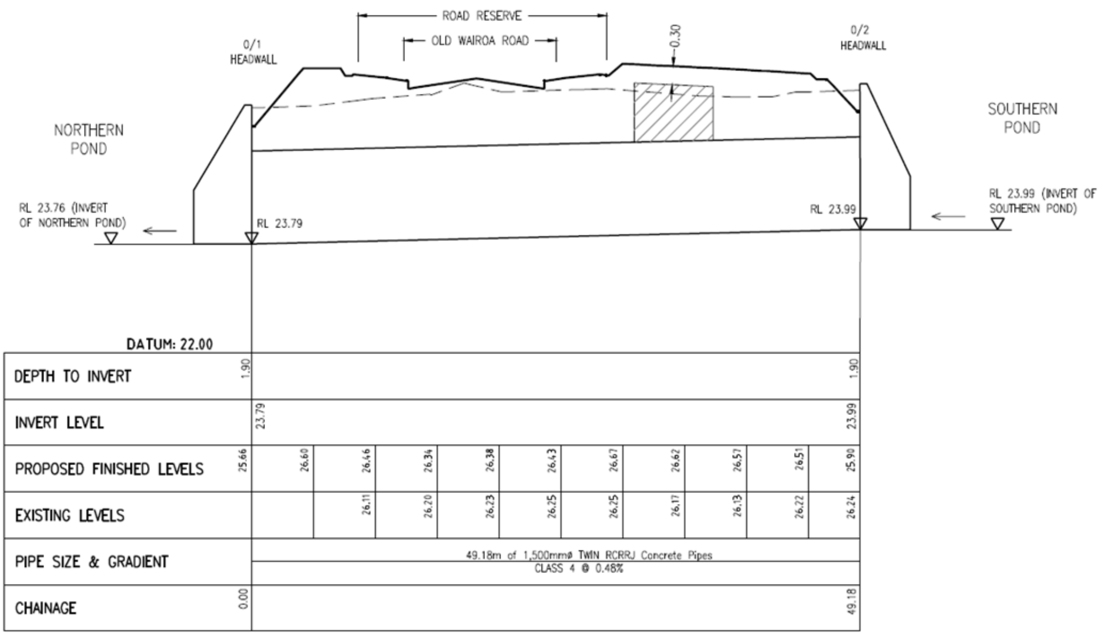

Figure 11 Old Wairoa Road Culvert longsection (MSC, October 2015)

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.

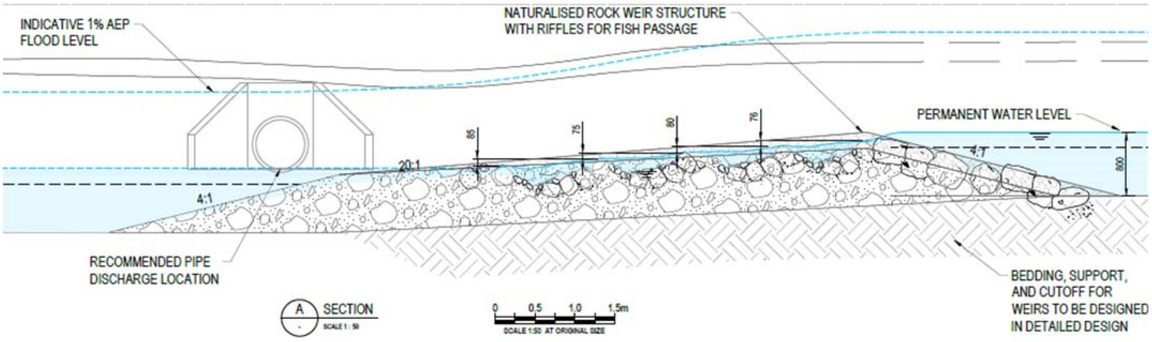

Figure 12 Typical connection longsection

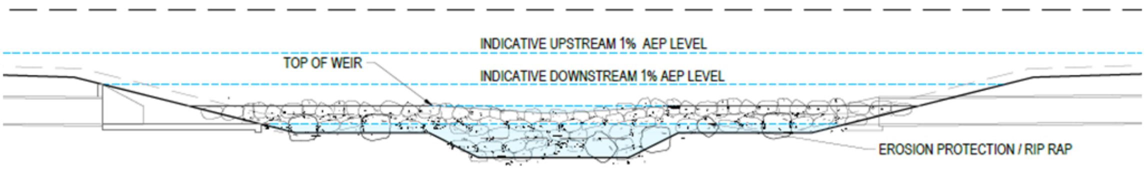

Figure 13 Typical connection cross section

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

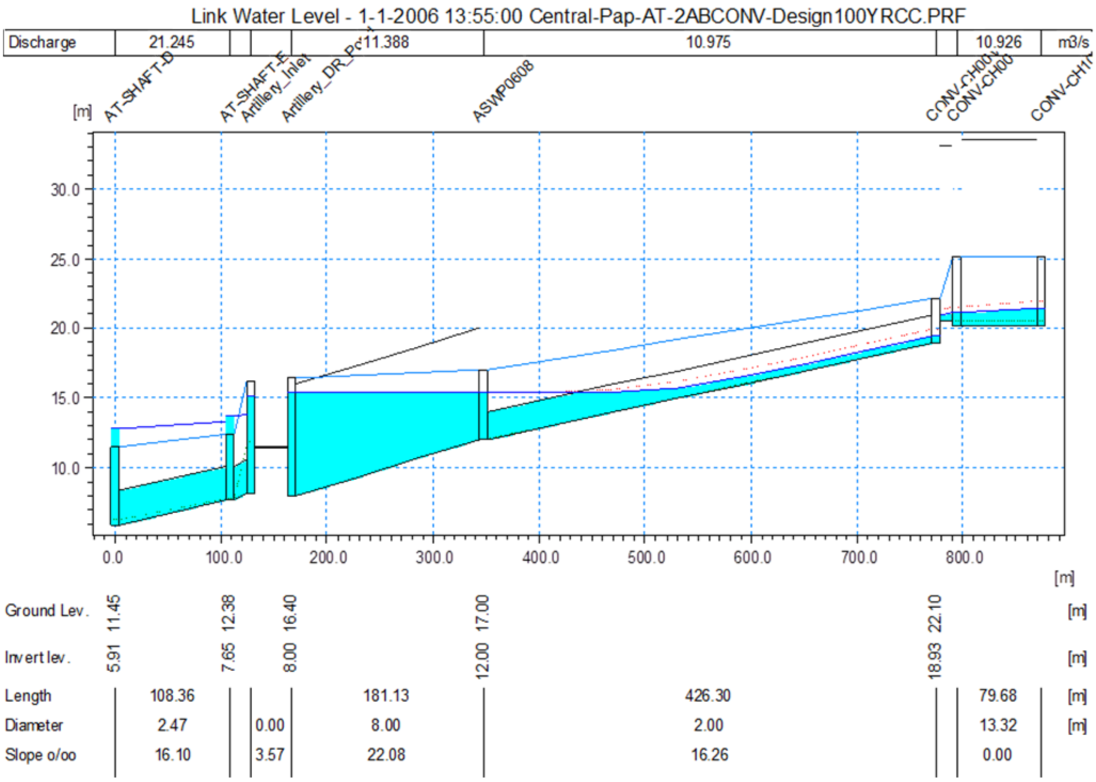

Figure 14 McLennan wetland model

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.

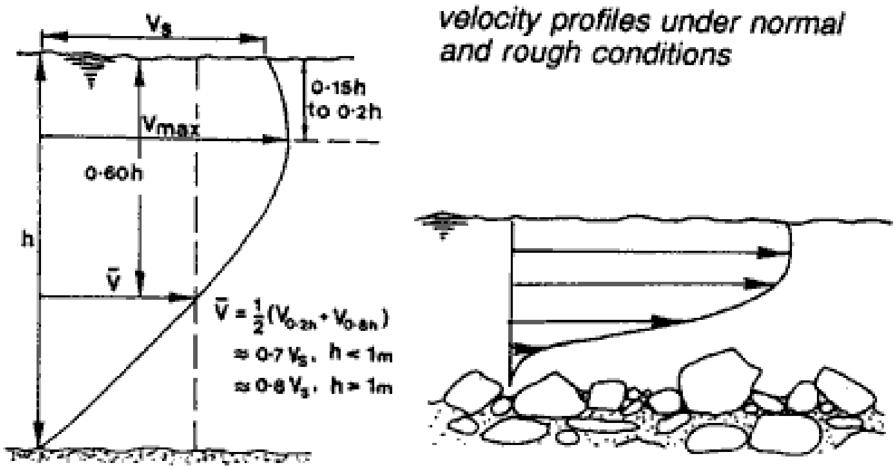

Figure 15 Typical velocity vertical profile (Australian Groundwater Research, 2013)

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.

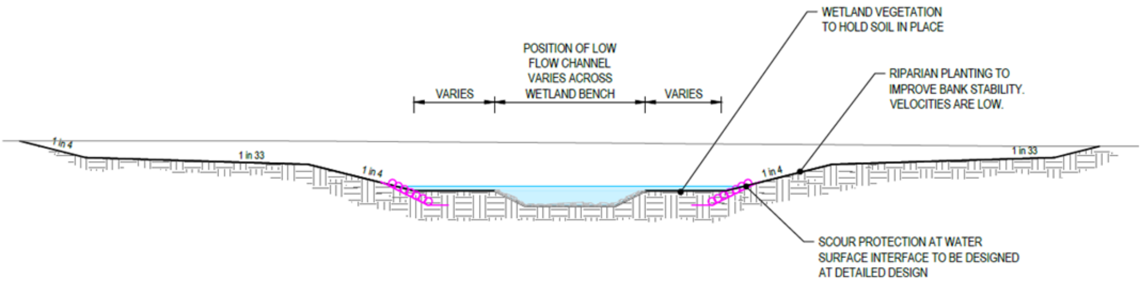

Figure 16 Possible channel erosion protection to be implemented if required

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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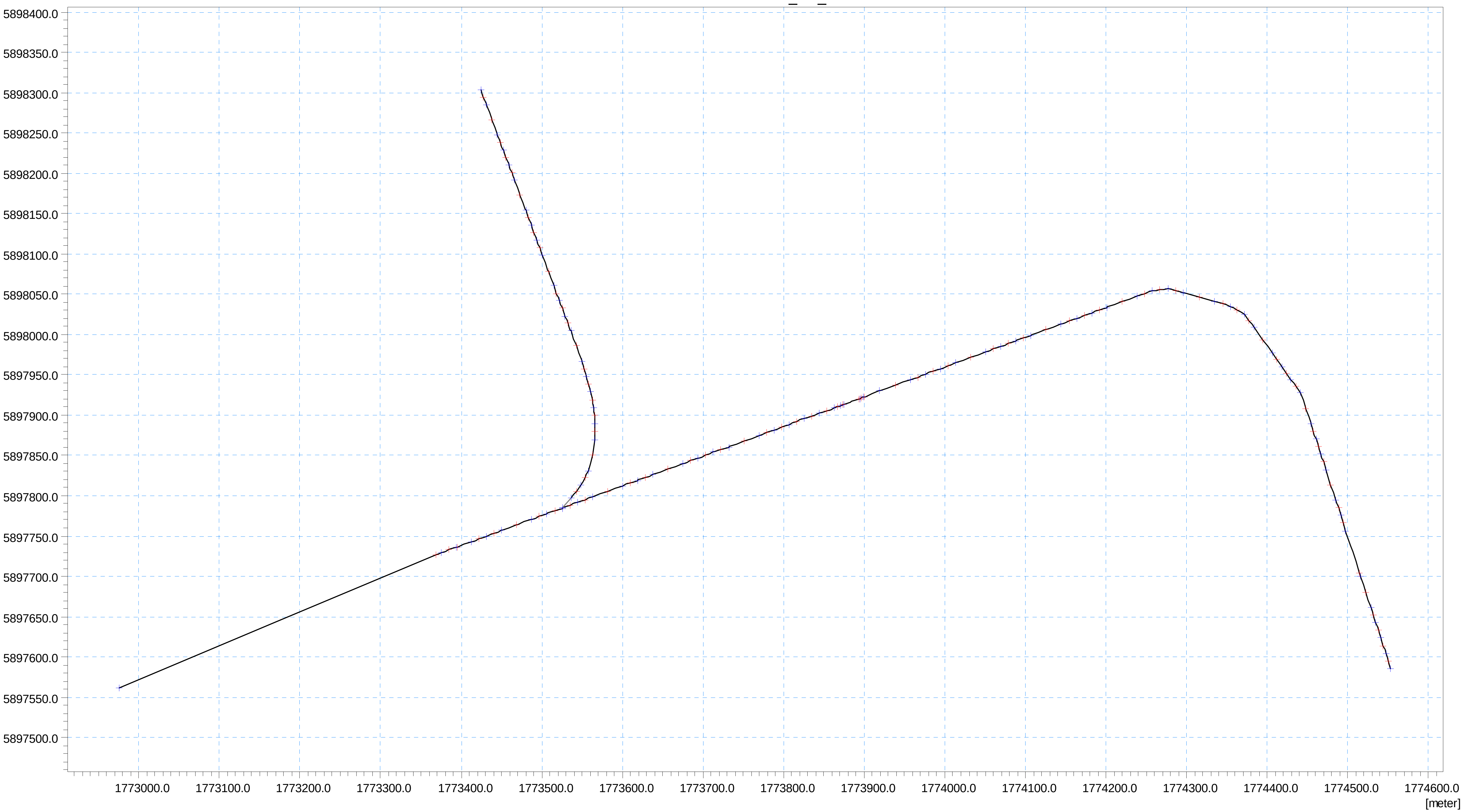
Appendices

Appendix A - (GHD MIKE11 modelling)

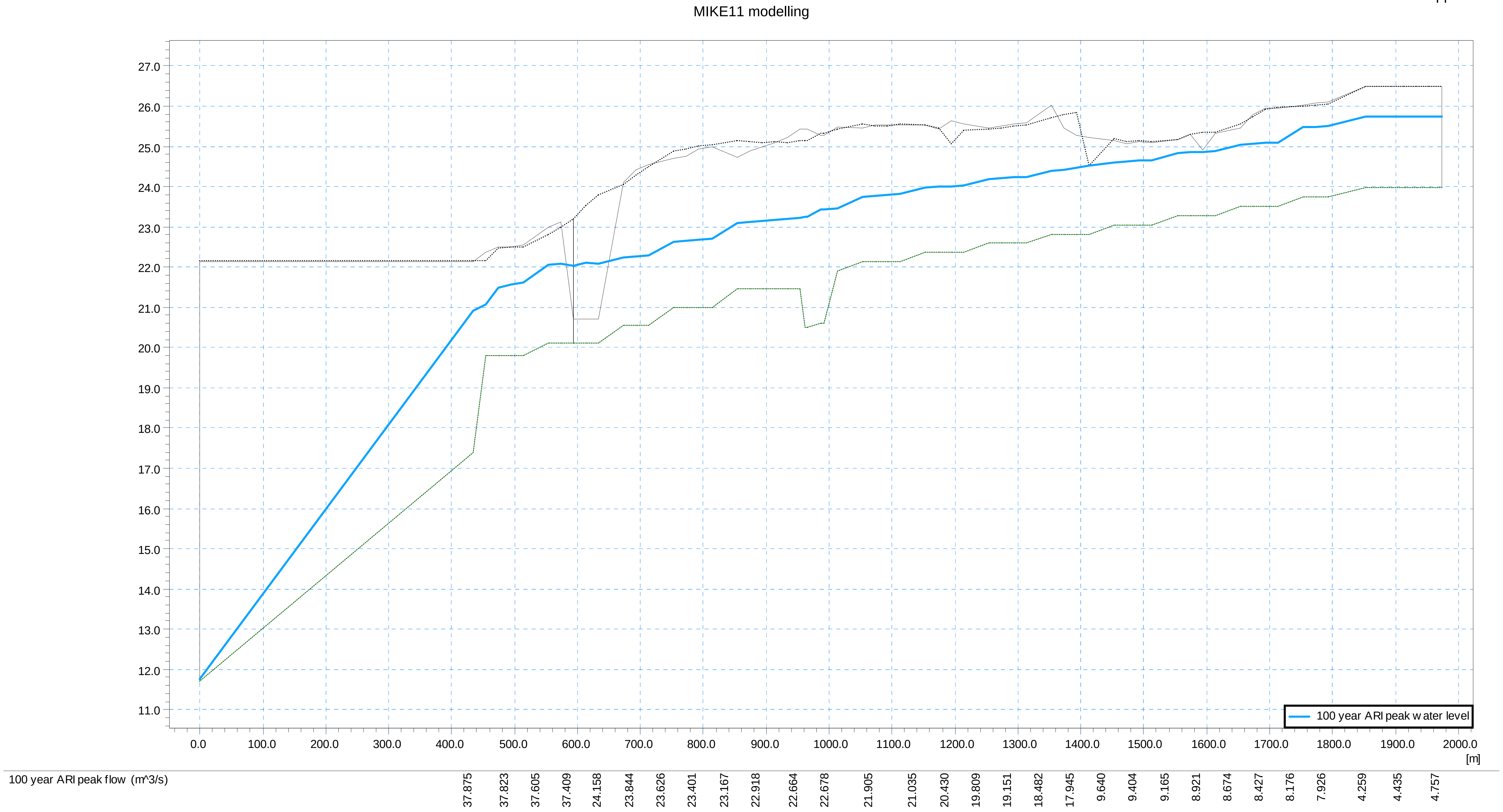
- MIKE11 model plan
- MIKE11 model long sections

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

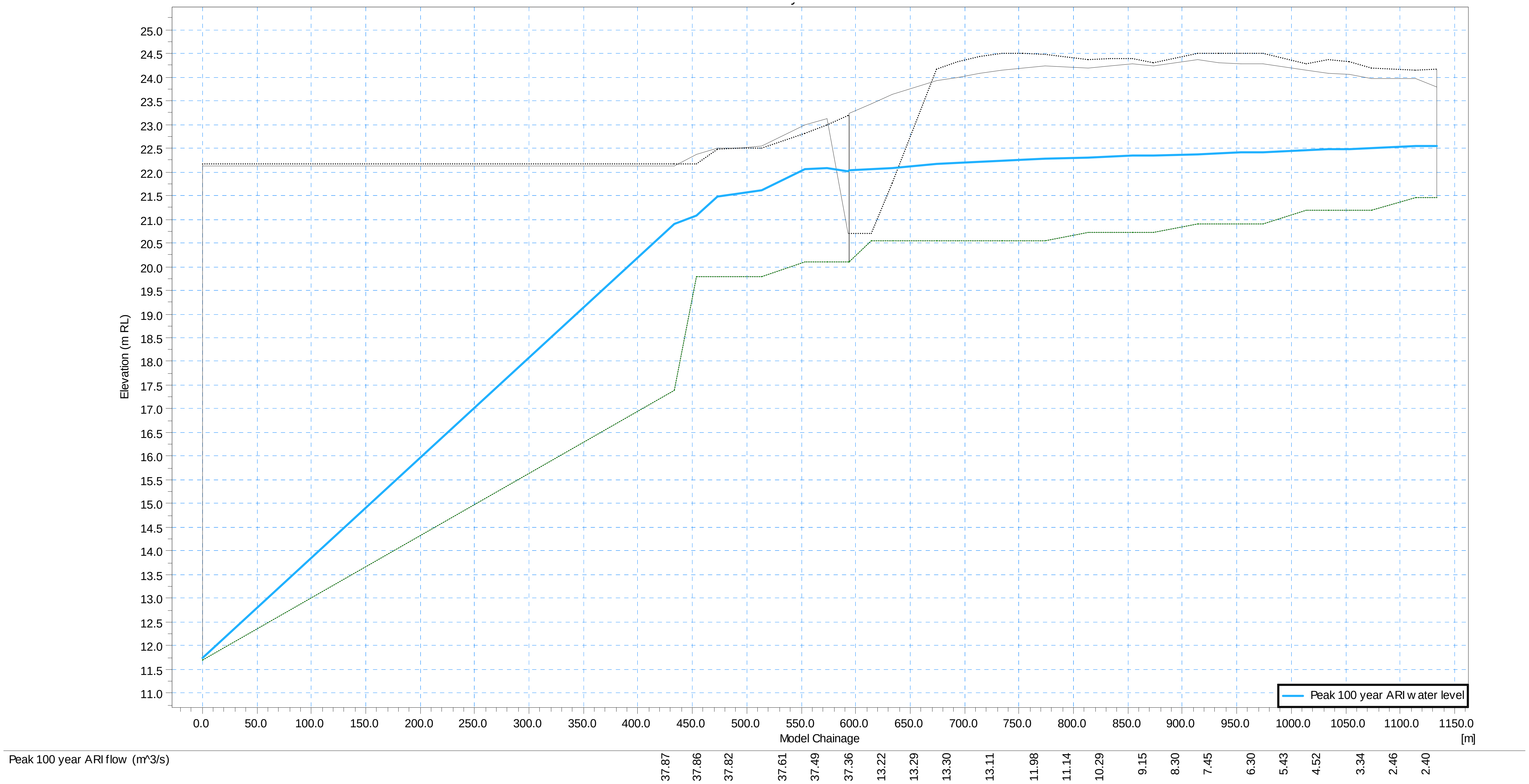


MIKE11 model plan



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

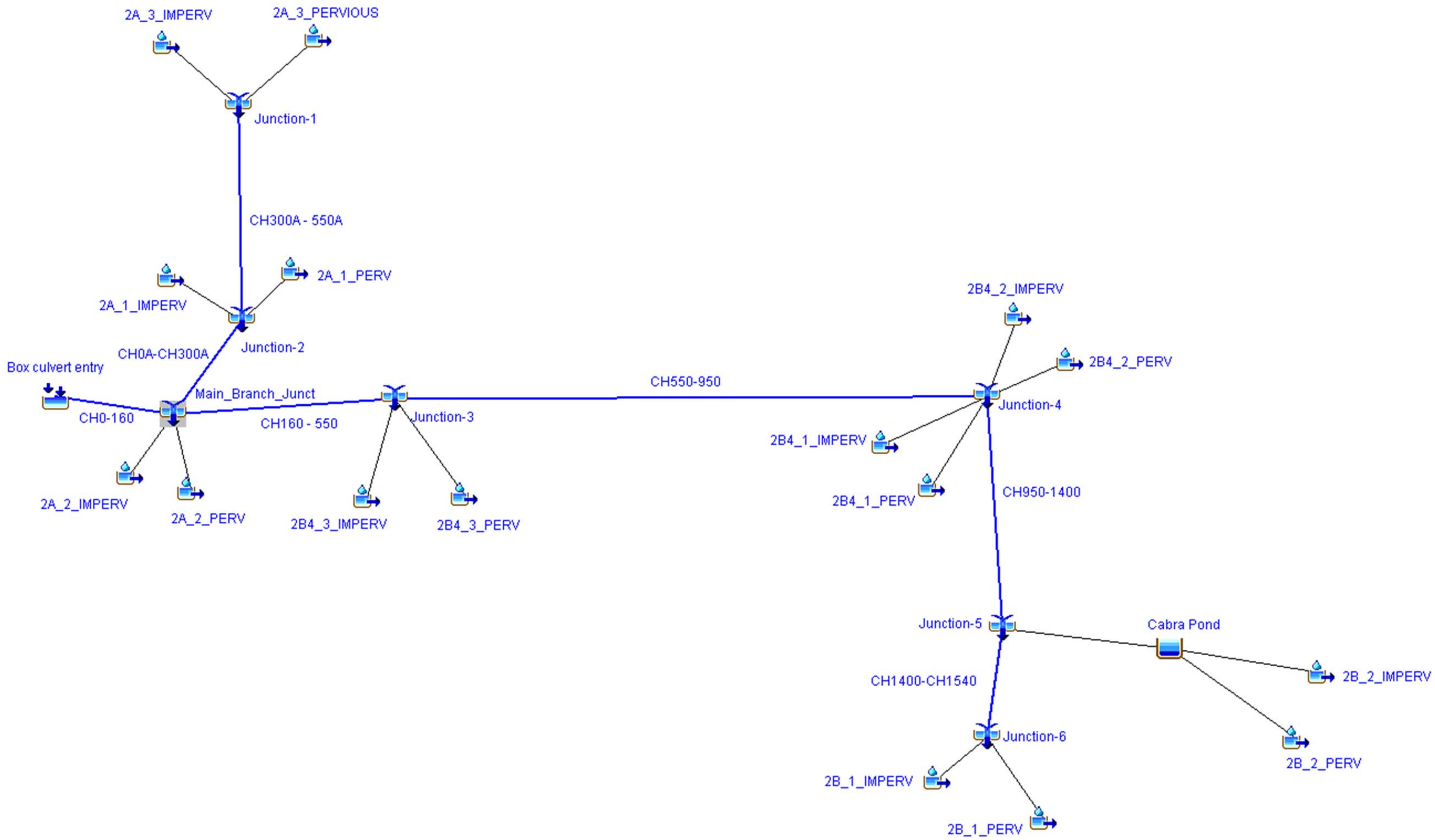
MIKE11 modelling



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

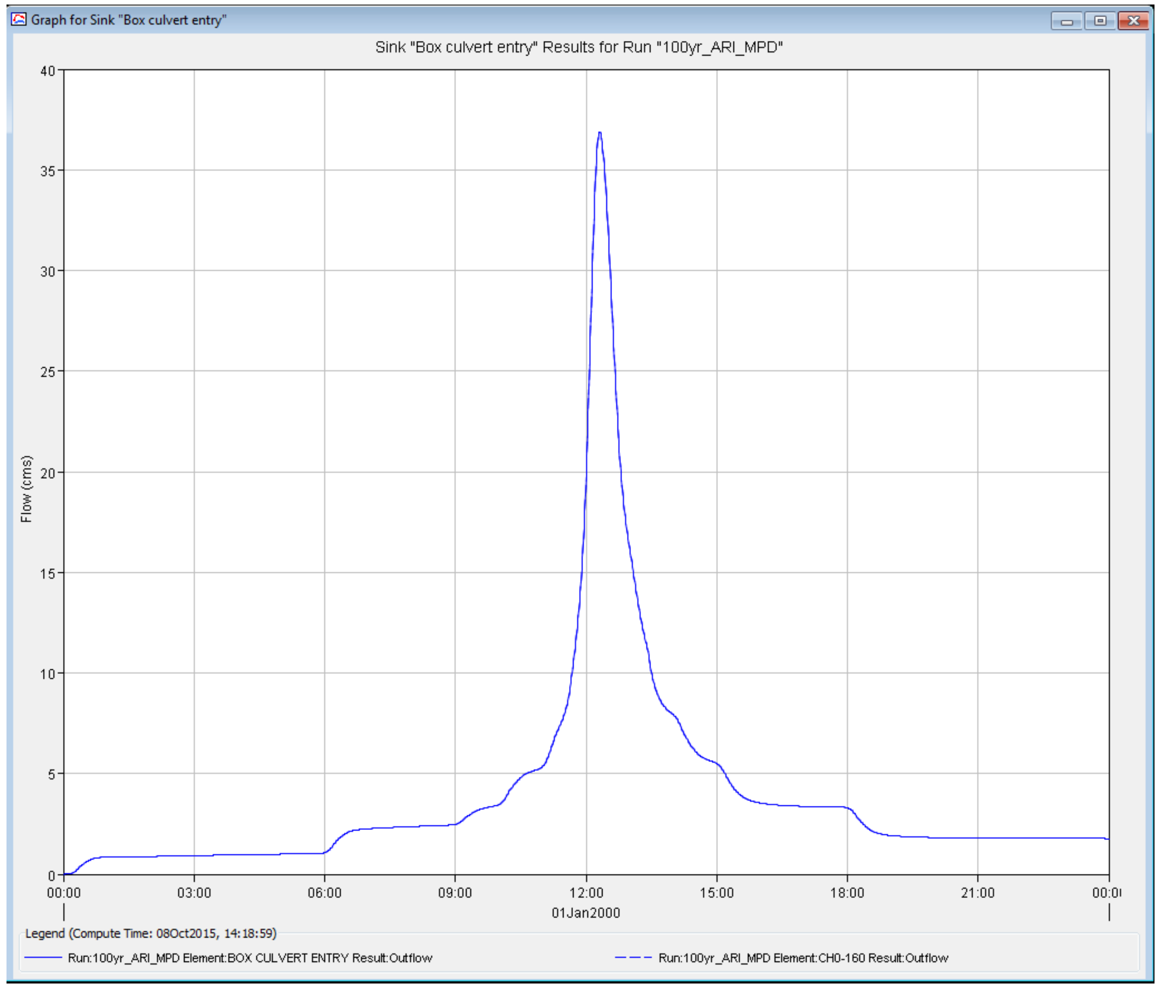
Appendix B - (HEC-HMS modelling)

- 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

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	5.06	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

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	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 1% AEP EVENT	10% AEP		Culvert 1% AEP EVENT	10% AEP		U/S channel 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			

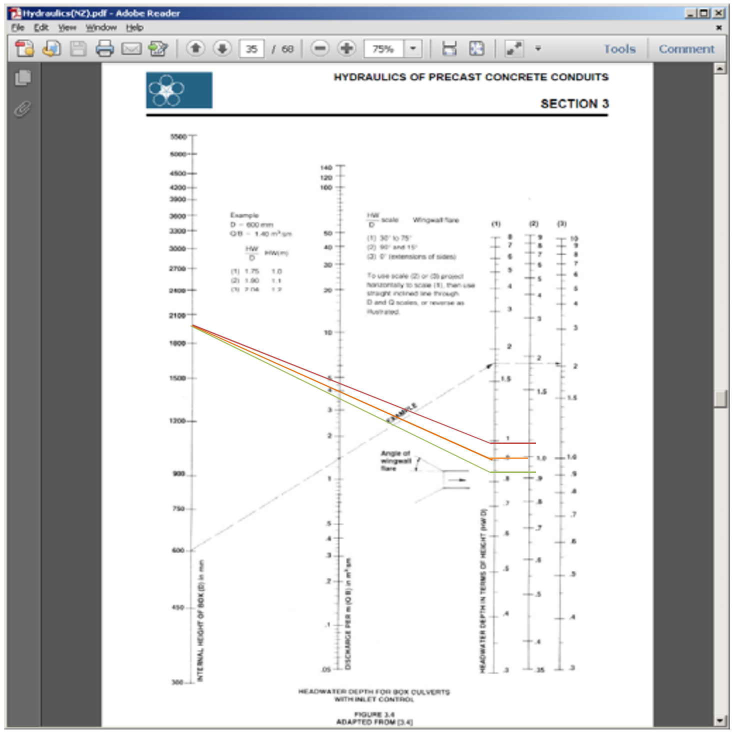
	d/s channel water level	**d/s culvert water level**	**u/s culvert water level**	**u/s channel water level**
1% AEP + CC	23.20	23.29	23.49	23.54
10% AEP + CC	22.95	22.97	23.04	23.06

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			

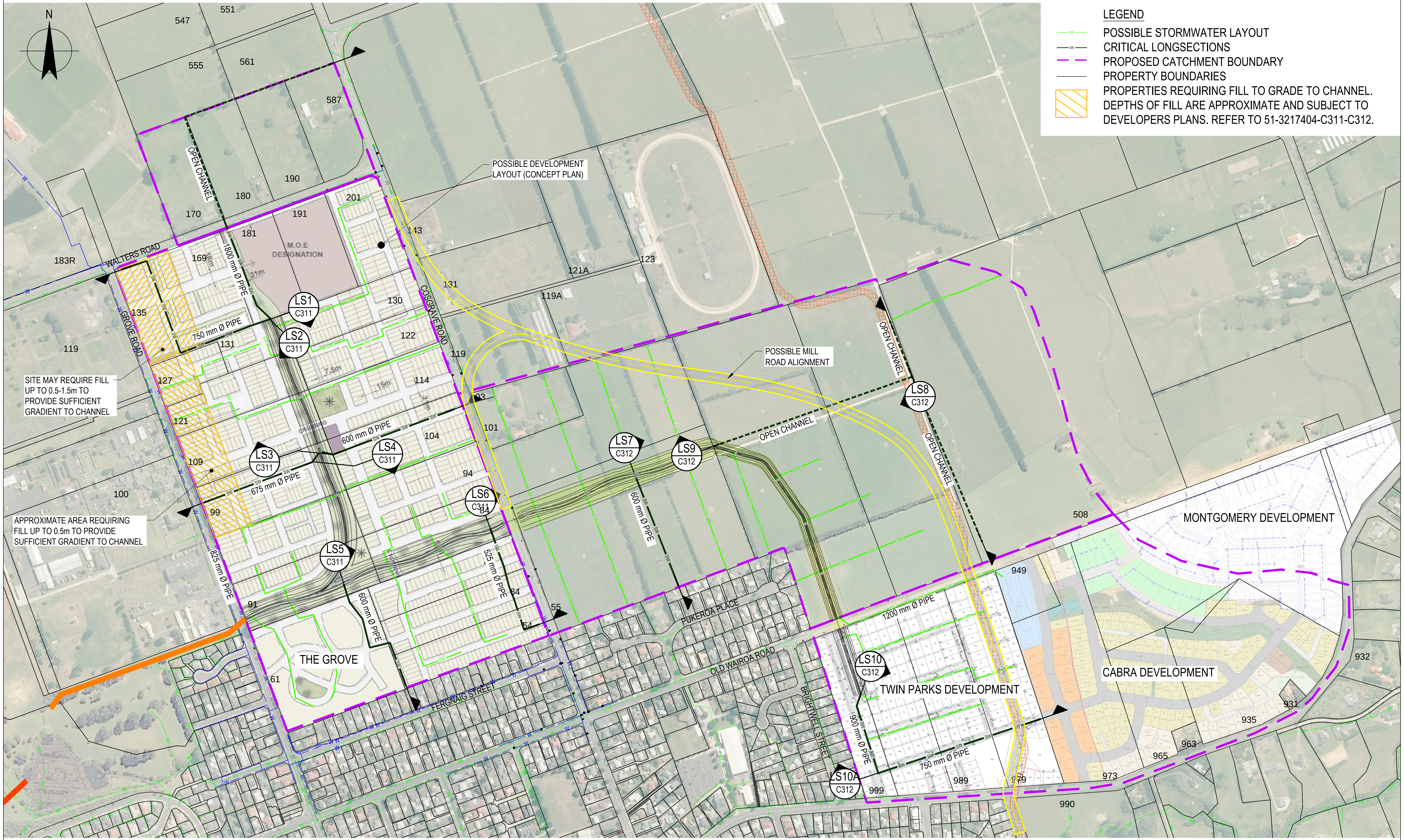
	d/s channel water level	**d/s culvert water level**	**u/s culvert water level**	**u/s channel water level**
1% AEP + CC	25.49	25.54	25.61	25.64
10% AEP + CC	25.32	25.33	25.35	25.36

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)



SCHEME DESIGN

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
Te Kaunihera o Tāmaki Makaurau

GHD
Level 3, GHD Centre
27 Napier Street, Freemans Bay, Auckland 1011 New Zealand
T 64 9 370 8000 F 64 9 370 8001
E auckland@ghd.com W www.ghd.com

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

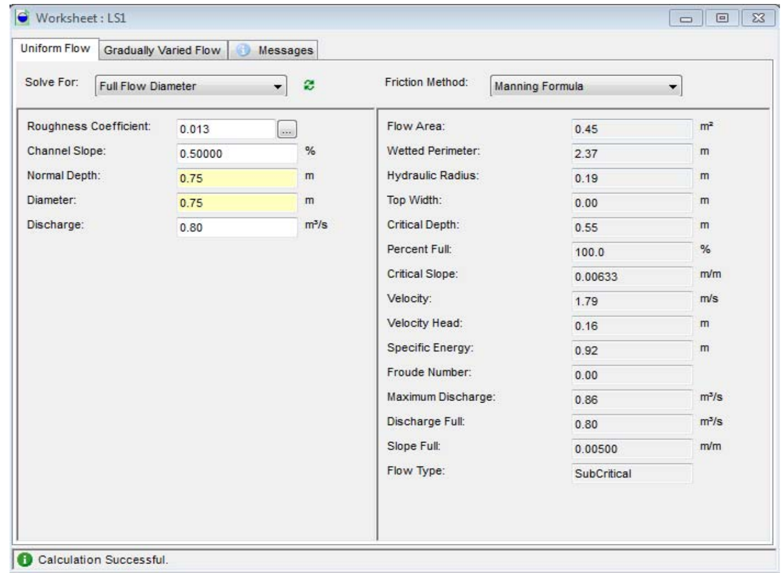
LS1

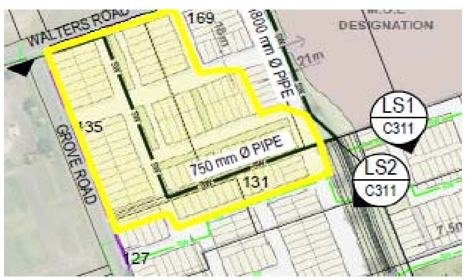
Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

Data entry cells
Result cells
Drop down menu

DEVELOPED CATCHMENT

Select appropriate design storm	→	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





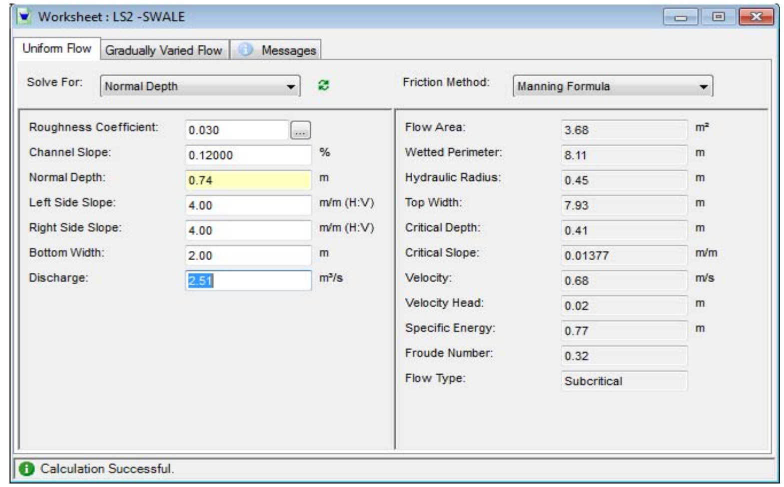
LS2

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

Data entry cells
Result cells
Drop down menu

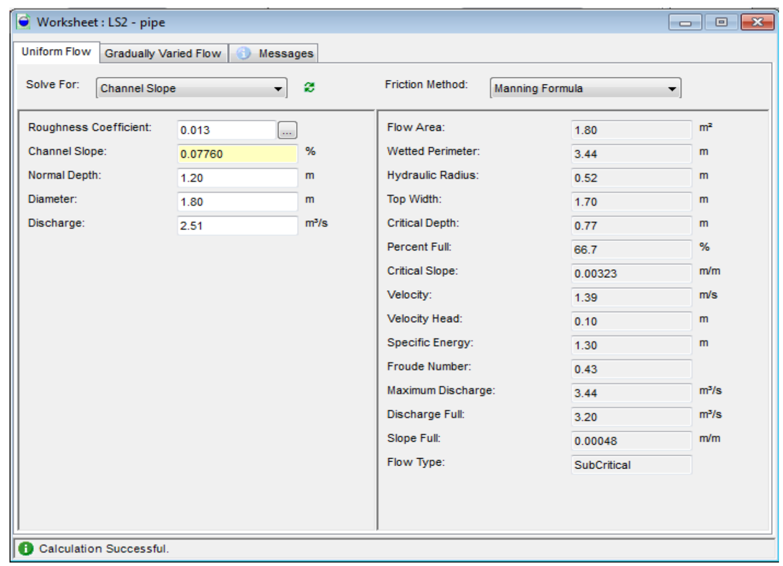
DEVELOPED CATCHMENT

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


Worksheet : LS2 -SWALE
Uniform Flow | Gradually Varied Flow | Messages
Solve For: Normal Depth
Friction Method: Manning Formula

Roughness Coefficient:	0.030		Flow Area:	3.68	m²
Channel Slope:	0.12000	%	Wetted Perimeter:	8.11	m
Normal Depth:	0.74	m	Hydraulic Radius:	0.45	m
Left Side Slope:	4.00	m/m (H:V)	Top Width:	7.93	m
Right Side Slope:	4.00	m/m (H:V)	Critical Depth:	0.41	m
Bottom Width:	2.00	m	Critical Slope:	0.01377	m/m
Discharge:	2.51	m³/s	Velocity:	0.68	m/s
			Velocity Head:	0.02	m
			Specific Energy:	0.77	m
			Froude Number:	0.32	
			Flow Type:	Subcritical	

Calculation Successful.


Worksheet : LS2 - pipe
Uniform Flow | Gradually Varied Flow | Messages
Solve For: Channel Slope
Friction Method: Manning Formula

Roughness Coefficient:	0.013		Flow Area:	1.80	m²
Channel Slope:	0.07760	%	Wetted Perimeter:	3.44	m
Normal Depth:	1.20	m	Hydraulic Radius:	0.52	m
Diameter:	1.80	m	Top Width:	1.70	m
Discharge:	2.51	m³/s	Critical Depth:	0.77	m
			Percent Full:	66.7	%
			Critical Slope:	0.00323	m/m
			Velocity:	1.39	m/s
			Velocity Head:	0.10	m
			Specific Energy:	1.30	m
			Froude Number:	0.43	
			Maximum Discharge:	3.44	m³/s
			Discharge Full:	3.20	m³/s
			Slope Full:	0.00048	m/m
			Flow Type:	SubCritical	

Calculation Successful.

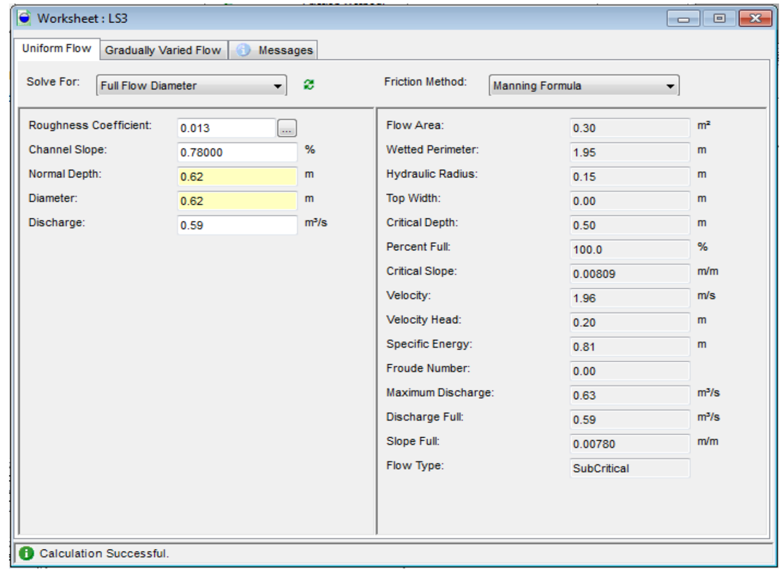
LS3

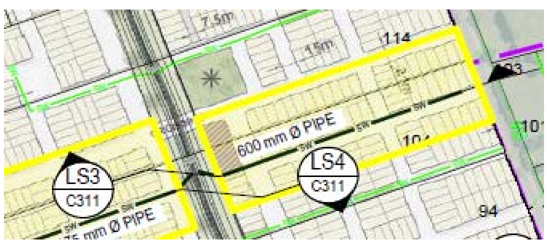
Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

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





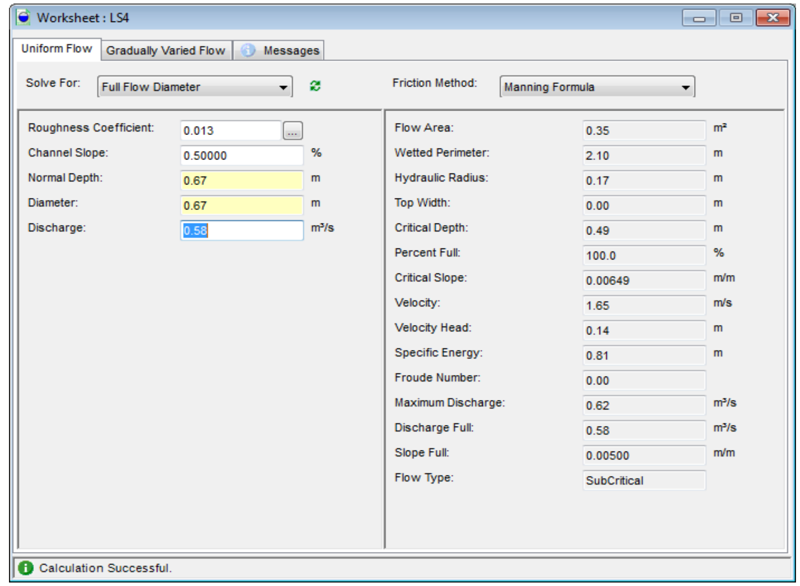
LS4

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



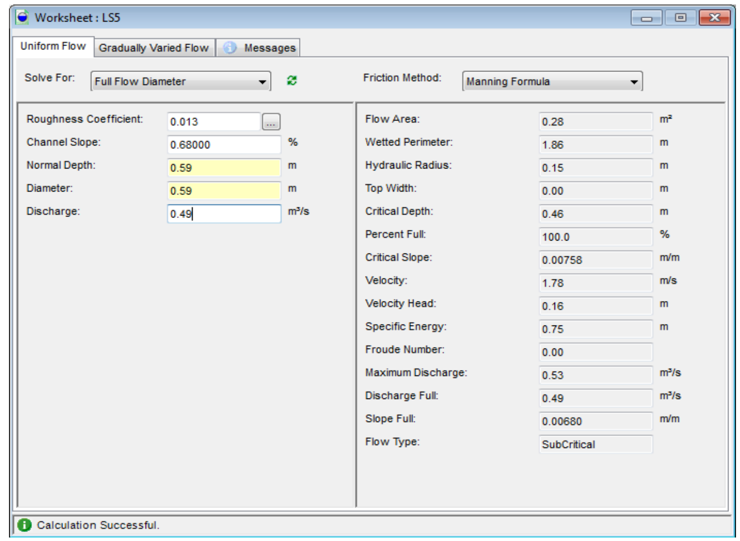
LS5

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	1.371565	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



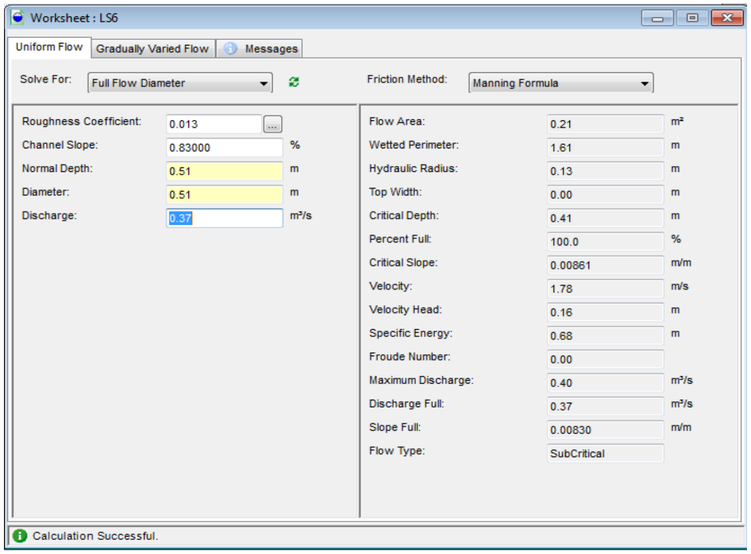
LS6

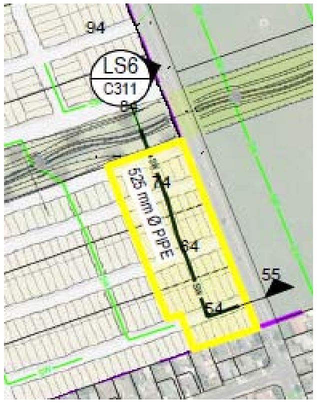
Data entry cells	
Result cells	
Drop down menu	

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

DEVELOPED CATCHMENT

		50% AEP + CC	10% AEP + CC	1% AEP + CC
Select appropriate design storm	→			
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





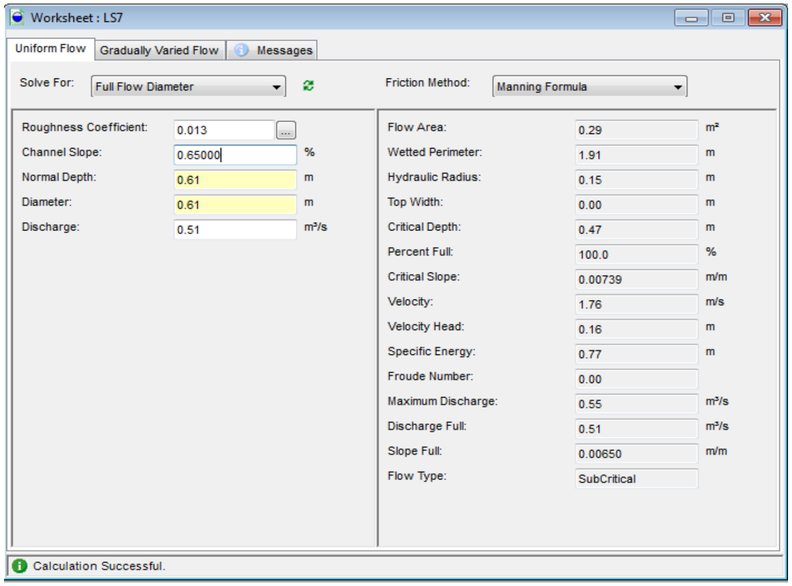
LS7

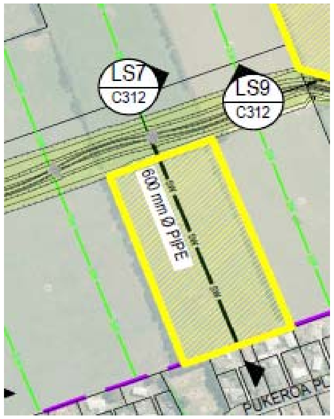
Project	Takanini 2a2b
Address	Takanini
Consultant	GHD
Date	22/01/2015

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	1.41372	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





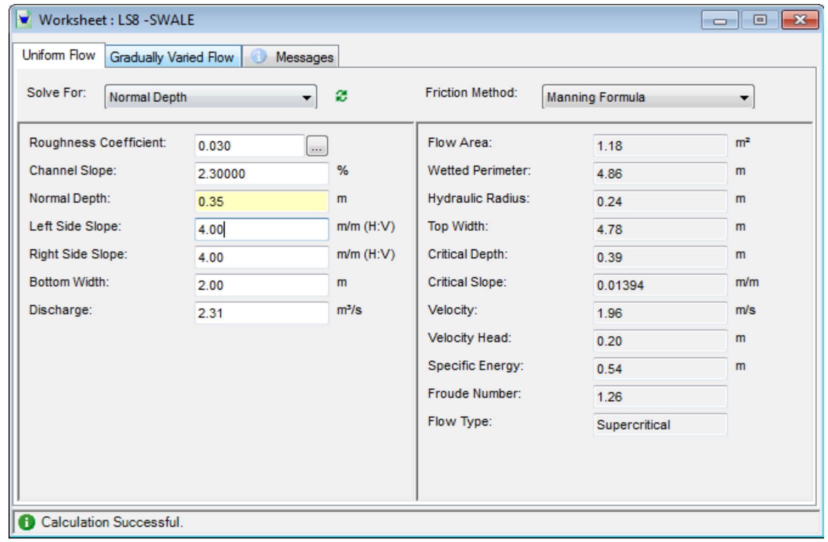
LS8

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

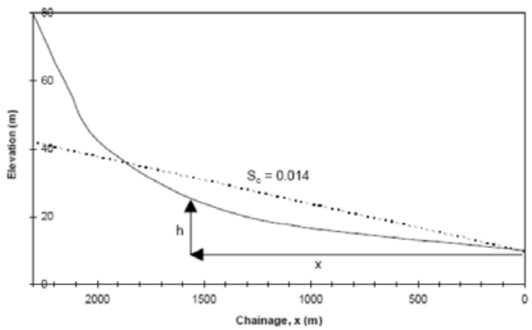
Data entry cells
Result cells
Drop down menu

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



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

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

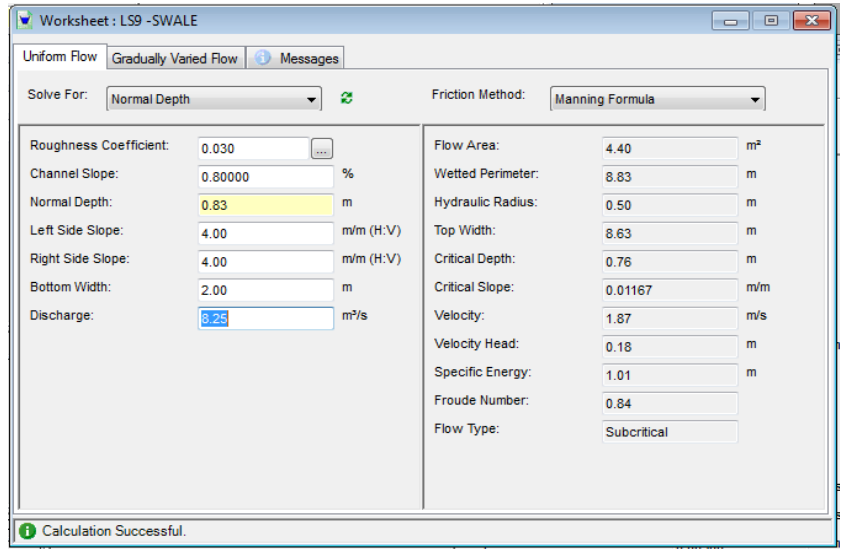
LS9

Data entry cells	
Result cells	
Drop down menu	

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

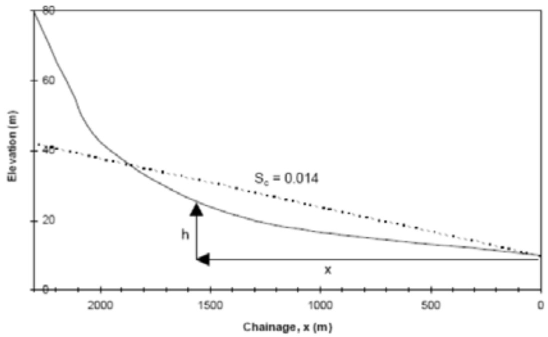
DEVELOPED CATCHMENT

Select appropriate design storm	→	50% AEP + CC	10% AEP + CC	1% AEP + CC
Impervious Area	ha	17.855586	17.855586	17.855586
Pervious Area	ha	10.486614	10.486614	10.486614
total area	ha	28.3422		
% Impervious		63%	63%	63%
Catchment Slope (S_c)	m/m	0.008	0.008	0.008
Catchment Length (l)	km	0.996	0.996	0.996
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	0.40	0.40	0.40
t_p	hours	0.27	0.27	0.27
Storage (S)	mm	31	31	31
c*=(P24-2Ia)/(P24-2Ia+2S)		0.538	0.713	0.803
q* (from Fig. 6.1)	Approx!!	0.093	0.108	0.114
Peak Flowrate (q_p)	m^3/s	2.01	4.82	8.25
24 hour rainfall depth (Q_{24})	mm	52.3	130.3	226.5
24 hour runoff volume (V_{24})	m^3	14819	36924	64199



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

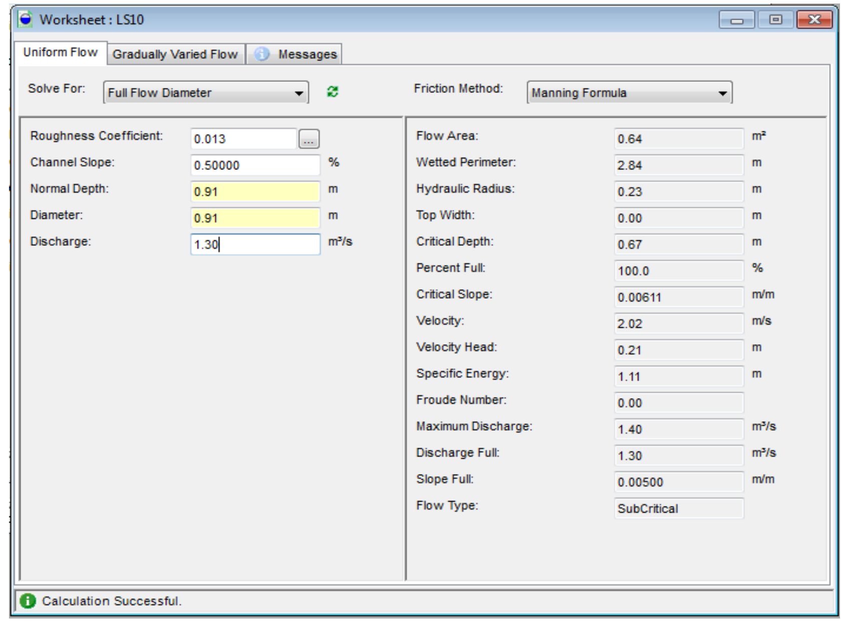
Data entry cells

Result cells

Drop down menu

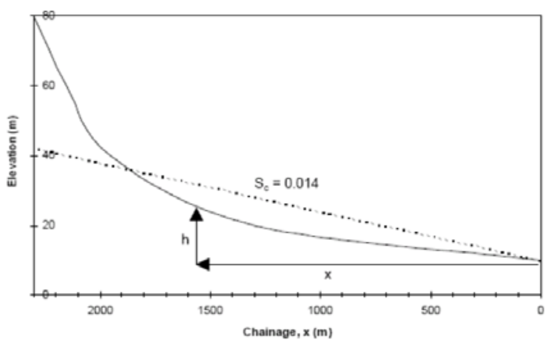
DEVELOPED CATCHMENT

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



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

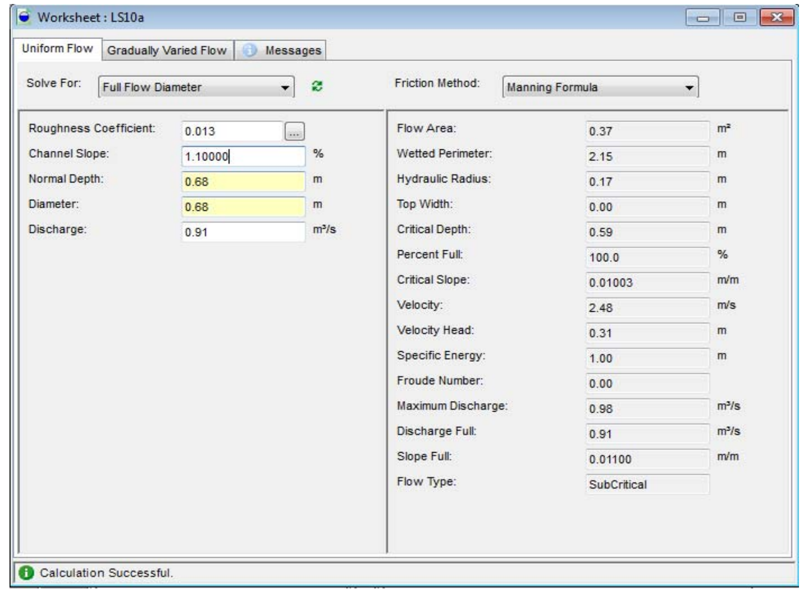
LS10A

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

Data entry cells	
Result cells	
Drop down menu	

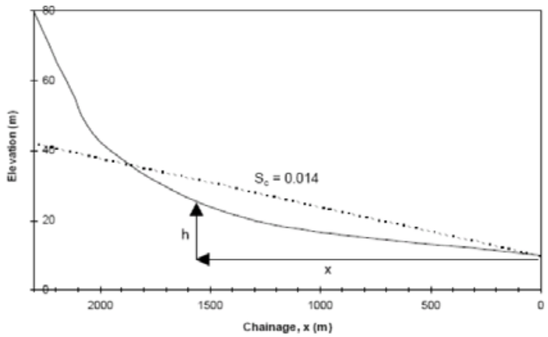
DEVELOPED CATCHMENT

		50% AEP + CC	10% AEP + CC	1% AEP + CC
Select appropriate design storm →				
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



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

$\mathbf{S_c}$	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.

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	Jesse Peeters	Tony Miller		Edward Reid		29/01/16
2	Jesse Peeters	Tony Miller		Edward Reid		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;	Western Catchment 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. Eastern Catchment 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.