STORMWATER MODELLING REPORT

FOR

PROPOSED WARKWORTH SOUTH

PLAN CHANGE AREA

Maven Associates	**Job Number** 211001		**Rev** D
Job Title 1711 & 1723 State Highway 1, Warkworth Plan Change Area **Title** Stormwater Modelling Report	**Author** YW	**Date** 18.01.23	**Checked** AO

CONTENTS

1 INTRODUCTION

1.1 PROJECT

Maven Associates have been engaged to assist in the development of a plan change application including determining setting baseline scenarios for predevelopment scenarios in various storm events and assessing the effects of development specific to the proposed plan change area at 1711 & 1723 State Highway 1, Warkworth. Figure 1.1 shows the study area.

The objective of this report is to provide a preliminary analysis of the overland flowpaths in terms of peak flows and water level constraints. This will enable the assessment of mitigation measures required to ensure the proposal does not result in any adverse effect on the downstream properties. The analysis will be for a range of annual return period storms and include rainfall increases due to climate change.

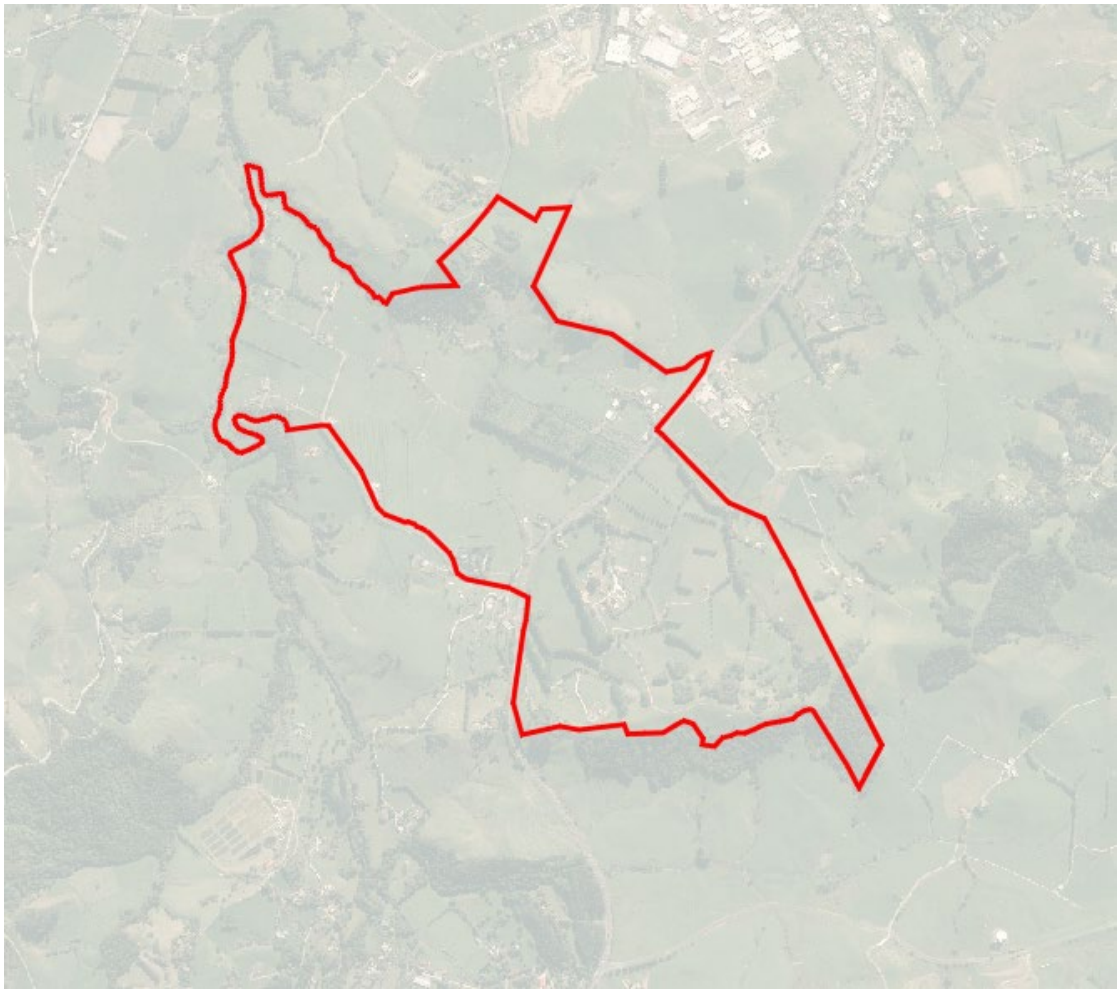


Figure 1.1 – Catchment Delineation

1.2 PREVIOUS STUDY

A Rapid Flood Hazard Assessment was undertaken by DHI in 2009. This was done on a 10m grid. This assessment did not include either climate change or land development changes.

1.3 PROPOSED STRATEGY

A 2D model will be used in the area around the Scheme Plan boundary. This will enable the identification of all overland flowpaths. The upper catchment area will be modelled as individual catchments to provide boundary inflows. All analyses will be done using TP108, HEC-HMS and HEC-RAS in accordance with guidelines of the Auckland Council Stormwater Code of Practice.

1.4 SCENARIOS MODELLED

Table 1.1 shows the scenarios modelled. Scenarios will indicate the difference between today's existing flow environment and the future.

Scenario	Return period	Land-use	Rainfall
1	100-year	Existing	Existing - historical
2	100-year	Existing	Climate change
3	100-year	Developed	Climate change
4	50-year	Developed	Climate change
5	20-year	Developed	Climate change
7	10-year	Developed	Climate change

Table 1.1 – Scenarios modelled

1.5 SOURCES OF DATA

Attribute	Organisation
Catchment Plans	Auckland Council Geomaps
Contours	LINZ DEM 1m. The Terrain datum is New Zealand Vertical Datum. LiDAR/Site Survey by Parrallax Ltd. LiDAR/Site Survey by Maven Associates.
Flow & WL data	Healthywaters
Flood level evidence	None

Table 1.2 – Source of Data

1.6 REFERENCE TECHNICAL DOCUMENTS

- AUCKLAND COUNCIL CODE OF PRACTICE FOR LAND DEVELOPMENT AND SUBDIVISION. CHAPTER4 – STORMWATER, VERSION 3.00
- ACCEPTABLE SOLUTIONS AND VERIFIABLE METHODS, DOCUMENT E1 SURFACE WATER, MINISTRYOF BUSINESS, INNOVATION AND EMPLOYMENT,
- AUCKLAND COUNCIL TP108

2 HYDROLOGICAL MODELLING WITH HEC-HMS

2.1 METHODOLOGY

The analysis was done using the following steps:

1. Delineate the catchments,
2. Use Tp108 to calculate parameters,
3. Use HEC-HMS to create a rainfall hyetograph and flow hydrographs,

2.2 RAINFALL DATA

TP108 gives the following rainfall depths which are then adjusted for climate change as shown in Table 2.2. Climate change factor have been applied in accordance with Auckland Council code of practice (Version 3) assuming a 2.1°C increase in temperature as shown below;

Annual Exceedance probability exceedance	Percentage Increase in 24-hour design rainfall depth due to future climate change*
10%	13.2%
5%	15.1%
2%	16.8%
1%	16.8%

* Assuming 2.1°C increase in temperature

Table 2.1 - Climate change factors

In accordance with TP108 section 2.3 an areal reduction factor (ARF) has been applies as the catchment has an area above 10 km2. ARF adjusted rainfalls are also shown in table 2.2. An ARF factor of 0.92 was used per TP108 table 2.2.

	TP108	Climate change	ARF adjusted
10-year	170	192	176
20-year	208	239	220
50-year	238	278	256
100-year	270	315	290

Table 2.2 – Rain depths

2.3 CATCHMENT SIZE

Figure 2.1 shows the catchment area modelled. The upper catchments are *A* to *F and downstream catchments* G to N. The red boundary is the 2D grid with the excess *Rain*. The catchment outflow of the Mahurangi River is at the northern edge. The Scheme Plan boundary is blue. The total area is 49km^2.

2.4 LAND-USE AND SOILS

The soil is assumed to be Group C with a curve number of 74. The land cover for the existing scenario has been obtained via delineation of impervious areas shown on the Auckland Council GIS aerial.The land-use is predominantly Rural-production and Rural-coastal with a small area of conservation, according to the AUP, see Figure 2.2. For the proposed scenario, the MPD (maximum probable development) of the proposed zoning has been used as well as MPD for the yellow designated FutureUrban. The FutureUrban zoning included in the developed scenarios assumes an average impervious area of 60%. The combined curve numbers and initial abstractions have been calculated according to TP108 and may be found in appendix D based on existing and developed land-use. Only catchments *Rain* and *F* will have a change in impervious area.

The full TP108 details to calculate the peak flows and times of concentration may be found in Appendix D. The total catchment area and the time of concentration suggests an area reduction factor of 0.92. This has been applied to the rainfall as per Table 2.2. This data can now be inserted into a HEC-HMS model.

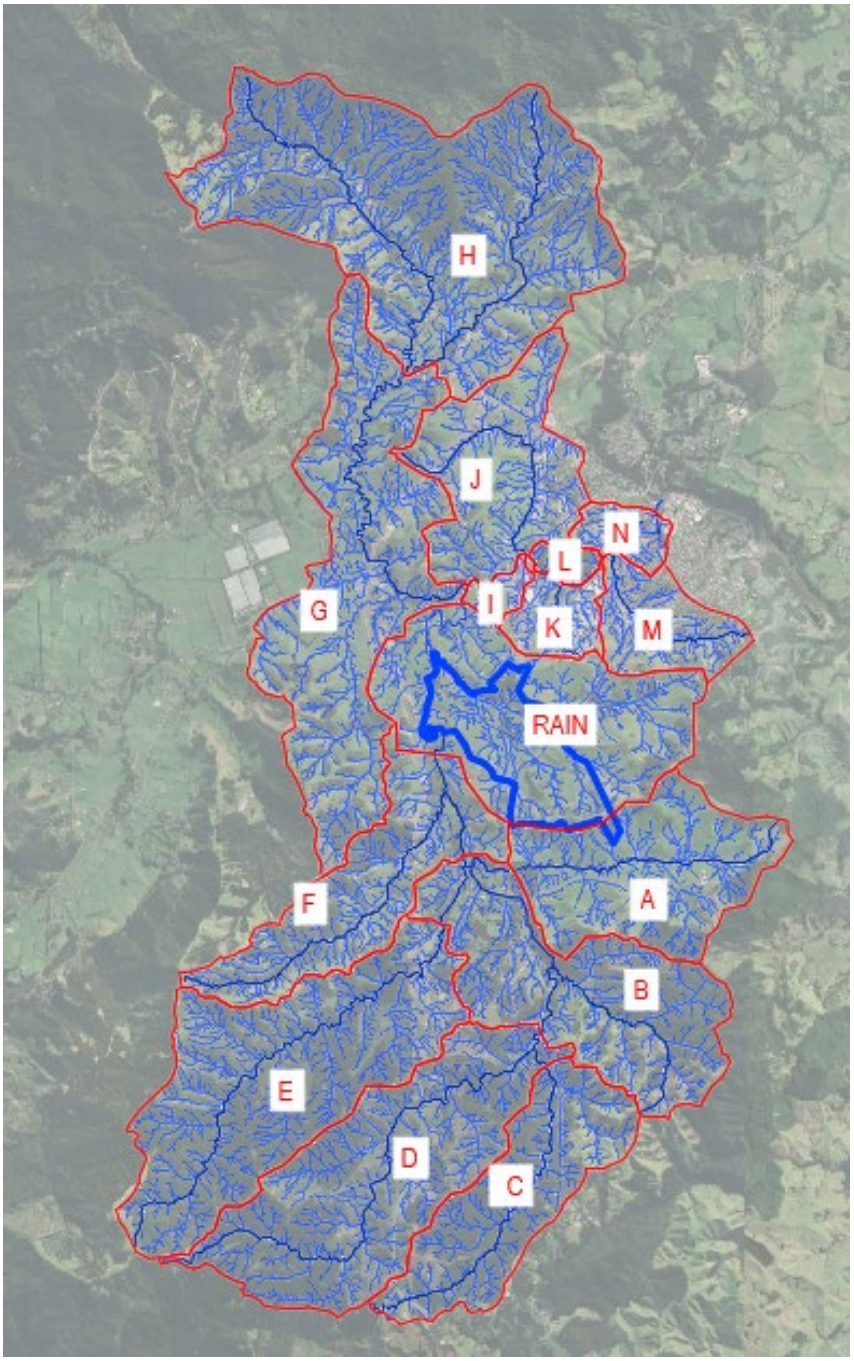


Figure 2.1 – Catchment Boundary

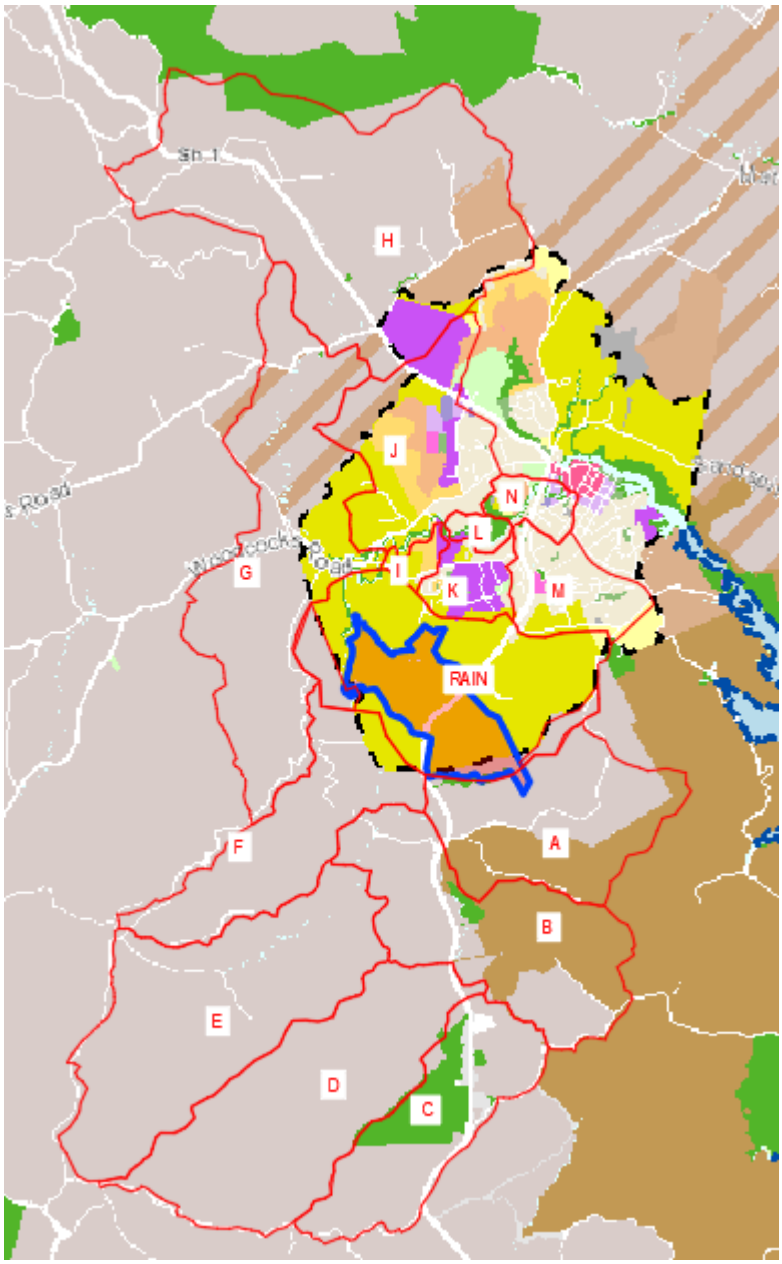


Figure 2.2 – Land-use zones

	Impervious %	Rain	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Total		485	334	412	292	510	573	304	585	849	24	284	72	22	128	49
Rural / Vegetated area	1%	471	331	405	291	481	572	302	581	845	12	276	27	22	15	10
Urban MPD to	60%	0	0	0	0	0	0	0	0	0	12	5	0	0	113	39
Open Space - Conservation	1%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transort Corridor	90%	13	3	7	1	0	0	2	4	4	0	3	0	0	0	0
Residential - Large Lot	35%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential - Single House	60%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential - Mixed Housing Urban	60%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential - Terrace & Apartment	70%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Business - Local Centre Zone	100%	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0
Impervious		16.42	6.01	10.35	3.81	4.81	5.72	4.82	9.41	12.05	7.32	8.46	45.27	0.22	67.71	23.60
Pervious		468.91	327.76	401.82	287.75	505.27	567.57	299.11	575.13	836.71	16.25	275.40	26.88	21.57	59.89	25.57

Figure 2.3 – Existing land use calculations

	Impervious %	Rain	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Total		485	334	412	292	510	573	304	585	849	24	284	72	22	128	49
Rural / Vegetated area	1%	51	331	405	291	481	572	285	581	845	12	276	27	22	15	10
Urban MPD to	60%	276	0	0	0	0	0	17	0	0	12	5	0	0	113	39
Open Space - Conservation	1%	5.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transort Corridor	90%	13.0	3	7	1	0	0	2	4	4	0	3	0	0	0	0
Residential - Large Lot	35%	13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential - Single House	60%	22.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential - Mixed Housing Urban	60%	74.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential - Terrace & Apartment	70%	25.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Business - Local Centre Zone	100%	3.4	0	0	0	0	0	0	0	0	0	0	45	0	0	0
Impervious		261.76	6.01	10.35	3.81	4.81	5.72	15.10	9.41	12.05	7.32	8.46	45.27	0.22	67.71	23.60
Pervious		223.57	327.76	401.82	287.75	505.27	567.57	288.83	575.13	836.71	16.25	275.40	26.88	21.57	59.89	25.57

Figure 2.4 – Developed land use calculations

2.5 HEC-HMS MODEL

The data was then transferred to HEC-HMS. Figure 2.7 shows the model set-up. Calculations for the time of concentration of the reaches may be found in Appendix D. The reaches between junctions have been incorporated respectively to reflect the time it would take to arrive at the downstream connection.

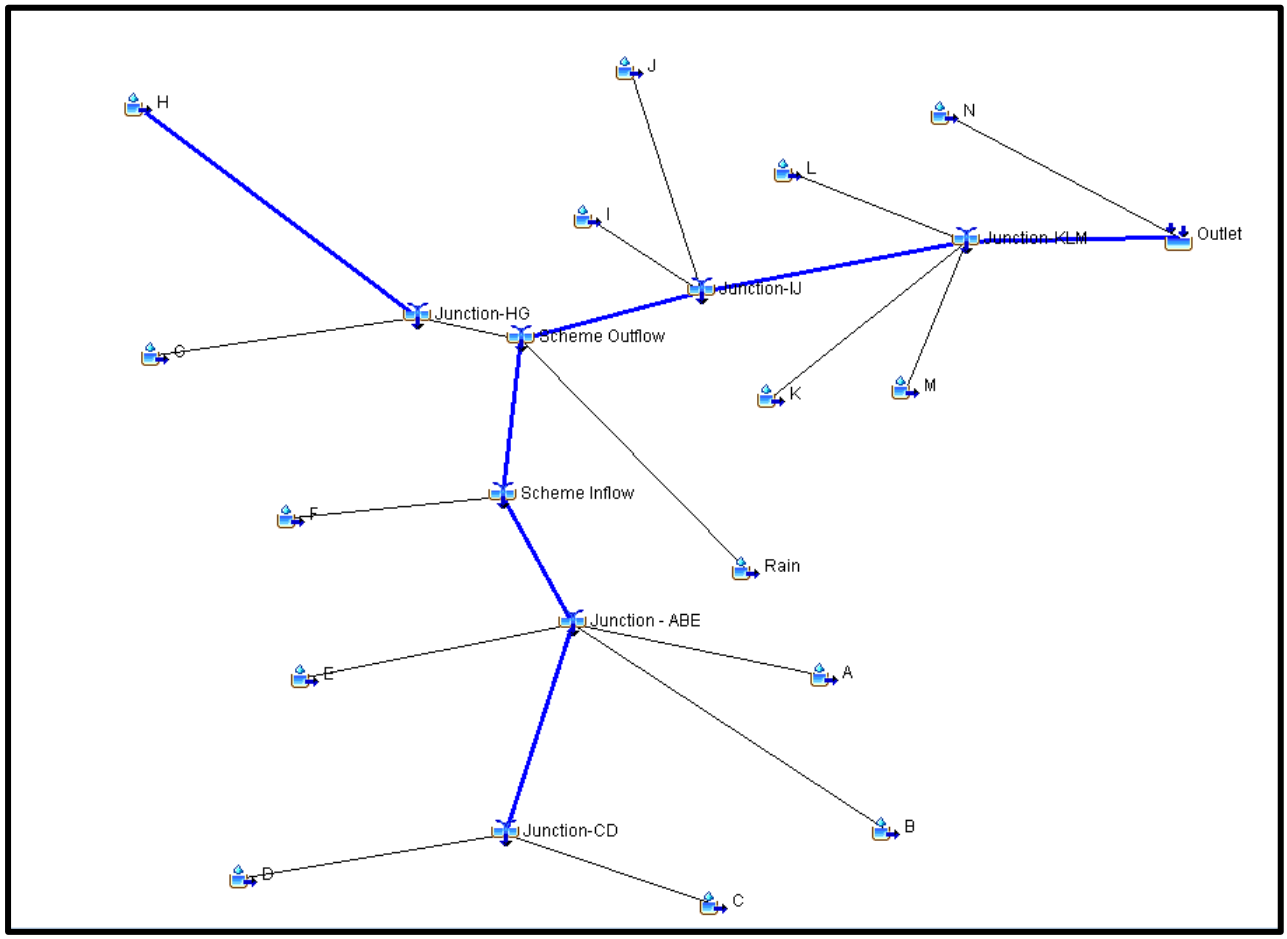


Figure 2.7 – HEC-HMS model set-up

Figure 2.8 shows the 100-year developed land-use rainfall hyetograph for the grid.

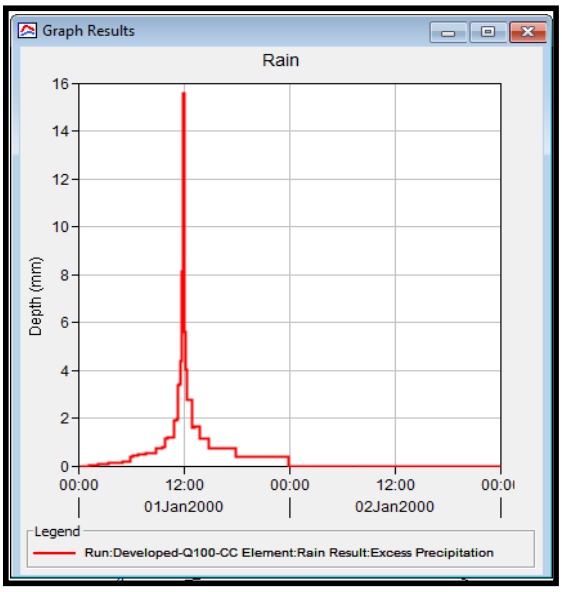


Figure 2.8 – Rainfall excess, 100-year, climate change, developed

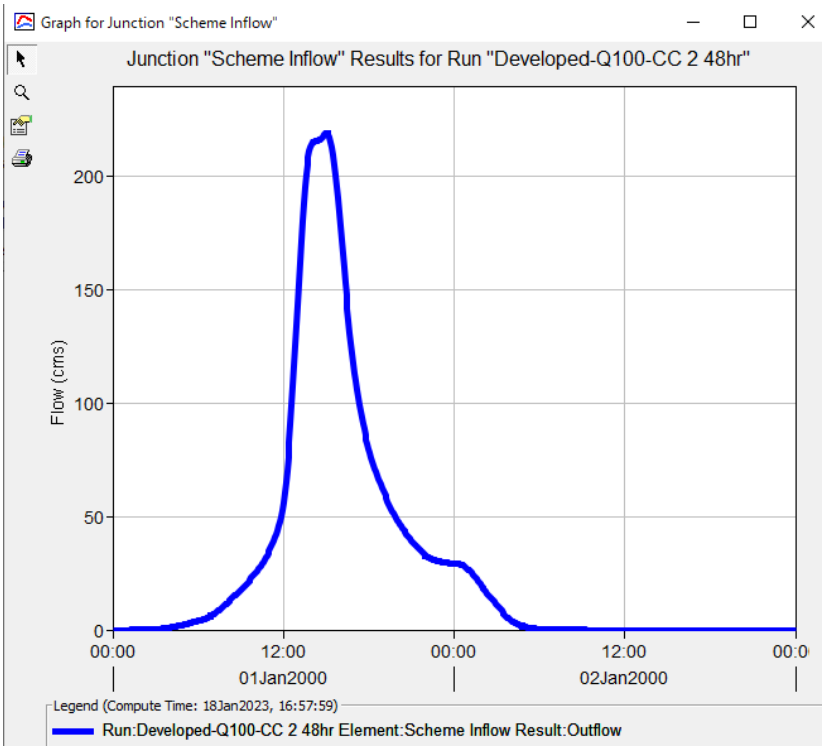


Figure 2.9 shows the hydrograph for scheme inflow for the 100-year storm with climate change rain and developed.

Figure 2.9 – Flow hydrograph, 100-year, climate change, developed

2.5.1 Effects of climate change

Figure 2.10 shows the global summary of the existing catchment flows against those that are expected to occur due to climate change and development. The scheme inflow has increased from 188m^3/s to 219^3/s. Most of the 31m^3/s increase is due to climate change. The volume increase is almost 0.72 million m^3.

At the scheme outflow the changes are 327^3/s to 383m^3/s. Thus, the catchment is expected to yield 56m^3/s, (this entire increase is due to climate change as explained in section 2.5.2). This increase is 17%. The volume increase is 1.4 million m^3.

Figure 2.10 – Global summary of flows and volumes for the 100-year storm (historical rain, existing land-use vs climate change rain and existing land-use vs. climate changed rain and developed)

Global Summary Results for Run "Existing-Q100-existing 3"

Project: Warkworth South Plan Change Simulation Run: Existing-Q100-existing 3

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time: 18Jan2023, 16:50:13

Basin Model: Existing Land-Use V2
Meteorologic Model: 100yr-existing-existing-land
Control Specifications: 24hr (Maven)

Show Elements: All Elements | Volume Units: MM / 1000 M3 | Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
A	3.338	34.9854	01Jan2000, 13:30	574.8533
B	4.122	44.9294	01Jan2000, 13:25	713.6943
C	2.9156	34.2147	01Jan2000, 13:15	505.2180
D	5.1008	54.5587	01Jan2000, 13:25	876.9597
E	5.7329	58.7550	01Jan2000, 13:35	982.5589
F	3.0393	38.8736	01Jan2000, 13:00	529.8983
G	5.8454	62.9972	01Jan2000, 13:25	1008.6598
H	8.4876	103.4464	01Jan2000, 13:05	1474.0228
I	0.2357	5.1299	01Jan2000, 12:20	46.2726
J	2.8386	36.4625	01Jan2000, 13:00	496.9987
Junction - ABE	21.2093	174.4654	01Jan2000, 14:35	3603.5080
Junction-CD	8.0164	88.1185	01Jan2000, 13:20	1382.1776
Junction-HG	14.3330	146.8338	01Jan2000, 14:25	2437.6070
Junction-IJ	46.5092	337.0465	01Jan2000, 15:45	7630.1277
Junction-KLM	48.7246	341.8011	01Jan2000, 16:25	7960.3802
K	0.7215	17.1789	01Jan2000, 12:20	156.4929
L	0.2179	5.1014	01Jan2000, 12:10	38.6693
M	1.276	25.0929	01Jan2000, 12:30	267.3881
N	0.4917	8.6788	01Jan2000, 12:40	101.0869
Outlet	49.2163	342.8506	01Jan2000, 17:05	7911.4359
Rain	4.8533	54.4178	01Jan2000, 13:20	844.5575
Reach-1	21.2093	174.3457	01Jan2000, 15:10	3559.4041
Reach-2	8.0164	88.0712	01Jan2000, 15:00	1332.4014
Reach-3	8.4876	103.4464	01Jan2000, 14:30	1428.9472
Reach-4	24.2486	187.5507	01Jan2000, 16:25	3963.1441
Reach-5	43.4349	327.3185	01Jan2000, 15:45	7086.8564
Reach-6	46.5092	337.0465	01Jan2000, 16:25	7497.8299
Reach-7	48.7246	341.8011	01Jan2000, 17:05	7810.3489
Scheme Inflow	24.2486	187.5577	01Jan2000, 15:05	4089.3024
Scheme Outflow	43.4349	327.3185	01Jan2000, 14:50	7245.3087

Global Summary Results for Run "Existing-Q100-existing-CC 3"

Project: Warkworth South Plan Change Simulation Run: Existing-Q100-existing-CC 3

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time: DATA CHANGED, RECOMPUTE

Basin Model: Existing Land-Use V2
Meteorologic Model: 100yr-CC-existing-land-use
Control Specifications: 24hr (Maven)

Show Elements: All Elements | Volume Units: MM / 1000 M3 | Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
A	3.3380	40.9965	01Jan2000, 13:30	674.7382
B	4.1220	52.6242	01Jan2000, 13:25	837.4442
C	2.9156	40.0810	01Jan2000, 13:15	592.9827
D	5.1008	63.9639	01Jan2000, 13:25	1029.6393
E	5.7329	68.8647	01Jan2000, 13:35	1153.7010
F	3.0393	45.5513	01Jan2000, 13:00	621.8082
G	5.8454	73.8226	01Jan2000, 13:25	1183.8716
H	8.4876	121.2557	01Jan2000, 13:05	1730.0024
I	0.2357	5.9360	01Jan2000, 12:20	53.7416
J	2.8386	42.7049	01Jan2000, 13:00	582.9794
Junction - ABE	21.2093	204.0993	01Jan2000, 14:35	4231.3183
Junction-CD	8.0164	103.2917	01Jan2000, 13:20	1622.6219
Junction-HG	14.3330	171.8731	01Jan2000, 14:25	2862.0979
Junction-IJ	46.5092	394.9782	01Jan2000, 15:45	8964.8247
Junction-KLM	48.7246	400.3957	01Jan2000, 16:25	9346.3239
K	0.7215	19.6426	01Jan2000, 12:20	179.8769
L	0.2179	5.9791	01Jan2000, 12:10	45.3680
M	1.2760	28.7999	01Jan2000, 12:30	308.3478
N	0.4917	9.9788	01Jan2000, 12:40	116.7730
Outlet	49.2163	401.5918	01Jan2000, 17:05	9290.6148
Rain	4.8533	63.7196	01Jan2000, 13:20	990.6374
Reach-1	21.2093	203.9602	01Jan2000, 15:05	4180.6487
Reach-2	8.0164	103.2240	01Jan2000, 15:00	1565.4349
Reach-3	8.4876	121.2557	01Jan2000, 14:30	1678.2264
Reach-4	24.2486	219.3093	01Jan2000, 16:25	4657.4784
Reach-5	43.4349	383.7495	01Jan2000, 15:45	8328.1037
Reach-6	46.5092	394.9782	01Jan2000, 16:25	8812.7311
Reach-7	48.7246	400.3957	01Jan2000, 17:05	9173.8418
Scheme Inflow	24.2486	219.3397	01Jan2000, 15:00	4802.4570
Scheme Outflow	43.4349	383.7495	01Jan2000, 14:50	8510.2137

Global Summary Results for Run "Developed-Q100-CC 2"

Project: Warkworth South Plan Change Simulation Run: Developed-Q100-CC 2

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time: 18Jan2023, 16:57:18

Basin Model: Developed Land-Use
Meteorologic Model: 100yr-CC-developed-land-use
Control Specifications: 24hr (Maven)

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
A	3.3380	40.9965	01Jan2000, 13:30	674.7382
B	4.1220	52.6242	01Jan2000, 13:25	837.4442
C	2.9156	40.0810	01Jan2000, 13:15	592.9827
D	5.1008	63.9639	01Jan2000, 13:25	1029.6393
E	5.7329	68.8647	01Jan2000, 13:35	1153.7010
F	3.0393	46.2770	01Jan2000, 13:00	628.6363
G	5.8454	73.8226	01Jan2000, 13:25	1183.8716
H	8.4876	121.2557	01Jan2000, 13:05	1730.0024
I	0.2357	5.9360	01Jan2000, 12:20	53.7416
J	2.8386	42.7049	01Jan2000, 13:00	582.9794
Junction - ABE	21.2093	204.0993	01Jan2000, 14:35	4231.3183
Junction-CD	8.0164	103.2917	01Jan2000, 13:20	1622.6219
Junction-HG	14.3330	171.8731	01Jan2000, 14:25	2862.0979
Junction-IJ	46.5092	394.2776	01Jan2000, 15:45	9139.8410
Junction-KLM	48.7246	399.6951	01Jan2000, 16:25	9520.7166
K	0.7215	19.6426	01Jan2000, 12:20	179.8769
L	0.2179	5.9791	01Jan2000, 12:10	45.3680
M	1.2760	28.7999	01Jan2000, 12:30	308.3478
N	0.4917	9.9788	01Jan2000, 12:40	116.7730
Outlet	49.2163	400.8912	01Jan2000, 17:05	9464.4429
Rain	4.8533	78.2525	01Jan2000, 13:10	1159.7915
Reach-1	21.2093	203.9602	01Jan2000, 15:05	4180.6487
Reach-2	8.0164	103.2240	01Jan2000, 15:00	1565.4349
Reach-3	8.4876	121.2557	01Jan2000, 14:30	1678.2264
Reach-4	24.2486	219.2942	01Jan2000, 16:25	4664.2349
Reach-5	43.4349	383.0489	01Jan2000, 15:45	8503.1199
Reach-6	46.5092	394.2776	01Jan2000, 16:25	8987.1238
Reach-7	48.7246	399.6951	01Jan2000, 17:05	9347.6699
Scheme Inflow	24.2486	219.3239	01Jan2000, 15:00	4809.2850
Scheme Outflow	43.4349	383.0489	01Jan2000, 14:50	8686.1244

2.5.2 Effects of the proposed development

A graph of the flows at the scheme outflow of the existing catchment flow with climate change against flow of the developed catchment with climate change can be found in the appendix, the table below summaries the findings.

Rain event	Land-use	Climate change	Catchments A-F (m3/s)	Rain (m3/s)	Catchment H & G (m3/s)	Scheme Outflow (m3/s)
100yr	Existing	Yes	219.3	63.7	171.9	383.7
100yr	Developed	Yes	219.3	78.2	171.9	383.0

Table 2.3 – Peak flow comparison, 100-year, climate change, existing vs developed

Table 2.3 shows that the peak flow for 100year storm events exiting the scheme area (Scheme outflow) decreases by 0.7m^3/s , even though there is an increase in impervious area of the development. This is explained by the decrease in time of concentration of the developed Rain catchment, which results in the runoff from the catchment reaching the Scheme outflow before the runoff from the upstream catchments (A-F). As shown in figure 2.10, for the developed catchment, the 100year time of peak flow of the *Rain* catchment is 13:10 and for the upstream catchments, *A to F* (Reach 4) is 16:25. This demonstrates the peak flow from the *Rain* catchment exits the catchment boundary three hour prior to the arrival of upper catchment peak flow.

Downstream effects

Table 2.4 below shows the peak 100year stormwater events at the catchment junctions downstream of the site. Similarly to the effects described above the it is noted that the peak flows decrease as a result of the development. This is explained by the decrease in time of concentration of the developed Rain catchment, which results in the runoff from the catchment reaching the Scheme outflow before the runoff from the upstream catchments (A-F).

Rain event	Land-use	Climate change	Junction IJ	Junction KLM
100yr	Existing	Yes	395.0	400.4
100yr	Developed	Yes	394.3	399.7

Table 2.4 Peak 100yr flows at junctions downstream of the proposed development

3 HYDRAULIC MODELLING WITH HEC-RAS

3.1 METHODOLOGY

The analysis was done using the following steps:

1. Delineate the perimeter for the grid,
2. Create a grid and sub-grid areas,
3. Input flow hydrographs and other boundaries
4. Input structures,
5. Run scenarios.

3.2 HEC-RAS MODEL LAYOUT

HEC-RAS software was used to generate water levels throughout the catchment. A 2D model was developed using a combination of LINZ Terrain data and site-specific LiDAR and topographical survey. A Manning's n of 0.1 was used in the grid.A 5m x 5m grid was used. Figure 3.1 shows the grid and its boundary conditions. Appendix B shows culvert details used in the model.

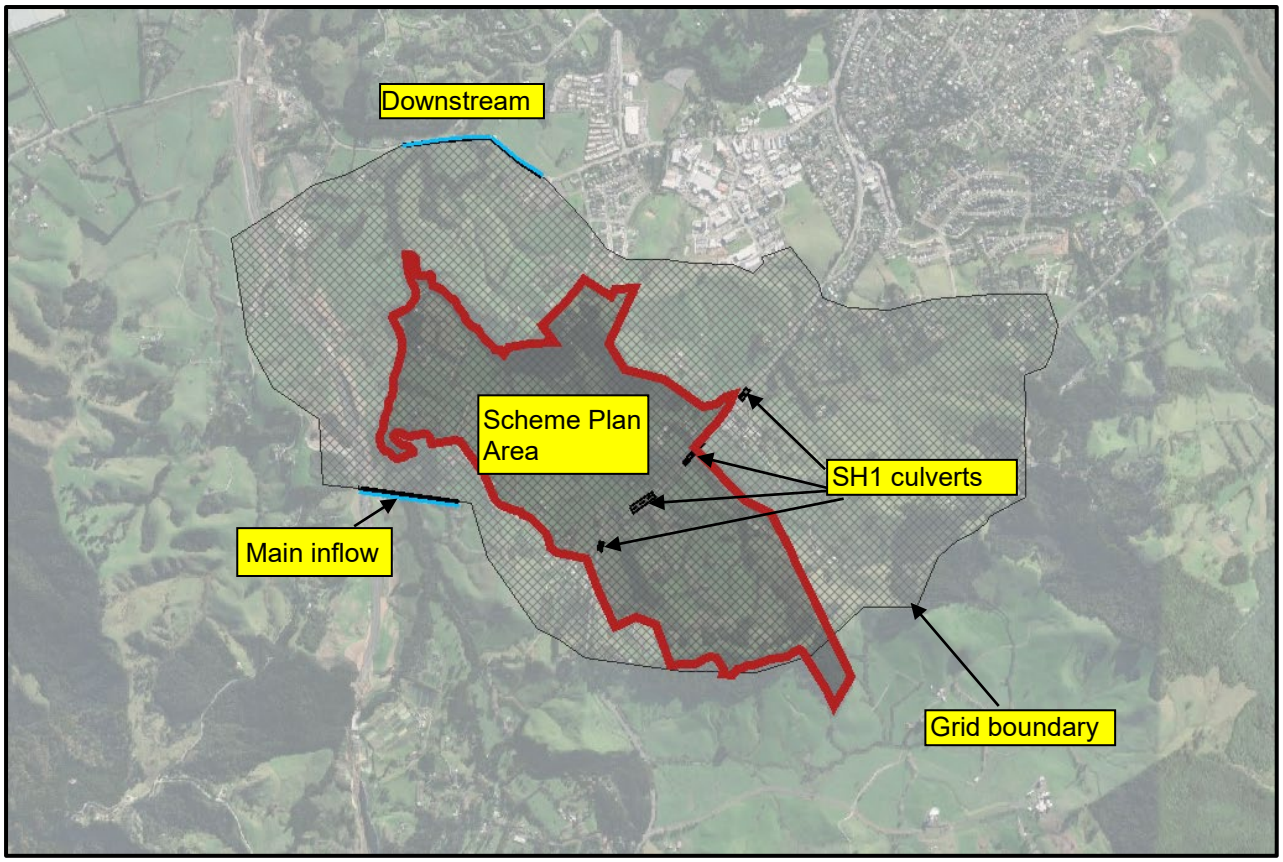


Figure 3.1 – HEC-RAS model set-up

3.3 BOUNDARIES

There are three boundaries. These are:

- Rain on grid – as per figure 3.1.
- Main inflow for mahurangi river
- Downstream boundary using a normal depth method with a gradient of 0.01.

3.4 FLOODPLAIN COMPARISON

Figure 3.4 compares the Geomaps floodplain against the 100-year storm for developed land and climate change rainfall. The patterns are similar. The flow at critical pinch points in the north-east at the confluence have similar widths.

The only difference of note is in the central scheme area, area A. Geomaps shows more flooding while the new model is more defined in the channels due to a specific site survey of the stream being modelled. In general, the new model appears to replicate the Geomaps floodplain.

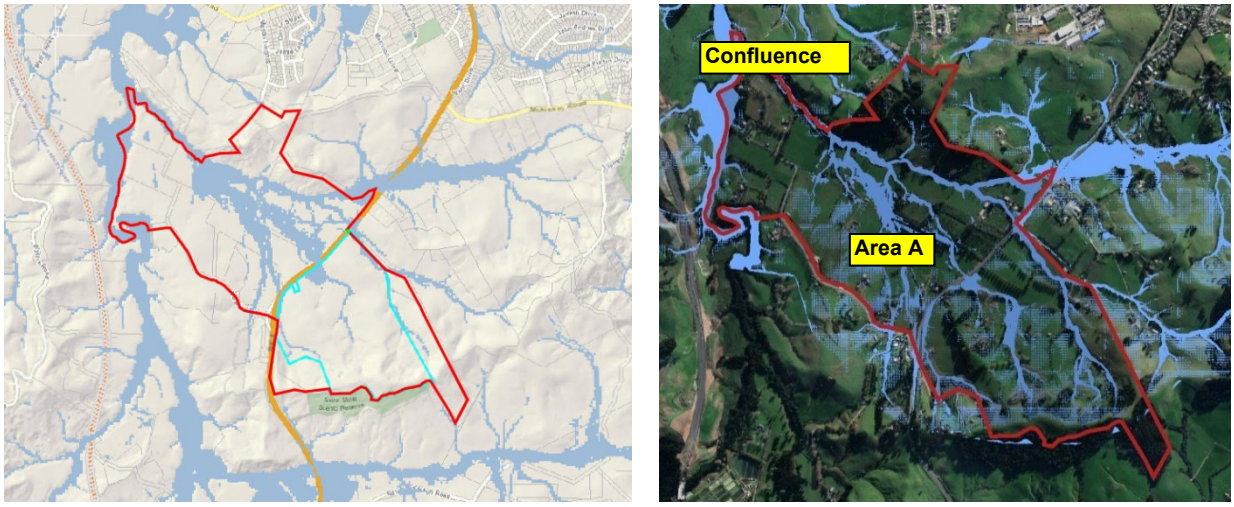


Figure 3.2 – Floodplain comparison – 100yr-storm

3.5 FLOW CHECK

All watercourse arrive at the point of confluence from the east making up about 332ha. The estimate TP108 graphical method 100-year peak flow is estimated at 47m^3/s. This is the existing rainfall and land-use. The modelled peak flow at this point is 53m^3/s. The model is higher than what TP108 estimates catchment run-off should be. However, the 2D terrain model uses a Manning's n of 0.1 which might be smoother than reality, but it also encourages higher flows. Importantly the model gives reasonable peak flows even though the finite volume method in HEC-RAS has pockets of water "stuck in hollows" inside the 5m grid. However, this does not affect the peak flow.

3.6 HYDRAULIC GRADE LINE

Figures 3.3 shows the HGL along the Mahurangi River on the west boundary of the scheme plan. The 100-year developed scenario ranges from RL32.4m to RL26.6m NZVD at a grade of 1 in 240. The range of water levels from 10-year to 100-year is about 1.3m.

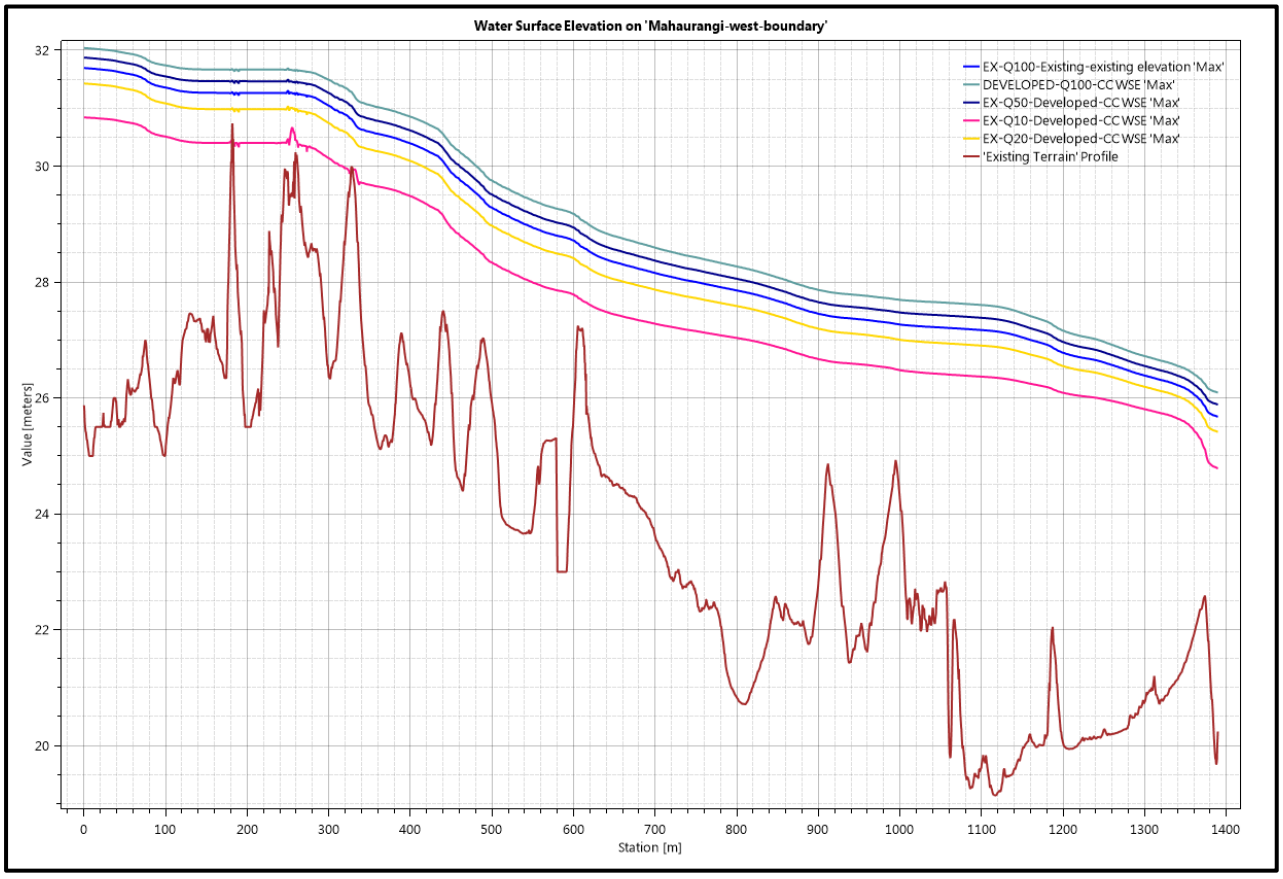


Figure 3.3 – HGL– Mahurangi River boundary (NZVD)

Figure 3.4 shows the HGL along the main scheme stream from east of the SH1 culverts across to the confluence with the Mahurangi River. The SH1 Culverts will cause a pond that is 200m long and 135m wide.

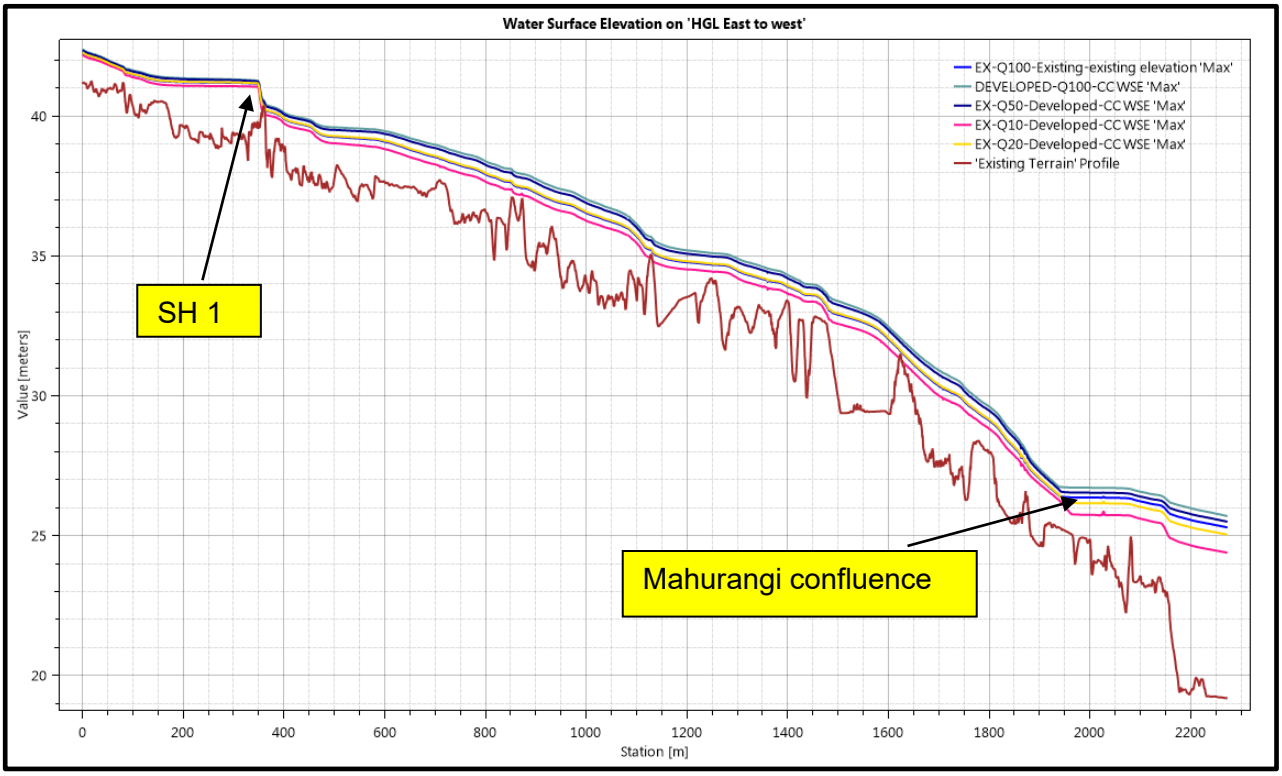


Figure 3.4 – HGL– Main east to west stream (NZVD)

3.7 FLOW HYDROGRAPHS

Figure 3.5 shows the flow hydrographs in the east-west stream just before the connection to the Mahurangi River. The existing 100-year storm flows (blue) changes to a 20-year storm flow (yellow) due to the development.

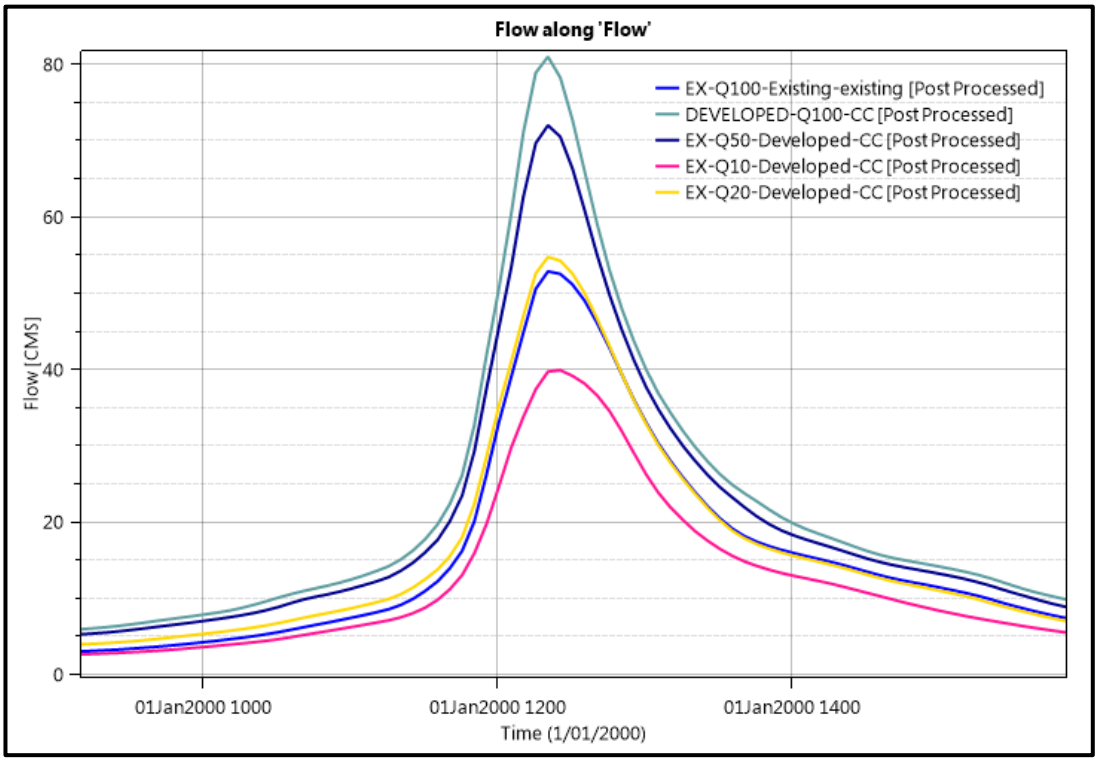


Figure 3.5 – Flow hydrograph for east-west stream outlet

3.8 CHECK ON DOWNSTREAM LEVEL

The model grid stops at Woodcocks Road bridge. The estimate road deck is RL23.5m. If the road deck was 1m deep this makes the soffit RL22.5m. The peak level at this location is RL21.90m. Therefore, the bridge is not impeding flow. This needs to be confirmed by a survey.

3.9 OUTFLOW VOLUME VALIDATION

HEC-RAS uses an Implicit Finite Volume Algorithm. The consequence of this is to have small volumes of water in the base of a cell that does not escape. A method to remove the potential holding back of water is to run the models with low flows in the initial stages to fill the hollows. The main storm run-off can then flow over the top. This is not a problem as long as there is volume continuity.

Figure 3.6 shows the volume generated in HEC-HMS for the existing land-use and 100- year historical rainfall. The volume is 4,942,000m^3. Figure 3.7 shows the volume accumulated at the HEC-RAS downstream boundary after 36 hours of simulation. The volume is 4,908,000m^3. This is an error of 0.0007% which is extremely small. The volume integrity is excellent.

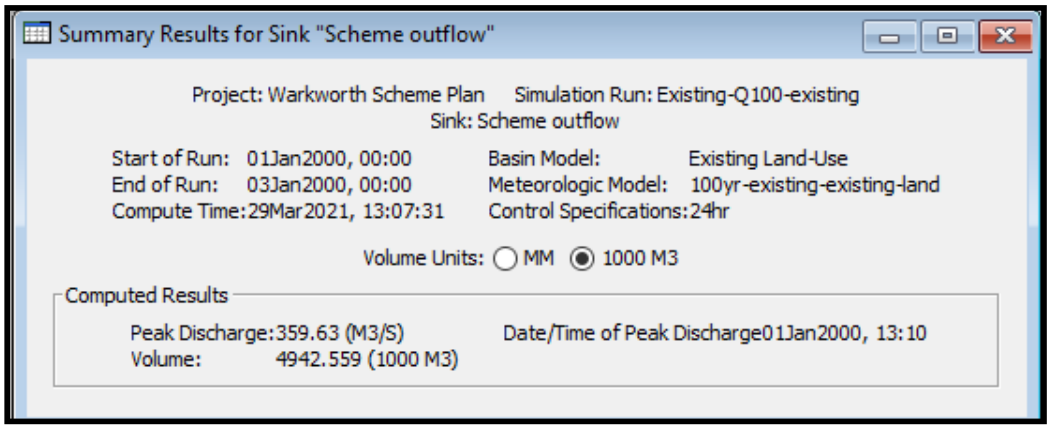


Figure 3.6 – HEC-HMS volume of run-off

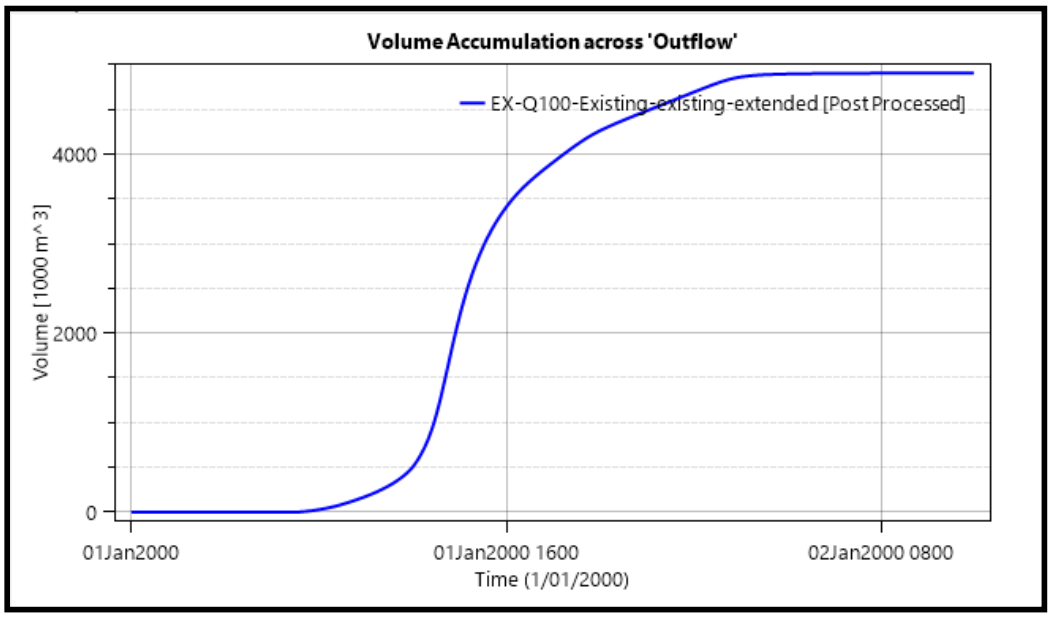


Figure 3.7 – HEC-RAS outflow boundary cumulative volume

3.10 HEALTHY WATERS MODELLING

Auckland Council HealthyWaters have supplied flow data of their modelling of the Warkworth catchment, for Mahurangi River. A comparison of this reports results and Healthywaters are summarised in the table below;

	SCHEME INFLOW (m3/s)					
	10yr Developed CC			100yr Developed CC		
Scenario	Peak Time	Peak Flow	Water level	Peak Time	Peak Flow	Water level
Healthy waters	13:45	199	31.34	13:40	340	32.88
Maven	13:40	156	31.96	13:35	299	33.22

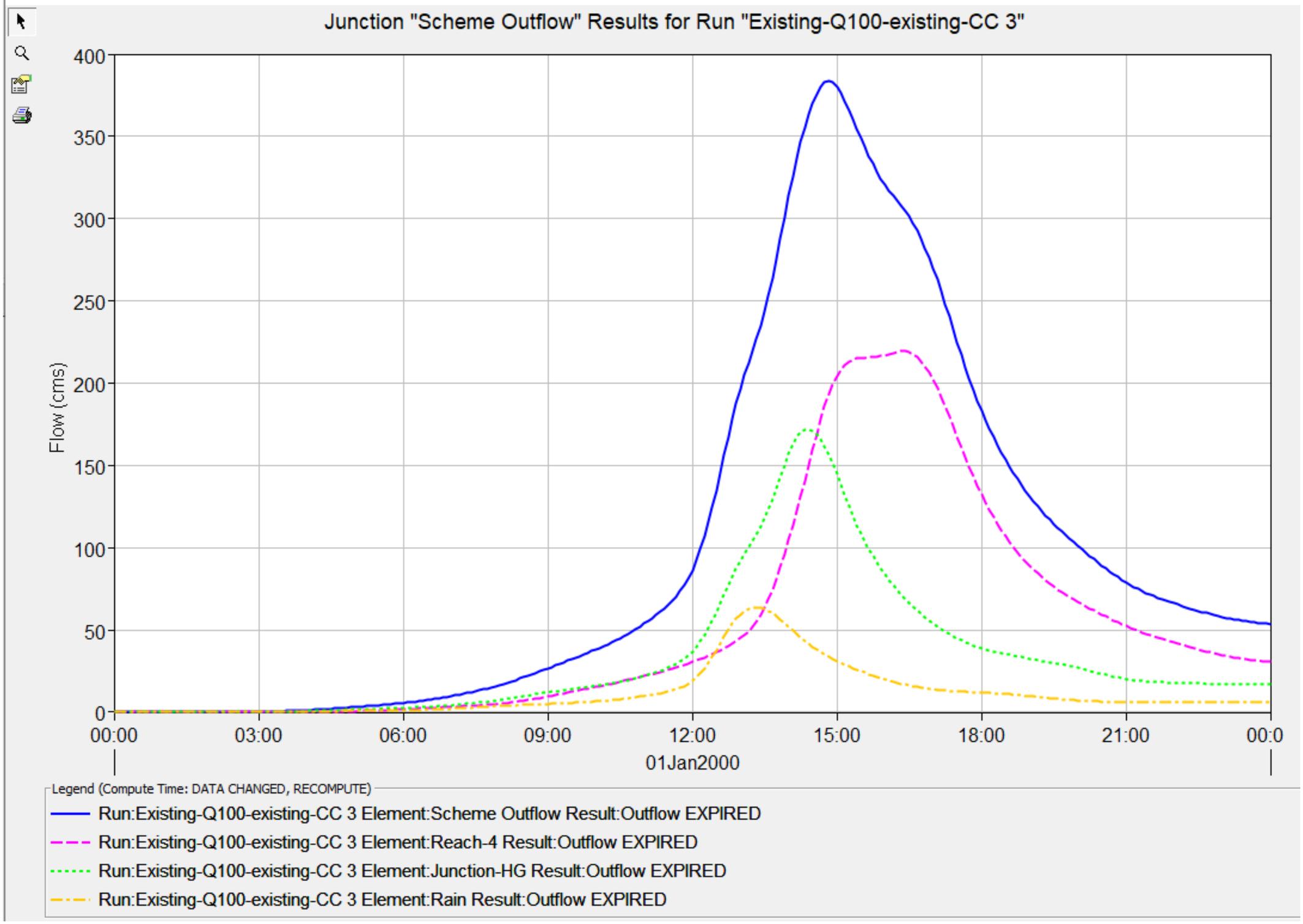
	SCHEME OUTFLOW (m3/s)					
	10yr Developed CC			100yr Developed CC		
Scenario	Peak Time	Peak Flow	Water level	Peak Time	Peak Flow	Water Level
Healthy waters	14:10	223	22.16	13:40	323	23.74
Maven	14:05	171	21.12	13:35	325	22.56

Figure 3.8 MPD Modelling results comparison to Healthy waters model

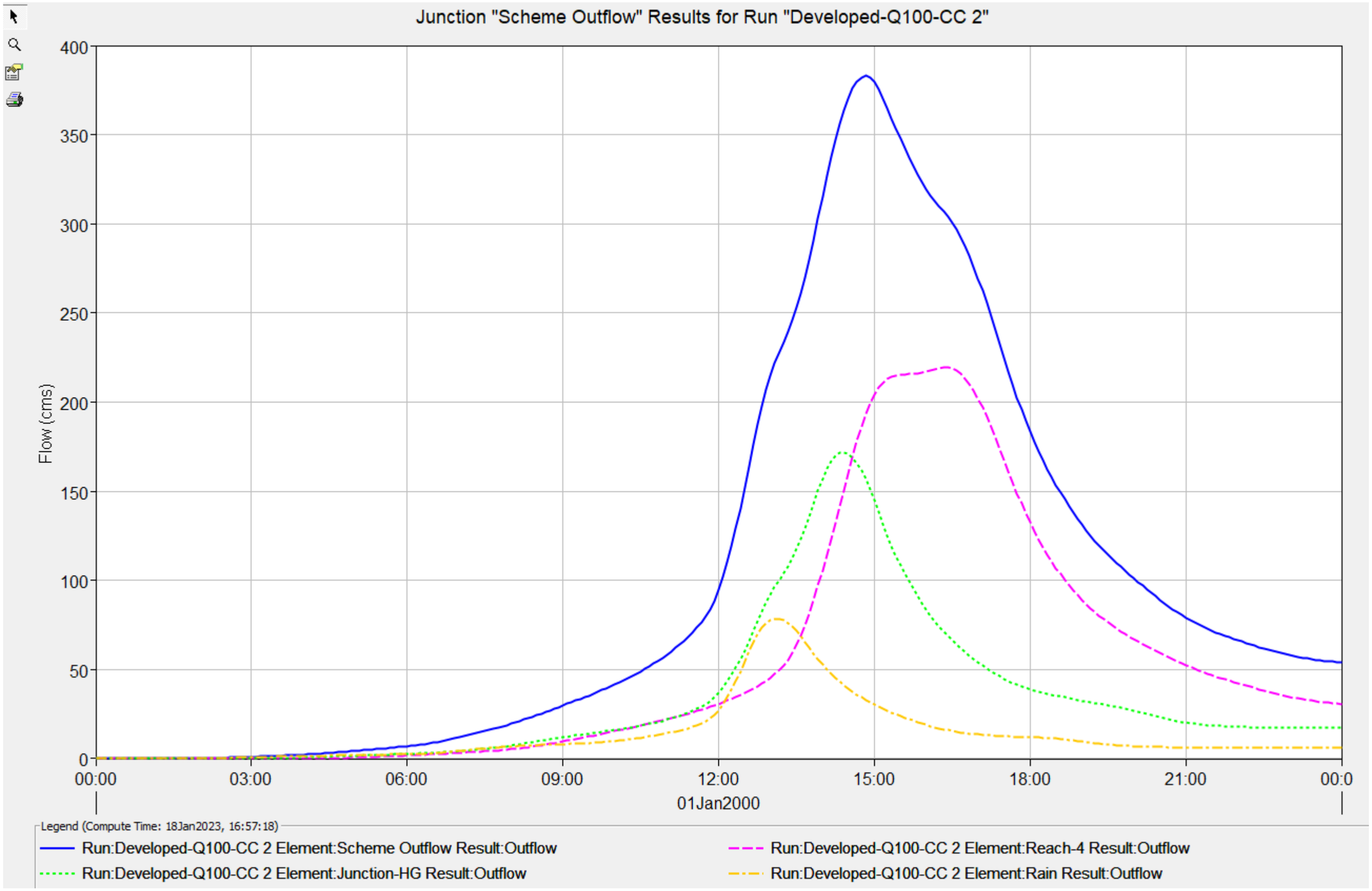
Two notable points of comparison of modelling results are the times of peak flows and the water levels. The peak flow time are in general accordance with each other, this provides validation of the times of concentration used in the model. However, comparison of the water levels show significant difference in peak flood levels up to 1.2m. This discrepancy is likely a result of the difference in terrain model used. As the terrain used in this reports model uses a combination of site survey and drone data, it has a higher degree of accuracy in comparison to the Lidar survey used in the Healthwaters model.

APPENDIX A – 100YR YEAR FLOW HYDROGRAPH

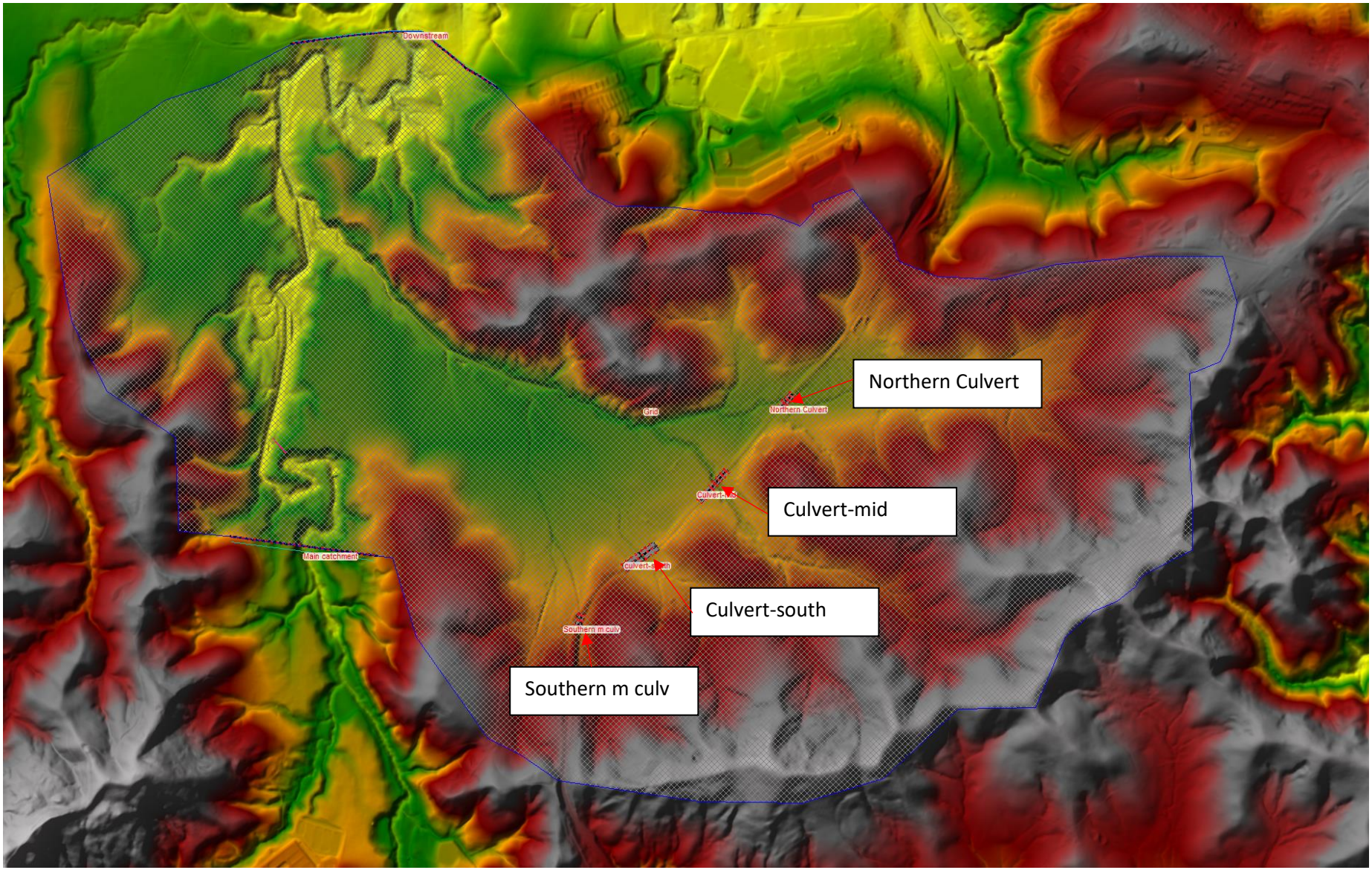
Graph for Junction "Scheme Outflow"



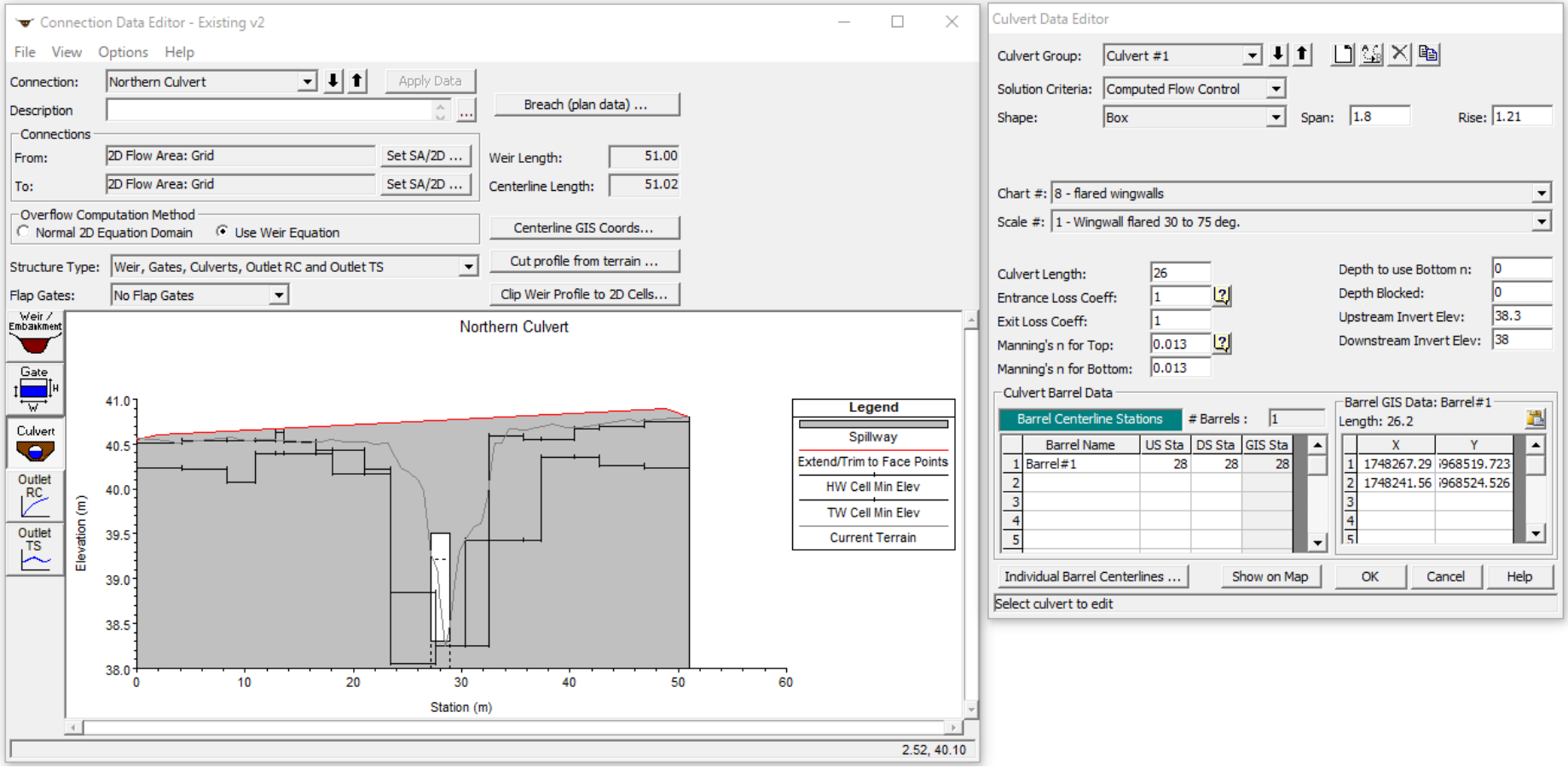
Graph for Junction "Scheme Outflow"



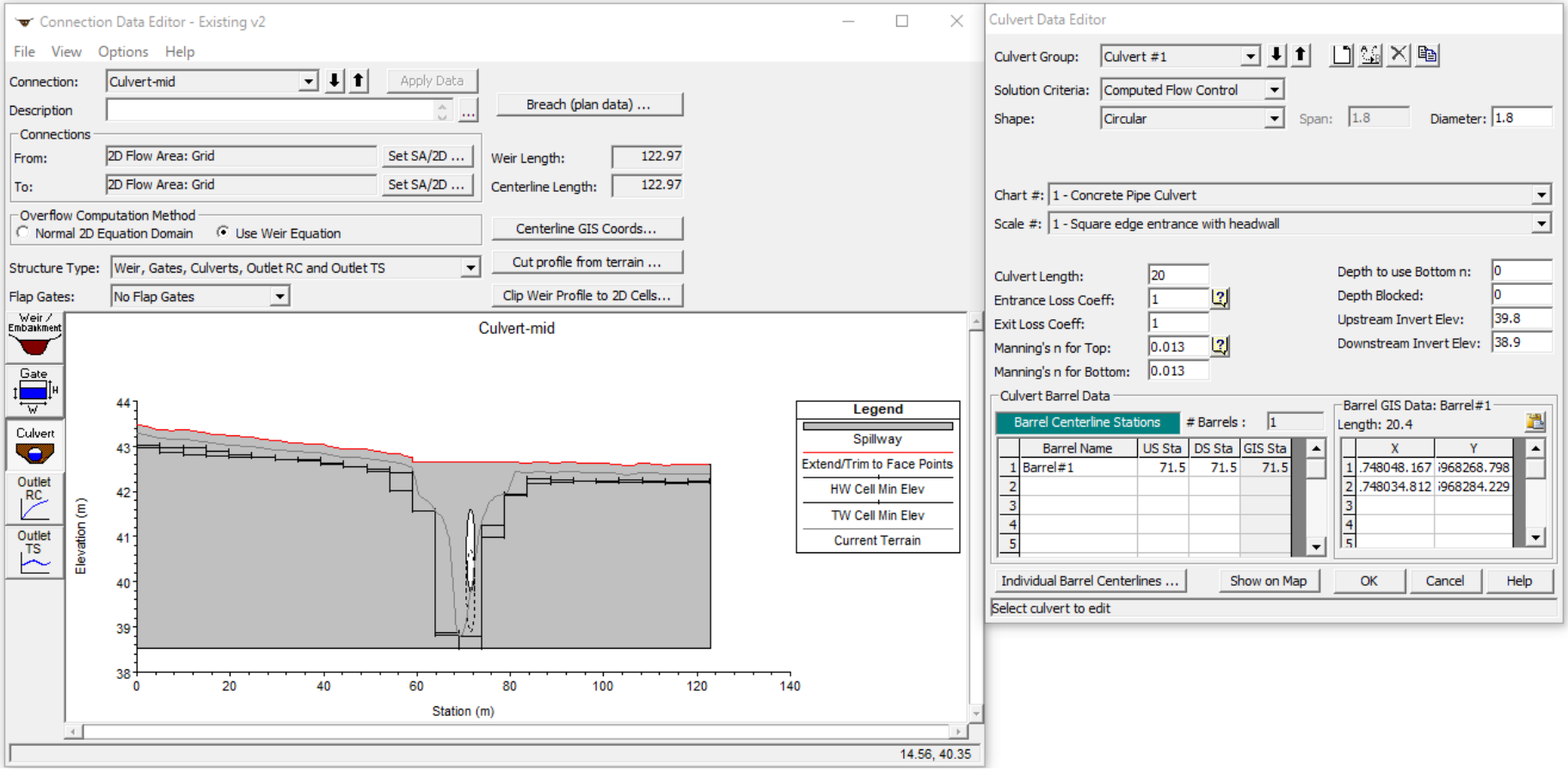
APPENDIX B – HEC RAS CULVERT DETAIL


Downstream
Northern Culvert
Grid
Culvert-mid
Main catchment
Culvert-south
Southern m culv
Northern Culvert
Culvert-mid
Culvert-south
Southern m culv

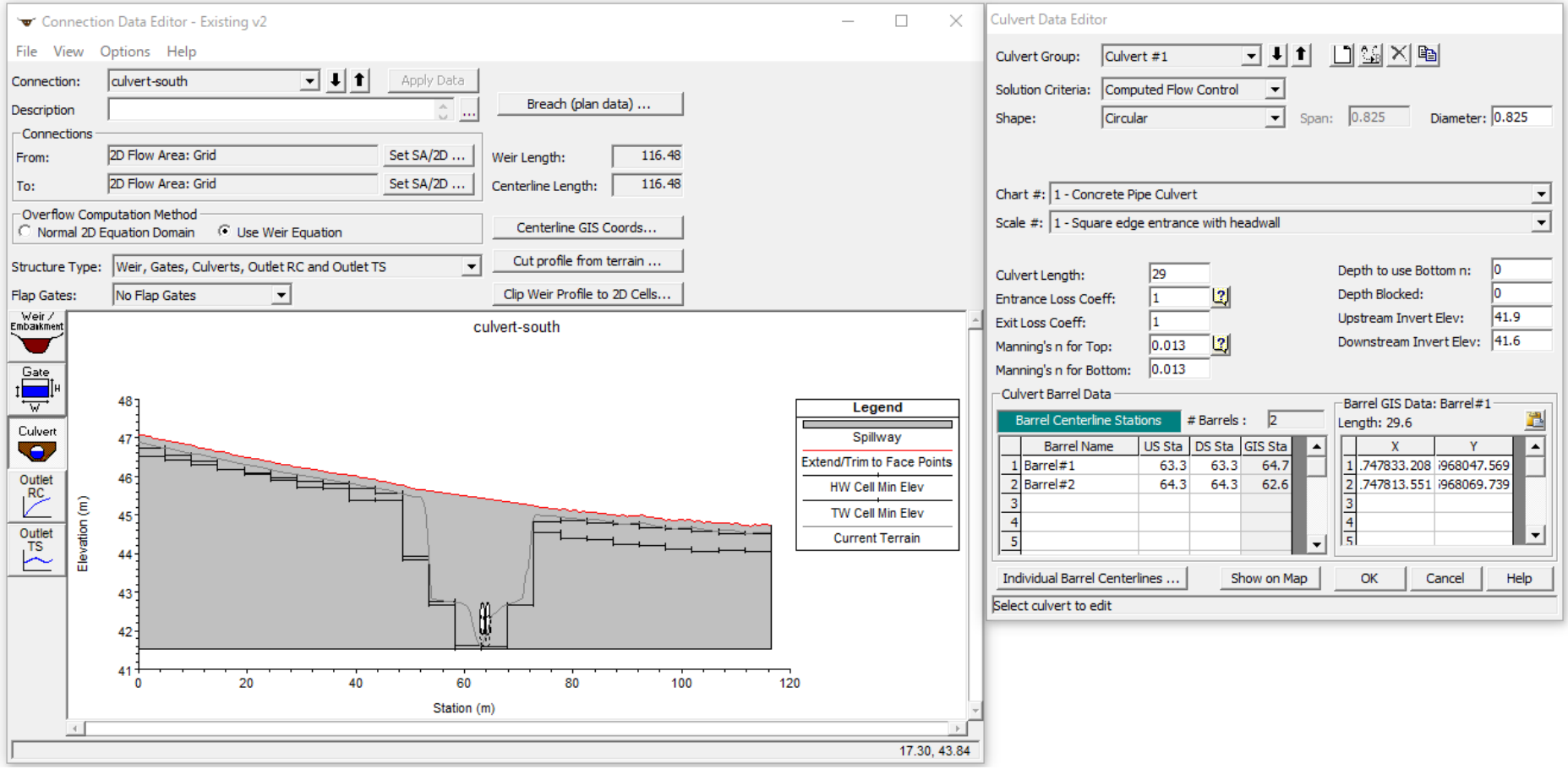
Northern Culvert - Details



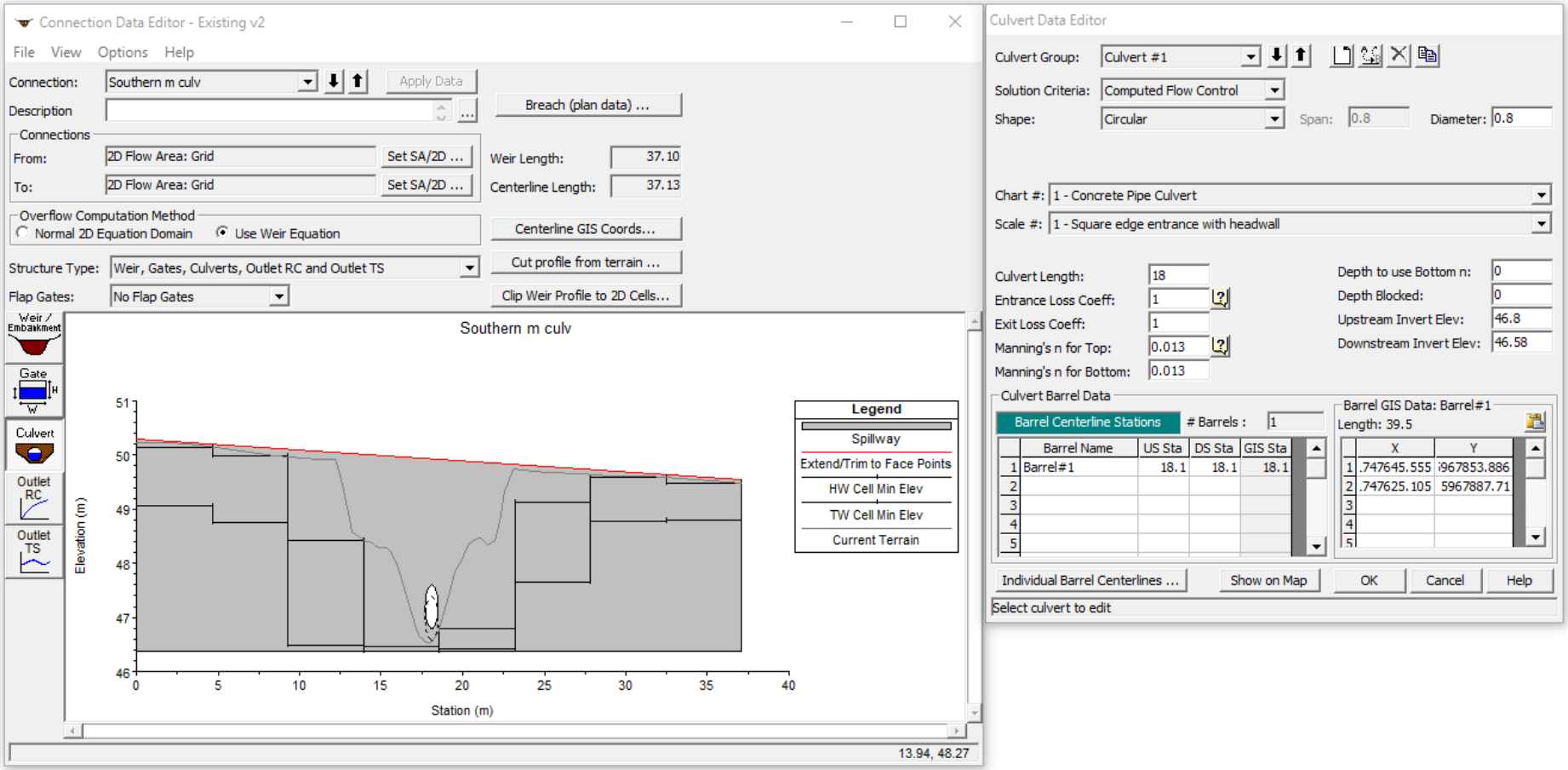
Culvert mid - Details



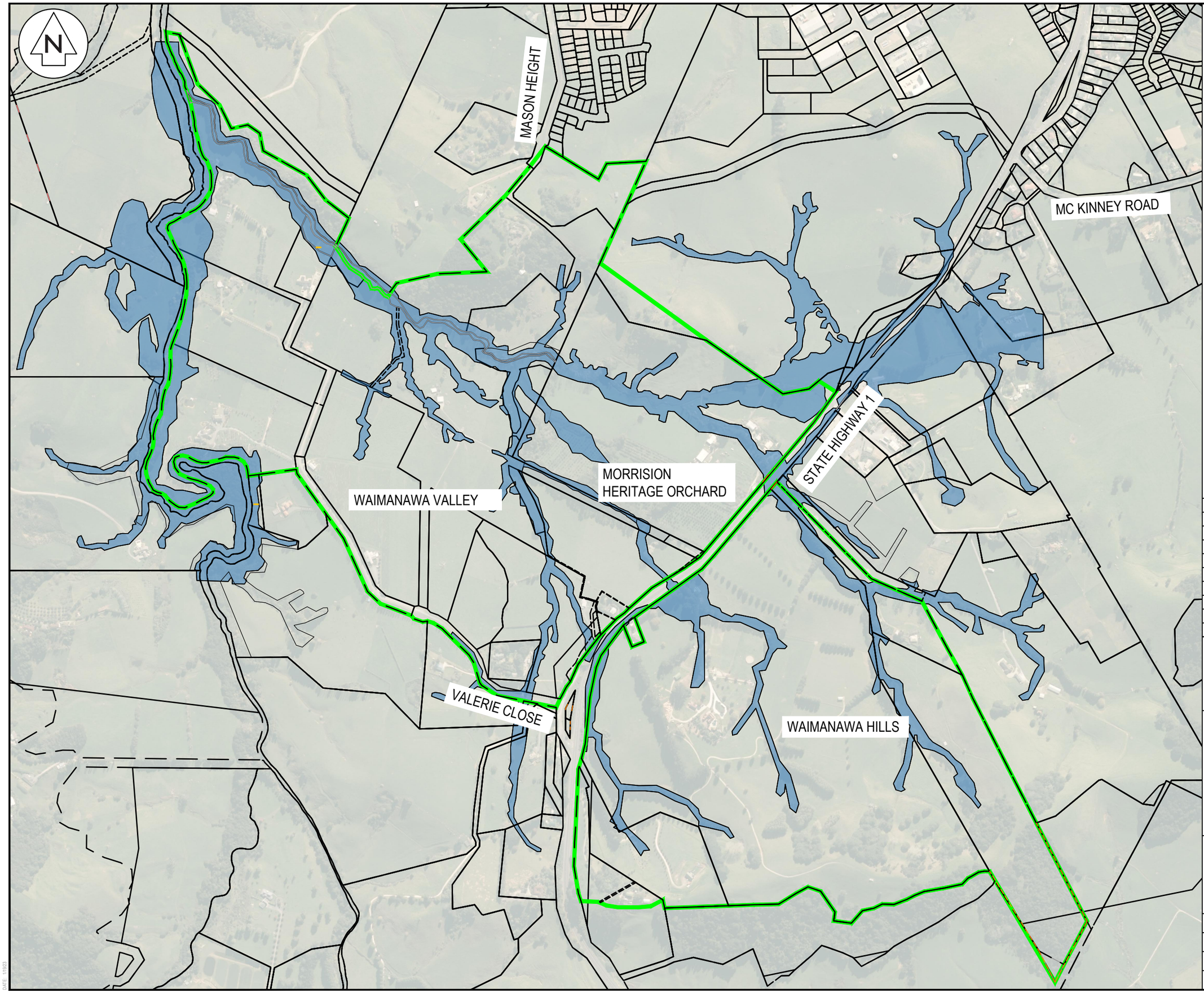
Culvert south - Details



Culvert m south - Details



APPENDIX C – Preliminary Pre & Post Development Flood Extent Plan



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

Legend

- EX BDY
- PLAN CHANGE BDY
- FLOOD EXTENT

Rev	Description	By	Date
B	PC EXTENT UPDATE	KH	12/22
A	PPC	KH	08/22

	By	Date
Survey	PARALAX & MAVEN	03/21
Design	-	-
Drawn	KH	08/22
Checked	GB	08/22

Maven Associates
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www.maven.co.nz
5 Owens Road, Epsom
Auckland 1023

Project

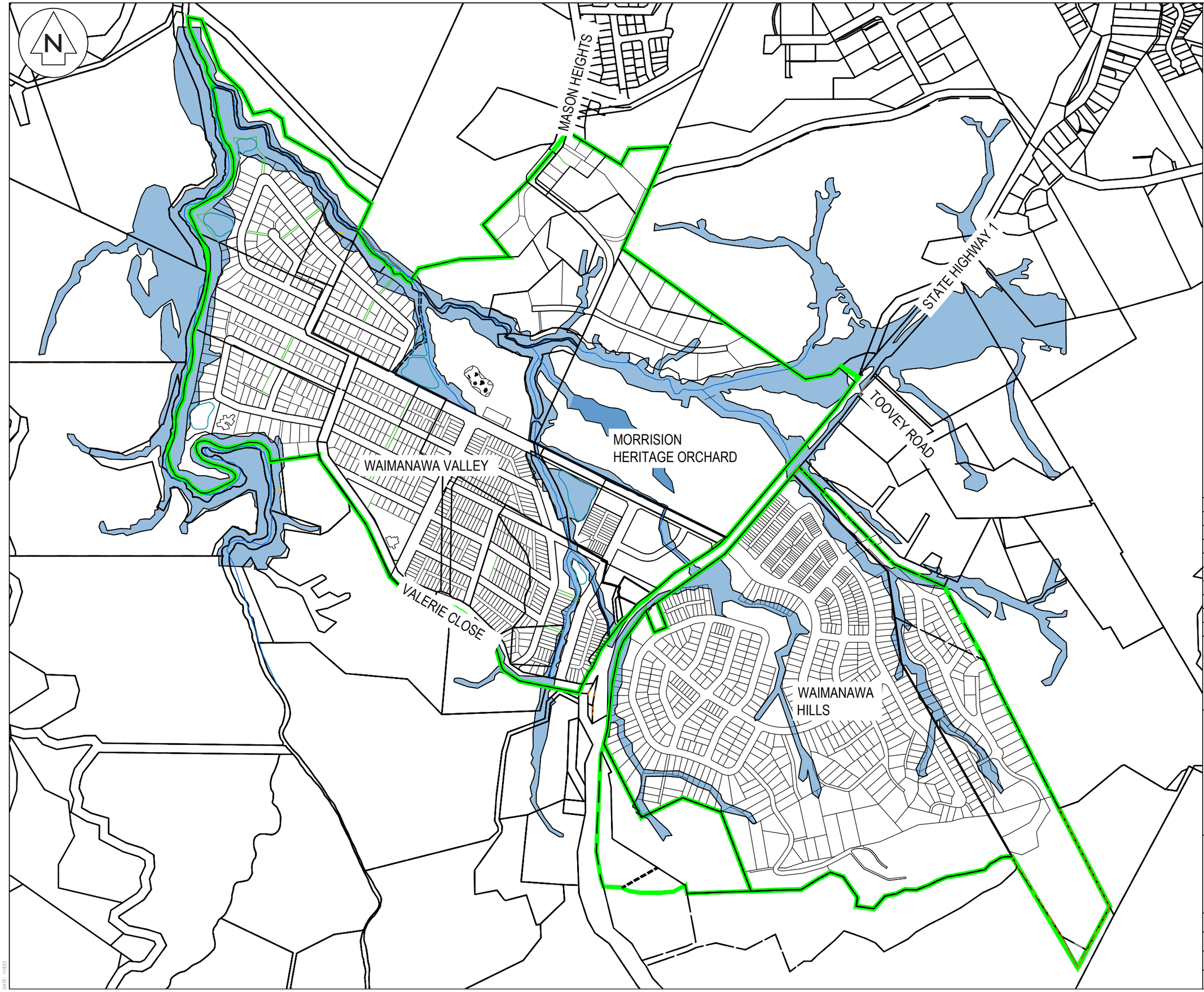
WARKWORTH SOUTH PLAN CHANGE FOR KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title

EXISTING 100 YEARS FLOOD EXTENT PLAN

Project no.	211001		
Scale	1:7500 @ A3		
Cad file	100YR EX FLOODING.DWG		
Drawing no.	C460	Rev	B

DATE: 17/5/23



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.
3. It is the contractors responsibility to locate all services that may be affected by his operations.

Legend

- EX BDY
- PLAN CHANGE BDY
- FLOOD EXTENT

Rev	Description	By	Date
B	PC EXTENT UPDATE	KH	12/22
A	PPC	KH	08/2022

	By	Date
Survey	PARALAX & MAVEN	03/21
Design	-	-
Drawn	KH	08/22
Checked	GB	08/22

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Project

WARKWORTH SOUTH PLAN CHANGE FOR KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title

PROPOSED 100 YEARS FLOOD EXTENT PLAN

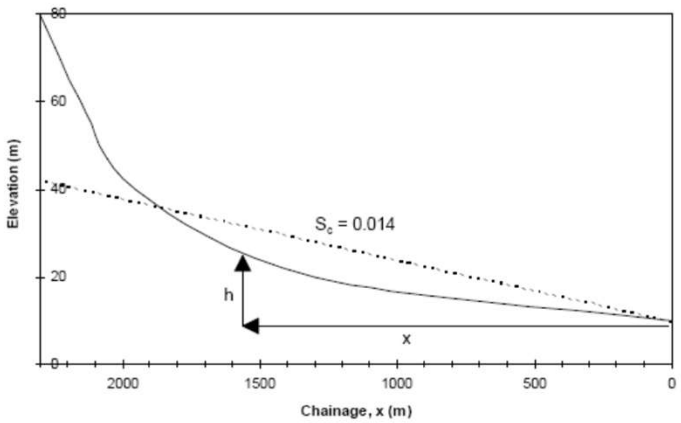
Project no.	211001		
Scale	1:7500 @ A3		
Cad file	100YR CC EX PROPOSED.DWG		
Drawing no.	C465	Rev	B

DATE: 1/18/23

APPENDIX D – TP108 and Time of concentration calculations

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment A	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	45	3	1729	1729	1.5	2593.5
3	56	14	3232	1503	8.5	12775.5
4	112	70	4054	822	42	34524
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 =	4054	**TOTAL =**	49893

S_c = 0.006

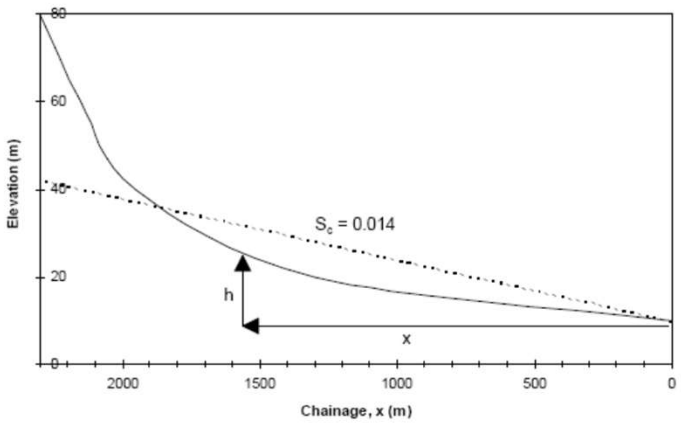
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	45	3	1729	1729	1.5	2593.5
3	56	14	3232	1503	8.5	12775.5
4	112	70	4054	822	42	34524
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 =	4054	**TOTAL =**	49893

S_c = 0.006

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment B	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	43	1	1688	1688	0.5	844
3	50	8	2808	1120	4.5	5040
4	70	28	3630	822	18	14796
5	169	127	4289	659	77.5	51072.5
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 =	4289	**TOTAL =**	71752.5

S_c = 0.008

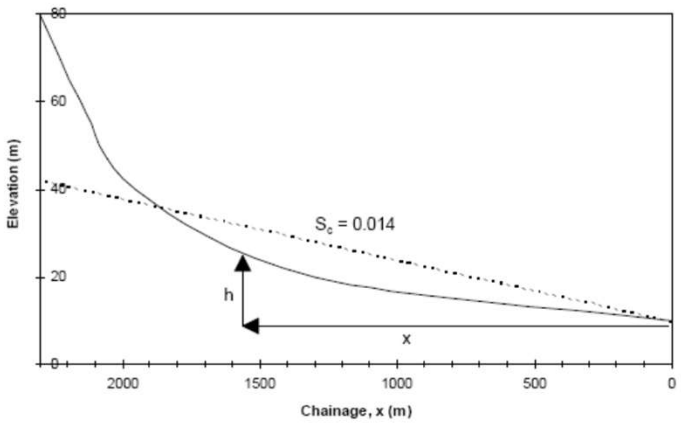
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	43	1	1688	1688	0.5	844
3	50	8	2808	1120	4.5	5040
4	70	28	3630	822	18	14796
5	169	127	4289	659	77.5	51072.5
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 =	4289	**TOTAL =**	71752.5

S_c = 0.008

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment C	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	43	0	0			
2	46	3	912	912	1.5	1368
3	74	31	2682	1770	17	30090
4	110	67	4378	1696	49	83104
5	219	176	5802	1424	121.5	173016
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 =	5802	**TOTAL =**	287578

S_c = 0.017

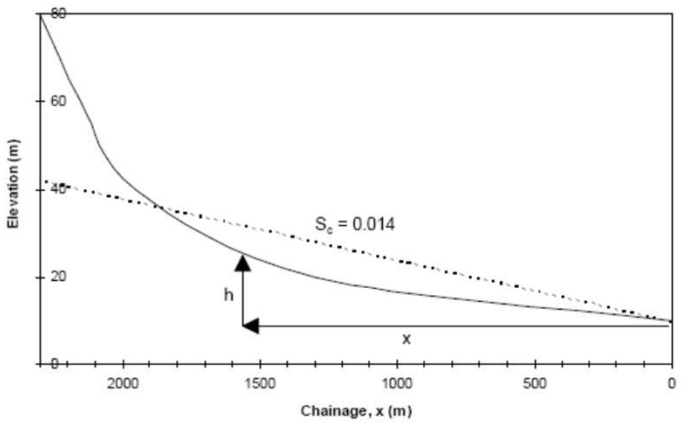
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	45	3	1729	1729	1.5	2593.5
3	56	14	3232	1503	8.5	12775.5
4	112	70	4054	822	42	34524
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 =	4054	**TOTAL =**	49893

S_c = 0.006

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment D	**CHKD BY:**	

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



(This graph is from the ARC TP 108, April 1999, pg.14)

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

Data Entry Cells
Result cells

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	43	0	0			
2	46	3	912	912	1.5	1368
3	81	38	3222	2310	20.5	47355
4	137	94	5206	1984	66	130944
5	204	161	6553	1347	127.5	171742.5
6	315	272	7599	1046	216.5	226459
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 =	7599	**TOTAL =**	577868.5

S_c = 0.020

Post-development

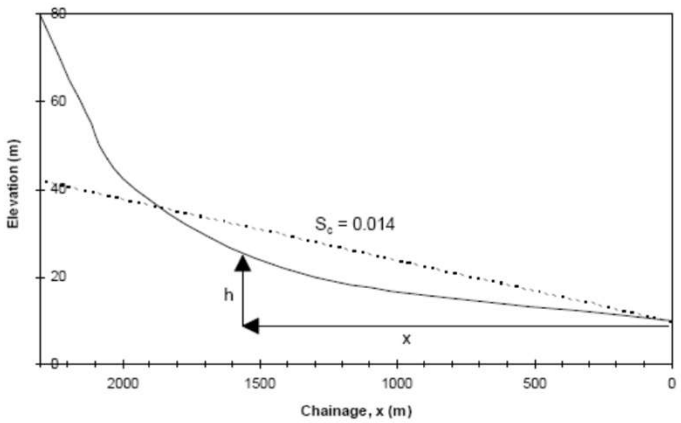
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	43	0	0			
2	46	3	912	912	1.5	1368
3	81	38	3222	2310	20.5	47355
4	137	94	5206	1984	66	130944
5	204	161	6553	1347	127.5	171742.5
6	315	272	7599	1046	216.5	226459
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	7599	**TOTAL =**	577868.5

D

S_c = 0.02

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment E	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	51	9	2659	2659	4.5	11965.5
3	67	25	3838	1179	17	20043
4	121	79	5124	1286	52	66872
5	275	233	6720	1596	156	248976
6	345	303	7154	434	268	116312
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 =	7154	**TOTAL =**	464168.5

S_c = 0.018

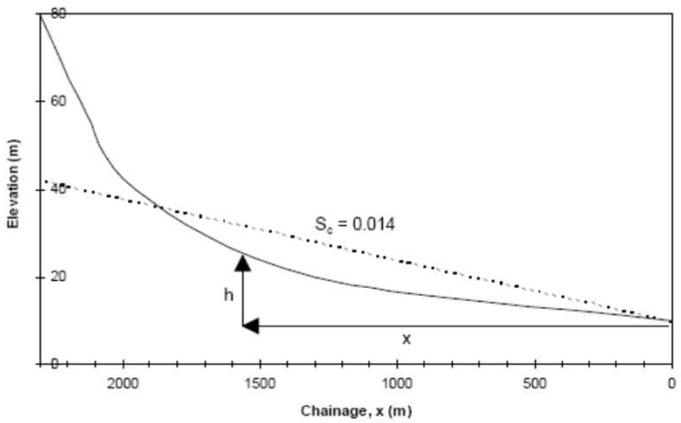
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	51	9	2659	2659	4.5	11965.5
3	67	25	3838	1179	17	20043
4	121	79	5124	1286	52	66872
5	275	233	6720	1596	156	248976
6	345	303	7154	434	268	116312
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 =	7154	**TOTAL =**	464168.5

S_c = 0.018

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment F	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	30	0	0			
2	42	12	1345	1345	6	8070
3	69	39	3029	1684	25.5	42942
4	165	135	3940	911	87	79257
5	296	266	4597	657	200.5	131728.5
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 =	4597	**TOTAL =**	261997.5

S_c = 0.025

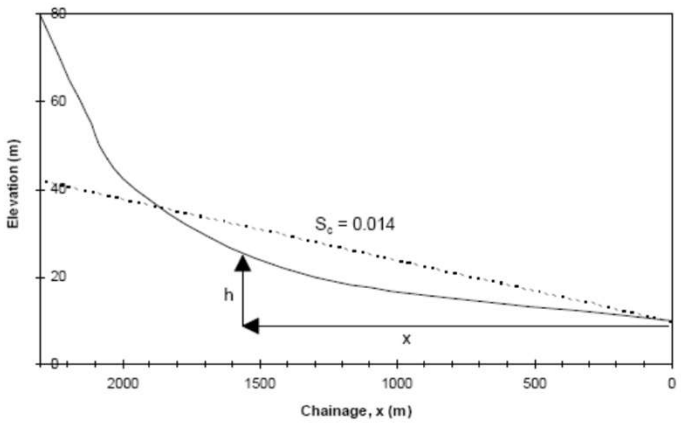
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	30	0	0			
2	42	12	1345	1345	6	8070
3	69	39	3029	1684	25.5	42942
4	165	135	3940	911	87	79257
5	296	266	4597	657	200.5	131728.5
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 =	4597	**TOTAL =**	261997.5

S_c = 0.025

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment G	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	17	0	0			
2	30	13	1098	1098	6.5	7137
3	35	18	2750	1652	15.5	25606
4	42	25	4847	2097	21.5	45085.5
5	47	30	6349	1502	27.5	41305
6	54	37	7725	1376	33.5	46096
7	287	270	9878	2153	153.5	330485.5
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 =	9878	**TOTAL =**	495715

S_c = 0.010

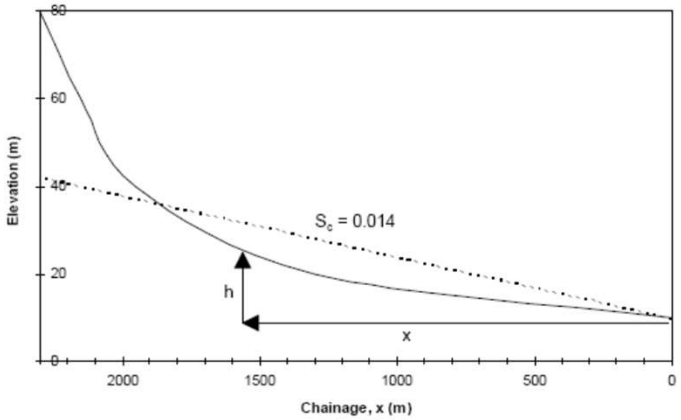
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	17	0	0			
2	30	13	1098	1098	6.5	7137
3	35	18	2750	1652	15.5	25606
4	42	25	4847	2097	21.5	45085.5
5	47	30	6349	1502	27.5	41305
6	54	37	7725	1376	33.5	46096
7	287	270	9878	2153	153.5	330485.5
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 =	9878	**TOTAL =**	495715

S_c = 0.01

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment H	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	47	5	1502	1502	2.5	3755
3	54	12	2878	1376	8.5	11696
4	287	245	5031	2153	128.5	276660.5
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 =	5031	**TOTAL =**	292111.5

S_c = 0.023

Post-development

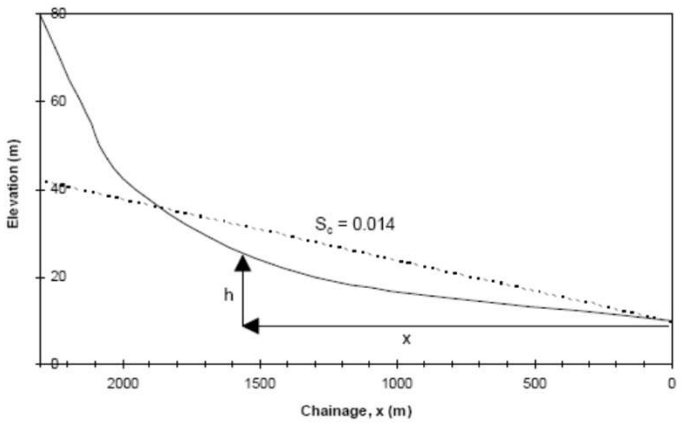
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	42	0	0			
2	47	5	1502	1502	2.5	3755
3	54	12	2878	1376	8.5	11696
4	287	245	5031	2153	128.5	276660.5
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	5031	**TOTAL =**	292111.5

D

S_c = 0.023

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment I	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A(=\overline{h}\Delta x)$
1	17	0	0			
2	29	12	1018	1018	6	6108
3		0	1018	0	0	0
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 =	1018	**TOTAL =**	6108

S_c = 0.012

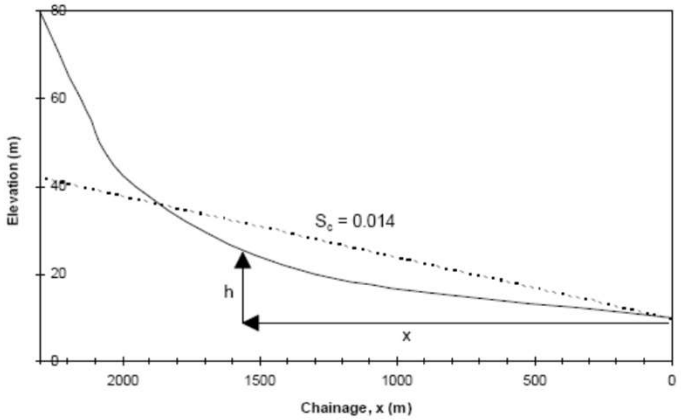
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A(=\overline{h}\Delta x)$
1	17	0	0			
2	29	12	1018	1018	6	6108
3		0	1018	0	0	0
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 =	1018	**TOTAL =**	6108

S_c = 0.012

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment J	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	17	0	0			
2	21	4	808	808	2	1616
3	33	16	2536	1728	10	17280
4	87	70	3056	520	43	22360
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 =	3056	**TOTAL =**	41256

S_c = 0.009

Post-development

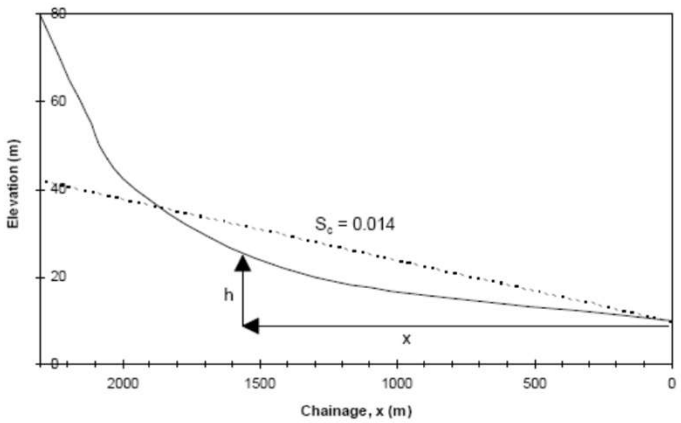
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	17	0	0			
2	21	4	808	808	2	1616
3	33	16	2536	1728	10	17280
4	87	70	3056	520	43	22360
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	3056	**TOTAL =**	41256

D

S_c = 0.009

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment K	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	8	0	0			
2	57	49	1665	1665	24.5	40792.5
3		0	1665	0	0	0
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 =	1665	**TOTAL =**	40792.5

S_c = 0.029

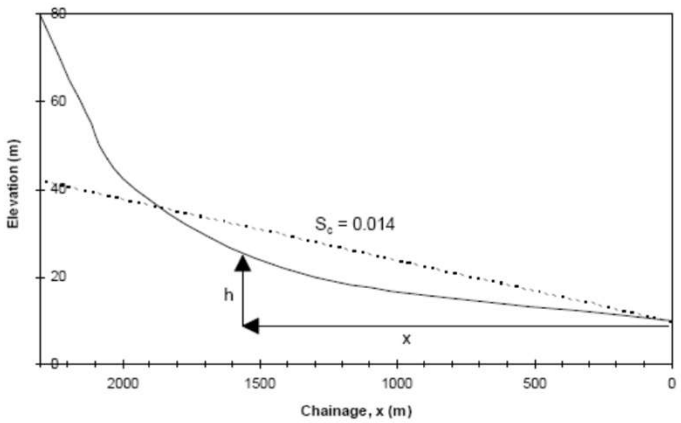
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	8	0	0			
2	57	49	1665	1665	24.5	40792.5
3		0	1665	0	0	0
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 =	1665	**TOTAL =**	40792.5

S_c = 0.029

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment L	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	8	0	0			
2	84	76	1076	1076	38	40888
3		0	1076	0	0	0
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 =	1076	**TOTAL =**	40888

S_c = 0.071

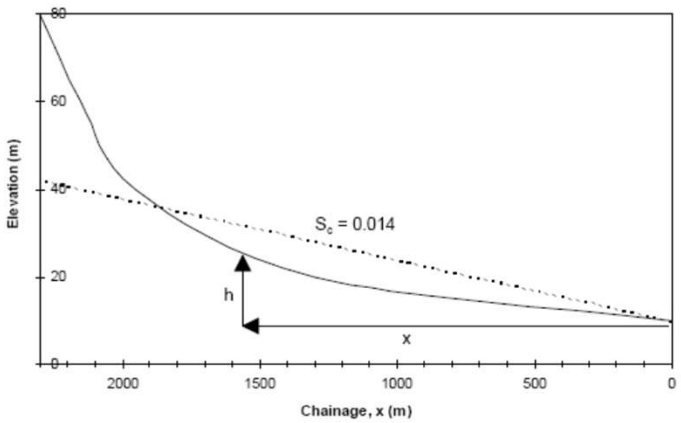
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	8	0	0			
2	84	76	1076	1076	38	40888
3		0	1076	0	0	0
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 =	1076	**TOTAL =**	40888

S_c = 0.071

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment N	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	8	0	0			
2	21	13	770	770	6.5	5005
3	35	27	1372	602	20	12040
4	73	65	2412	1040	46	47840
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 =	2412	**TOTAL =**	64885

S_c = 0.022

Post-development

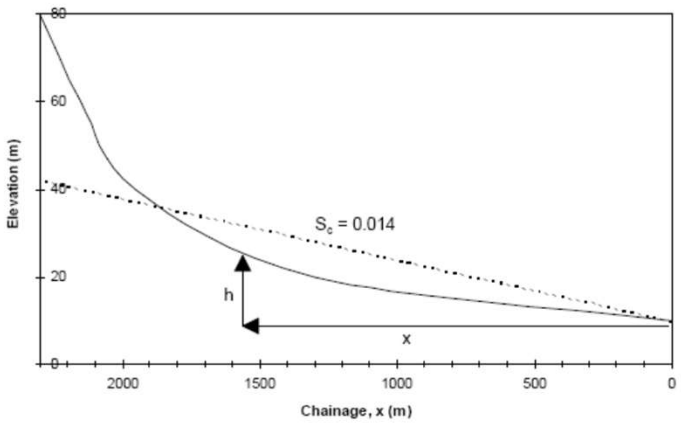
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	8	0	0			
2	21	13	770	770	6.5	5005
3	35	27	1372	602	20	12040
4	73	65	2412	1040	46	47840
5		0		0	0	0
6		0		0	0	0
7		0		0	0	0
8		0		0	0	0
9		0		0	0	0
10		0		0	0	0
11		0		0	0	0
12		0		0	0	0
			TOTAL =	2412	**TOTAL =**	64885

D

S_c = 0.022

JOB NAME:	Warkwork South Plan Change	**DATE:**	17/01/2023
JOB NO:	211001	**DES BY:**	YW
SUBJECT:	Catchment M	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

(This graph is from the ARC TP 108, April 1999, pg.14)

Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	3	0	0			
2	8	5	1112	1112	2.5	2780
3		0	1112	0	0	0
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 =	1112	**TOTAL =**	2780

S_c = 0.004

Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	3	0	0			
2	8	5	1112	1112	2.5	2780
3		0	1112	0	0	0
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 =	1112	**TOTAL =**	2780

S_c = 0.004

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment A	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	6.0077	588.75
C	Total Pervious	74	327.7623	24254.41
* from Appendix B		Totals =	333.770	24843.16

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{24843.16}{333.770} =$ 74.4

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 327.7623}{333.770}$ 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.117 km (along drainage path)

Catchment Slope Sc= 0.006 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.4}{200-74.4} =$ 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.54 1.33 4.64 = 2.20 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.48 hrs

OK
use
2.2040513 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment A	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	3.3377	km2(100ha =1km2)
Runoff curve number	CN=	74.4	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	2.20	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 87.3 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.045	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**42.205**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.8	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	700219.32	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment B	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	10.3517	1014.47
C	Total Pervious	74	401.8183	29734.55
* from Appendix B		Totals =	412.170	30749.02

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{30749.02}{412.170} =$ 74.6

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 401.8183}{412.170}$ 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.29 km (along drainage path)

Catchment Slope Sc= 0.008 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.6}{200-74.6} =$ 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.61 1.33 4.26 = 2.07 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.39 hrs

OK
use
2.0733185 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment B	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	4.1217	km2(100ha =1km2)
Runoff curve number	CN=	74.6	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	2.07	hrs (from worksheet 1)

2. Calculate storage, $S = (1000/CN - 10)25.4$ = 86.5 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute $c^* = P24 - 2Ia/P24 - 2Ia+2S$	0.61	
6. Specific peak flow rate q*	0.047	
7. Peak flow rate, $q_p = q^*A^*P_{24}$	**54.435**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	210.3	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	866696.79	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment C	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	3.8056	372.95
C	Total Pervious	74	287.7544	21293.83
* from Appendix B		Totals =	291.560	21666.77

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{21666.77}{291.560} = 74.3$

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 287.7544}{291.560}$ 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.89 km (along drainage path)

Catchment Slope Sc= 0.017 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.3}{200-74.3} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

$= 0.14 \quad 1 \quad 2.85 \quad 1.34 \quad 3.40 = 1.81$ hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c = 1.21$ hrs

OK
use
1.809089 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment C	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	2.9156	km2(100ha =1km2)
Runoff curve number	CN=	74.3	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	1.81	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 87.8 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.049	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**40.145**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.5	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	610682.18	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment D	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	4.8100	471.38
C	Total Pervious	74	505.2700	37389.98
* from Appendix B		Totals =	510.080	37861.36

CN (weighted) = total product / total area = 37861.36 / 510.080 = 74.2

Ia (average) = 5 x pervious area / total area = 5 x 505.2700 / 510.080 = 5.0 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 6.687 km (along drainage path)

Catchment Slope Sc= 0.02 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.2 / (200- 74.2) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 3.50 1.34 3.23 = 2.12 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.42 hrs

OK
use
2.1205047 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES		Job Number 211001	Sheet 2	Rev A
Job Title	Warkworth South Plan Change	Author	Date	Checked
Calc Title	TP108 Calculation - Pre-Development Catchment D	YW	18/01/2023	0

1. Data

Catchment Area	A=	5.1008	km2(100ha =1km2)
Runoff curve number	CN=	74.2	(from worksheet 1)
Initial abstraction	Ia=	5.0	mm (from worksheet 1)
Time of concentration	tc=	2.12	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 88.2 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.045	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**64.500**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.2	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1067118.42	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment E	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	5.7200	560.56
C	Total Pervious	74	567.5700	42000.18
* from Appendix B		Totals =	573.290	42560.74

CN (weighted) = total product / total area = 42560.74 / 573.290 = 74.2

Ia (average) = 5 x pervious area / total area = 5 x 567.5700 / 573.290 = 5.0 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 7.153 km (along drainage path)

Catchment Slope Sc= 0.018 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.2 / (200- 74.2) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 3.66 1.34 3.34 = 2.29 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.53 hrs

OK
use
2.2877512 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment E	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	5.7329	km2(100ha =1km2)
Runoff curve number	CN=	74.2	(from worksheet 1)
Initial abstraction	Ia=	5.0	mm (from worksheet 1)
Time of concentration	tc=	2.29	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 88.1 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.042	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**67.660**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.2	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1199571.87	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment F	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	4.8193	472.29
C	Total Pervious	74	299.1107	22134.19
* from Appendix B		Totals =	303.930	22606.48

CN (weighted) = total product / total area = 22606.48 / 303.930 = 74.4

Ia (average) = 5 x pervious area / total area = 5 x 299.1107 / 303.930 = 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.596 km (along drainage path)

Catchment Slope Sc= 0.025 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.4 / (200- 74.4) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.74 1.33 3.02 = 1.55 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.04 hrs

OK
use
1.545594 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment F	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	3.0393	km2(100ha =1km2)
Runoff curve number	CN=	74.4	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	1.55	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 87.5 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.055	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**46.972**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.6	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	637173.21	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change TP108 Calculation - Post Development Catchment F	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	15.1030	1480.09
C	Total Pervious	74	288.8270	21373.20
* from Appendix B		Totals =	303.930	22853.29

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{22853.29}{303.930} =$ 75.2

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 288.8270}{303.930}$ 4.8 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.596 km (along drainage path)

Catchment Slope Sc= 0.025 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{75.2}{200-75.2} =$ 0.60

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.74 1.32 3.02 = 1.53 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.03 hrs

OK
use
1.5309205 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title: Warkworth South Plan Change Calc Title: TP108 Calculation - Post Development Catchment F	Author: YW	Date: 18/01/2023	Checked

1. Data

Catchment Area	A=	3.0393	km2(100ha =1km2)
Runoff curve number	CN=	75.2	(from worksheet 1)
Initial abstraction	Ia=	4.8	mm (from worksheet 1)
Time of concentration	tc=	1.53	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 83.8 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.62	
6. Specific peak flow rate q*	0.055	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**46.972**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	212.0	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	644189.15	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment G	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	9.4054	921.73
C	Total Pervious	74	575.1346	42559.96
* from Appendix B		Totals =	584.540	43481.69

CN (weighted) = total product / total area = 43481.69 / 584.540 = 74.4

Ia (average) = 5 x pervious area / total area = 5 x 575.1346 / 584.540 = 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.848 km (along drainage path)

Catchment Slope Sc= 0.01 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.4 / (200- 74.4) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.83 1.33 3.98 = 2.11 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.41 hrs

OK
use
2.1074111 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment G	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	5.8454	km2(100ha =1km2)
Runoff curve number	CN=	74.4	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	2.11	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 87.5 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.045	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**73.915**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.7	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1225550.48	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment H	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	12.0476	1180.66
C	Total Pervious	74	836.7124	61916.72
* from Appendix B		Totals =	848.760	63097.38

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{63097.38}{848.760} =$ 74.3

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 836.7124}{848.760}$ 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 5.031 km (along drainage path)

Catchment Slope Sc= 0.023 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.3}{200-74.3} =$ 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.90 1.33 3.10 = 1.68 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.13 hrs

OK
use
1.683 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment H	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	8.4876	km2(100ha =1km2)
Runoff curve number	CN=	74.3	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	1.68	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 87.7 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.053	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**126.406**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	209.5	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1778417.67	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment I	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	7.3200	717.36
C	Total Pervious	74	16.2500	1202.50
* from Appendix B		Totals =	23.570	1919.86

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{1919.86}{23.570} =$ 81.5

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 16.2500}{23.570}$ 3.4 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.018 km (along drainage path)

Catchment Slope Sc= 0.012 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{81.5}{200-81.5} =$ 0.69

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.01 1.23 3.77 = 0.66 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.44 hrs

OK
use
0.6563348 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment I	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	0.2357	km2(100ha =1km2)
Runoff curve number	CN=	81.5	(from worksheet 1)
Initial abstraction	Ia=	3.4	mm (from worksheet 1)
Time of concentration	tc=	0.66	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 57.8 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.70	
6. Specific peak flow rate q*	0.090	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**5.961**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	229.7	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	54138.30	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change / TP108 Calculation - Pre-Development Catchment J	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	8.4586	828.94
C	Total Pervious	74	275.4014	20379.70
* from Appendix B		Totals =	283.860	21208.65

CN (weighted) = total product / total area = 21208.65 / 283.860 = 74.7

Ia (average) = 5 x pervious area / total area = 5 x 275.4014 / 283.860 = 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 3.056 km (along drainage path)

Catchment Slope Sc= 0.009 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.7 / (200- 74.7) = 0.60

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.09 1.33 4.11 = 1.60 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.07 hrs

OK
use
1.5978127 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment J	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	2.8386	km2(100ha =1km2)
Runoff curve number	CN=	74.7	(from worksheet 1)
Initial abstraction	Ia=	4.9	mm (from worksheet 1)
Time of concentration	tc=	1.60	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 86.0 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.055	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**43.871**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	210.6	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	597798.05	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment K	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	45.2715	4436.61
C	Total Pervious	74	26.8785	1989.01
* from Appendix B		Totals =	72.150	6425.62

CN (weighted) = total product / total area = 6425.62 / 72.150 = 89.1

Ia (average) = 5 x pervious area / total area = 5 x 26.8785 / 72.150 = 1.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.665 km (along drainage path)

Catchment Slope Sc= 0.029 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 89.1 / (200- 89.1) = 0.80

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.40 1.13 2.89 = 0.64 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.43 hrs

OK
use
0.6397632 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment K	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	0.7215	km2(100ha =1km2)
Runoff curve number	CN=	89.1	(from worksheet 1)
Initial abstraction	Ia=	1.9	mm (from worksheet 1)
Time of concentration	tc=	0.64	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 31.2 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.82	
6. Specific peak flow rate q*	0.100	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**20.274**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	251.1	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	181147.71	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment L	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	0.2200	21.56
C	Total Pervious	74	21.5700	1596.18
* from Appendix B		Totals =	21.790	1617.74

CN (weighted) = total product / total area = 1617.74 / 21.790 = 74.2

Ia (average) = 5 x pervious area / total area = 5 x 21.5700 / 21.790 = 4.9 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.076 km (along drainage path)

Catchment Slope Sc= 0.071 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.2 / (200- 74.2) = 0.59

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.05 1.34 2.21 = 0.43 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.29 hrs

OK
use
0.4341425 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment M	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	67.7100	6635.58
C	Total Pervious	74	59.8900	4431.86
* from Appendix B		Totals =	127.600	11067.44

CN (weighted) = total product / total area = 11067.44 / 127.600 = 86.7

Ia (average) = 5 x pervious area / total area = 5 x 59.8900 / 127.600 = 2.3 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 2.412 km (along drainage path)

Catchment Slope Sc= 0.022 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 86.7 / (200- 86.7) = 0.77

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.79 1.16 3.14 = 0.91 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.61 hrs

OK
use
0.9109907 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment M	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	1.276	km2(100ha =1km2)
Runoff curve number	CN=	86.7	(from worksheet 1)
Initial abstraction	Ia=	2.3	mm (from worksheet 1)
Time of concentration	tc=	0.91	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 38.8 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.78	
6. Specific peak flow rate q*	0.082	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**29.402**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	244.6	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	312059.96	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment N	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	23.6020	2313.00
C	Total Pervious	74	25.5680	1892.03
* from Appendix B		Totals =	49.170	4205.03

CN (weighted) = total product / total area = 4205.03 / 49.170 = 85.5

Ia (average) = 5 x pervious area / total area = 5 x 25.5680 / 49.170 = 2.6 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.471 km (along drainage path)

Catchment Slope Sc= 0.004 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 85.5 / (200- 85.5) = 0.75

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.29 1.17 5.24 = 1.11 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.74 hrs

OK
use
1.1112135 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment N	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	0.4917	km2(100ha =1km2)
Runoff curve number	CN=	85.5	(from worksheet 1)
Initial abstraction	Ia=	2.6	mm (from worksheet 1)
Time of concentration	tc=	1.11	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 43.0 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.76	
6. Specific peak flow rate q*	0.078	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**10.777**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	241.1	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	118572.76	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment Rain	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	16.4233	1609.48
C	Total Pervious	74	468.9067	34699.10
* from Appendix B		Totals =	485.330	36308.58

CN (weighted) = total product / total area = 36308.58 / 485.330 = 74.8

Ia (average) = 5 x pervious area / total area = 5 x 468.9067 / 485.330 = 4.8 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.054 km (along drainage path)

Catchment Slope Sc= 0.008 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.8 / (200- 74.8) = 0.60

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.52 1.33 4.26 = 1.99 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.33 hrs

OK
use
1.9924106 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: Warkworth South Plan Change TP108 Calculation - Pre-Development Catchment Rain	Author YW	Date 18/01/2023	Checked 0

1. Data

Catchment Area	A=	4.8533	km2(100ha =1km2)
Runoff curve number	CN=	74.8	(from worksheet 1)
Initial abstraction	Ia=	4.8	mm (from worksheet 1)
Time of concentration	tc=	1.99	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 85.5 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.61	
6. Specific peak flow rate q*	0.050	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**68.189**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	210.9	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1023424.02	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES	Job Number 211001 78	Sheet 1	Rev A
Job Title / Calc Title: 2 - 4 Ronald Road, Greenhithe TP108 Calculation - Post Development Catchment Rain	Author YW	Date 18/01/2023	Checked

1. Runoff Curve Number (CN) and initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (ha) 10000m2= 1ha	Product of CN x area
C	Total Impervious	98	261.7558	25652.07
C	Total Pervious	74	223.5742	16544.49
* from Appendix B		Totals =	485.330	42196.56

CN (weighted) = total product / total area = 42196.56 / 485.330 = 86.9

Ia (average) = 5 x pervious area / total area = 5 x 223.5742 / 485.330 = 2.3 mm

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.054 km (along drainage path)

Catchment Slope Sc= 0.008 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 86.9 / (200- 86.9) = 0.77

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 2.52 1.16 4.26 = 1.73 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.16 hrs

OK use 1.734338 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 2	Rev A
Job Title / Calc Title: 2 - 4 Ronald Road, Greenhithe / TP108 Calculation - Post Development Catchment Rain	Author YW	Date 18/01/2023	Checked

1. Data

Catchment Area	A=	4.8533	km2(100ha =1km2)
Runoff curve number	CN=	86.9	(from worksheet 1)
Initial abstraction	Ia=	2.3	mm (from worksheet 1)
Time of concentration	tc=	1.73	hrs (from worksheet 1)

2. Calculate storage, S =(1000/CN - 10)25.4 = 38.1 mm

3. Average recurrence interval, ARI	100	(yr)
4. 24 hour rainfall depth, P24	281	(mm)
5. Compute c* = P24 - 2Ia/P24 - 2Ia+2S	0.78	
6. Specific peak flow rate q*	0.059	
7. Peak flow rate, $q_p=q^*A^*P_{24}$	**80.463**	m3/s
8. Runoff depth, $Q_{24} = (P_{24}-Ia)^2/(P_{24}-Ia)+S$	245.1	
9. Runoff volume, $V_{24} = 1000xQ_{24}A$	1189769.15	(m3)

Worksheet 2: Graphical Peak Flow Rate

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change Reach CD to ABE Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 2.6 km (along drainage path)

Catchment Slope Sc= 0.0015 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200 - 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.88 1.34 7.03 = 2.48 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.66 hrs

OK
use
2.4791878 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change Reach ABE to Scheme Inflow Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.187 km (along drainage path)

Catchment Slope Sc= 0.01 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200 - 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

$= 0.14 \quad 1 \quad 1.12 \quad 1.34 \quad 3.98 = 0.84$ hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.56 hrs

OK
use
0.8363573 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change — Reach Scheme Inflow to Scheme out — Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 2.986 km (along drainage path)

Catchment Slope Sc= 0.004 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200 - 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

$= 0.14 \quad 1 \quad 2.06 \quad 1.34 \quad 5.24 = 2.02$ hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c = 1.36$ hrs

OK
use
2.0239308 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES	Job Number 211001	Sheet 1	Rev A
Job Title / Calc Title: Warkworth South Plan Change — Reach Scheme Inflow to Scheme out — Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.848 km (along drainage path)

Catchment Slope Sc= 0.01 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200 - 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

$= 0.14 \quad 1 \quad 2.83 \quad 1.34 \quad 3.98 =$ 2.12 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.42 hrs

OK
use
2.1170237 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change Reach Scheme out to IJ Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 0.926 km (along drainage path)

Catchment Slope Sc= 0.0011 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200- 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 0.95 1.34 7.76 = 1.38 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.93 hrs

OK
use
1.3842067 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change Reach IJ TO KLM Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.283 km (along drainage path)

Catchment Slope Sc= 0.0062 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200 - 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.18 1.34 4.59 = 1.01 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.68 hrs

OK
use
1.0144368 hrs

Worksheet 1: Runoff Parameters and Time of Concentration

MAVEN ASSOCIATES		Job Number 211001	Sheet 1	Rev A
Job Title Calc Title	Warkworth South Plan Change Reach IJ TO KL Time of Concentration	Author YW	Date 18/01/2023	Checked

2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.112 km (along drainage path)

Catchment Slope Sc= 0.0045 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{74.0}{200 - 74.0} = 0.59$

$t_c = 0.14\ C\ L^{0.66}\ (CN/200\text{-}CN)^{-0.55}\ Sc^{-0.30}$

= 0.14 1 1.07 1.34 5.06 = 1.02 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.68 hrs

OK
use
1.0181786 hrs

Worksheet 1: Runoff Parameters and Time of Concentration