# STORMWATER MODELLING REPORT

## FOR

## PROPOSED WARKWORTH SOUTH

## PLAN CHANGE AREA

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

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# 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 (PCA) 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.

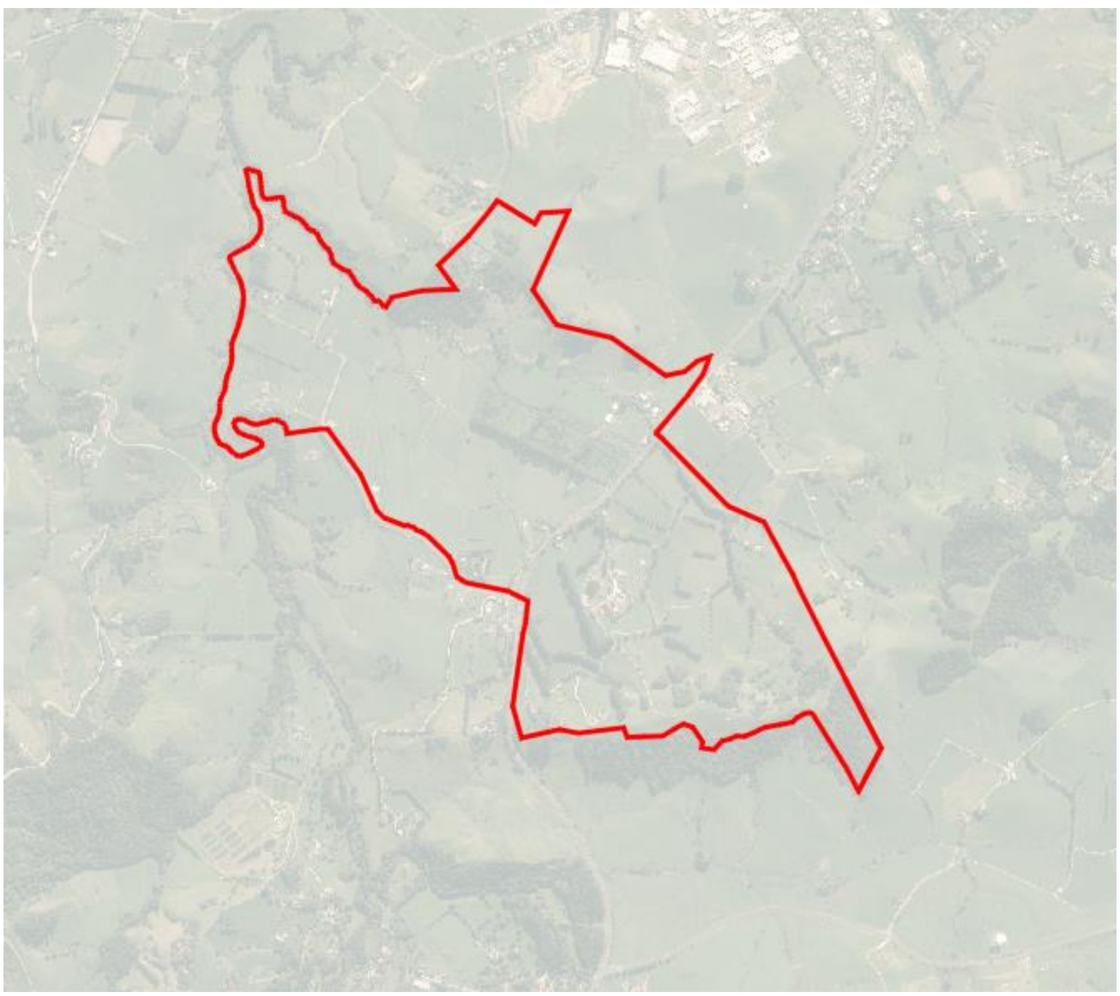


**Figure 1.1 – Catchment Delineation**

## 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.<br>LiDAR/Site Survey by Parrallax Ltd.<br>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* |
|---|---|
| 50% | 9.0% |
| 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 |
|---|---|---|---|
| 2-year | 112 | 122 | 112 |
| 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. Naming conventions of the subcatchments have been split between upstream and downstream of the PCA. The upper catchments are named upstream A to F and downstream catchments, downstream A to H. The yellow area (including 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 upstream catchment *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.

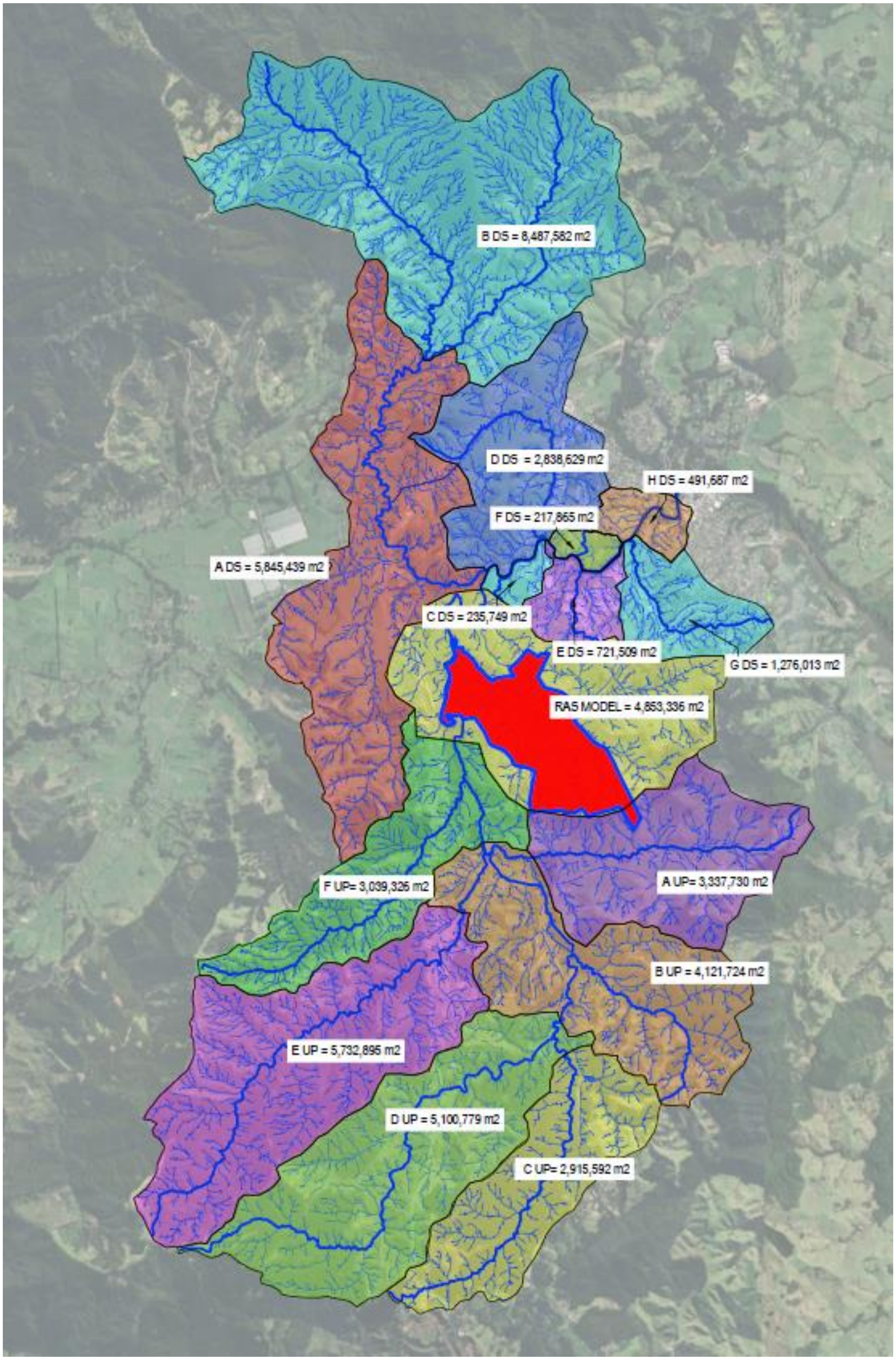



**Figure 2.1 – Catchment Boundary**

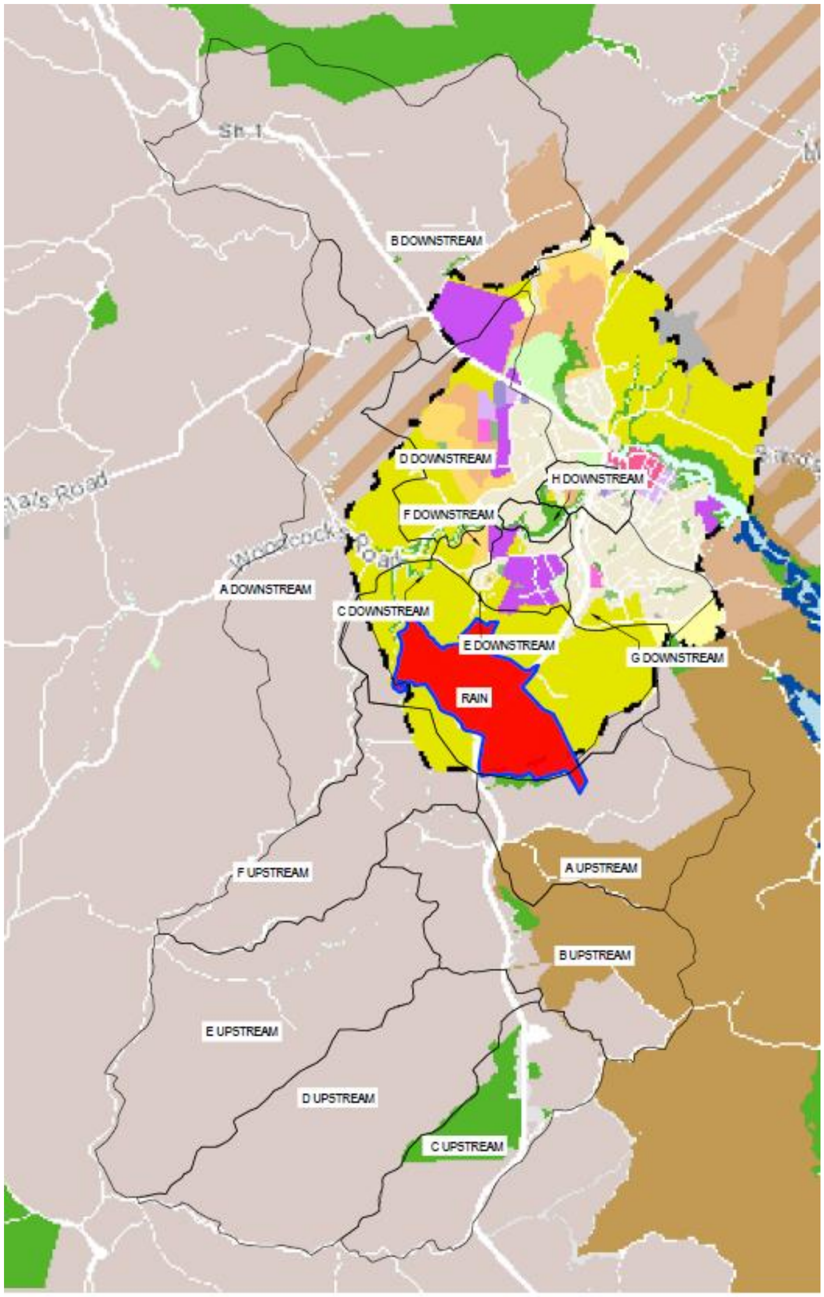



**Figure 2.2 – Land-use zones**

| | | Upstream of PCA | | | | | | | Downstream of PCA | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Impervious % | Rain | A | B | C | D | E | F | A | B | C | D | E | F | G | H |
| 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 | 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**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upstream of PCA | | | | | | | | Downstream of PCA | | | | | | | |
| | Impervious % | Rain | A | B | C | D | E | F | A | B | C | D | E | F | G | H |
| 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 2.5 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.

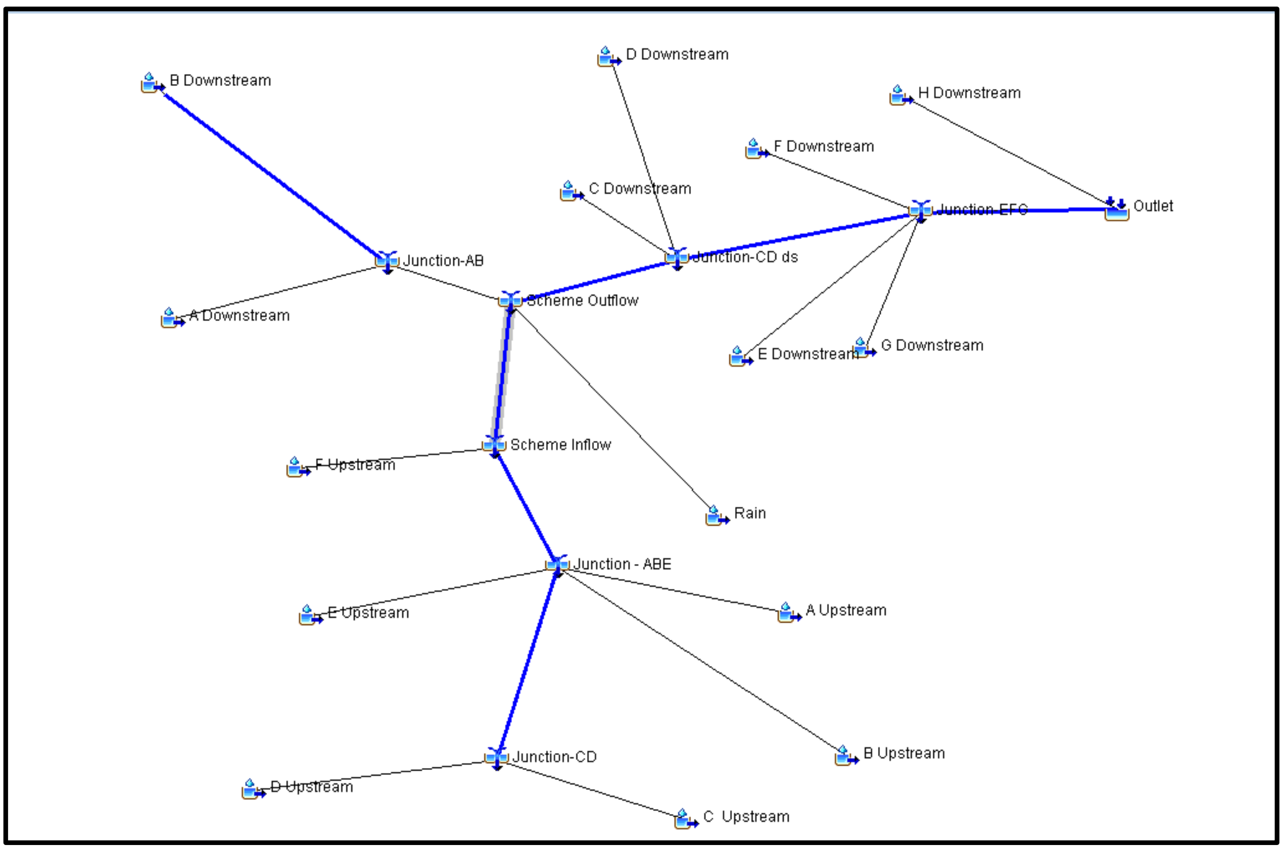



**Figure 2.5 – HEC-HMS model set-up**

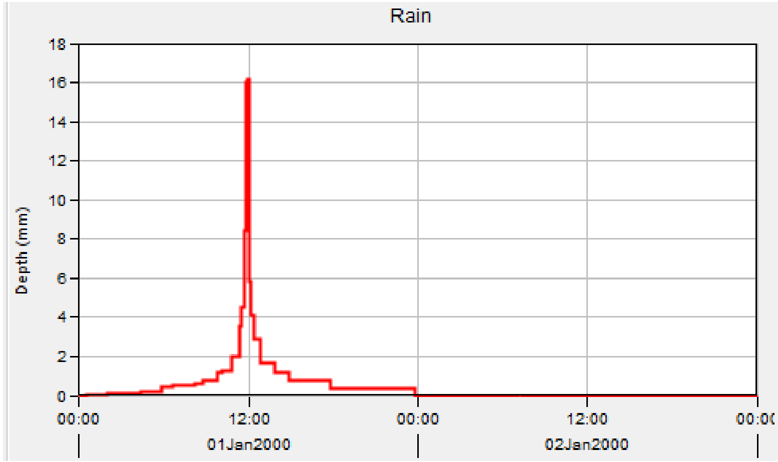



Figure 2.6 shows the 100-year developed land-use rainfall hyetograph for the grid.

**Figure 2.6 – Rainfall excess, 100-year, climate change, developed**

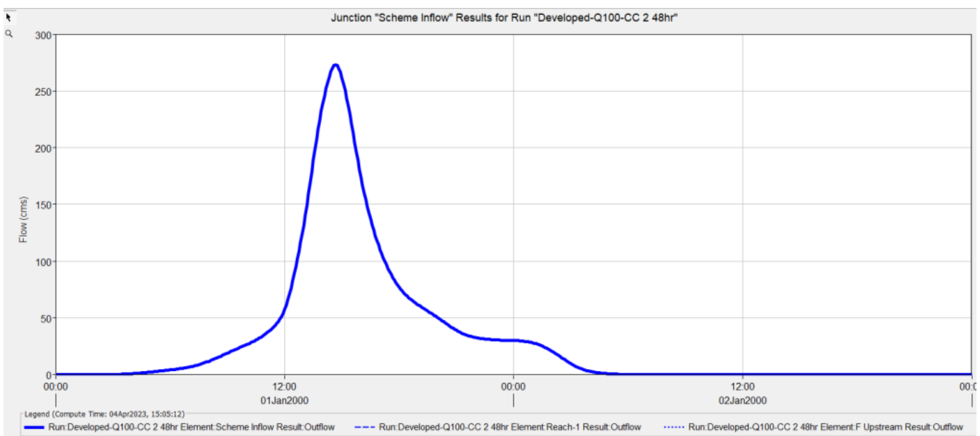



Figure 2.7 shows the hydrograph for scheme inflow for the 100-year storm with climate change rain and developed.

**Figure 2.7 – Flow hydrograph, 100-year, climate change, developed**

2.5.1 Effects of climate change

Figure 2.8 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 224$m^3$/s to 273$m^3$/s. Most of the 49$m^3$/s increase is due to climate change. The volume increase is almost 0.91 million $m^3$.

At the scheme outflow the changes are 347$m^3$/s to 421$m^3$/s. Thus, the catchment is expected to yield 74$m^3$/s, (this entire increase is due to climate change as explained in section 2.5.2). This increase is 17%. The volume increase is 1.6 million $m^3$.

*Figure 2.8 – 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. historical rain, proposed land-use vs climate changed rain and developed)*

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

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

Start of Run: 01Jan2000, 00:00    Basin Model: Existing Land-Use
End of Run: 02Jan2000, 00:00    Meteorologic Model: 100yr-existing-existing-land
Compute Time: 04Apr2023, 11:34:28    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 Downstream | 5.8454 | 55.71354 | 01Jan2000, 13:50 | 999.18175 |
| A Upstream | 3.3380 | 36.86217 | 01Jan2000, 13:20 | 576.96580 |
| B Downstream | 8.4876 | 91.34174 | 01Jan2000, 13:25 | 1462.51227 |
| B Upstream | 4.1220 | 46.67449 | 01Jan2000, 13:20 | 715.49697 |
| C Downstream | 0.2357 | 5.01350 | 01Jan2000, 12:25 | 46.24902 |
| C Upstream | 2.9156 | 35.38431 | 01Jan2000, 13:10 | 506.20497 |
| D Downstream | 2.8386 | 36.46248 | 01Jan2000, 13:00 | 496.99865 |
| D Upstream | 5.1008 | 56.15127 | 01Jan2000, 13:20 | 878.69326 |
| E Downstream | 0.7215 | 16.17126 | 01Jan2000, 12:25 | 156.27172 |
| E Upstream | 5.7329 | 58.75500 | 01Jan2000, 13:35 | 982.55892 |
| F Downstream | 0.2179 | 4.58160 | 01Jan2000, 12:20 | 38.57723 |
| F Upstream | 3.0393 | 38.64703 | 01Jan2000, 13:00 | 529.75106 |
| G Downstream | 1.2760 | 25.09295 | 01Jan2000, 12:30 | 267.38809 |
| H Downstream | 0.4917 | 11.32758 | 01Jan2000, 12:20 | 101.86108 |
| Junction - ABE | 21.2093 | 208.34781 | 01Jan2000, 13:55 | 3628.33498 |
| Junction-AB | 14.3330 | 132.15756 | 01Jan2000, 14:50 | 2411.57944 |
| Junction-CD | 8.0164 | 90.79421 | 01Jan2000, 13:15 | 1384.89822 |
| Junction-CD ds | 46.5092 | 354.71174 | 01Jan2000, 16:05 | 7668.43491 |
| Junction-EFG | 48.7246 | 359.38568 | 01Jan2000, 16:45 | 8008.70568 |
| Outlet | 49.2163 | 360.41859 | 01Jan2000, 17:25 | 7969.16268 |
| Rain | 4.8533 | 54.41783 | 01Jan2000, 13:20 | 844.55754 |
| Reach-1 | 21.2093 | 208.07416 | 01Jan2000, 14:45 | 3564.45241 |
| Reach-2 | 8.0164 | 90.70163 | 01Jan2000, 14:20 | 1353.31328 |
| Reach-3 | 8.4876 | 91.30646 | 01Jan2000, 15:00 | 1412.39769 |
| Reach-4 | 24.2486 | 224.27160 | 01Jan2000, 15:55 | 3978.68919 |
| Reach-5 | 43.4349 | 346.41930 | 01Jan2000, 16:10 | 7125.18723 |
| Reach-6 | 46.5092 | 354.68892 | 01Jan2000, 16:45 | 7546.46865 |
| Reach-7 | 48.7246 | 359.38568 | 01Jan2000, 17:25 | 7867.30160 |
| Scheme Inflow | 24.2486 | 224.27160 | 01Jan2000, 14:40 | 4094.20347 |
| Scheme Outflow | 43.4349 | 346.50079 | 01Jan2000, 15:30 | 7234.82617 |

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

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

Start of Run: 01Jan2000, 00:00 Basin Model: Existing Land-Use
End of Run: 02Jan2000, 00:00 Meteorologic Model: 100yr-CC-existing-land-use
Compute Time: 04Apr2023, 11:25:23 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 Downstream | 5.8454 | 67.89074 | 01Jan2000, 13:50 | 1220.76543 |
| A Upstream | 3.3380 | 44.93661 | 01Jan2000, 13:20 | 704.70863 |
| B Downstream | 8.4876 | 111.35746 | 01Jan2000, 13:25 | 1786.68282 |
| B Upstream | 4.1220 | 56.84513 | 01Jan2000, 13:20 | 873.60158 |
| C Downstream | 0.2357 | 6.01131 | 01Jan2000, 12:25 | 55.75929 |
| C Upstream | 2.9156 | 43.11220 | 01Jan2000, 13:10 | 618.28270 |
| D Downstream | 2.8386 | 44.41328 | 01Jan2000, 13:00 | 606.60934 |
| D Upstream | 5.1008 | 68.48363 | 01Jan2000, 13:20 | 1073.67741 |
| E Downstream | 0.7215 | 19.12037 | 01Jan2000, 12:25 | 186.00455 |
| E Upstream | 5.7329 | 71.63279 | 01Jan2000, 13:35 | 1200.75451 |
| F Downstream | 0.2179 | 5.57805 | 01Jan2000, 12:20 | 47.09980 |
| F Upstream | 3.0393 | 47.10883 | 01Jan2000, 13:00 | 646.89674 |
| G Downstream | 1.2760 | 29.80892 | 01Jan2000, 12:30 | 319.54365 |
| H Downstream | 0.4917 | 13.48195 | 01Jan2000, 12:20 | 121.97268 |
| Junction - ABE | 21.2093 | 253.81225 | 01Jan2000, 13:55 | 4433.46367 |
| Junction-AB | 14.3330 | 160.93311 | 01Jan2000, 14:45 | 2947.84554 |
| Junction-CD | 8.0164 | 110.71134 | 01Jan2000, 13:15 | 1691.96012 |
| Junction-CD ds | 46.5092 | 431.66357 | 01Jan2000, 16:05 | 9377.50515 |
| Junction-EFG | 48.7246 | 437.12556 | 01Jan2000, 16:45 | 9785.00179 |
| Outlet | 49.2163 | 438.34159 | 01Jan2000, 17:25 | 9738.70730 |
| Rain | 4.8533 | 66.26538 | 01Jan2000, 13:20 | 1030.78437 |
| Reach-1 | 21.2093 | 253.46225 | 01Jan2000, 14:40 | 4357.48934 |
| Reach-2 | 8.0164 | 110.56449 | 01Jan2000, 14:20 | 1654.39895 |
| Reach-3 | 8.4876 | 111.29836 | 01Jan2000, 15:00 | 1727.08011 |
| Reach-4 | 24.2486 | 273.06652 | 01Jan2000, 15:55 | 4866.95901 |
| Reach-5 | 43.4349 | 421.57056 | 01Jan2000, 16:05 | 8715.13652 |
| Reach-6 | 46.5092 | 431.59631 | 01Jan2000, 16:45 | 9232.35379 |
| Reach-7 | 48.7246 | 437.12556 | 01Jan2000, 17:25 | 9616.73461 |
| Scheme Inflow | 24.2486 | 273.06652 | 01Jan2000, 14:40 | 5004.38608 |
| Scheme Outflow | 43.4349 | 421.69390 | 01Jan2000, 15:30 | 8845.58892 |

Global Summary Results for Run "Developed-Q100"

Project: Warkworth South    Simulation Run: Developed-Q100

Start of Run: 01Jan2000, 00:00    Basin Model: Developed Land-Use
End of Run: 02Jan2000, 00:00    Meteorologic Model: 100yr-existing-existing-land
Compute Time: 05Apr2023, 15:26:21    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 Downstream | 5.8454 | 55.71354 | 01Jan2000, 13:50 | 999.18175 |
| A Upstream | 3.3380 | 36.86217 | 01Jan2000, 13:20 | 576.96580 |
| B Downstream | 8.4876 | 91.34174 | 01Jan2000, 13:25 | 1462.51227 |
| B Upstream | 4.1220 | 46.67449 | 01Jan2000, 13:20 | 715.49697 |
| C Downstream | 0.2357 | 5.01350 | 01Jan2000, 12:25 | 46.24902 |
| C Upstream | 2.9156 | 35.38431 | 01Jan2000, 13:10 | 506.20497 |
| D Downstream | 2.8386 | 36.46248 | 01Jan2000, 13:00 | 496.99865 |
| D Upstream | 5.1008 | 56.15127 | 01Jan2000, 13:20 | 878.69326 |
| E Downstream | 0.7215 | 16.17126 | 01Jan2000, 12:25 | 156.27172 |
| E Upstream | 5.7329 | 58.75500 | 01Jan2000, 13:35 | 982.55892 |
| F Downstream | 0.2179 | 4.58160 | 01Jan2000, 12:20 | 38.57723 |
| F Upstream | 3.0393 | 39.32813 | 01Jan2000, 13:00 | 536.15710 |
| G Downstream | 1.2760 | 25.09295 | 01Jan2000, 12:30 | 267.38809 |
| H Downstream | 0.4917 | 11.32758 | 01Jan2000, 12:20 | 101.86108 |
| Junction - ABE | 21.2093 | 208.34781 | 01Jan2000, 13:55 | 3628.33498 |
| Junction-AB | 14.3330 | 132.15756 | 01Jan2000, 14:50 | 2411.57944 |
| Junction-CD | 8.0164 | 90.79421 | 01Jan2000, 13:15 | 1384.89822 |
| Junction-CD ds | 46.5092 | 354.24160 | 01Jan2000, 16:05 | 7835.33315 |
| Junction-EFG ds | 48.7246 | 358.90511 | 01Jan2000, 16:45 | 8174.93964 |
| Outlet | 49.2163 | 359.93801 | 01Jan2000, 17:25 | 8134.74845 |
| Rain | 4.8533 | 68.19996 | 01Jan2000, 13:10 | 1005.79512 |
| Reach-1 | 21.2093 | 208.07416 | 01Jan2000, 14:45 | 3564.45241 |
| Reach-2 | 8.0164 | 90.70163 | 01Jan2000, 14:20 | 1353.31328 |
| Reach-3 | 8.4876 | 91.30646 | 01Jan2000, 15:00 | 1412.39769 |
| Reach-4 | 24.2486 | 224.28327 | 01Jan2000, 15:55 | 3985.02675 |
| Reach-5 | 43.4349 | 345.89698 | 01Jan2000, 16:10 | 7292.08547 |
| Reach-6 | 46.5092 | 354.20834 | 01Jan2000, 16:45 | 7712.70260 |
| Reach-7 | 48.7246 | 358.90511 | 01Jan2000, 17:25 | 8032.88737 |
| Scheme Inflow | 24.2486 | 224.28327 | 01Jan2000, 14:40 | 4100.60950 |
| Scheme Outflow | 43.4349 | 345.98777 | 01Jan2000, 15:30 | 7402.40131 |

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

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

Start of Run: 01Jan2000, 00:00 Basin Model: Developed Land-Use
End of Run: 02Jan2000, 00:00 Meteorologic Model: 100yr-CC-developed-land-use
Compute Time: 04Apr2023, 11:34:07 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 Downstream | 5.8454 | 67.89074 | 01Jan2000, 13:50 | 1220.76543 |
| A Upstream | 3.3380 | 44.93661 | 01Jan2000, 13:20 | 704.70863 |
| B Downstream | 8.4876 | 111.35746 | 01Jan2000, 13:25 | 1786.68282 |
| B Upstream | 4.1220 | 56.84513 | 01Jan2000, 13:20 | 873.60158 |
| C Downstream | 0.2357 | 6.01131 | 01Jan2000, 12:25 | 55.75929 |
| C Upstream | 2.9156 | 43.11220 | 01Jan2000, 13:10 | 618.28270 |
| D Downstream | 2.8386 | 44.41328 | 01Jan2000, 13:00 | 606.60934 |
| D Upstream | 5.1008 | 68.48363 | 01Jan2000, 13:20 | 1073.67741 |
| E Downstream | 0.7215 | 19.12037 | 01Jan2000, 12:25 | 186.00455 |
| E Upstream | 5.7329 | 71.63279 | 01Jan2000, 13:35 | 1200.75451 |
| F Downstream | 0.2179 | 5.57805 | 01Jan2000, 12:20 | 47.09980 |
| F Upstream | 3.0393 | 47.85160 | 01Jan2000, 13:00 | 653.82898 |
| G Downstream | 1.2760 | 29.80892 | 01Jan2000, 12:30 | 319.54365 |
| H Downstream | 0.4917 | 13.48195 | 01Jan2000, 12:20 | 121.97268 |
| Junction - ABE | 21.2093 | 253.81225 | 01Jan2000, 13:55 | 4433.46367 |
| Junction-AB | 14.3330 | 160.93311 | 01Jan2000, 14:45 | 2947.84554 |
| Junction-CD | 8.0164 | 110.71134 | 01Jan2000, 13:15 | 1691.96012 |
| Junction-CD ds | 46.5092 | 430.57852 | 01Jan2000, 16:05 | 9554.84443 |
| Junction-EFG | 48.7246 | 436.03322 | 01Jan2000, 16:45 | 9961.73207 |
| Outlet | 49.2163 | 437.24925 | 01Jan2000, 17:25 | 9914.85577 |
| Rain | 4.8533 | 80.98906 | 01Jan2000, 13:10 | 1201.88354 |
| Reach-1 | 21.2093 | 253.46225 | 01Jan2000, 14:40 | 4357.48934 |
| Reach-2 | 8.0164 | 110.56449 | 01Jan2000, 14:20 | 1654.39895 |
| Reach-3 | 8.4876 | 111.29836 | 01Jan2000, 15:00 | 1727.08011 |
| Reach-4 | 24.2486 | 273.05174 | 01Jan2000, 15:55 | 4873.82581 |
| Reach-5 | 43.4349 | 420.48551 | 01Jan2000, 16:05 | 8892.47580 |
| Reach-6 | 46.5092 | 430.50396 | 01Jan2000, 16:45 | 9409.08407 |
| Reach-7 | 48.7246 | 436.03322 | 01Jan2000, 17:25 | 9792.88309 |
| Scheme Inflow | 24.2486 | 273.05174 | 01Jan2000, 14:40 | 5011.31833 |
| Scheme Outflow | 43.4349 | 420.57851 | 01Jan2000, 15:30 | 9023.55489 |

2.5.3 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 A, the table below summaries the findings.

| Rain event | Land-use | Climate change | Catchments A-F (m3/s) | Rain (m3/s) | Downstream Catchment A & B (m3/s) outflow | Scheme Outflow (m3/s) |
|---|---|---|---|---|---|---|
| 100yr | Existing | No | 224.3 | 54.4 | 132.2 | 346.5 |
| 100yr | Existing | Yes | 273.1 | 66.3 | 160.9 | 421.7 |
| 100yr | Developed | No | 224.6 | 68.2 | 132.2 | 344.2 |
| 100yr | Developed | Yes | 273.1 | 81.0 | 160.9 | 420.6 |

*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 0.9$m^3$/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 2.8, 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 15:55. This demonstrates the peak flow from the *Rain* catchment exits the catchment boundary 2 hour 45 min 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 | Downstream Junction CD (m3/s) | Downstream Junction EFG (m3/s) |
|---|---|---|---|---|
| 100yr | Existing | No | 354.7 | 359.4 |
| 100yr | Existing | Yes | 431.7 | 437.1 |
| 100yr | Developed | No | 352.3 | 358.9 |
| 100yr | Developed | Yes | 430.6 | 436.0 |

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

2.5.3 Localised event scenario

A localised event scenario has been modelled which includes an Upstream PCA 2yr event and a 100yr event within the PCA (rain catchment) and downstream catchments of the PCA 100yr ARI for before and post development, no climate change. These runs are considered necessary to understand the effects of the development on the existing scenarios.

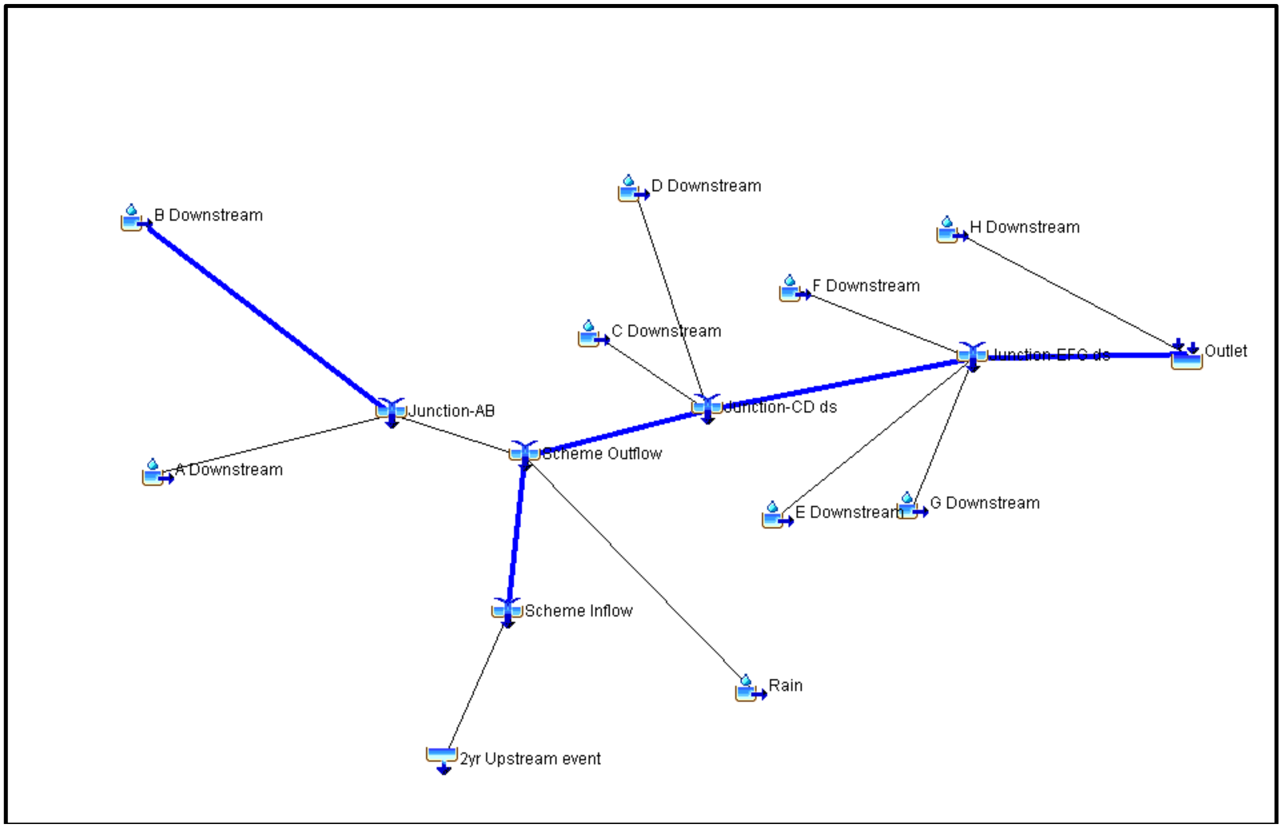



*Figure 2.-9 Localised Event Scenario*

| Rain event | Land-use | Climate change | Scheme Outflow (m3 /s) | Downstream Junction CD (m3/s) | Downstream Junction EFG (m3/s) |
|---|---|---|---|---|---|
| 100yr | Existing | No | 212.6 | 222.8 | 227.6 |
| 100yr | Developed | No | 212.4 | 222.6 | 227.4 |

*Table 2.5 Peak 100yr flows at junctions downstream of the proposed development for a localised 100yr event scenario without climate change*

Table 2.5 above shows the 100yr peak stormwater event for a localised 100yr event for the PCA area and downstream PCA area. Similarly to the effects described above the it is noted that the peak flows slightly 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).

# 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.

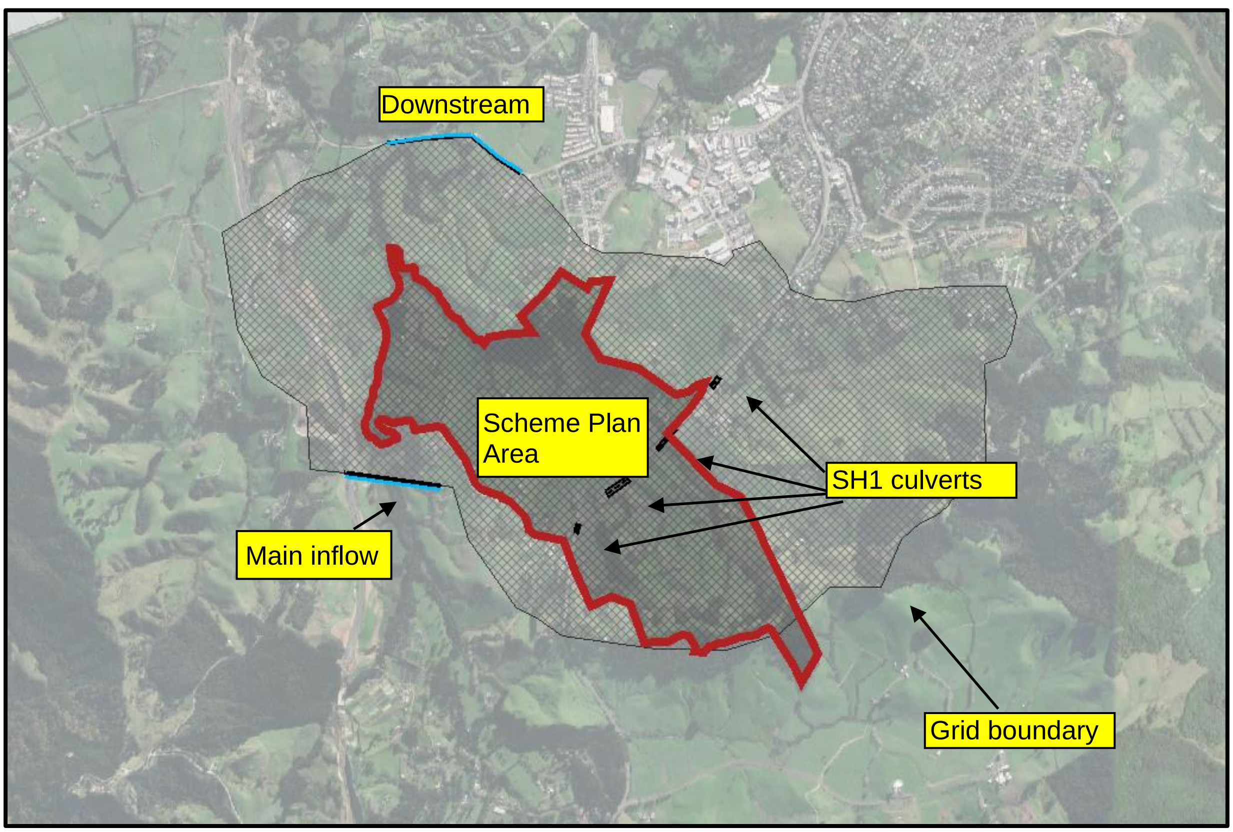



**Figure 3.1 – HEC-RAS model set-up**

## 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 0.002.

## 3.4 FLOODPLAIN COMPARISON

Figure 3.2 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.

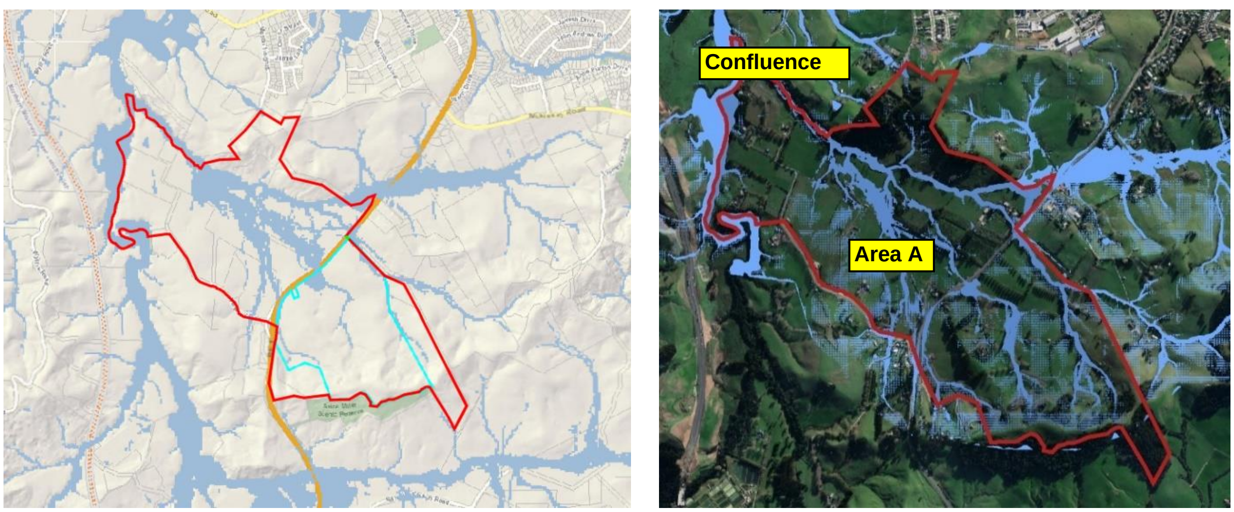


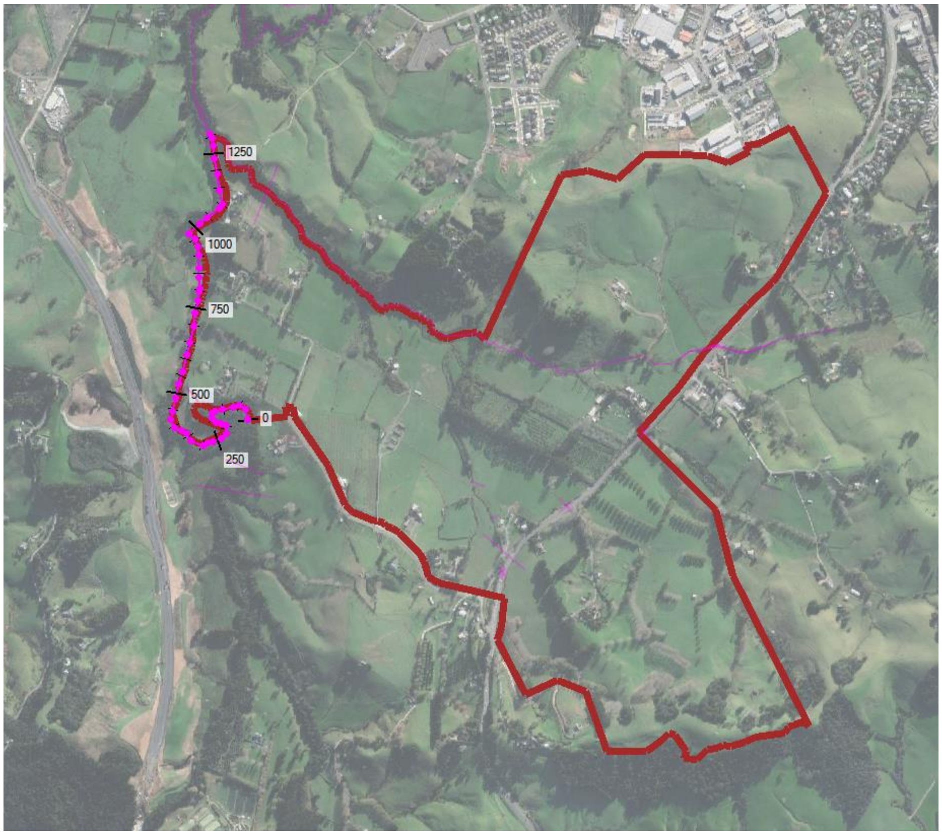

**Figure 3.2 – Floodplain comparison – 100yr-storm**

## 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.



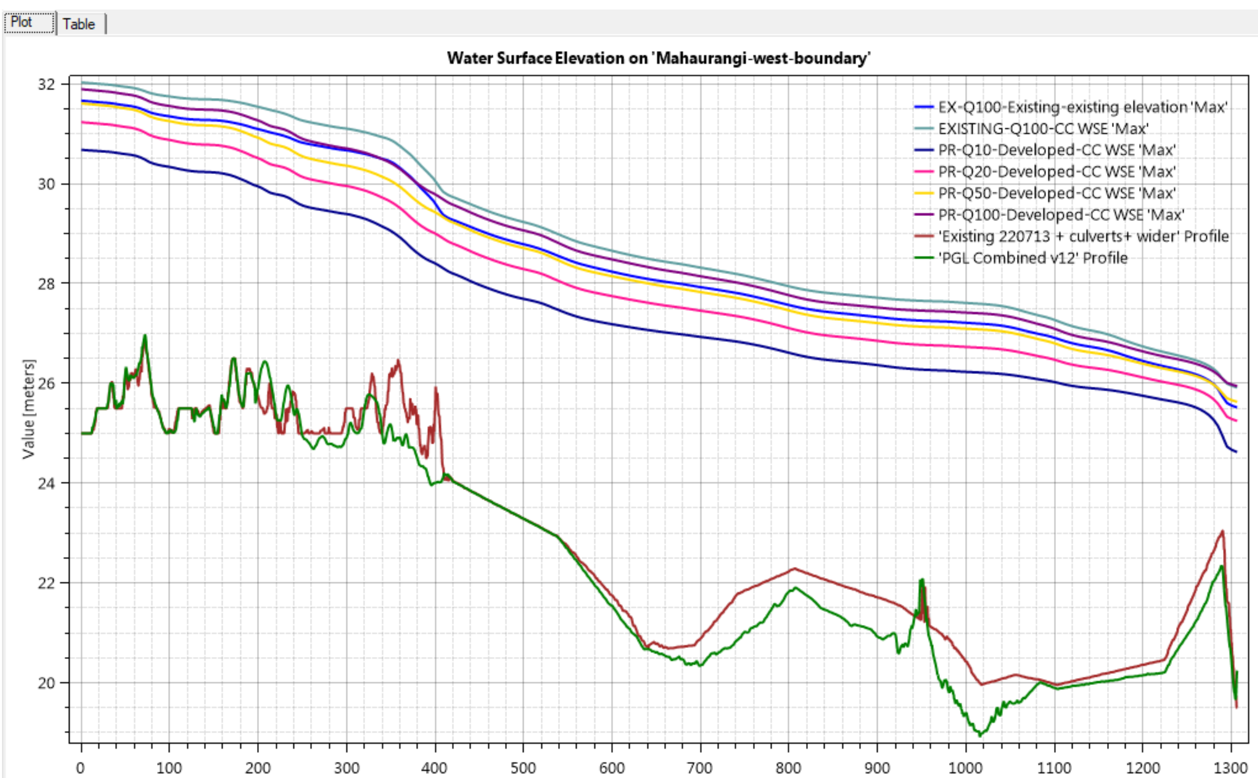




**Figure 3.3 – HGL– Mahurangi River boundary (NZVD)**

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.

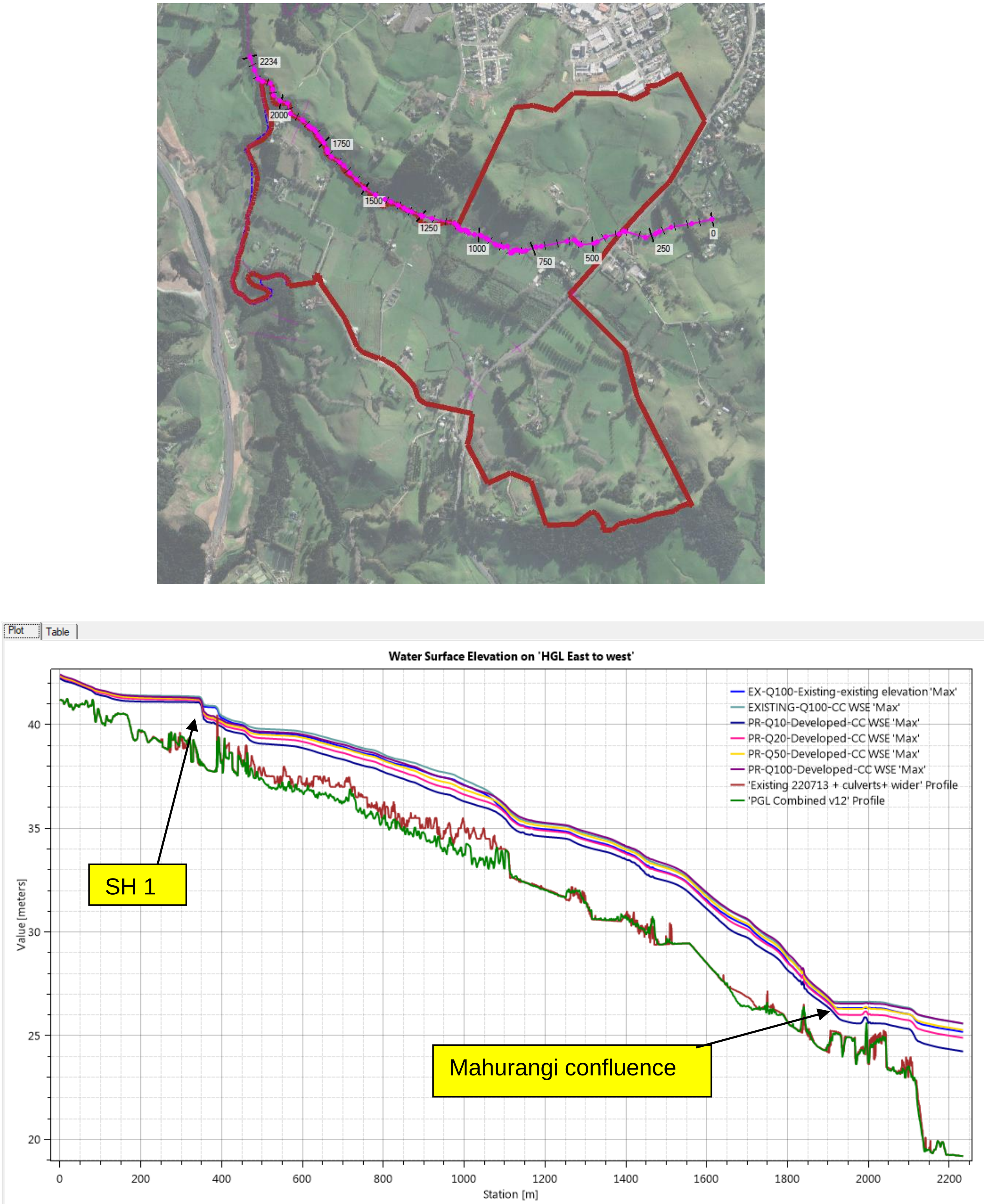



**Figure 3.4 – HGL– Main east to west stream (NZVD)**

## 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 without climate change flows (blue) is approximately equivalent to a 20-year storm with climate change flow (yellow) due to the development. And the existing 100-year storm with climate change is approximately equivalent to a 50-year storm post development.

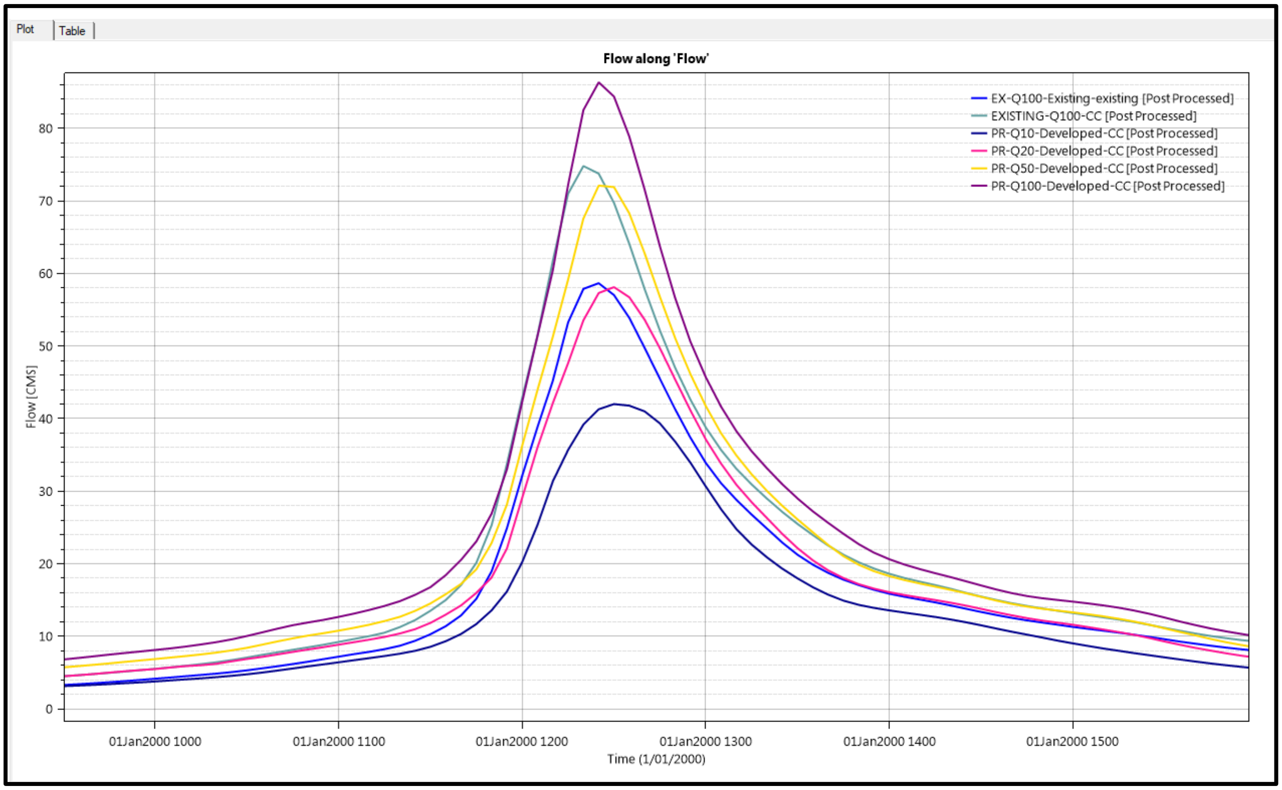



**Figure 3.5 – Flow hydrograph for east-west stream outlet**

## 3.8 CHECK ON DOWNSTREAM LEVEL

The model grid stops at Woodcocks Road bridge. The road deck of the bridge has been surveyed to be RL23.75. The peak 1% AEP event with climate change flow level at this location has been calculated to be RL 22.17 and 22.16 for the existing and proposed scenario respectively.

The manning calculation may be found in appendix E. It is noted that the contours used for the mannings calculation have been obtained from Auckland Council Geomaps. As the Lidar contours indicate the water surface elevation (rather than the streambed) of the stream baseflow it is noted that the flow depth may be considered conservative. Therefore, the bridge is not impeding flow.

### 3.9 CULVERTS CAPACITY ASSESSMENT

Cross sections showing water surface elevations across the four culverts through SH 1 maybe found in appendix B.

Cross sections indicate the two northern culverts (names Culvert north and Culvert mid) are under capacity and are overtopped for all modelled storm events (10yr through to 100yr). The next adjacent culvert to the south (culvert south) is show to only overtop during a 100yr event for the developed scenario. The southern most culvert is shown to have sufficient capacity for the developed scenario.

It is noted that the entire section of SH1 which is shown to be have under capacity culvert is proposed to be upgraded in the future by Auckland Transport once the road is eventually repurposed as an arterial road and the opening of Ara Tūhono – Pūhoi to Warkworth statehighway.

### 3.10 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.

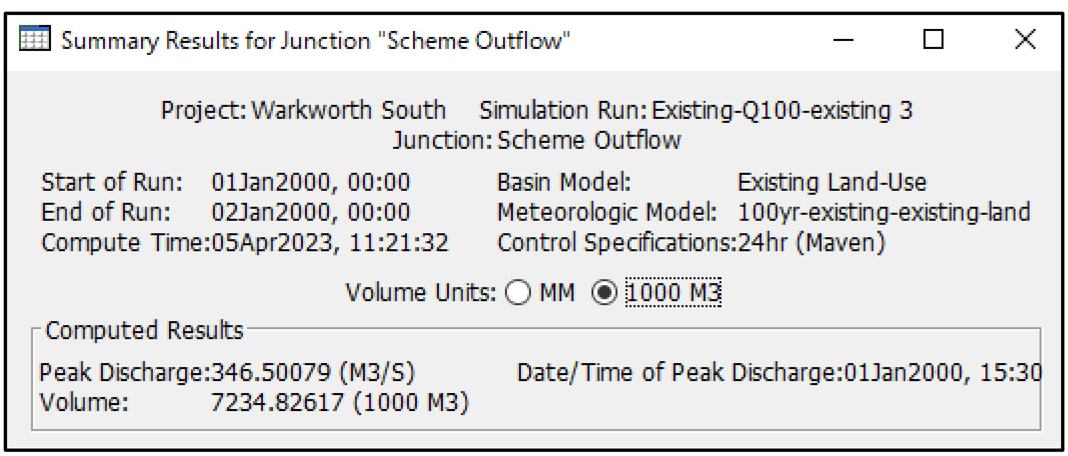



**Figure 3.6 – HEC-HMS volume of run-off**

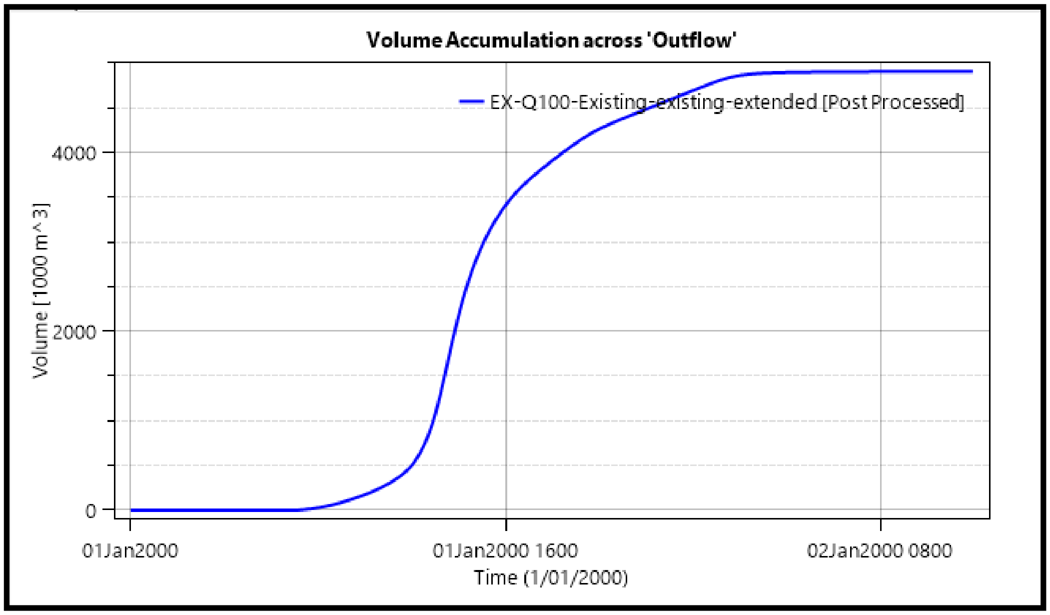



**Figure 3.7 – HEC-RAS outflow boundary cumulative volume**

## 3.11 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;

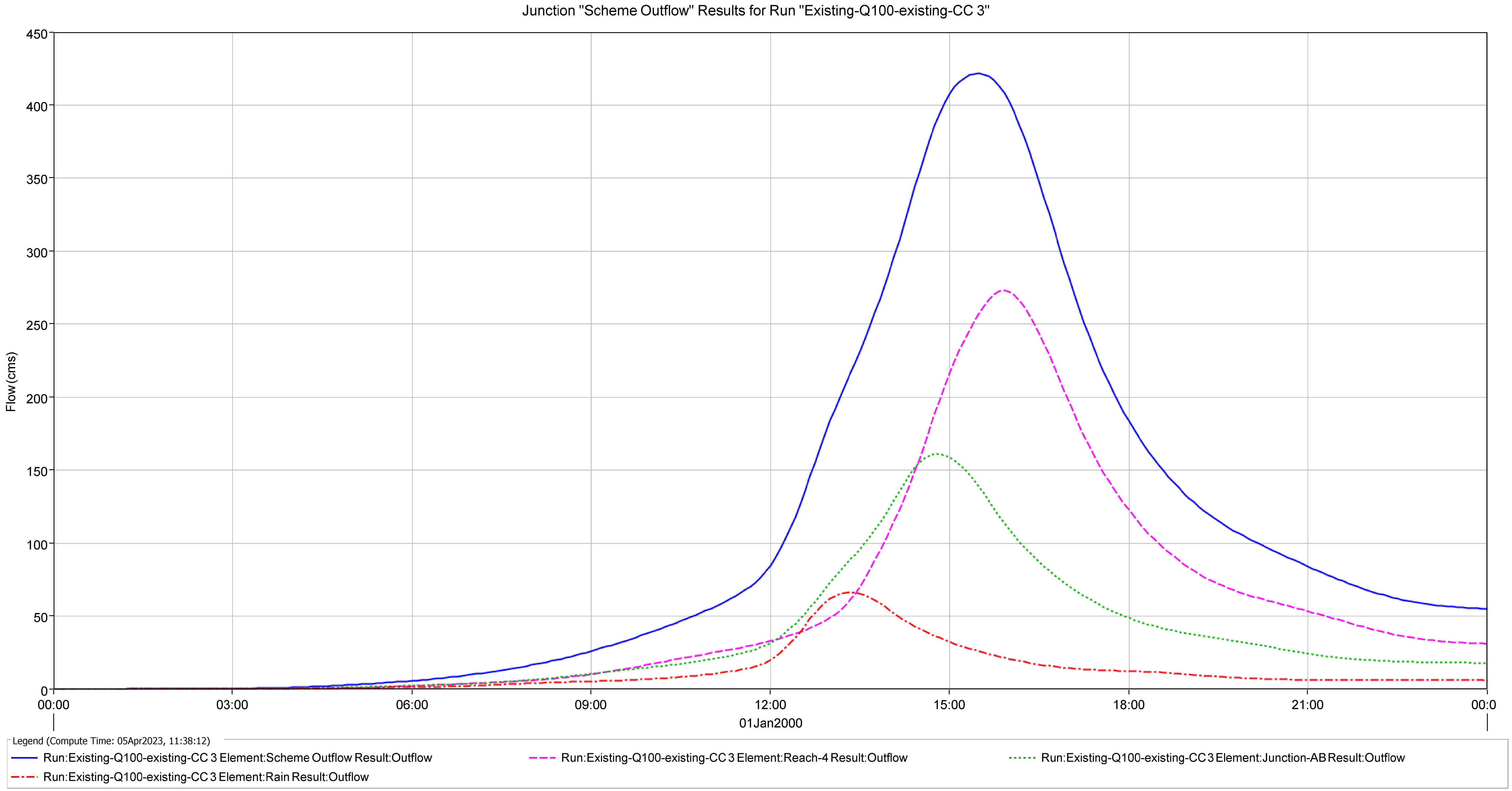
| | XS 95 - SCHEME INFLOW (m3/s) | | | | | |
|---|---|---|---|---|---|---|
| | 10yr Developed CC | | | 100yr Developed CC | | |
| **Scenario** | Peak Time | Peak Flow | Water level | Peak Time | Peak Flow | Water level |
| **Healthy waters** | 13:40 | 199 | 31.34 | 13:40 | 340 | 32.88 |
| **Maven** | 14:45 | 142 | 31.78 | 14:40 | 273 | 33.05 |

| | XS87 - 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 | 14:15 | 326 | 23.74 |
| **Maven** | 15:10 | 151 | 22.12 | 15:15 | 285 | 23.89 |

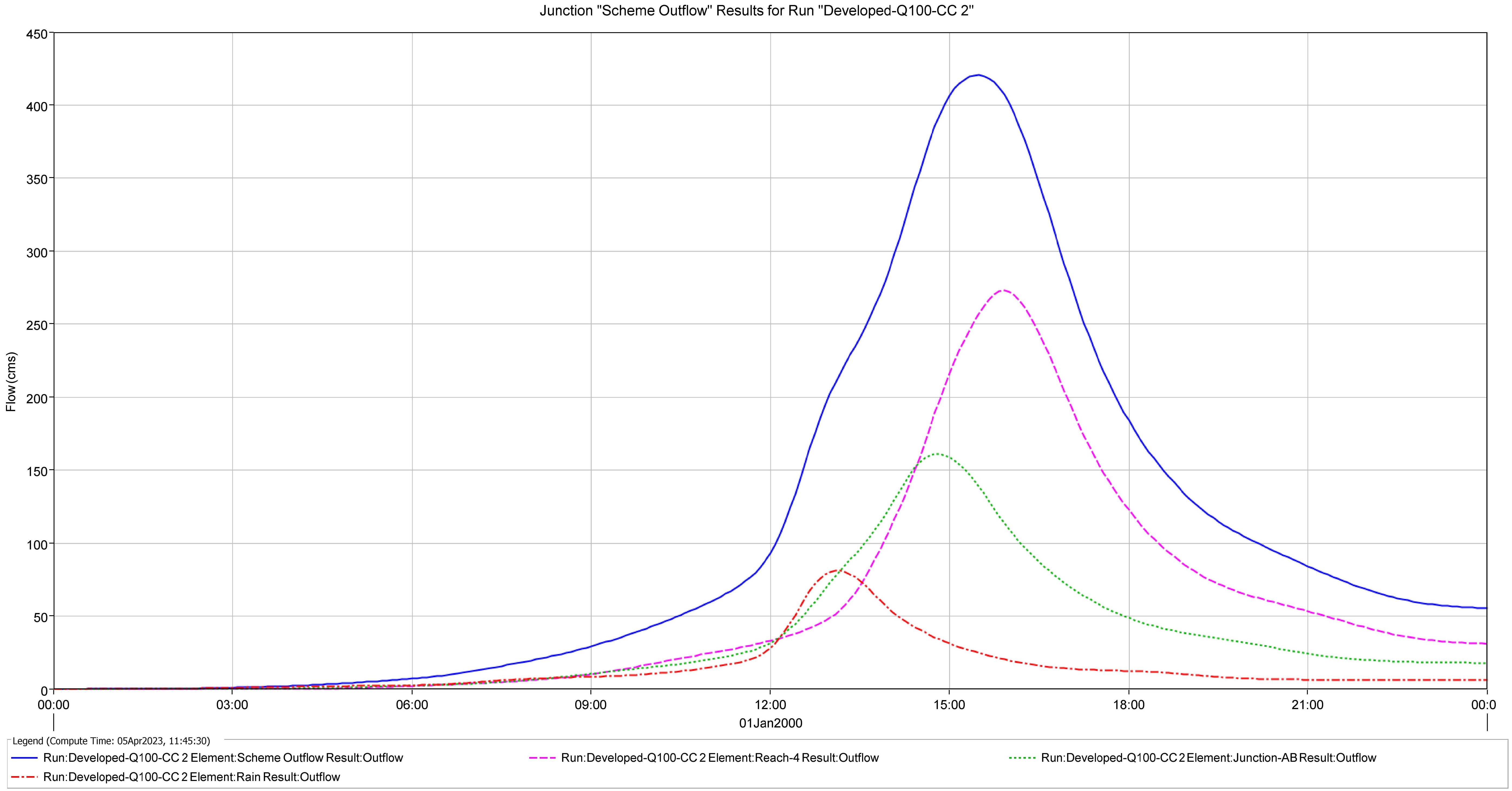
**Figure 3.8 MPD Modelling results comparison to Healthy waters model**

Two notable points of comparison of modelling results are the times of peak flows and the water levels. The peak flow times produced in the model are generally 1 hour later than that from the Healthywaters model. A comparison of the water levels show similar peak flood levels with a difference of upto to 0.32m. 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.

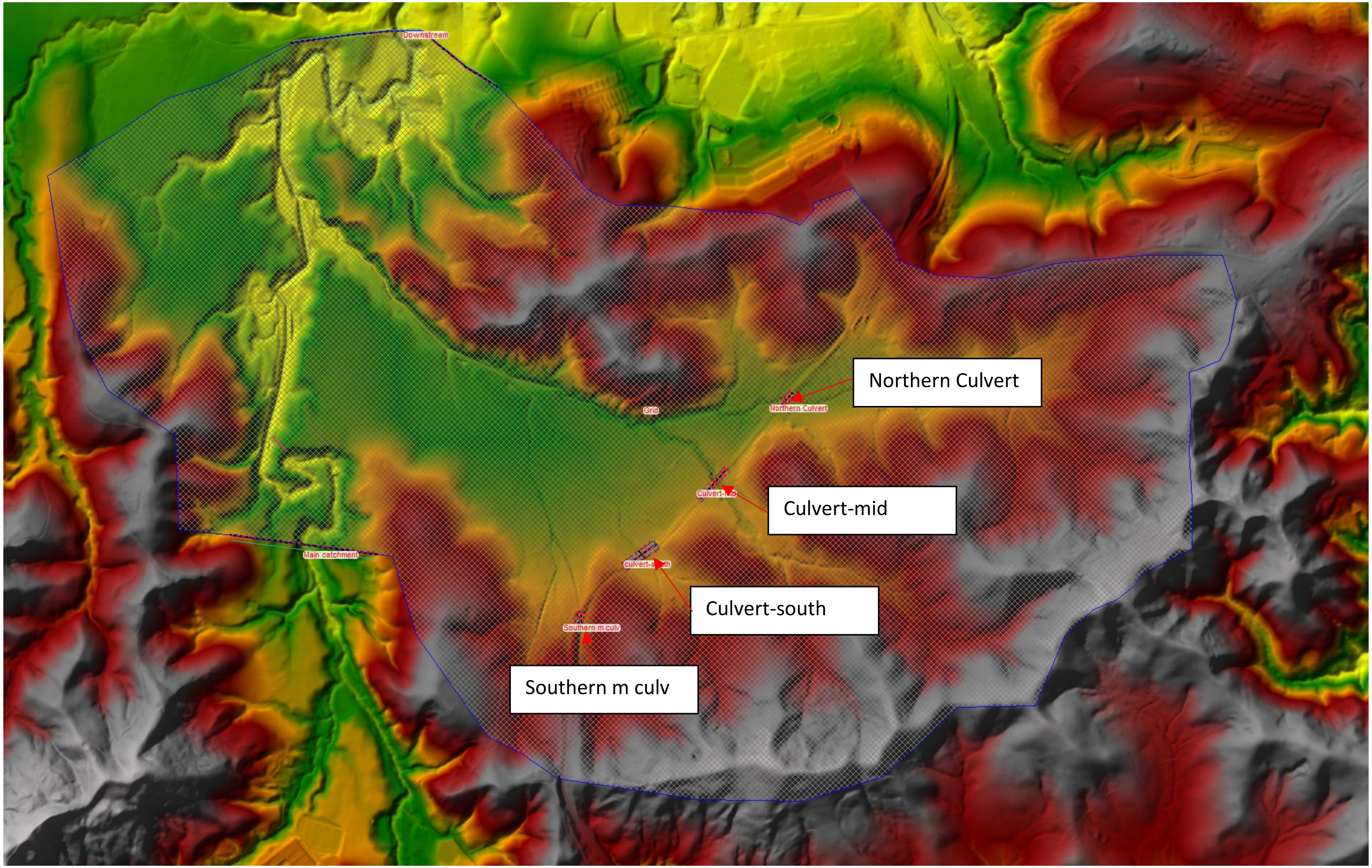
## APPENDIX A – 100YR YEAR FLOW HYDROGRAPH



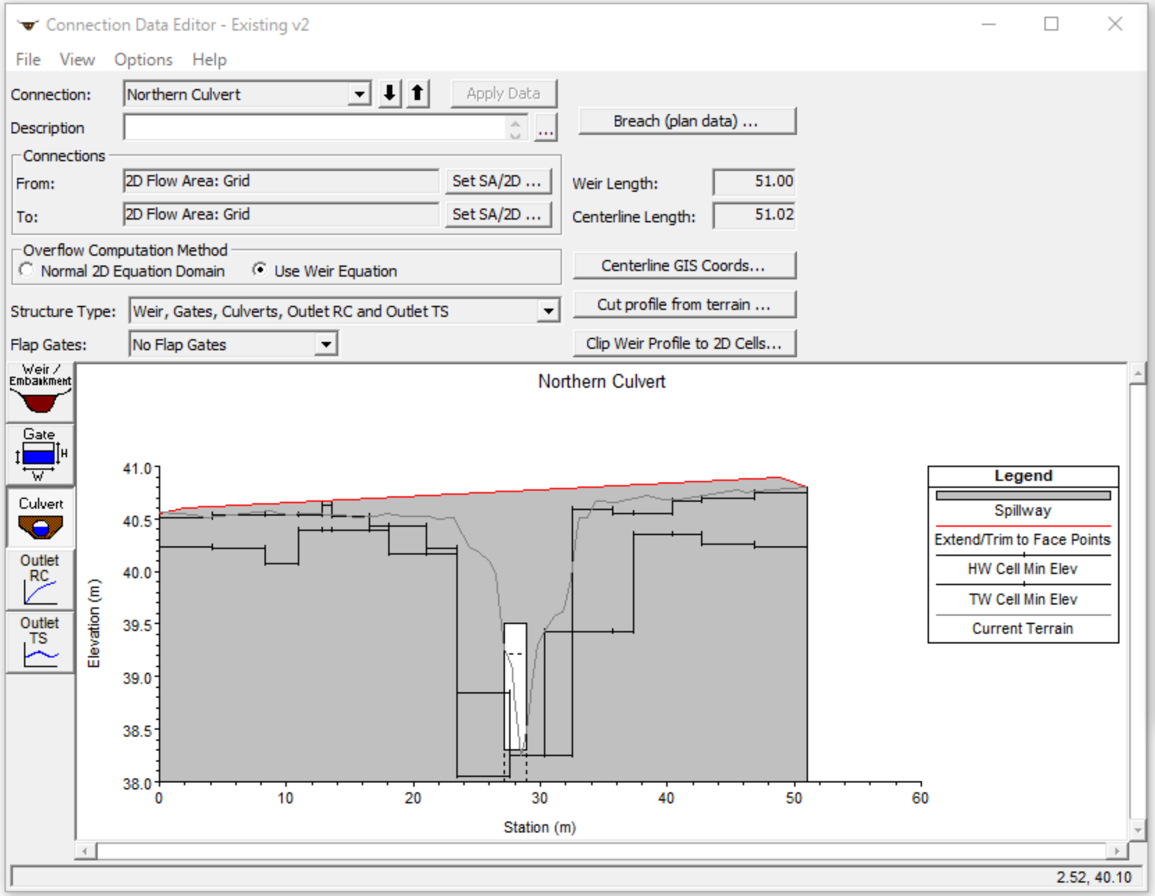
Junction "Scheme Outflow" Results for Run "Existing-Q100-existing-CC 3"
Flow (cms)
450
400
350
300
250
200
150
100
50
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:0
01Jan2000
Legend (Compute Time: 05Apr2023, 11:38:12)
Run:Existing-Q100-existing-CC 3 Element:Scheme Outflow Result:Outflow
Run:Existing-Q100-existing-CC 3 Element:Reach-4 Result:Outflow
Run:Existing-Q100-existing-CC 3 Element:Junction-AB Result:Outflow
Run:Existing-Q100-existing-CC 3 Element:Rain Result:Outflow

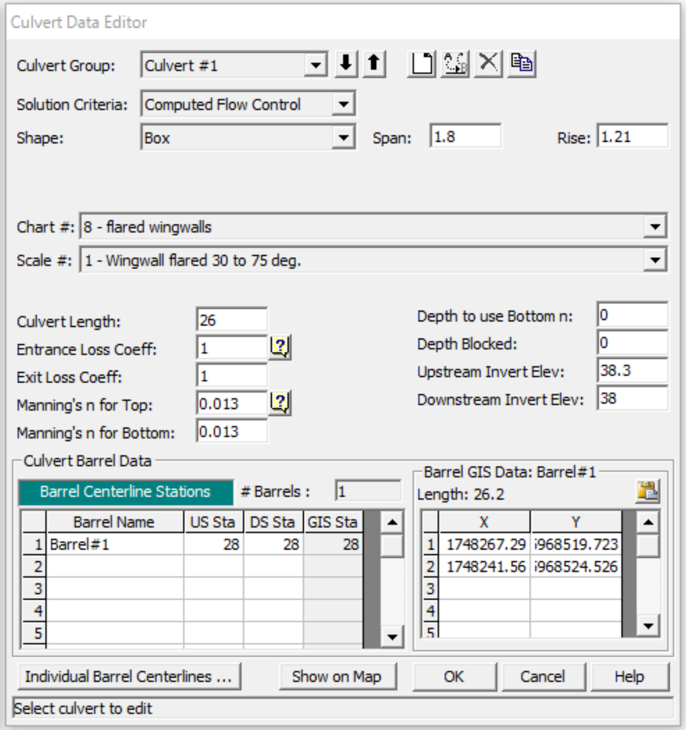

Junction "Scheme Outflow" Results for Run "Developed-Q100-CC 2"
Flow (cms)
450
400
350
300
250
200
150
100
50
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:0
01Jan2000
Legend (Compute Time: 05Apr2023, 11:45:30)
Run:Developed-Q100-CC 2 Element:Scheme Outflow Result:Outflow
Run:Developed-Q100-CC 2 Element:Reach-4 Result:Outflow
Run:Developed-Q100-CC 2 Element:Junction-AB Result:Outflow
Run:Developed-Q100-CC 2 Element:Rain Result:Outflow

## APPENDIX B – HEC RAS CULVERT DETAIL

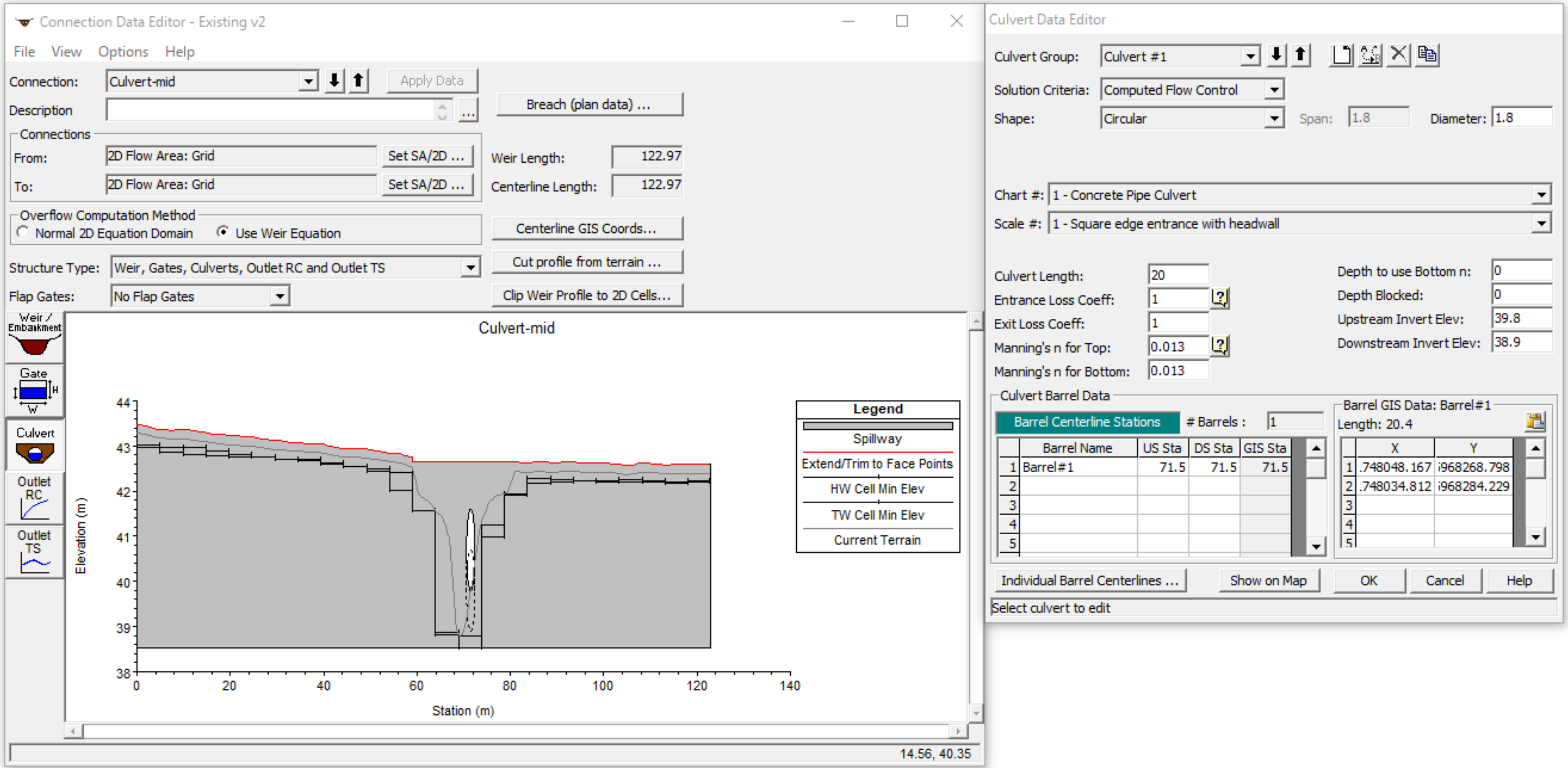

Downstream
Northern Culvert
Grid
Northern Culvert
Culvert-mid
Culvert-mid
Main catchment
culvert-south
Culvert-south
Southern m culv
Southern m culv

Northern Culvert - Details

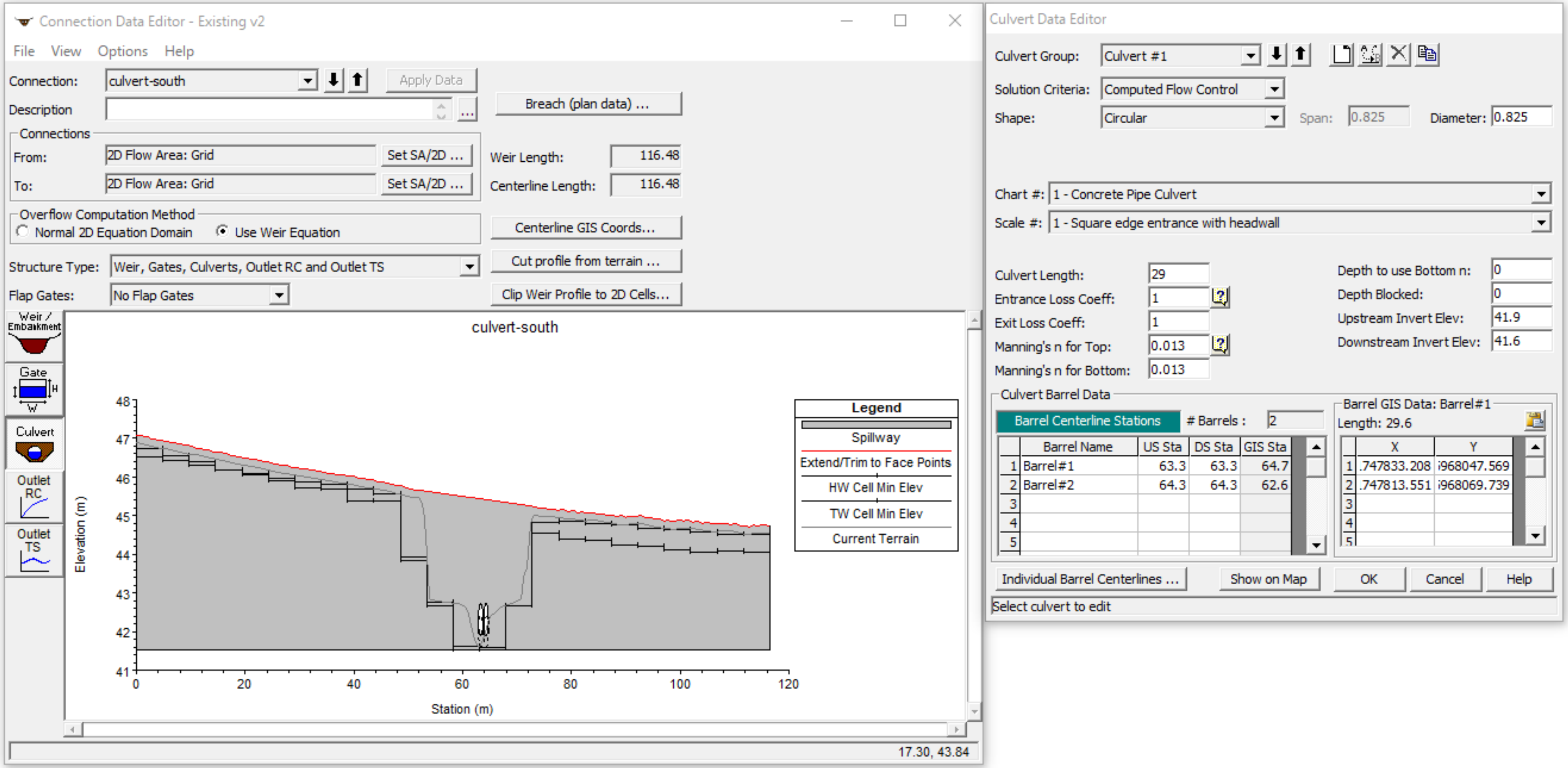


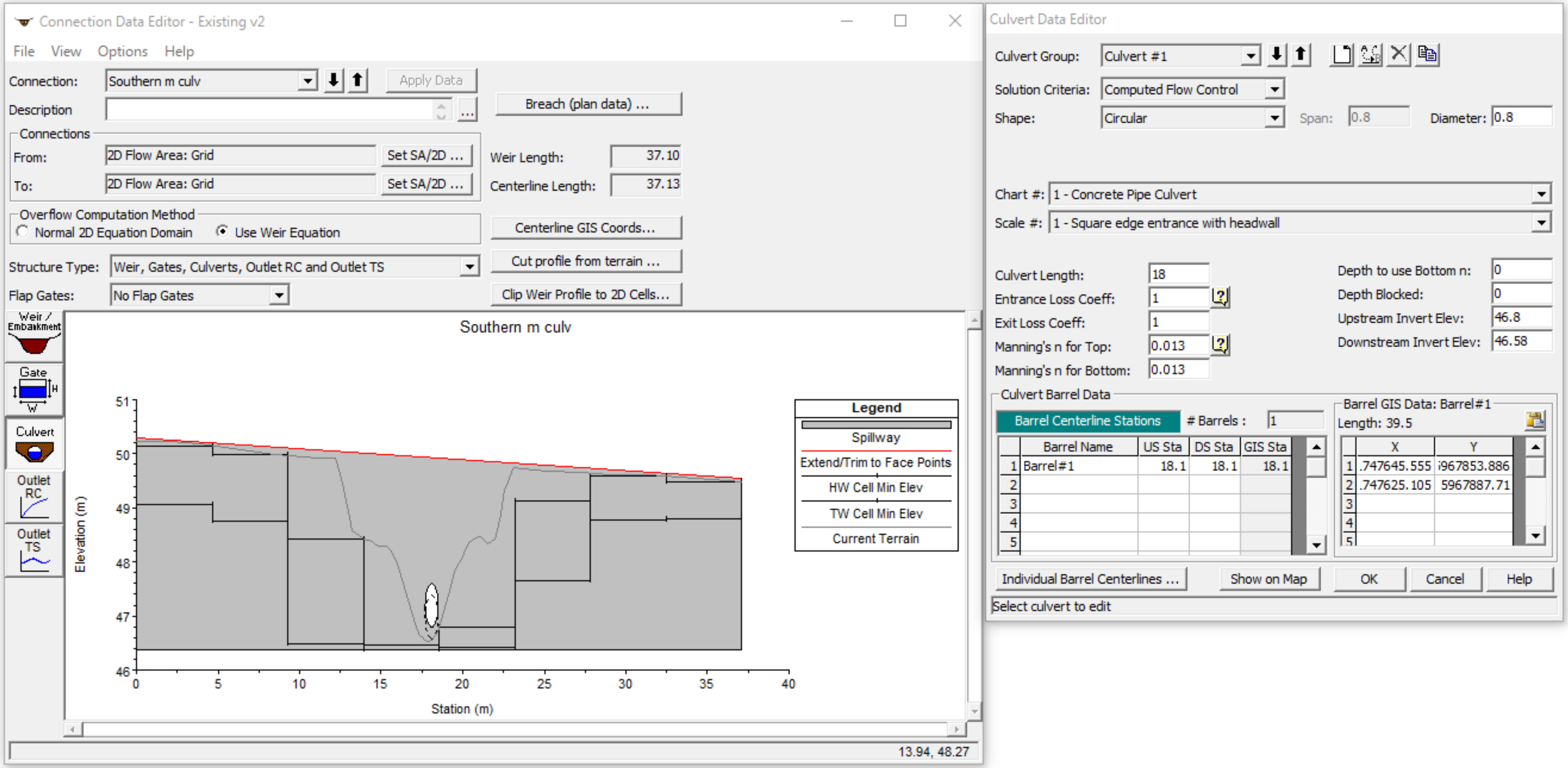
Culvert mid - Details



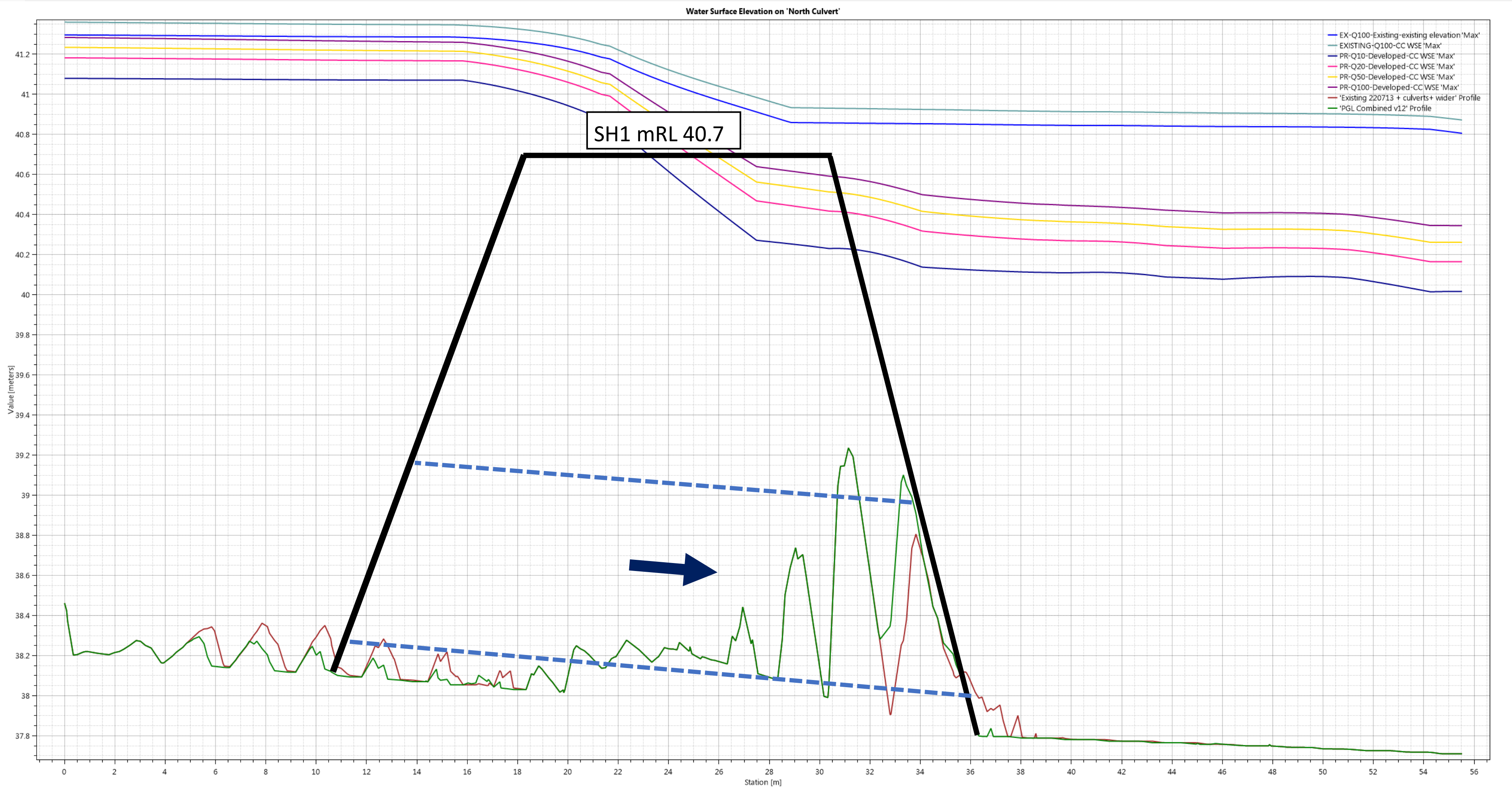
# Culvert south - Details



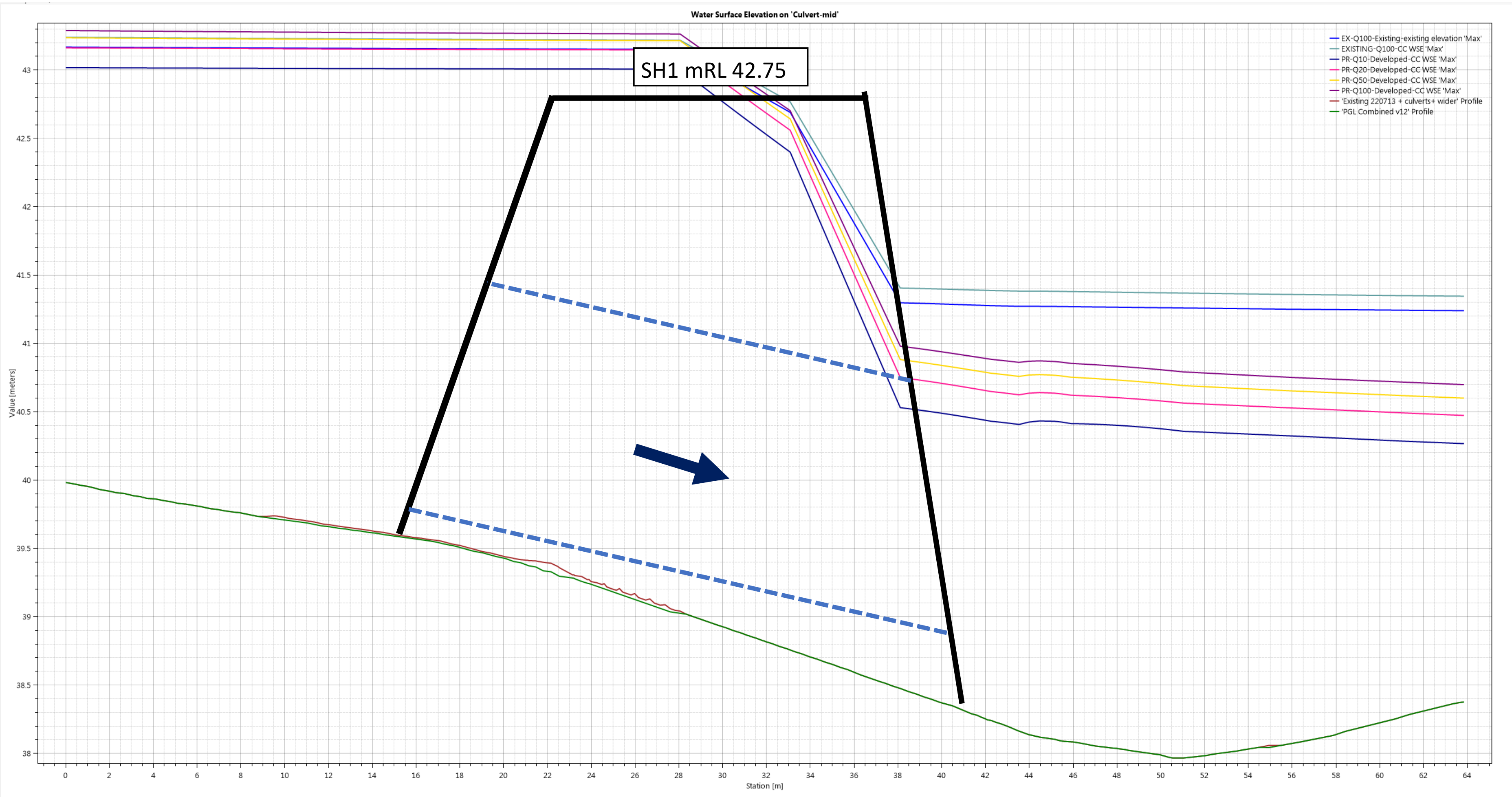
Culvert m south - Details



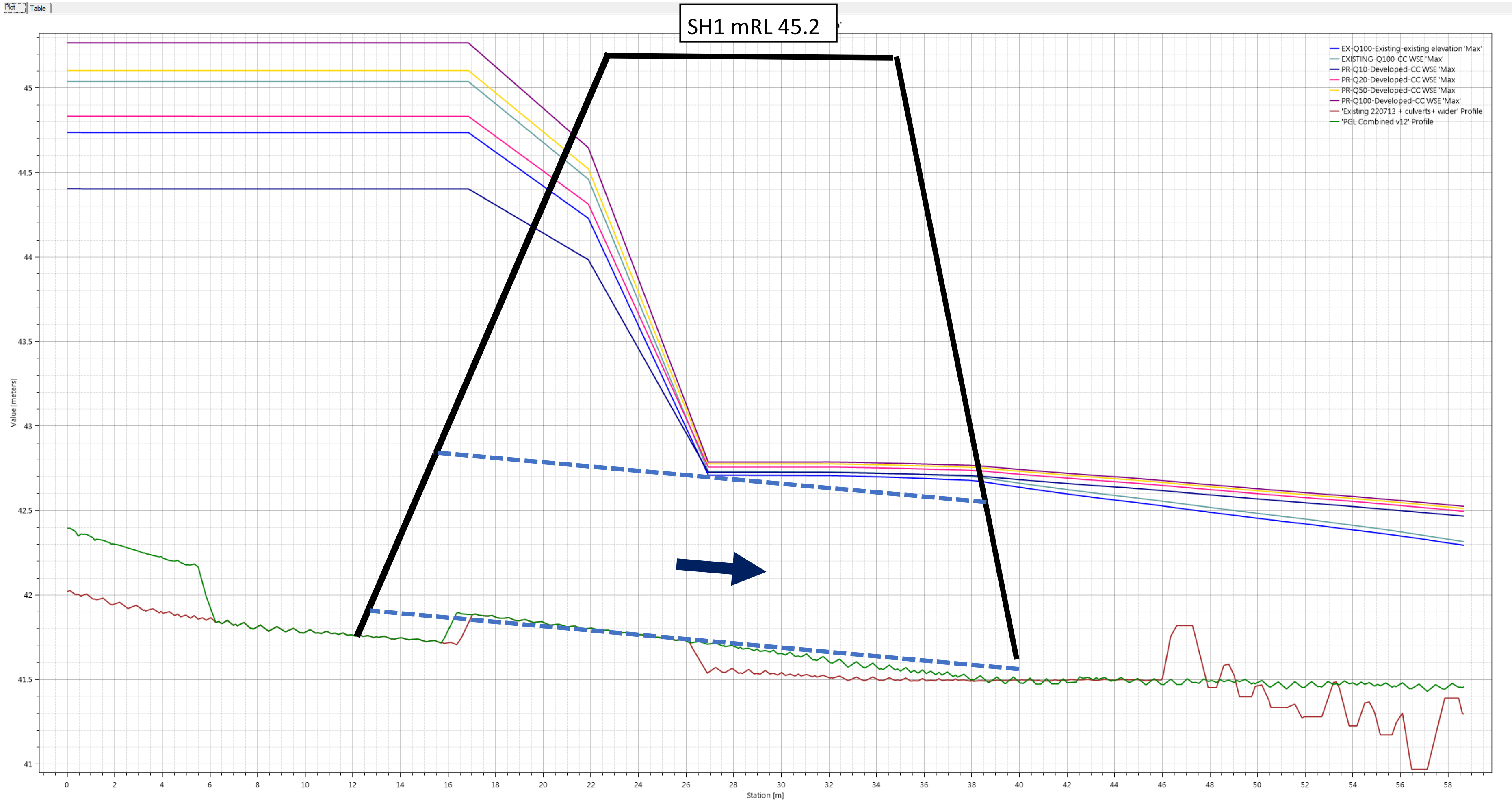
## Northern Culvert (1800mm x 1200mm box)



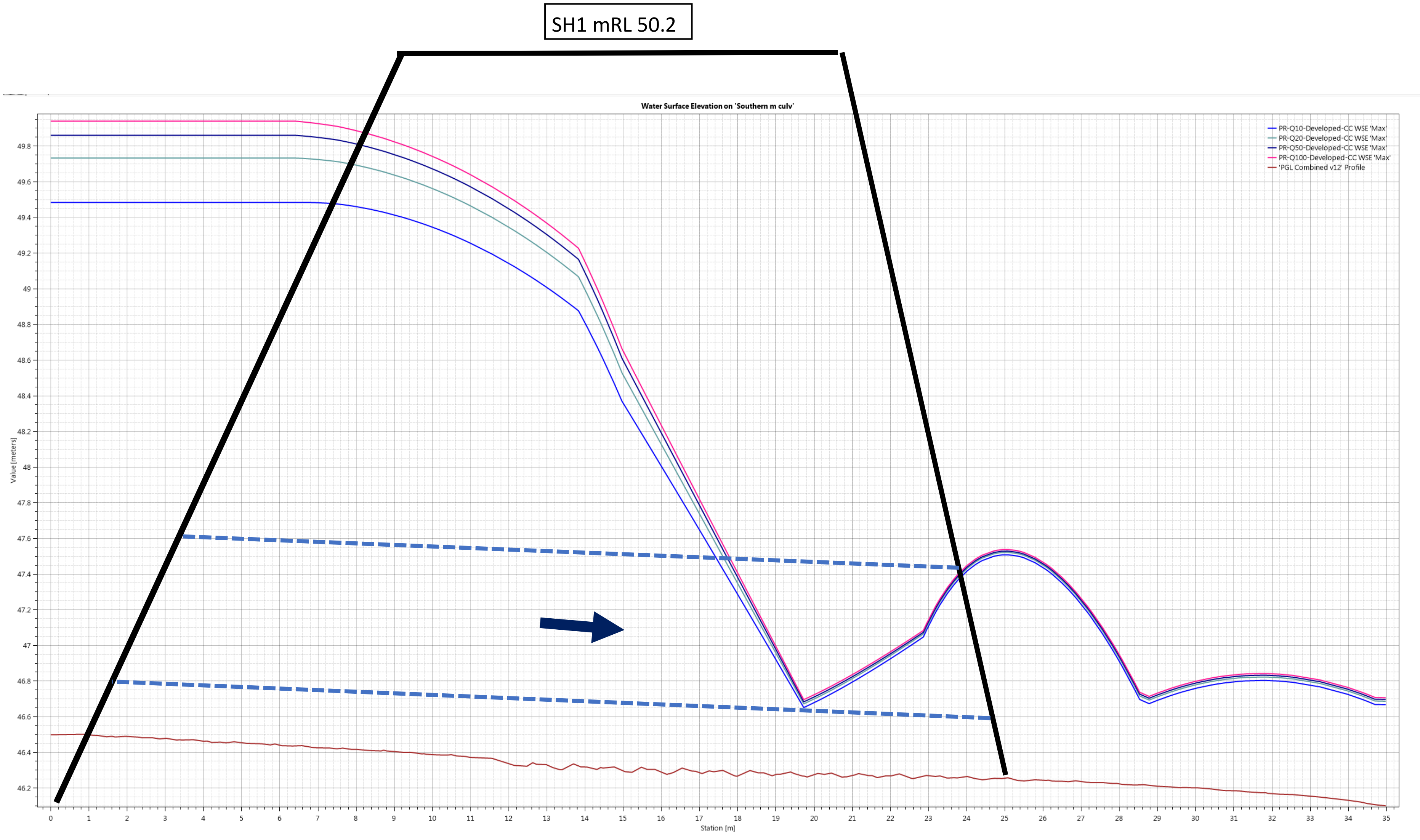
## Mid Culvert (1800mm circular)



## Culvert South (825mm circular x 2)



## Culvert m south (800mm circular)



**APPENDIX C – Preliminary Pre & Post Development Flood Extent Plan**

Notes

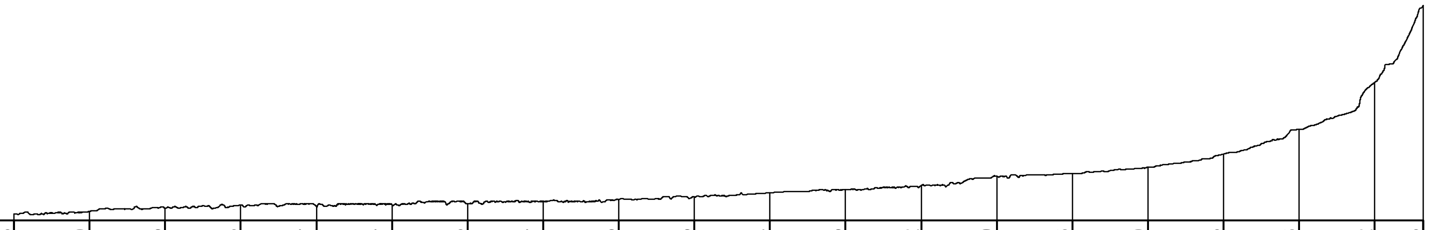
1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

DATUM 28.00m

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 32.28 | 34.00 | 36.25 | 39.17 | 40.12 | 41.28 | 42.75 | 44.24 | 44.70 | 46.13 | 48.24 | 49.61 | 51.99 | 54.17 | 58.84 | 64.00 | 75.19 | 99.44 |
| DESIGN LEVELS | 32.28 | 34.00 | 36.25 | 39.17 | 40.12 | 41.28 | 42.75 | 44.24 | 44.70 | 46.13 | 48.24 | 49.61 | 51.99 | 54.17 | 58.84 | 64.00 | 75.19 | 99.44 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4175.47 |

Upstream A Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3



DATUM 28.00m

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 32.28 | 34.00 | 36.25 | 38.23 | 37.17 | 38.27 | 39.08 | 40.57 | 41.75 | 43.25 | 46.24 | 48.25 | 50.92 | 57.29 | 58.86 | 63.00 | 71.78 | 88.16 | 119.12 | 169.78 |
| DESIGN LEVELS | 32.28 | 34.00 | 36.25 | 38.23 | 37.17 | 38.27 | 39.08 | 40.57 | 41.75 | 43.25 | 46.24 | 48.25 | 50.92 | 57.29 | 58.86 | 63.00 | 71.78 | 88.16 | 119.12 | 169.78 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4659.46 |

Upstream B Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |

MAVEN
Maven Associates
09 571 0050
info@maven.co.nz
www.maven.co.nz
5 Owens Road, Epsom
Auckland 1023

Project

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

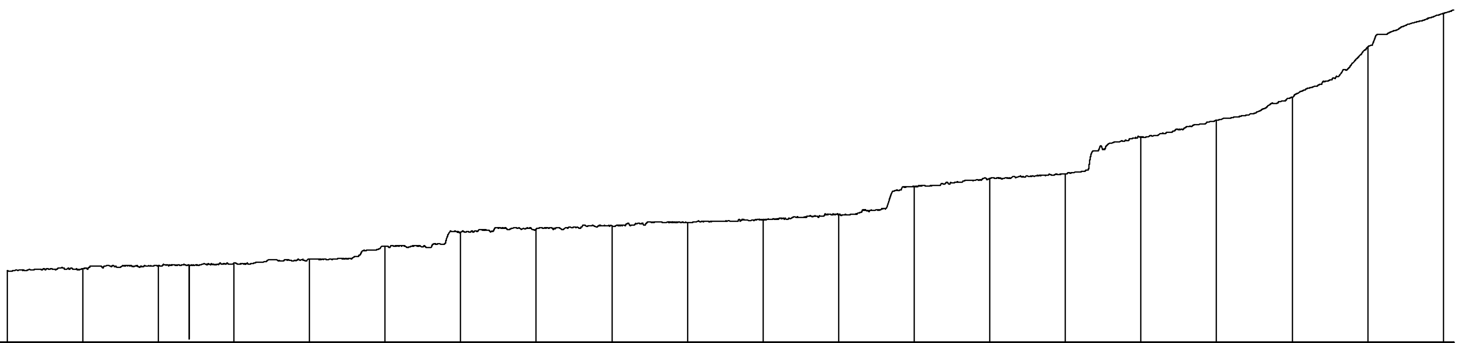
Title

**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK001 |
| Rev | A |

**DRAFT FOR REVIEW**

DATE: 4/6/23

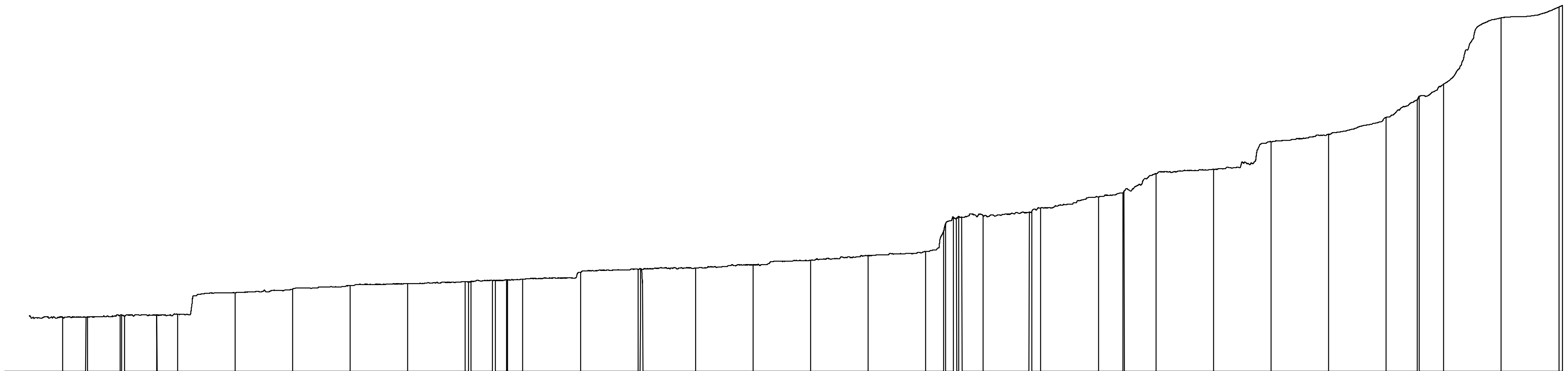


DATUM -2.00m

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 45.50 | 46.62 | 48.65 | 50.35 | 53.20 | 61.68 | 70.62 | 73.09 | 74.95 | 77.25 | 79.02 | 82.58 | 101.03 | 106.38 | 109.38 | 133.64 | 144.97 | 160.00 | 193.31 | 215.51 |
| DESIGN LEVELS | 45.50 | 46.62 | 48.65 | 50.35 | 53.20 | 61.68 | 70.62 | 73.09 | 74.95 | 77.25 | 79.02 | 82.58 | 101.03 | 106.38 | 109.38 | 133.64 | 144.97 | 160.00 | 193.31 | 215.51 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4750.00 [illegible] |

Upstream C Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3



DATUM -2.00m

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | | 46.95 | 48.59 | 49.62 | 68.25 | 71.28 | 74.24 | 76.00 | 78.00 | 80.00 | 86.00 | 88.56 | 89.51 | 92.54 | 96.42 | 100.66 | 104.05 | 134.95 | 141.95 | 151.52 | 171.50 | 175.39 | 199.50 | 205.84 | 220.55 | 249.44 | 307.01 | [illegible] |
| DESIGN LEVELS | | 46.95 | 48.59 | 49.62 | 68.25 | 71.28 | 74.24 | 76.00 | 78.00 | 80.00 | 86.00 | 88.56 | 89.51 | 92.54 | 96.42 | 100.66 | 104.05 | 134.95 | 141.95 | 151.52 | 171.50 | 175.39 | 199.50 | 205.84 | 220.55 | 249.44 | 307.01 | [illegible] |
| CUT/FILL | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | [illegible] |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4750.00 | 5000.00 | 5250.00 | 5500.00 | 5750.00 | 6000.00 | 6250.00 | 6500.00 | [illegible] |

Upstream D Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

**DRAFT FOR REVIEW**

DATE: 4/6/23

Notes

1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |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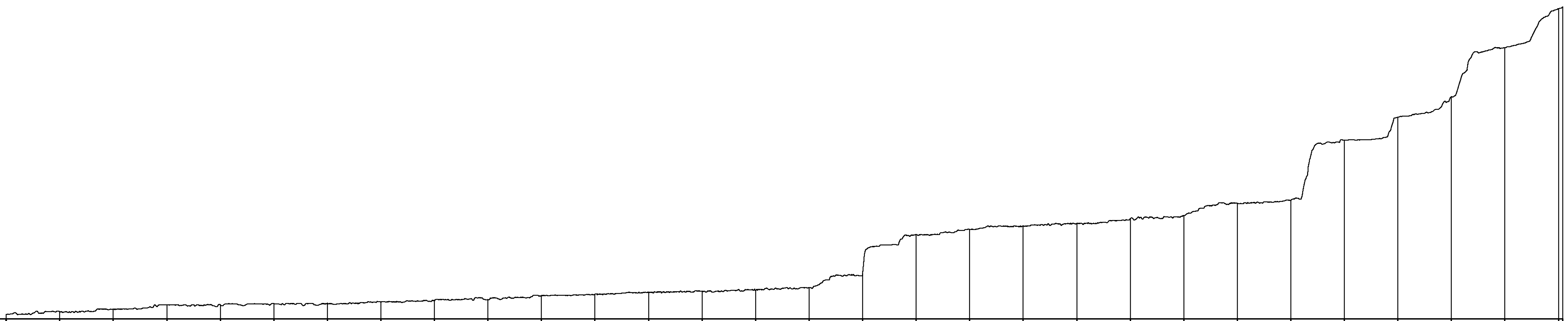
Project
**WARKWORTH SOUTH PLAN CHANGE FOR KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD**

Title
**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK002 |
| Rev | A |

Notes

1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

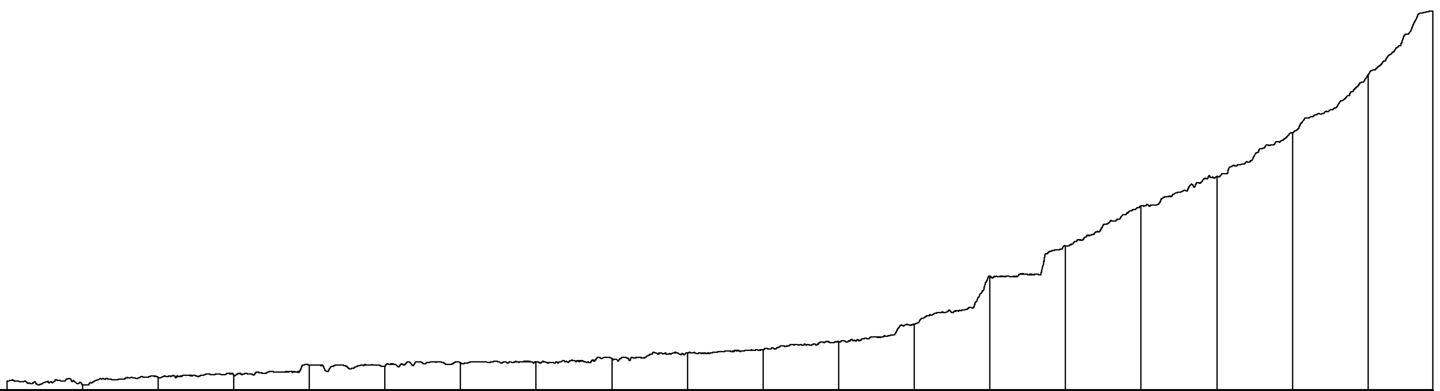


DATUM 28.00m

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 32.28 | 34.30 | 36.89 | 40.94 | 41.10 | 42.21 | 42.20 | 43.56 | 45.09 | 45.93 | 49.28 | 50.91 | 52.65 | 53.91 | 54.75 | 57.17 | 70.10 | 106.58 | 111.41 | 114.56 | 117.06 | 121.38 | 124.48 | 135.68 | 138.56 | 194.75 | 216.09 | 235.23 | 280.99 | 317.36 | [illegible] |
| DESIGN LEVELS | 32.28 | 34.30 | 36.89 | 40.94 | 41.10 | 42.21 | 42.20 | 43.56 | 45.09 | 45.93 | 49.28 | 50.91 | 52.65 | 53.91 | 54.75 | 57.17 | 70.10 | 106.58 | 111.41 | 114.56 | 117.06 | 121.38 | 124.48 | 135.68 | 138.56 | 194.75 | 216.09 | 235.23 | 280.99 | 317.36 | [illegible] |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4750.00 | 5000.00 | 5250.00 | 5500.00 | 5750.00 | 6000.00 | 6250.00 | 6500.00 | 6750.00 | 7000.00 | 7250.00 | [illegible] |

Upstream E Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3



DATUM 24.00m

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 29.95 | 27.50 | 32.26 | 33.64 | 40.50 | 39.50 | 41.91 | 42.75 | 44.86 | 48.59 | 50.50 | 55.91 | 67.32 | 99.25 | 119.28 | 145.68 | 165.10 | 194.00 | 232.28 | 274.71 |
| DESIGN LEVELS | 29.95 | 27.50 | 32.26 | 33.64 | 40.50 | 39.50 | 41.91 | 42.75 | 44.86 | 48.59 | 50.50 | 55.91 | 67.32 | 99.25 | 119.28 | 145.68 | 165.10 | 194.00 | 232.28 | 274.71 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4714.37 |

Upstream F Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |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Project

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

Title

**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK003 |
| Rev | A |

**DRAFT FOR REVIEW**

DATE: 4/6/23

Notes
1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

DATUM 24.00m

| | | | | | | |
|---|---|---|---|---|---|---|
| EXISTING LEVELS | 29.95 | 27.50 | 31.89 | 32.02 | 32.01 | 32.28 |
| DESIGN LEVELS | 29.95 | 27.50 | 31.89 | 32.02 | 32.01 | 32.28 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1186.53 |

Upstream Reach ABE to Inflow

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

DATUM 28.00m

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 32.28 | 34.00 | 36.25 | 38.23 | 37.17 | 38.27 | 39.08 | 40.57 | 41.67 | 42.07 | | | |
| DESIGN LEVELS | 32.28 | 34.00 | 36.25 | 38.23 | 37.17 | 38.27 | 39.08 | 40.57 | 41.67 | 42.07 | | | |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 2864.59 |

Upstream Reach CD TO ABE

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |


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

Title
**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK004 — Rev A |

**DRAFT FOR REVIEW**

Notes
1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

DATUM 22.00m

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | | | | 27.00 | 29.21 | 29.97 | 29.94 | 30.28 | 32.47 | 32.26 | 33.04 | 32.75 | 33.50 | 34.33 | 36.28 | 37.86 | 37.42 | 38.05 | 39.90 | 40.55 | 45.00 | 52.27 | 58.22 | 67.56 | 97.30 | 140.02 |
| DESIGN LEVELS | | | | 27.00 | 29.21 | 29.97 | 29.94 | 30.28 | 32.47 | 32.26 | 33.04 | 32.75 | 33.50 | 34.33 | 36.28 | 37.86 | 37.42 | 38.05 | 39.90 | 40.55 | 45.00 | 52.27 | 58.22 | 67.56 | 97.30 | 140.02 |
| CUT/FILL | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4750.00 | 5000.00 | 5250.00 | 5500.00 | 5750.00 | 6000.00 | 6121.08 |

Downstream A Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

DATUM 36.00m

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 40.68 | 42.00 | 43.75 | 45.80 | 48.87 | 49.50 | 53.82 | 56.49 | 62.25 | 94.33 | 148.64 | 288.82 |
| DESIGN LEVELS | 40.68 | 42.00 | 43.75 | 45.80 | 48.87 | 49.50 | 53.82 | 56.49 | 62.25 | 94.33 | 148.64 | 288.82 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 500.00 | 1000.00 | 1500.00 | 2000.00 | 2500.00 | 3000.00 | 3500.00 | 4000.00 | 4500.00 | 5000.00 | 5305.61 |

Downstream B Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

**DRAFT FOR REVIEW**

DATE: 4/8/23

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |


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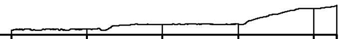
Project
**WARKWORTH SOUTH PLAN CHANGE FOR KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD**

Title
**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK005 |
| Rev | A |

Notes
1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

DATUM 8.00m



| | | | | | | |
|---|---|---|---|---|---|---|
| EXISTING LEVELS | 11.10 | 12.01 | 15.07 | 15.32 | 25.65 | 27.77 |
| DESIGN LEVELS | 11.10 | 12.01 | 15.07 | 15.32 | 25.65 | 27.77 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1077.43 |

## Downstream C Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

DATUM 8.00m

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 11.10 | 15.39 | 16.50 | 18.89 | 20.21 | 21.24 | 23.25 | 26.41 | 29.58 | 31.42 | 32.24 | 33.74 | 43.47 | 79.73 | |
| DESIGN LEVELS | 11.10 | 15.39 | 16.50 | 18.89 | 20.21 | 21.24 | 23.25 | 26.41 | 29.58 | 31.42 | 32.24 | 33.74 | 43.47 | 79.73 | |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3331.05 |

## Downstream D Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

DATUM 6.00m

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 8.98 | 11.99 | 10.36 | 18.24 | 26.47 | 34.17 | 44.66 | 57.08 |
| DESIGN LEVELS | 8.98 | 11.99 | 10.36 | 18.24 | 26.47 | 34.17 | 44.66 | 57.08 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1695.06 |

## Downstream E Longsection

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

**DRAFT FOR REVIEW**

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |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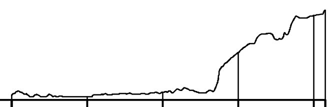
Project
# WARKWORTH SOUTH PLAN CHANGE FOR KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title
# FLOOD MODELLING CATCHMENT LONGSECTION PLAN

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK006 |
| Rev | A |



DATUM 6.00m

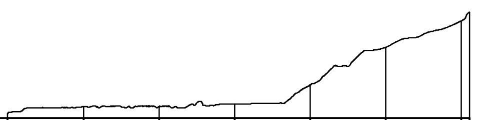
| | | | | | | |
|---|---|---|---|---|---|---|
| EXISTING LEVELS | 8.98 | 8.25 | 10.88 | 37.35 | 64.78 | 65.08 |
| DESIGN LEVELS | 8.98 | 8.25 | 10.88 | 37.35 | 64.78 | 65.08 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1050.58 |

Downstream F Longsection
HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

DATUM 6.00m

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 9.39 | 13.78 | 16.27 | 20.00 | 27.46 | 31.75 | 35.09 | 38.48 | 42.35 | 51.20 | 67.66 | 71.51 |
| DESIGN LEVELS | 9.39 | 13.78 | 16.27 | 20.00 | 27.46 | 31.75 | 35.09 | 38.48 | 42.35 | 51.20 | 67.66 | 71.51 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2553.95 |

Downstream G Longsection
HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3



DATUM -4.00m

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | -0.75 | 3.75 | 3.58 | 5.25 | 18.08 | 43.07 | 60.60 | 66.28 |
| DESIGN LEVELS | -0.75 | 3.75 | 3.58 | 5.25 | 18.08 | 43.07 | 60.60 | 66.28 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1527.10 |

Downstream H Longsection
HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

**DRAFT FOR REVIEW**

Notes
1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |

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Auckland 1023

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

Title
**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK007 |
| Rev | A |

DATE: 4/6/23

Notes

1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

DATUM 12.00m

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 15.00 | 16.00 | 16.25 | 18.76 | 19.25 | 21.21 | 22.75 | 21.19 | 25.66 | 23.47 | 25.60 | 26.79 | 31.12 |
| DESIGN LEVELS | 15.00 | 16.00 | 16.25 | 18.76 | 19.25 | 21.21 | 22.75 | 21.19 | 25.66 | 23.47 | 25.60 | 26.79 | 31.12 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 2873.05 |

Reach Scheme In to Scheme Out

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

DATUM 12.00m

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | | | | 29.43 | 29.86 | 30.15 | 31.76 | 33.75 | 32.25 | 33.75 | 33.58 | 33.34 | 34.85 | 35.73 | 37.29 | 37.03 | 38.50 | 37.84 | 40.12 | 42.08 | 41.68 |
| DESIGN LEVELS | 15.02 | 23.42 | | | | | | | | | | | | | | | | | | | |
| CUT/FILL | | | | | | | | | | | | | | | | | | | | | |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1500.00 | 1750.00 | 2000.00 | 2250.00 | 2500.00 | 2750.00 | 3000.00 | 3250.00 | 3500.00 | 3750.00 | 4000.00 | 4250.00 | 4500.00 | 4750.00 | 4847.70 |

Downstream Reach B to A Scheme Out

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

| | | | |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |
| Rev | Description | By | Date |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |


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Project

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

Title

**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK008 Rev A |

**DRAFT FOR REVIEW**

DATE: 4/8/23

DATUM 8.00m

| DATUM 8.00m | | | | | |
|---|---|---|---|---|---|
| EXISTING LEVELS | 11.10 | 11.77 | 15.05 | 15.33 | 15.00 / 15.00 |
| DESIGN LEVELS | 11.10 | 11.77 | 15.05 | 15.33 | 15.00 / 15.00 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 / 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 / 1006.09 |

Downstream Reach Scheme Out B to CD

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

| DATUM 6.00m | | | | | | | |
|---|---|---|---|---|---|---|---|
| EXISTING LEVELS | 9.38 | 9.81 | 9.88 | 11.71 | 11.00 | 11.02 | 11.11 |
| DESIGN LEVELS | 9.38 | 9.81 | 9.88 | 11.71 | 11.00 | 11.02 | 11.11 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1250.00 | 1303.55 |

Downstream Reach CD to EFG

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

| DATUM 0.00m | | | | | | |
|---|---|---|---|---|---|---|
| EXISTING LEVELS | 2.75 | 3.92 | 3.45 | 5.74 | 8.00 | 9.41 |
| DESIGN LEVELS | 2.75 | 3.92 | 3.45 | 5.74 | 8.00 | 9.41 |
| CUT/FILL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CHAINAGE | 0.00 | 250.00 | 500.00 | 750.00 | 1000.00 | 1078.37 |

Downstream Reach EFH to Out

HORIZONTAL SCALE 1:25000 @ A3
VERTICAL SCALE 1:5000 @ A3

**DRAFT FOR REVIEW**

Notes

1. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000. Levels in terms of the Auckland Vertical Datum 1946.

| Rev | Description | By | Date |
|---|---|---|---|
| A | FOR INFORMATION | YW | 03/2023 |

| | By | Date |
|---|---|---|
| Survey | ## | MM/YYYY |
| Design | ## | MM/YYYY |
| Drawn | BY | MM/YYY |
| Checked | ## | #### |


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Project

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

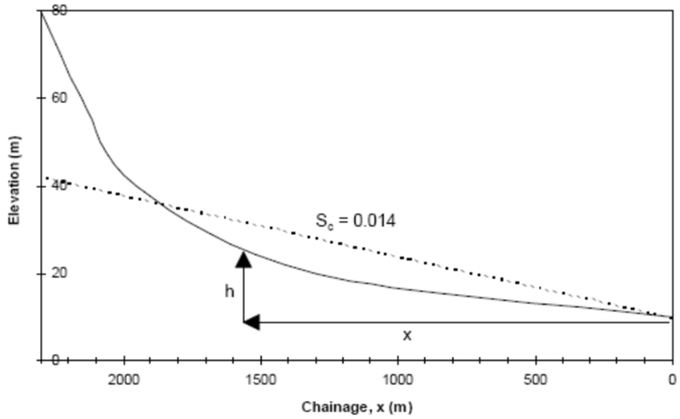
Title

**FLOOD MODELLING CATCHMENT LONGSECTION PLAN**

| | |
|---|---|
| Project no. | 211001 |
| Scale | |
| Cad file | CATCHMENT BDYS & LENGTHS EDEN2K.DWG |
| Drawing no. | SK009 |
| Rev | A |

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Upstream 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 32.3 | 0 | 0 | | | |
| 2 | 42.75 | 10.45 | 1500 | 1500 | 5.225 | 7837.5 |
| 3 | 52 | 19.7 | 3000 | 1500 | 15.075 | 22612.5 |
| 4 | 64 | 31.7 | 3750 | 750 | 25.7 | 19275 |
| 5 | 99.4 | 67.1 | 4175 | 425 | 49.4 | 20995 |
| 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 = | 4175 | TOTAL = | 70720 |

$S_c$ = 0.008

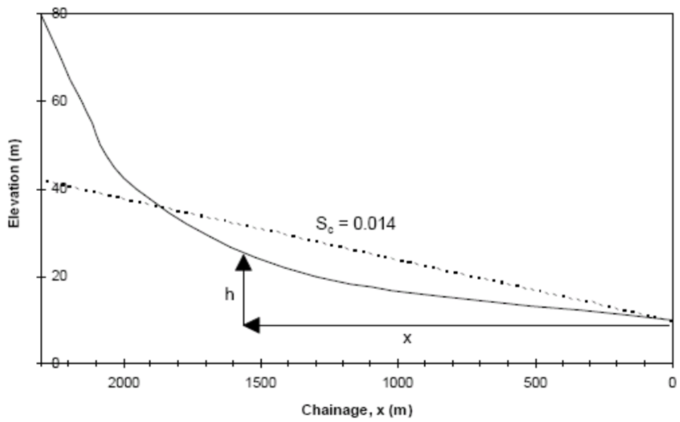
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Upstream Catchment B | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 32.3 | 0 | 0 | | | |
| 2 | 40.6 | 8.3 | 1750 | 1750 | 4.15 | 7262.5 |
| 3 | 50.9 | 18.6 | 3000 | 1250 | 13.45 | 16812.5 |
| 4 | 57.3 | 25 | 3250 | 250 | 21.8 | 5450 |
| 5 | 88 | 55.7 | 4250 | 1000 | 40.35 | 40350 |
| 6 | 169.8 | 137.5 | 4660 | 410 | 96.6 | 39606 |
| 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 = | 4660 | TOTAL = | 109481 |

**$S_c$ =** 0.010

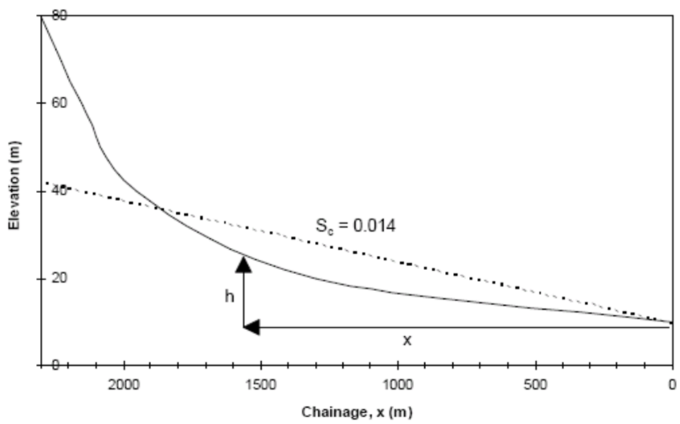
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

**$S_c$ =** #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Upstream Catchment C | 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 45.5 | 0 | 0 | | | |
| 2 | 70.6 | 25.1 | 1500 | 1500 | 12.55 | 18825 |
| 3 | 82.6 | 37.1 | 2750 | 1250 | 31.1 | 38875 |
| 4 | 101 | 55.5 | 3500 | 750 | 46.3 | 34725 |
| 5 | 133.6 | 88.1 | 3750 | 250 | 71.8 | 17950 |
| 6 | 215.5 | 170 | 4750 | 1000 | 129.05 | 129050 |
| 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 = | 4750 | TOTAL = | 239425 |

**$S_c$ =** 0.021

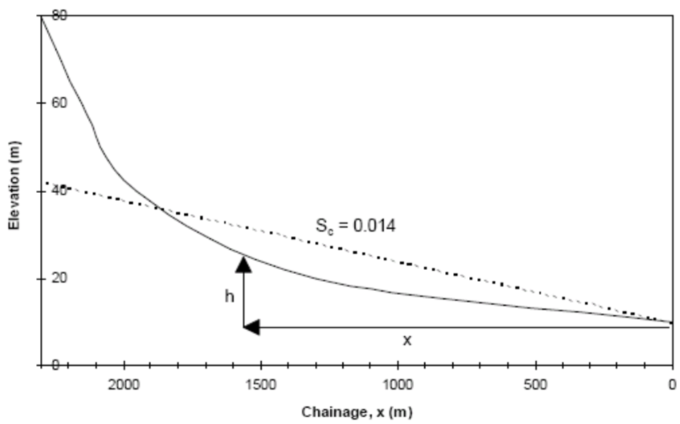
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

**$S_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Upstream Catchment D | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A(=\bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 46.95 | 0 | 0 | | | |
| 2 | 76 | 29.05 | 1750 | 1750 | 14.525 | 25418.75 |
| 3 | 92.5 | 45.55 | 3250 | 1500 | 37.3 | 55950 |
| 4 | 142 | 95.05 | 4500 | 1250 | 70.3 | 87875 |
| 5 | 205.84 | 158.89 | 5750 | 1250 | 126.97 | 158712.5 |
| 6 | 317 | 270.05 | 6750 | 1000 | 214.47 | 214470 |
| 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 =** | 6750 | **TOTAL =** | 542426.25 |

**S$_c$ =** 0.024

**Post-development**

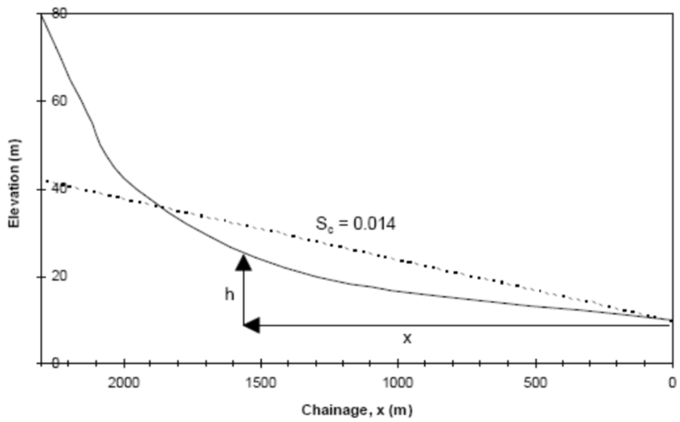
| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A(=\bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 0 | 0 | 0 |
| 4 | | 0 | | 0 | 0 | 0 |
| 5 | | 0 | | 0 | 0 | 0 |
| 6 | | 0 | | 0 | 0 | 0 |
| 7 | | 0 | | 0 | 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 =** | 0 | **TOTAL =** | 0 |

D

**S$_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Upstream Catchment E | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 32.3 | 0 | 0 | | | |
| 2 | 45.1 | 12.8 | 2000 | 2000 | 6.4 | 12800 |
| 3 | 57.2 | 24.9 | 3750 | 1750 | 18.85 | 32987.5 |
| 4 | 111.4 | 79.1 | 4500 | 750 | 52 | 39000 |
| 5 | 135.7 | 103.4 | 5750 | 1250 | 91.25 | 114062.5 |
| 6 | 194.8 | 162.5 | 6250 | 500 | 132.95 | 66475 |
| 7 | 317 | 284.7 | 7250 | 1000 | 223.6 | 223600 |
| 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 = | 7250 | TOTAL = | 488925 |

$S_c$ = 0.019

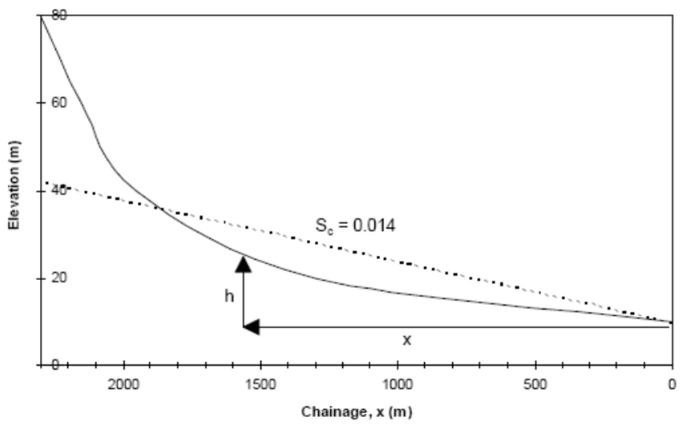
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Upstream 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 29.95 | 0 | 0 | | | |
| 2 | 44.86 | 14.91 | 2000 | 2000 | 7.455 | 14910 |
| 3 | 55.91 | 25.96 | 2750 | 750 | 20.435 | 15326.25 |
| 4 | 99.25 | 69.3 | 3250 | 500 | 47.63 | 23815 |
| 5 | 165.1 | 135.15 | 4000 | 750 | 102.225 | 76668.75 |
| 6 | 274.7 | 244.75 | 4714.4 | 714.4 | 189.95 | 135700.28 |
| 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 = | 4714.4 | TOTAL = | 266420.28 |

**$S_c$ =** 0.024

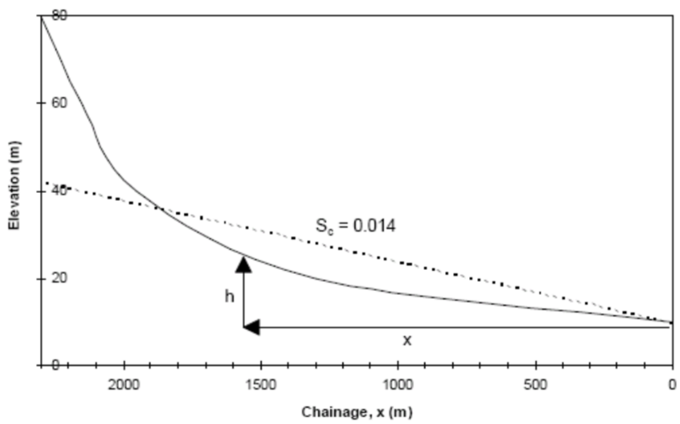
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

**$S_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Upstream Reach ABE to Scheme Inflow | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 29.95 | 0 | 0 | | | |
| 2 | 31.9 | 1.95 | 500 | 500 | 0.975 | 487.5 |
| 3 | 32.01 | 2.06 | 750 | 250 | 2.005 | 501.25 |
| 4 | 32.28 | 2.33 | 1186 | 436 | 2.195 | 957.02 |
| 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 =** | 1186 | **TOTAL =** | 1945.77 |

**$S_c$ =** 0.003

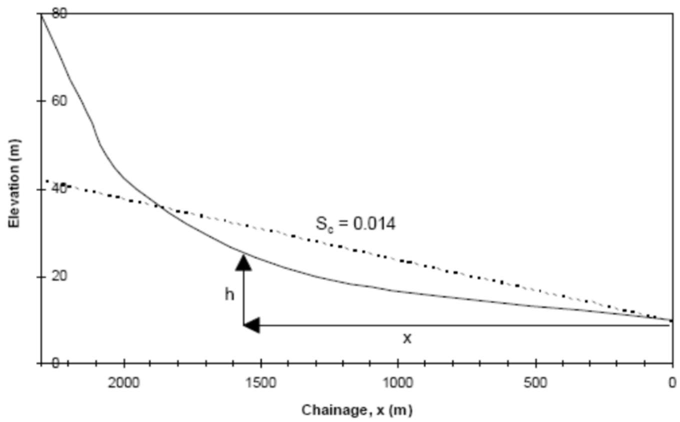
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

**$S_c$ =** #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Upstream Reach CD to ABE | 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 32.3 | 0 | 0 | | | |
| 2 | 37.2 | 4.9 | 1000 | 1000 | 2.45 | 2450 |
| 3 | 39.1 | 6.8 | 1500 | 500 | 5.85 | 2925 |
| 4 | 42.1 | 9.8 | 2250 | 750 | 8.3 | 6225 |
| 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 = | 2250 | TOTAL = | 11600 |

**$S_c$ =** 0.005

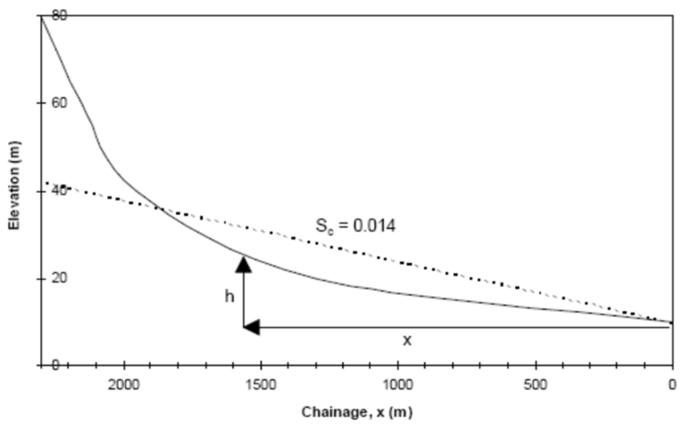
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

**$S_c$ =** #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
| --- | --- | --- | --- |
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Downstream 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A(=\bar{h}\Delta x)$ |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 27 | 0 | 0 | | | |
| 2 | 33.5 | 6.5 | 3000 | 3000 | 3.25 | 9750 |
| 3 | 39.9 | 12.9 | 4500 | 1500 | 9.7 | 14550 |
| 4 | 67.56 | 40.56 | 5750 | 1250 | 26.73 | 33412.5 |
| 5 | 140 | 113 | 6120 | 370 | 76.78 | 28408.6 |
| 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 = | 6120 | TOTAL = | 86121.1 |

$S_c$ = 0.005

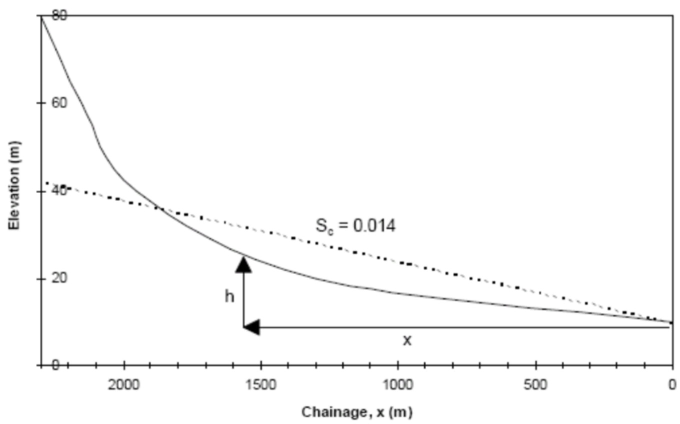
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A(=\bar{h}\Delta x)$ |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 40.7 | 0 | 0 | | | |
| 2 | 48.87 | 8.17 | 2000 | 2000 | 4.085 | 8170 |
| 3 | 56.5 | 15.8 | 3500 | 1500 | 11.985 | 17977.5 |
| 4 | 94.3 | 53.6 | 4500 | 1000 | 34.7 | 34700 |
| 5 | 148.64 | 107.94 | 5000 | 500 | 80.77 | 40385 |
| 6 | 288.82 | 248.12 | 5306 | 306 | 178.03 | 54477.18 |
| 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 =** | 5306 | **TOTAL =** | 155709.68 |

**$S_c$ =** 0.011

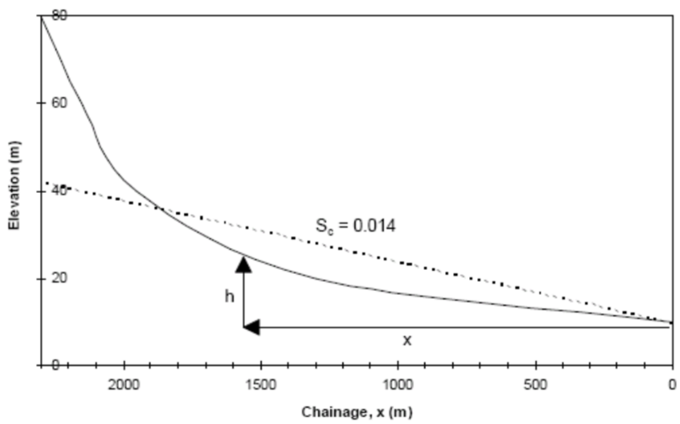
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

**$S_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream 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) $\Delta x$ | (m) $\overline{h}$ | $\Delta A (= \overline{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 11.1 | 0 | 0 | | | |
| 2 | 15.07 | 3.97 | 500 | 500 | 1.985 | 992.5 |
| 3 | 15.3 | 4.2 | 750 | 250 | 4.085 | 1021.25 |
| 4 | 25.67 | 14.57 | 1000 | 250 | 9.385 | 2346.25 |
| 5 | 27.77 | 16.67 | 1077 | 77 | 15.62 | 1202.74 |
| 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 =** | 1077 | **TOTAL =** | 5562.74 |

**$S_c$ =** 0.010

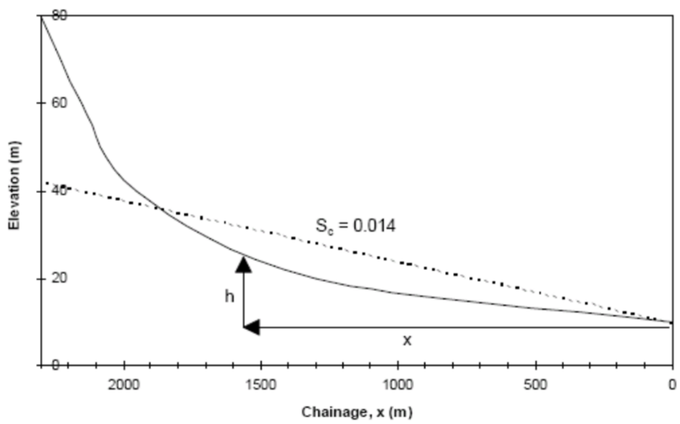
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\overline{h}$ | $\Delta A (= \overline{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

**$S_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream D | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 11.1 | 0 | 0 | | | |
| 2 | 20.2 | 9.1 | 1000 | 1000 | 4.55 | 4550 |
| 3 | 29.6 | 18.5 | 2000 | 1000 | 13.8 | 13800 |
| 4 | 33.74 | 22.64 | 2750 | 750 | 20.57 | 15427.5 |
| 5 | 43.5 | 32.4 | 3000 | 250 | 27.52 | 6880 |
| 6 | 79.7 | 68.6 | 3250 | 250 | 50.5 | 12625 |
| 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 =** | 3250 | **TOTAL =** | 53282.5 |

**$S_c$ =** 0.010

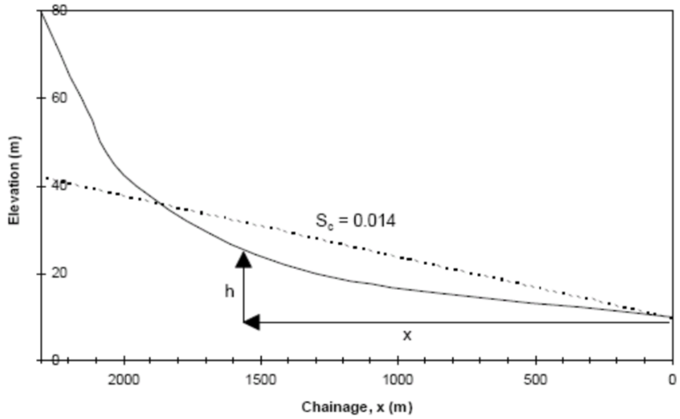
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

**$S_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream E | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 8.9 | 0 | 0 | | | |
| 2 | 10.36 | 1.46 | 500 | 500 | 0.73 | 365 |
| 3 | 18.24 | 9.34 | 750 | 250 | 5.4 | 1350 |
| 4 | 34.2 | 25.3 | 1250 | 500 | 17.32 | 8660 |
| 5 | 57.1 | 48.2 | 1695 | 445 | 36.75 | 16353.75 |
| 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 = | 1695 | TOTAL = | 26728.75 |

**$S_c$ =** 0.019

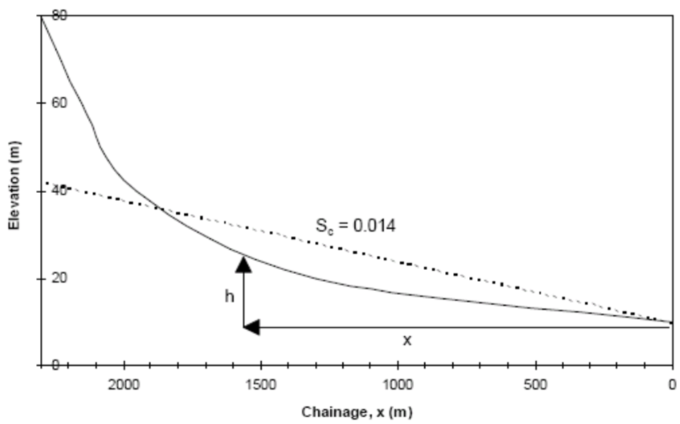
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

**$S_c$ =** #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Downstream 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 8.98 | 0 | 0 | | | |
| 2 | 10.88 | 1.9 | 500 | 500 | 0.95 | 475 |
| 3 | 37.35 | 28.37 | 750 | 250 | 15.135 | 3783.75 |
| 4 | 65 | 56.02 | 1036 | 286 | 42.195 | 12067.77 |
| 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 = | 1036 | TOTAL = | 16326.52 |

$S_c$ = 0.030

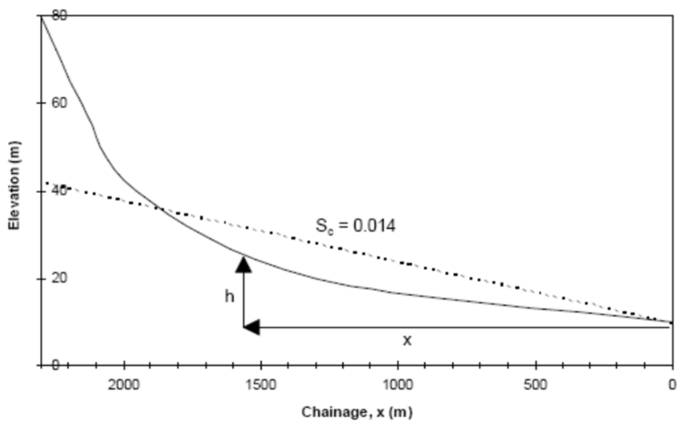
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Downstream G | 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 9.4 | 0 | 0 | | | |
| 2 | 27.5 | 18.1 | 1000 | 1000 | 9.05 | 9050 |
| 3 | 38.5 | 29.1 | 1750 | 750 | 23.6 | 17700 |
| 4 | 71.5 | 62.1 | 2553 | 803 | 45.6 | 36616.8 |
| 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 = | 2553 | TOTAL = | 63366.8 |

$S_c$ = 0.019

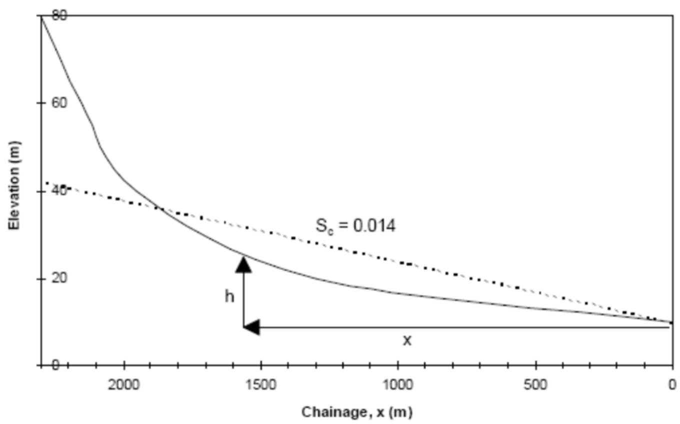
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | | | |
| 2 | 3.75 | 3.75 | 250 | 250 | 1.875 | 468.75 |
| 3 | 5.25 | 5.25 | 750 | 500 | 4.5 | 2250 |
| 4 | 18.1 | 18.1 | 1000 | 250 | 11.675 | 2918.75 |
| 5 | 43.1 | 43.1 | 1250 | 250 | 30.6 | 7650 |
| 6 | 60 | 60 | 1520 | 270 | 51.55 | 13918.5 |
| 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 = | 1520 | TOTAL = | 27206 |

$S_c$ = 0.024

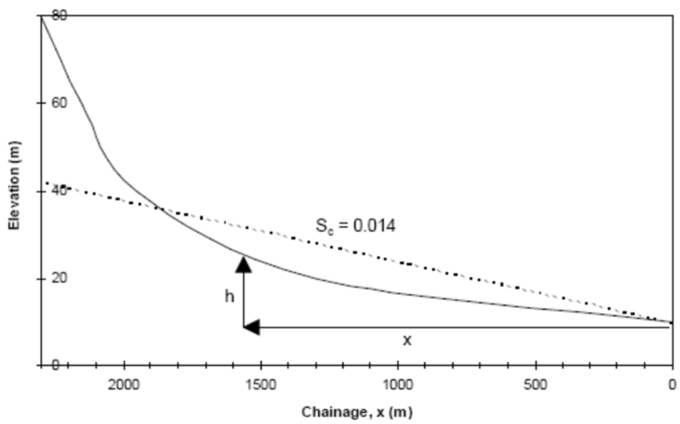
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h} \Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream Reach Scheme In to Out | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A(=\bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 15 | 0 | 0 | | | |
| 2 | 19.25 | 4.25 | 1000 | 1000 | 2.125 | 2125 |
| 3 | 25.66 | 10.66 | 2000 | 1000 | 7.455 | 7455 |
| 4 | 31.1 | 16.1 | 2973 | 973 | 13.38 | 13018.74 |
| 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 =** | 2973 | **TOTAL =** | 22598.74 |

**$S_c$ =** 0.005

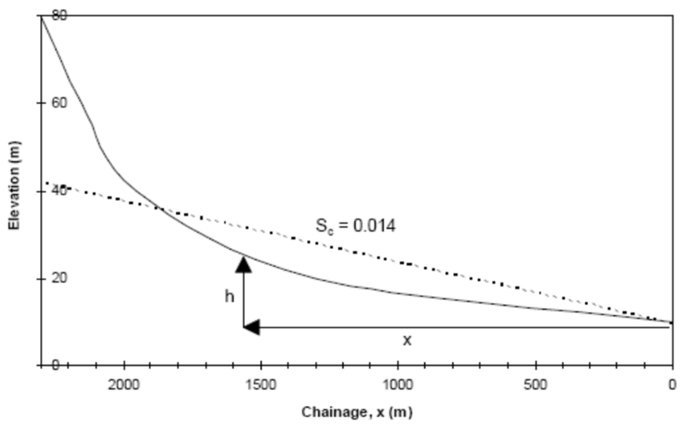
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A(=\bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

**$S_c$ =** #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream Reach Bto Scheme Out | **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) $\Delta x$ | (m) $\overline{h}$ | $\Delta A(=\overline{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 15 | 0 | 0 | | | |
| 2 | 29.43 | 14.43 | 750 | 750 | 7.215 | 5411.25 |
| 3 | 32.25 | 17.25 | 2000 | 1250 | 15.84 | 19800 |
| 4 | 35.73 | 20.73 | 3250 | 1250 | 18.99 | 23737.5 |
| 5 | 41.7 | 26.7 | 4850 | 1600 | 23.715 | 37944 |
| 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 =** | 4850 | **TOTAL =** | 86892.75 |

**$S_c$ =** 0.007

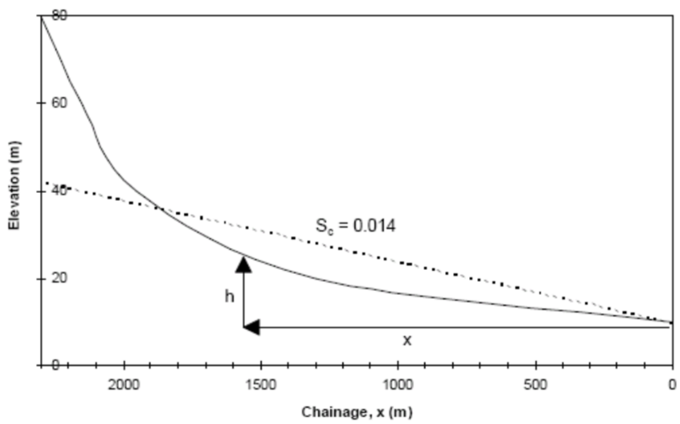
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\overline{h}$ | $\Delta A(=\overline{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

**$S_c$ =** #DIV/0!

| JOB NAME: | Warkwork South Plan Change | DATE: | 30/03/2023 |
|---|---|---|---|
| JOB NO: | 211001 | DES BY: | YW |
| SUBJECT: | Downstream Reach Scheme Out B to CD | 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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 11.1 | 0 | 0 | | | |
| 2 | 11.77 | 0.67 | 250 | 250 | 0.335 | 83.75 |
| 3 | 15 | 3.9 | 1000 | 750 | 2.285 | 1713.75 |
| 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 = | 1000 | TOTAL = | 1797.5 |

$S_c$ = 0.004

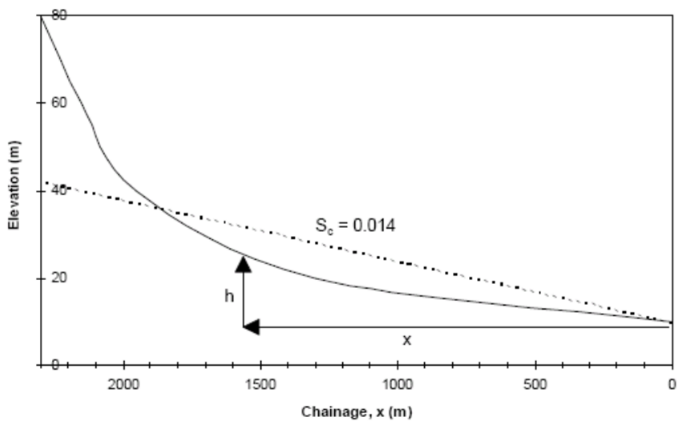
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream Reach CD to EFG | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 9.38 | 0 | 0 | | | |
| 2 | 9.8 | 0.42 | 250 | 250 | 0.21 | 52.5 |
| 3 | 11 | 1.62 | 1000 | 750 | 1.02 | 765 |
| 4 | 11.11 | 1.73 | 1303 | 303 | 1.675 | 507.525 |
| 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 = | 1303 | TOTAL = | 1325.025 |

$S_c$ = 0.002

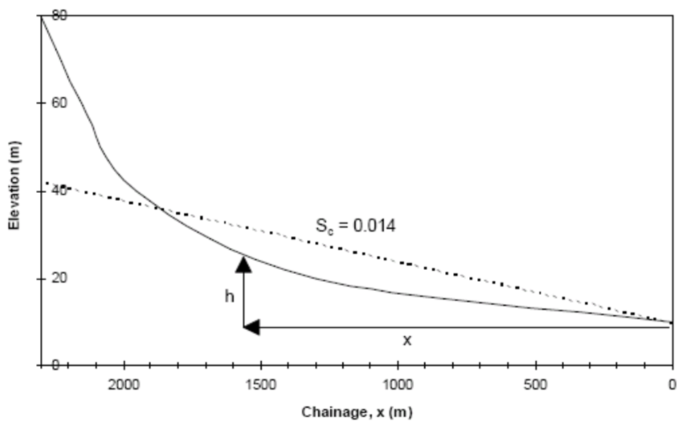
**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 = | 0 | TOTAL = | 0 |

$S_c$ = #DIV/0!

| | | | |
|---|---|---|---|
| **JOB NAME:** | Warkwork South Plan Change | **DATE:** | 30/03/2023 |
| **JOB NO:** | 211001 | **DES BY:** | YW |
| **SUBJECT:** | Downstream Reach EFG TO OUT | **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) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | 2.75 | 0 | 0 | | | |
| 2 | 3.45 | 0.7 | 500 | 500 | 0.35 | 175 |
| 3 | 8 | 5.25 | 1000 | 500 | 2.975 | 1487.5 |
| 4 | 9.41 | 6.66 | 1080 | 80 | 5.955 | 476.4 |
| 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 =** | 1080 | **TOTAL =** | 2138.9 |

$S_c$ = 0.004

**Post-development**

| Point | RL (m) | (m) $h$ | (m) $x$ | (m) $\Delta x$ | (m) $\bar{h}$ | $\Delta A (= \bar{h}\Delta x)$ |
|---|---|---|---|---|---|---|
| 1 | | 0 | | | | |
| 2 | | 0 | | 0 | 0 | 0 |
| 3 | | 0 | | 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 =** | 0 | **TOTAL =** | 0 |

$S_c$ = #DIV/0!

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Upstream Catchment A | Author YW | Date 30/03/2023 | 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) = total product / total area = ###### / ###### = 74.4

Ia (average) = 5 x pervious area / total area = 5 x 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= 0.008 m/m (by equal area method)

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

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

= 0.14 1 2.54 1.33 4.26 = 2.02 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 1.35 hrs

OK
use
2.0218088 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Upstream Catchment B | Author YW | Date 30/03/2023 | 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) = total product / total area = ###### / ###### = 74.6

Ia (average) = 5 x pervious area / total area = 5 x 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= 0.01 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 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 3.98 = 1.94 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.30 hrs

OK
use
1.939068 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Upstream 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) = total product / total area = ###### / ###### = 74.3

Ia (average) = 5 x pervious area / total area = 5 x 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= 0.021 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 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 2.85 1.34 3.19 = 1.70 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.14 hrs

OK
use
1.6979653 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Upstream 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= 0.024 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 3.06 = 2.01 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.35 hrs

OK
use
2.0076355 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|---|
| Job Title<br>Calc Title | Warkworth South Plan Change<br>TP108 Calculation - Pre-Development<br>Upstream Catchment E | Author YW | Date 30/03/2023 | 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= 0.019 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 3.28 = 2.25 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.51 hrs

OK
use
2.2509428 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|---|
| Job Title<br>Calc Title | Warkworth South Plan Change<br>TP108 Calculation - Pre-Development<br>Upstream 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) = $\frac{\text{total product}}{\text{total area}} = \frac{22606.48}{303.930} = 74.4$

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 299.1107}{303.930}$ 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= 0.024 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 2.74 1.33 3.06 = 1.56 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.05 hrs

OK
use
1.5646387 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number<br>211001 | Sheet<br>1 | Rev<br>A |
|---|---|---|---|
| Job Title / Calc Title — Warkworth South Plan Change<br>TP108 Calculation - Post Development<br>Upstream Catchment F | Author<br>YW | Date<br>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) = total product / total area = 22853.29 / 303.930 = 75.2

Ia (average) = 5 x pervious area / total area = 5 x 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= 0.024 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 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 3.06 = 1.55 hrs

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

OK
use
1.5497843 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| **Job Title** Warkworth South Plan Change<br>**Calc Title** TP108 Calculation - Pre-Development<br>pstream Reach Catchment ABE - Inflow | **Author** YW | **Date** 30/03/2023 | **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 | 22.0794 | 2163.78 |
| C | Total Pervious | 74 | 1297.1506 | 95989.14 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 1319.230 | 98152.93 |

CN (weighted) = total product / total area = ###### / ###### = 74.4

Ia (average) = 5 x pervious area / total area = 5 x 1297.1506 / 1319.230 = 4.9 mm

**2. Time of Concentration**

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.186 km (along drainage path)

Catchment Slope Sc= 0.003 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 1.12 1.33 5.71 = 1.19 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.80 hrs

OK
use
1.193873089 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Upstream Reach CD to ABE | 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 | 8.6156 | 844.33 |
| C | Total Pervious | 74 | 793.0244 | 58683.81 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 801.640 | 59528.13 |

CN (weighted) = total product / total area = ###### / ###### = 74.3

Ia (average) = 5 x pervious area / total area = 5 x 793.0244 / 801.640 = 4.9 mm

**2. Time of Concentration**

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 2.25 km (along drainage path)

Catchment Slope Sc= 0.005 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 74.3 / (200- 74.3) = 0.59

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

= 0.14 1 1.71 1.34 4.90 = 1.57 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.05 hrs

OK
use
1.5656087 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream Catchment A | Author YW | Date 30/03/2023 | 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) = $\frac{\text{total product}}{\text{total area}} = \frac{43481.69}{584.540} = 74.4$

Ia (average) = $\frac{\text{5 x pervious area}}{\text{total area}} = \frac{5 \times 575.1346}{584.540}$ 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= 0.005 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 2.83 1.33 4.90 = 2.59 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.74 hrs

OK
use
2.5945274 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream Catchment B | Author YW | Date 30/03/2023 | 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) = total product / total area = 63097.38 / 848.760 = 74.3

Ia (average) = 5 x pervious area / total area = 5 x 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= 0.011 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 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 3.87 = 2.10 hrs

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

OK
use
2.0998325 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream Catchment C | Author YW | Date 30/03/2023 | 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= 0.01 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 3.98 = 0.69 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.46 hrs

OK
use
0.6932339 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development<br>TP108 Downstream 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 | 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= 0.01 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 3.98 = 1.55 hrs

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

OK
use
1.5480986 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Down 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 | 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= 0.019 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 3.28 = 0.73 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.49 hrs

OK
use
0.7262942 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream 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 | 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= 0.03 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 2.86 = 0.56 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.38 hrs

OK
use
0.5621775 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream 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 | 67.7100 | 6635.58 |
| C | Total Pervious | 74 | 59.8900 | 4431.86 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 127.600 | 11067.44 |

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{11067.44}{127.600} = 86.7$

Ia (average) = $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 59.8900}{127.600}$ = 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= 0.019 m/m (by equal area method)

Runoff factor, $\frac{CN}{200 - CN} = \frac{86.7}{200 - 86.7} = 0.77$

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

= 0.14 1 1.79 1.16 3.28 = 0.95 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 0.64 hrs

OK
use
0.9519511 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream 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 | 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= 0.024 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 3.06 = 0.65 hrs

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

OK
use
0.6491606 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Reach Scheme in to out | 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 | 30.9143 | 3029.60 |
| C | Total Pervious | 74 | 2111.7450 | 156269.13 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 2142.659 | 159298.73 |

CN (weighted) = total product / total area = ####### / 2142.659 = 74.3

Ia (average) = 5 x pervious area / total area = 5 x 2111.7450 / 2142.659 = 4.9 mm

## 2. Time of Concentration

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 2.973 km (along drainage path)

Catchment Slope Sc= 0.005 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 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 2.05 1.33 4.90 = 1.88 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 1.26 hrs

OK
use
1.87974775 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 Downstream Reach B to SCHEME OUT | Author YW | Date 30/03/2023 | 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) = total product / total area = 63097.38 / 848.760 = 74.3

Ia (average) = 5 x pervious area / total area = 5 x 836.7124 / 848.760 = 4.9 mm

**2. Time of Concentration**

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 4.85 km (along drainage path)

Catchment Slope Sc= 0.007 m/m (by equal area method)

Runoff factor, CN / (200 - CN) = 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 2.84 1.33 4.43 = 2.35 hrs

SCS Lag for HEC-HMS.... $t_p = 2/3\ t_c$ = 1.57 hrs

OK
use
2.3473116 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream Reach Scheme out to CD | 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 | 68.7906 | 6741.48 |
| C | Total Pervious | 74 | 3992.4987 | 295444.90 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 4061.289 | 302186.38 |

CN (weighted) = total product / total area = ####### / 4061.289 = 74.4

Ia (average) = 5 x pervious area / total area = 5 x 3992.4987 / 4061.289 = 4.9 mm

**2. Time of Concentration**

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1 km (along drainage path)

Catchment Slope Sc= 0.004 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 1.00 1.33 5.24 = 0.98 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.66 hrs

OK
use
0.97848894 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|---|
| Job Title<br>Calc Title | Warkworth South Plan Change<br>TP108 Calculation - Pre-Development<br>Downstream Reach CD to EFG | 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 | 84.5692 | 8287.78 |
| C | Total Pervious | 74 | 4284.1501 | 317027.11 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 4368.719 | 325314.89 |

CN (weighted) = total product = ####### = 74.5
total area 4368.719

Ia (average) = 5 x pervious area = 5 x 4284.1501 4.9 mm
total area 4368.719

**2. Time of Concentration**

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1 km (along drainage path)

Catchment Slope Sc= 0.002 m/m (by equal area method)

Runoff factor, CN = 74.5 = 0.59
200 - CN 200- 74.5

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

= 0.14 1 1.00 1.33 6.45 = 1.20 hrs

SCS Lag for HEC-HMS…. $t_p = 2/3\ t_c$ = 0.81 hrs

OK
use
1.2038381 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

| MAVEN ASSOCIATES | Job Number 211001 | Sheet 1 | Rev A |
|---|---|---|---|
| Job Title: Warkworth South Plan Change<br>Calc Title: TP108 Calculation - Pre-Development Downstream Reach EFG to Outlet | Author YW | Date 31/03/2023 | 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 | 197.7707 | 19381.53 |
| C | Total Pervious | 74 | 4392.4886 | 325044.16 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| * from Appendix B | | Totals = | 4590.259 | 344425.69 |

CN (weighted) = total product / total area = ####### / 4590.259 = 75.0

Ia (average) = 5 x pervious area / total area = 5 x 4392.4886 / 4590.259 = 4.8 mm

**2. Time of Concentration**

Channelisation factor C = 1 (From Table 4.2)

Catchment length L = 1.08 km (along drainage path)

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

Runoff factor, CN / (200 - CN) = 75.0 / (200- 75.0) = 0.60

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

= 0.14 1 1.05 1.32 5.24 = 1.02 hrs

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

OK
use
1.02191107 hrs

**Worksheet 1: Runoff Parameters and Time of Concentration**

**APPENDIX D – TP108 and Time of concentration calculations**

# Channel Report

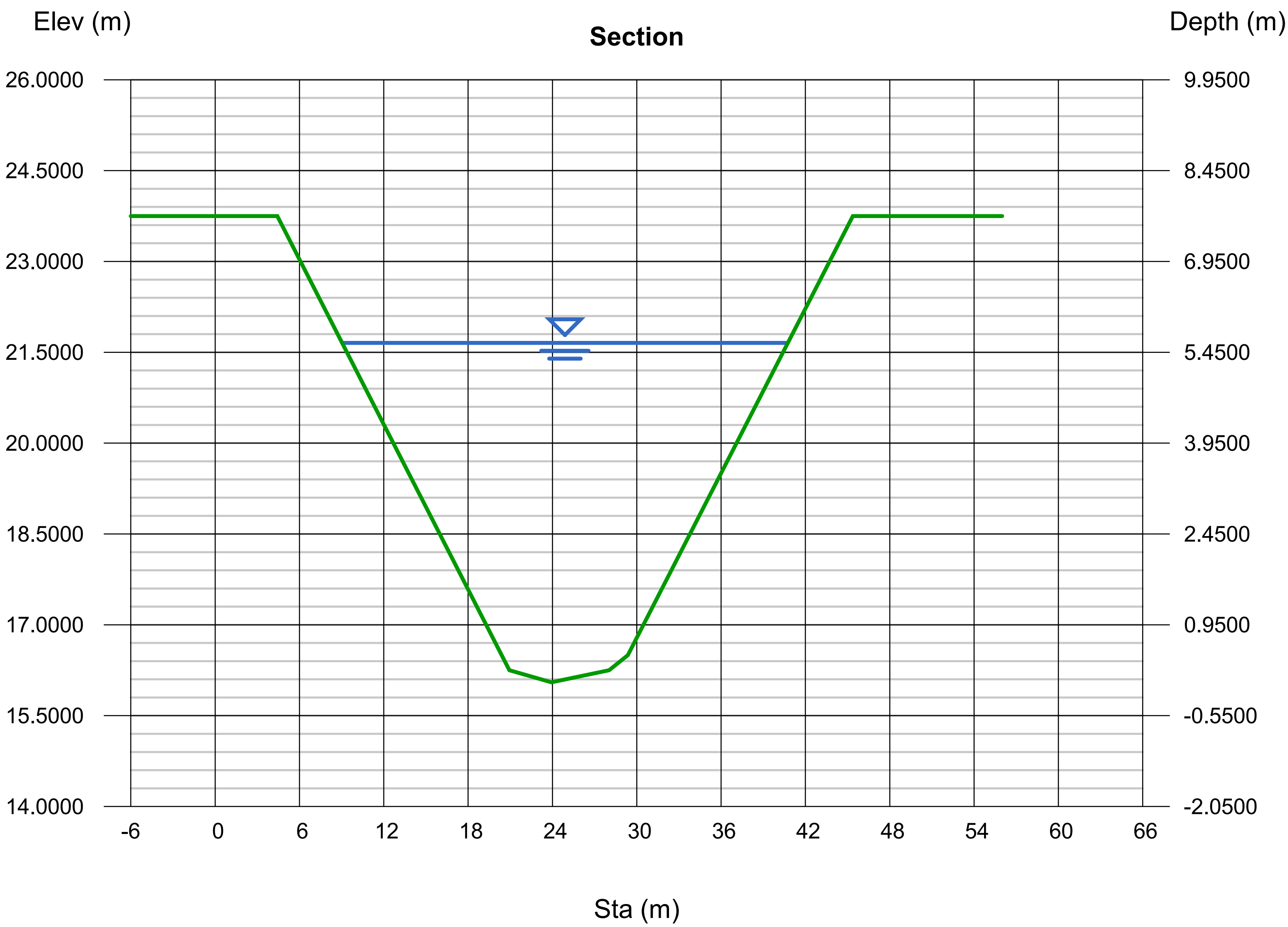
Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Apr 5 2023

## WOODCOCK BRIDGE (Existing scenario 100yr no Climate Change)

| **User-defined** | | **Highlighted** | |
|---|---|---|---|
| Invert Elev (m) | = 16.0500 | Depth (m) | = 5.6054 |
| Slope (%) | = 0.2000 | Q (cms) | = 347 |
| N-Value | = 0.030 | Area (sqm) | = 107.6504 |
| | | Velocity (m/s) | = 3.2187 |
| **Calculations** | | Wetted Perim (m) | = 34.0348 |
| Compute by: | Known Q | Crit Depth, Yc (m) | = 4.2215 |
| Known Q (cms) | = 346.5000 | Top Width (m) | = 31.7164 |
| | | EGL (m) | = 6.1338 |

**(Sta, El, n)-(Sta, El, n)...**

( 0.0000, 23.7500)-(4.4200, 23.7500, 0.030)-(20.9300, 16.2500, 0.030)-(23.9300, 16.0500, 0.030)-(28.0300, 16.2500, 0.030)-(29.3700, 16.5000, 0.030)-(45.3700, 23
-(50.0000, 23.7500, 0.030)



# Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. — Wednesday, Apr 5 2023

## WOODCOCK BRIDGE (Existing scenario 100yr + Climate Change)

**User-defined**

| | | |
|---|---|---|
| Invert Elev (m) | = | 16.0500 |
| Slope (%) | = | 0.2000 |
| N-Value | = | 0.030 |

**Calculations**

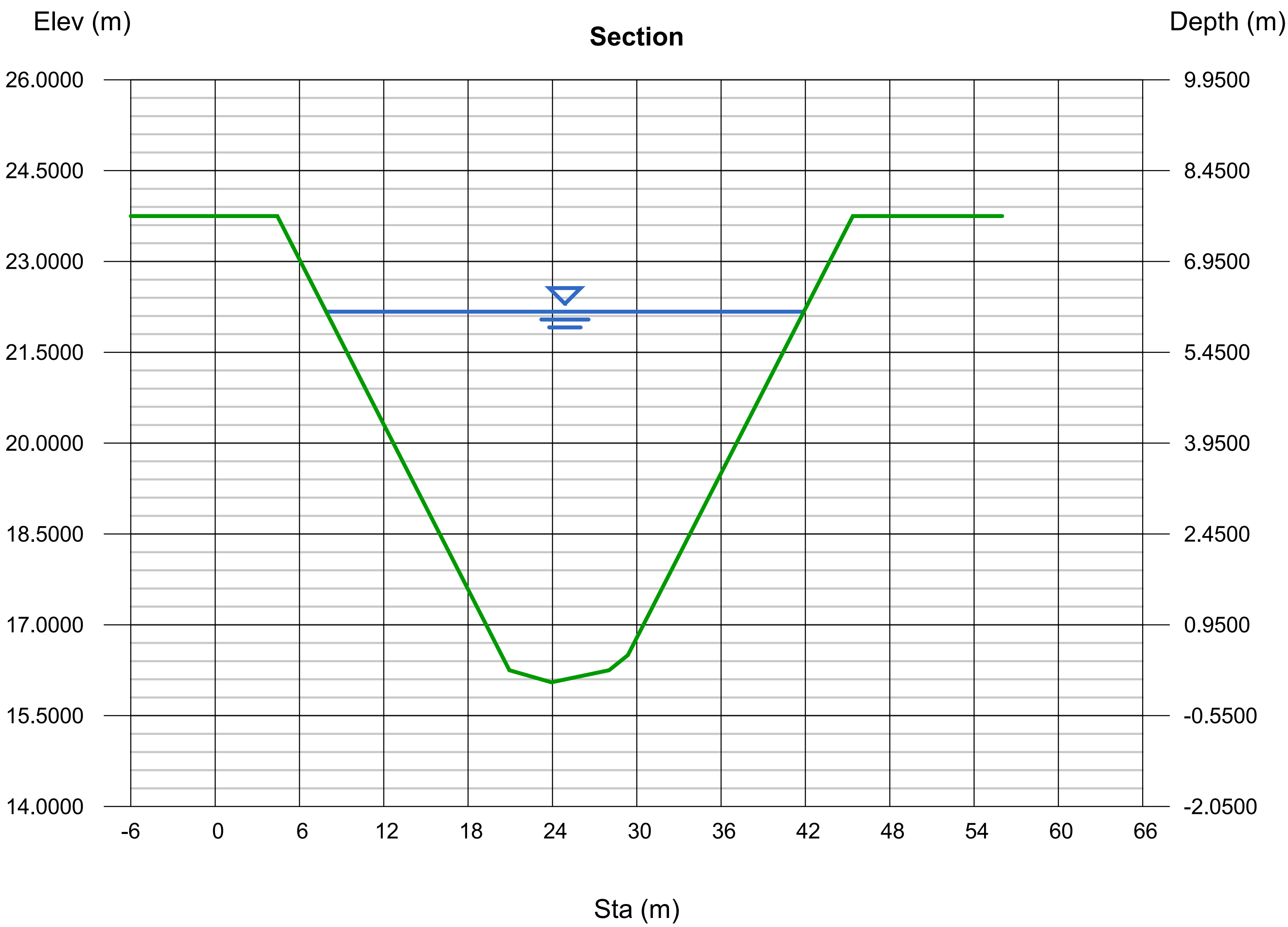
| | | |
|---|---|---|
| Compute by: | | Known Q |
| Known Q (cms) | = | 421.7000 |

**Highlighted**

| | | |
|---|---|---|
| Depth (m) | = | 6.1205 |
| Q (cms) | = | 422 |
| Area (sqm) | = | 124.5731 |
| Velocity (m/s) | = | 3.3851 |
| Wetted Perim (m) | = | 36.5283 |
| Crit Depth, Yc (m) | = | 4.6483 |
| Top Width (m) | = | 33.9872 |
| EGL (m) | = | 6.7050 |

**(Sta, El, n)-(Sta, El, n)...**

( 0.0000, 23.7500)-(4.4200, 23.7500, 0.030)-(20.9300, 16.2500, 0.030)-(23.9300, 16.0500, 0.030)-(28.0300, 16.2500, 0.030)-(29.3700, 16.5000, 0.030)-(45.3700, 23
-(50.0000, 23.7500, 0.030)



# Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Wednesday, Apr 5 2023

## WOODCOCK BRIDGE (Proposed scenario 100yr + Climate Change)

**User-defined**
Invert Elev (m) = 16.0500
Slope (%) = 0.2000
N-Value = 0.030

**Calculations**
Compute by: Known Q
Known Q (cms) = 420.6000

**Highlighted**
Depth (m) = 6.1144
Q (cms) = 421
Area (sqm) = 124.3660
Velocity (m/s) = 3.3819
Wetted Perim (m) = 36.4988
Crit Depth, Yc (m) = 4.6422
Top Width (m) = 33.9603
EGL (m) = 6.6978

**(Sta, El, n)-(Sta, El, n)...**
( 0.0000, 23.7500)-(4.4200, 23.7500, 0.030)-(20.9300, 16.2500, 0.030)-(23.9300, 16.0500, 0.030)-(28.0300, 16.2500, 0.030)-(29.3700, 16.5000, 0.030)-(45.3700, 23
-(50.0000, 23.7500, 0.030)