PRELIMINARY THREE WATERS STRATEGY REPORT

Sunfield – FAB Application

Ardmore, Auckland

CIVIL ENGINEERING ▼ SURVEYING ▼ LAND DEVELOPMENT

PROJECT INFORMATION

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1.0 INTRODUCTION

1.1 OVERVIEW

Sunfield Developments Limited (SDL) is proposing to develop a contiguous 244.5 hectare (ha) site to allow the development of a masterplanned community to be known as “Sunfield”.

This report outlines the Three Waters strategy for the Sunfield development and will support the Fast-track Approvals Bill Application (FAB) application and subsequent development of the site.

The engineering information provided herein relates to the stormwater, wastewater, water supply, and the strategies proposed to service future development.

The scope of this report includes the identification of key design strategies, developing design solutions for stormwater and wastewater disposal and water supply, and articulating the designs into a Three Waters Strategy report.

The assessments included in this report are formed from a desktop analysis based on information available at time of issue. Final solutions will require detailed design and further consultation with third party stakeholders including Veolia, Watercare, Auckland Council, Auckland Transport and Healthy Waters.

The engineering solution for Sunfield outlined within this Three Waters Report has been prepared based on Auckland Council, Watercare and Healthy Waters standards and requirements and in line with best practice options.

1.2 SITE DESCRIPTION

The project site is located over several sites as shown on the aerial photo below. The site is bounded by Old Wairoa Road to the south, Cosgrave Road to the west and Airfield Road to the north.

Figure 1 – Aerial Photo (extent of site shown in yellow dashed outline)

The current land zoning for the the development site comprises of approximately 57ha of land identified as Future Urban Zone (FUZ) and 187ha as Mixed Rural Zone (MRZ) under the Auckland Unitary Plan (AUP(OP)).

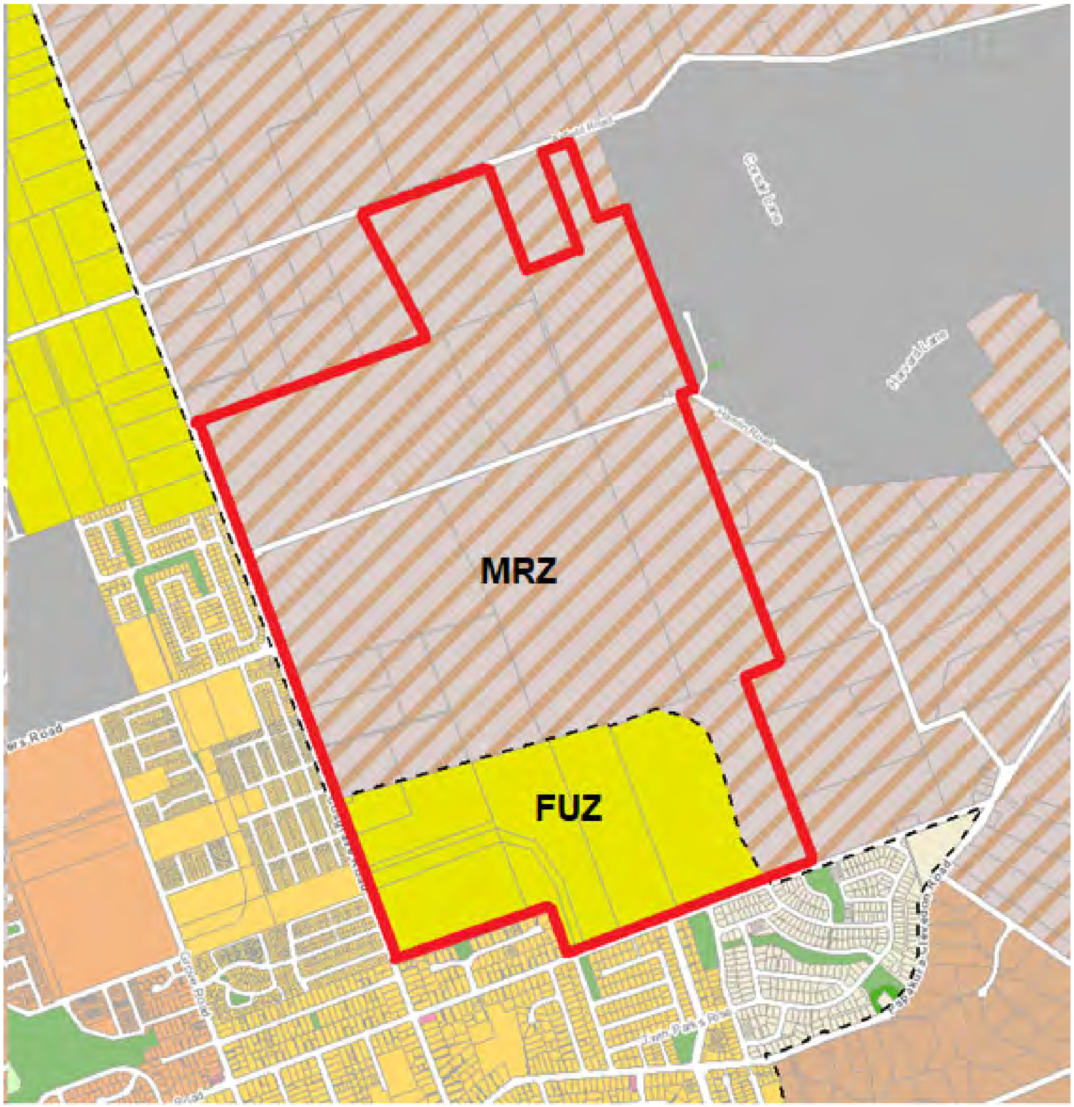


Figure 2- Current Zoning Plan (extent of FUZ land shown in yellow)

Auckland Council's Framework plan for the area provides a possible lot layout for the majority of the FUZ land. When a similar density is interpolated through the full FUZ land approximately 1,550 lots can be developed.

The subdivision yield of 1,550 lots in this environment sets the development baseline for the site, from which stormwater and wastewater discharges are compared against and limited to within this Three Waters Strategy report.

1.3 LEGAL DESCRIPTION

The legal description and underlying zoning of the existing sites that are within the development area is shown below.

Address	Legal Description	Record of Title	Area (ha)	Underlying Zoning
55 Cosgrave Road, Papakura	Section 3-4 Survey Office Plan 495342	828127	9.2433	Future Urban
Old Wairoa Road, Papakura	Section 5-6 Survey Office Plan 495342	828128	11.8128	Future Urban
Old Wairoa Road, Papakura	Lot 1 Deposited Plan 55480	NA6C/1128	5.8014	Future Urban
Old Wairoa Road, Papakura	Lot 4 Deposited Plan 55480	NA6C/1131	10.3587	Future Urban
508 Old Wairoa Road, Ardmore	Deposited Plan 10383	NA258/245	23.6336	Future Urban & Rural
85 Hamlin Road, Ardmore	Lot 8 Deeds Plan Whau 38	NA778/296	22.5233	Rural
80 Hamlin Road, Ardmore	Part Lot 2 Deposited Plan 22141	NA1B/856	18.9937	Rural
80 Hamlin Road, Ardmore	Lot 2 Deposited Plan 21397	NA477/291	10.1171	Rural
80 Hamlin Road, Ardmore	Lot 1 Deposited Plan 21397	NA477/75	30.7192	Rural
80 Hamlin Road, Ardmore	Lot 5 Deposited Plan 12961	NA631/77	35.9057	Rural
80 Hamlin Road, Ardmore	Lot 4 Deposited Plan 12961	NA636/71	21.8505	Rural
279 Airfields Road, Armore	Lot 2 Deposited Plan 199521	NA128A/553	14.4224	Rural
92 Hamlin Road, Ardmore	Lot 1 Deposited Plan 46615	NA1666/17	0.0911	Rural
143 Cosgrave Road, Papakura	Lot 1 Deposited Plan 103787	NA57A/1149	3.0400	Rural

131 Cosgrave Road, Papakura	Lot 2 Deposited Plan 103787	NA57A/1150	3.0370	Rural
121A Cosgrave Road, Papakura	Lot 3 Deposited Plan 103787 and 1/3 Share in Lot 7 Deposited Plan 103787	NA57A/1151	3.0400	Rural
123 Cosgrave Road, Papakura	Lot 4 Deposited Plan 103787 and 1/3 Share in Lot 7 Deposited Plan 103787	NA57A/1152	8.6325	Rural
119A Cosgrave Road, Papakura	Lot 5 Deposited Plan 103787 and 1/3 Share in Lot 7 Deposited Plan 103787	NA61A/530	3.0370	Rural
119A, 121A and 123 Cosgrave Road, Papakura	Lot 7 Deposited Plan 103787		0.2417	Rural
119 Cosgrave Road, Papakura	Lot 6 Deposited Plan 45156	NA578A/1154	3.0360	Rural
101 Cosgrave Road, Papakura	Part Lot 1 Deposited Plan 45156	NA24C/216	1.9425	Future Urban
103 Cosgrave Road, Papakura	Lot 1 Deposited Plan 62629	NA18B/646	0.0809	Future Urban
55A Cosgrave Road, Papakura	Section 1-2 Survey Office Plan 495342	828126	2.9300	Future Urban
Total			244.4904	

Table 1- Legal & Existing Zoning Summary

1.4 PROPOSAL

The proposed development is for a large-scale masterplanned community, consisting of approximately 4,000 residential lots and approximately 56.5ha of industrial/employment land. In addition to residential and industrial use, other uses to support a new community of this size are proposed such as town centre, health care, aged care, local hub, a school, parks/open space, stormwater reserves and green connections/shared pathways. The Sunfield development concept plan is shown in Figure 3 below.

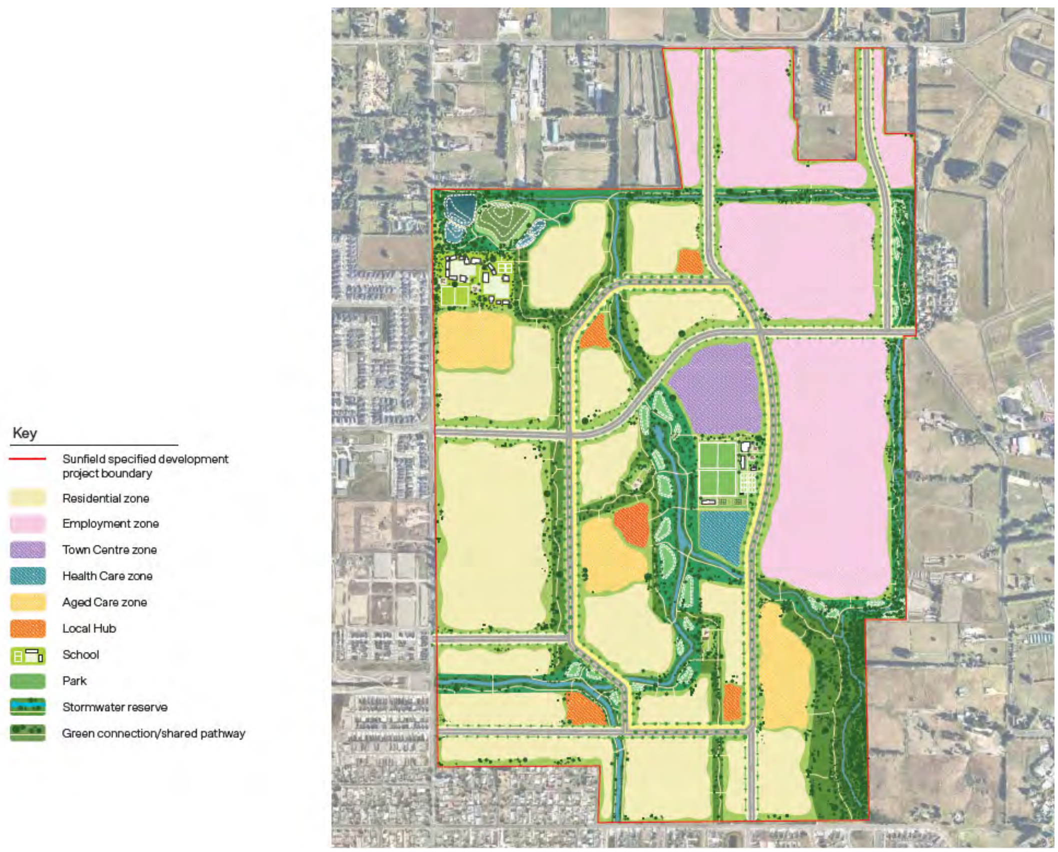


Figure 3: Sunfield Concept Plan

2.0 THREE WATERS STRATEGY

2.2 DESIGN STRATEGY

A key issue in developing and consenting a masterplanned community is ensuring the development can be serviced by necessary and appropriate infrastructure, in particular relating to stormwater, wastewater and water supply.

The purpose of this Three Waters Strategy report is to identify servicing strategies and determine the extent of infrastructure required to service the future development of the site.

This report helps shape the masterplan by incorporating the infrastructure solutions, while also providing an initial basis for consultation with third party stakeholders including Veolia, Watercare, Auckland Council, Auckland Transport and Healthy Waters, and Mana Whenua engagement.

The overarching design principle driving the Three Waters Strategy for this development is incorporation of Water Sensitive Urban Design (WSUD) wherever possible.

WSUD is a land planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, to minimise environmental degradation and improve aesthetic and recreational outcomes.

The Three Waters Strategy incorporates WSUD engineering design principles to create a low impact, sustainable development which manages stormwater and wastewater discharge from the site.

The outcomes sought by the Sunfield Three Waters Strategy are:

Stormwater

- Recognise the key constraints and opportunities on site and in the Pahurehure Inlet and Papakura Stream catchments.
- Devise an integrated stormwater management approach to facilitate urban development optimise available land.
- Develop a set of best practicable option (BPOs) for stormwater management that can be incorporated into the development.
- Emphasise a water-sensitive design approach that:
    - manages the impact of land use change from rural to urban.
    - minimises or mitigates the adverse effects on water quality, freshwater systems, stream health, and ecological values of the receiving environment through the implementation of stormwater management devices.
    - protects and enhances stream systems and natural hydrology while mitigating hydrological changes and managing flooding effects.
- Minimise the generation and discharge of contaminants/sediments into the sensitive receiving environment of the Manukau Harbour.
- Protect key infrastructure, people and the environment from significant flooding events and not worsen downstream flooding.

Wastewater & Water supply

- Wastewater networks, including new and existing private connections to the networks allow the minimum practicable seepage into and out of the networks.
- Waste materials entering the networks are controlled to avoid or minimise adverse effects on physical assets, wastewater treatment processes and the environment.
- Overflows from the networks during both dry and wet weather are minimised as far as practicable.
- Infrastructure that is created, is of good quality, meets health requirements and minimises ongoing maintenance costs.
- Meets future demands on maintainability and access as infrastructure age and the natural environment change.
- Water is used efficiently and wastage is minimised as best practicable.

Key legislative documents have also been acknowledged in developing the Three Waters Strategy, which include but are not limited to:

- Auckland Unitary Plan (AUP(OP)).
- Regionwide Network Discharge Consent (NDC).
- NZS 4404: 2010 - Auckland Code of Practice for Land Development and Subdivision (Chapter 4 – Stormwater).
- NZS 4404: 2010 Auckland Code of Practice: For Land Development and Subdivision (Chapter 5 - Wastewater).
- Stormwater Management Devices in the Auckland Region – Guideline Document 2017/001 (GD01) December 2017.
- Auckland Transport Code of Practice (2013).
- National Policy Statement for Freshwater Management 2020.

The Three Waters Strategy is consistent with the policies and objectives of these key documents. High level strategy summaries for each of the Three Waters are detailed below.

2.2 STORMWATER STRATEGY (SUMMARY)

The stormwater approach adopted has been developed in accordance with Auckland Council policies and plans, and based on best practice stormwater management techniques to meet AUP regulatory policies and provisions, Auckland Council's stormwater-specific guidelines and Network Discharge Consent (NDC) requirements, National Policy Statement on Urban Development (NPS-UD) and consultation with Mana Whenua.

Where Schedule 4 requirements cannot be achieved the proposed stormwater strategy utilises Best Practical Option (BPO) alternatives consistent with the requirements of Schedule 2. Due to the presence of peat soils onsite and their recharge requirements best practice alternatives are recommended which are currently standard practice for developments in this area.

An Integrated Stormwater Management Approach has been adopted in the design and associated stormwater management in accordance with the policies in the AUP -Sections E1.3, B7 and B8.

For analysis purposes, this report has divided the development site and upstream stormwater catchments into four main catchments (detailed in Section 3.1 of the report) – Catchments A, B, C and D as summarised in Table 2 below. The catchments have different strategies tailored to their specific stormwater management requirements.

To achieve the outcomes (stated above in Section 2.2) sought by the Sunfield Three Waters Strategy, the stormwater strategy is to implement stormwater management to achieve the following:

- Hydrological mitigation to minimise the change in hydrology (maintain predevelopment), peak flow rate, levels and volumes, and groundwater changes, as a result of development. It comprises two components:
  - Retention: the process of reducing runoff volumes, which can be achieved by:
    - ensuring that the initial abstraction (rainfall losses due to soakage which occur before runoff begins) volume from pre-development conditions is infiltrated into the ground, which is beneficial to groundwater and baseflow to streams i.e. infiltration.
  - Detention: Temporary storage and slower release of runoff, which effectively reduces peak flows and protects the downstream receiving environment.
- Convey stormwater runoff from upstream and development site for up to 100 year flow.
- Flood management within the site by conveying overland flows through the site via roads and swales and directing flows into attenuation devices.
- Flood management to maintain predevelopment flood hazard conditions for upstream and downstream of the development site in terms of peak flow rate and levels.
- Providing stormwater quality treatment through communal treatment devices such as a stormwater conveyance channel and wetland.
- Provide ground water recharge via soakage pit/recharge pit to ensure the retention of existing groundwater levels. The retention provided by the the recharge pits will also provide hydrological mitigation via supporting stream baseflows and reducing erosive flows during small storm events.

Table 2 below, summarises the stormwater management proposed for the Sunfield Project Site:

Table 2: Stormwater management approach for the Sunfield project site.

Proposed Catchment	**Catchment A**	**Catchment B**	**Catchment C**	**Catchment D1**	**Catchment D2**
Approach	Attenuation	Attenuation	Diversion of upstream catchment around site.	Passing flows forward (No attenuation)	Attenuation
Discharge to	Pahurehure Inlet Catchment Immediate discharge point: TSWCC/Awakeri Wetland Final Discharge: Manukau Harbour	Papakura Stream Catchment Immediate discharge point: land adjacent to site (maintain existing discharge position) Final Discharge: Manukau Harbour			
Pre-Development Discharge	94 ha (Of which 50ha is in FUZ Zone)	-	548 ha undeveloped		36 ha undeveloped
Post-Development Discharge	175 ha (Total Catchment) developed	71 ha developed	374 ha undeveloped	22 ha developed	36 ha developed
Outcomes	-Attenuate 10 to 100 year flows to achieve peak flow rate and peak water level design criteria provided by Healthy Waters for Stage 2 & 3 Awakeri Wetland (based on MPD of FUZ land). -Manage flood hazards -Ground water recharge, Provide retention of 15mm runoff depth for all impervious area. -Water quality in accordance with GD01.	-Attenuate 10 to 100 year flows to maintain peak flow rate and peak water level to pre-development. -Manage flood hazards -Ground water recharge, Provide retention of 15mm runoff depth for all impervious area -Water quality in accordance with GD01.	-Convey upstream catchment. -Manage flood hazards.	-Ground water recharge, provide retention of 15mm runoff depth for all impervious area -Manage flood hazards -Water quality in accordance with GD01.	-Attenuate 10 to 100 year flows to maintain peak flow rate and peak water level to pre-development. -Manage flood hazards -Ground water recharge, Provide retention of 15mm runoff depth for all impervious area -Water quality in accordance with GD01.

Proposed Catchment	Catchment A	Catchment B	Catchment C	Catchment D1	Catchment D2
Proposed Devices to Achieve Performance Standards					
Conveyance up to 10 year flow	Piped reticulation, Swales & TSWCC	Piped reticulation, Swales	N/A	Piped reticulation, Swales	
Conveyance up to 100 year flow	Public Roads, Swales & TSWCC	Public Roads & Swales	Swale	Public Roads & Swales	
Overland flow & Flood management for 10 to 100 year flow	-Overland flow to attenuation basin/swale (extension of TSWCC) -Remove existing flood plain from the development site.	-Overland flow to attenuation pond. -Remove existing flood plain from the development site.	Overland flow to existing discharge point. -Remove existing flood plain from the development site.	Overland flow to existing discharge point. -Remove existing flood plain from the development site.	Overland flow to attenuation pond. -Remove existing flood plain from the development site.
Water quality – Primary Treatment	Use of non-contaminating building materials, grated catchpits and inlets to stormwater, gross pollutant filters within catchpits.		N/A	Use of non-contaminating building materials, grated catchpits and inlets to stormwater, gross pollutant filters within catchpits.	
Water quality – Secondary Primary Treatment	Swales		N/A	Swales	
Water quality – Tertiary Treatment	TSWCC and Existing McLennan Wetland .	Wetland	N/A	Wetland	
Ground Water Recharged	Soakage/Recharge Pits		N/A	Soakage/Recharge Pits	

2.4 WASTEWATER STRATEGY (SUMMARY)

The wastewater strategy for the site is to restrict wastewater discharge to an acceptable level to avoid any capacity issues with downstream wastewater infrastructure.

Wastewater discharge from the developed site will be limited to the discharge anticipated from the maximum probable development (MPD) of the FUZ land.

The proposed Wastewater Strategy outlined in this report entails the utilisation of a Low-Pressure Sewer (LPS) wastewater system. LPS systems eliminate peak wet weather flows by utilising a sealed network which eliminates inflow and infiltration.

Due to the flat topography of the site, poor ground conditions and high water table a LPS system is considered an acceptable alternative solution to a standard gravity option which is able to provide wastewater servicing for the site.

2.5 WATER SUPPLY STRATEGY (SUMMARY)

The proposed strategy outlined in this Three Waters Strategy report is to reticulate the development with a new water supply network for potable water and firefighting services.

Preliminary investigations with Veolia have indicated that a connection to the nearest Bulk Pressure Supply Point (BSP) will be necessary to provide the minimum firefighting water supply classification for the development of the site. A new public water supply reticulation will need to be extended from the BSP to service the development.

There are two BSP points on the existing 450mmØ transmission line located in the near vicinity of the site, the The closest being in the front berm of 393 Porchester Road and the other being at the intersectin of Porchester Road and Airfield Road.

The BSP may need to be upgraded as part of these works.If this BSP point does not have sufficient capacity a new BSP point may need to be constructed on the transmission line. Consultation with Veolia and Watercare will be required to confirm the preferred connection point and capacity.

3.0 STORMWATER

3.1 STORMWATER CATCHMENT

3.1.1 EXISTING STORMWATER CATCHMENT

The proposed development site is identified as having flood hazards across the site and is located within both the Auckland Council Pahurehure Inlet and Papakura Stream Stormwater Catchments.

Most of the development site is identified as draining to the Papakura Stream catchment to the North; however, it must be noted that Council's stormwater catchment boundaries may not accurately define the exact boundaries between the two catchments due to the difficulties in delineating the boundaries from the flat topography.

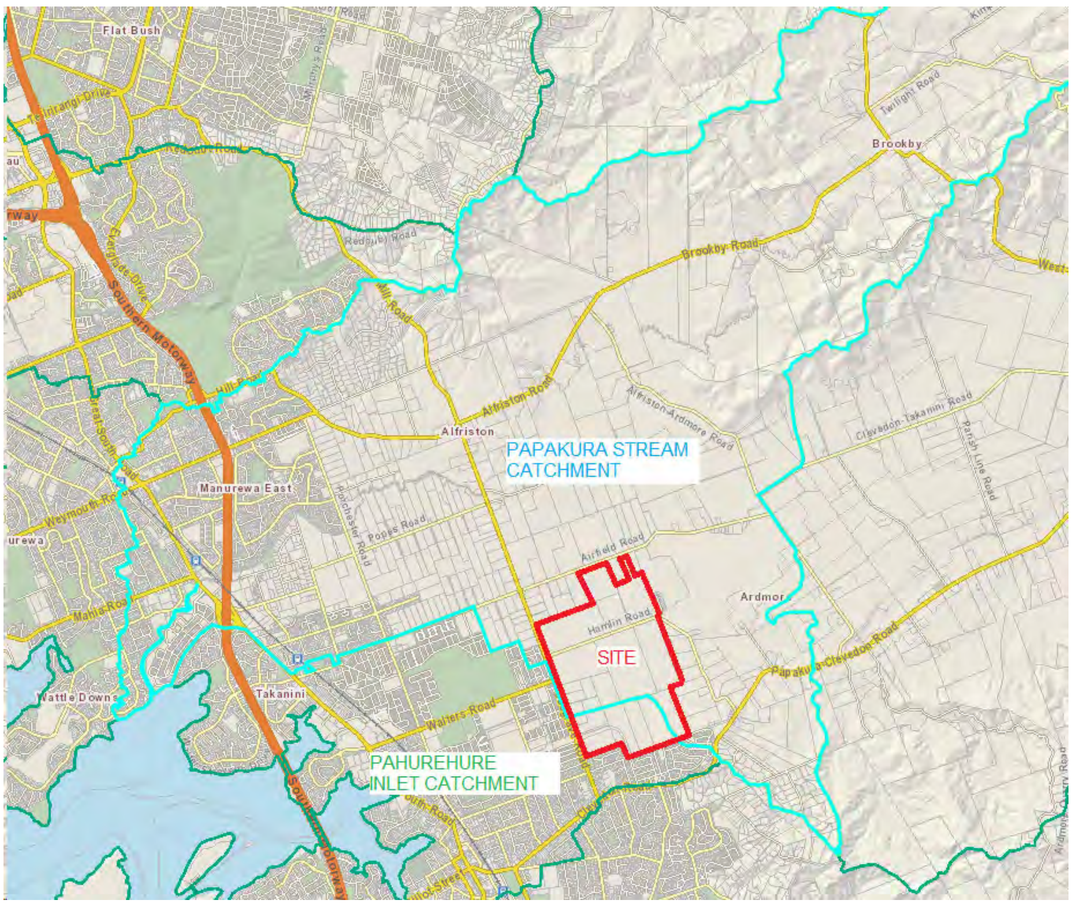


Figure 4: Stormwater Catchment Plan (Existing)

The site is located in the upper half of the Pahurehure inlet catchment and midway of the Papakura stream catchment. Refer to Figure 4 – Stormwater Catchment Plan. It is standard industry practice that attenuation should be avoided in the lower third of the overall stormwater catchment and encouraged in the upper half.

The location of the site in each of the catchment supports the use of attenuation for stormwater mitigation and the release of controlled stormwater discharge over a delayed/ extended period. The use of attenuating flows on-site will not create coincident peak flows with those from upstream catchments.

Stormwater attenuation and the release of controlled stormwater discharge over a delayed/ extended period decreases the velocity of stormwater exiting the site and limits downstream effects including erosion of channels and increased risk of flooding.

3.1.2 PROPOSED STORMWATER CATCHMENT

For stormwater analysis purposes, the site has been divided into four catchments – Catchments A, B,C, D. In the Stormwater Modelling Report Catchment A is identified as Western Catchment and Catchment B,C,D & E is identified as the Eastern Catchment.

Refer to Figure 5A & 5B (or **Appendix A**) below for pre and post-development stormwater catchment plan for the 1% AEP storm event.

Catchment A (Diverted from Papakura Stream Catchment to Pahurehure Inlet Catchment) encompasses all land south of the Hamlin Road realignment. Post-development Catchment A discharges to the TSWCC and ultimately to the Manukau Harbour.

Catchment B (will continue to discharge to Papakura Stream Catchment) features a portion of land north of the Hamlin Road realignment. Post-development Catchment B discharges north to 526 Mill Road & 237 Airfield Road, this discharge point will be referred to as “Northern Outflow 1”.

Catchment C (will continue to discharge to Papakura Stream Catchment) relates to the existing upstream catchment from which overland flow traverses the site. Post-development Catchment C discharges to Northern Outflow 1.

Catchment D1 (will continue to discharge to Papakura Stream Catchment) encompasses of land between Airfield Road and Catchment B. Post-development Catchment D discharges to Airfield Road, this discharge point will be referred as “Northern Outflow 2”.

Catchment D2 (will continue to discharge to Papakura Stream Catchment) encompasses of land between Airfield Road and Catchment B in north-eastern portion of the site. Post-development Catchment D discharges to Airfield Road, this discharge point will be referred as “Northern Outflow 3”.

The Hamlin Road realignment is considered the best location for stormwater catchment delineation. Hamlin Road will become a key collector road linking the development site and the industrial land to the east to the existing urban area to the west. It is preferable not to have stormwater flows crossing a main road. The proposed road level will be raised above the floodplain to provide safe vehicle egress and help direct flood flows away from Hamlin Road during storm events (to the north and south discharge points).

Figure 5A –Pre – Development Stormwater Catchment Plan for 1% AEP storm event

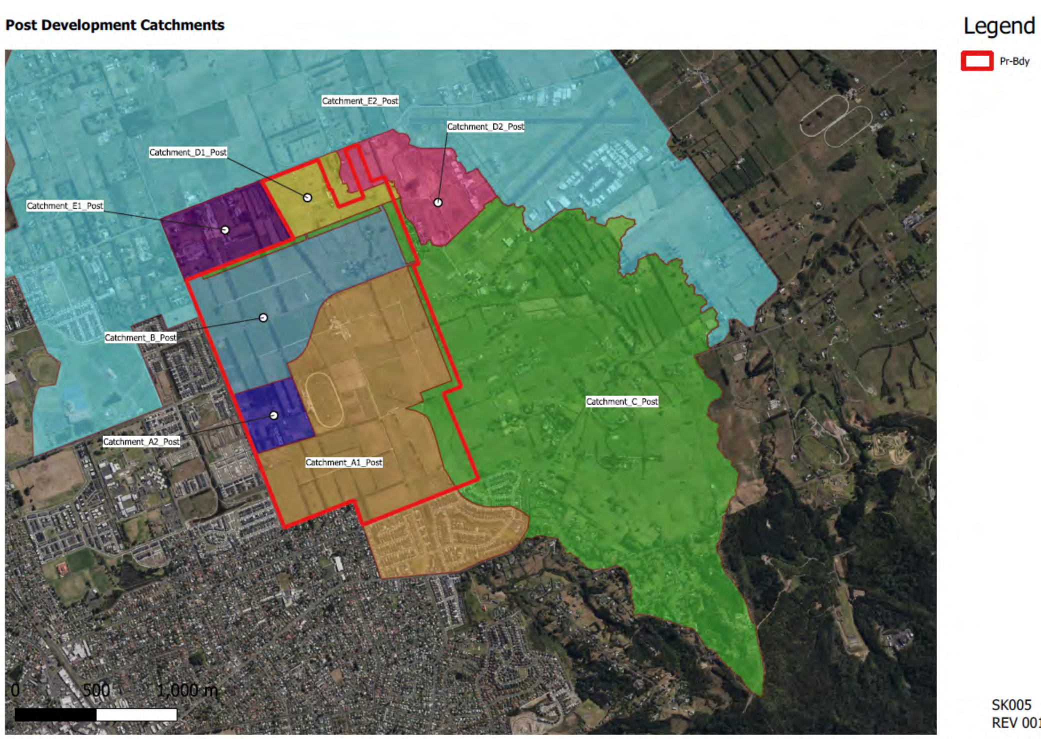


Figure 5A - Post – Development Stormwater Catchment Plan for 1% AEP storm event

3.2 FLOOD MITIGATION

3.2.1 100 YEAR FLOOD FLOWS

The flood management approach is to manage flood hazards within the subject site and to not worsen flooding effects upstream and downstream of the project site.

The site is low lying and is contained within the 100 year flood plain as identified within Auckland Council Geomaps. The flood plain encompasses the majority of the Takanini/ Papakura area.

Stage 1 of the TSWCC was recently commissioned by Healthy Waters and provides stormwater servicing and flood management to land parcels west of Cosgrave Road.

Stage 2 and 3 of the TSWCC are to be constructed in the future and will provide stormwater servicing and floodplain management for the FUZ land within the site.

There is currently no stormwater servicing of the Mixed Rural Zoned (MRZ) land, currently this land would naturally recharge via localised ponding/ flooding with overflow (via sheet flow) during larger storm events to Papakura Stream to the north of the site.

Refer to Image 6A & 6B below which shows the current extent (assumes FUZ Zone is developed) of flooding over the site in a 1% AEP storm event.

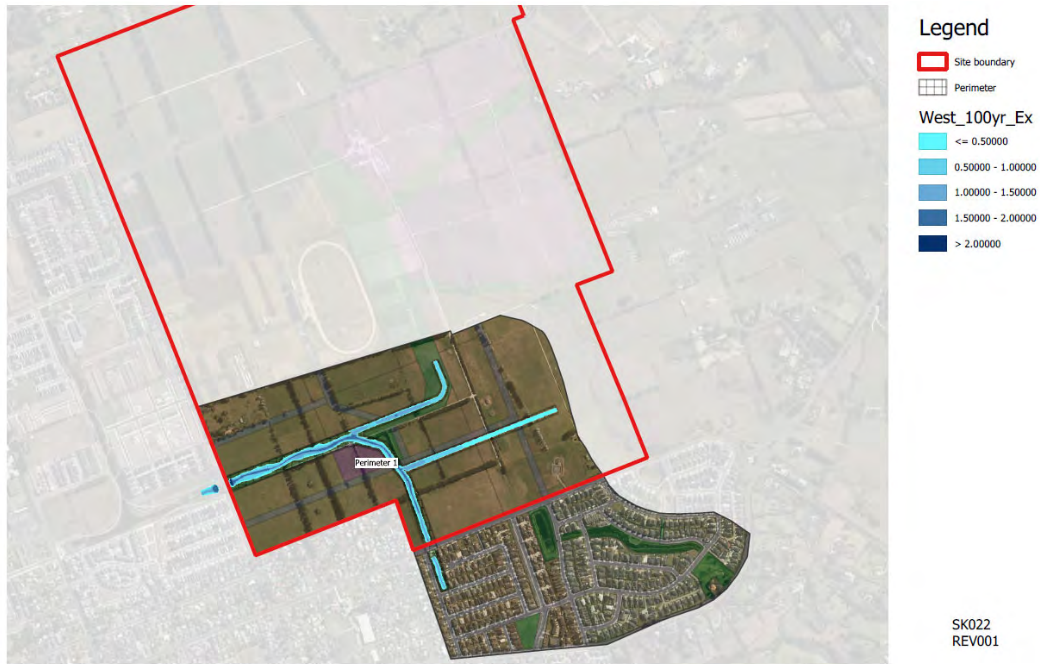


Figure 6A- Pre-development (Assumes FUZ – developed scenario) extent of flooding in Catchment A for 1% AEP storm event

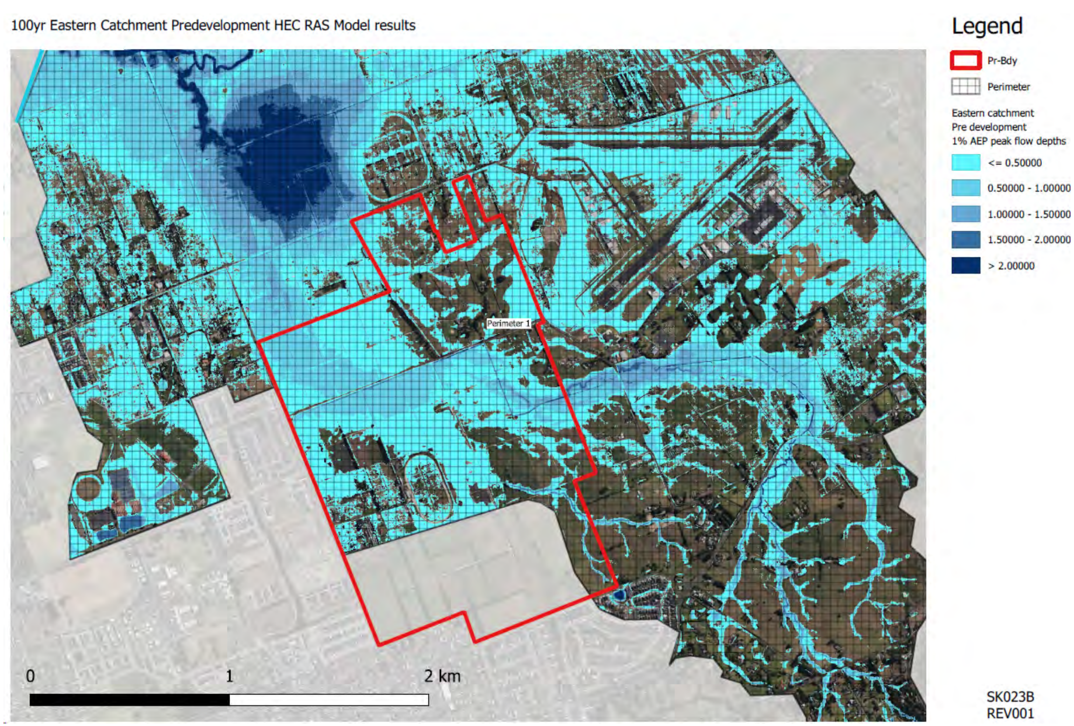


Figure 6B- Pre-development extent of flooding in Catchment B,C & D for 1% AEP storm event

The Three Waters Strategy addresses flooding in the MRZ land by providing the following attenuation stormwater management devices for each Catchment:

Catchment A:
-Extension to the Awakeri Wetland/TSWCC Stage 4.
-A dry pond referred to as “Stage 4 Dry Pond”.
-Secondary stormwater swales within FUZ land.

Catchment B & C:
-Conveyance channel to redirect upstream SW catchment around perimeter pf the proposed development.
-Wetland/pond referred to as “Northern Wetland”
-A dry pond reffered to as “Northern Dry Pond”

Catchment D2:
-Wetland/pond reffered to as “Pond 208”.

These stormwater management devices are detailed later within the report respectively to their Catchments.

The TSWCC and other public stormwater devices will control the 100-year flood level of the surrounding area by containing flood flows up to the 100 year capacity within the proposed channel corridor, effectively removing the floodplain from the reminder of the site.

Refer to Image 6D & 6E below which shows the predicted extent of inundation after stormwater mitigation.

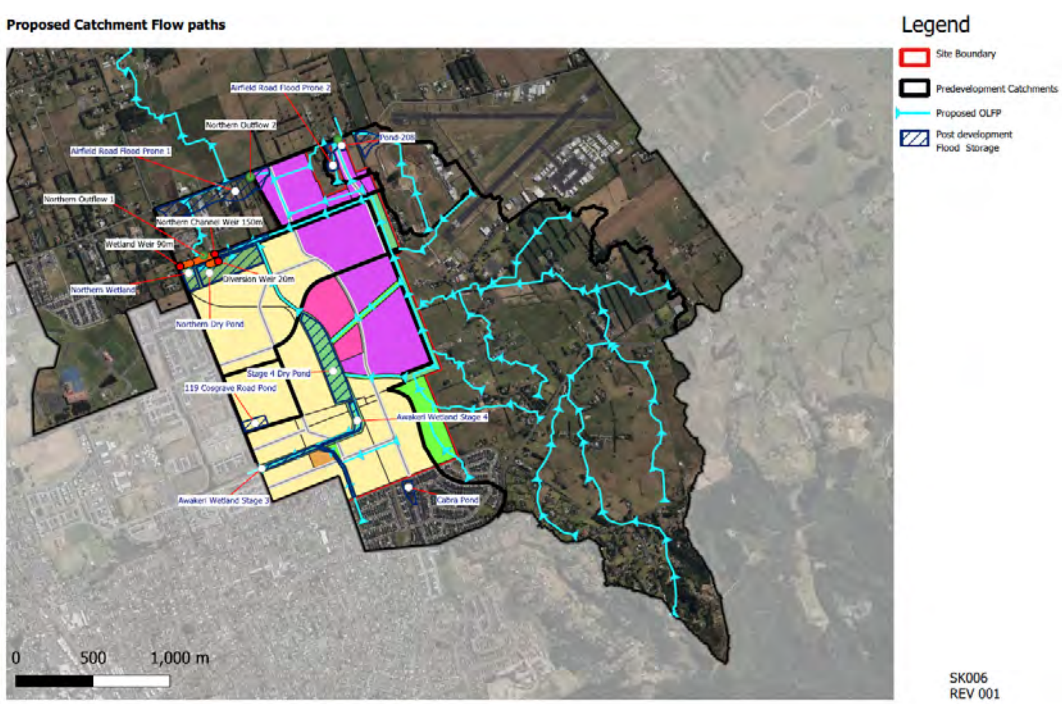


Figure 6C- Stormwater Management Devices and Proposed Catchment Flow paths for 1% AEP storm event

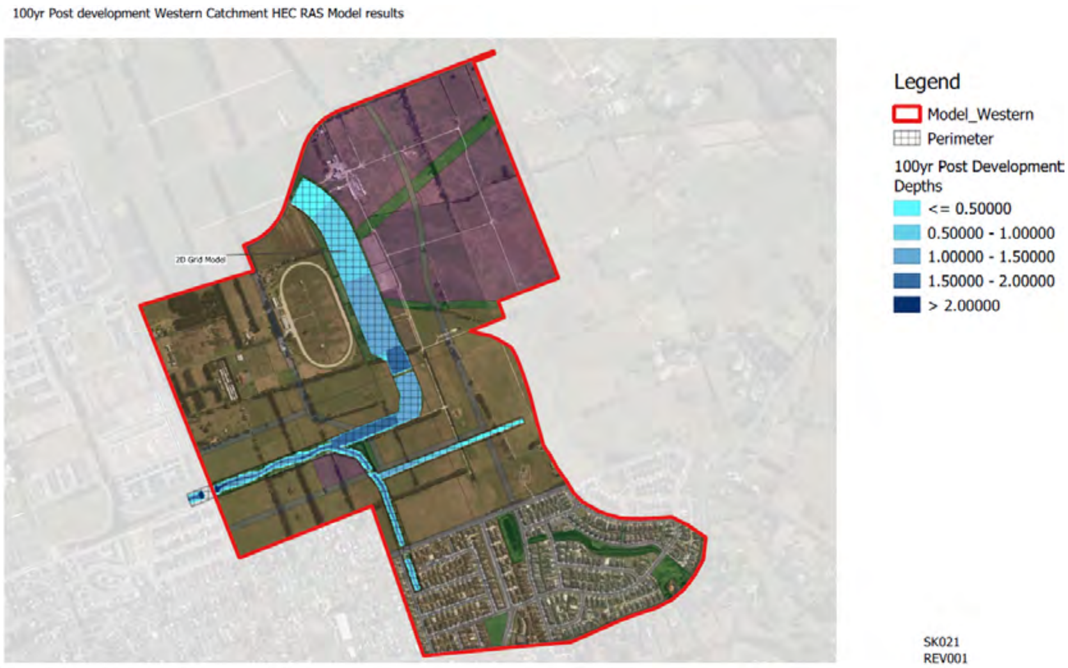


Figure 6D- Takanini Stormwater Conveyance Channel and proposed extensions

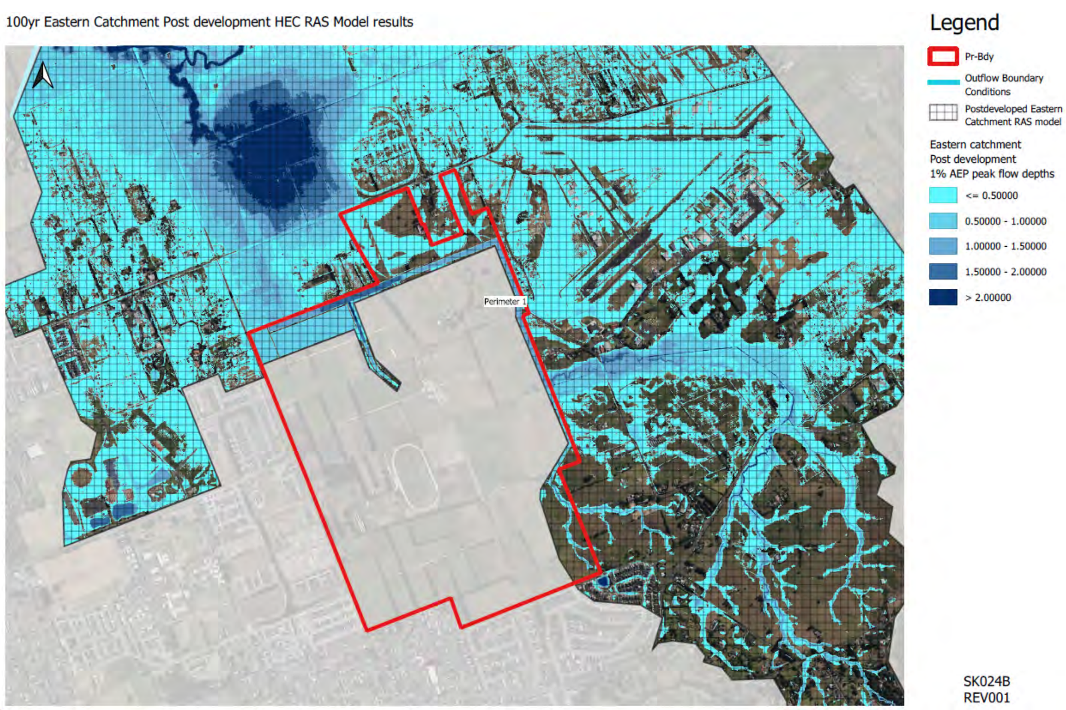


Figure 6E - Takanini Stormwater Conveyance Channel and proposed extensions

For analysis contained within this report stormwater modelling has focused on the 100 year flood flows and associated flood levels, the 10 year flows and associated flood levels will be modelled at detailed design stage and will be a proportion of the 100 year flow.

A full Stormwater Management Plan (SMP) including a detailed flood hazard assessment will be prepared and submitted as part of the future consenting process.

3.2.2 10 YEAR FLOOD FLOWS

Within both the FUZ land and MRZ land (the development land) secondary stormwater swales have been incorporated into the design to convey stormwater flows from rain fall events to the communal stormwater devices (TSWCC extension and proposed Wetland Pond B) and also provide additional attenuation for the 100-year rain event when required.

The stormwater swales will convey flows from the development site to the public stormwater devices. Each stormwater channel will be 1.5 – 1.8m deep with base widths 3 – 10m, side slopes will be 1:3 batters with overall channel widths ranging from 17- 22m.

The 10 year pipe reticulation will be designed to outfall to either the stormwater swales or directly to the main conveyance channel where possible. The primary 10 year reticulation network will be installed to the invert of the channels with ground levels raising away at gradients similar to pipe gradients to maintain pipe cover.

This design principle has been used on sites adjacent to the existing Stage 1 conveyance channel where there was limited cover and fall to maintain minimum ground cover as per the SWCOP (some surcharge in the pipe networks were considered acceptable).

Detailed engineering design of the 10 year pipe reticulation including exact alignment and levels are to be confirmed with Auckland Council and Healthy Waters as part of the future consenting process.

The 10 year flood levels will be modelled at detailed design stage and will be a proportion of the 100 year flow depth. It is envisaged the 10 year flows will be restricted to the lower portions of the TSWCC extension and proposed Wetland Pond B, with limited backflow into the secondary stormwater swales and/or the stormwater pipe reticulation.

For Catchment A - 10 year flood levels will be restricted to the 100m wide (600m long) main channel in the lower 0.5m. For Catchment B - 10 year flood levels will be restricted in the lower 0.5m of the proposed northern wetland and northern dry pond.

For stormwater modelling purposes, although initial stormwater runoff recharges directly to ground before overflowing to the public network, no initial abstraction (decrease in initial runoff) has been used for stormwater modelling purposes (assume full saturation during 100 year event).

It is likely however that a portion of stormwater discharge during rainfall events up to and including the 10 year event would recharge to ground via the recharge pits prior to discharge to the reticulation network and public stormwater devices.

3.3 ONSITE STORMWATER MITIGATION

A geotechnical review of the development site has indicated that peat soils are present throughout the majority of the site and therefore stormwater recharge of the ground will be required wherever impervious area is proposed.

Geotechnical investigations recorded groundwater depths ranging from 1.5m to 3m below ground level. In order to maintain the groundwater levels as close to their current state as possible, recharge pits will be installed to allow recharge of the peat soils. Recharge pits will be installed wherever impervious surfaces are proposed to capture runoff and infiltrate into the peat to recharge the localised groundwater table.

Recharge pits will be designed to retain the stormwater runoff from all impervious areas from the first 15mm of any rainfall event. Recharge pits will be designed as per the Auckland Council guidance document GD07 - Stormwater Code of Practice and Stormwater Soakage and Groundwater Recharge in the Auckland Region.

The retention provided by the the recharge pits will provide hydrological mitigation via supporting stream baseflows and reducing erosive flows during small storm events.

Recharge pits will be installed as part of each lot specific development. Preliminary calculations have indicated that onsite recharge pits for each lot would entail a 4.7m² below ground recharge pit for every house, based on 150m² impervious area per lot. (100m² roof captured and 50m² pavement) Refer **Appendix B.**

Recharge pits will also be installed as part of the public road design located adjacent to proposed catchpits, based on impervious areas typically ranging from 100m² up to 1,000m².

3.4 STORMWATER QUALITY TREATMENT

Stormwater runoff from the development will achieve a high level of stormwater quality treatment. This will be provided via stormwater management devices mainly consistent with the requirements of Auckland Council guidance document GD01 - Stormwater Management Devices.

Stormwater quality will be achieved via a stormwater treatment train. Primary treatment of stormwater will occur at the source, via use of non-contaminating building materials, grated catchpits and inlets to stormwater, gross pollutant filters such as tetra traps within catchpits to ensure a high quality of stormwater recharge into the underlying peat soils (via recharge pits).

Roof water is generally considered clean when non-contaminant generating roofing material is used and will discharge directly into recharge pits located on individual sites. Runoff from public roads will be captured by a catchpit fitted with a 'tetra trap' or similar over the outlet pipe before overflow to the reticulated pipe network. This will help prevent coarse sediment and other gross pollutants entering the recharge pits. Although tetra traps do not provide GD01 level of treatment as per the NDC requirements, their use is currently standard practice in peat land areas and is considered the Best Practical Option.

Secondary treatment will be provided via stormwater swales which will collect runoff from the development before discharge into the TSWCC. The stormwater swales will capture and treat stormwater flows via planting and weirs resulting in fine particle and sediment removal. The swales will also limit the number of outfall structures to the TSWCC and decrease erosion to the channel banks. The stormwater swales will convey 10-year and 100-year flows from within the site to discharge into the TSWCC and proposed Wetland B at a controlled rate. Each stormwater swale / channel will be up to 3m deep, have side slopes that are 1:3, batters and range in width from 10m to 20m.

For Catchment A, tertiary treatment will be provided by a combination of TSWCC and existing McLennan Wetland which is a public stormwater device that uses biological processes to provide sediment removal through enhanced sedimentation and biological uptake. The site is located within the overall McLennan Wetland catchment. The McLennan Wetland provides stormwater quality treatment for the zoned upstream land before ultimately discharging stormwater to Pahurehure Inlet.

For Catchment B, D & E tertiary treament will provided by wetlands. This will provide a high level of stormwater quality treatment before ultimately discharging to the Papakura Stream.

3.5 STORMWATER STRATEGY (CATCHMENT A)

The Post-development Catchment A (174ha) consists of the following components:

- Existing FUZ area (50ha) that flows to the TSWCC – Pre-development Catchment A.
- The MRZ area south of Hamlin Road (124ha) – part of Pre-development Catchment C (Papakura stream catchment).

Due to the increase in catchment area for the post development scenario flowing to the TSWCC, the Stormwater Strategy proposes that Catchment A peak flows be attenuated to those allowable under the development of the FUZ land (being the permitted development baseline).

3.5.1 STORMWATER ATTENUATION

Overall stormwater flow (QA) from Catchment A (174ha) post development will be attenuated to the same unattenuated flow anticipated from the development of the FUZ land (50ha).

Detailed design has been undertaken by Healthy Waters into the development of the TSWCC. Work done by Healthy Waters, Hill Young and Cooper and GHD have set the parameters and constraints to consider for the upstream development. The proposed culvert system under Cosgrave Road (referred to as Stage 2) has a peak flow of 23m^3/s.

Stormwater attenuation will limit stormwater runoff from both the FUZ and MRZ land, plus the upstream catchment which also drains to the Stage 3 TSWCC to the peak flow of 23m^3/s, specifically by providing additional stormwater storage during rainfall events up to and including the 100 year event in both zones (previously the FUZ land had no requirement for stormwater attenuation and drained directly to the TSWCC).

Stormwater attenuation will be provided by incorporating communal public attenuation devices provided within the development site in the form of an extension to the Awakeri Wetland /TSWCC (Stage 4), dry pond and secondary stormwater swales within FUZ zone. These stormwater management devices are detailed further below in sections 3.5.3 and 3.5.4.

3.5.2 DOWNSTREAM STORMWATER EFFECTS

Stormwater attenuation will prevent any increase in peak flows resulting from future land use changes/ increase in impervious surfaces. By restricting flows at the Cosgrave Road culvert to that anticipated under the development of the FUZ land, there will be no potential downstream backwater effects on the existing TSWCC stages.

There will be no increase in water levels or flood levels in the downstream sections of the TSWCC or on the existing adjacent development's local stormwater network.

Attention is commonly avoided in the lower third of the overall stormwater catchment and encouraged in the upper half, as it is likely to create coincidence of flood peaks that would worsen the downstream flooding and increase flood risk upstream. The location of the site is in the upper half of the catchment and will therefore not create coincident peak flows.

There will be no increased risk of flooding from displaced flood storage as compensatory flood storage will be provided within the TSWCC Stage 4 extension and additional stormwater swales proposed as part of this stormwater strategy, which have been designed to have capacity to contain 100- year flood flows.

3.5.3 TAKANINI STORMWATER CONVEYANCE CHANNEL

The TSWCC will control the 100-year flood level in the area by containing the 100-year flood flows within the proposed channel corridor, effectively removing the floodplain from the surrounding area.

Stage 1 of the TSWCC was recently commissioned by Healthy Waters which provides stormwater servicing to land parcels west of Cosgrave Road. The recent extreme storm events in Auckland which generated rainfall in excess of a 1% AEP event (atleast 1 in 200 year) provided a means of testing the performance of the already constructed and operational Stage 1 of TSWCC. OLFPs were conveyed within the road network and discharged into the existing TSWCC. The TSWCC performed as designed with the flood hazards being contained and conveyed within the TSWCC. The proposed Stage 3 and 4 of TSWCC which will service the Catchment A area and will be designed to the same standards. This provides validation that the stormwater management approach adopted for the extension of the TSWCC can perform in real life scenario and perform to withstand rarer storm events.

SDL has reached an agreement with Auckland Council to undertake the design and consenting of Stage 2 and 3 of the TSWCC. It is envisaged the construction of the channel will be completed in 2026.

Stage 2 and 3 of the TSWCC will provide stormwater servicing for the FUZ land. Detailed engineering plans have been prepared and are currently available. The TSWCC Stage 3 entails a 40m wide channel up to 3m in depth with a low-level permanent stream and batters ranging from 1:3 to 1:5 to ground level.

To provide stormwater servicing of the remainder of Catchment A (part MRZ land) an extension to the Awakeri Wetland/TSWCC (Stage 4) and a dry pond is proposed. The proposal is for a 40m wide channel extension to the northern border of the FUZ land, and a 100m wide extension through the MRZ land. Refer to Figure 7- Takanini Stormwater Conveyance Channel Location Plan.

The extension will be 2m deep and have 1:3 batters on each side. It is envisaged that weirs will be incorporated between the 40m and 100m sections to ensure that flows are adequately restricted through each stage and prevent any downstream tailwater effects.

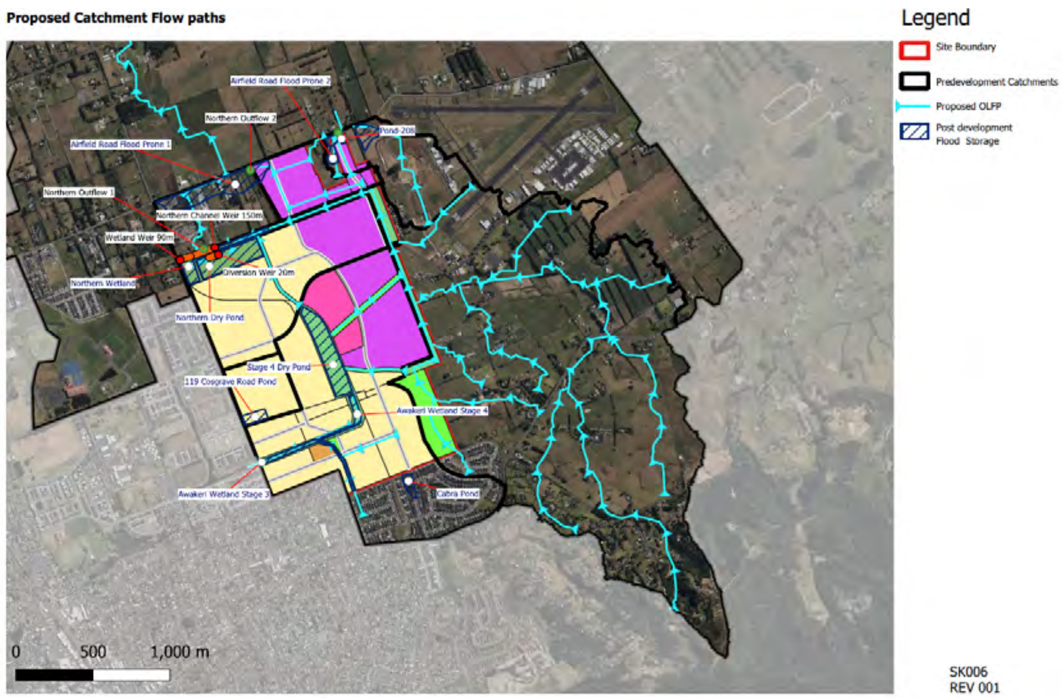


Figure 7- Takanini Stormwater Conveyance Channel Location Plan – proposed Stage 4 Extension

Detailed engineering design, including exact alignment and levels are to be confirmed with Auckland Council and Healthy Waters as part of the future consenting process.

3.5.4 ADDITIONAL STORMWATER SWALES

Within the FUZ land land secondary stormwater swales have been incorporated into the overall masterplan to convey stormwater runoff from rain fall events up to the 10-year event and also provide additional storage for the 100-year flood flows.

The stormwater swales will convey flows from the development area to the centralised main conveyance channel. Each stormwater channel will be 1.5 – 1.8m deep with base widths 3 -10m. side slopes will be 1:3 batters with overall channel widths ranging from 17- 22m.

The 10 year pipe reticulation will be designed to outfall to either the stormwater swales or directly to the conveyance channel where possible. The primary 10 year reticulation network will be installed to the invert of the channels with ground levels raising away at gradients similar to pipe gradients to maintain cover where necessary.

Detailed engineering design, including exact alignment and levels are to be confirmed with Auckland Council and Healthy Waters as part of the future consenting process. A schematic showing finished ground levels and channel/ swale gradients is in **Appendix A**.

3.5.5 ASSOCIATED EARTHWORKS

A large volume of excess peat soil will be generated from the construction of the TSWCC Stage 3. The proposed Stage 4 extension will also generate a lot of excess peat soils. To create an earthworks balance onsite it is proposed to raise the road profile of Hamlin Road.

Raising of Hamlin Road will provide safe vehicle egress by directing stormwater flood flow away from Hamlin Road during storm events. This will also help the hydraulic gradients for the conveyance channel extension (Stage 4) and associated stormwater swales.

The maximum proposed fill is approximately 1.5m which should not have implications on settlement of the peat soils. Fill areas will be monitored for settlement and will likely have preload. Preloading and monitoring requirements will be confirmed from the geotechnical engineer as part of future works.

The TSWCC extension and stormwater swales proposed as part of the stormwater strategy are limited to 2m depth maximum, with the main channel extension proposed at 2m deep and contributing stormwater swales ranging from 1.5-1.8m in depth.

Limiting the depth of cut onsite will mitigate any potential impacts on ground water on the surrounding land. Under Stage 1 of the TSWCC only areas which were more than 3m in depth required additional mitigation to prevent dewatering of adjacent land. All proposed channels are less than 2m and therefore it is considered that any impacts on ground water levels will be negligible.

3.6 STORMWATER STRATEGY (CATCHMENT B,C,D & E – PAPAKURA STREAM CATCHMENT)

Overall stormwater flow from Catchment B (70ha) postdevelopment and Catchment C (374ha) undeveloped will be attenuated to existing predevelopment levels.

Stormwater attenuation will limit stormwater runoff to the pre-development levels by providing additional stormwater storage during rain fall events up to and including the 100year event.

Stormwater attenuation will prevent any increase in flows resulting from future land use changes/ increase in impervious surfaces associated with the development of the site.

It is standard industry practice that attenuation should be avoided in the lower third of the overall stormwater catchment and encouraged in the upper half. The location of the site is in the upper half of the catchment and will therefore not create coincident peak flows.

There will be no increased risk of flooding from displaced flood storage as compensatory flood storage will be provided within the proposed wetland pond and stormwater swales which have been designed to contain 100-year flood flows.

3.6.1 STORMWATER STRATEGY (CATCHMENT B – PAPAKURA STREAM CATCHMENT)

The post-development Catchment B (70ha) consists of the following components:

- 70 ha of MRZ area north of Hamlin Road.
- Stormwater discharged to stormwater wetland pond ("Northern Wetland") providing attenuation volume of 13,800m^3 and dry stormwater pond ("Northern Dry Pond") providing attenuation volume of 40,500m^3 for the 100yr storm event .
- Stormwater runoff will continue to discharge the north to the Papakura Stream. Stormwater Mitigation Hydraulic Modelling using HEC-RAS has determined existing pre-development peak flow for Catchments B and C dicharging at Northern Outflow 1 of 44.97 m^3/s.

Catchment B is approximately 70ha and is entirely zoned MRZ. Post-development Catchment B (70ha) will continue to discharge stormwater to the north and onwards to the Papakura Stream.

Post development 100 year flows are proposed to be attenuated to existing pre-development levels via a wetland and dry a pond and a secondary stormwater swale which will convey flows from the catchment to the wetland pond.

The Northern Wetland provides a 100yr storm event attenuation volume of 13,800m^3 and provides 6,900m^3 for stormwater quality. The Northern Dry Pond provides 100yr storm event attenuation volume of 40,500m^3. The Northern Dry Pond is directly connected to and has the same invert level as the engineered swale/weir located on the northern boundary of the site (proposed as part of Catchment C). These stormwater devices combine to provide attenuation of rain fall events up to and including the 100 year event for both Catchment B and C.

Stormwater attenuation for smaller rainfall events up to the 10-year event will be attenuated within the lower base of Dry pond with flows from higher rainfall events utilising the secondary stormwater swale. The Northern Wetland and Dry Pond will remain shallow (1.5 m maximum in depth) to remain above ground water levels and will be approximately 175m x 93m and 421 x 135m respectiviely.

3.6.2 STORMWATER STRATEGY (CATCHMENT C - UPSTREAM) – PAPAKURA STREAM CATCHMENT)

Stormwater runoff from upstream Catchment C (374ha) currently flows through the development site via overland flow during larger rain events. It is proposed to redirect this flow along the eastern perimeter of the site via an engineered swale. Refer to Figure 8- Overland Flowpath Diversion Swale.

HEC- RAS calculations have determined that the proposed channel will require an area ranging from 20-40m wide and will encompass a trapezoid shape up to 1.5m deep. This engineered swale will be formed with a low flow channel representing a natural stream during final design.

Once the swale reaches the northern boundary it is proposed to continue the swale along the northern site boundary at a flat grade to form a basin with a level spreader outlet structure, whereby stormwater would pond before overflowing to the north via controlled sheet flow over the level spreader at the existing pre-development flows.

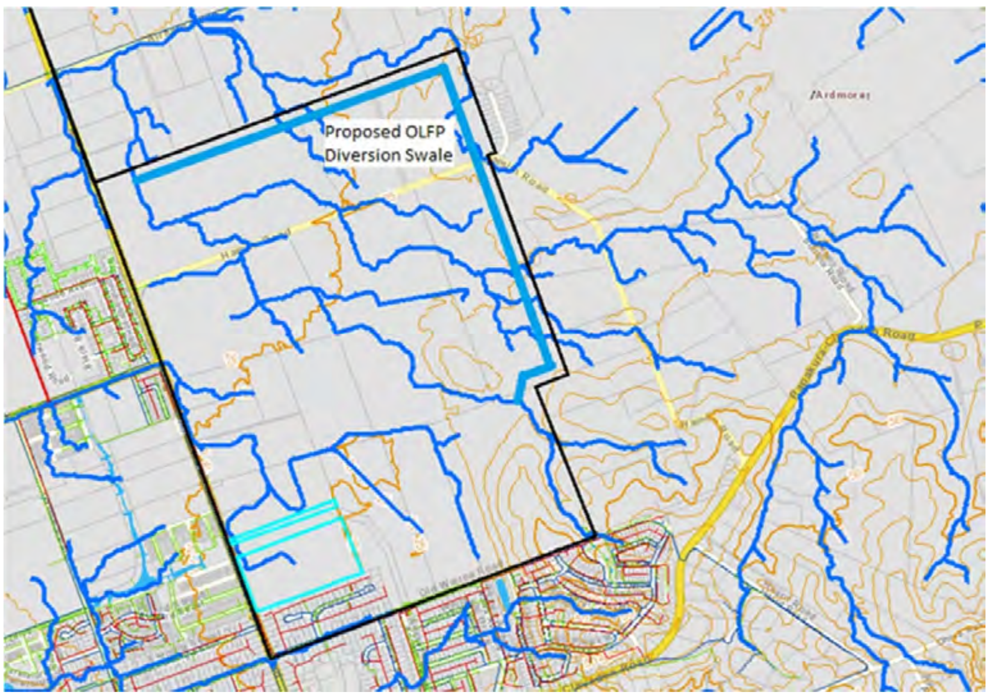


Figure 8 - Overland Flowpath Diversion Swale

The interface from the eastern boundary to northern boundary will incorporate specific erosion control with a raised turnout area to ensure stormwater flows do not overtop the channel during larger storm events as per Figure 9 below.

Auckland Council Geomaps identifies two permanent watercourses which traverse the site east to west, which discharge into the Hamlin Road table drain before exiting into the Cosgrave Road table drain (western side). Onsite these watercourses are in the form of artificial farm drains.

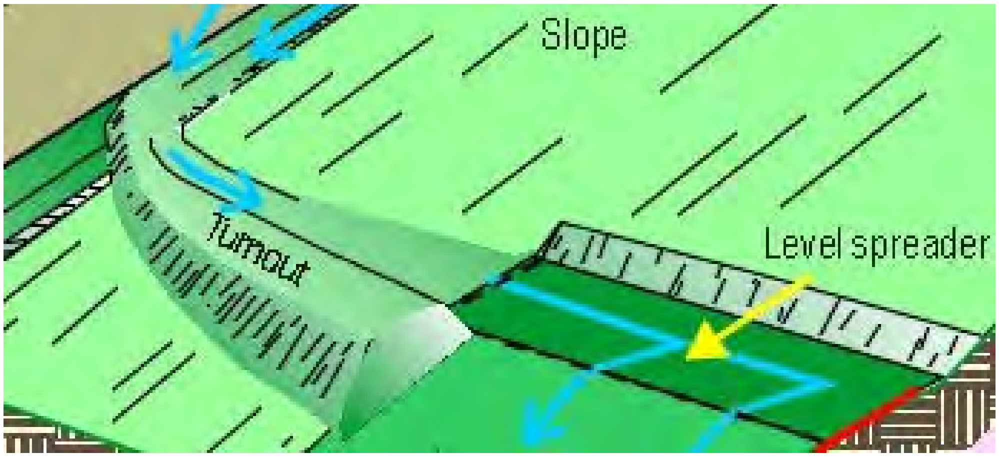


Figure 9 - Level Spreader Example

The Stormwater Strategy proposes to redirect these flows via an engineered swale along the eastern boundary of the subject site and discharge to the existing overland flow exit point to the north and onwards to Papakura Stream.

The stormwater 100yr flows within the channel are designed to have minimum 500mm freeboard to finished floor level of any habital buildings in the adjcent neighbouring properties.

The proposed alignment intercepts all stormwater runoff from the adjacent upstream land to be captured and conveyed through a grass channel along the outer boundary. It is likely that the low flow will form a permanent natural steam shape, with large riparian banks either side to cater for larger storm events.

3.6.3 STORMWATER STRATEGY (CATCHMENT D1)

Catchment D1 is approximately 22ha and is entirely zoned Industrial/employment. Post-development Catchment D1 (22ha) will continue to discharge stormwater to the north ("Northern Outflow 2") and onwards to the Papakura Stream.

The predevelopment catchment is 73.8ha and postdevelopment catchment is 22ha. The decrease catchment results in the post-developent 100yr peak flow rate reducing from 10.26m^3/s to 7.26m^3/s and therefore no attenuation is required for Catchment D.

3.6.4 STORMWATER STRATEGY (CATCHMENT D2)

Catchment D2 is approximately 36.6ha and is entirely zoned Industrial/employment. Post-development Catchment D2 (36.6ha) will continue to discharge stormwater to the north ("Northern Outflow 2") and onwards to the Papakura Stream.

The predevelopment catchment D2 is 36.4ha and postdevelopment catchment is 36.6ha. The increase in catchment and the impervious catchment requires dry pond to limit the 100yr peak peak flow rate. A dry pond is proposed to provide 2,630m^3 of attenuation volume to limit 100yr peak flow below pre-development flow rate of 0.72m^3/s.

3.7 SUMMARY OF STORMWATER MODELLING

Stormwater Mitigation Hydraulic Modelling has been undertaken by Maven, refer to **Appendix C** for detailed report.

Below are are summary of the stormwater modelling results:

Catchment A - Discharge to TSWCC			
	Pre-development	Post-	Change
Catchment Area	93.5 Ha	173.8 Ha	80.3 Ha
10% AEP (10yr ARI) Peak Flow	14.6 m^3/s	14.6 m^3/s	
1% AEP (100yr ARI) Peak flow	23.0 m^3/s (Not Pre-development but design parameters provided by HW for the existing TSWCC.	22.7 m^3/s	
10% AEP (10yr ARI) Attenuation Volume		51100 m^3	
1% AEP (100yr ARI) Attenuation Volume		85,700 m^3	
Catchment B & C - Northern Outflow 1			
	Pre-development	Post-	Change
Catchment Area	472.7 Ha	443.3 Ha	-29.4
10% AEP (10yr ARI) Peak Flow	21.31 m^3/s	20.37 m^3/s	-0.94
1% AEP (100yr ARI) Peak flow	44.97 m^3/s	43.99 m^3/s	-0.98
10% AEP (10yr ARI) Attenuation Volume		54,300 m^3	
1% AEP (100yr ARI) Attenuation Volume		46,400 m^3	
Catchment D1 - Northern Outflow 2			
	Pre-development	Post-	Change
Catchment Area	73.8 Ha	22.4 Ha	-51.4
10% AEP (10yr ARI) Peak Flow	5.66 m^3/s	4.86 m^3/s	-0.80
1% AEP (100yr ARI) Peak flow	10.26 m^3/s	7.26 m^3/s	-3.00
10% AEP (10yr ARI) Attenuation Volume		No	
1% AEP (100yr ARI) Attenuation Volume		No	
Catchment D2 - Northern Outflow 3			
	Pre-development	Post-	Change
Catchment Area	36.4 Ha	36.6 Ha	0.2
10% AEP (10yr ARI) Peak Flow	0.38 m^3/s	0.37 m^3/s	-0.3
1% AEP (100yr ARI) Peak flow	0.72 m^3/s	0.65 m^3/s	-0.7
10% AEP (10yr ARI) Attenuation Volume		1,580 m^3	
1% AEP (100yr ARI) Attenuation Volume		2,630 m^3	

3.8 EROSION RISK MANAGEMENT

Unless carefully managed, urbanisation can lead to adverse stream bank erosion effects due to the increased runoff rate and volume. Mitigation measures (such as increased detention, flood plain management or in-stream works) may be required to manage these when there are already bank erosion and stream stability issues in the downstream watercourses.

The scale and severity of this requires more detailed geomorphological assessment as a part of engineering design, and so will be addressed within future consenting.

Erosion susceptibility is typically mitigated through retention of post-development stormwater flows. Retention requires a portion of flows to kept out of the stormwater network to reduce the risks associated with flash flows in regular small events. For the proposed development, the hydrological mitigation to the flash flows provided are provided through the retention that is being provided for ground water recharge of 15mm runoff depth for all impervious area. This is greater level of retention than the 5mm retention that is set out by AUP frame work(Chapter E10) SMAF hydrological requirements. In addition, the improvements to the riparian plantings are also expected to improve bank erosion vulnerability.

4.0 WASTEWATER AND WATER SUPPLY

4.1 CURRENT WASTEWATER CONTEXT

Watercare Services are tasked with servicing the greater Auckland region with both wastewater and potable water supply. The only area of Auckland to which this applies to a lesser extent is Papakura. Within this area Watercare are responsible for the overall network and trunk mains, whilst Veolia Water operate the local network.

Wastewater generated by the existing activities within the development area is treated through septic tanks.

The surrounding developed residential areas dispose of wastewater via Low-Pressure Sewer (“LPS”) system and gravity reticulation to the existing 525mmØ Takanini Branch Sewer line located on Walters Road on the eastern boundary of Bruce Pullman Park. The transmission line traverses northwest and discharges into the transmission pump station located at the Wattle Farm Ponds Reserve in Manurewa. From there, the transmission network continues to traverse northwest and ultimately discharges into the Māngere Wastewater Treatment Plant.

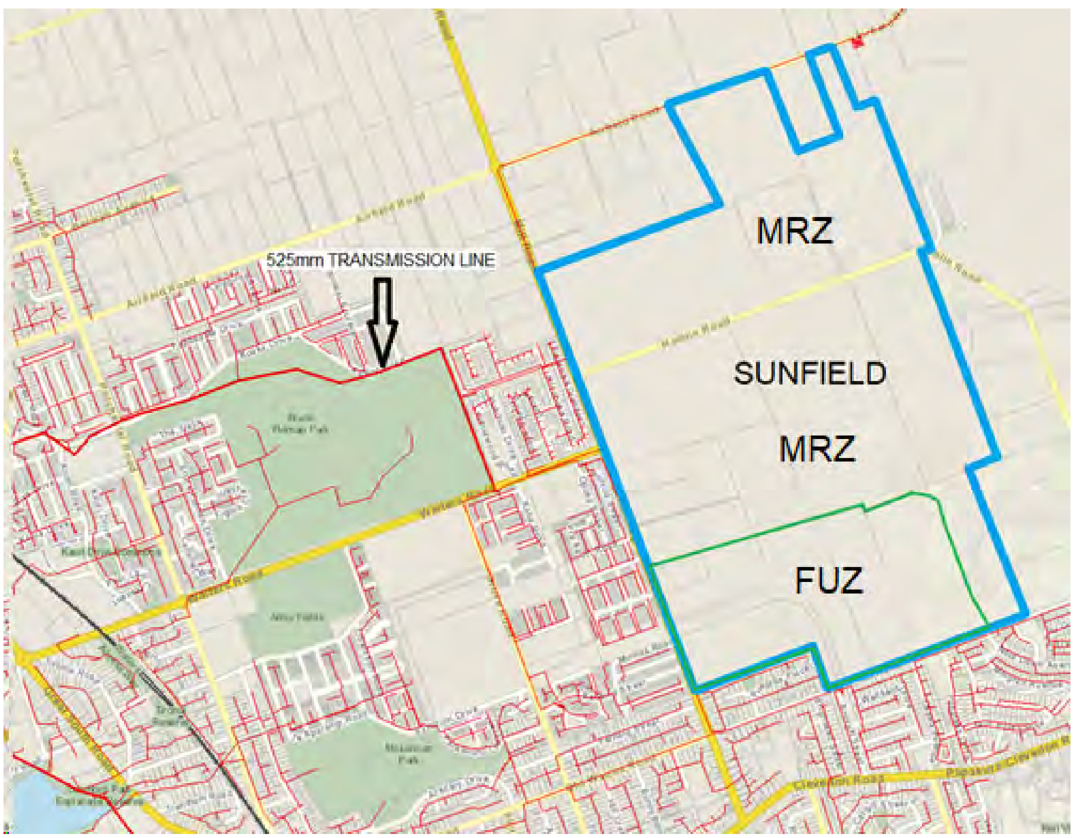


Figure 10: Existing Wastewater assets

4.2 PROPOSED WASTEWATER STRATEGY

Wastewater discharge from the developed catchment will be restricted to the allowable discharge anticipated under the development of the FUZ land to avoid adverse downstream effects.

Veolia and Watercare have confirmed that the existing Watercare Transmission network has capacity to service the peak wet weather flow ("PWWF") from the FUZ upon its development into 1,550 dwellings, this entails a PWWF of 64.91L/s. This has been calculated by taking 1550 household units (as shown in the FUZ masterplan) and calculating wastewater disposal as per Watercare standards, using PWWF (peak wet weather flow) factor of 6.7.

The proposed wastewater servicing strategy for the subject development site is to design and construct a Low Pressure Sewer (LPS) system. The final design will be detailed at engineering approval stage.

The wastewater network will provide wastewater reticulation within the development and will discharge flows to the downstream Takanini Branch Sewer (being the existing 525mmØ transmission line) via a new rising main along Cosgrave Road, Walters Road and Mill Road. Refer to attached engineering plans for the proposed wastewater network.

LPS systems are considered an acceptable alternative to the typical gravity wastewater disposal systems in areas that have:

- flat low-lying terrain,
- poor underlying soil quality, and
- a high water table.

The subject development includes each of these components. Its underlying low strength peat soils and high water table (which varies from 1m to 3m below the ground surface) have historically led to gravity wastewater networks 'dipping' and holding wastewater overtime and increases the risk of inflow and infiltration.

This is supported by evidence during the construction of the downstream Takanini Branch Sewer, whereby it was noted significant baseflows were entering the system due to the high ground water table.

LPS systems have been successfully implemented, and adopted by Watercare, in residential developments throughout Auckland including at the Kuaka Drive development of 210 lots and the Mill Road development of 330 lots both of which are located in close proximity to Sunfield.

Both of these developments utilise LPS due to the reasons outlined above (being flat ground structure, underlying ground conditions and high water table) and have been successfully operational for a number of years.

The incorporation of an LPS system greatly reduces the ultimate peak discharge. Without inflow and infiltration, the Watercare standards indicate that ADWF ("Average Dry Weather Flow") with an added capacity safety factor of 1.2 per dwelling unit can be used for discharge instead of the PWWF. Through the inclusion of an LPS system, the preliminary calculations for the demand for development is entails a flow of 57.63L/s which less than the 64.91L/s of capacity of network anticipated from the FUZ land.

Relevant wastewater demand calculations are contained within Figure 11.

This option would therefore provide wastewater servicing for the proposed development, keeping discharge below the existing downstream capacity.

This ensures that subject to the network extensions proposed, no downstream infrastructure upgrades are required to service the intended development.

4.3 LOW PRESSURE SEWER OWNERSHIP MODEL

For LPS systems Watercare has adopted the private pump ownership model. As such, all on-site installation responsibilities fall onto the property owner.

Under the private ownership model, the property owner is responsible for selecting and purchasing the grinder pump and associated on-property equipment usually from a list of pre assessed pumps defined by the system designer and approved by the Council.

Under this option, the property owner (or their representative, such as a residential builder or building company) is primarily responsible for the installation. The public reticulation from the point of supply, including the boundary kit is designed, installed, and vested in Council by the developer.

The publicly vested pressure reticulation network will be located in the public road reserve parallel to the property boundaries. Where a subdivision does not provide a dwelling with direct public road frontage a multi-kit box shall be provided.

A multi-kit box shall not house more than six individual boundary kits. Where more than six individual boundary kits are required for dwellings not fronted by a public road, a bulk point installation shall be used with individual private boundary kits located inside the property.

For industrial and commercial lots ‘custom’ storage tanks with multiple pumps can be installed. Further investigations with the supplier will be required for the design and use of the custom units.

4.3.1 MONITORING AND MAINTENANCE

The development will set up a residents society to monitor and maintain the LPS system. The monitoring and maintenance of the system will be controlled by a reputable supplier similar to Ecoflow which will use a OneBox/smart controller on each pump to control the pumps.

The smart controller allows the private pumps to ‘talk’ to each other and allows pumps to activate at different times. This allows the morning and evening peak flows to be decreased, decreasing the chance of any overflow.

Each smart controller will have an alarm to alert potential overflow and allow emptying as required. An uncommon issue is an extended power cut. The developments solar power energy supply would help prevent this issue. Monitoring and maintenance from a reputable supplier though a residents society would ensure potential overflow would not occur. A sucker truck can also be dispatched to empty private pumps systems to prevent overflow if necessary.

4.3.2 FLUSHING

Flushing will be provided for the LPS system at the subdivision staged occupancy rates of 30%, 50%, 80% and greater. The developer will provide the expected development occupancy fill rate. Based on the expected speed of development and flushing requirements the developer will be responsible for the flushing costs until an occupancy rate is achieved that will provide adequate self-cleansing flowrates in the pressure main.

The developer will fund these costs before connecting to the Watercare system and will also be control the residents society. A flushing programme with fresh water and/or injection of special chemicals will prevent any potential for Hydrogen Sulphide build up.

4.4 LOW PRESSURE SEWER SYSTEMS

As per Watercare's Code of Practice, the use of an LPS system will require approval from Veolia and Watercare. The LPS must be demonstrated to provide:

(a) Equivalent or lower life cycle cost to Watercare than other options.

The public reticulation will consist of shallow pressure mains and boundary kits located in the public road reserve. The overall network reticulation will be less than a standard gravity wastewater model which would incorporate pump stations and deep gravity lines requiring increased maintenance overtime.

(b) Costs passed onto homeowners are reasonable.

LPS systems place instalment and maintenance costs onto the property owners. Site purchasers will be aware of the installation costs, and this will be factored into sale prices. Ongoing maintenance costs will be minimal and be covered by the residents society which will levy owners.

(c) A reliable service in accordance with Watercare's customer charter so that failure of a component does not cause total system failure.

The development will set up a residents society to monitor and maintain the LPS system. The monitoring and maintenance of the system will be controlled by a reputable supplier similar to Ecoflow which will use a OneBox/smart controller on each pump to control the pumps to prevent system failure.

(d) Which site specific problems it will overcome and how.

The site contains low strength peat soils which have historically led to gravity wastewater networks 'dipping' and holding wastewater overtime. The risk of inflow and infiltration is high in peat soils, LPS systems create a sealed network eliminating inflow and infiltration.

(e) How the system will impact on the environment from events arising from system failures such as spills, power outage or pipe breaks and how the system mitigates these issues.

The residents society will ensure that the maintenance and operation of the LPS system will be ongoing and prevent owners not maintaining or replacing their private wastewater infrastructure causing system failure or overflow.

(f) A discharge point that can be integrated into the existing wastewater network.

The site is located less than 500m away from the 525mmØ transmission line located on Walters Road on the eastern boundary of Bruce Pullman Park, identified as the Takanini Branch Sewer. A connection to this line along Walter Road is feasible.

4.4.1 PEAK FLOWS

LPS systems create a sealed network eliminating inflow and infiltration reducing peak flow discharge. Without inflow and infiltration the Watercare standards determine that ADWF (average dry weather flow) be used for discharge instead of PWWF, an LPS safety factor of 1.2 is specified.

<u>**FUZ using Gravity/ Pumpstaiton**</u>			
Population	Dwellings	People	Occupancy
Permitted Discharge	1550	3	4650
Permitted Discharge	Persons	Rate l/p/day	Flow l/s
ADWF	4650	180	9.69
PDWDF	4650	540	29.06
PWWF	4650	1206	64.91 l/s
<u>**Development Site using LPS**</u>			
Residential/ Retirement	Dwellings	People	
	4000	3	
Discharges	Persons	Rate l/p/day	Flow l/s
ADWF	12000	180	25.00
Light Industrial	Ha		
	55.9		
Assume 55% building coverage	30.8		
Discharges	Ha	Rate l/m2/day	Flow l/s
ADWF	30.8	4.5	16.04
Retail, Town Centre & Health Care	Ha		
5.3ha + 4.9ha + 3.3ha	13.5		
Assume 55% building coverage	7.4		
Assume 80% net area	5.9		
Discharges	Ha	Rate l/ha/s	Flow l/s
ADWF	5.94	1	5.94
Schools	Students	Rate l/person/day	
	2000	45	
Discharges	Persons	Rate l/person/day	Flow l/s
ADWF	2000	45	1.04
ADWF			48.02
PWWF(1.2 LPS Peaking Factor)	48.02	1.2	57.63 l/s
Total Discharge			57.63 l/s

Figure 11- Allowable and Predicted Wastewater Discharge

**The table above indicates using an LPS system will generate similar wastewater discharge as a typical gravity feed system servicing the FUZ area – based on using a 1.2 PWWF Factor of safety factor on all ADWF flows.*

Utilising an LPS system decreases calculated discharge volumes and consequently the number of equivalent household units able to discharge into the downstream Watercare network can be increased (refer to the Figure 11- Wastewater discharge). This option would therefore provide wastewater servicing for the proposed development of the entire Sunfield site whilst keeping discharge to the permitted development baseline.

Detailed design and acceptance of the LPS system is to be confirmed with Watercare and Veolia Water as part of the future consenting process.

4.5 PROPOSED WATER SUPPLY STRATEGY

The proposed strategy outlined in this Three Waters Strategy report is to reticulate the development with a new water supply network for potable water and firefighting services, to be supplied from the existing water supply network.

The proposed Sunfield development is located fully within the old Papakura District Council area and is partly included in Watercare's identified Takanini Water Supply Zone. Responsibility for the operation, maintenance and connections to the public water supply networks are with Veolia.

Future development of the site will require a network water supply for potable water and firefighting servicing designed to Watercare's Code of Practice requirements and subject to approval from Veolia Water.

Water supply demand calculations for the proposed development have been completed and are attached in **Appendix D**. Water demand is calculated at approximately 70.56 l/s for Average Daily demand, 85.84 l/s peak day demand and 154.59 l/s for peak hourly demand.

4.5.1 WATER SUPPLY/ FIRE FIGHTING REQUIREMENTS

The Watercare Code of Practice for Land Development and Subdivision sets out the design principles for water supply and requires assessment against SNZPAS 4509:2008 NZ Fire Service Fire Fighting Water Supply Code of Practice.

The minimum firefighting water supply classification for residential development is FW2. Therefore, any future residential development must meet the following water supply requirements:

A primary water flow of 12.5 litres/sec within a laid distance of 135m.

An additional secondary flow of 12.5 litres/sec within a radial distance of 270m.

The required flow must be achieved from a maximum of one or two hydrants operating simultaneously.

A minimum running pressure of 100kPa.

For the industrial and commercial areas, specific design will be required to identify the FW classification as per SNZPAS 4509:2008 NZ Fire Service Fire Fighting Water Supply Code of Practise.

4.5.2 BULK SUPPLY POINT

Preliminary Investigations with Veolia have indicated that a connection to the nearest Bulk Supply Point (BSP) will be necessary to provide the minimum firefighting water supply classification for the development of the site. A public water main will need to be extended from the BSP point to the site.

Figure 12 – Wastewater and Water supply transmission lines below indicates the closest BSP points located on Airfield Road. The two closest BSP's identified from Watercare's BSP GIS file are the Airfield #1 and Porchester Road BSP's.

To provide sufficient water supply for future development of the site, a new public water main will connect the site to the bulk supply point Airfeild #1 located on the 450mmØ transmission line on Airfield. The BSP may need to be upgraded as part of these works.

If this BSP point does not have sufficient capacity a new BSP point may need to be constructed on the transmission line closer to the Cosgrave Road intersection. Consultation with Veolia and Watercare will be required to confirm the preferred connection point and capacity.

As the majority of water supply for Auckland originates in the south and the close proximity of transmission line to the site, it is likely that an engineering solution for either an upgraded BSP or new BSP can be developed to supply the development's water demand.

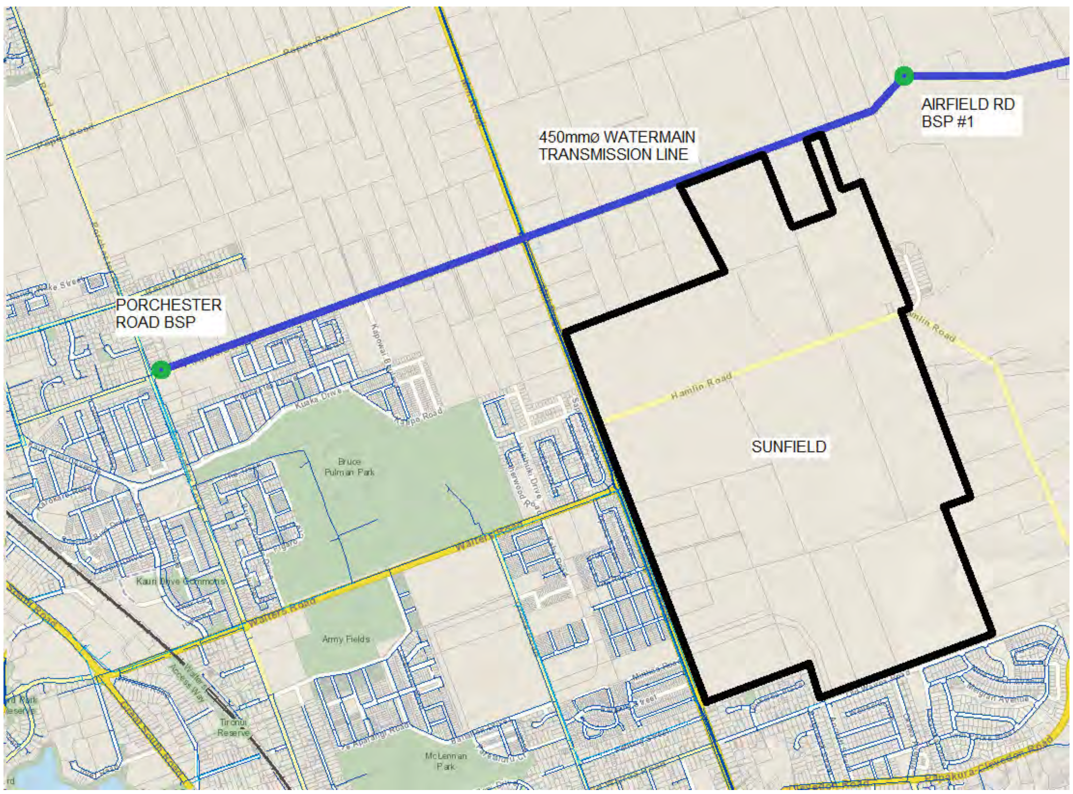


Figure 12 - Wastewater and Water supply Transmission lines

5.0 CONCLUSIONS

The Three Waters Strategy for the site is to incorporate a water sensitive urban design approach to create a low impact, sustainable development which minimises stormwater and wastewater discharge from the site.

The overarching principle of the Sunfield Three Waters Strategy is to implement an integrated management approach, which:

Stormwater

- Recognise the key constraints and opportunities on site and in the Pahurehure Inlet and Papakura Stream catchments.
- Devise an integrated stormwater management approach to facilitate urban development optimise available land.
- Develop a set of BPOs for stormwater management that can be incorporated into the development.
- Emphasise a water-sensitive design approach that:
    - manages the impact of land use change from rural to urban.
    - minimises or mitigates the adverse effects on water quality, freshwater systems, stream health, and ecological values of the receiving environment through the implementation of stormwater management devices.
    - protects and enhances stream systems and natural hydrology while mitigating hydrological changes and managing flooding effects.
- Minimise the generation and discharge of contaminants/sediments into the sensitive receiving environment of the Manukau Harbour.
- Protect key infrastructure, people and the environment from significant flooding events and not worsen downstream flooding.

Wastewater & Water supply

- Wastewater networks, including new and existing private connections to the networks allow the minimum practicable seepage into and out of the networks.
- Waste materials entering the networks are controlled to avoid or minimise adverse effects on physical assets, wastewater treatment processes and the environment.
- Overflows from the networks during both dry and wet weather are minimised as far as practicable.
- Protect Watercare's and other publicly owned assets are not damaged and future access is not compromised by the actions of third parties.
- Infrastructure that is created, is of good quality, meets health requirements and minimises ongoing maintenance costs.
- Meets future demands on maintainability and access as infrastructure age and the natural environment change.
- Water is used efficiently and wastage is minimised as best practicable.

5.1 STORMWATER

To achieve these outcomes, the proposed stormwater management strategy adopts integrated best-practice approach across the site to:

- Mitigate downstream effects from hydrology via hydrological mitigation to minimise the change in hydrology (maintain predevelopment), peak flow rate, levels and volumes, and groundwater changes, as a result of development. It comprises two components:
  - Retention: the process of reducing runoff volumes, which can be achieved by:
    - ensuring that the initial abstraction (rainfall losses due to soakage which occur before runoff begins) volume from pre-development conditions is infiltrated into the ground, which is beneficial to groundwater and baseflow to streams i.e. infiltration.
  - Detention: Temporary storage and slower release of runoff, which effectively reduces peak flows and protects the downstream receiving environment.
- Convey stormwater runoff from upstream and development site for up to 100 year flow.
- Flood management within the site by conveying overland flows through the site via roads and swales and directing flows into attenuation devices.
- Flood management to maintain predevelopment flood hazard conditions for upstream and downstream of the development site in terms of peak flow rate and levels.
- Providing stormwater quality treatment through communal treatment devices such as a stormwater conveyance channel and wetland.
- Provide ground water recharge via soakage pit/recharge pit to ensure the retention of existing groundwater levels. The retention provided by the the recharge pits will also provide hydrological mitigation via supporting stream baseflows and reducing erosive flows during small storm events.

Catchment A – Pahurehure Inlet Catchment (174ha) which includes the FUZ area (50ha) and MRZ south of Hamlin Road (124ha), is to drain to the proposed Takanini Storm Water Conveyance Channel (TSWCC) being a proposed extension to Stage 1 of the channel referred to as Stage 2, 3 and 4.

Catchment A will provide stormwater attenuation (via extension extension to the Awakeri Wetland/TSWCC Stage 4, a dry pond and secondary stormwater swales within FUZ land) to the discharge anticipated under the development of the FUZ land via an extension to the TSWCC and a number of proposed smaller contributing stormwater swales within the development.

Catchment B – Papakura Stream Catchment(70ha) will continue to discharge stormwater to the north. Post development flow will be attenuated (via wetland/pond and a dry pond) to predevelopment conditions (existing predevelopment catchment discharging north) via a combination of a proposed stormwater wetland pond and stormwater swales.

Catchment C – Papakura Stream Catchment (374ha) stormwater runoff from upstream currently flows through the subject site. It is proposed to redirect this flow via an engineered swale along the eastern boundary of the subject site and discharge north via a newly constructed level spreader outlet structure (upgrade of existing exit point).

Catchment D1 & D2 – Papakura Stream Catchment (22ha & 36ha respectively) - Will continue to discharge stormwater to the north. Post development flow in catchment D2 will be attenuated (via dry pond) to predevelopment conditions (existing predevelopment catchment discharging north) via a combination of a proposed stormwater wetland ponds.

5.2 WASTEWATER AND WATER SUPPLY

A Low Pressure Sewer system will minimise wastewater discharge by utilising a sealed network which eliminates inflow and infiltration. This option will provide wastewater servicing for a proposed development of 4000 lots, 56ha of light industrial land, 13.5ha of retail, town centre, healthcare and schools.

A water supply connection to the nearest Bulk Supply Point (BSP) will be necessary to provide the minimum water supply requirements for potable water and firefighting for the development. The two closest BSP's identified from Watercare's BSP GIS file are located in the road reserve fronting 394 Airfield Road and at the intersection of Airfield Road and Porchester.A public water main reticulation will need to be extended from the BSP point to the site.

If the existing BSP's do not have sufficient capacity a new BSP point may need to be constructed on the transmission line. Consultation with Veolia and Watercare will be required to confirm the preferred connection point and capacity.

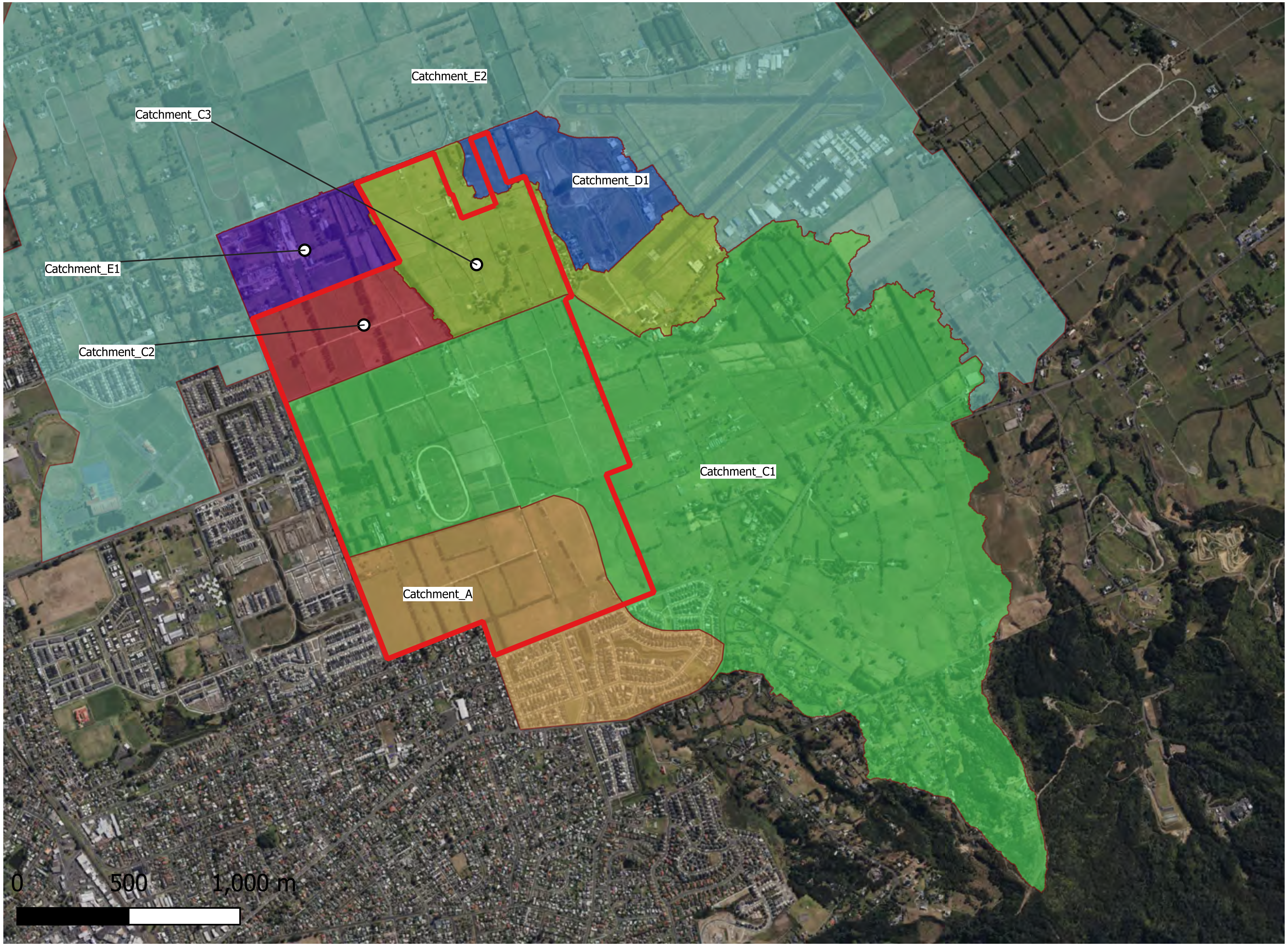
5.3 RECOMMENDATIONS

From an engineering perspective, proposed infrastructure servicing can be achieved via methods consistent with current relevant AUP requirements and Engineering Standards. Subject to detailed design and approval from the local authorities, there are no infrastructure issues that would preclude the land being developed for the proposed land use.

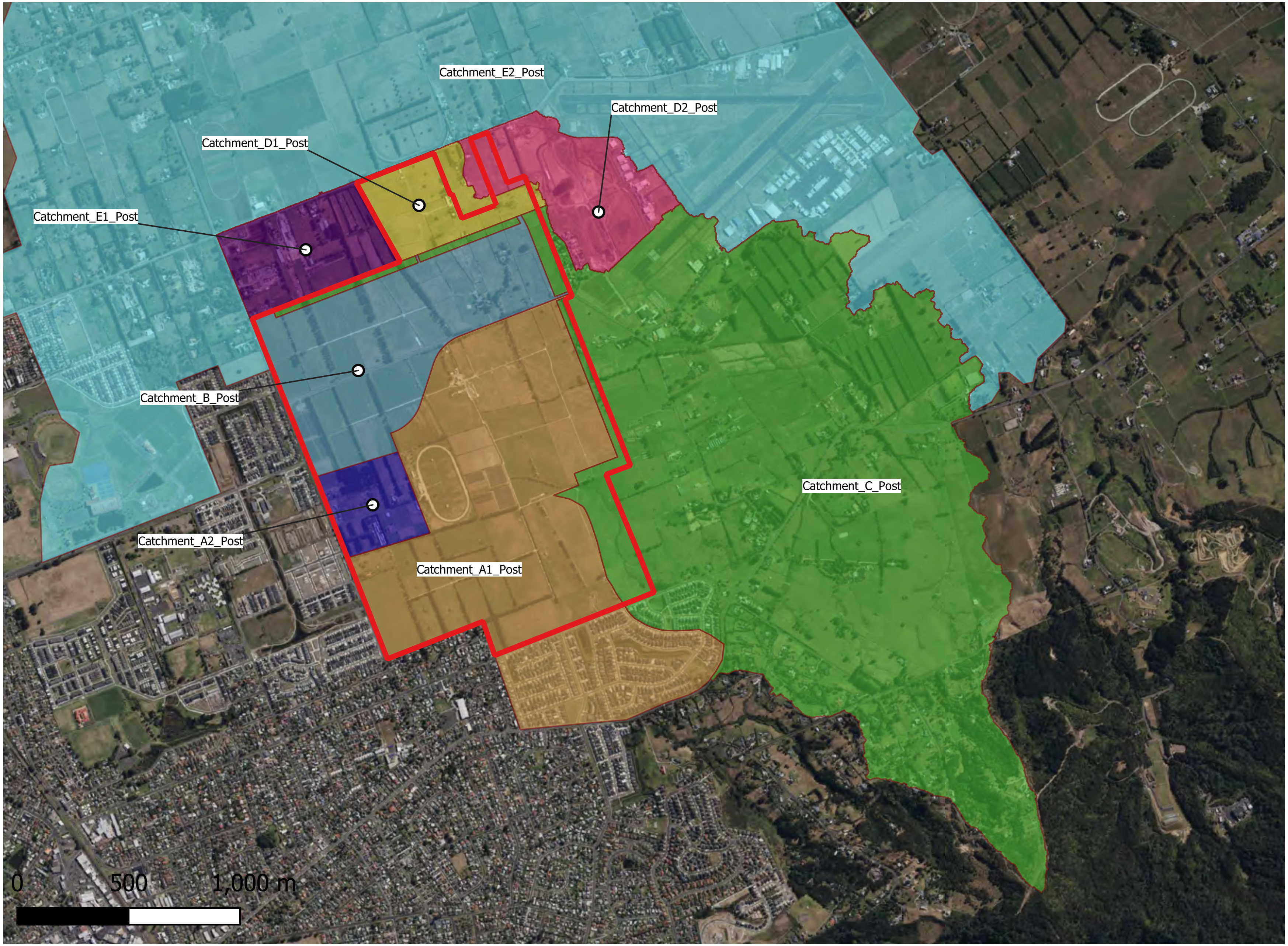
Final solutions will require further detailed design after consultation with third party stakeholders including Veolia, Watercare, Auckland Council, Auckland Transport and Healthy Waters. It is considered the next step is to continue discussions with these third-party stakeholders and progress further documentation / detailed desing.

APPENDIX A – STORMWATER CATCHMENT PLANS & HIGH LEVEL ENGINEERING PLANS.

Pre development Catchments



Post Development Catchments

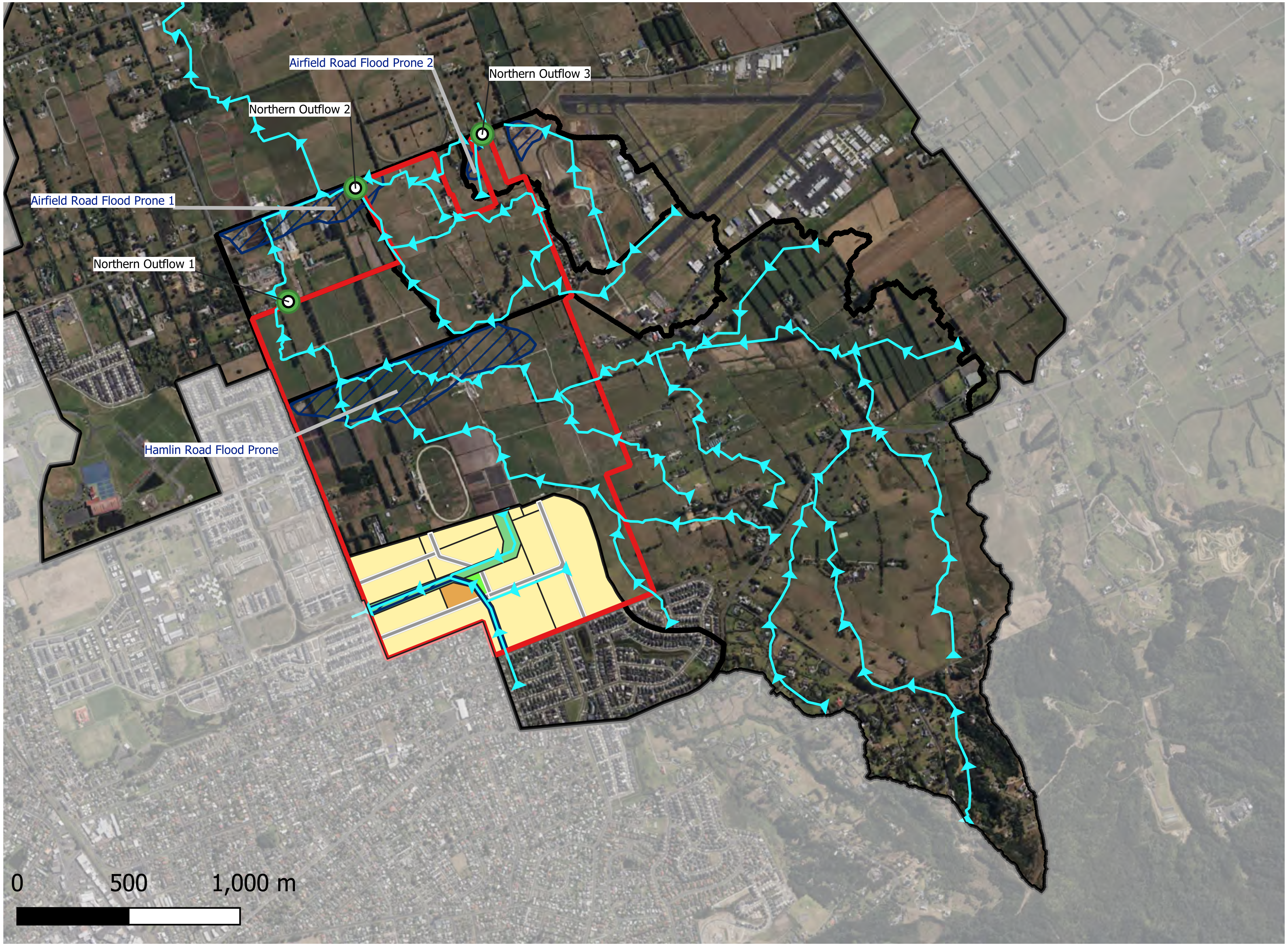


Legend

Pr-Bdy

SK005
REV 001

Existing Catchment Flow paths

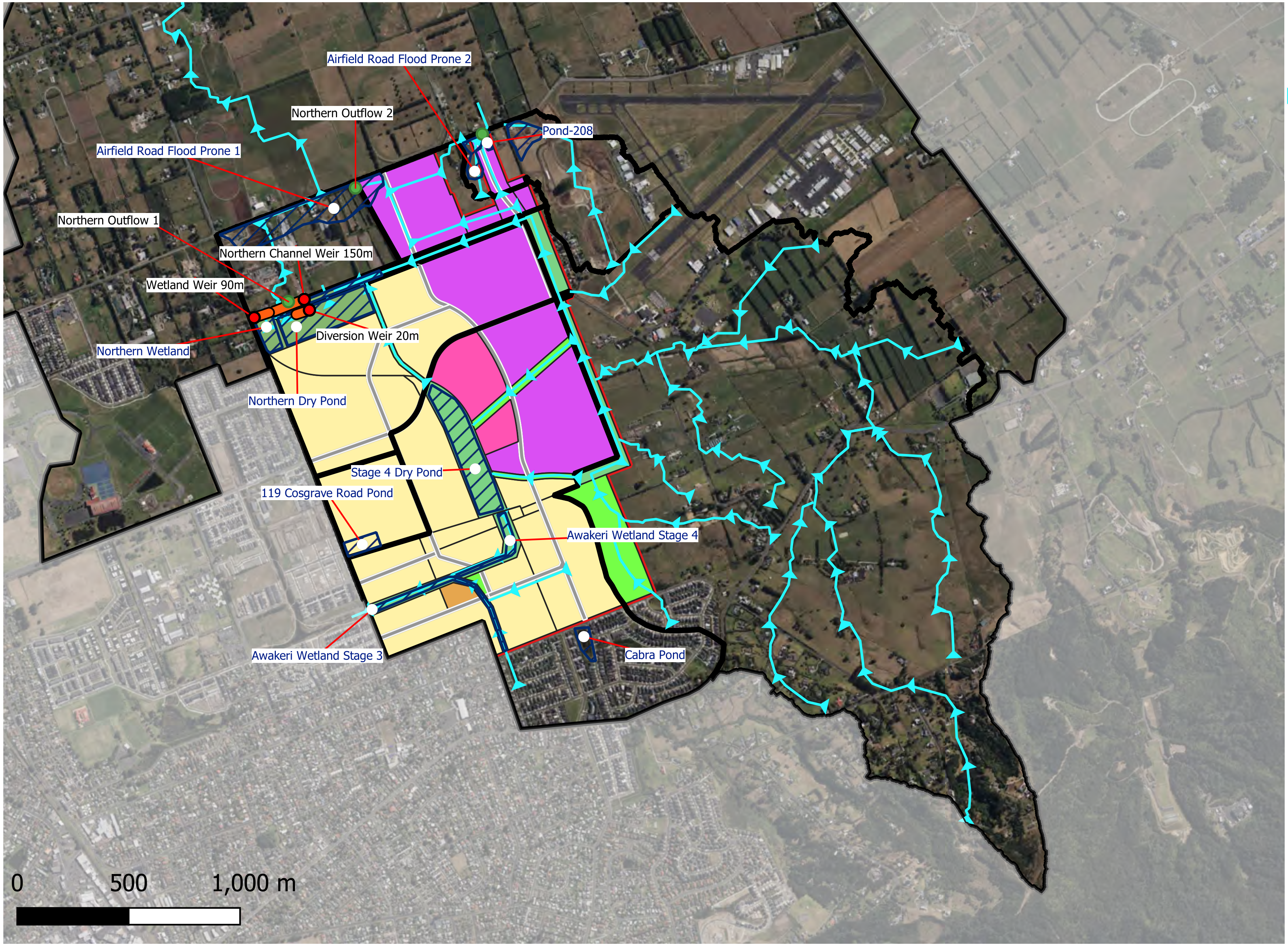


Legend

- Site Boundary
- Predevelopment Catchments
- Existing OLFP
- Existing Flood Prone Storage

SK003
REV 001

Proposed Catchment Flow paths



Legend

- Site Boundary
- Predevelopment Catchments
- Proposed OLFP
- Post development Flood Storage

SK006
REV 001

DRAFT FOR REVIEW

Notes

1. BEARING AND COORDINATE DATUM IS NZGD2000 MOUNT EDEN CIRCUIT 2000 LEVELS ARE IN TERMS OF LANDS AND SURVEY DATUM (MSL) AUCKLAND 1946.
2. ORIGIN OF SURVEY CE 34 (AEE6) 783303.09mN,417353.67mE, RL 24.746m
3. CHECK ORIGIN OF SURVEY SM 5813 (C6AM) (SO 58209) 781995.74mN, 418450.50mE, RL 34.51m

Legend

- EX BDY
- PROP BDY
- EX MAJOR CONTOUR
- EX MINOR CONTOUR
- PR MAJOR CONTOUR
- PR MINOR CONTOUR
- EXISTING GAS EASEMENT

Rev	Description	By	Date
E	REVISED CONTOURS	CE	02/2024
D	FOR INFORMATION	CE	12/2023

	By	Date
Survey	BY	MM/YYYY
Design	CE	12/2023
Drawn	CE	12/2023
Checked	WM	12/2023

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Project

SUNFIELD DEVELOPMENT ARDMORE FOR WINTON PROPERTY LTD

Title

PROPOSED BULK EARTHWORKS PLAN

Project no.	215001
Scale	1:9000 @ A3
Cad file	C200-EARTHWORKS SITEWIDE 1.DWG
Drawing no.	C200
Rev	A

EARTH WORKS (SURFACE EXISTING COMPARISON WITH SURFACE PROPOSED BULK EARTHWORKS)
CUT/FILL VOLUMES ARE APPROXIMATE

CUT VOLUME	850,000 m³
FILL VOLUME	1,030,000 m³
CUT TO FILL BALANCE	180,000 m³

EXCESS FILL TO BE SOURCED FROM CIVIL WORKS SURPLUS MATERIAL.

NOTE: NO ALLOWANCE FOR SERVICES TRENCHES, VOLUMES ARE UNFACTORED AND IN SITU

Notes

1. BEARING AND COORDINATE DATUM IS NZGD2000 MOUNT EDEN CIRCUIT 2000 LEVELS ARE IN TERMS OF LANDS AND SURVEY DATUM (MSL) AUCKLAND 1946.
2. ORIGIN OF SURVEY CE 34 (AEE6) 783303.09mN, 417353.67mE, RL 24.746m
3. CHECK ORIGIN OF SURVEY SM5813 (C6AM) (SO 58209) 781995.74mN, 418450.50mE, RL 34.51m

LEGEND

- EX BDY
- PROP BDY
- PROP EXTENT WORK
- EXISTING GAS EASEMENT

Cut/Fill Table

Number #	Minimum Elevation	Maximum Elevation	Color
1	-6.277	-1.000	
2	-1.000	-0.500	
3	-0.500	0.000	
4	0.000	0.500	
5	0.500	1.000	
6	1.000	1.500	
7	1.500	2.000	
8	2.000	3.301	

Rev	Description	By	Date
E	REVISED CUT/FILL CONTOURS	CE	02/2024
D	FOR INFORMATION	CE	12/2023

	By	Date
Survey	BY	MM/YYYY
Design	CE	12/2023
Drawn	CE	12/2023
Checked	WM	12/2023

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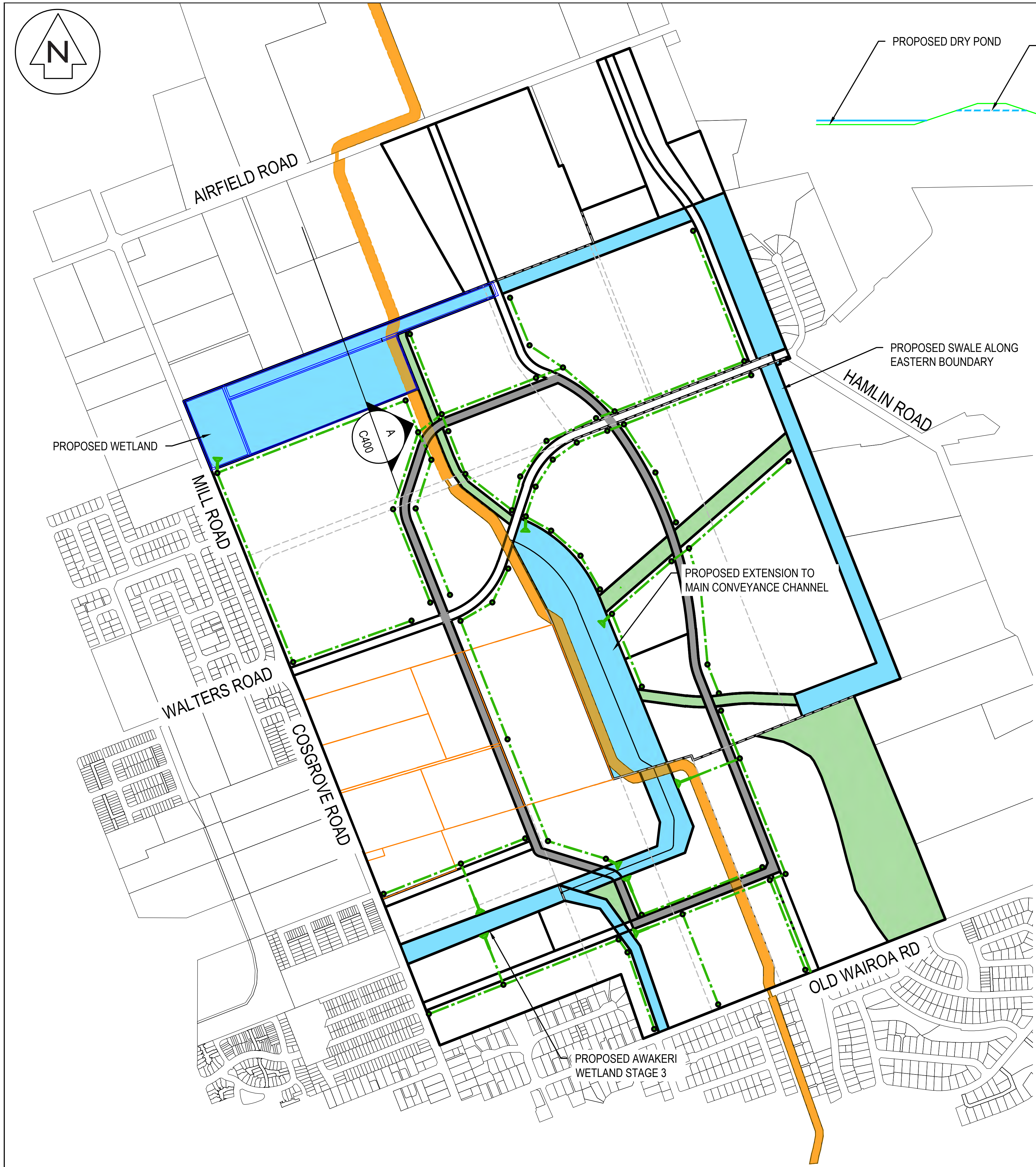
Project

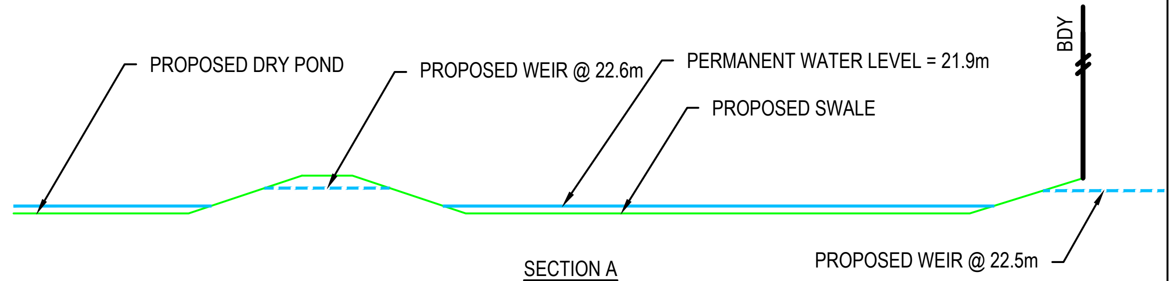
SUNFIELD DEVELOPMENT ARDMORE FOR WINTON PROPERTY LTD

Title

PROPOSED BULK EARTHWORKS CUT TO FILL PLAN

Project no.	215001
Scale	1:9000 @A3
Cad file	C220-EARTHWORKS SITEWIDE.DWG
Drawing no.	C201
Rev	E





SECTION A
SCALE 1:300@A3

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

LEGEND
- EX BDY
- PROP BDY
- PR STORMWATER
- EX/PROP SWMH
- EXISTING GAS EASEMENT

Rev	Description	By	Date
A	FOR INFORMATION	JP	08/21

	By	Date
Survey	N/A	01/21
Design	CE	03/2024
Drawn	CE	03/2024
Checked	JP	03/2024

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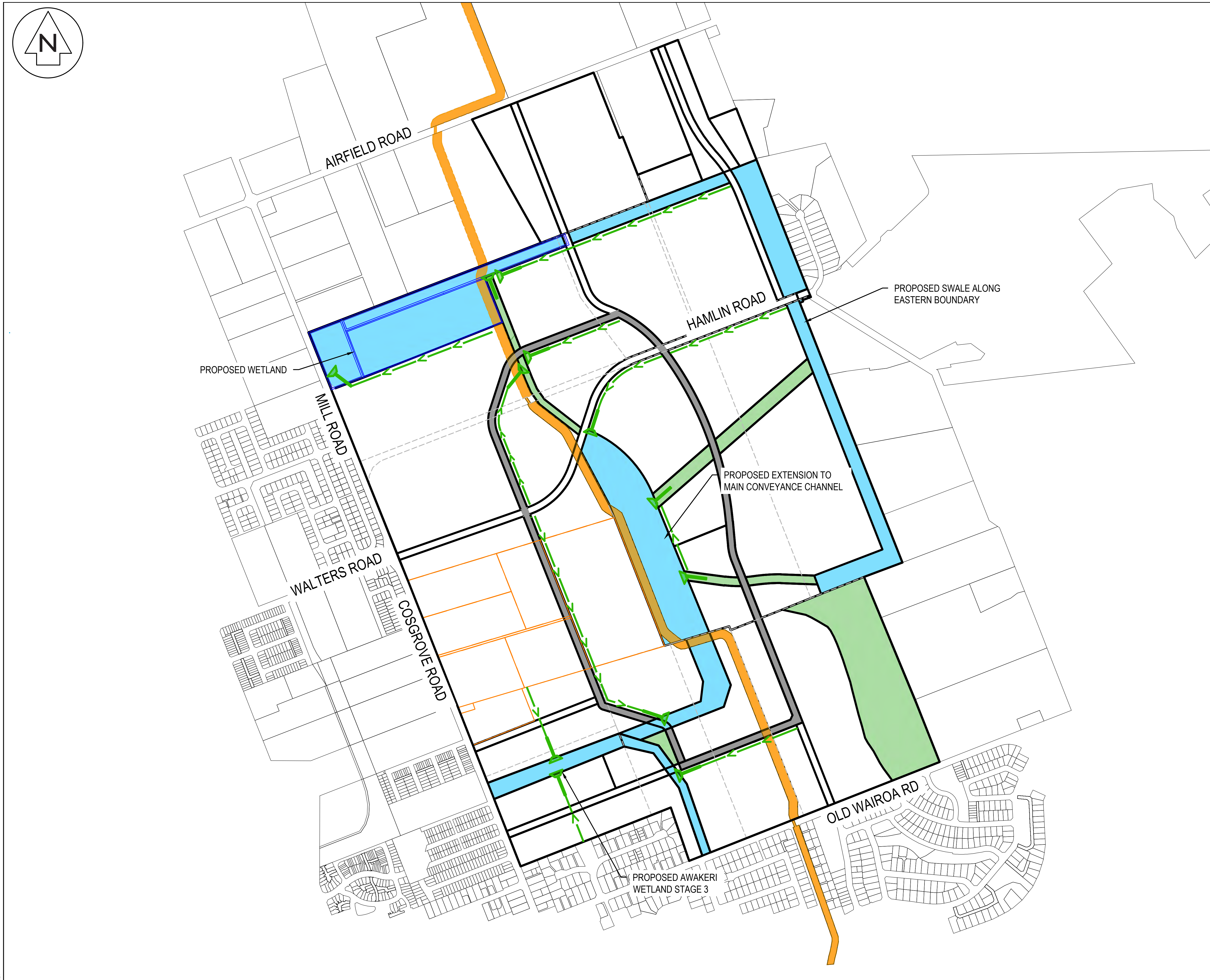
Project
SUNFIELD DEVELOPMENT ARDMORE FOR WINTON PROPERTY LTD

Title
PROPOSED STORMWATER 10YR CONCEPT PLAN

Project no.	-
Scale	1:10000 @ A3
Cad file	C400 STORMWATER 10YR.DWG
Drawing no.	C400
Rev	A



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

LEGEND
EX BDY
PROP BDY
PR STORMWATER SWALE
EXISTING GAS EASEMENT

Rev	Description	By	Date
A	FOR INFORMATION	JP	08/21

	By	Date
Survey	N/A	01/21
Design	JP	04/21
Drawn	JP	12/23
Checked	WM	12/23

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Project
SUNFIELD DEVELOPMENT ARDMORE FOR WINTON PROPERTY LTD

Title
PROPOSED STORMWATER 100YR CONCEPT PLAN

Project no.	-
Scale	1:10000 @ A3
Cad file	C400 STORMWATER 100YR.DWG
Drawing no.	C401
Rev	A

DATE: 3/8/24

APPENDIX B – STORMWATER CALCULATIONS

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

As per PDC SW - 21 & 22

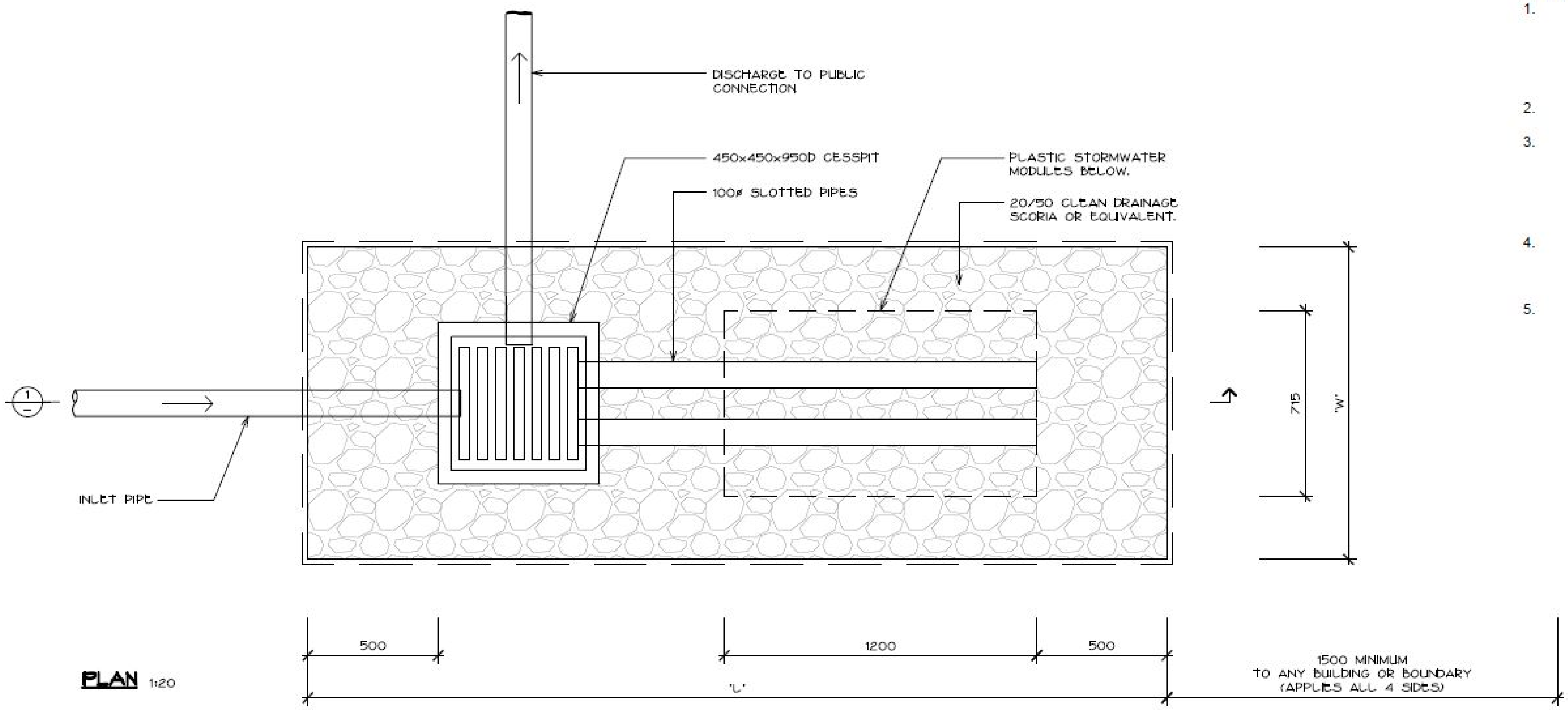
X= IMPERVIOUS AREA (m^2)

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

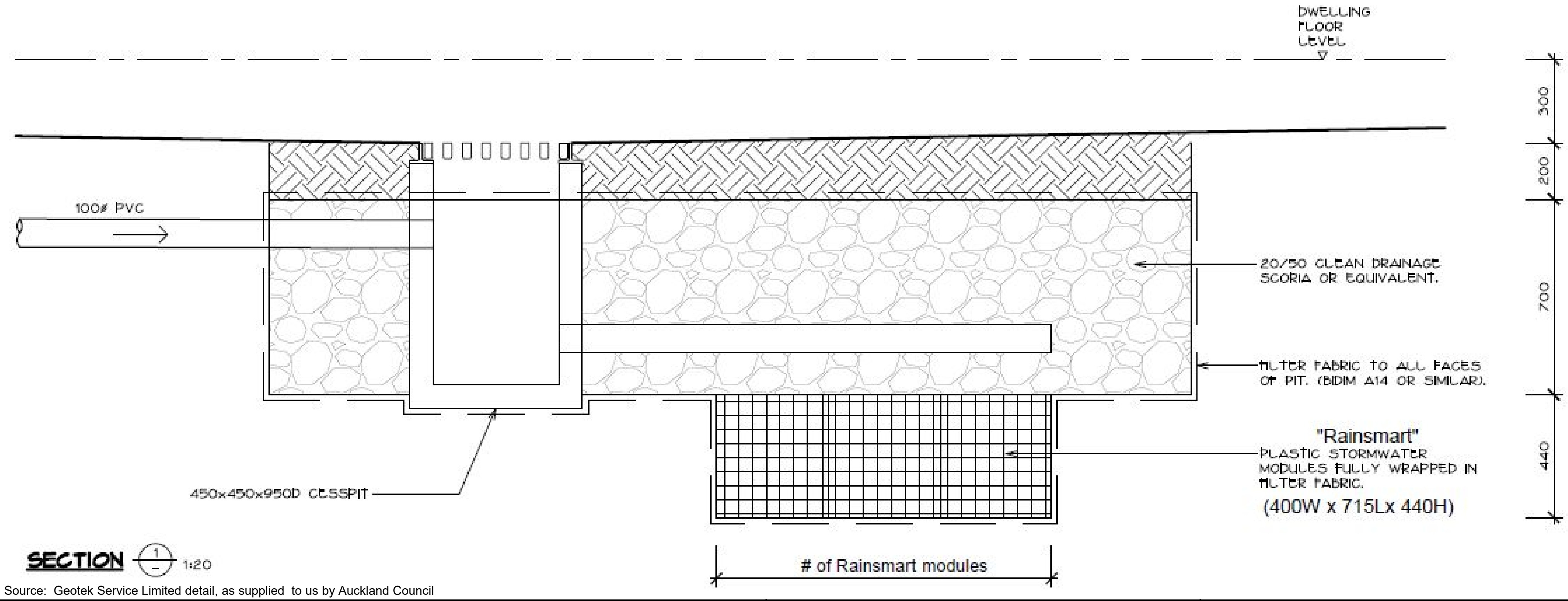
PIT LENGTH(m) = $0.2275X^{.5423}$

85% Impervious Area

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



PLAN 1:20



SECTION 1:20

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

CONSTRUCTION NOTES:

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

See Note 3.

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

Minimum Width 0.8m

OPERATION & MAINTENANCE NOTES:

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

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

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

2. **Removal of accumulated sediments**

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

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

   - Removal of sediment and disposal to an approved receiving environment

3. **Debris removal**

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

revision	description	drawn	approved	date

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

LANDER geotechnical

client:

project:

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

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

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

RainSmart
Modular Tank System

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

DESCRIPTION

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

APPLICATION

Application includes inground water storage and water flow detention.

TYPICAL PROPERTIES – TANK DIMENSIONS

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

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

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

Maven Associates		Job Number 215001	Sheet 1 OF 1	Rev A
Job Title Calc Title	Sunfield, Ardmore Wetland Sizing - Water Quality Only	Author JP	Date 2/08/2021	Checked JP

Detention volume for stream protection and flood mitigation is provided by basin, therefore
Pond to provide water quality volume only.

Site Characteristics:

Catchment Area:	75 ha	
Post-development land-use	70% Impervious (52.5Ha)	CN = 98
	30% Pervious (22.5Ha)	CN = 74

Storm Intensities:

	Rainfall Across 24 hours (mm)
90th Percentile Storm	25mm

Permenant Water Volume (PWV): Runoff Volume from 90th Percentile Storm

The calculations based on TP108

PWV = **8,412 m3**
Forebay Volume= 1,262 m3 (15% of PWV)

Forebay is assumed to be 10% of total pond area)
Wetland to be 1.5m deep

APPENDIX C – STORMWATER MODELLING

STORMWATER MODELLING REPORT

FOR

SUNFIELD FAB APPLICATION

<table>
<tr><td colspan="2">Maven Associates</td><td>Job Number
215001</td><td></td><td>Rev
C</td></tr>
<tr><td>Job Title
Title</td><td>Sunfield FAB Application
Stormwater Modelling Report</td><td>Author
YW</td><td>Date
29/04/2024</td><td>Checked
JP</td></tr>
</table>

CONTENTS

Appendix

1 INTRODUCTION

1.1 PROJECT

This report outlines stormwater modelling that was undertaken by Maven Associates to support Winton's proposed Sunfield FAB application (Fast-track Approvals Bill).

The modelling outlines the proposed overall stormwater mitigation strategy for the site in terms of incoming flows and mitigation through conveyance channels. The latest Master Plan has been incorporated as shown in the image below.

Figure 1.1 – Master plan

1.2 MODELLING APPROACH

The software packages HEC HMS and HEC RAS have been used for the hydrological and hydraulic assessment. All analysis has been completed in accordance with TP108 and in accordance with guidelines of the Auckland Council Stormwater Code of Practice. Both a HEC HMS and HEC RAS models were developed for the site. HMS was used to develop a baseline solution for the site and HEC RAS was used to refine and finalise the solution.

The analysis was done using the following steps:

HEC HMS (hydrological modelling)

1. Delineate the catchments,
2. Use Tp108 to calculate parameters,
3. Iteratively compute attenuation devices in post developed model to meet flow requirements.

HEC RAS (hydraulic modelling)

4. Delineate the inflow catchments,
5. Delineate the perimeter for the grid,
6. Create grid and sub-grid areas,
7. Input flow hydrographs and other boundaries
8. Input structures,
9. Run scenarios.

TP108 Modelling Limitations

Areal reduction has not been applied for the subbasins. The reduction factor should be based on sub catchment size not the size of the entire catchment (Shamseldin,2008). The largest sub catchment used is Catchment C with an area of 3.7 km2.

1.3 WESTERN CATCHMENT

The western catchment includes areas which discharge to the Awakeri Wetland and Cosgrave Road Culvert. The total areas are summarised in table 1.1 below.

Please refer to Appendix A for predevelopment and post development catchment plans.

	Catchments names	**Total Catchment Area**
Predevelopment	A	93.5 Ha
Post development	A1 and A2	173.8 Ha
Change		+80.3 Ha

Table 1.1 Summary of catchment discharging to Cosgrave Road Culvert

Predevelopment (Catchment A)

For the purposes of this report the existing western catchment is defined as the catchment discharging to Cosgrave Road Culvert outlined in the existing Healthy Waters Awakeri Wetland Stage 2 & 3 design. The catchment comprises of the FUZ area and the existing residential area to the south of Old Wairoa Road and has a total area of 93.5Ha.

Post development (Catchment A1 and A2)

Catchment A1 has an area of 158.8 Ha and A2 has an area of 15.0 Ha, with a combined total area of 173.8 Ha. The catchment includes the existing predevelopment catchment A with additional catchment areas to the north (comprising of proposed residential, business and town center zones and stormwater reserves).

1.4 EASTERN CATCHMENT

The eastern catchment discharges to the north site boundary towards Airfield Road. Three discharge points across the northern site boundary were identified as shown on plan SK003 (appendix A).

Discharging to Northern discharge point 1		
	Catchments names	**Total Catchment Area**
Predevelopment	C1, C2	472.7 Ha
Post development	B, C	443.3 Ha
Change		-29.4 Ha

Discharging to Northern discharge point 2		
	Catchments names	**Total Catchment Area Ha**
Predevelopment	C3	73.8 Ha
Post development	D1	22.4 Ha
Change		-51.4 Ha

Discharging to Northern discharge point 3		
	Catchments names	**Total Catchment Area Ha**
Predevelopment	D1	36.4 Ha
Post development	D2	36.6 Ha
Change		+0.2 Ha

Table 1.2 Summary of Eastern catchment areas

Predevelopment (Catchment C1, C2, C3 & D1)

Flows from catchment C1 and C2 exit the site across the northern site boundary, shown on plan SK003 as Northern Outflow 1.

The catchment comprises almost entirely of existing rural zones with a small residential area to the south of Old Wairoa Road, the catchment has an area of 472.7 Ha.

Catchment C3 exits Northern outflow 2 and comprises of an existing rural zone to the north of Hamlin Road and a portion of the Ardmore Airport Runway and has an area of 73.8 Ha.

Catchment D1 exits Northern outflow 3 and comprises of the underway at industrial and commercial development at Ardmore airport and a small rural zoned area and has an area of 36.4Ha.

It should be noted that catchment E1 and E2 have been included in the HEC RAS model outlined in section 3 and 4 for the report to accurately model the downstream conditions.

Post development (Catchment C)

Catchment B (70.0 Ha) and C (373.3 Ha) have a total area of 443.3 Ha. The catchment includes the entire pre development catchment C2 and portions of the predevelopment catchment C and C3. The post development catchment consists of the existing rural zones to the east of the site and the proposed development within the site (comprising of residential, business and town center zones and a stormwater reserve).

Post development (Catchment D1)

Catchment D1 has a total area of 22.4 Ha and is the remaining area of predevelopment catchment C3 discharging to outflow 2 post development. The post development catchment comprises of a portion of existing rural zone and a proposed business zone.

Post development (Catchment D2)

Catchment D2 has a total area of 36.6Ha. The catchment area generally remains unchanged from predevelopment catchment D1 and discharges to existing Northern outflow 3. A change in land use is proposed for the land area within the site boundary from rural to business zoning.

1.5 PROPOSED STRATEGY

The results from the previous report (dated September 2019) were used for guidance to channel width starting dimensions. The model area was split into two catchments as shown below East catchment, Western catchment, and a separate catchment for 279 Airfield Road.

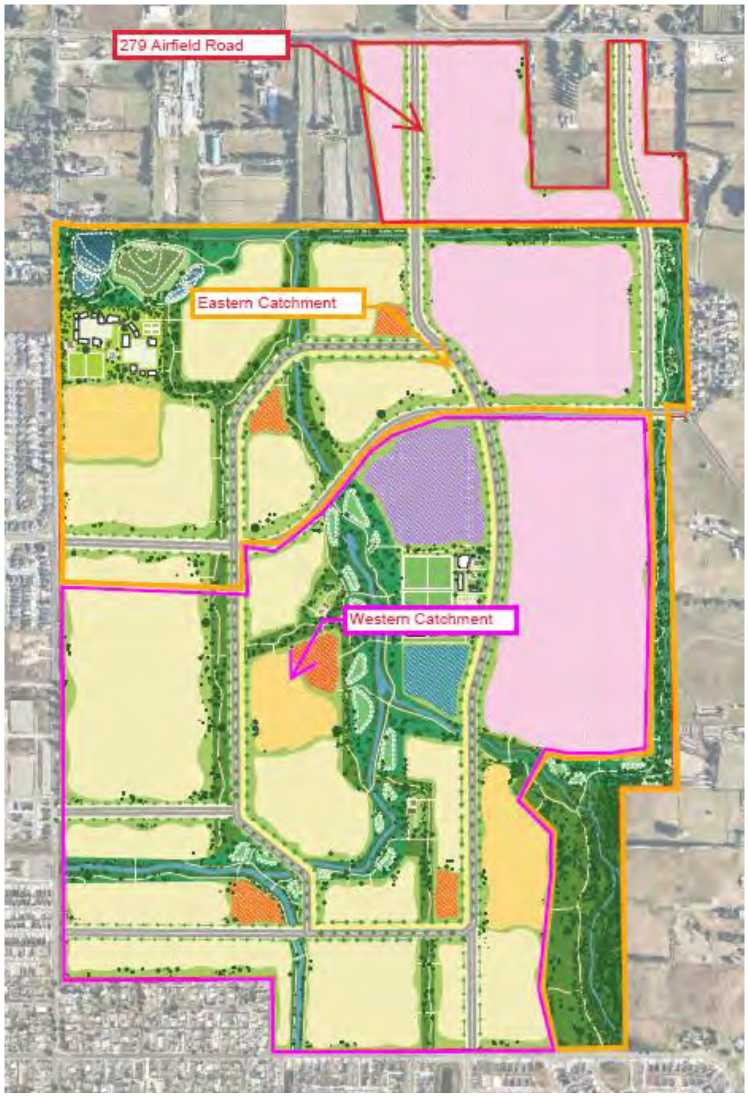


Figure 1.2 - Post development internal site catchment

<u>Western catchment</u>

Post development Catchment A1

Post development Catchment A1 shall discharge into the Awakeri Wetland via a branch extension channel. Flow from the additional 65.3Ha area is to be attenuated via a stormwater detention pond.

Post development Catchment A2

Post development Catchment A2 has a total area of 15.0 Ha. Due to the flatness of the catchment and its existing contours falling to the west, away from the proposed catchment A1 dry pond, an isolated stormwater pond is proposed to attenuate flows from this catchment and discharge to stage 3 Awakeri Wetland channel via a pipe.

The combined attenuation from catchment A1 and A2 shall ensure the post development catchment discharge to the wetland and through cosgrave road culvert meets the design requirements outlined by Healthywaters.

Please refer to Appendix A for catchment plans.

<u>Eastern catchment</u>

Flows from the eastern catchment are to maintain the existing predevelopment outflow location (shown on plan SK003).

Northern outflow 1

Overland flows from catchment C and the majority of catchment B are proposed to be routed to the northwestern corner of the site. Two weirs are located at the end of the channel. The primary weir (150m) routes the flow across the northern boundary maintaining the existing flow path. The secondary weir (20m) functions to attenuate the peak flow by routing/diverting the peak flows to a dry pond to the south of the channel.

The western portion of catchment B shall discharge to a wetland located in the northwestern site corner. Flows from this portion shall be attenuated by the wetland and discharged across the northern site boundary. The combination of these two attenuation devices shall ensure post development peak discharge from the site maintains predevelopment conditions.

Northern Outflow 2

Catchment D1 is proposed to maintain northern outflow 2. It is noted that the catchment area discharging to the outflow is proposed to be decreased by 51.4Ha, therefore no attenuation is anticipated.

Northern Outflow 3

Catchment D2 is proposed to maintain its existing discharge location at northern outflow 3. It is noted that the catchment area remains approximately the same, an attenuation pond shall be proposed to attenuate the additional flow generated from the increase in impervious area from the development.

1.6 DESIGN FLOW REQUIREMENTS

Western catchment

As part of correspondence with Healthywater the design of the Stage 2 & 3 Awakeri Wetland peak flow rate and peak water level constraints were provided and outlined in the table below.

Storm Event	Peak flow (m3/s)
50% AEP (2yr ARI)	5.7
10% AEP (10yr ARI)	14.6
1% AEP (100yr ARI)	23.0

Table 1.3 Awakeri Wetlands Stage 2 Peak Flow Design Requirements

Storm Event	Value
Low flow water level	22.25 mRL
1% AEP tailwater level	23.25 mRL
Maximum 1% AEP upstream water level	23.80 mRL
Invert level of Waikato No.1 Watermain	23.25 mRL
Awakeri Wetlands channel invert U/S and D/S end	20.96 mRL

Table 1.4 Hydraulic parameter requirements

Eastern catchment

The proposed catchments are to provide stormwater mitigation to ensure future properties within the site and downstream of the site are not adversely affected.

1.7 SCENARIOS MODELLED

Table 1.5 shows the scenarios modelled.

Scenario	Return period	Land-use	Rainfall
1	10-year	Developed	Climate change
2	100-year	Developed	Climate change

Table 1.5 – Scenarios modelled

1.8 SOURCES OF DATA

Attribute	Organisation
Catchment Plans	Maven Associates and Auckland Council Geomaps
Contours	GHD & Healthy Waters (previous design level / stage 1 channel asbuilt) Maven Associates Design (Stage 2&3)
Flow & WL data	None
Flood level evidence	None

Table 1.6 – Source of Data

1.9 REFERENCE TECHNICAL DOCUMENTS

- AUCKLAND COUNCIL CODE OF PRACTICE FOR LAND DEVELOPMENT AND SUBDIVISION. CHAPTER4 – STORMWATER, VERSION 3.00
- AUCKLAND COUNCIL TP108
- ACCEPTABLE SOLUTIONS AND VERIFIABLE METHODS, DOCUMENT E1 SURFACE WATER, MINISTRY OF BUSINESS, INNOVATION AND EMPLOYMENT,
- AWAKERI WETLANDS STAGE 2, COSGROVE CULVERT, HEALTHY WATERS, 1 JULY 2019
- TAKANINI STORMWATER CONVEYANCE CHANNEL, HILL YOUNG COOPER, APRIL 2016

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 2.1. A climate change factor was applied in accordance with the Auckland Council code of practice (Version 3) assuming a 2.1°C increase in temperature as shown below;

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

* Assuming 2.1°C increase in temperature

Table 2.1 - Climate change factors

It is noted at the time of the writing of this report Auckland Council have published Version 4 of the Stormwater Code of Practice dated March 2024 which proposes changes to the allowances for climate change effects. However, the version is only available for industry feedback and is not operative.
The proposed code of practice, version 4, if implemented would require the 1% AEP system to be designed to service a future temperature increase of 3.8^0 (or 32.7% increase from design rainfall depth). It should be noted additional modelling would be required if this proposed change was implemented.

2.3 RAINFALL HYETOGRAPH

The normalised 24-hour temporal rainfall intensity profiles for the existing condition and future climate change condition were used in accordance with Auckland Council code of practice (Version 3) section 4.2.10 Table 2.

2.4 RAINFALL DEPTH

Western model (Discharge to the Awakeri Wetland)

For consistency with the previous modelling of the Awakeri wetlands by Healthywaters the same rainfall depths have been used (as outlined in the GHD Awakeri wetland design report table 5).

Rain event	24 hr rainfall (not including climate change) (mm)	24 hr design rainfall including climate change (mm)
1% AEP	220	256
10% AEP	140	148

Table 2.2 Western catchment rainfall depths for 100yr event scenario

It is noted the TP108 rainfall depths used are conservative in comparison to that on NIWA Hirds version 4. (the total rainfall depth 24 hour for a 100year storm event for the climate change scenario RCP8.5 scenario on HIRDSv4 is 206mm, 50mm less than the implemented TP108 depth).

Eastern model

Rainfall depths were obtained from TP108 rainfall maps at 6 locations. A spatial distribution of the rainfall depths was then extrapolated using the inverse distance squared method. Refer to plan SK007 in appendix B showing location of gauges. Climate change factors were applied per Auckland council Code of practice. Table 2.3 and 2.4 shows the rainfall depths at each of the gauges the proposed 100year and 10year storm scenarios.

	TP108 (mm)	TP 108 with Climate change (mm)
Gauge 1	260	304
Gauge 2	225	263
Gauge 3	225	263
Gauge 4	223	260
Gauge 5	235	274
Gauge 6	234	273

Table 2.3 – Eastern catchment rain depths for 100yr scenario.

	TP108	Climate change
Gauge 1	159	180
Gauge 2	142	160
Gauge 3	145	164
Gauge 4	145	164
Gauge 5	153	173
Gauge 6	150	170

Table 2.4 – Eastern catchment rain depths for 10yr proposed scenario

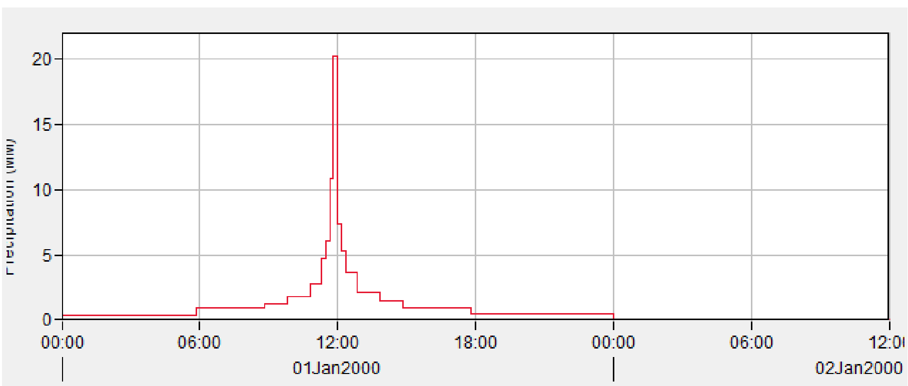


Figure 2.1 shows the 10-year pre developed land-use rainfall hyetograph for rain gauge 1.

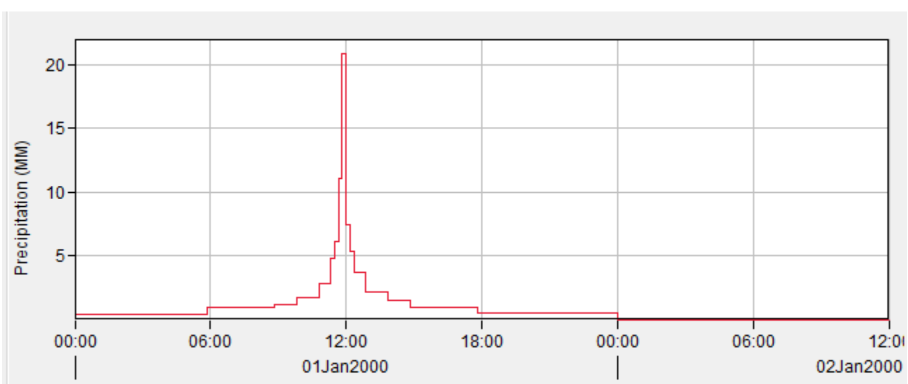


Figure 2.2 shows the 10-year post developed land-use rainfall hyetograph for rain gauge 1.

2.5 CATCHMENT SIZE

Figures below shows the catchment areas used in the HEC HMS model. The downstream boundary for the western catchment is located at the interface to the existing stage 1 channel. The downstream boundary for the eastern catchment is located at two ponding and tipping points across Airfield Road.

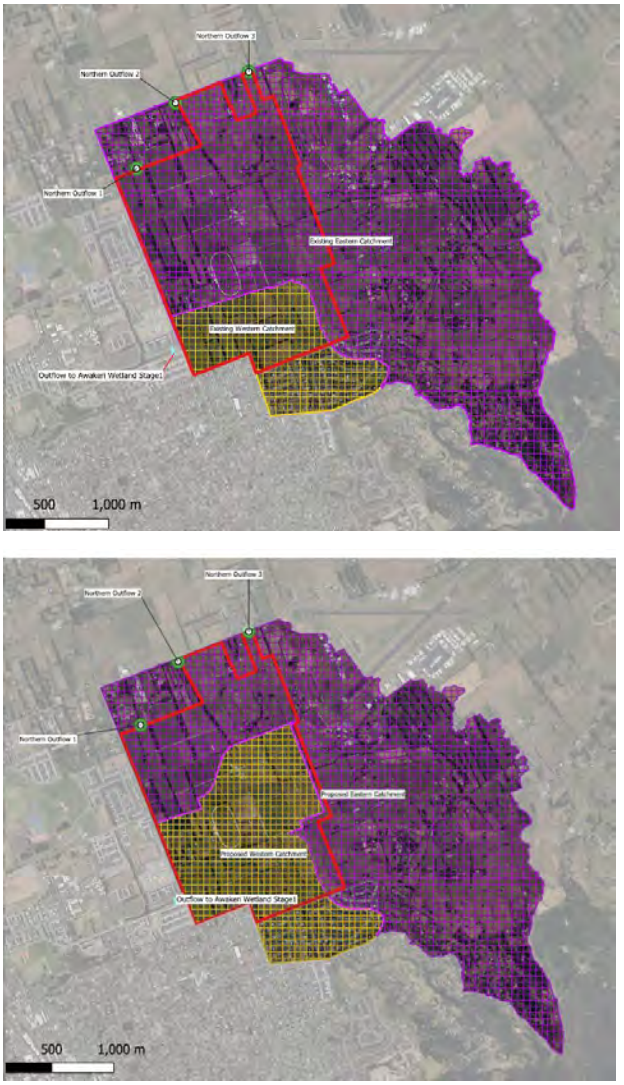


Figure 2.3 Pre and Post HEC HMS model extents

2.6 SOILS PARAMETERS

A SCS Curve Number (CN) of 74 has been used for peat soils for the predevelopment scenario as per the Papakura ICMP, as per TP108. The post-developed scenario also uses a CN of 74 for pervious areas based on likely imported fill characteristics or existing peat soils as per above. For impervious areas in the catchment a CN of 98 has been used.

2.7 LAND-USE

For the purposes of this analysis table below shows the Impervious percentages used for the proposed zoning and existing zoning within the model extents. Appendix K shown plan of the zoning.

Zone	Impervious %
Commercial	100
Business	90
Mix housing Urban	60
Single House	60
Special Airport	70
Special Quarry	90
Special Recreational	50
Special School	70
Road	85
Rural	10
Open space	10
SW channel	30
Wetland	100

Table 2.5 – Impervious percentage for Zoning

2.8 CHANNELISATION FACTORS AND TIME OF CONCENTRATION

The channelisation factors in Table 6 were used for each of the storm events respectively.

	Storm event	
Factor	10 yr Storm	100yr Storm
Channelisation factor	0.6	0.8

Table 2.6 – Channelisation factors

<u>Time of concentration</u>

The values for flow length and time of peak flow have been derived from calculations based on the TP108 methodology. The slopes and catchment lengths consider the developed slopes of the catchment draining to the proposed channel. Appendix D and E shows equal area slope calculations.

2.9 SUBBASIN PARAMETERS

Please refer to Appendix C for a summary of the HEC HMS parameters.

2.10 HEC-HMS MODEL

The data was then transferred to HEC-HMS. Figures below shows the model set-up for the western and eastern catchments. Calculations for the time of concentration of the sub catchments were completed in accordance with TP108.

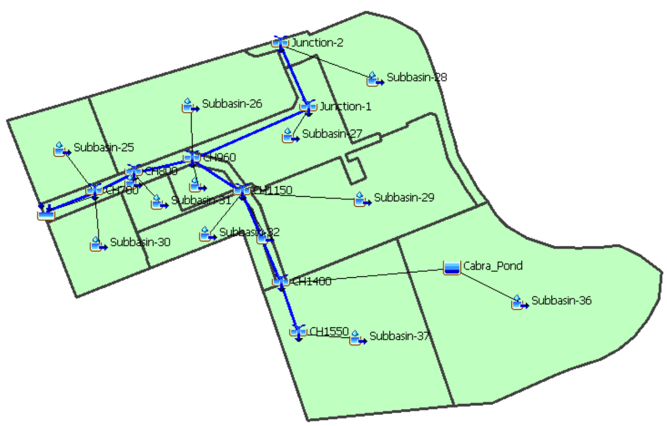


Figure 2.4 – Predevelopment Western Catchment Hec-Hms Model Set-Up

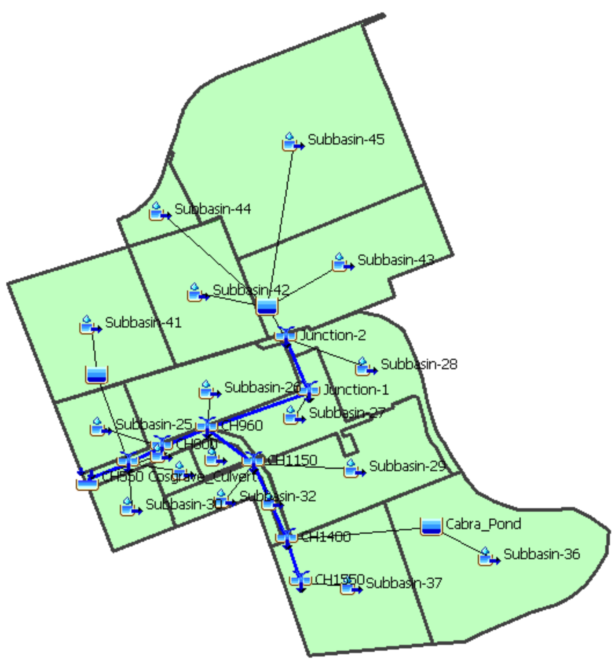


Figure 2.5 – Postdevelopment Western Catchment Hec-Hms Model Set-Up

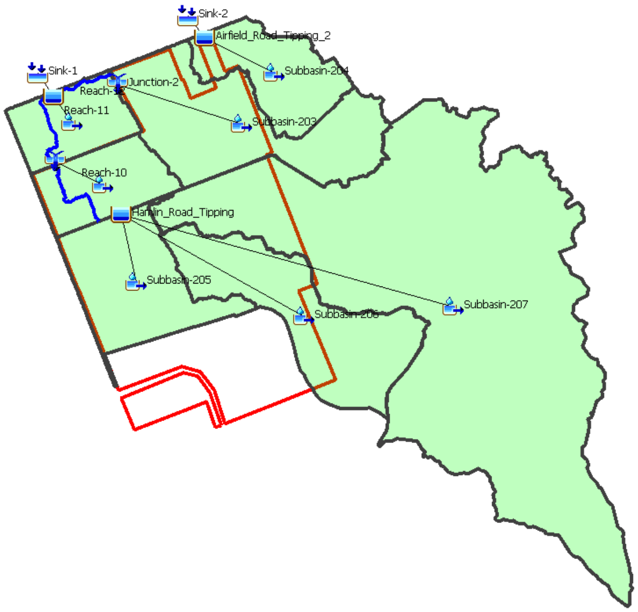


Figure 2.6 – Pre-Development Eastern Catchment Hec-Hms Model Set-Up

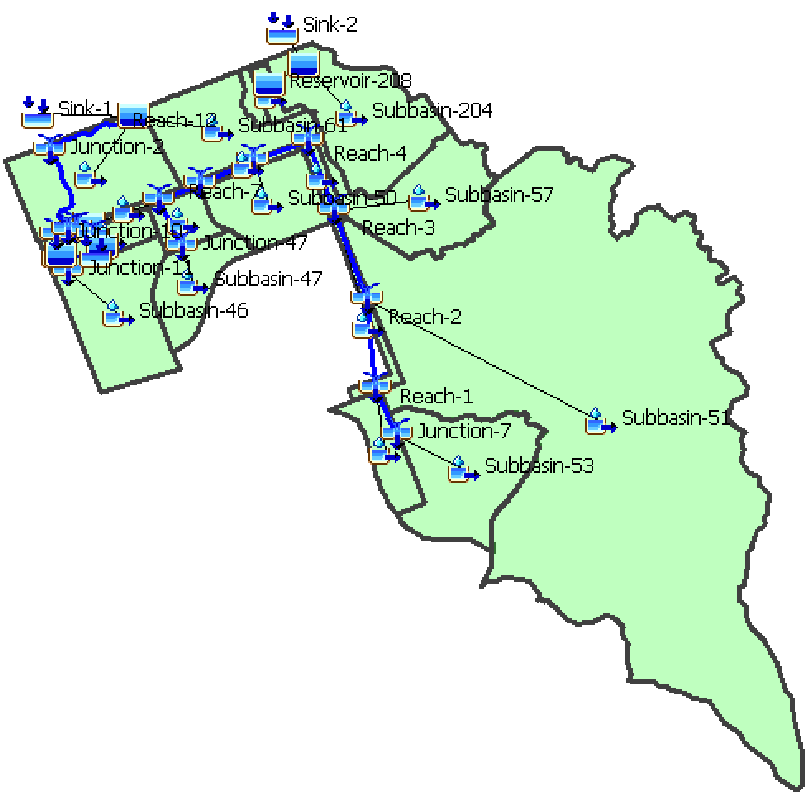


Figure 2.7 – Post-Development Eastern Catchment 1%Aep Hec-Hms Model Set-Up

2.11 EXISTING CATCHMENT ATTENUATION

Please refer to Appendix C for a summary HEC HMS pair and cross section parameters data associated with the existing attenuation reservoirs.

2.11.1 Western catchment- Cabra Pond attenuation (Subbasin-36)

Generally, there is limited attenuation in the existing western catchment, as the proposed Awakeri Wetlands was designed to convey post-development flows. The exception is for the sub-catchment which constructed by Cabra Investments. A permanent stormwater pond was constructed to attenuate flows from the Cabra development up to the 1% AEP event to pre-development levels.
The effect of the pond has been flow routed by the HMS model and incorporated into the hydraulic model. The peak discharge from the pond in the 1% AEP event has been modelled as 3.5 m3/s.

2.11.2 Eastern catchment - Hamlin Road Flood Prone

Flow from the existing eastern catchment Subbasin 205, 206 and 207 accumulate and pond on the south side of Hamlin Road. Flows then spill across the Road. A reservoir and spillway have been extracted from the terrain and incorporated in the model.

2.11.3 Eastern catchment - Airfield Road Flood Prone 1

It is noted that flow downstream of the site (downstream of Northern Outflow 1 and 2) pond on the south side of Airfield Road. Flow from the existing eastern catchment Subbasin 201, 202, 203, 205, 206 and 207 accumulate and pond on the south side of Airfield Road. Flows then spill across the Road. A reservoir and spillway have been extracted from the terrain and input in the model.

2.11.4 Eastern catchment - Airfield Road Flood Prone 2

It is noted that flows at Northern Outflow 3 pond on the south side of Airfield Road. Flow from the existing eastern catchment Subbasin 204 and 208 accumulates and ponds on the south side of Airfield Road. Flows then spill across the Road. A reservoir and spillway have been extracted from the terrain and input in the model.

2.12 PROPOSED CATCHMENT ATTENUATION

Please refer to Appendix C for a summary HEC HMS pair and cross section parameters data associated with the proposed attenuation reservoirs.

2.12.1 Western catchment - Stage 4 Dry Pond

The stage 4 dry pond has been sized to attenuate 1% and 10% AEP flows from the additional catchments subbasin 42, 43, 44 and 45 before discharging into the Awakeri wetland while maintaining the Awakeri Wetland flow requirements for the Cosgrave Road culvert. Please refer to Appendix C for a summary of the HEC HMS parameters.

2.12.2 Western catchment - Number 119 Cosgrave Road Pond

The Number 119 Cosgrave Road pond has been sized to attenuate 1% and 10% AEP flow from subbasin-41 before discharging into the Awakeri wetland while maintaining Awakeri Wetland flow requirements for the Cosgrave Road culvert. Please refer to Appendix C for a summary of the HEC HMS parameters.

2.12.3 Eastern catchment – Main channel

The termination section of the diversion channel has been included in the model as a reservoir. The reservoir was modelled with two outlets. The first a weir spillway exiting the site across the northern boundary, and the second an auxiliary outlet spillway (weir) flowing into a dry pond.

2.12.4 Eastern catchment – Northern Wetland

The proposed wetland was modelled as a reservoir. The bottom of the pond was modelled at the permanent water level of the pond. One outlet was included in the model as a weir spillway across the northern boundary.

2.12.5 Eastern catchment – Northern Dry pond

The proposed dry pond was modelled as a reservoir. The pond is proposed to be connected to the Wetland via stormwater pipes which shall convey flow between the dry pond and wetland during a 10%AEP storm event (but assumed blocked during a 1%AEP storm event).

2.12.6 Pond-208 – Wetland and attenuation device for subbasin 208

A wetland / stormwater pond is proposed for subbasin-208. The pond has been sized to attenuate 1% and 10% AEP flow from subbasin-208 to predevelopment conditions.

2.13 HEC HMS SENSITIVITY ANALYSIS (EASTERN CATCHMENT)

As the modelled eastern catchment is large and has a flat topography, the time of concentration of the upstream catchment plays a crucial role. A sensitivity analysis was undertaken for the time of concentration of the catchment upstream of each of the outflows using a simple distribution (uniform) method in HEC HMS. Please refer to appendix C for sensitivity analysis results.

The conducted sensitivity analysis highlighted that the site peak outflows were most sensitive to the time of concentration of Subbasin 203, 207 and 208.

It is noted that even though sensitive the calculated time of concentration for Subbasin-208 has high confidence due to the short slope length, it was concluded that no amendment was necessary.

Due to the sensitivity of site outflow to subbasins 203 and 207 a conservative approach was implemented, whereby the adopted times of concentration for the sensitive subbasins were increased by 15%.

The time to peak for subbasin 203 was increased from 66 minutes to 76 minutes and the time to peak for subbasin 207 was increased from 100 minutes to 115 minutes. (The time to peak for subbasin-51 was also increased from 82.1 to 94.4 minutes.

Component	Outflow 1 (Junction -1) Peak 1%AEP Flow (m3/s)		
	Mean	Mean minus 1 Standard Deviation σ	Mean plus 1 Standard Deviation σ
Subbasin-201	51.8	51.6 (-0.4%)	52.0 (0.4%)
Subbasin-205	51.7	51.0 (-1.4%)	52.4 (1.4%)
Subbasin-206	51.5	50.6 (-1.7%)	52.5 (1.9%)
Subbasin-207	52.8	46.1 (-12.7%)	60.2 (14.0%)

Table 2.7 – Sensitivity analysis of sub catchment discharging to Outflow -1

Component	Outflow 2 (Subbasin -203) Peak 1%AEP Flow (m3/s)		
	Mean	Mean minus 1 Standard Deviation σ	Mean plus 1 Standard Deviation σ
Subbasin-203	10.9	10.1 (-7.3%)	12.4 (13.8%)

Table 2.8 - Sensitivity analysis of sub catchment discharging to Outflow -2

Component	Outflow 3 (Subbasin-208) Peak 1%AEP Flow (m3/s)		
	Mean	Mean minus 1 Standard Deviation σ	Mean plus 1 Standard Deviation σ
Subbasin-208	0.7	0.7 (-8.2%)	0.8 (13.7%)

Table 2.9 - Sensitivity analysis of sub catchment discharging to Outflow -3

2.14 HEC HMS RESULTS

Please refer to Appendix F and G for a summary of the HEC HMS results.

Western catchment

It should be noted that previous modelling of the Awakeri wetland has indicated the HMS model to overestimate flow across the Cosgrave culvert. This is attributed to the HEC HMS modelling constraints of not accounting for the flood storage and hydraulics within the Awakeri wetland and culverts.

Previous *HEC RAS modelling* of the wetland has indicated the storage and culvert hydraulics attenuated the flow by 5.8 m3/s and 3.2 m3/s for the 1% AEP and 10%AEP storm respectively. For this assessment the HEC HMS target peak flows at Cosgrave culvert were altered accordingly (1% AEP peak flow target increased to 28.8 m3/s and the 10% AEP peak flow target increased to 17.8 m3/s).

Iterative modelling computations were conducted to optimise the outflow to the target flows, the results are summarised below;.

	Storm event	
Element	10yrCC peak flow (m3/s)	100yrCC peak flow (m3/s)
Target flow	17.8	28.8
Post Development	18.4*	28.0

Table 2.10 Western Catchment Cosgrave Road Flow results

**Iteration of HEC RAS modelling outlined in section 4 concluded proposed attenuation is sufficient once hydraulics is included.*

Element	10yr Pond Peak storage Vol (m3)	100yr Pond Peak storage Vol (m3)	Outlet
Stage 4 Dry Pond	43,530	74,300	Box Culvert 1.0m x 1.5m
119 Cosgrave Rd Pond	8,680	13,460	Pipe Culvert 0.75m

Table 2.11 Western Catchment Attenuation device sizing

The HEC HMS modelling indicated the proposed stormwater strategy for the western catchment will attenuate flow to meet the Cosgrave Culvert discharge requirements outlined by healthy waters. Please refer to section 4 where HEC RAS is used to confirm this conclusion.

Eastern catchment

HEC HMS modelling of the eastern catchment indicates peak flow attenuation is required for Northern Outflow 1 and 3. For northern outflow 2 the post development peak flow across the northern site boundary is decreased and that no attenuation of the flows is required. This can likely be attributed to the significant decrease in catchment area (due to diversion towards northern outflow 1) .

Iterative modelling computations were conducted to optimise the outflow to the target flows, the results are summarised below;

	Storm event	
Element	10yrCC peak flow m3/s	100yrCC peak flow m3/s
Pre Development	23.04	43.25
Post Development (attenuated)	22.99	41.83

Table 2.12 East Catchment Northern outflow 1 (Junction-1) HMS results

	Storm event	
Element	10yrCC peak flow m3/s	100yrCC peak flow m3/s
Pre Development	5.66	10.26
Post Development (no attenuation)	4.86	7.26

Table 2.13 East Catchment Northern outflow 2 (Junction-2) HMS results

	Storm event	
Element	10yrCC peak flow m3/s	100yrCC peak flow m3/s
Pre Development	0.38	0.72
Post Development (attenuated)	0.37	0.65

Table 2.14 East Catchment Northern outflow 3 (Subbasin-208) HMS results

Element	10yr Pond Peak storage Vol (m3)	100yr Pond Peak storage Vol (m3)	Outlet
Dry Pond	9,610	29,040	2m x 1m box culvert to Wetland
Wetland	12,380	14,650	20m weir @ mRL 22.6 1m weir @ mRL 21.9
Reservoir-208	1,580	2,630	
Main channel	25,700	28,250	150m weir @ mRL 22.5

Table 2.15 Eastern Catchment Attenuation device sizing

The HEC HMS modelling indicated the proposed stormwater strategy for the eastern catchment will attenuate flow to meet the pre development peak flows. Please refer to section 4 where HEC RAS is used to confirm this conclusion.

3 WESTERN CATCHMENT 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 within the main channels and proposed stage 4 dry pond (for the post development scenario). A 2D model was developed using proposed design contours. A Manning's n of 0.03 was used for the low flow areas and 0.045 for the rest of the channel. (Manning values have been used in consistency with previous modelling by healthy waters).

A 2m x 2m grid was used for the modelled 2D grid. Figure 3.1 and 3.2 shows the grids and its boundary conditions. Appendix H shows the model layout.

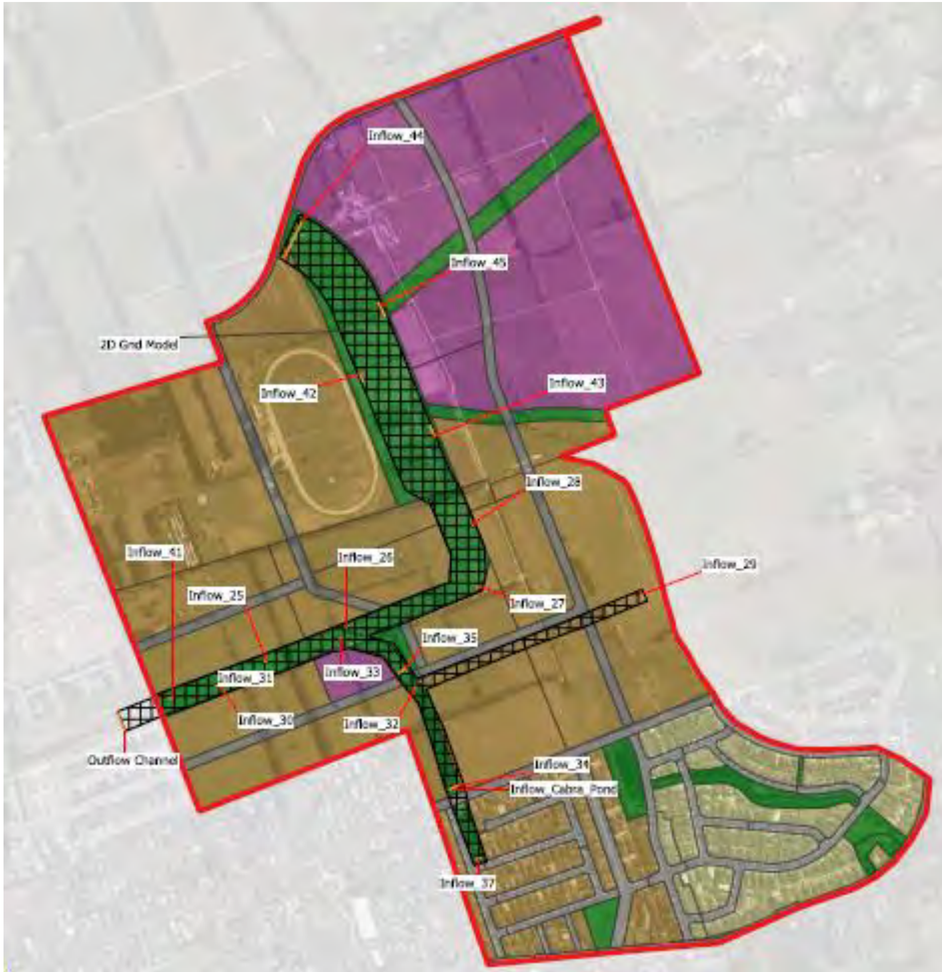


Figure 3.1 – HEC-RAS Post development Western model set-up

3.3 BOUNDARIES

The below boundary conditions were used in the model:

- A 2d grid – as per figure 3.1 and 3.2

  In the post development scenario the proposed detention pond, stage 4 dry pond, to the north of Awakeri wetland has been included which convey flows attenuated flow from subbasins 42, 43, 44 and 45

- Inflow hydrographs imported from HEC HMS (outlined in section 2)
- The downstream boundary condition was developed using a rating curve based on existing stage 1 channel capacity above the permanent water level
- Permanent water level – Initial water elevations were set at the top of weir levels

3.4 HYDRAULIC STRUCTURES AND CULVERTS

A total of four culverts have been included in the model as well as weir structures. A summary of the structures in included below.

Culverts

Name	Chainage	Size
Proposed Cosgrave Culvert	550	3 x Box culvert 1.5m x 2.5m
Proposed Chainage 1140 Culvert	1140	2 x Box culvert 1.5m x 2.0m
Existing Wairoa Road Culvert	1400	2 x 1500ø
Stage 4 Attenuation Pond Culvert	-	2 x Box culvert 1.0m x 1.0m

Table 3.1 – Western catchment Culvert summary

Proposed Weir

Chainage	Height mRL
580	22.59
610	22.93
690	23.16
800	23.39
900	23.63
950	23.85
1160	24.14
1240	24.34
1300	24.75

Table 3.2 – Western catchment weir summary

Figure 3.2 Proposed Weirs

Figure 3.3 Initial Water Surface Elevation (permanent water level)

3.5 WESTERN CATCHMENT PEAK FLOW RESULTS

Review of the modelling results from western post development catchment conclude flows meet the design flow requirements outlined by healthywater, with a peak flow 10year flow of 14.6m3/s (with the requirement of 14.6 m3/s) and a peak 100 year flow of 22.7 m3/s (with the requirement of 23.0 m3/s).

3.6 WESTERN CATCHMENT PEAK FLOW DEPTHS RESULTS

Peak post development 1% and 10% AEP water levels within the Awakeri wetland are shown in figure 3.4 below. Review of the modelling results from western catchment conclude the below;

<u>Cosgrave road culvert head water</u>

The post development peak 1% AEP headwater for the Cosgrave road culvert is 23.77 mRL, meeting the healthy water requirement level of 23.8 mRL.

<u>Cosgrave road culvert tail water</u>

The post development peak 1% AEP tailwater for the Cosgrave Road culvert is 23.25 mRL. This meets the healthy water requirement level of 23.25 mRL.

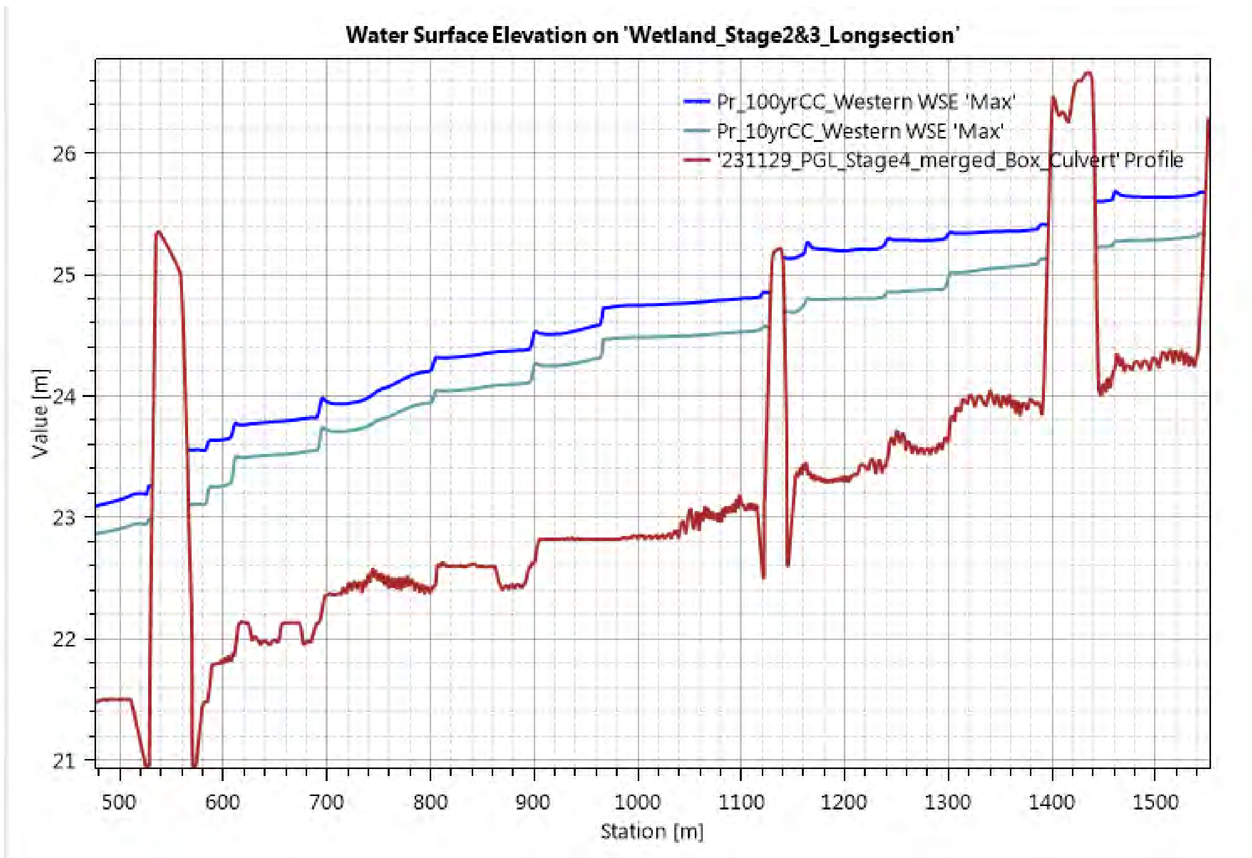


Figure 3.4 Post development peak 1% and 10% AEP water levels within Awakeri wetland

3.7 WESTERN CATCHMENT ATTENUATION VOLUMES

Element	10yr Pond Peak storage Vol (m3)	100yr Pond Peak storage Vol (m3)	Outlet
Within Awakeri Stage 3 channel (above PWL)	19,430	29,560	Cosgrave culvert 3 box culverts (2.5m x 1.5m)
Stage 4 Dry Pond	31,670	56,140	Box Culvert 1.0m x 1.5m
119 Cosgrave Rd Pond	8,680	13,460	Pipe Culvert 0.75m

Table 3.3 – Western catchment attenuation volumes

3.8 OUTFLOW VOLUME CHECK

The HEC RAS computation volume error for each scenario is summarised in the table below;

Scenario	Volumes error m3	Error as percentage
10% AEP Post development	210	0.09%
1% AEP Post development	123	0.03%

Table 3.4 – Outflow volume check for western catchment HEC RAS model

Figure 3.5 shows the volume generated in HEC-HMS for the post development 1% AEP scenario . The volume is 381,000m3. Figure 3.6 shows the volume accumulated at the HEC-RAS downstream boundary after 36 hours of simulation. The volume is 378,000m3. This is volume difference of 3,000 m3 or 0.7%. This difference is attributed to flood storage with the terrain and volume integrity is concluded to be sufficient.

HEC HMS volume at Cosgrave road culvert

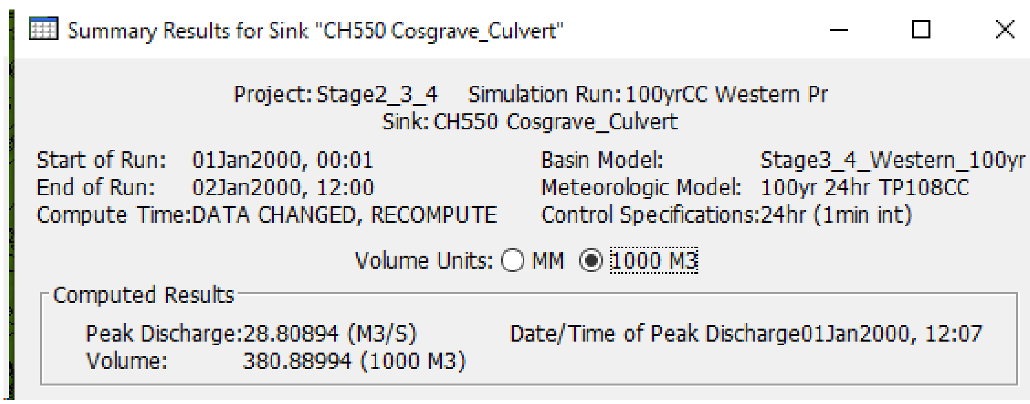


Figure 3.5 – HEC HMS 100yr storm volume discharging through Cosgrave Road culvert

HEC RAS volume through Cosgrave road Culvert

Time Series	Maximum	Time at Max	Volume 1000 m³
Stage HW	23.54	01Jan2000 1220	
Stage TW	23.25	01Jan2000 1220	
Total Flow	22.7	01Jan2000 1220	377.73

Figure 3.6 HEC RAS 100yr storm volume discharging through Cosgrave Road culvert

4 EASTERN CATCHMENT HYDRAULIC MODELLING WITH HEC-RAS

4.1 METHODOLOGY

The analysis was done using the following steps:

6. Delineate the perimeter for the grid,
7. Create a grid and sub-grid areas,
8. Input flow hydrographs and other boundaries
9. Input structures,
10. Run scenarios.

4.2 HEC-RAS MODEL LAYOUT

HEC-RAS software was used to generate water levels within the main channels and downstream of the site. A 2D model was developed using a proposed design contour, LINZ Terrain data and site-specific LiDAR and topographical survey. Review of difference in LINZ terrain and topographical survey showed minor levels differences especially at critical points, no adjustments were required for the import.

A mannings n of 0.2 was used for the majority of the 2D grid, this value was arrived at via initial calibration to HEC HMS time of concentration. A manning's n of 0.045 used for the main diversion channel. A 20m x 20m grid was used for the modelled 2D grid with a refinement region grid of 5m x 5m used within the proposed channel. Break lines were drawn along critical channels and crests within the terrain. Figure 4.1 shows the grid and its boundary conditions. A predevelopment and post development SCS curve number infiltration layer number was used based on the zoning. Appendix H shows the model layout.

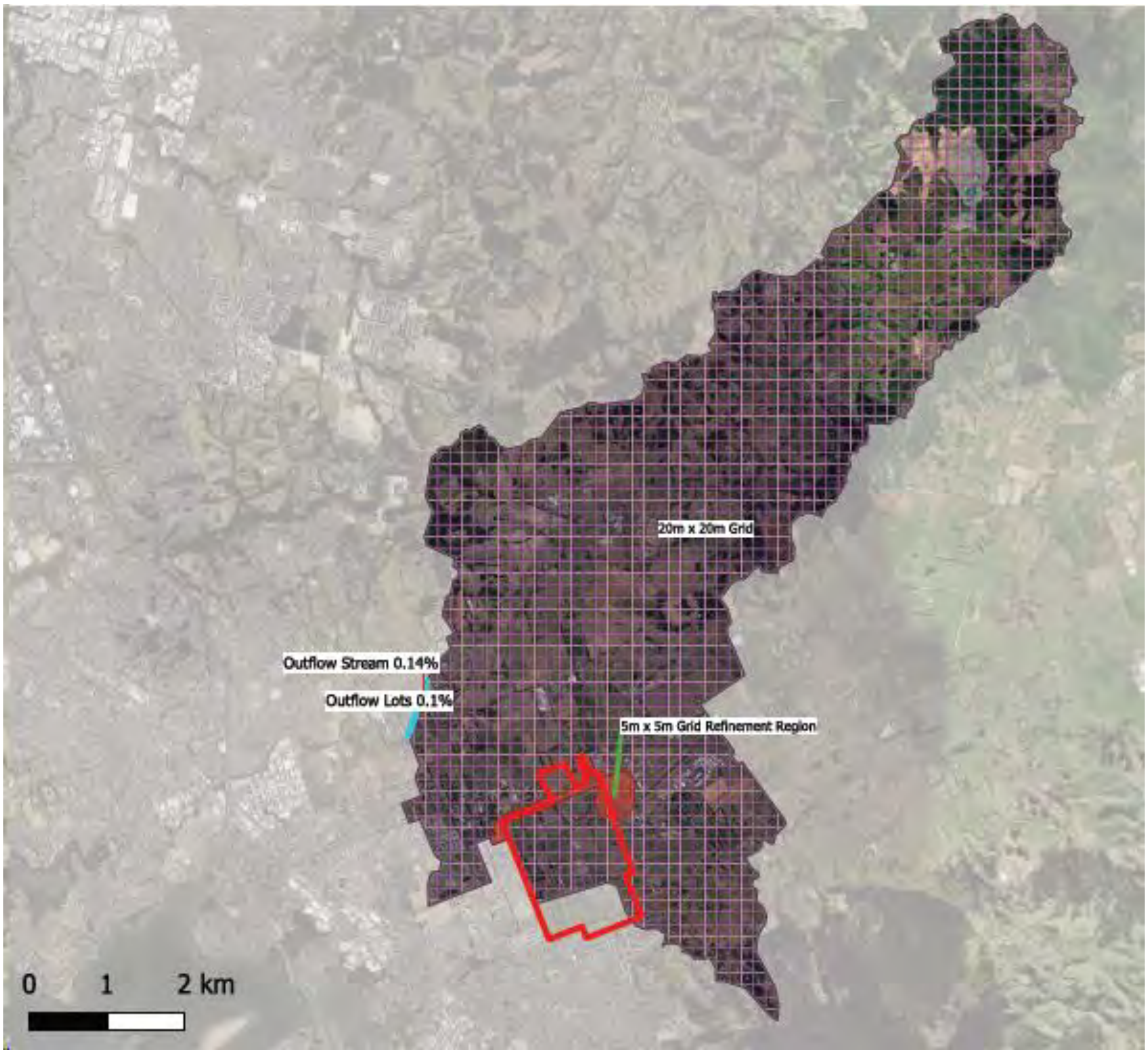


Figure 4.1 – HEC-RAS Predevelopment Eastern model set-up

4.3 BOUNDARIES

There are three boundaries. These are:

- Rain on grid – as per figure 4.1.
- Inflow hydrographs imported from HEC HMS (outlined in section 2)

  HEC HMS subbasins have been used as inflows (please refer to appendix I for plan)
- Outflow boundary –

Runoff from the eastern catchment eventually discharges to Papakura stream approximately 2,300m to the north of the site. The downstream boundary was constructed using a nominal depth into Papakura stream and its banks on each side. A downstream catchment (catchment E1) of approximately area 35 km2 has been included in the model to account for downstream tailwater effects. The normal depth gradient was obtained from streambed the terrain as 0.14% and adjacent banks 0.10%.

4.4 HYDRAULIC STRUCTURES

At the end of the eastern main diversion channel a lateral weir of length 150m is proposed across the northern site boundary at mRL 22.60 to control flow exiting the northern site boundary. A second weir of length 20m is proposed across a southern portion of the channel into the dry pond at mRL 22.65 to attenuate peak flow.

A wetland with permanent water level mRL 21.90 is proposed in the northwestern corner of the site. The wetland has a weir of length 90m outlet across northern boundary at mRL 22.60. The wetland is connected to the dry pond via three 750mm diameter stormwater pipes at mRL 21.90 allowing 10%AEP flow between the wetland and the dry pond.

4.5 FLOODPLAIN OUTPUT VALIDATION

Figure 4.2 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.

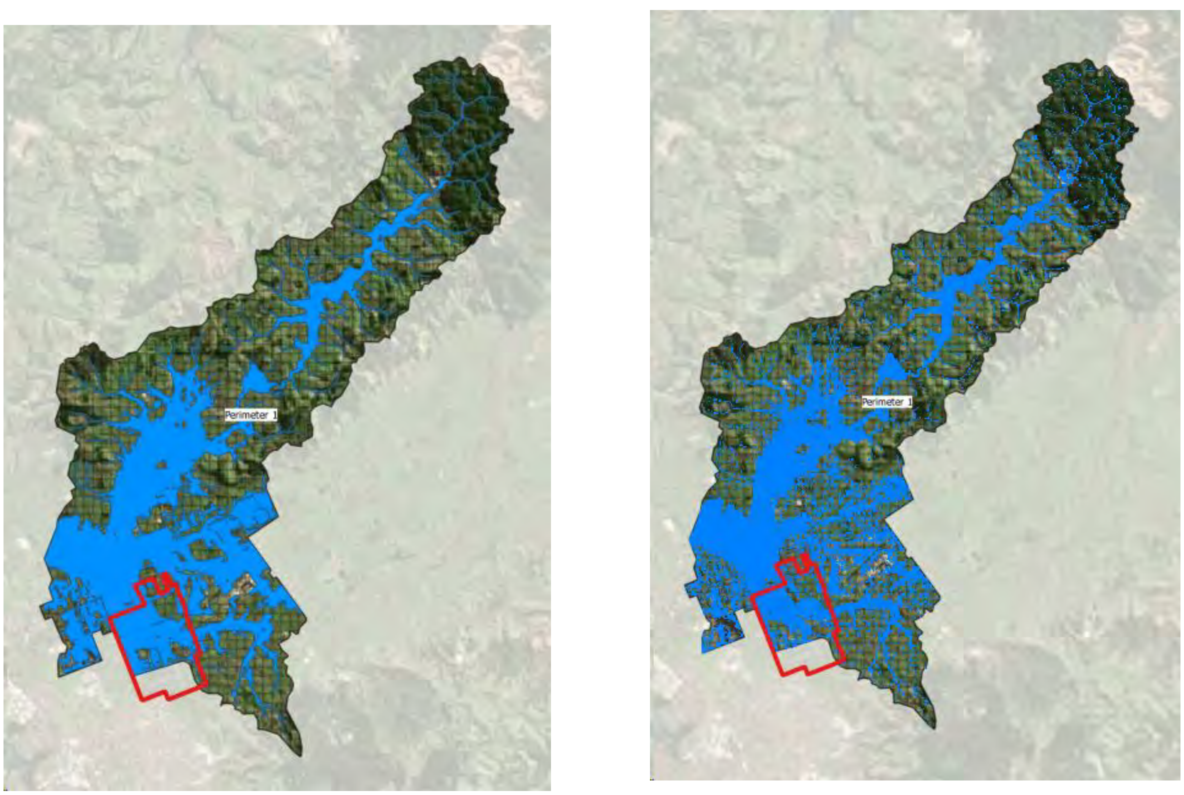


Figure 4.2 – Geomaps (left) HEC RAS model (Right) 100yr Flood plain

4.6 EASTERN CATCHMENT PEAK FLOW COMPARISON

Comparison of initial HEC RAS computations indicated the HEC HMS model predevelopment peak flow exiting the Northern outflow 1 showed the HEC RAS and HMS models to generally align. A comparison of the flows may be seen below;

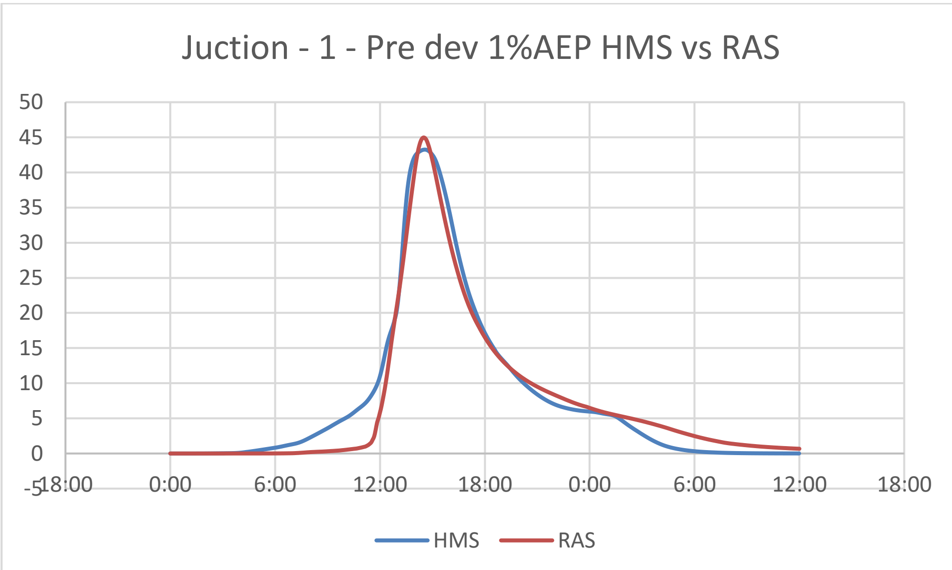
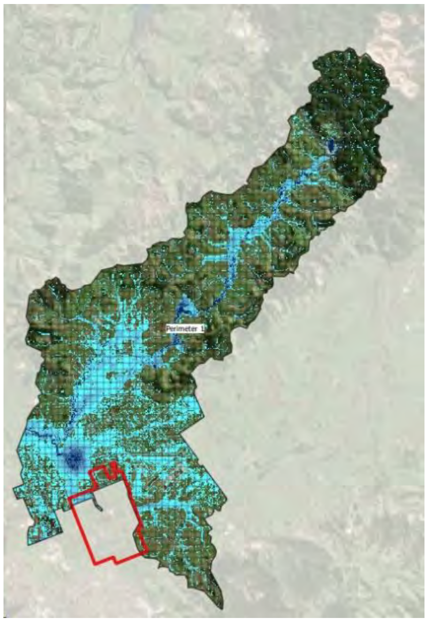


Table 4.3

4.7 EASTERN CATCHMENT PEAK FLOW RESULTS

Results for the eastern catchment may be found in the Appendix C.



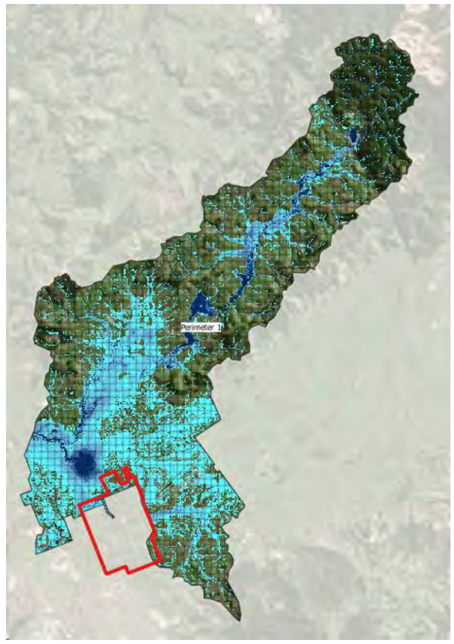


Table 4.4 10yr (left) and 100yr (right) modelled post development flood depths

Review of the modelling results (at the northern outflow 1), show a predevelopment a peak flow 100year peak flow of 44.97m3/s. Post development shows a decrease in flow to 43.99 m3/s (2% reduction). Similarly. For the 10year peak flow the predevelopment peak flow was 21.31 m3/s. Post development shows a decrease in flow to 20.37 m3/s (4% reduction). It is concluded that the proposed development has no adverse effects on downstream properties during a 100year event.
Plans SK026 show a comparison in flood levels and hydrographs exiting the northern boundary.

4.8 EASTERN CATCHMENT PEAK FLOW LEVEL RESULTS

The modelling results from the eastern catchment are shown on plans SK025 and SK026 and associated cross sections in appendix H.
The weir outlet along the northern boundary has been iteratively designed to simulate the predevelopment flow exiting the site as much as possible however it is noted that localised changes in pre and post development were observed. Generally, no notable increase in downstream flood levels was observed in the post development model with decreases in water levels.
In the property located directly adjacent the weir (526 Mill Road and 237 Airfield Road), a maximum change in peak water depth of approximately 180mm was shown to be localised directly adjacent the center of the weir with changing in levels generally being approximately 30mm. Given the context that the existing flood depth in this area adjacent the weir ranges between 700mm and 900mm we conclude this localised increase in peak flood depth to have no adverse impact on the downstream property.

4.9 EASTERN CATCHMENT ATTENUATION DEVICES

Element	10yr Pond Peak storage Vol (m3)	100yr Pond Peak storage Vol (m3)	Outlet
Dry Pond	32,000	40,500	150m weir
Wetland	14,400	13,800	20m weir
Reservoir-208*	1,580	2,630	

*Attenuation volumes from HEC HMS

Table 4.1 Eastern catchment attenuation volumes summary

Element	10yr Pond Peak flow (m3/s)	100yr Pond Peak flow (m3/s)	Outlet
Channel Main Weir	20.10	42.58	150m weir
Channel Diversion Weir	0.89	3.31	20m weir
Wetland Weir	11.65	7.96	90m weir

*For 10%AEP event pipes connect wetland to Dry pond allowing free flow between and combined storage volume

Table 4.2 Eastern catchment attenuation peak flow summary

4.10 OUTFLOW VOLUME CHECK

The HEC RAS computation volume error for each scenario is summarised in the table below;

Scenario	Volumes error m3	Error as percentage
10%AEP Predevelopment	1,080	0.02%
10% AEP Post development	1,021	0.02%
1%AEP Predevelopment	1,711	0.02%
1% AEP Post development	681	0.01%

Table 4.3 Outflow volume check for eastern catchment HEC RAS model

Figure 4.5 shows the volume generated in HEC-HMS for the pre development 1% AEP scenario . The volume is 1,010,700m3. Figure 4.6 shows the volume accumulated at the HEC-RAS downstream boundary after 36 hours of simulation. The volume is 962,000m3. This is an volume difference of 48,700 m3 or 4.8%. This difference is attributed to flood storage with the terrain and volume integrity is concluded to be sufficient.

<u>HEC HMS volume at Junction-1 (100yr Predevelopment)</u>

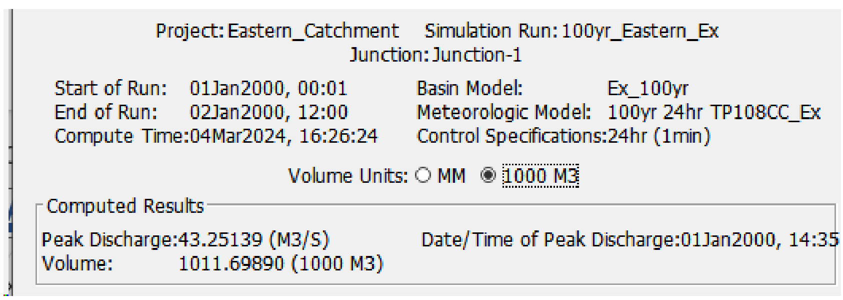


Figure 4.5 HEC HMS 100yr storm volume discharging through Junction-1

<u>HEC RAS volume at Juction-1 corresponding cross section (100yr Predevelopment)</u>

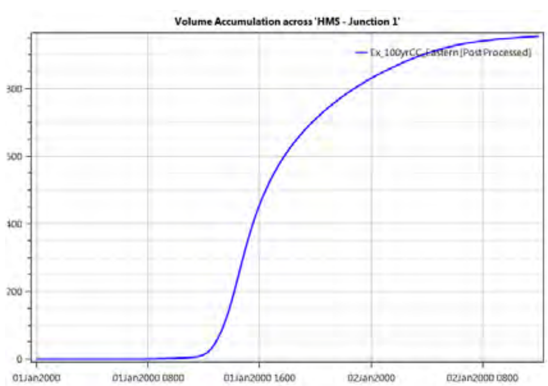
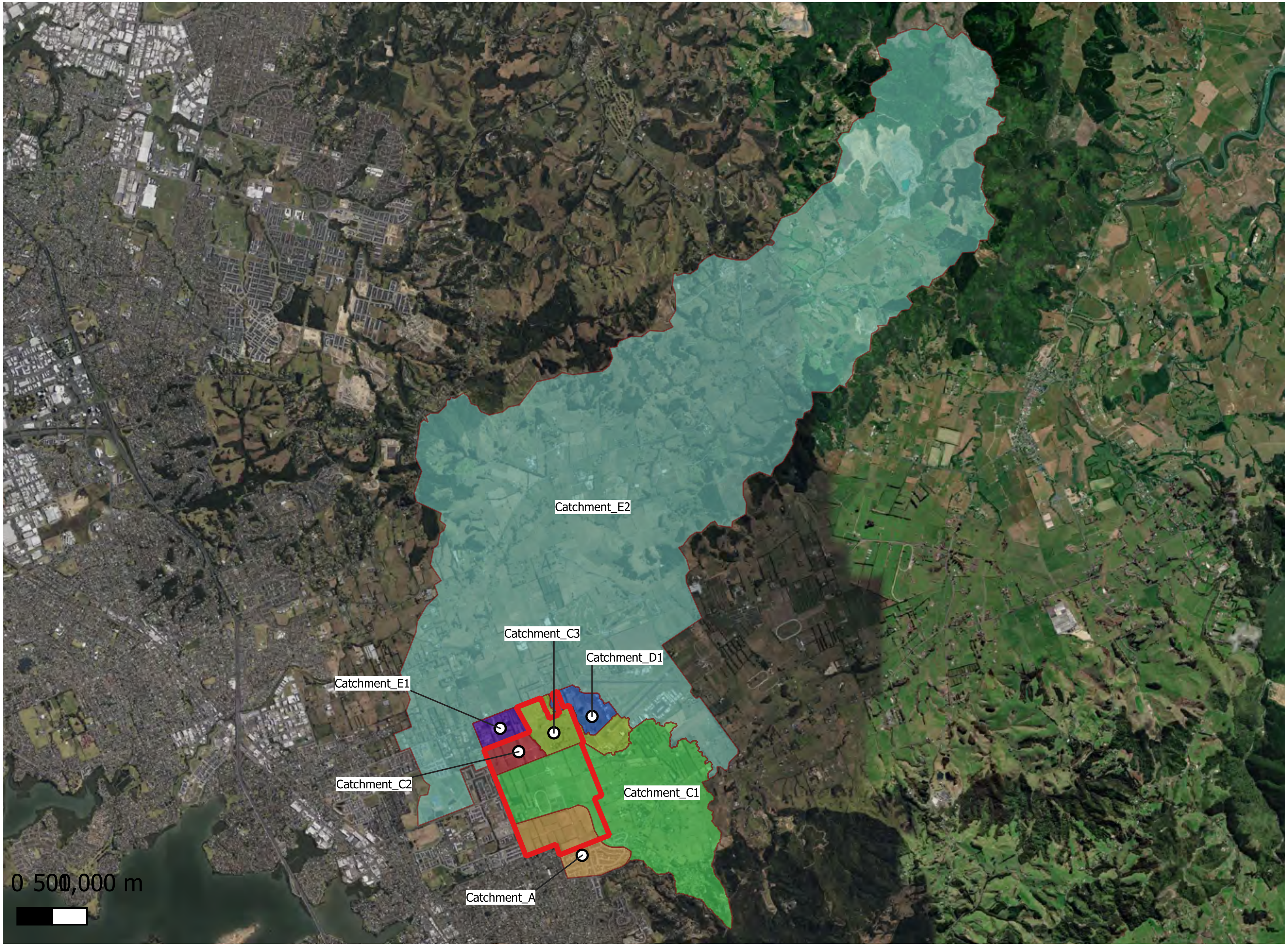


Figure 4.6 HEC RAS 100yr storm volume discharging across Junction-1

APPENDIX A – CATCHMENT PLANS

Pre Development Catchments Overview

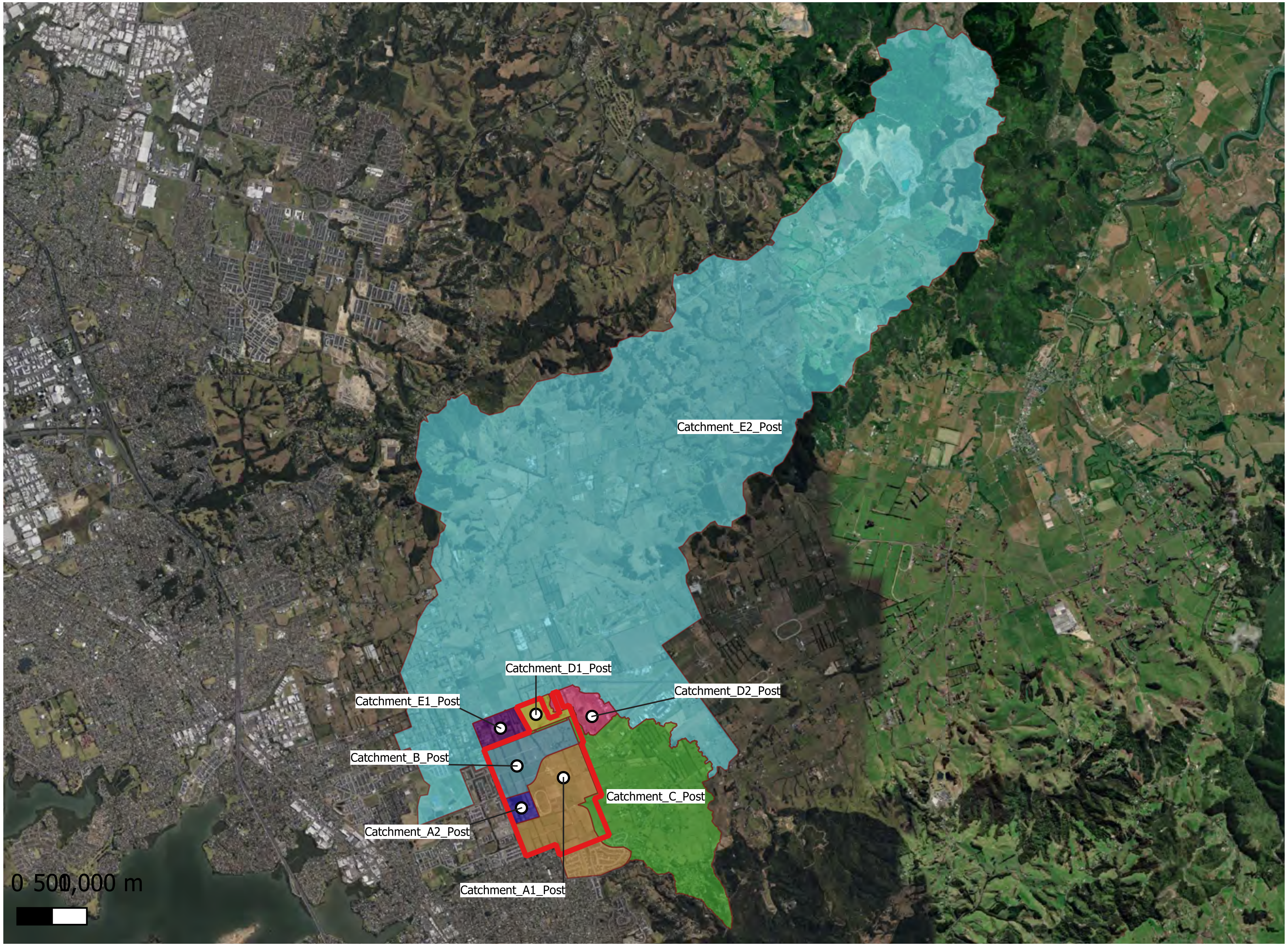


Legend

Site Boundary

SK001
REV 001

Post Development Catchments Overview

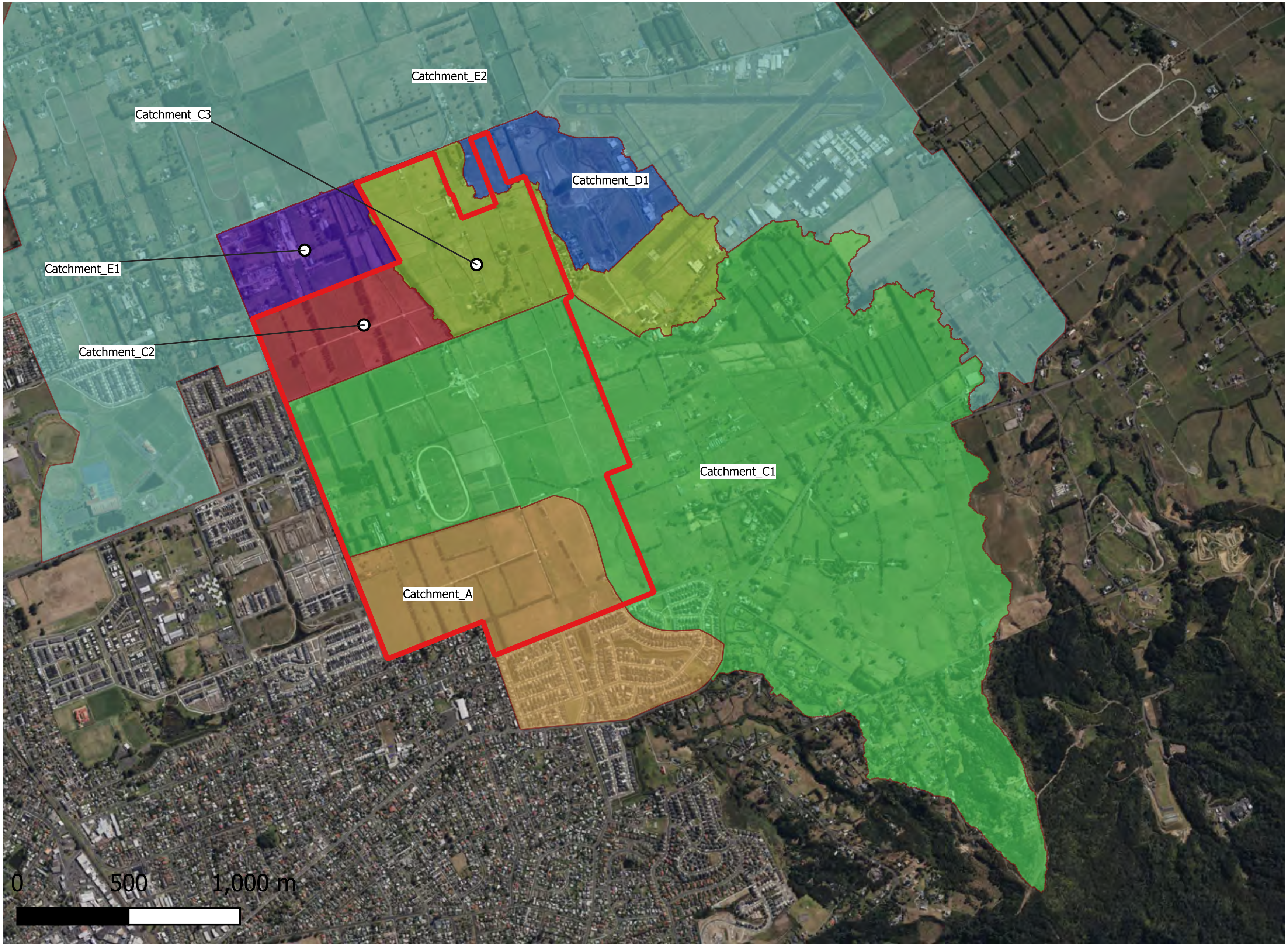


Legend

Site Boundary

SK004
REV 001

Pre development Catchments

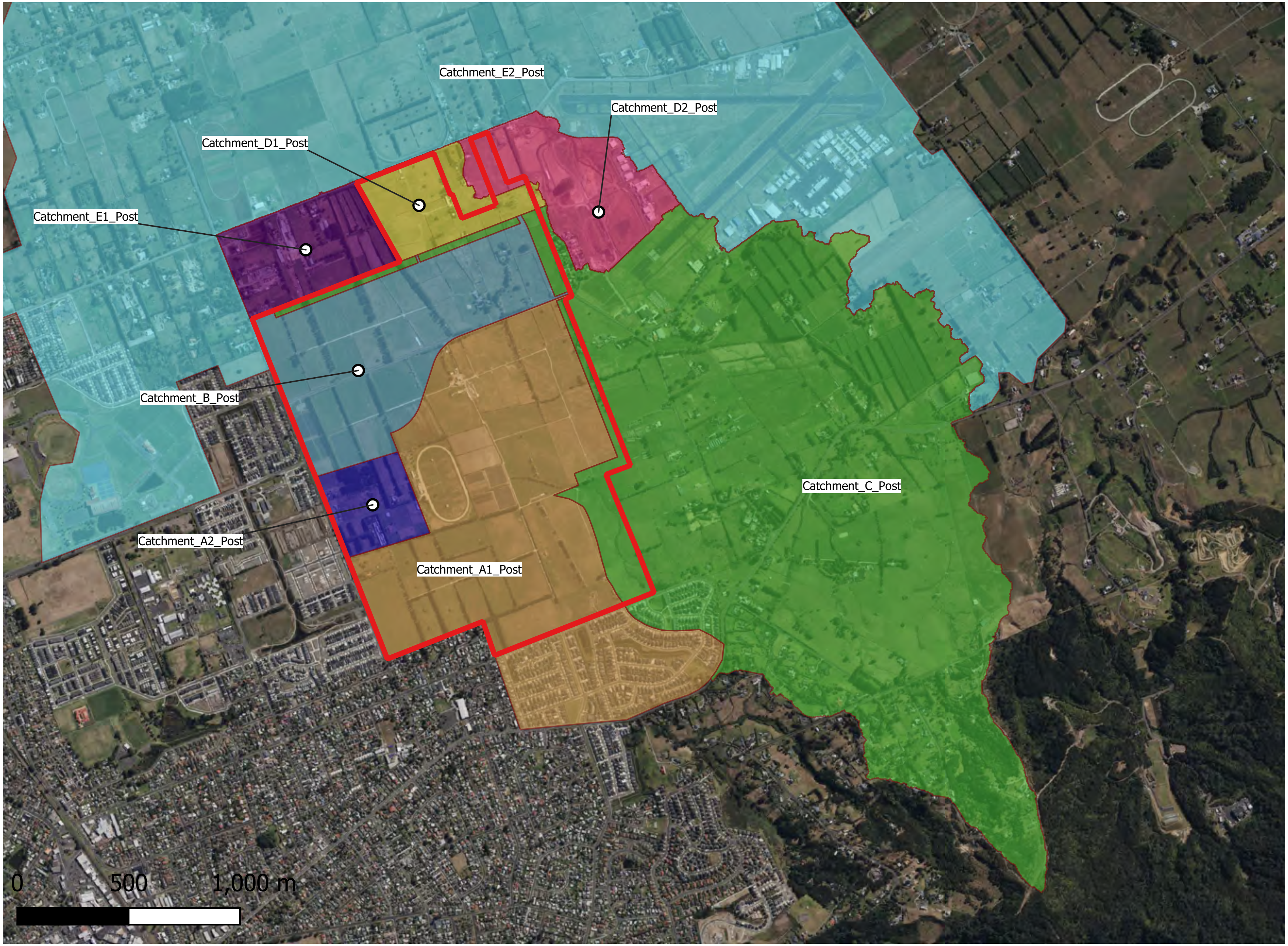


Legend

Pr-Bdy

SK002
REV 001

Post Development Catchments

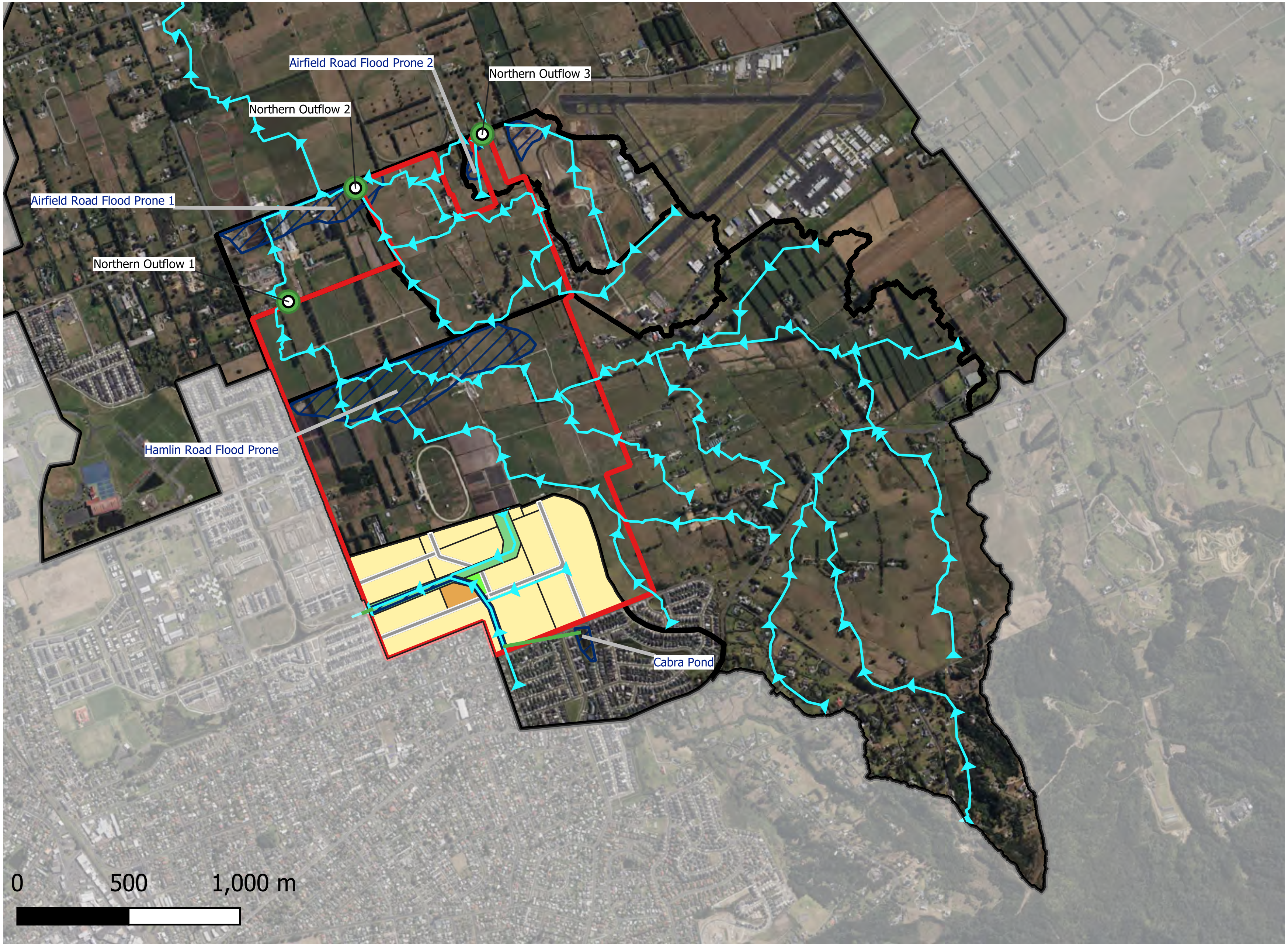


Legend

Pr-Bdy

SK005
REV 001

Existing Catchment Flow paths



Legend

Site Boundary

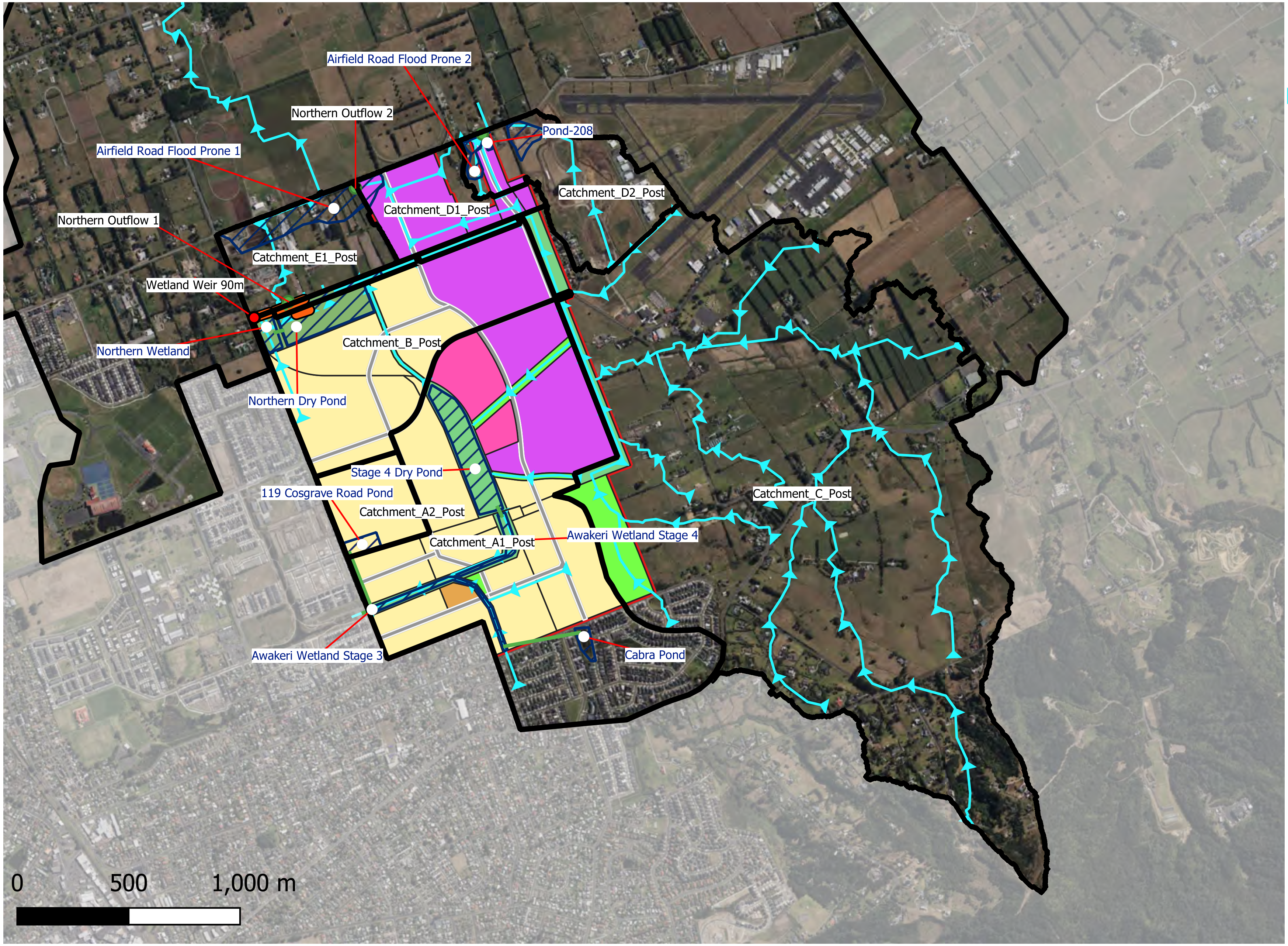
Predevelopment Catchments

Existing OLFP

Existing Flood Prone Storage

SK003
REV 001

Proposed Catchment Flow paths



Legend

- Site Boundary
- Postdevelopment Catchments
- Proposed OLFP
- Post development Flood Storage
- Proposed Culvert

SK006
REV 001

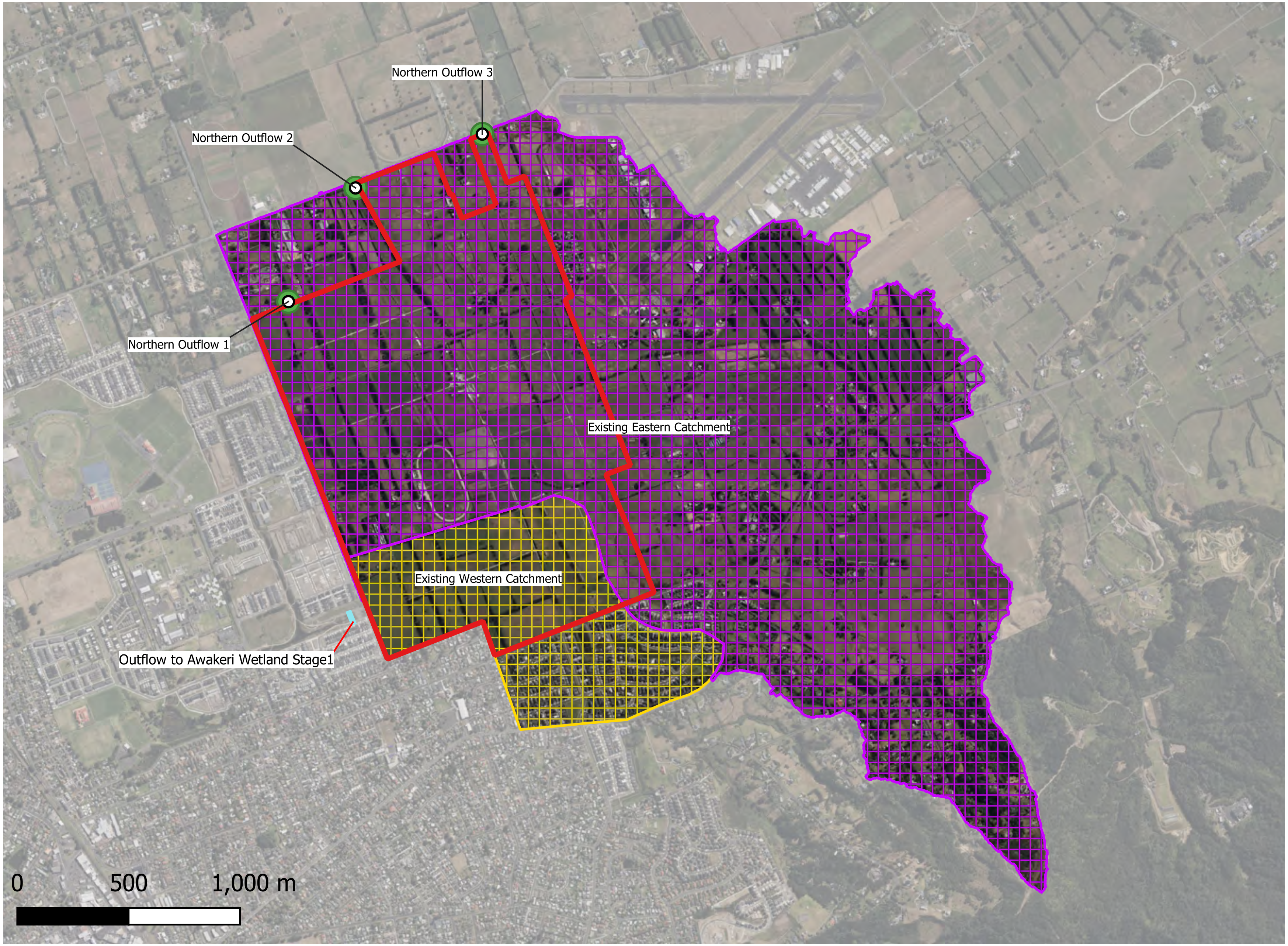
APPENDIX B – RAIN GAUGE LOCATIONS

Rain Gauge Locations

SK007
REV 001

APPENDIX C – HMS model

Existing HEC HMS Catchments



Legend

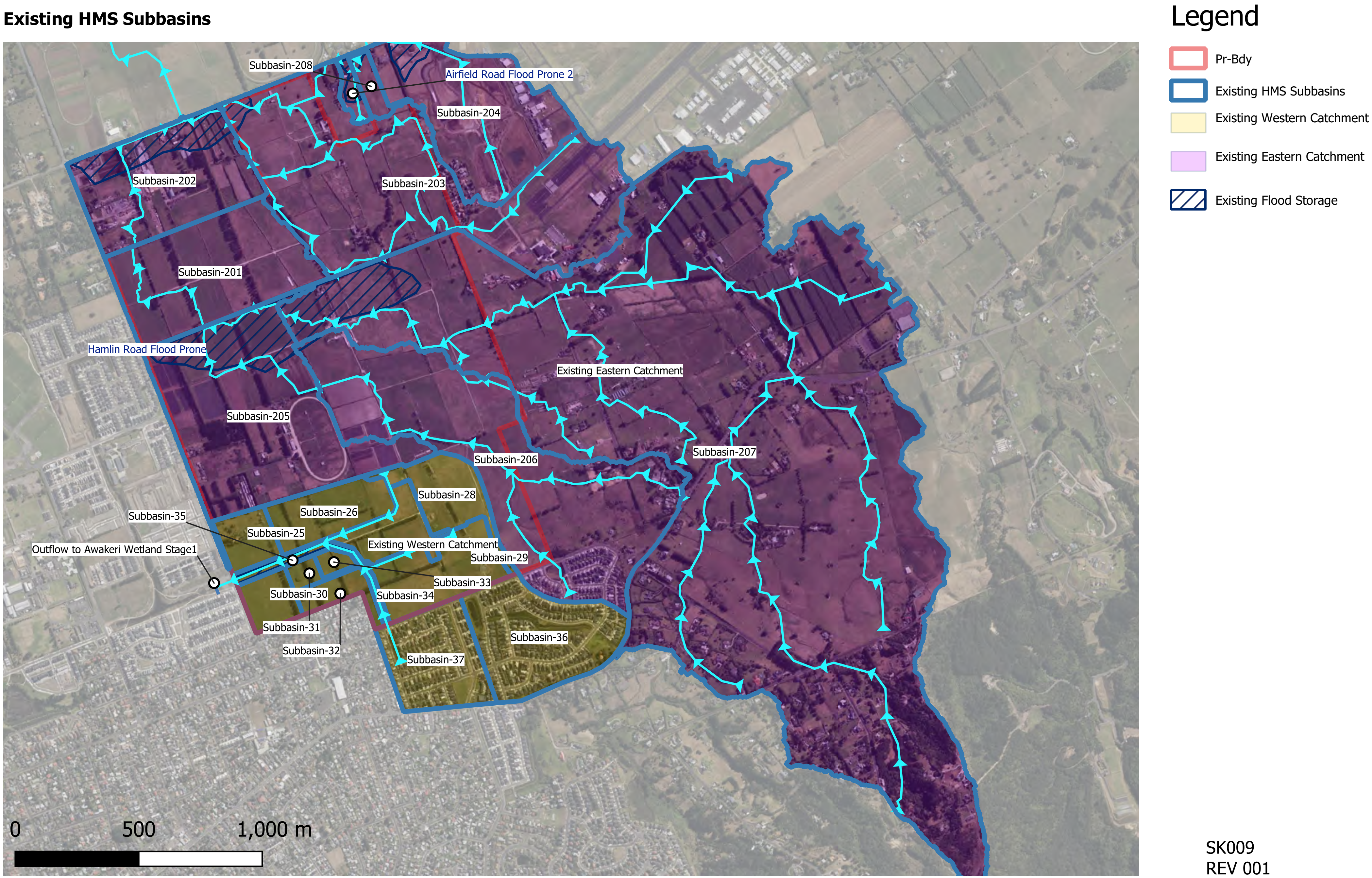
Pr-Bdy

Existing Western Catchment

Existing Eastern Catchment

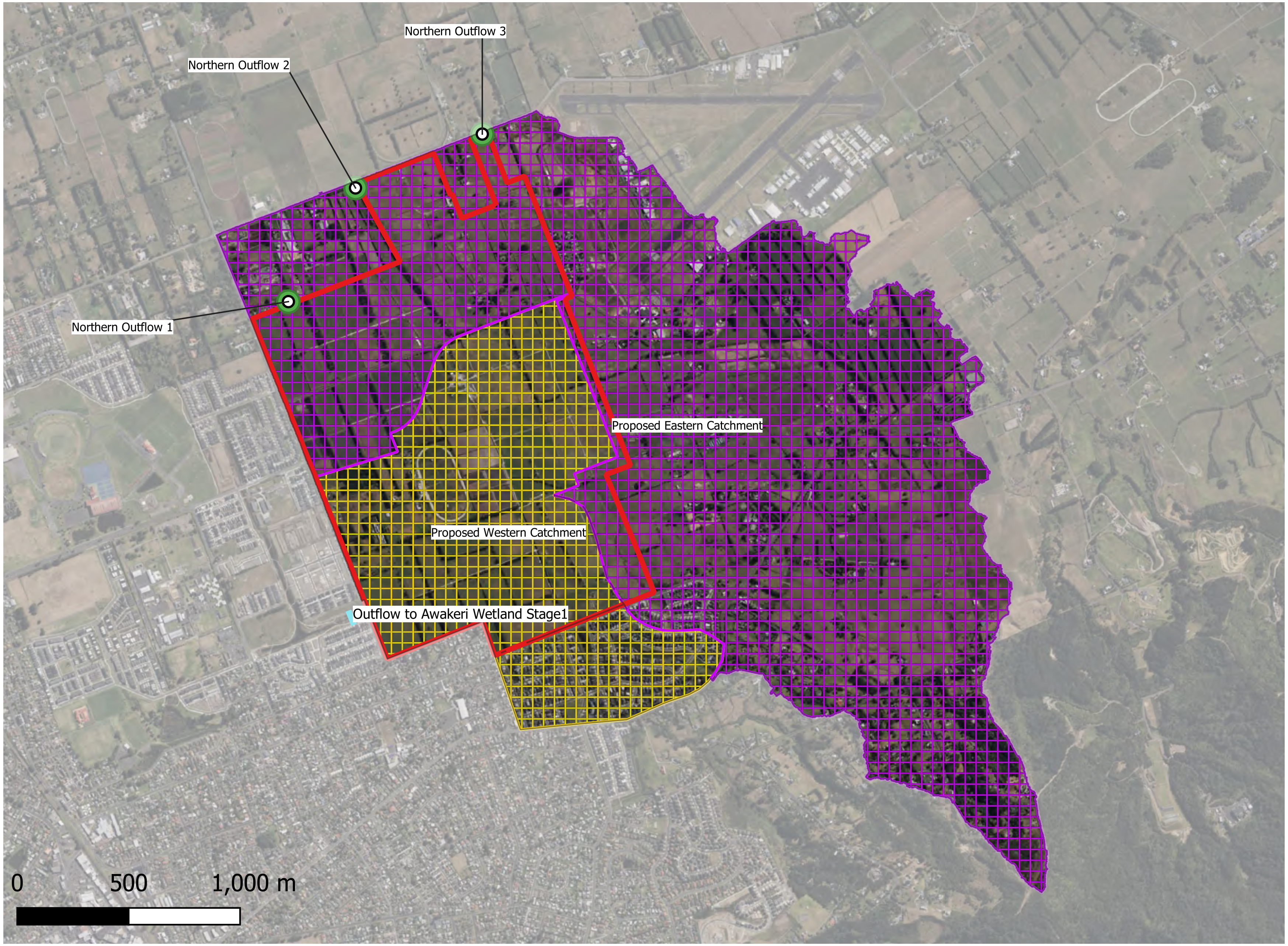
SK008
REV 001

Existing HMS Subbasins

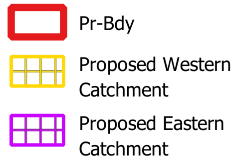


SK009
REV 001

Proposed HMS Model Catchments

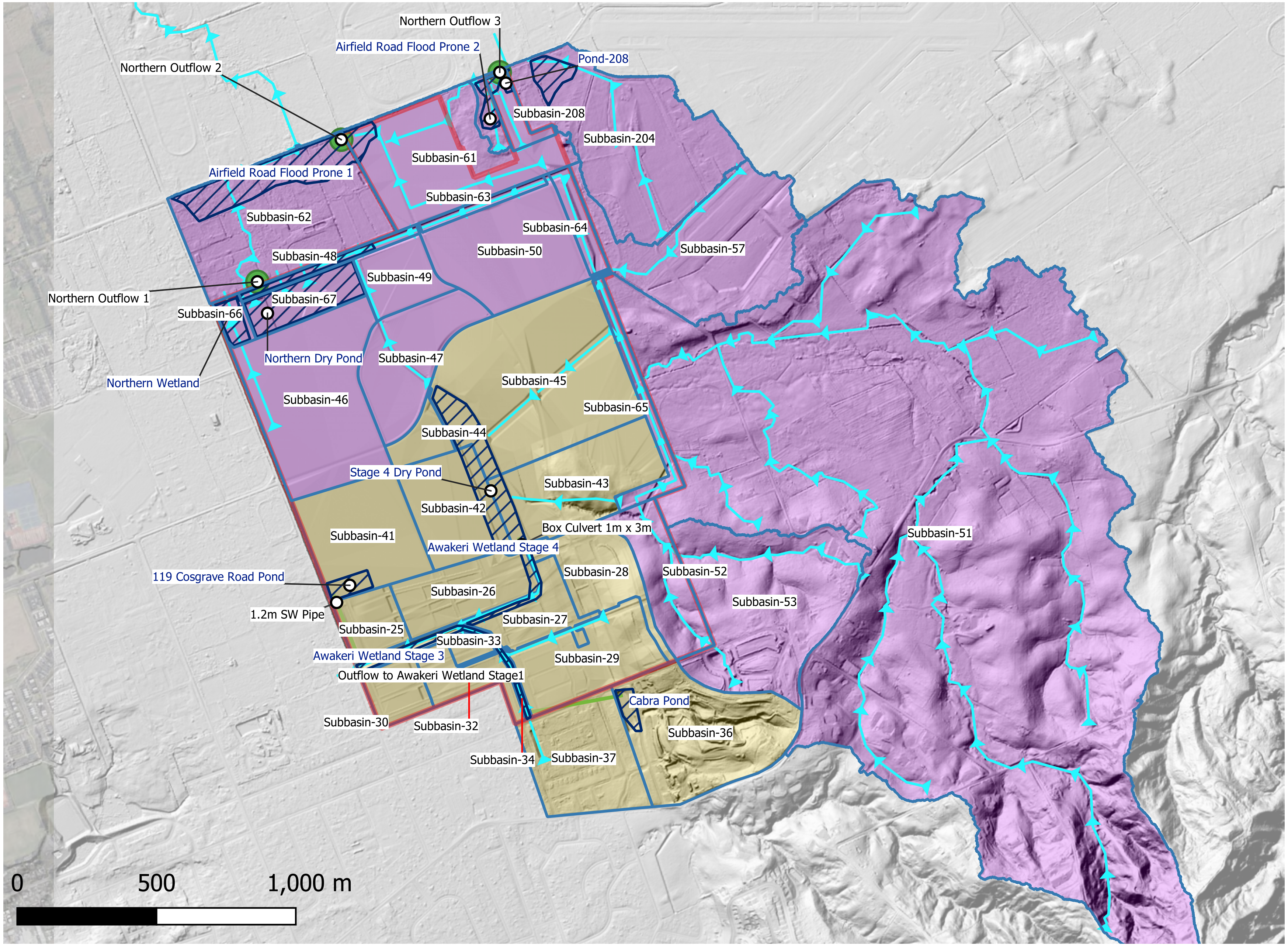


Legend



SK010
REV 001

Proposed HMS Subbasins



Legend

- Pr-Bdy
- Proposed HMS Subbasins
- Eastern Catchment
- Western Catchment
- POST DEVELOPMENT OLFP
- Flood Storage Area Post Development

SK011
REV 001

Eastern Pre Development HEC HMS Subbasins

											10 year						100 year					
Catchment	Area Ha	Area km2	Imper %		Impervious Total (Ha)	Pervious Total (Ha)	Impervious CN	Pervious CN	Weighted CN	Ia (average)	C factor	Slope	Length	Tc	Tp	tp min	C factor	Slope	Length	Tc	Tp	tp min
Subbasin-201	30.53079	0.305307928	0.13	13%	3.8689	26.6618	98	74	77.0	4.4	1	0.003	948.3	1.0	0.7	39.9	1	0.003	948.3	1.0	0.7	39.9
Subbasin-202	27.98404	0.279840402	0.13	13%	3.5529	24.4312	98	74	77.0	4.4	1	0.001	1062.3	1.5	1.0	59.9	1	0.001	1062.3	1.5	1.0	59.9
Subbasin-203	73.75997	0.737599748	0.32	32%	23.8929	49.8671	98	74	81.8	3.4	1	0.006	3009.7	1.6	1.1	75.7	1	0.006	3009.7	1.6	1.1	75.7
Subbasin-204	34.05261	0.340526087	0.60	60%	20.4104	13.6422	98	74	88.4	2.0	0.6	0.005	1211.2	0.5	0.4	21.2	0.8	0.005	1211.2	0.7	0.5	28.3
Subbasin-205	50.99817	0.509981674	0.13	13%	6.4911	44.5071	98	74	77.1	4.4	1	0.003	1105.9	1.1	0.7	44.2	1	0.003	1105.9	1.1	0.7	44.2
Subbasin-206	68.37765	0.683776497	0.19	19%	13.0526	55.3250	98	74	78.6	4.0	1	0.011	2349.1	1.2	0.8	48.4	1	0.011	2349.1	1.2	0.8	48.4
Subbasin-207	324.0157	3.240157197	0.15	15%	49.4022	274.6135	98	74	77.7	4.2	1	0.009	6318.2	2.5	1.7	124.0	1	0.009	6318.2	2.5	1.7	124.0
Subbasin-208	2.357516	0.023575159	0.10	10%	0.2358	2.1218	98	74	76.4	4.5	1	0.008	285.9	0.3	0.2	13.6	1	0.008	285.9	0.3	0.2	13.6

Reach	Length	Ave Velocity	Lag time
Reach-10	685	0.2	57.1
Reach-11	510	0.2	42.5
Reach-12	514	0.2	42.8

* Adjust +15%

Eastern Post Development HEC HMS Subbasins

											10 year						100 year					
Catchment	Area Ha	Area km2	Imper %		Impervious Total (Ha)	Pervious Total (Ha)	Impervious CN	Pervious CN	Weighted CN	Ia (average)	C factor	Slope	Length	Tc	Tp	tp min	C factor	Slope	Length	Tc	Tp	tp min
Subbasin-46	25.4827	0.254826996	0.61	61%	15.6236	9.8591	98	74	88.7	1.9	0.6	0.005	562.7	0.3	0.2	12.8	0.8	0.005	562.7	0.4	0.3	17.0
Subbasin-47	12.78057	0.12780566	0.62	62%	7.8897	4.8909	98	74	88.8	1.9	0.6	0.008	325.7	0.2	0.1	7.7	0.8	0.008	325.7	0.3	0.2	10.3
Subbasin-48	2.373507	0.02373507	0.30	30%	0.7117	1.6618	98	74	81.2	3.5	0.6	0.01	100.0	0.1	0.1	3.6	0.8	0.01	100.0	0.1	0.1	4.8
Subbasin-49	6.234005	0.062340052	0.60	60%	3.7465	2.4875	98	74	88.4	2.0	0.6	0.009	338.3	0.2	0.1	7.7	0.8	0.009	338.3	0.3	0.2	10.2
Subbasin-50	17.69748	0.176974836	0.90	90%	15.8396	1.8579	98	74	95.5	0.5	0.6	0.007	452.3	0.2	0.2	9.3	0.8	0.007	452.3	0.3	0.2	12.4
Subbasin-51	296.8111	2.968110992	0.16	16%	46.1932	250.6179	98	74	77.7	4.2	1	0.011	5162.3	2.1	1.4	94.4	1	0.011	5162.3	2.1	1.4	94.4
Subbasin-52	9.255945	0.092559454	0.10	10%	0.9278	8.3282	98	74	76.4	4.5	1	0.015	736.1	0.5	0.4	21.0	1	0.015	736.1	0.5	0.4	21.0
Subbasin-53	30.63653	0.306365264	0.30	30%	9.2997	21.3368	98	74	81.3	3.5	1	0.021	934.6	0.5	0.4	21.0	1	0.021	934.6	0.5	0.4	21.0
Subbasin-57	25.5602	0.255602047	0.70	70%	17.9309	7.6293	98	74	90.8	1.5	0.8	0.004	1036.5	0.7	0.4	26.6	0.8	0.004	1036.5	0.7	0.4	26.6
Subbasin-61	21.9952	0.219951953	0.76	76%	16.6977	5.2975	98	74	92.2	1.2	0.6	0.01	787.1	0.3	0.2	12.4	0.8	0.01	787.1	0.4	0.3	16.6
Subbasin-62	28.40857	0.284085657	0.13	13%	3.5969	24.8116	98	74	77.0	4.4	0.8	0.002	721.8	0.8	0.5	30.1	0.8	0.002	721.8	0.8	0.5	30.1
Subbasin-63	1.650043	0.016500434	0.31	31%	0.5070	1.1430	98	74	81.4	3.5	0.6	0.012	558.5	0.3	0.2	10.6	0.8	0.012	558.5	0.4	0.2	14.1
Subbasin-64	2.869134	0.028691338	0.30	30%	0.8613	2.0078	98	74	81.2	3.5	0.6	0.003	393.4	0.3	0.2	12.8	0.8	0.003	393.4	0.4	0.3	17.0
Subbasin-65	4.225083	0.042250829	0.30	30%	1.2633	2.9618	98	74	81.2	3.5	0.6	0.004	862.5	0.5	0.3	19.7	0.8	0.004	862.5	0.7	0.4	26.3
Subbasin-66	1.74875	0.017487496	1.00	100%	1.7455	0.0032	98	74	98.0	0.0	0.6	0.004	100.0	0.1	0.1	3.9	0.8	0.004	100.0	0.1	0.1	5.3
Subbasin-67	6.019408	0.060194075	0.10	10%	0.6106	5.4088	98	74	76.4	4.5	0.6	0.004	100.0	0.1	0.1	5.0	0.8	0.004	100.0	0.2	0.1	6.7
Subbasin-204	34.04607	0.340460668	0.63	63%	21.5911	12.4550	98	74	89.2	1.8	0.6	0.005	1211.2	0.5	0.4	21.1	0.8	0.005	1211.2	0.7	0.5	28.1
Subbasin-208	2.592841	0.025928414	0.89	89%	2.3029	0.2899	98	74	95.3	0.6	0.6	0.004	274.0	0.2	0.1	7.9	0.8	0.004	274.0	0.3	0.2	10.5

* Adjust +15%

Reach	Length	Ave Velocity	Lag time
Reach-1	454	1	7.6
Reach-11	510	0.2	42.5
Reach-12	514	0.2	42.8
Reach-2	260	1	4.3
Reach-3	422	1	7.0
Reach-4	374	1	6.2
Reach-5	306	1	5.1
Reach-6	230	1	3.8
Reach-7	172	1	2.9
Reach-8	261	1	4.4

Western Pre Development HEC HMS Subbasins

											10 year						100 year					
Catchment	**Area Ha**	**Area km2**	**Imper %**		**Impervious Total (Ha)**	**Pervious Total (Ha)**	**Impervious CN**	**Pervious CN**	**Weighted CN**	**Ia (average)**	**C factor**	**Slope**	**Length**	**Tc**	**Tp**	**tp min**	**C factor**	**Slope**	**Length**	**Tc**	**Tp**	**tp min**
Subbasin-25	4.841655	0.04841655	0.62	62%	3.0144	1.8272	98	74	88.9	1.9	0.6	0.006	210	0.2	0.1	6.3	0.8	0.006	210	0.2	0.1	8.4
Subbasin-26	9.617732	0.09617732	0.61	61%	5.9135	3.7043	98	74	88.8	1.9	0.6	0.005	340	0.2	0.2	9.1	0.8	0.005	340	0.3	0.2	12.2
Subbasin-27	6.628724	0.06628724	0.58	58%	3.8759	2.7528	98	74	88.0	2.1	0.6	0.02	85	0.1	0.0	2.4	0.8	0.02	85	0.1	0.1	3.2
Subbasin-28	9.213457	0.09213457	0.61	61%	5.6491	3.5643	98	74	88.7	1.9	0.6	0.026	780	0.2	0.2	9.7	0.8	0.026	780	0.3	0.2	12.9
Subbasin-29	12.56291	0.12562912	0.61	61%	7.6673	4.8956	98	74	88.6	1.9	0.6	0.028	380	0.1	0.1	5.9	0.8	0.028	380	0.2	0.1	7.8
Subbasin-30	4.277408	0.04277408	0.62	62%	2.6693	1.6081	98	74	89.0	1.9	0.6	0.009	95	0.1	0.1	3.3	0.8	0.009	95	0.1	0.1	4.4
Subbasin-31	1.615277	0.01615277	0.65	65%	1.0420	0.5732	98	74	89.5	1.8	0.6	0.005	300	0.2	0.1	8.4	0.8	0.005	300	0.3	0.2	11.1
Subbasin-32	3.573248	0.03573248	0.62	62%	2.2147	1.3585	98	74	88.9	1.9	0.6	0.084	160	0.1	0.0	2.4	0.8	0.084	160	0.1	0.1	3.2
Subbasin-33	1.267505	0.01267505	0.90	90%	1.1404	0.1271	98	74	95.6	0.5	0.6	0.005	90	0.1	0.1	3.5	0.8	0.005	90	0.1	0.1	4.7
Subbasin-34	0.6295	0.006295	0.50	50%	0.3153	0.3142	98	74	86.0	2.5	0.6	0.005	90	0.1	0.1	3.9	0.8	0.005	90	0.1	0.1	5.2
Subbasin-35	2.2976	0.022976	0.50	50%	1.1541	1.1435	98	74	86.1	2.5	0.6	0.005	90	0.1	0.1	3.9	0.8	0.005	90	0.1	0.1	5.2
Subbasin-36	21.851	0.21851	0.60	60%	13.0584	8.7926	98	74	88.3	2.0	0.6	0.007	400	0.2	0.2	9.2	0.8	0.007	400	0.3	0.2	12.3
Subbasin-37	15.052	0.15052	0.66	66%	9.8981	5.1539	98	74	89.8	1.7	0.6	0.037	687	0.2	0.1	7.9	0.8	0.037	687	0.3	0.2	10.5

Reach	**Length**	**Ave Velocity**	**Lag time**
CH550-700	150	1	2.5
CH700-800	100	1	1.7
CH800-960	160	1	2.7
CH960-1150	190	1	3.2
CH1050-1150	100	1	1.7
CH1150-1400	250	1	4.2
CH1400-1550	150	1	2.5

Western Post Development HEC HMS Subbasins

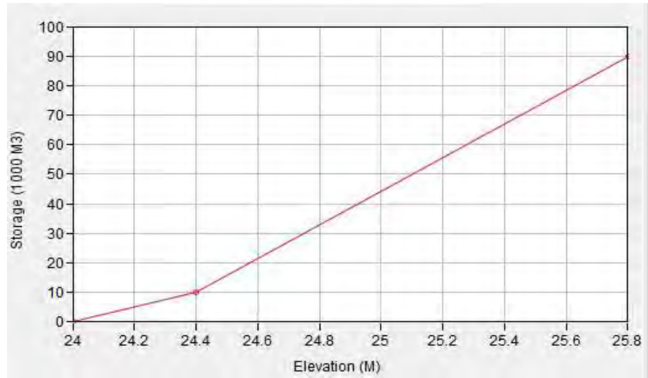
											10 year						100 year					
Catchment	Area Ha	Area km2	Imper %		Impervious Total (Ha)	Pervious Total (Ha)	Impervious CN	Pervious CN	Weighted CN	Ia (average)	C factor	Slope	Length	Tc	Tp	tp min	C factor	Slope	Length	Tc	Tp	tp min
Subbasin-25	4.841655	0.04841655	0.62	62%	3.0144	1.8272	98	74	88.9	1.9	0.6	0.006	210	0.2	0.1	6.3	0.8	0.006	210	0.2	0.1	8.4
Subbasin-26	9.617732	0.09617732	0.61	61%	5.9135	3.7043	98	74	88.8	1.9	0.6	0.005	340	0.2	0.2	9.1	0.8	0.005	340	0.3	0.2	12.2
Subbasin-27	6.628724	0.06628724	0.58	58%	3.8759	2.7528	98	74	88.0	2.1	0.6	0.02	85	0.1	0.0	2.4	0.8	0.02	85	0.1	0.1	3.2
Subbasin-28	9.213457	0.09213457	0.61	61%	5.6491	3.5643	98	74	88.7	1.9	0.6	0.026	780	0.2	0.2	9.7	0.8	0.026	780	0.3	0.2	12.9
Subbasin-29	12.56291	0.12562912	0.61	61%	7.6673	4.8956	98	74	88.6	1.9	0.6	0.028	380	0.1	0.1	5.9	0.8	0.028	380	0.2	0.1	7.8
Subbasin-30	4.277408	0.04277408	0.62	62%	2.6693	1.6081	98	74	89.0	1.9	0.6	0.009	95	0.1	0.1	3.3	0.8	0.009	95	0.1	0.1	4.4
Subbasin-31	1.615277	0.01615277	0.65	65%	1.0420	0.5732	98	74	89.5	1.8	0.6	0.005	300	0.2	0.1	8.4	0.8	0.005	300	0.3	0.2	11.1
Subbasin-32	3.573248	0.03573248	0.62	62%	2.2147	1.3585	98	74	88.9	1.9	0.6	0.084	160	0.1	0.0	2.4	0.8	0.084	160	0.1	0.1	3.2
Subbasin-33	1.267505	0.01267505	0.90	90%	1.1404	0.1271	98	74	95.6	0.5	0.6	0.005	90	0.1	0.1	3.5	0.8	0.005	90	0.1	0.1	4.7
Subbasin-34	0.6295	0.006295	0.50	50%	0.3153	0.3142	98	74	86.0	2.5	0.6	0.005	90	0.1	0.1	3.9	0.8	0.005	90	0.1	0.1	5.2
Subbasin-35	2.2976	0.022976	0.50	50%	1.1541	1.1435	98	74	86.1	2.5	0.6	0.005	90	0.1	0.1	3.9	0.8	0.005	90	0.1	0.1	5.2
Subbasin-36	21.851	0.21851	0.60	60%	13.0584	8.7926	98	74	88.3	2.0	0.6	0.007	400	0.2	0.2	9.2	0.8	0.007	400	0.3	0.2	12.3
Subbasin-37	15.052	0.15052	0.66	66%	9.8981	5.1539	98	74	89.8	1.7	0.6	0.037	687	0.2	0.1	7.9	0.8	0.037	687	0.3	0.2	10.5
Subbasin-41	15.0314	0.150313999	0.61	61%	9.1173	5.9141	98	74	88.6	2.0	0.6	0.005	800	0.4	0.3	16.1	0.8	0.005	800	0.5	0.4	21.5
Subbasin-42	11.58109	0.115810893	0.59	59%	6.7889	4.7922	98	74	88.1	2.1	0.6	0.005	600	0.3	0.2	13.4	0.8	0.005	600	0.4	0.3	17.9
Subbasin-43	16.03339	0.1603339	0.77	77%	12.2763	3.7571	98	74	92.4	1.2	0.6	0.012	560	0.2	0.2	9.4	0.8	0.012	560	0.3	0.2	12.5
Subbasin-44	3.042273	0.030422733	0.63	63%	1.9133	1.1290	98	74	89.1	1.9	0.6	0.014	995	0.3	0.2	13.6	0.8	0.014	995	0.5	0.3	18.1
Subbasin-45	34.7286	0.347286	0.82	82%	28.3783	6.3503	98	74	93.6	0.9	0.6	0.009	790	0.3	0.2	12.7	0.8	0.009	790	0.4	0.3	16.9

Reach	Length	Ave Velocity	Lag time
CH550-700	150	1	2.5
CH700-800	100	1	1.7
CH800-960	160	1	2.7
CH960-1150	190	1	3.2
CH1050-1150	100	1	1.7
CH1150-1400	250	1	4.2
CH1400-1550	150	1	2.5
STG4 CH0-150	150	1	2.5
STG4 CH150-400	250	1	4.2

Western Post Development HEC HMS Paired Data

Stage4_Pond

Elevation (M)	Storage (1000 M3)
24.0	0.000
24.4	10.000
25.8	90.000



10yr Outlet

Basin Name: Stage3_4_Western_10yr

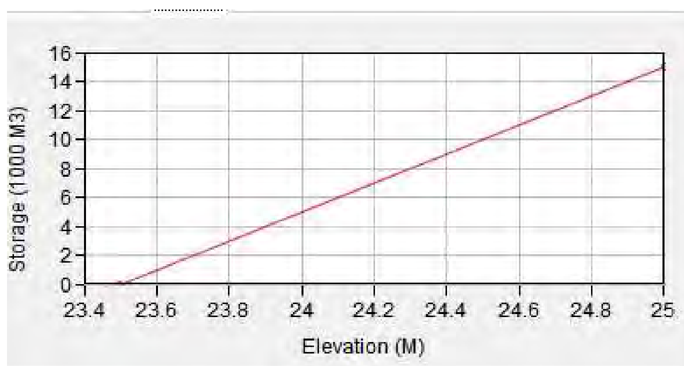
Element Name:	Stage4_Pond
Method:	Culvert Outlet
Direction:	Main
Number Barrels:	1
Solution Method:	Automatic
Shape:	Box
Chart:	8: Flared Wingwalls
Scale:	1: Wingwalls flared 30 to 75 degrees
*Length (M)	25
*Rise (M)	1
*Span (M)	1.5
*Inlet Elevation (M)	24
*Entrance Coefficient:	0.5
*Outlet Elevation (M)	23.9
*Exit Coefficient:	0.5
*Mannings n:	0.013

100yr Outlet

Element Name:	Stage4_Pond
Method:	Broad-Crested Spillway
Direction:	Main
*Elevation (M)	25.1
*Length (M)	2
*Coefficient (M^0.5/S)	2.07
Gates:	0

119_Cosgrave_Pond

Elevation (M)	Storage (1000 M3)
23.5	0
25.0	15



10yr Outlet

Method:	Orifice Outlet
Direction:	Main
Number Barrels:	1
Center Elevation (M)	23.875
Area (M2)	0.44179
Coefficient:	0.62

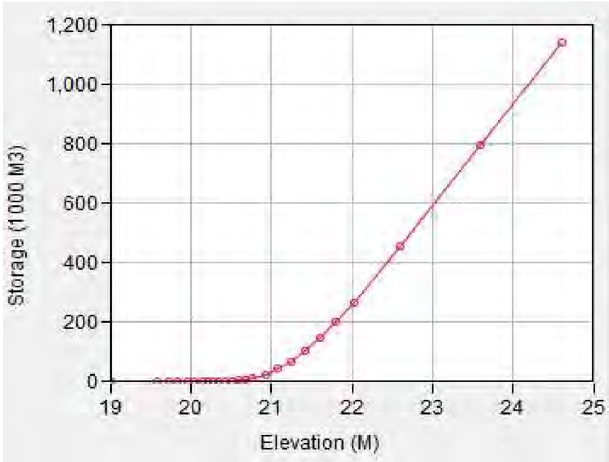
100yr Outlet

Method:	Broad-Crested Spillway
Direction:	Main
*Elevation (M)	24.7
*Length (M)	1
Coefficient (M^0.5/S)	2.07
Gates:	0

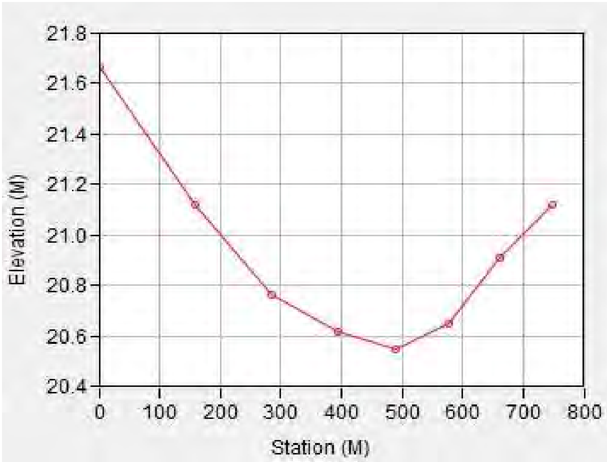
East HEC HMS Paired Data

Airfield_Road_Storage

Elevation Storage

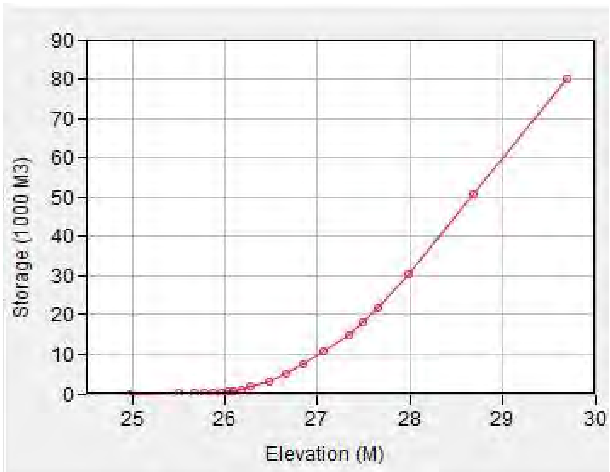


Spillway

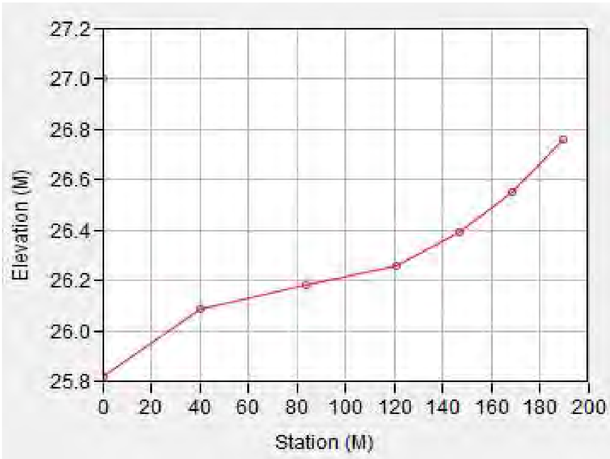


Airfield_Road_Storage_2

Elevation Storage

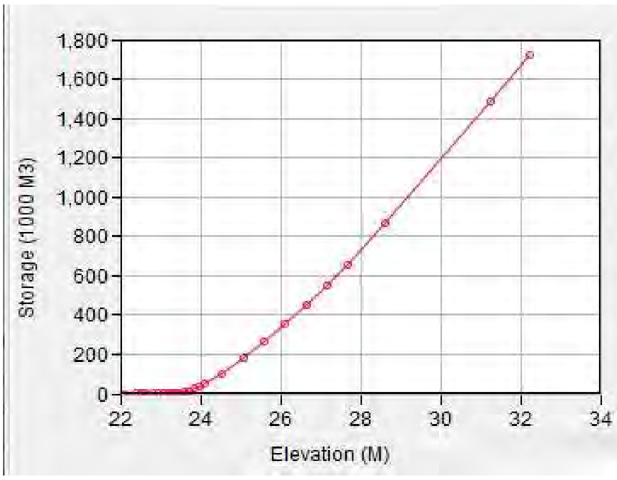


Spillway

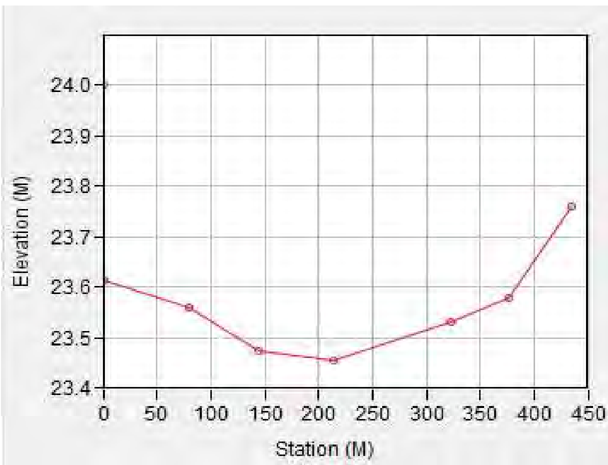


Hamlin_Road_Storage

Elevation Storage



Spillway



East HEC HMS Paired Data

Main northern Channel

Elevation Storage

Elevation (M)	Storage (1000 M3)
21.59	0
23.00	33

Spillway

Basin Name: Pr_10yr_v2
Element Name: Reservoir-Main_Northern_Chan
Method: Broad-Crested Spillway
Direction: Main
*Elevation (M) 22.5
*Length (M) 150
oefficient (M^0.5/S) 1.66
Gates: 0

Basin Name: Pr_10yr_v2
Element Name: Reservoir-Main_Northern_Chan
Method: Level Overflow
Direction: Auxillary
*Elevation (M) 22.6
*Length (M) 20
*Coefficient (M^0.5/S) 1.66

Reservoir - Dry Pond

Elevation Storage

Elevation (M)	Storage (1000 M3)
21.90	0
22.75	45

Box culvert (1m 2m) to Reservoir - Wetland

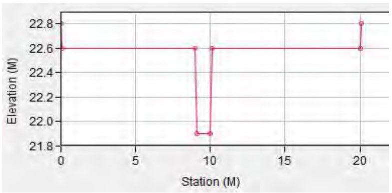
Reservoir - Wetland

Elevation Storage

Elevation (M)	Storage (1000 M3)
21.9	0.0
22.7	12.5
23.0	17.0

Spillway

Basin Name: Pr_100yr_v2
Element Name: Reservoir-Wetland
Method: Non-Level Overflow
Direction: Main
*Cross Section: Wetland_Weir
Coefficient: (M^0.5/S) 1.66



Reservoir - 208

Elevation Storage

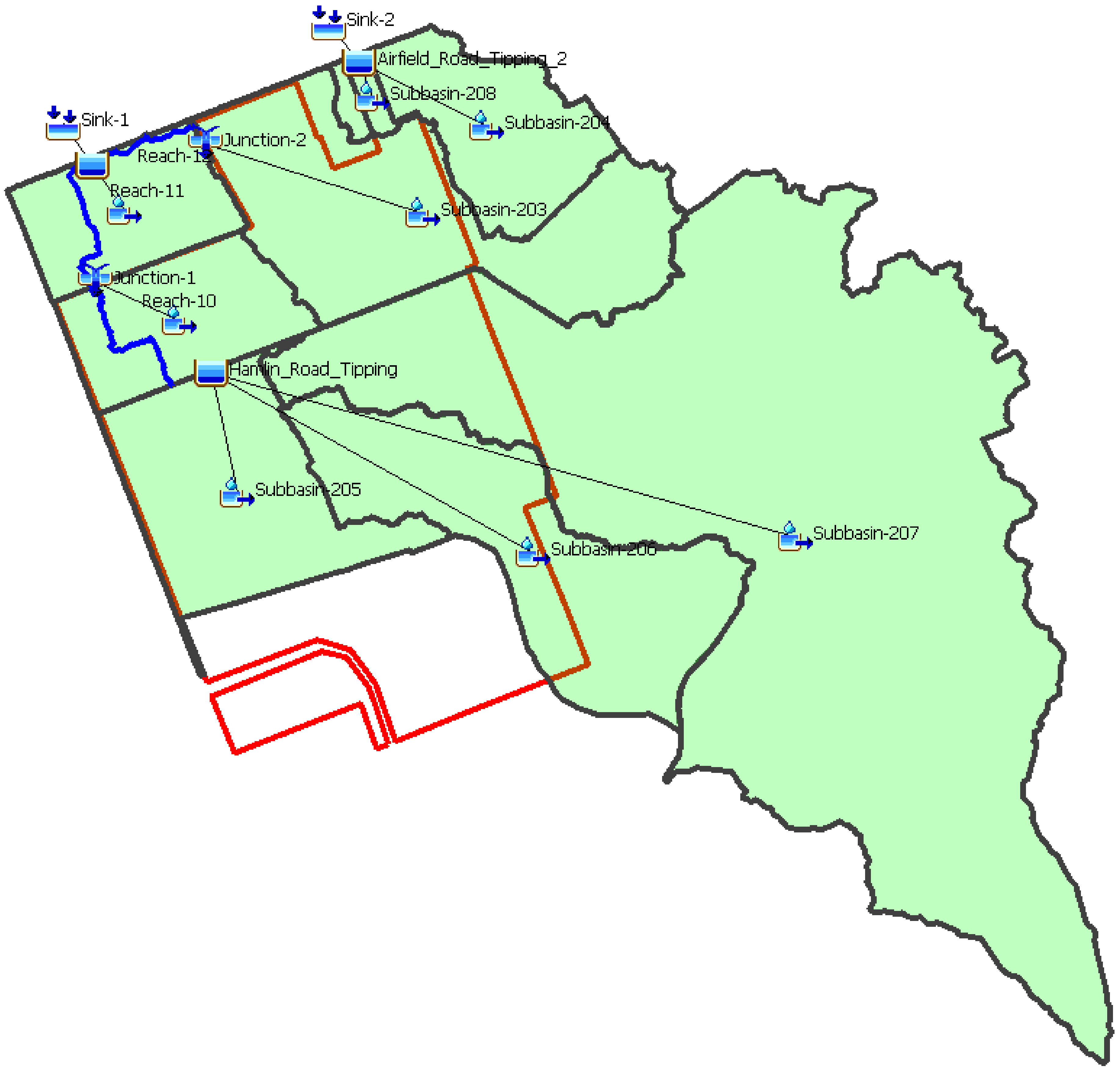
Elevation (M)	Storage (1000 M3)
0.0	0.00
1.5	3.80

Orifice

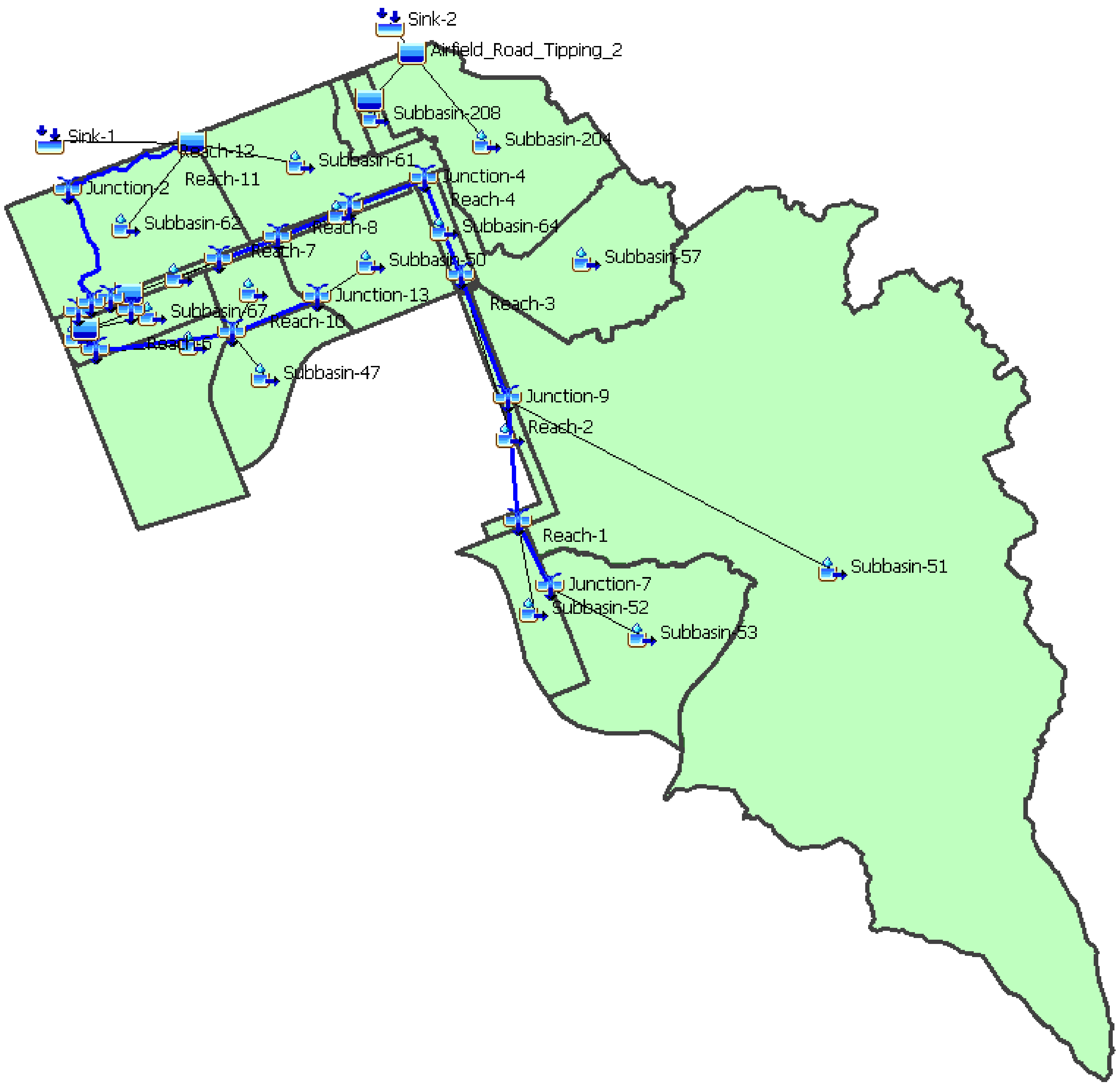
Basin Name: Pr_100yr_v2
Element Name: Reservoir-208
Method: Orifice Outlet
Direction: Main
Number Barrels: 1
Center Elevation (M) 0.15
Area (M2) 0.070686
Coefficient: 0.62

HEC HMS – Western Catchment Post development 1%AEP & 10%AEP

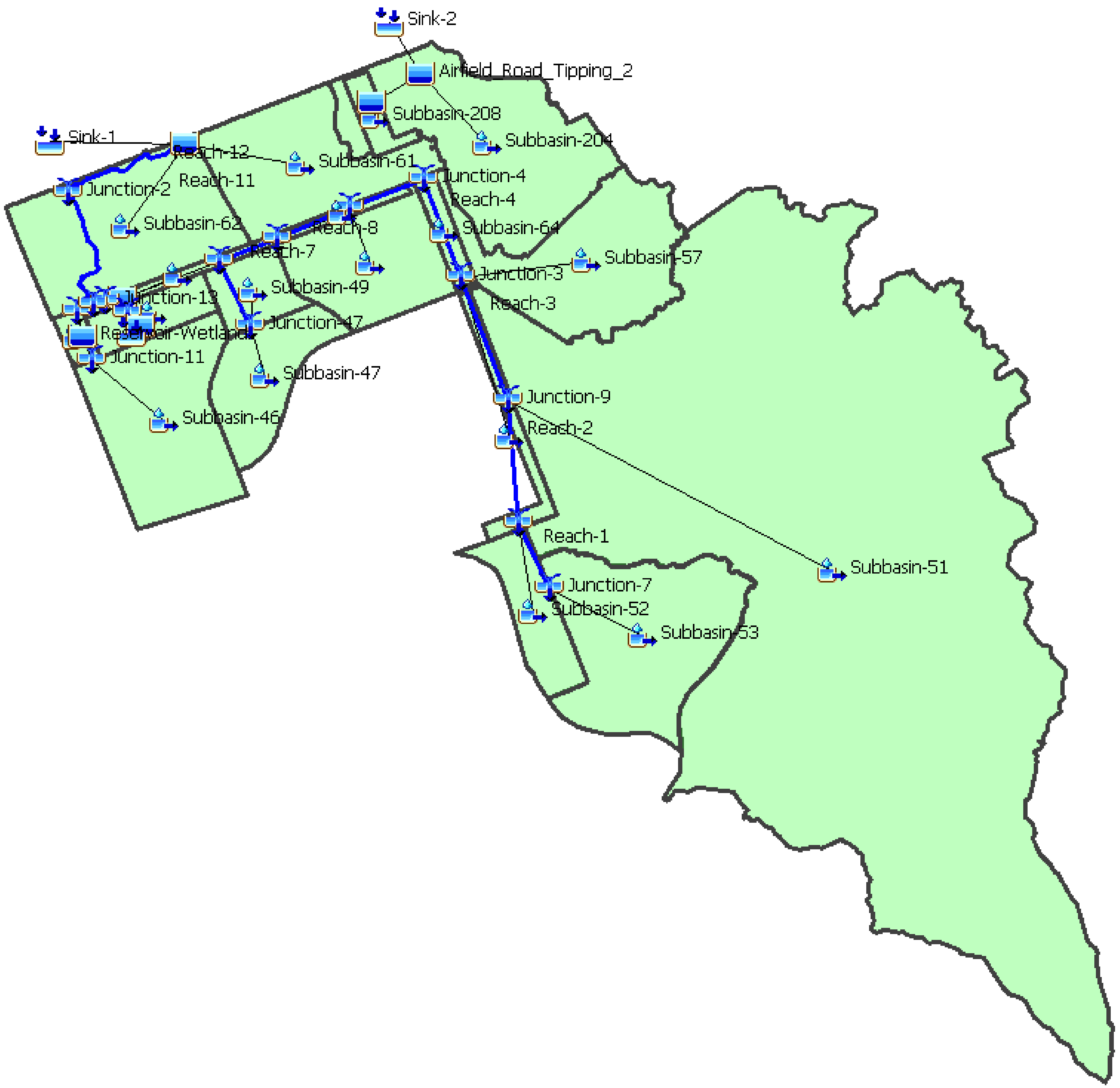
HEC HMS – Eastern Catchment Pre development 1%AEP & 10%AEP



HEC HMS – Eastern Catchment Post development 10%AEP



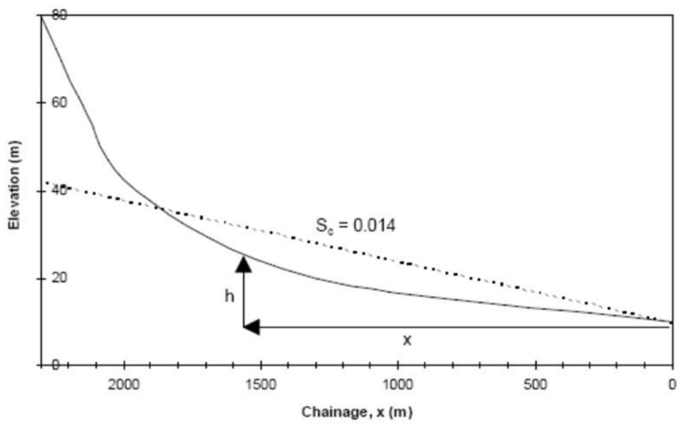
HEC HMS – Eastern Catchment Post development 1%AEP



APPENDIX D – HMS EASTERN CATCHMENT PREDEVELOPMENT SLOPES

JOB NAME: Sunfield FAB		**DATE:**	2024-02-16
JOB NO: 215001		**DES BY:**	YW
SUBJECT: Ex_Northern_Subbasin-201		**CHKD BY:**	

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



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

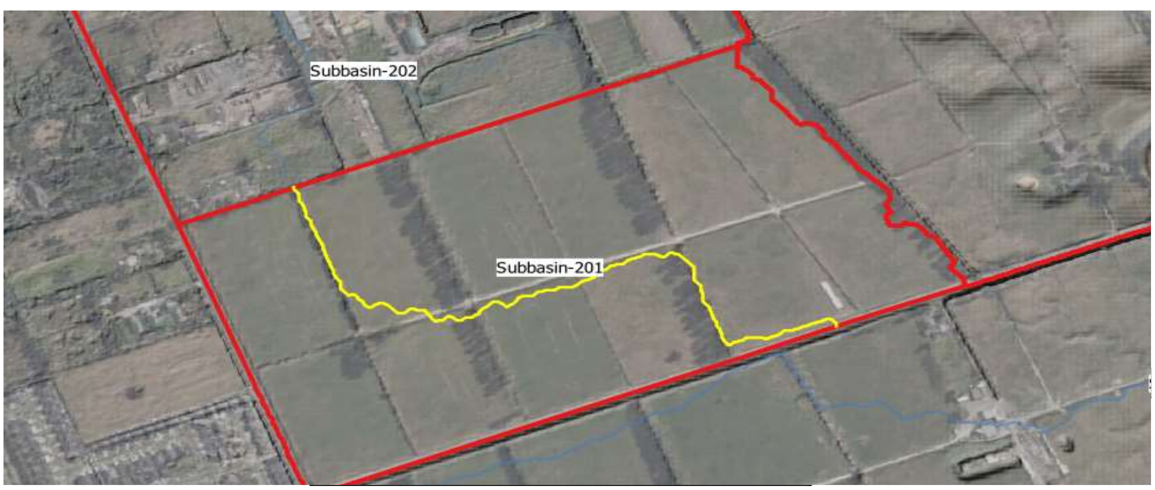
Data Entry Cells
Result cells

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

Pre-development

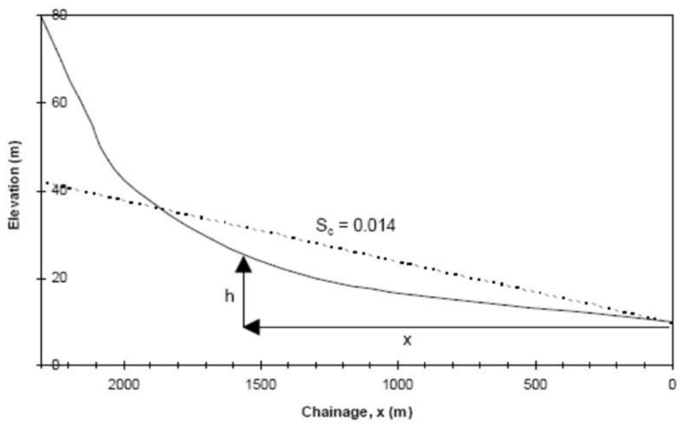
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	21.34375	0	0			
2	21.40625	0.0625	57.28427	57.284	0.03125	1.790133476
3	21.36719	0.0234375	114.7401	57.456	0.0429688	2.468805802
4	21.8125	0.46875	174.6812	59.941	0.2460938	14.75113635
5	21.95313	0.609375	234.6224	59.941	0.5390625	32.31201296
6	22.20313	0.859375	293.7351	59.113	0.734375	43.41088787
7	22.30469	0.9609375	355.333	61.598	0.9101563	56.06378625
8	22.4375	1.09375	418.5879	63.255	1.0273438	64.98445836
9	22.53125	1.1875	476.0437	57.456	1.140625	65.5355722
10	22.73438	1.390625	533.4996	57.456	1.2890625	74.06417406
11	22.84375	1.5	592.6123	59.113	1.4453125	85.43632187
12	24.45313	3.109375	948.3179	355.71	2.3046875	819.7903133
			TOTAL =	948.32	**TOTAL =**	1260.607603

S_c = 0.003



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin-202	**CHKD BY:**	

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



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

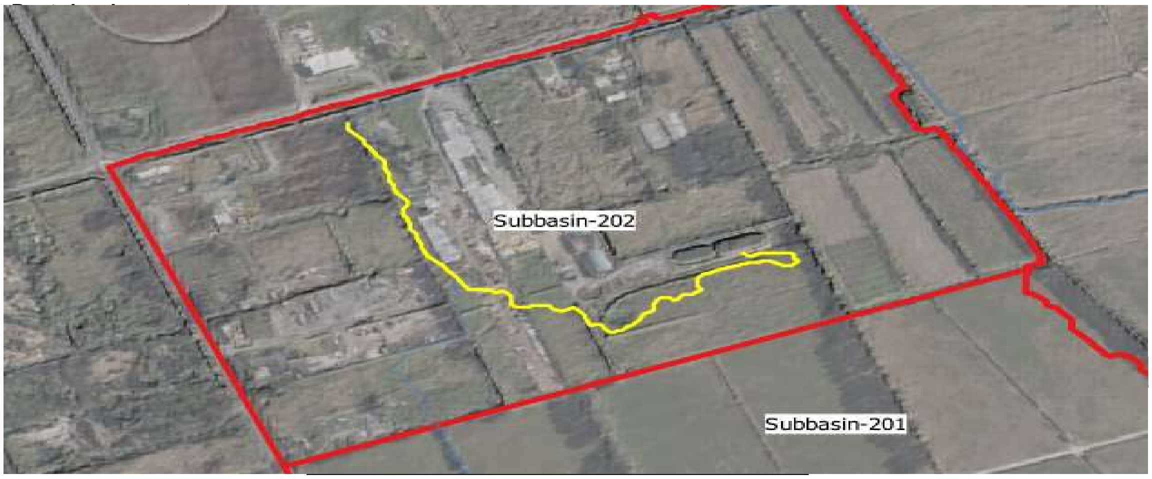
Data Entry Cells
Result cells

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

Pre-development

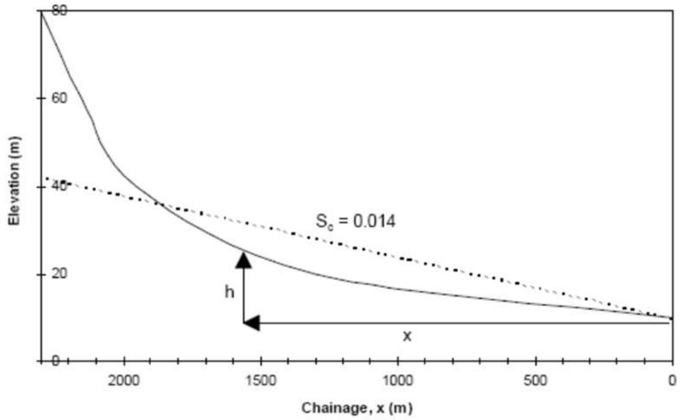
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h} \Delta x)$
1	20.40625	0	0			
2	20.24219	-0.164063	100.9533	100.95	-0.082031	-8.28132693
3	20.32031	-0.085938	194.2082	93.255	-0.125	-11.6568542
4	20.4375	0.03125	286.6346	92.426	-0.027344	-2.52728456
5	20.5625	0.15625	384.86	98.225	0.09375	9.208630945
6	20.51563	0.109375	478.9432	94.083	0.1328125	12.49543312
7	20.71094	0.3046875	573.8549	94.912	0.2070313	19.64968546
8	21.28906	0.8828125	667.9382	94.083	0.59375	55.86193629
9	21.66406	1.2578125	762.0214	94.083	1.0703125	100.6984904
10	21.74219	1.3359375	859.4184	97.397	1.296875	126.311695
11	21.89063	1.484375	953.5017	94.083	1.4101563	132.6720987
12	22.44531	2.0390625	1062.271	108.77	1.7617188	191.6213603
			TOTAL =	1062.3	TOTAL =	626.0538644

S_c = 0.001



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin 203	**CHKD BY:**	

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



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

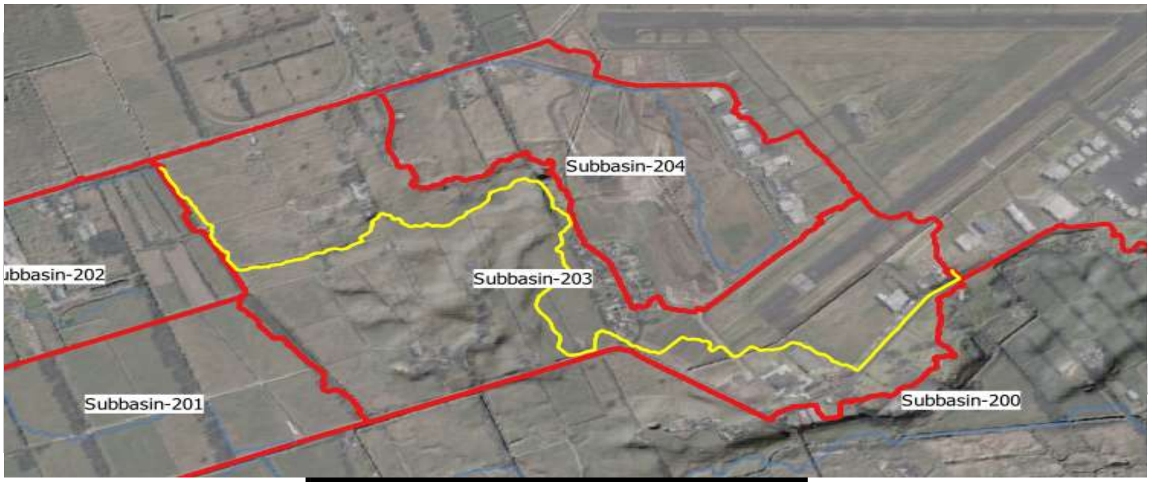
Data Entry Cells
Result cells

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

Pre-development

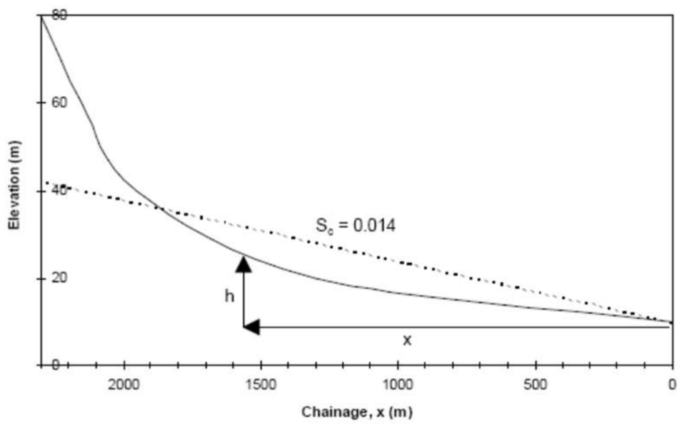
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	19.74219	0	0			
2	21.02344	1.28125	268.2914	268.29	0.640625	171.874187
3	22.89063	3.1484375	523.0854	254.79	2.2148438	564.3287639
4	25.75781	6.015625	784.5067	261.42	4.5820313	1197.840824
5	26.96094	7.21875	1046.756	262.25	6.6171875	1735.355988
6	29.5625	9.8203125	1307.349	260.59	8.5195313	2220.129603
7	30.28906	10.546875	1569.599	262.25	10.183594	2670.645255
8	30.35938	10.617188	1835.163	265.56	10.582031	2810.20117
9	30.82813	11.085938	2092.442	257.28	10.851563	2791.881542
10	31.14063	11.398438	2369.603	277.16	11.242188	3115.901232
11	33.875	14.132813	2635.995	266.39	12.765625	3400.659341
12	37.20313	17.460938	3009.666	373.67	15.796875	5902.836283
			TOTAL =	3009.7	TOTAL =	26581.65419

S$_c$ = 0.006



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin 204	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

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

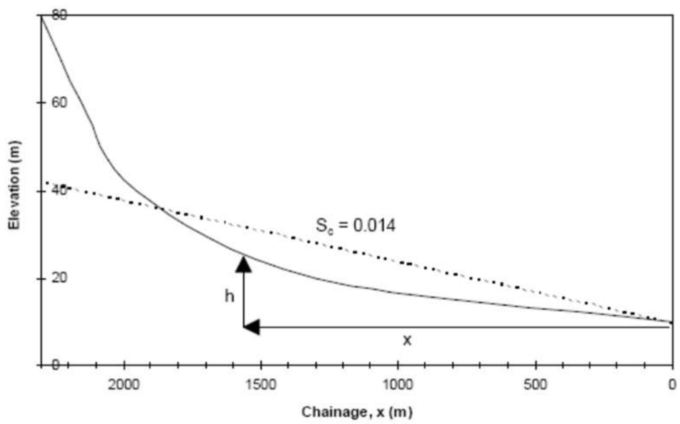
Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	26.98438	0	0			
2	27.42188	0.4375	111.2665	111.27	0.21875	24.33954964
3	28.50781	1.5234375	223.6929	112.43	0.9804688	110.2305786
4	29.26563	2.28125	342.7467	119.05	1.9023438	226.4812978
5	30.07031	3.0859375	450.2026	107.46	2.6835938	288.3678317
6	30.57031	3.5859375	570.9133	120.71	3.3359375	402.6832778
7	30.73438	3.75	684.1681	113.25	3.6679688	415.4151919
8	30.75781	3.7734375	801.5651	117.4	3.7617188	441.6143818
9	30.71875	3.734375	912.3346	110.77	3.7539063	415.8185159
10	30.875	3.890625	1032.217	119.88	3.8125	457.0510819
11	31.27344	4.2890625	1162.04	129.82	4.0898438	530.9573249
12	31.48438	4.5	1211.153	49.113	4.3945313	215.8272878
			TOTAL =	1211.2	TOTAL =	3528.78632

S_c = 0.005

JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin 205	**CHKD BY:**	

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



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

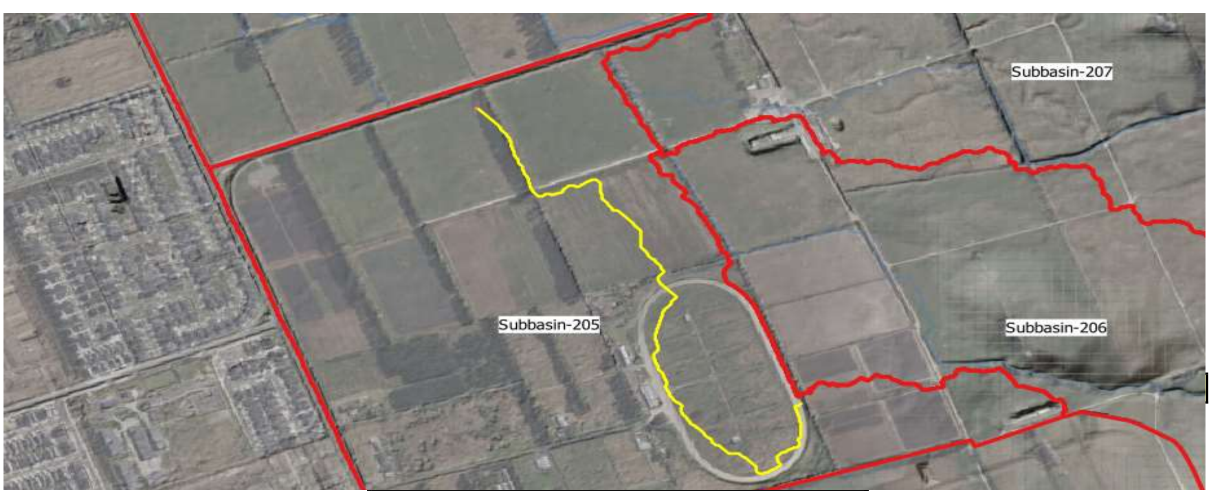
Data Entry Cells
Result cells

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

Pre-development

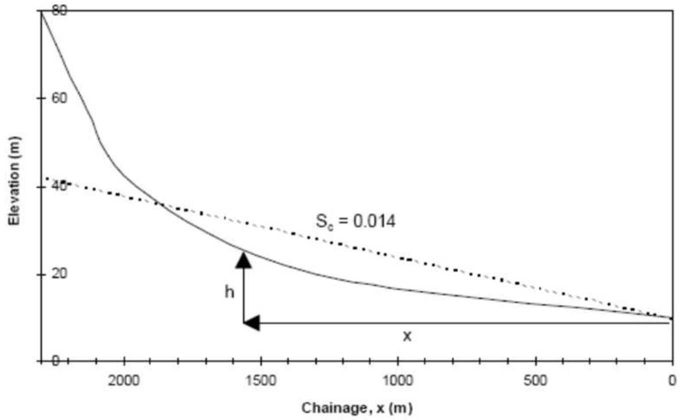
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h} \Delta x)$
1	23.33594	0	0			
2	23.3125	-0.023438	100.1014	100.1	-0.011719	-1.1730635
3	24.01563	0.6796875	195.8415	95.74	0.328125	31.41472536
4	24.28125	0.9453125	289.9248	94.083	0.8125	76.44264966
5	24.6875	1.3515625	388.1502	98.225	1.1484375	112.8057291
6	24.99219	1.65625	483.8903	95.74	1.5039063	143.9841579
7	25.26563	1.9296875	587.0863	103.2	1.7929688	185.0271305
8	25.46094	2.125	676.199	89.113	2.0273438	180.6620721
9	25.57813	2.2421875	772.7675	96.569	2.1835938	210.8664658
10	25.64844	2.3125	875.135	102.37	2.2773438	233.12606
11	25.67969	2.34375	972.532	97.397	2.328125	226.7523199
12	26.23438	2.8984375	1105.929	133.4	2.6210938	349.6459633
			TOTAL =	1105.9	TOTAL =	1749.55421

S_c = 0.003



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin 206	**CHKD BY:**	

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



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

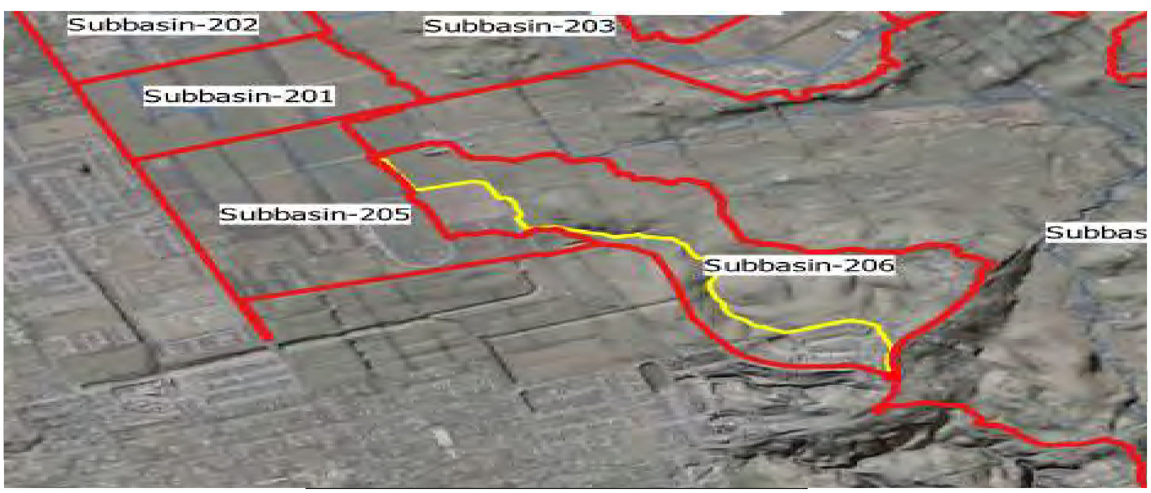
Data Entry Cells
Result cells

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

Pre-development

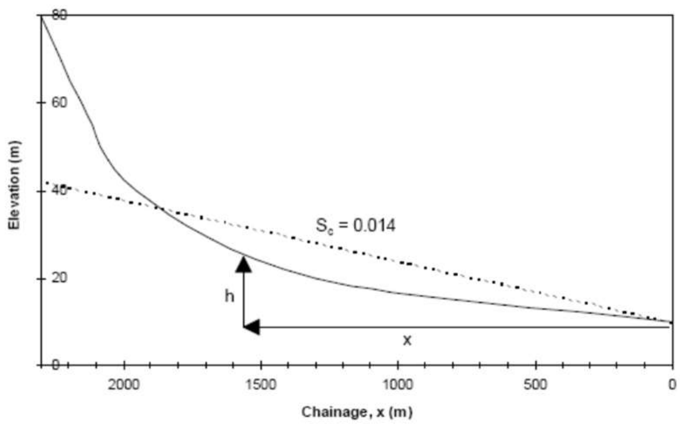
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A(=\overline{h}\Delta x)$
1	24.125	0	0			
2	25.02344	0.8984375	217.1076	217.11	0.4492188	97.52882613
3	25.59375	1.46875	421.132	204.02	1.1835938	241.4819888
4	26.53906	2.4140625	634.2691	213.14	1.9414063	413.7856689
5	28.58594	4.4609375	835.8082	201.54	3.4375	692.7906743
6	30.82813	6.703125	1041.489	205.68	5.5820313	1148.119114
7	32.52344	8.3984375	1251.313	209.82	7.5507813	1584.330417
8	36.05469	11.929688	1457.823	206.51	10.164063	2098.977172
9	40.0625	15.9375	1675.93	218.11	13.933594	3039.023357
10	53.34375	29.21875	1884.925	208.99	22.578125	4718.714091
11	57.95313	33.828125	2093.92	208.99	31.523438	6588.239224
12	63.9375	39.8125	2349.116	255.2	36.820313	9396.394977
			TOTAL =	2349.1	TOTAL =	30019.38551

S_c = 0.011



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin 207	**CHKD BY:**	

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



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

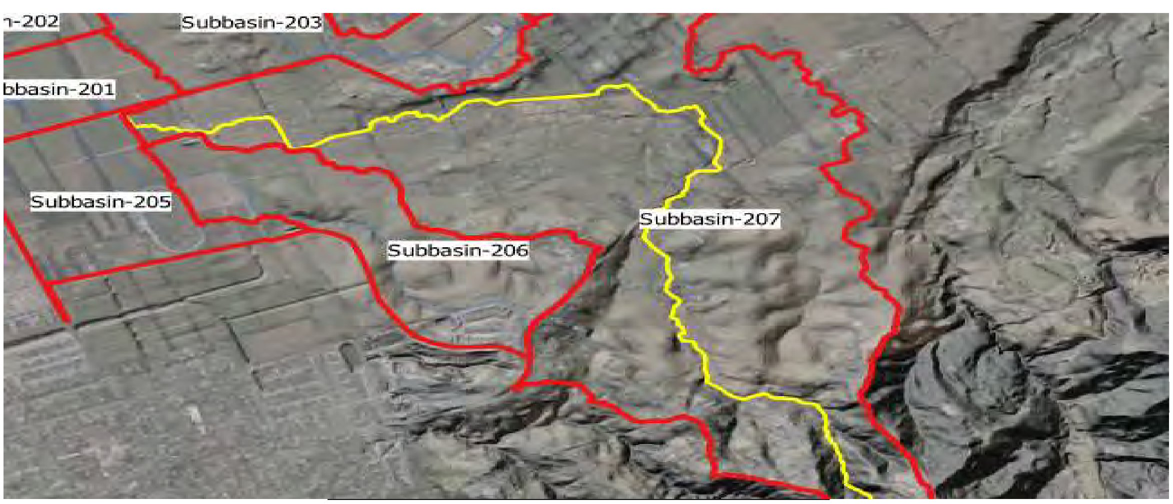
Data Entry Cells
Result cells

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

Pre-development

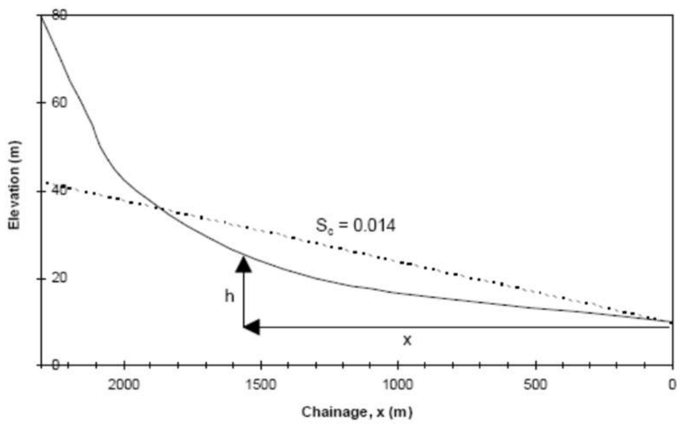
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A(=\bar{h}\Delta x)$
1	23.625	0	0			
2	27.63281	4.0078125	536.4579	536.46	2.0039063	1075.011411
3	28.40625	4.78125	1070.188	533.73	4.3945313	2345.493226
4	31.36719	7.7421875	1609.717	539.53	6.2617188	3378.37888
5	31.32031	7.6953125	2133.506	523.79	7.71875	4042.995484
6	34.57813	10.953125	2690.432	556.93	9.3242188	5192.899605
7	36.60156	12.976563	3242.387	551.96	11.964844	6604.060248
8	42.64844	19.023438	3791.029	548.64	16	8778.267238
9	50.13281	26.507813	4338.842	547.81	22.765625	12471.31159
10	60.50781	36.882813	4880.028	541.19	31.695313	17153.0549
11	74.04688	50.421875	5410.444	530.42	43.652344	23153.9149
12	193.9297	170.30469	6318.164	907.72	110.36328	100178.948
			TOTAL =	6318.2	TOTAL =	184374.3355

S_c = 0.009



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Subbasin 208	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

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

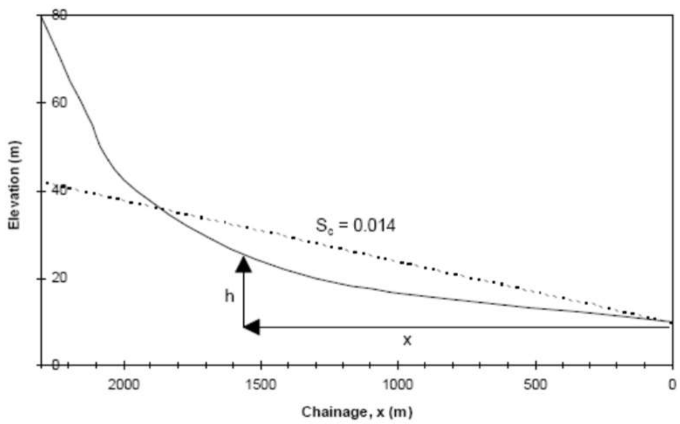
Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A(=\overline{h}\Delta x)$
1	25.96094	0	0			
2	26.01563	0.0546875	23.18653	23.187	0.0273438	0.634006676
3	26.19531	0.234375	46.37306	23.187	0.1445313	3.351178145
4	26.5	0.5390625	74.07458	27.702	0.3867188	10.71269561
5	26.76563	0.8046875	102.5222	28.448	0.671875	19.11328027
6	27.30469	1.34375	131.3367	28.814	1.0742188	30.9529804
7	27.55469	1.59375	156.5971	25.26	1.46875	37.10125273
8	27.71094	1.75	181.2358	24.639	1.671875	41.19283006
9	27.66406	1.703125	202.7671	21.531	1.7265625	37.17510182
10	27.72656	1.765625	225.8143	23.047	1.734375	39.97260387
11	27.51563	1.5546875	253.1163	27.302	1.6601563	45.32555541
12	28.30469	2.34375	285.8787	32.762	1.9492188	63.86104136
			TOTAL =	285.88	TOTAL =	329.3925264

S_c = 0.008

JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Reach10	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

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

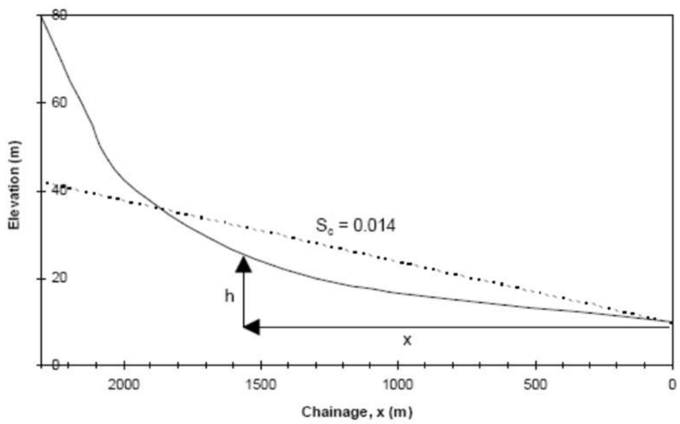
Pre-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	21.44531	0	0			
2	21.5625	0.1171875	57.34175	57.342	0.0585938	3.359867886
3	21.65625	0.2109375	117.269	59.927	0.1640625	9.831819946
4	21.34375	-0.101563	174.7117	57.443	0.0546875	3.141396407
5	21.8125	0.3671875	234.225	59.513	0.1328125	7.904106363
6	22	0.5546875	293.7382	59.513	0.4609375	27.43189109
7	21.90625	0.4609375	353.6653	59.927	0.5078125	30.43169215
8	22.24219	0.796875	416.077	62.412	0.6289063	39.25112579
9	22.35156	0.90625	475.1758	59.099	0.8515625	50.32632719
10	22.28906	0.84375	534.2749	59.099	0.875	51.7116962
11	22.27344	0.828125	592.9599	58.685	0.8359375	49.05705014
12	23.75	2.3046875	685.3796	92.42	1.5664063	144.7667937
			TOTAL =	685.38	**TOTAL =**	417.2137668

S_c = 0.002

JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Reach11	**CHKD BY:**	

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



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

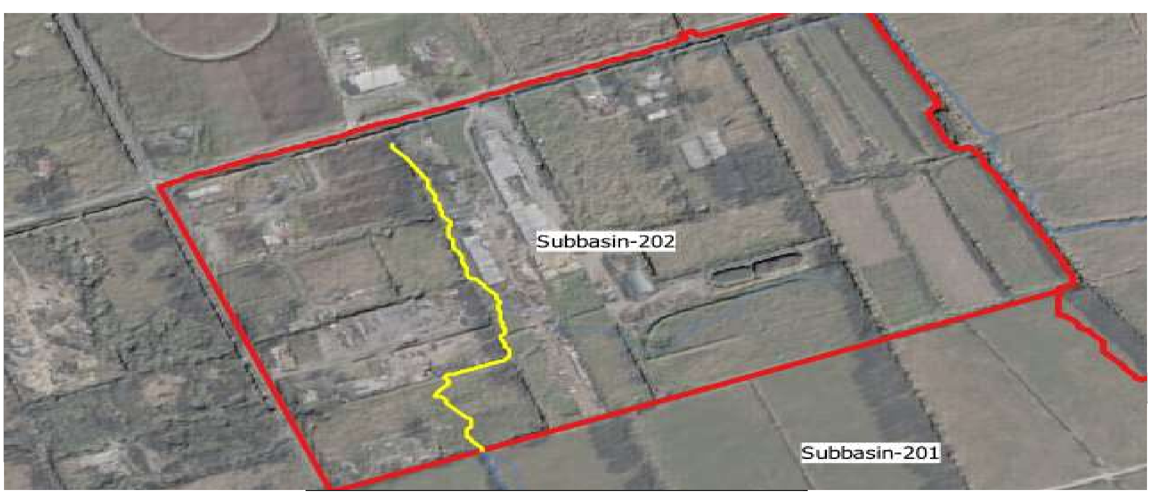
Data Entry Cells
Result cells

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

Pre-development

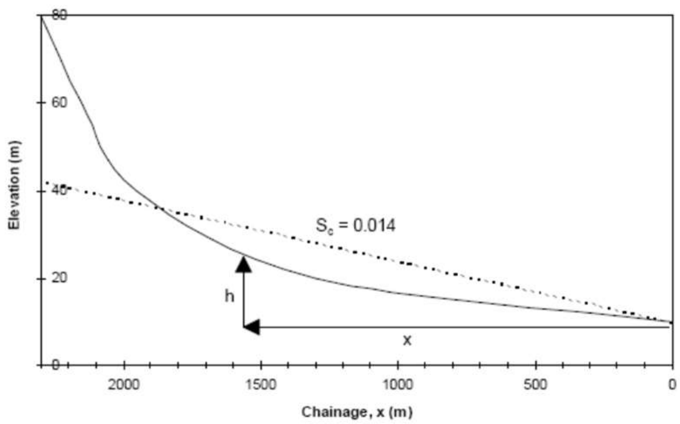
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	20.5625	0	0			
2	20.57031	0.0078125	51.59798	51.598	0.0039063	0.201554608
3	20.69531	0.1328125	97.39697	45.799	0.0703125	3.220241475
4	20.55469	-0.007813	144.0244	46.627	0.0625	2.914213562
5	20.64844	0.0859375	188.9949	44.971	0.0390625	1.756662607
6	20.82031	0.2578125	238.9361	49.941	0.171875	8.583630945
7	20.82813	0.265625	282.2498	43.314	0.2617188	11.33600965
8	20.77344	0.2109375	328.8772	46.627	0.2382813	11.11043921
9	20.84375	0.28125	375.5046	46.627	0.2460938	11.4747159
10	21.16406	0.6015625	424.6173	49.113	0.4414063	21.67865202
11	21.17188	0.609375	473.73	49.113	0.6054688	29.73620409
12	21.34375	0.78125	509.8066	36.077	0.6953125	25.08451254
			TOTAL =	509.81	TOTAL =	127.0968366

S_c = 0.001



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Ex_Northern_Reach12	**CHKD BY:**	

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



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

Data Entry Cells
Result cells

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

Pre-development

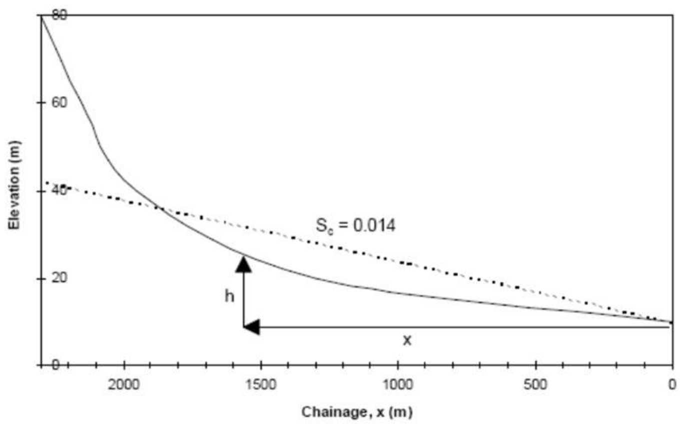
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	20.5625	0	0			
2	20.61719	0.0546875	50.76955	50.77	0.0273438	1.388229954
3	20.5625	0	99.05382	48.284	0.0273438	1.320273042
4	20.21094	-0.351563	144.0244	44.971	-0.175781	-7.90498173
5	20.22656	-0.335938	190.6518	46.627	-0.34375	-16.0281746
6	20.22656	-0.335938	233.9655	43.314	-0.335938	-14.5506989
7	20.48438	-0.078125	287.2203	53.255	-0.207031	-11.0254149
8	20.34375	-0.21875	338.8183	51.598	-0.148438	-7.65907512
9	20.21875	-0.34375	385.4457	46.627	-0.28125	-13.113961
10	20.0625	-0.5	434.5584	49.113	-0.421875	-20.7194196
11	20.35938	-0.203125	480.3574	45.799	-0.351563	-16.1012074
12	20.52344	-0.039063	514.1564	33.799	-0.121094	-4.09284643
			TOTAL =	514.16	TOTAL =	-108.487277

S_c = -0.001

APPENDIX E – HMS EASTERN CATCHMENT POSTDEVELOPMENT SLOPES

JOB NAME:	Sunfield FAB	DATE:	2024-02-16
JOB NO:	215001	DES BY:	YW
SUBJECT:	Pr_Eastern_Subbasin-46	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)

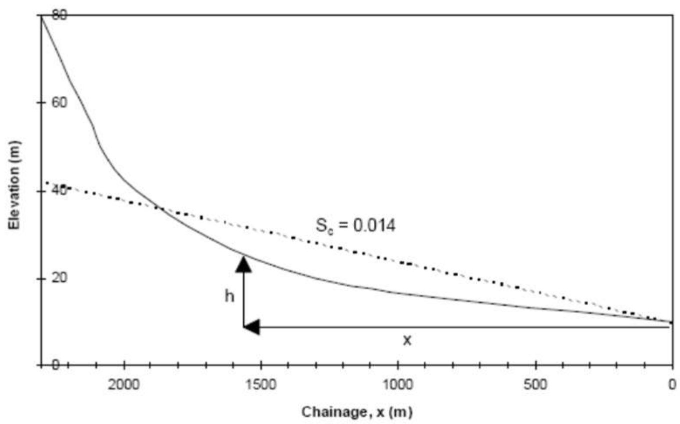
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	23.14063	0	0			
2	23.47656	0.3359375	53.06993	53.07	0.1679688	8.914089587
3	23.76563	0.625	109.1827	56.113	0.4804688	26.96042644
4	23.99219	0.8515625	165.2954	56.113	0.7382813	41.42699672
5	24.22656	1.0859375	221.4082	56.113	0.96875	54.35923379
6	24.46094	1.3203125	277.521	56.113	1.203125	67.51066132
7	24.82813	1.6875	333.6357	56.115	1.5039063	84.3912672
8	25.20313	2.0625	389.7518	56.116	1.875	105.2177961
9	25.57031	2.4296875	438.4234	48.672	2.2460938	109.3210135
10	25.97656	2.8359375	486.7032	48.28	2.6328125	127.1116569
11	26.375	3.234375	534.983	48.28	3.0351563	146.5367321
12	26.57813	3.4375	562.7439	27.761	3.3359375	92.60857436
			TOTAL =	562.74	TOTAL =	864.358448

S_c = 0.005

JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-47	**CHKD BY:**	

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



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

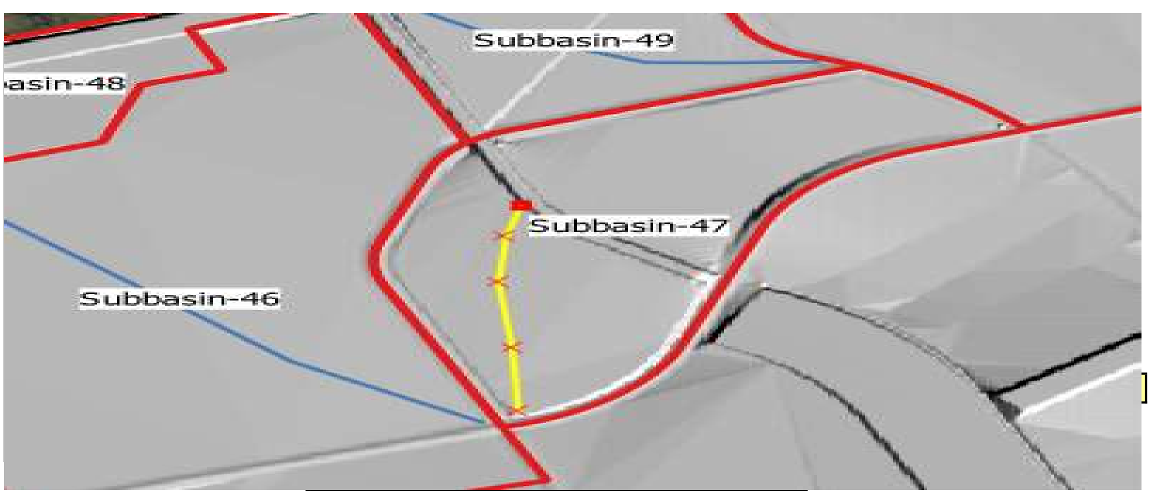
Data Entry Cells
Result cells

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

Post-development

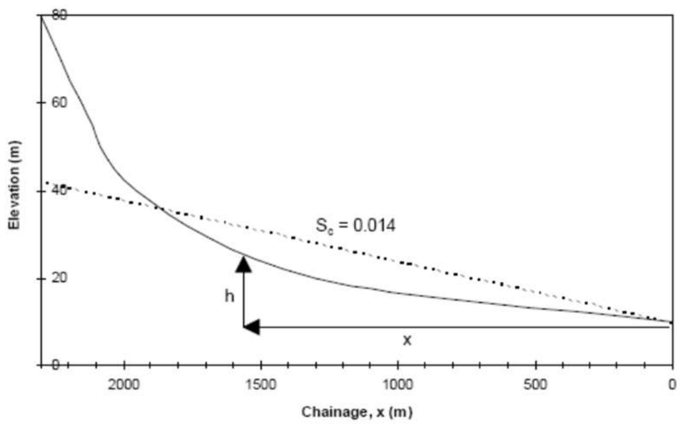
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	23.61719	0	0			
2	23.96875	0.3515625	31.11717	31.117	0.1757813	5.469815527
3	24.19531	0.578125	61.94032	30.823	0.4648438	14.32794938
4	24.42969	0.8125	92.25562	30.315	0.6953125	21.07860486
5	24.66406	1.046875	122.5709	30.315	0.9296875	28.18375256
6	24.89844	1.28125	152.8221	30.251	1.1640625	35.21430444
7	25.13281	1.515625	183.0711	30.249	1.3984375	42.30134267
8	25.35938	1.7421875	213.3201	30.249	1.6289063	49.272793
9	25.59375	1.9765625	243.4673	30.147	1.859375	56.05494414
10	25.875	2.2578125	273.5467	30.079	2.1171875	63.68357062
11	26.0625	2.4453125	303.626	30.079	2.3515625	70.73341239
12	26.14844	2.53125	325.6842	22.058	2.4882813	54.88693473
			TOTAL =	325.68	TOTAL =	441.2074243

S_c = 0.008



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-49	**CHKD BY:**	

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



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

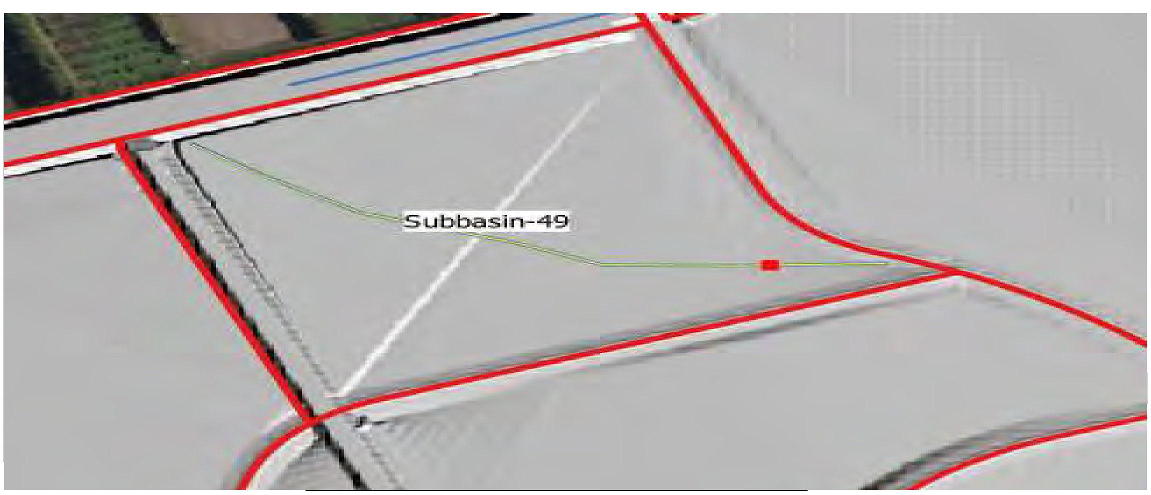
Data Entry Cells
Result cells

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

Post-development

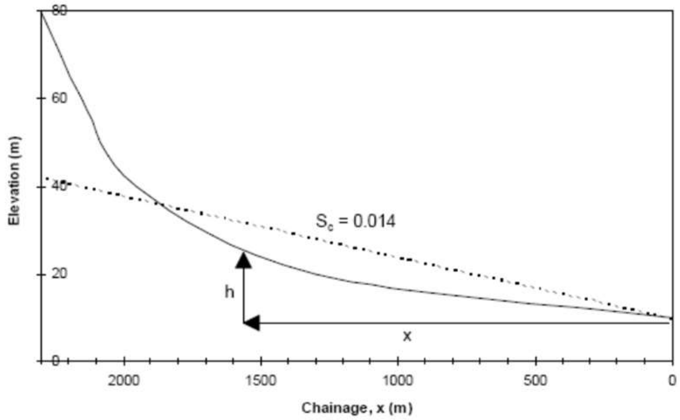
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	22.39844	0	0			
2	22.64844	0.25	30.16575	30.166	0.125	3.770718288
3	22.90625	0.5078125	60.33149	30.166	0.3789063	11.42998981
4	23.14063	0.7421875	90.54009	30.209	0.625	18.88037423
5	23.36719	0.96875	120.7617	30.222	0.8554688	25.85366929
6	23.83594	1.4375	153.2816	32.52	1.203125	39.12548849
7	24.07813	1.6796875	185.8142	32.533	1.5585938	50.70504575
8	24.28125	1.8828125	217.7458	31.932	1.78125	56.87819409
9	24.53906	2.140625	250.2732	32.527	2.0117188	65.43605602
10	24.79688	2.3984375	286.6735	36.4	2.2695313	82.61154205
11	25.0625	2.6640625	324.3491	37.676	2.53125	95.36629623
12	25.07031	2.671875	338.2804	13.931	2.6679688	37.16822035
			TOTAL =	338.28	TOTAL =	487.2255946

S_c = 0.009



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-50	**CHKD BY:**	

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



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

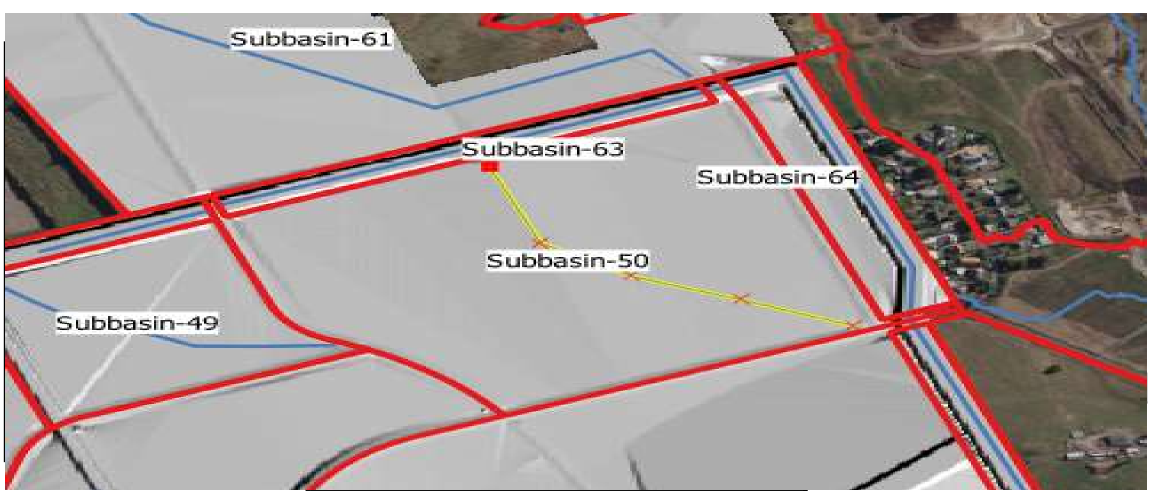
Data Entry Cells
Result cells

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

Post-development

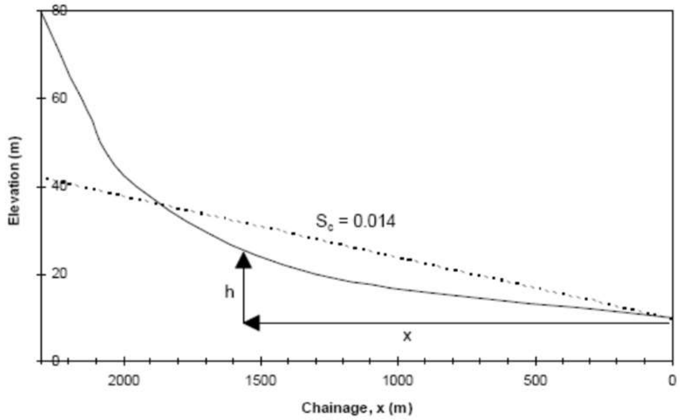
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	25.94531	0	0			
2	25.94531	0	43.43629	43.436	0	0
3	26.22656	0.28125	86.87258	43.436	0.140625	6.108228105
4	26.5	0.5546875	130.3089	43.436	0.4179688	18.15501131
5	26.92969	0.984375	176.4225	46.114	0.7695313	35.48584842
6	27.46875	1.5234375	223.0085	46.586	1.2539063	58.41454518
7	28.01563	2.0703125	266.5596	43.551	1.796875	78.2559076
8	28.36719	2.421875	309.0991	42.539	2.2460938	95.54763055
9	28.67969	2.734375	351.6982	42.599	2.578125	109.8257013
10	29.0625	3.1171875	394.5025	42.804	2.9257813	125.2360914
11	29.45313	3.5078125	437.3068	42.804	3.3125	141.7893265
12	29.63281	3.6875	452.2883	14.982	3.5976563	53.89833655
			TOTAL =	452.29	TOTAL =	722.716627

S_c = 0.007



JOB NAME:	Sunfield FAB	DATE:	2024-02-16
JOB NO:	215001	DES BY:	YW
SUBJECT:	Pr_Eastern_Subbasin-51	CHKD BY:	

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



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

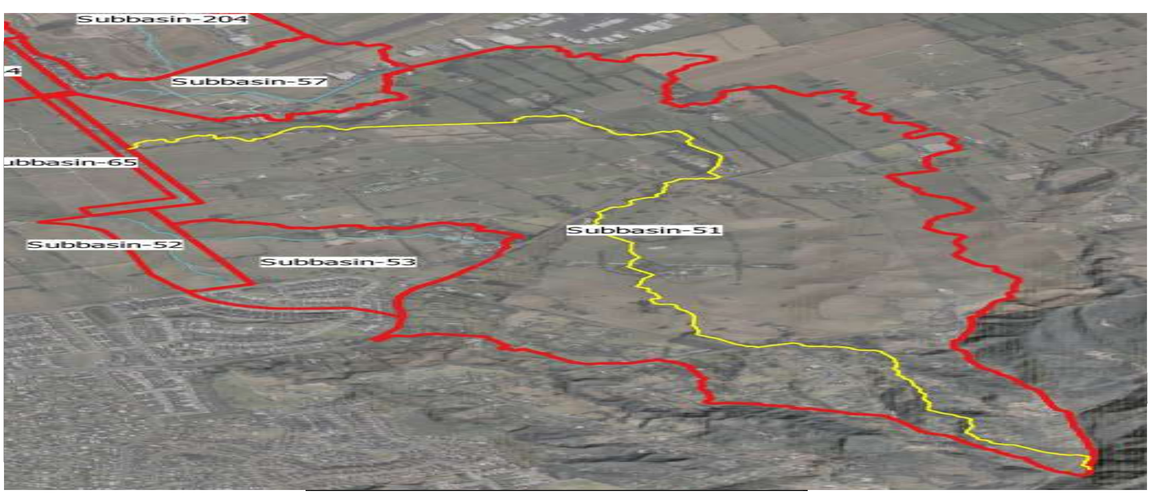
Data Entry Cells
Result cells

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

Post-development

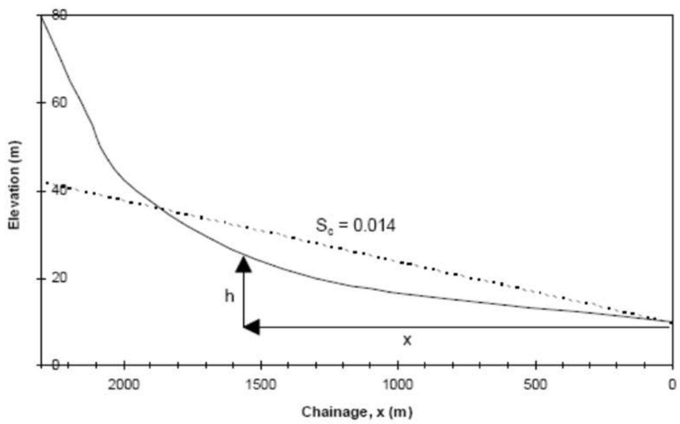
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	28.96094	0	0			
2	31.10938	2.1484375	448.1737	448.17	1.0742188	481.4365541
3	31.24219	2.28125	889.4773	441.3	2.2148438	977.4185363
4	34.21875	5.2578125	1332.438	442.96	3.7695313	1669.753302
5	35.4375	6.4765625	1810.192	477.75	5.8671875	2803.074648
6	38.59375	9.6328125	2246.525	436.33	8.0546875	3514.526319
7	43.77344	14.8125	2710.196	463.67	12.222656	5667.292952
8	49.77344	20.8125	3154.814	444.62	17.8125	7919.745936
9	56.83594	27.875	3592.804	437.99	24.34375	10662.3166
10	65.71875	36.757813	4039.078	446.27	32.316406	14421.97738
11	85.02344	56.0625	4477.068	437.99	46.410156	20327.17964
12	193.9297	164.96875	5162.278	685.21	110.51563	75726.43847
			TOTAL =	5162.3	TOTAL =	144171.1603

S_c = 0.011



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-52	**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)

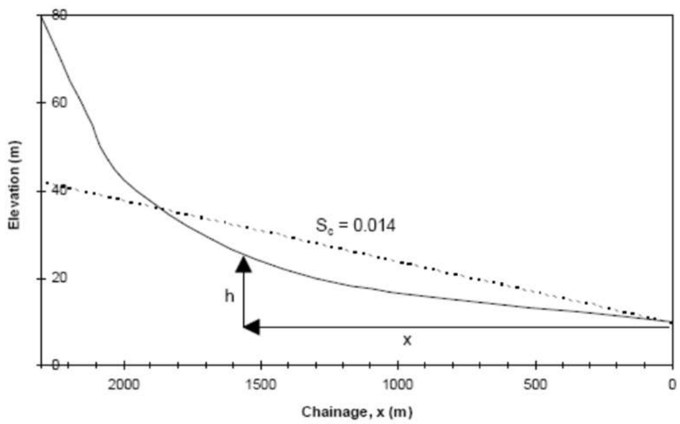
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	30.91406	0	0			
2	31.28125	0.3671875	65.2132	65.213	0.1835938	11.97273657
3	31.82813	0.9140625	136.8112	71.598	0.640625	45.86745578
4	32.52344	1.609375	208.4092	71.598	1.2617188	90.33651351
5	33.57813	2.6640625	282.4924	74.083	2.1367188	158.2950931
6	34.625	3.7109375	346.6346	64.142	3.1875	204.4530573
7	36.05469	5.140625	414.9188	68.284	4.4257813	302.2112474
8	36.82813	5.9140625	486.5168	71.598	5.5273438	395.7466459
9	38.55469	7.640625	554.8011	68.284	6.7773438	462.785979
10	40.0625	9.1484375	633.0265	78.225	8.3945313	656.6655375
11	50.89063	19.976563	702.9676	69.941	14.5625	1018.51764
12	52.9375	22.023438	736.0803	33.113	21	695.3666658
			TOTAL =	736.08	TOTAL =	4042.218572

S_c = 0.015

JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-53	**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)

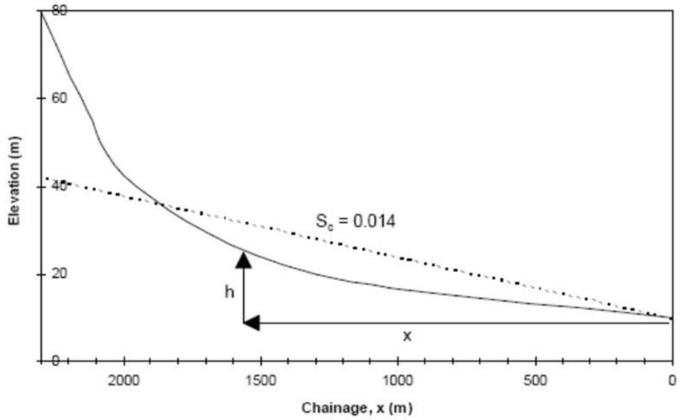
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A(=\overline{h}\Delta x)$
1	33.78906	0	0			
2	34.46875	0.6796875	86.45584	86.456	0.3398438	29.38147828
3	35.5	1.7109375	174.7401	88.284	1.1953125	105.527293
4	36.71875	2.9296875	264.6812	89.941	2.3203125	208.6915178
5	38.58594	4.796875	355.4508	90.77	3.8632813	350.6683107
6	40.60156	6.8125	444.5635	89.113	5.8046875	517.2713663
7	43.59375	9.8046875	533.6762	89.113	8.3085938	740.4012087
8	48.96094	15.171875	629.4163	95.74	12.488281	1195.629488
9	53.89844	20.109375	722.6711	93.255	17.640625	1645.073556
10	54.8125	21.023438	815.926	93.255	20.566406	1917.916801
11	56.8125	23.023438	911.6661	95.74	22.023438	2108.526447
12	57.48438	23.695313	934.6367	22.971	23.359375	536.5779892
			TOTAL =	934.64	**TOTAL =**	9355.665455

S_c = 0.021

JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-57	**CHKD BY:**	

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



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

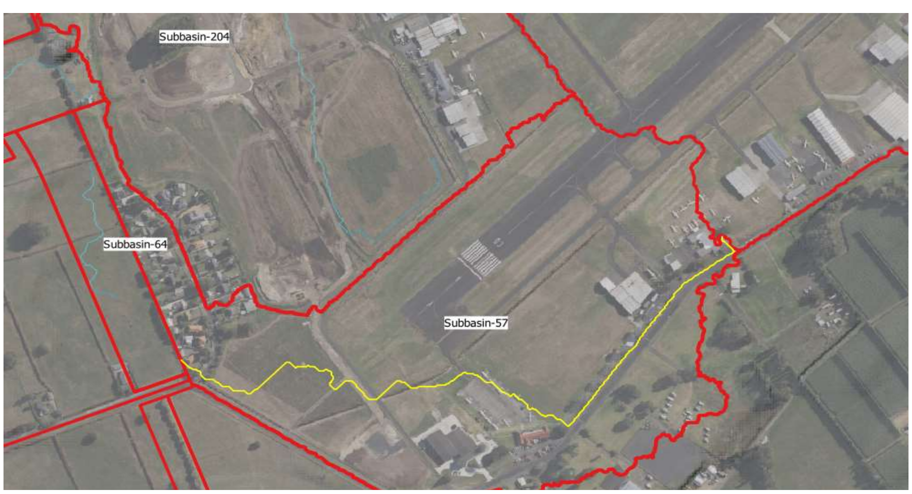
Data Entry Cells
Result cells

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

Post-development

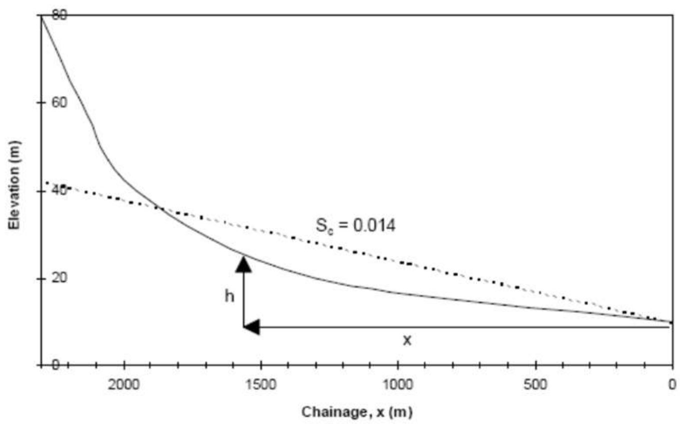
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	30.51563	0	0			
2	30.79688	0.28125	95.15433	95.154	0.140625	13.38107751
3	30.85938	0.34375	199.1787	104.02	0.3125	32.50762082
4	31.24219	0.7265625	294.9188	95.74	0.5351563	51.23592112
5	31.14063	0.625	396.4579	101.54	0.6757813	68.61822347
6	31.22656	0.7109375	488.8843	92.426	0.6679688	61.73795146
7	31.875	1.359375	587.1097	98.225	1.0351563	101.6786333
8	33.96094	3.4453125	689.4773	102.37	2.4023438	245.9220016
9	34.60156	4.0859375	793.5017	104.02	3.765625	391.7168309
10	35.28906	4.7734375	896.6976	103.2	4.4296875	457.1258518
11	35.97656	5.4609375	999.8936	103.2	5.1171875	528.073074
12	37.20313	6.6875	1036.521	36.627	6.0742188	222.4829431
			TOTAL =	1036.5	TOTAL =	2174.480129

S_c = 0.004



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-61	**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)

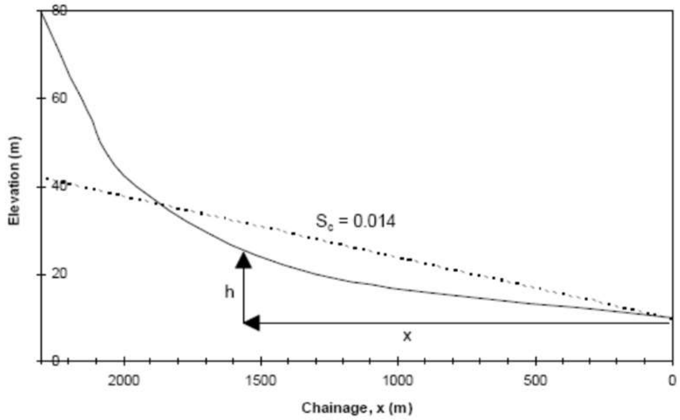
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h} \Delta x)$
1	20.57813	0	0			
2	21.125	0.546875	75.1574	75.157	0.2734375	20.55085177
3	21.4375	0.859375	140.7465	65.589	0.703125	46.1173421
4	22.35156	1.7734375	206.3356	65.589	1.3164063	86.34191271
5	23.27344	2.6953125	271.9664	65.631	2.234375	146.6436952
6	24.19531	3.6171875	338.8046	66.838	3.15625	210.9580297
7	25.01563	4.4375	405.6427	66.838	4.0273438	269.1803571
8	25.89063	5.3125	472.4809	66.838	4.875	325.8361646
9	26.49219	5.9140625	539.3191	66.838	5.6132813	375.1815453
10	26.71094	6.1328125	616.564	77.245	6.0234375	465.2798682
11	26.92969	6.3515625	688.2519	71.688	6.2421875	447.4891022
12	27.52344	6.9453125	787.113	98.861	6.6484375	657.2718826
			TOTAL =	787.11	TOTAL =	3050.850752

S_c = 0.010

JOB NAME:	Sunfield FAB	DATE:	2024-02-16
JOB NO:	215001	DES BY:	YW
SUBJECT:	Pr_Eastern_Subbasin-62	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)

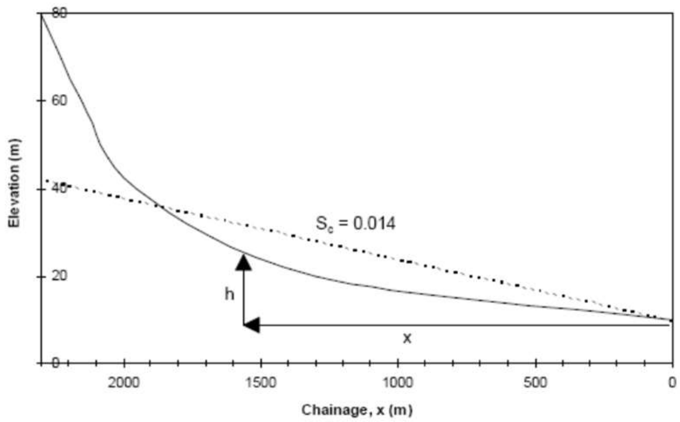
Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	20.58594	0	0			
2	20.51563	-0.070313	74.34195	74.342	-0.035156	-2.61358434
3	20.75781	0.171875	145.1115	70.77	0.0507813	3.593766344
4	20.78906	0.203125	215.8811	70.77	0.1875	13.26929112
5	21.21094	0.625	287.479	71.598	0.4140625	29.64603849
6	21.39063	0.8046875	353.6922	66.213	0.7148438	47.33209464
7	21.35938	0.7734375	428.6039	74.912	0.7890625	59.11000401
8	21.71094	1.125	501.4446	72.841	0.9492188	69.14168268
9	21.84375	1.2578125	572.2141	70.77	1.1914063	84.3152873
10	21.97656	1.390625	640.0842	67.87	1.3242188	89.87480295
11	22.09375	1.5078125	705.8832	65.799	1.4492188	95.35712986
12	22.41406	1.828125	721.7826	15.899	1.6679688	26.5198607
			TOTAL =	721.78	TOTAL =	515.5463737

S_c = 0.002

JOB NAME:	Sunfield FAB	DATE:	2024-02-16
JOB NO:	215001	DES BY:	YW
SUBJECT:	Pr_Eastern_Subbasin-63	CHKD BY:	

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



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

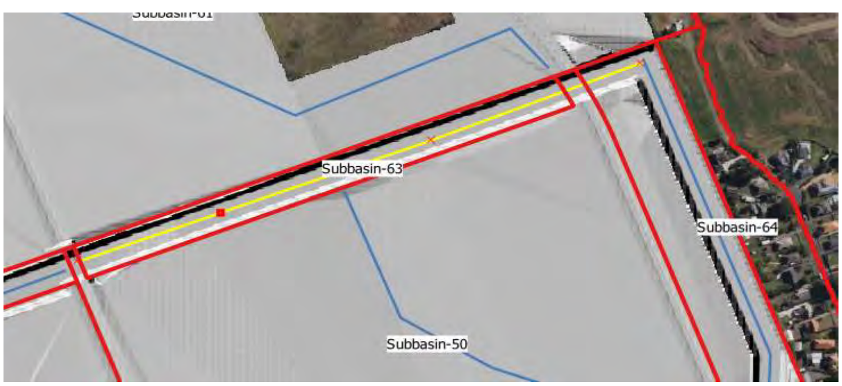
Data Entry Cells
Result cells

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

Post-development

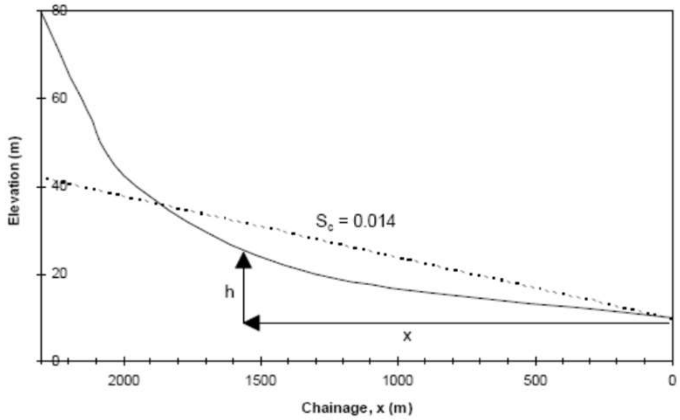
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A(=\overline{h}\Delta x)$
1	21.60156	0	0			
2	22.35938	0.7578125	54.09627	54.096	0.3789063	20.49741407
3	24.61719	3.015625	108.1925	54.096	1.8867188	102.0644433
4	24.79688	3.1953125	162.2888	54.096	3.1054688	167.99427
5	24.96094	3.359375	216.2981	54.009	3.2773438	177.0070205
6	25.125	3.5234375	269.7731	53.475	3.4414063	184.0292717
7	25.28906	3.6875	323.2481	53.475	3.6054688	192.8025174
8	25.45313	3.8515625	376.7232	53.475	3.7695313	201.575763
9	25.625	4.0234375	430.1982	53.475	3.9375	210.5578955
10	25.78125	4.1796875	483.6732	53.475	4.1015625	219.3311411
11	25.95313	4.3515625	537.1482	53.475	4.265625	228.1043867
12	26.01563	4.4140625	558.5382	21.39	4.3828125	93.74839631
			TOTAL =	558.54	TOTAL =	1797.712519

S_c = 0.012



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-64	**CHKD BY:**	

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



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

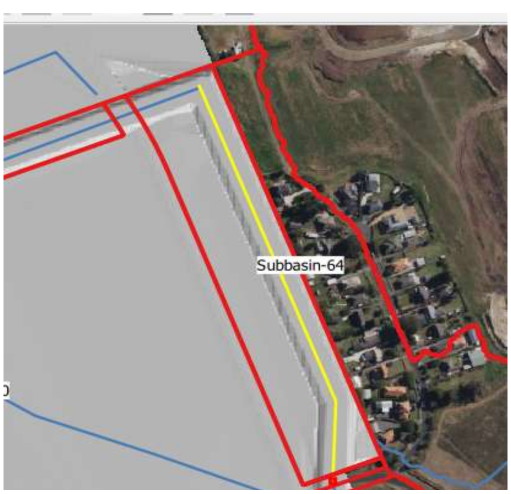
Data Entry Cells
Result cells

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

Post-development

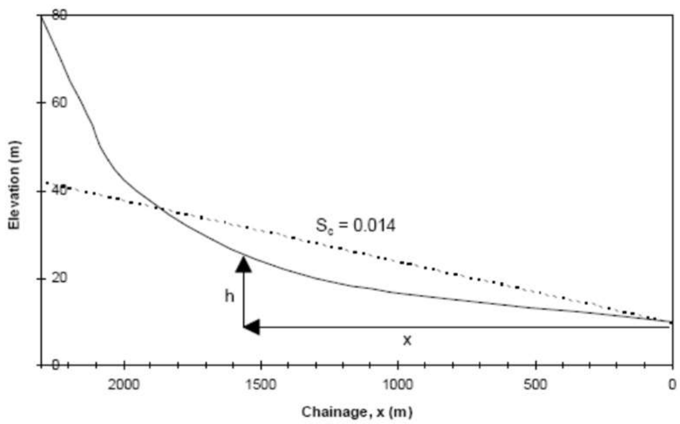
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	26.02344	0	0			
2	26.14063	0.1171875	35.07635	35.076	0.0585938	2.055254821
3	26.25781	0.234375	70.1527	35.076	0.1757813	6.165764462
4	26.375	0.3515625	107.5245	37.372	0.2929688	10.94877651
5	26.49219	0.46875	145.2789	37.754	0.4101563	15.48520433
6	26.60938	0.5859375	183.0333	37.754	0.5273438	19.90954843
7	26.72656	0.703125	220.7877	37.754	0.6445313	24.33389253
8	26.84375	0.8203125	258.5421	37.754	0.7617188	28.75823662
9	26.96875	0.9453125	296.2965	37.754	0.8828125	33.33005885
10	27.07813	1.0546875	334.0509	37.754	1	37.75440295
11	27.1875	1.1640625	371.8053	37.754	1.109375	41.88379077
12	27.25	1.2265625	393.3793	21.574	1.1953125	25.78760559
			TOTAL =	393.38	TOTAL =	246.4125359

S_c = 0.003



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-65	**CHKD BY:**	

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



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

Data Entry Cells

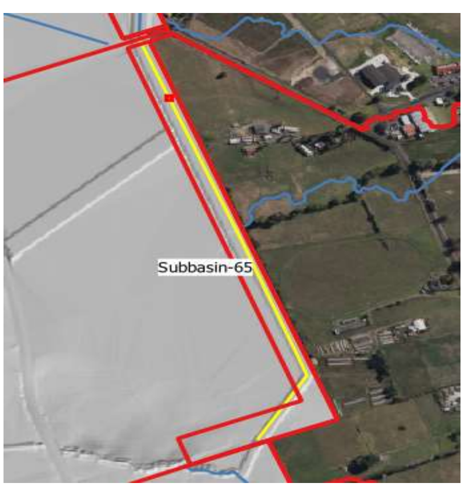
Result cells

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

Post-development

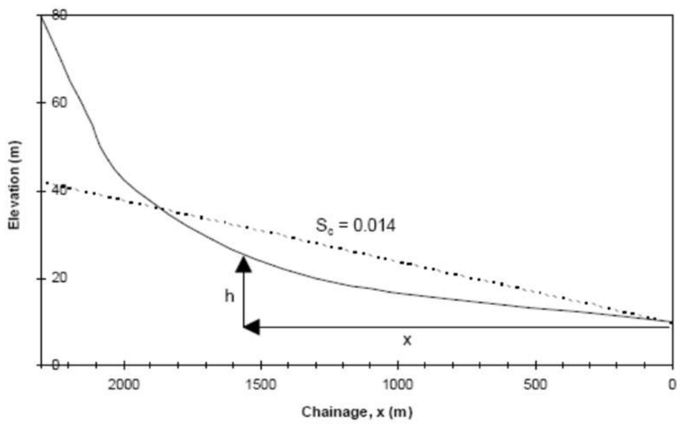
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\overline{h}$	$\Delta A (= \overline{h}\Delta x)$
1	27.27344	0	0			
2	27.50781	0.234375	82.65548	82.655	0.1171875	9.686188884
3	27.74219	0.46875	163.7073	81.052	0.3515625	28.49478604
4	27.97656	0.703125	238.8791	75.172	0.5859375	44.04598412
5	28.21875	0.9453125	314.0509	75.172	0.8242188	61.95801766
6	28.45313	1.1796875	389.2228	75.172	1.0625	79.8700512
7	29.125	1.8515625	464.6415	75.419	1.515625	114.3065448
8	29.4375	2.1640625	540.3217	75.68	2.0078125	151.9516823
9	29.75	2.4765625	616.0019	75.68	2.3203125	175.6017496
10	30.07031	2.796875	691.6822	75.68	2.6367188	199.5474427
11	30.40625	3.1328125	767.3624	75.68	2.9648438	224.3800133
12	30.84375	3.5703125	862.5032	95.141	3.3515625	318.8704786
			TOTAL =	862.5	TOTAL =	1408.712939

S_c = 0.004



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-204	**CHKD BY:**	

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



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

Data Entry Cells

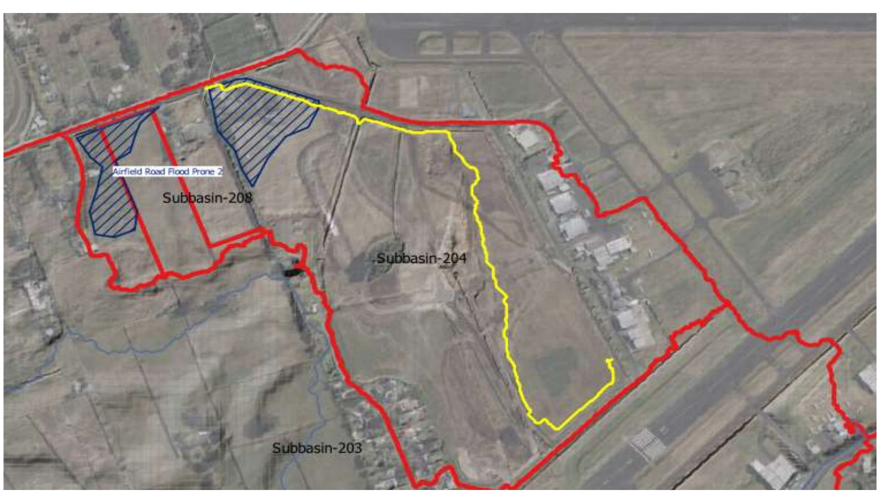
Result cells

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

Post-development

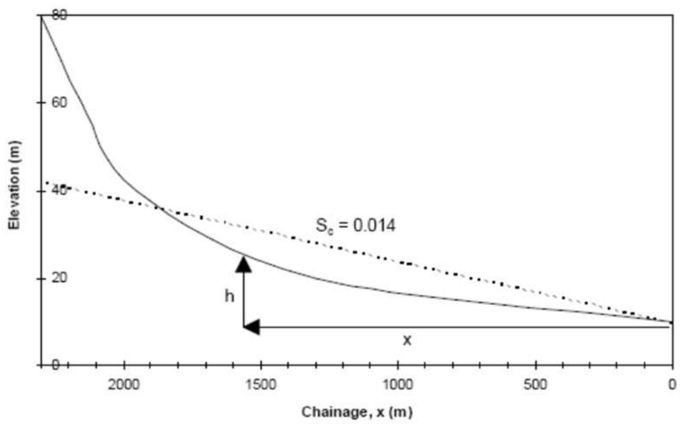
Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h} \Delta x)$
1	26.98438	0	0			
2	27.42188	0.4375	111.2665	111.27	0.21875	24.33954964
3	28.50781	1.5234375	223.6929	112.43	0.9804688	110.2305786
4	29.26563	2.28125	342.7467	119.05	1.9023438	226.4812978
5	30.07031	3.0859375	450.2026	107.46	2.6835938	288.3678317
6	30.57031	3.5859375	570.9133	120.71	3.3359375	402.6832778
7	30.73438	3.75	684.1681	113.25	3.6679688	415.4151919
8	30.75781	3.7734375	801.5651	117.4	3.7617188	441.6143818
9	30.71875	3.734375	912.3346	110.77	3.7539063	415.8185159
10	30.875	3.890625	1032.217	119.88	3.8125	457.0510819
11	31.27344	4.2890625	1162.04	129.82	4.0898438	530.9573249
12	31.48438	4.5	1211.153	49.113	4.3945313	215.8272878
			TOTAL =	1211.2	TOTAL =	3528.78632

S_c = 0.005



JOB NAME:	Sunfield FAB	**DATE:**	2024-02-16
JOB NO:	215001	**DES BY:**	YW
SUBJECT:	Pr_Eastern_Subbasin-204	**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)

Post-development

Point	RL (m)	(m) h	(m) x	(m) Δx	(m) $\bar{h}$	$\Delta A (= \bar{h}\Delta x)$
1	25.75781	0	0			
2	25.85938	0.1015625	21.59704	21.597	0.0507813	1.096724506
3	25.96094	0.203125	43.19407	21.597	0.1523438	3.290173518
4	26.0625	0.3046875	64.79111	21.597	0.2539063	5.483622529
5	26.17188	0.4140625	86.38815	21.597	0.359375	7.761434964
6	26.27344	0.515625	107.9852	21.597	0.4648438	10.0392474
7	26.375	0.6171875	129.5822	21.597	0.5664063	12.23269641
8	26.47656	0.71875	151.1793	21.597	0.6679688	14.42614542
9	26.54688	0.7890625	172.7763	21.597	0.7539063	16.28214074
10	26.60156	0.84375	194.3733	21.597	0.8164063	17.63195552
11	26.66406	0.90625	215.9704	21.597	0.875	18.89740687
12	26.89844	1.140625	274.2824	58.312	1.0234375	59.6786858
			TOTAL =	274.28	TOTAL =	166.8202337

S_c = 0.004

APPENDIX F – HMS WESTERN RESULTS

Global Summary Results for Run "10yrCC Western Ex"

Project: Stage2_3_4 Simulation Run: 10yrCC Western Ex

Start of Run: 01Jan2000, 00:01
End of Run: 02Jan2000, 12:00
Compute Time: 04Mar2024, 22:05:30

Basin Model: Stage3_Western_10yr
Meteorologic Model: 10yr 24hr TP108CC
Control Specifications: 24hr (1min int)

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)
Cabra_Pond	0.21980	2.54961	1 January 2000, 12...	28.20532
CH1150	0.53680	8.40250	1 January 2000, 12...	69.53547
CH1400	0.36920	5.87012	1 January 2000, 12...	47.91788
CH1550	0.14940	3.57874	1 January 2000, 12...	19.71256
CH550 Cosgrave_C...	0.93440	16.83812	1 January 2000, 12...	121.00675
CH700	0.91140	16.44175	1 January 2000, 12...	118.17657
CH800	0.82020	14.46412	1 January 2000, 12...	106.33469
CH960	0.80410	14.08880	1 January 2000, 12...	104.22277
Junction-1	0.15840	3.58834	1 January 2000, 12...	20.36552
Junction-2	0.09210	2.04329	1 January 2000, 12...	11.90830
Reach-1	0.15840	3.58834	1 January 2000, 12...	20.36552
Reach-2	0.09210	2.04329	1 January 2000, 12...	11.90830
R-CH1150-960	0.53680	8.40250	1 January 2000, 12...	69.53547
R-CH1400-1150	0.36920	5.87012	1 January 2000, 12...	47.91788
R-CH1550-1400	0.14940	3.57874	1 January 2000, 12...	19.71256
R-CH700-550	0.91140	16.44175	1 January 2000, 12...	118.17657
R-CH800-700	0.82020	14.46412	1 January 2000, 12...	106.33469
R-CH960-800	0.80410	14.08880	1 January 2000, 12...	104.22277
Subbasin-25	0.04840	1.21261	1 January 2000, 12...	6.27946
Subbasin-26	0.09620	2.17787	1 January 2000, 12...	12.45974
Subbasin-27	0.06630	1.82889	1 January 2000, 12...	8.45723
Subbasin-28	0.09210	2.04329	1 January 2000, 12...	11.90830
Subbasin-29	0.12560	3.17746	1 January 2000, 12...	16.21196
Subbasin-30	0.04280	1.17708	1 January 2000, 12...	5.56242
Subbasin-31	0.01610	0.37804	1 January 2000, 12...	2.11192
Subbasin-32	0.03570	0.99682	1 January 2000, 12...	4.63175
Subbasin-33	0.01270	0.37281	1 January 2000, 12...	1.86204
Subbasin-34	0.00630	0.16291	1 January 2000, 12...	0.77387
Subbasin-35	0.02300	0.59564	1 January 2000, 12...	2.83017
Subbasin-36	0.21980	4.92634	1 January 2000, 12...	28.20402
Subbasin-37	0.14940	3.57874	1 January 2000, 12...	19.71256

Global Summary Results for Run "100yrCC Western Ex"

Project: Stage2_3_4 Simulation Run: 100yrCC Western Ex

Start of Run: 01Jan2000, 00:01
End of Run: 02Jan2000, 12:00
Compute Time: 04Mar2024, 22:05:35

Basin Model: Stage3_Western_100yr
Meteorologic Model: 100yr 24hr TP108CC
Control Specifications: 24hr (1min int)

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)
Cabra_Pond	0.21980	3.65701	1 January 2000, 12...	49.29768
CH1150	0.53680	12.95950	1 January 2000, 12...	121.13478
CH1400	0.36920	8.68625	1 January 2000, 12...	83.41898
CH1550	0.14940	5.54465	1 January 2000, 12...	34.12130
CH550 Cosgrave_C...	0.93440	26.12023	1 January 2000, 12...	210.81241
CH700	0.91140	25.39428	1 January 2000, 12...	205.79373
CH800	0.82020	22.08192	1 January 2000, 12...	185.18034
CH960	0.80410	21.51476	1 January 2000, 12...	181.51714
Junction-1	0.15840	5.58473	1 January 2000, 12...	35.57188
Junction-2	0.09210	3.14205	1 January 2000, 12...	20.75904
Reach-1	0.15840	5.58473	1 January 2000, 12...	35.57188
Reach-2	0.09210	3.14205	1 January 2000, 12...	20.75904
R-CH1150-960	0.53680	12.95950	1 January 2000, 12...	121.13478
R-CH1400-1150	0.36920	8.68625	1 January 2000, 12...	83.41898
R-CH1550-1400	0.14940	5.54465	1 January 2000, 12...	34.12130
R-CH700-550	0.91140	25.39428	1 January 2000, 12...	205.79373
R-CH800-700	0.82020	22.08192	1 January 2000, 12...	185.18034
R-CH960-800	0.80410	21.51476	1 January 2000, 12...	181.51714
Subbasin-25	0.04840	1.91955	1 January 2000, 12...	10.93379
Subbasin-26	0.09620	3.35538	1 January 2000, 12...	21.70760
Subbasin-27	0.06630	3.08010	1 January 2000, 12...	14.81284
Subbasin-28	0.09210	3.14205	1 January 2000, 12...	20.75904
Subbasin-29	0.12560	5.07137	1 January 2000, 12...	28.27792
Subbasin-30	0.04280	1.94087	1 January 2000, 12...	9.67960
Subbasin-31	0.01610	0.58466	1 January 2000, 12...	3.66320
Subbasin-32	0.03570	1.66911	1 January 2000, 12...	8.06480
Subbasin-33	0.01270	0.59092	1 January 2000, 12...	3.10288
Subbasin-34	0.00630	0.27215	1 January 2000, 12...	1.37308
Subbasin-35	0.02300	0.99440	1 January 2000, 12...	5.01868
Subbasin-36	0.21980	7.61127	1 January 2000, 12...	49.29718
Subbasin-37	0.14940	5.54465	1 January 2000, 12...	34.12130

Global Summary Results for Run "10yrCC Western Pr"

Project: Stage2_3_4 Simulation Run: 10yrCC Western Pr

Start of Run: 01Jan2000, 00:01
End of Run: 02Jan2000, 12:00
Compute Time: 04Mar2024, 22:05:31

Basin Model: Stage3_4_Western_10yr
Meteorologic Model: 10yr 24hr TP108CC
Control Specifications: 24hr (1min int)

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)
Cabra_Pond	0.21980	2.54961	1 January 2000, 12:18	28.20532
CH1150	0.53680	8.40250	1 January 2000, 12:03	69.53547
CH1400	0.36920	5.87012	1 January 2000, 12:07	47.91788
CH1550	0.14940	3.57874	1 January 2000, 12:03	19.71256
CH550 Cosgrave_Cul...	1.73840	18.38110	1 January 2000, 12:06	224.78011
CH700	1.71540	18.03861	1 January 2000, 12:04	221.96187
CH800	1.50620	16.37432	1 January 2000, 12:03	197.23803
CH960	1.45780	15.17097	1 January 2000, 12:02	190.96449
Junction-1	0.81210	4.64215	1 January 2000, 12:01	107.10725
Junction-2	0.74580	3.23780	1 January 2000, 12:06	98.65002
Reach-1	0.81210	4.64215	1 January 2000, 12:01	107.10725
Reach-2	0.74580	3.23780	1 January 2000, 12:06	98.65002
R-CH1150-960	0.53680	8.40250	1 January 2000, 12:04	69.53547
R-CH1400-1150	0.36920	5.87012	1 January 2000, 12:10	47.91788
R-CH1550-1400	0.14940	3.57874	1 January 2000, 12:06	19.71256
R-CH700-550	1.71540	18.03861	1 January 2000, 12:06	221.94994
R-CH800-700	1.50620	16.37432	1 January 2000, 12:04	197.23208
R-CH960-800	1.45780	15.17097	1 January 2000, 12:03	190.95856
Sink-1	0.00000	0.00000	1 January 2000, 00:01	0.00000
Stage4_Pond	0.65370	2.00519	1 January 2000, 13:39	86.74173
Subbasin-25	0.04840	1.21261	1 January 2000, 12:02	6.27946
Subbasin-26	0.09620	2.17787	1 January 2000, 12:05	12.45974
Subbasin-27	0.06630	1.82889	1 January 2000, 12:00	8.45723
Subbasin-28	0.09210	2.04329	1 January 2000, 12:05	11.90830
Subbasin-29	0.12560	3.17746	1 January 2000, 12:02	16.21196
Subbasin-30	0.04280	1.17708	1 January 2000, 12:00	5.56242
Subbasin-31	0.01610	0.37804	1 January 2000, 12:04	2.11192
Subbasin-32	0.03570	0.99682	1 January 2000, 12:00	4.63175
Subbasin-33	0.01270	0.37281	1 January 2000, 12:00	1.86204
Subbasin-34	0.00630	0.16291	1 January 2000, 12:01	0.77387
Subbasin-35	0.02300	0.59564	1 January 2000, 12:01	2.83017
Subbasin-36	0.21980	4.92634	1 January 2000, 12:05	28.20402
Subbasin-37	0.14940	3.57874	1 January 2000, 12:03	19.71256
Subbasin-41	0.15030	2.73992	1 January 2000, 12:11	19.38556
Subbasin-42	0.11580	2.25607	1 January 2000, 12:08	14.79689
Subbasin-43	0.16030	3.76959	1 January 2000, 12:05	22.17984
Subbasin-44	0.03040	0.59758	1 January 2000, 12:09	3.95764
Subbasin-45	0.34720	7.42357	1 January 2000, 12:08	49.11538
119 Cosgrave Pipe	0.15030	0.85179	1 January 2000, 12:59	17.05545
119 Cosgrave Road	0.15030	0.85179	1 January 2000, 12:53	17.05545

Summary Results for Reservoir "Stage4_Pond"

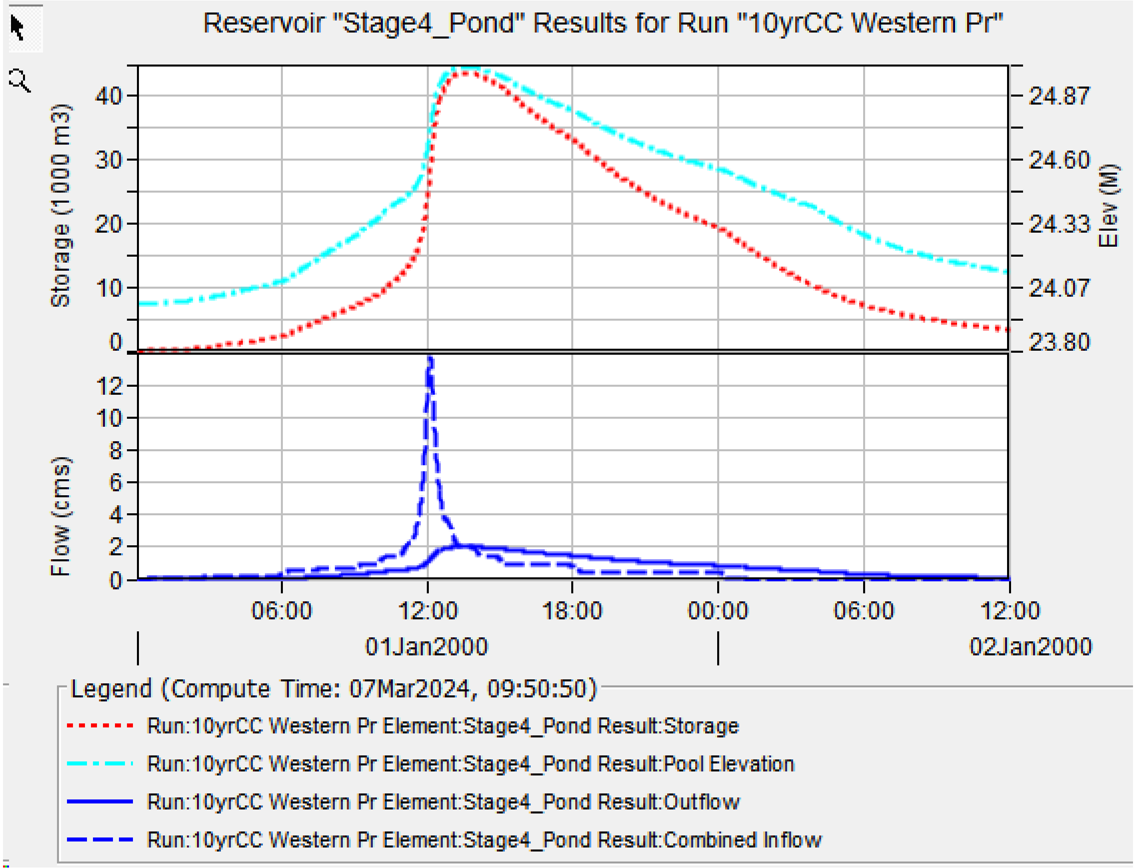
Project: Stage2_3_4 Simulation Run: 10yrCC Western Pr
Reservoir: Stage4_Pond

Start of Run:	01Jan2000, 00:01	Basin Model:	Stage3_4_Western_10yr
End of Run:	02Jan2000, 12:00	Meteorologic Model:	10yr 24hr TP108CC
Compute Time:	07Mar2024, 09:50:50	Control Specifications:	24hr (1min int)

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Inflow:	13.85820 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:07
Peak Discharge:	2.00519 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:39
Inflow Volume:	90.04974 (1000 M3)	Peak Storage:	43.52647 (1000 M3)
Discharge Volume:	86.74173 (1000 M3)	Peak Elevation:	24.98671 (M)



Project: Stage2_3_4 Simulation Run: 10yrCC Western Pr
Reservoir: 119 Cosgrave Road

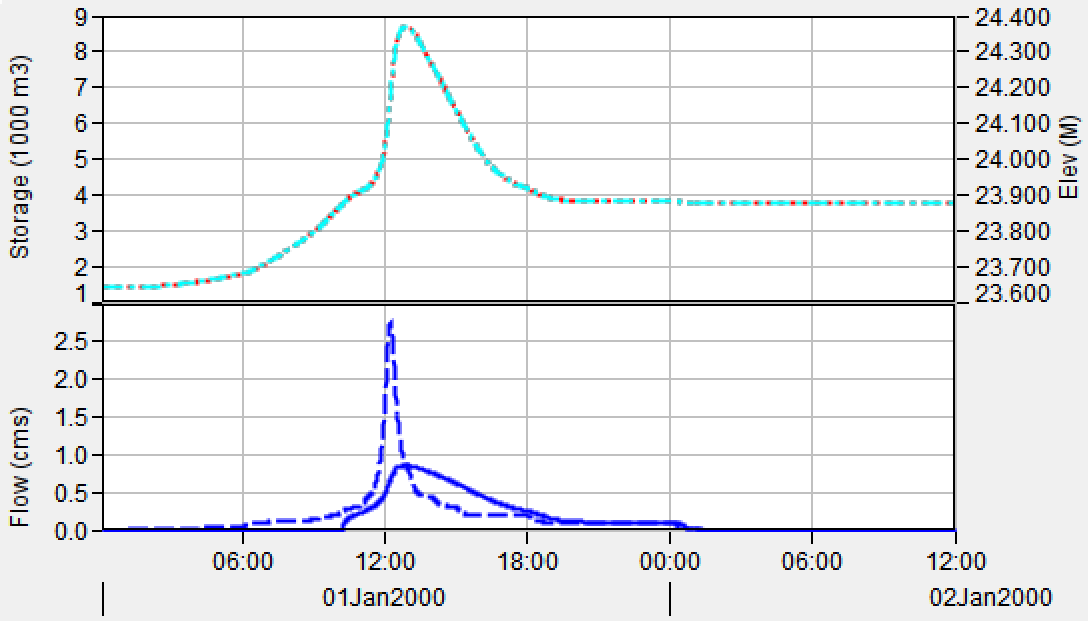
Start of Run:	01Jan2000, 00:01	Basin Model:	Stage3_4_Western_10yr
End of Run:	02Jan2000, 12:00	Meteorologic Model:	10yr 24hr TP108CC
Compute Time:	07Mar2024, 09:50:50	Control Specifications:	24hr (1min int)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	2.73992 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:11
Peak Discharge:	0.85179 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:53
Inflow Volume:	19.38556 (1000 M3)	Peak Storage:	8.68058 (1000 M3
Discharge Volume:	17.05545 (1000 M3)	Peak Elevation:	24.36806 (M)

Reservoir "119 Cosgrave Road" Results for Run "10yrCC Western Pr"



Legend (Compute Time: 07Mar2024, 09:50:50)

- Run:10yrCC Western Pr Element:119 Cosgrave Road Result:Storage
- Run:10yrCC Western Pr Element:119 Cosgrave Road Result:Pool Elevation
- Run:10yrCC Western Pr Element:119 Cosgrave Road Result:Outflow
- Run:10yrCC Western Pr Element:119 Cosgrave Road Result:Combined Inflow

Global Summary Results for Run "100yrCC Western Pr"

Project: Stage2_3_4 Simulation Run: 100yrCC Western Pr

Start of Run: 01Jan2000, 00:01 Basin Model: Stage3_4_Western_100yr
End of Run: 02Jan2000, 12:00 Meteorologic Model: 100yr 24hr TP108CC
Compute Time: 04Mar2024, 22:05:36 Control Specifications: 24hr (1min int)

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)
Cabra_Pond	0.21980	3.65701	1 January 2000, 12:...	49.29768
CH1150	0.53680	12.95950	1 January 2000, 12:...	121.13478
CH1400	0.36920	8.68625	1 January 2000, 12:...	83.41898
CH1550	0.14940	5.54465	1 January 2000, 12:...	34.12130
CH550 Cosgrave_Cu...	1.73840	28.02325	1 January 2000, 12:...	388.22713
CH700	1.71540	27.40469	1 January 2000, 12:...	383.24076
CH800	1.50620	24.91345	1 January 2000, 12:...	338.41995
CH960	1.45780	23.01890	1 January 2000, 12:...	327.50219
Junction-1	0.81210	6.55504	1 January 2000, 12:...	181.58887
Junction-2	0.74580	4.98768	1 January 2000, 12:...	166.82351
R-CH1150-960	0.53680	12.95950	1 January 2000, 12:...	121.13478
R-CH1400-1150	0.36920	8.68625	1 January 2000, 12:...	83.41898
R-CH1550-1400	0.14940	5.54465	1 January 2000, 12:...	34.12130
R-CH700-550	1.71540	27.40469	1 January 2000, 12:...	383.20845
R-CH800-700	1.50620	24.91345	1 January 2000, 12:...	338.40387
R-CH960-800	1.45780	23.01890	1 January 2000, 12:...	327.48616
Stage4_Pond	0.65370	4.05299	1 January 2000, 13:...	146.06447
STG4 CH0-150	0.81210	6.55504	1 January 2000, 12:...	181.55693
STG4 CH150-400	0.74580	4.98768	1 January 2000, 12:...	166.77603
Subbasin-25	0.04840	1.91955	1 January 2000, 12:...	10.93379
Subbasin-26	0.09620	3.35538	1 January 2000, 12:...	21.70760
Subbasin-27	0.06630	3.08010	1 January 2000, 12:...	14.81284
Subbasin-28	0.09210	3.14205	1 January 2000, 12:...	20.75904
Subbasin-29	0.12560	5.07137	1 January 2000, 12:...	28.27792
Subbasin-30	0.04280	1.94087	1 January 2000, 12:...	9.67960
Subbasin-31	0.01610	0.58466	1 January 2000, 12:...	3.66320
Subbasin-32	0.03570	1.66911	1 January 2000, 12:...	8.06480
Subbasin-33	0.01270	0.59092	1 January 2000, 12:...	3.10288
Subbasin-34	0.00630	0.27215	1 January 2000, 12:...	1.37308
Subbasin-35	0.02300	0.99440	1 January 2000, 12:...	5.01868
Subbasin-36	0.21980	7.61127	1 January 2000, 12:...	49.29718
Subbasin-37	0.14940	5.54465	1 January 2000, 12:...	34.12130
Subbasin-41	0.15030	4.13555	1 January 2000, 12:...	33.82411
Subbasin-42	0.11580	3.43815	1 January 2000, 12:...	25.90161
Subbasin-43	0.16030	5.66863	1 January 2000, 12:...	37.74927
Subbasin-44	0.03040	0.90573	1 January 2000, 12:...	6.88295
Subbasin-45	0.34720	10.95437	1 January 2000, 12:...	82.92508
119 Cosgrave Pipe	0.15030	1.30993	1 January 2000, 13:...	31.49409
119 Cosgrave Road	0.15030	1.30993	1 January 2000, 13:...	31.49409

Summary Results for Reservoir "Stage4_Pond"

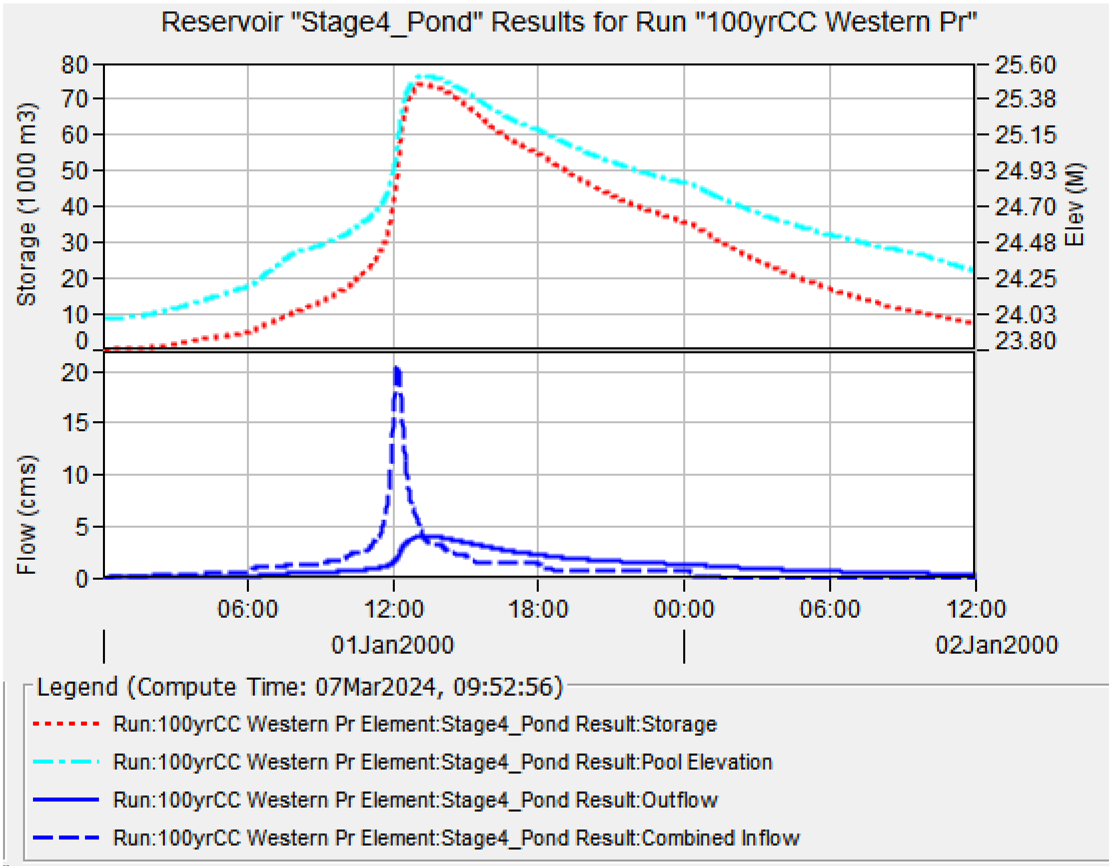
Project: Stage2_3_4 Simulation Run: 100yrCC Western Pr
Reservoir: Stage4_Pond

Start of Run:	01Jan2000, 00:01	Basin Model:	Stage3_4_Western_100yr
End of Run:	02Jan2000, 12:00	Meteorologic Model:	100yr 24hr TP108CC
Compute Time:	07Mar2024, 09:52:56	Control Specifications:	24hr (1min int)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	20.66325 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:10
Peak Discharge:	4.05299 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:14
Inflow Volume:	153.45891 (1000 M3)	Peak Storage:	74.30054 (1000 M3
Discharge Volume:	146.06447 (1000 M3)	Peak Elevation:	25.52526 (M)



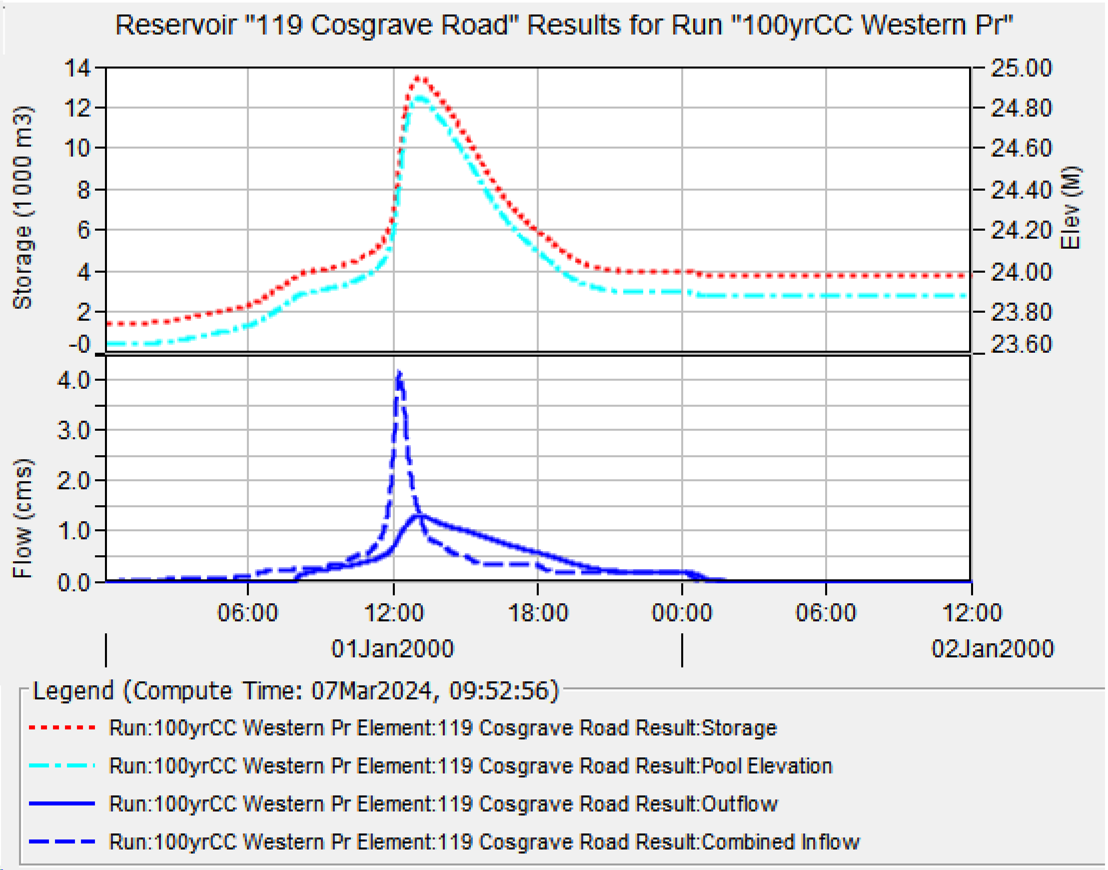
Project: Stage2_3_4   Simulation Run: 100yrCC Western Pr
Reservoir: 119 Cosgrave Road

Start of Run:	01Jan2000, 00:01	Basin Model:	Stage3_4_Western_100yr
End of Run:	02Jan2000, 12:00	Meteorologic Model:	100yr 24hr TP108CC
Compute Time:	07Mar2024, 09:52:56	Control Specifications:	24hr (1min int)

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Inflow:	4.13555 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:16
Peak Discharge:	1.30993 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:07
Inflow Volume:	33.82411 (1000 M3)	Peak Storage:	13.45504 (1000 M3
Discharge Volume:	31.49409 (1000 M3)	Peak Elevation:	24.84550 (M)



APPENDIX G – HMS EASTERN RESULTS

Global Summary Results for Run "10yr_Eastern_Ex"

Project: Eastern_Catchment   Simulation Run: 10yr_Eastern_Ex

Start of Run: 01Jan2000, 00:01   Basin Model: Ex_10yr_
End of Run: 02Jan2000, 12:00   Meteorologic Model: 10yr 24hr TP108CC_Ex
Compute Time: 04Mar2024, 16:26:17   Control Specifications: 24hr (1min)

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)
Airfield_Road_Tipping	5.75670	27.32664	1 January 2000, 1...	655.41880
Airfield_Road_Tippi...	0.36410	5.98684	1 January 2000, 1...	48.94383
Hamlin_Road_Tipping	4.43400	22.32964	1 January 2000, 1...	504.86554
Junction-1	4.73930	23.04406	1 January 2000, 1...	537.50296
Junction-2	0.73760	5.66429	1 January 2000, 1...	88.45651
Reach-10	4.43400	22.32964	1 January 2000, 1...	504.84792
Reach-11	4.73930	23.04406	1 January 2000, 1...	537.48518
Reach-12	0.73760	5.66429	1 January 2000, 1...	88.45651
Sink-1	5.75670	27.32664	1 January 2000, 1...	655.41880
Sink-2	0.36410	5.98684	1 January 2000, 1...	48.94383
Subbasin-201	0.30530	2.97146	1 January 2000, 1...	32.65504
Subbasin-202	0.27980	2.17713	1 January 2000, 1...	29.81230
Subbasin-203	0.73760	5.66429	1 January 2000, 1...	88.45651
Subbasin-204	0.34050	5.68688	1 January 2000, 1...	46.40639
Subbasin-205	0.51000	4.74973	1 January 2000, 1...	55.11406
Subbasin-206	0.68380	6.42894	1 January 2000, 1...	78.28842
Subbasin-207	3.24020	17.76540	1 January 2000, 1...	371.58675
Subbasin-208	0.02360	0.38137	1 January 2000, 1...	2.54249

Global Summary Results for Run "100yr_Eastern_Ex"

Project: Eastern_Catchment Simulation Run: 100yr_Eastern_Ex

Start of Run: 01Jan2000, 00:01
End of Run: 02Jan2000, 12:00
Compute Time: 04Mar2024, 16:26:24

Basin Model: Ex_100yr
Meteorologic Model: 100yr 24hr TP108CC_Ex
Control Specifications: 24hr (1min)

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)
Airfield_Road_Tipping	5.75670	51.46607	1 January 2000, 14...	1229.32218
Airfield_Road_Tippi...	0.36410	8.96549	1 January 2000, 12...	85.93757
Hamlin_Road_Tipping	4.43400	41.91922	1 January 2000, 13...	949.94648
Junction-1	4.73930	43.25139	1 January 2000, 14...	1011.69890
Junction-2	0.73760	10.25883	1 January 2000, 13...	161.59843
Reach-10	4.43400	41.91922	1 January 2000, 14...	949.92566
Reach-11	4.73930	43.25139	1 January 2000, 15...	1011.67711
Reach-12	0.73760	10.25883	1 January 2000, 13...	161.59843
Sink-1	5.75670	51.46607	1 January 2000, 14...	1229.32218
Sink-2	0.36410	8.96549	1 January 2000, 12...	85.93757
Subbasin-201	0.30530	5.60929	1 January 2000, 12...	61.77325
Subbasin-202	0.27980	4.11284	1 January 2000, 12...	56.41103
Subbasin-203	0.73760	10.25883	1 January 2000, 13...	161.59843
Subbasin-204	0.34050	8.53382	1 January 2000, 12...	81.14003
Subbasin-205	0.51000	8.95788	1 January 2000, 12...	104.18380
Subbasin-206	0.68380	11.96625	1 January 2000, 12...	146.45029
Subbasin-207	3.24020	33.35883	1 January 2000, 14...	699.44576
Subbasin-208	0.02360	0.71623	1 January 2000, 12...	4.80035

Global Summary Results for Run "10yr_Eastern_Pr_48hr"

Project: Eastern_Catchment   Simulation Run: 10yr_Eastern_Pr_48hr

Start of Run: 01Jan2000, 00:01   Basin Model: Pr_10yr_v3
End of Run: 03Jan2000, 00:00   Meteorologic Model: 10yr 24hr TP108CC_Pr
Compute Time: DATA CHANGED, RECOMPUTE   Control Specifications: 48hr (1min)

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)
Airfield_Road_Tipp...	4.68080	23.92947	1 January 2000, 1...	534.96331
Airfield_Road_Tipp...	0.36640	5.98647	1 January 2000, 1...	50.65801
Junction-1	4.17690	22.53240	1 January 2000, 1...	473.44839
Junction-10	0.00000	0.86554	1 January 2000, 1...	6.50566
Junction-11	0.62180	12.57097	1 January 2000, 1...	86.73794
Junction-12	0.69950	11.07547	1 January 2000, 1...	99.19116
Junction-13	0.17690	4.06741	1 January 2000, 1...	27.06199
Junction-14	3.47740	20.28461	1 January 2000, 1...	374.25722
Junction-15	0.06020	0.21436	1 January 2000, 1...	10.48574
Junction-3	3.40850	20.97513	1 January 2000, 1...	393.94649
Junction-4	3.43720	21.05844	1 January 2000, 1...	397.35593
Junction-47	0.36700	7.59206	1 January 2000, 1...	52.63788
Junction-5	3.45370	21.10528	1 January 2000, 1...	399.30670
Junction-50	3.43720	21.05844	1 January 2000, 1...	397.35593
Junction-6	3.47740	21.15615	1 January 2000, 1...	402.06033
Junction-7	0.30630	4.75670	1 January 2000, 1...	37.33746
Junction-8	0.39880	5.97666	1 January 2000, 1...	47.49654
Junction-9	3.36630	20.84760	1 January 2000, 1...	388.90009
Reach-1	0.30630	4.75670	1 January 2000, 1...	37.33746
Reach-10	0.17690	4.06741	1 January 2000, 1...	27.06199
Reach-11	4.17690	22.53240	1 January 2000, 1...	473.43626
Reach-12	0.00000	0.00000	1 January 2000, 0...	0.00000
Reach-2	0.39880	5.97666	1 January 2000, 1...	47.49654
Reach-3	3.36630	20.84760	1 January 2000, 1...	388.90009
Reach-4	3.40850	20.97513	1 January 2000, 1...	393.94649
Reach-5	3.43720	21.05844	1 January 2000, 1...	397.35593
Reach-6	0.36700	7.59206	1 January 2000, 1...	52.63788
Reach-7	3.45370	21.10528	1 January 2000, 1...	399.30670
Reach-8	3.43720	21.05844	1 January 2000, 1...	397.35593
Reach-9	0.62180	12.57097	1 January 2000, 1...	86.73794
Reservoir-Dry Pond	0.06020	0.21436	1 January 2000, 1...	10.48574
Reservoir-Main_No...	3.47740	20.28461	1 January 2000, 1...	374.25722
Reservoir-Wetland...	0.69950	11.07547	1 January 2000, 1...	99.19116
Reservoir-208	0.02590	0.13337	1 January 2000, 1...	3.57508
Sink-1	4.68080	23.92947	1 January 2000, 1...	534.96331
Sink-2	0.36640	5.98647	1 January 2000, 1...	50.65801
Subbasin-204	0.34050	5.89030	1 January 2000, 1...	47.08723
Subbasin-208	0.02590	0.68966	1 January 2000, 1...	3.95505
Subbasin-46	0.25480	4.97891	1 January 2000, 1...	34.10006
Subbasin-47	0.12780	3.08064	1 January 2000, 1...	17.24337
Subbasin-48	0.02370	0.59158	1 January 2000, 1...	2.75363
Subbasin-49	0.06230	1.49138	1 January 2000, 1...	8.33251
Subbasin-50	0.17690	4.06741	1 January 2000, 1...	27.06199
Subbasin-51	2.96750	19.47633	1 January 2000, 1...	341.40355
Subbasin-52	0.09250	1.29380	1 January 2000, 1...	10.15908
Subbasin-53	0.30630	4.75670	1 January 2000, 1...	37.33746
Subbasin-57	0.25560	4.07682	1 January 2000, 1...	36.55501
Subbasin-61	0.21990	4.86492	1 January 2000, 1...	31.63660
Subbasin-62	0.28400	3.24573	1 January 2000, 1...	30.26336
Subbasin-63	0.01650	0.32982	1 January 2000, 1...	1.95078
Subbasin-64	0.02870	0.53630	1 January 2000, 1...	3.40944
Subbasin-65	0.04220	0.66165	1 January 2000, 1...	5.04640

Summary Results for Reservoir "Reservoir-208"

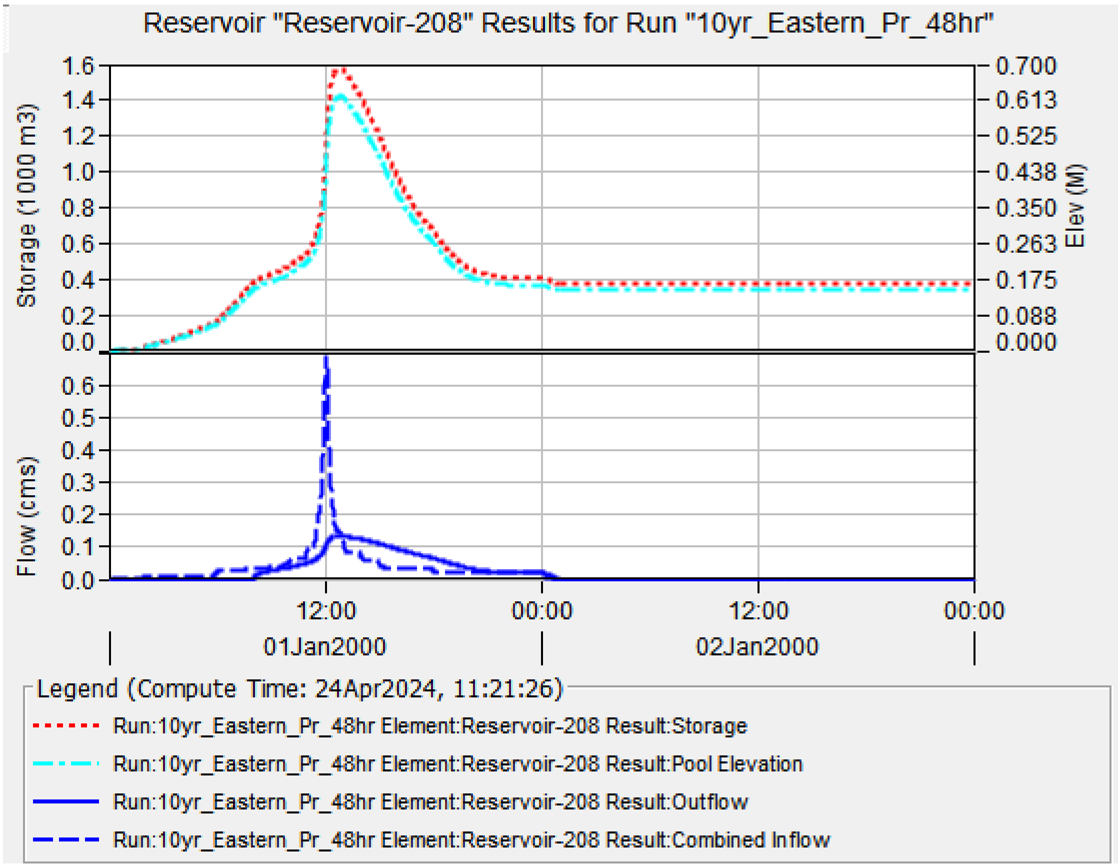
Project: Eastern_Catchment   Simulation Run: 10yr_Eastern_Pr_48hr
Reservoir: Reservoir-208

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_10yr_v3
End of Run:	03Jan2000, 00:00	Meteorologic Model:	10yr 24hr TP108CC_Pr
Compute Time:	24Apr2024, 11:21:26	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	0.68966 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:03
Peak Discharge:	0.13337 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:55
Inflow Volume:	3.95505 (1000 M3)	Peak Storage:	1.57620 (1000 M3)
Discharge Volume:	3.57508 (1000 M3)	Peak Elevation:	0.62218 (M)



Summary Results for Reservoir "Reservoir-Main_Northern_Chan"

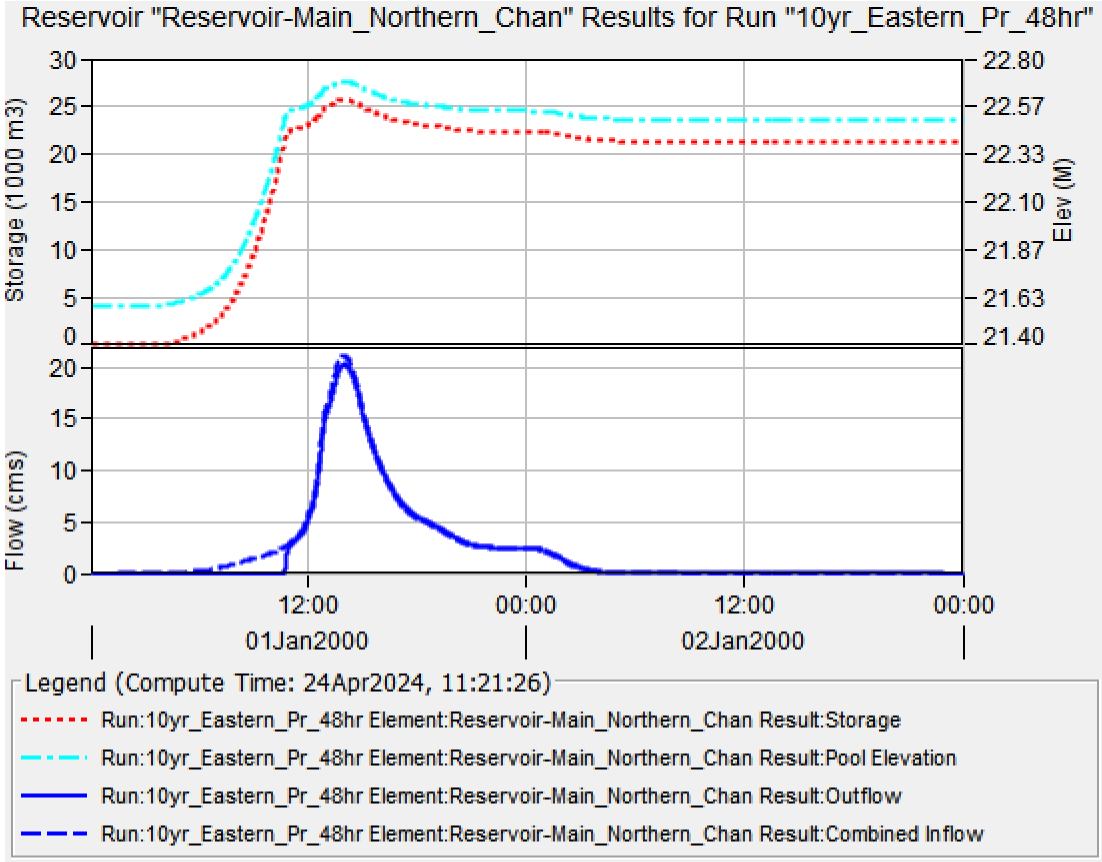
Project: Eastern_Catchment Simulation Run: 10yr_Eastern_Pr_48hr
Reservoir: Reservoir-Main_Northern_Chan

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_10yr_v3
End of Run:	03Jan2000, 00:00	Meteorologic Model:	10yr 24hr TP108CC_Pr
Compute Time:	24Apr2024, 11:21:26	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	21.15615 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 13:57
Peak Discharge:	20.28461 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:59
Inflow Volume:	402.06033 (1000 M3)	Peak Storage:	25.69605 (1000 M3
Discharge Volume:	374.25722 (1000 M3)	Peak Elevation:	22.68792 (M)



Summary Results for Reservoir "Reservoir-Wetland"

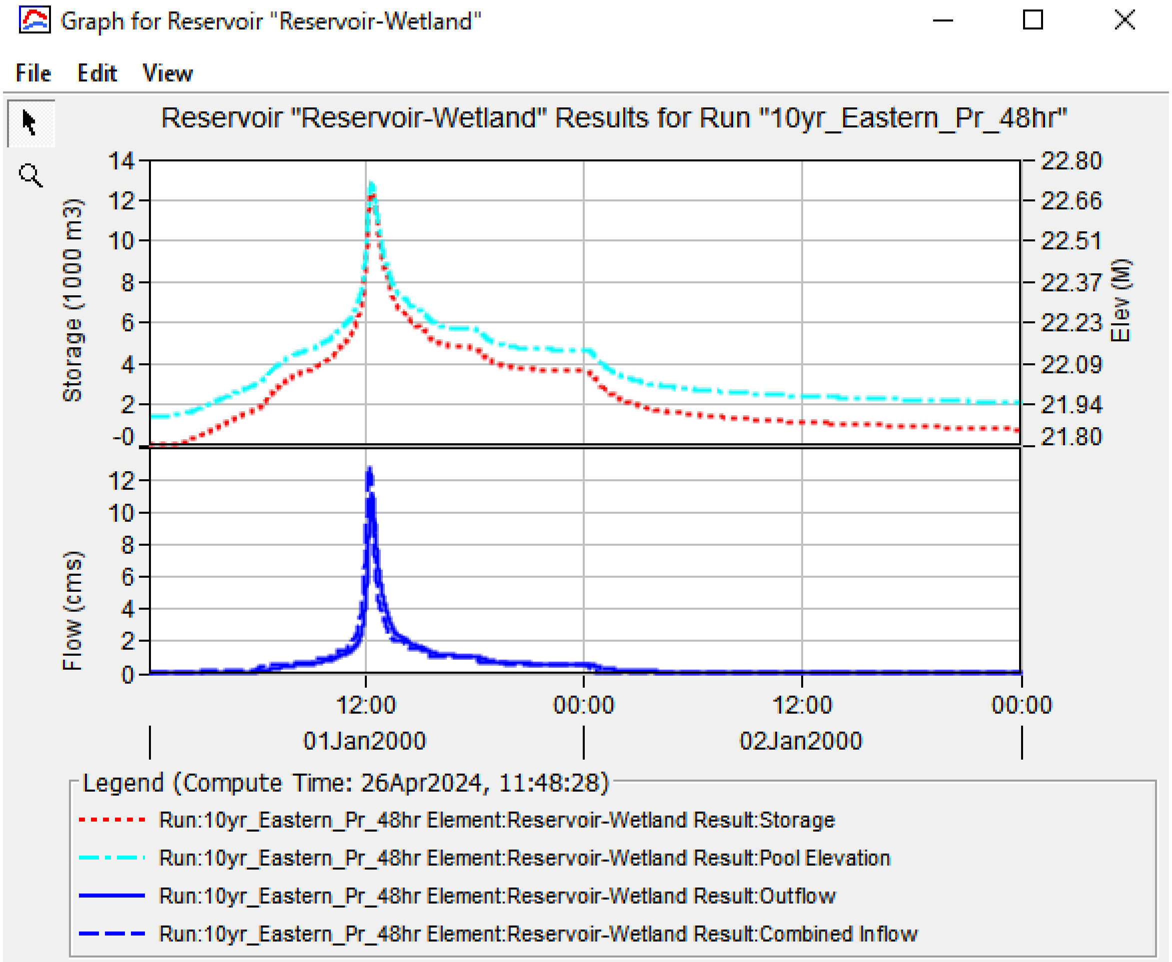
Project: Eastern_Catchment Simulation Run: 10yr_Eastern_Pr_48hr
Reservoir: Reservoir-Wetland

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_10yr_v3
End of Run:	03Jan2000, 00:00	Meteorologic Model:	10yr 24hr TP108CC_Pr
Compute Time:	26Apr2024, 11:48:28	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	12.81243 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:10
Peak Discharge:	11.07547 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:17
Inflow Volume:	99.96697 (1000 M3)	Peak Storage:	12.71305 (1000 M3)
Discharge Volume:	99.19116 (1000 M3)	Peak Elevation:	22.71420 (M)



Summary Results for Reservoir "Reservoir-Dry Pond"

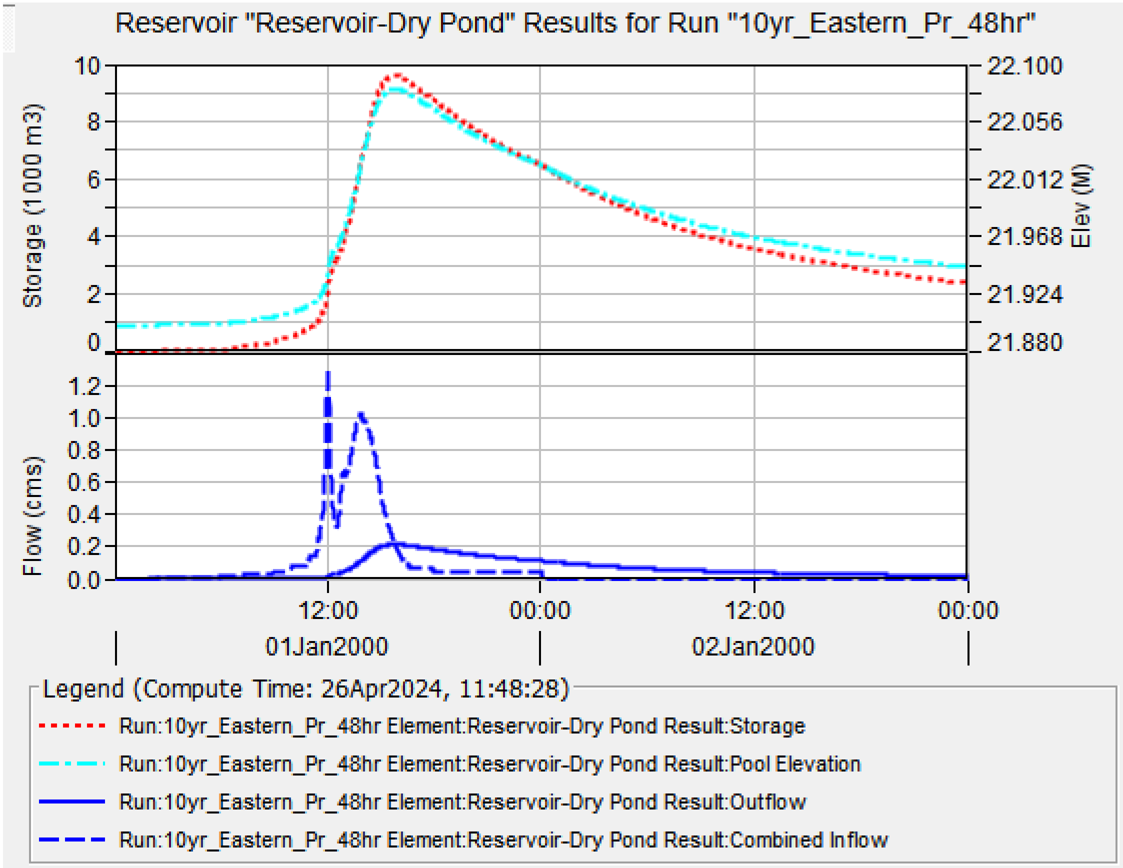
Project: Eastern_Catchment   Simulation Run: 10yr_Eastern_Pr_48hr
Reservoir: Reservoir-Dry Pond

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_10yr_v3
End of Run:	03Jan2000, 00:00	Meteorologic Model:	10yr 24hr TP108CC_Pr
Compute Time:	26Apr2024, 11:48:28	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	1.31248 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:01
Peak Discharge:	0.21436 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 15:47
Inflow Volume:	12.85482 (1000 M3)	Peak Storage:	9.60965 (1000 M3)
Discharge Volume:	10.48574 (1000 M3)	Peak Elevation:	22.08152 (M)



Global Summary Results for Run "100yr_Eastern_Pr_48hr"

Project: Eastern_Catchment Simulation Run: 100yr_Eastern_Pr_48hr

Start of Run: 01Jan2000, 00:01 Basin Model: Pr_100yr_v2
End of Run: 03Jan2000, 00:00 Meteorologic Model: 100yr 24hr TP108CC_Pr
Compute Time: 24Apr2024, 11:26:34 Control Specifications: 48hr (1min)

Show Elements: All Elements Volume Un... ○ MM ◉ 1000 M3 Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
Airfield_Road_Tip...	4.93640	45.99582	1 January 2000, ...	1070.37753
Airfield_Road_Tip...	0.36640	8.94157	1 January 2000, ...	88.15296
Junction-1	4.43250	42.57219	1 January 2000, ...	959.45511
Junction-10	0.33250	7.09467	1 January 2000, ...	105.40476
Junction-11	0.25480	8.08789	1 January 2000, ...	59.85869
Junction-12	0.00000	2.90543	1 January 2000, ...	33.19354
Junction-13	4.10000	40.32569	1 January 2000, ...	854.05035
Junction-14	0.06020	1.22173	1 January 2000, ...	42.03753
Junction-2	0.00000	0.00000	1 January 2000, ...	0.00000
Junction-3	3.66410	40.97724	1 January 2000, ...	803.43511
Junction-4	3.69280	41.12455	1 January 2000, ...	809.68484
Junction-47	0.19010	7.36412	1 January 2000, ...	44.85761
Junction-5	3.88620	42.14142	1 January 2000, ...	858.61396
Junction-50	3.86970	42.05875	1 January 2000, ...	855.03742
Junction-6	4.07630	43.12094	1 January 2000, ...	903.47157
Junction-7	0.30630	8.66561	1 January 2000, ...	68.79467
Junction-8	0.39880	10.96765	1 January 2000, ...	88.07835
Junction-9	3.36630	39.06761	1 January 2000, ...	731.15254
Reach-1	0.30630	8.66561	1 January 2000, ...	68.79467
Reach-11	4.43250	42.57219	1 January 2000, ...	959.43449
Reach-12	0.00000	0.00000	1 January 2000, ...	0.00000
Reach-2	0.39880	10.96765	1 January 2000, ...	88.07835
Reach-3	3.36630	39.06761	1 January 2000, ...	731.15254
Reach-4	3.66410	40.97724	1 January 2000, ...	803.43511
Reach-5	3.69280	41.12455	1 January 2000, ...	809.68484
Reach-6	0.19010	7.36412	1 January 2000, ...	44.85761
Reach-7	3.88620	42.14142	1 January 2000, ...	858.61396
Reach-8	3.86970	42.05875	1 January 2000, ...	855.03742
Reservoir-Dry Pond	0.06020	1.22173	1 January 2000, ...	42.03753
Reservoir-Main_N...	4.10000	40.32569	1 January 2000, ...	854.05035
Reservoir-Wetland	0.33250	7.09467	1 January 2000, ...	105.40476
Reservoir-208	0.02590	0.18302	1 January 2000, ...	6.24659
Sink-1	4.93640	45.99582	1 January 2000, ...	1070.37753
Sink-2	0.36640	8.94157	1 January 2000, ...	88.15296
Subbasin-204	0.34050	8.79033	1 January 2000, ...	81.90809
Subbasin-208	0.02590	1.03859	1 January 2000, ...	6.62657
Subbasin-46	0.25480	8.08789	1 January 2000, ...	59.85869
Subbasin-47	0.12780	4.95341	1 January 2000, ...	30.22108
Subbasin-48	0.02370	1.03405	1 January 2000, ...	5.06969
Subbasin-49	0.06230	2.41245	1 January 2000, ...	14.63653
Subbasin-50	0.17690	6.67875	1 January 2000, ...	45.35258
Subbasin-51	2.96750	36.58193	1 January 2000, ...	643.07419
Subbasin-52	0.09250	2.44804	1 January 2000, ...	19.28368
Subbasin-53	0.30630	8.66561	1 January 2000, ...	68.79467
Subbasin-57	0.25560	6.89007	1 January 2000, ...	63.01176
Subbasin-61	0.21990	7.25950	1 January 2000, ...	54.13998
Subbasin-62	0.28400	6.12514	1 January 2000, ...	57.26307
Subbasin-63	0.01650	0.53455	1 January 2000, ...	3.57654
Subbasin-64	0.02870	0.86457	1 January 2000, ...	6.24973
Subbasin-65	0.04220	1.05255	1 January 2000, ...	9.27081
Subbasin-66	0.01750	0.82913	1 January 2000, ...	4.53575
Subbasin-67	0.06020	2.32450	1 January 2000, ...	12.05895

Summary Results for Reservoir "Reservoir-208"

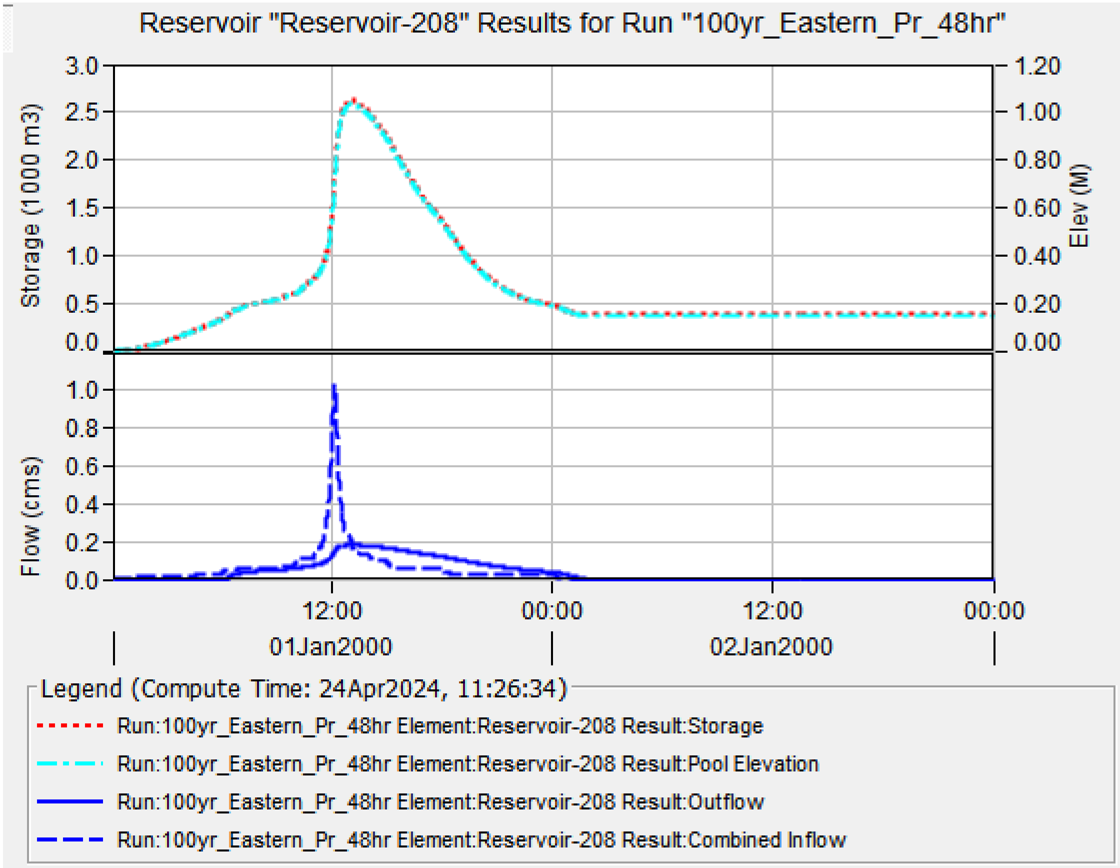
Project: Eastern_Catchment   Simulation Run: 100yr_Eastern_Pr_48hr
Reservoir: Reservoir-208

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_100yr_v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	100yr 24hr TP108CC_Pr
Compute Time:	24Apr2024, 11:26:34	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	1.03859 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:06
Peak Discharge:	0.18302 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:03
Inflow Volume:	6.62657 (1000 M3)	Peak Storage:	2.63253 (1000 M3)
Discharge Volume:	6.24659 (1000 M3)	Peak Elevation:	1.03916 (M)



Summary Results for Reservoir "Reservoir-Wetland"

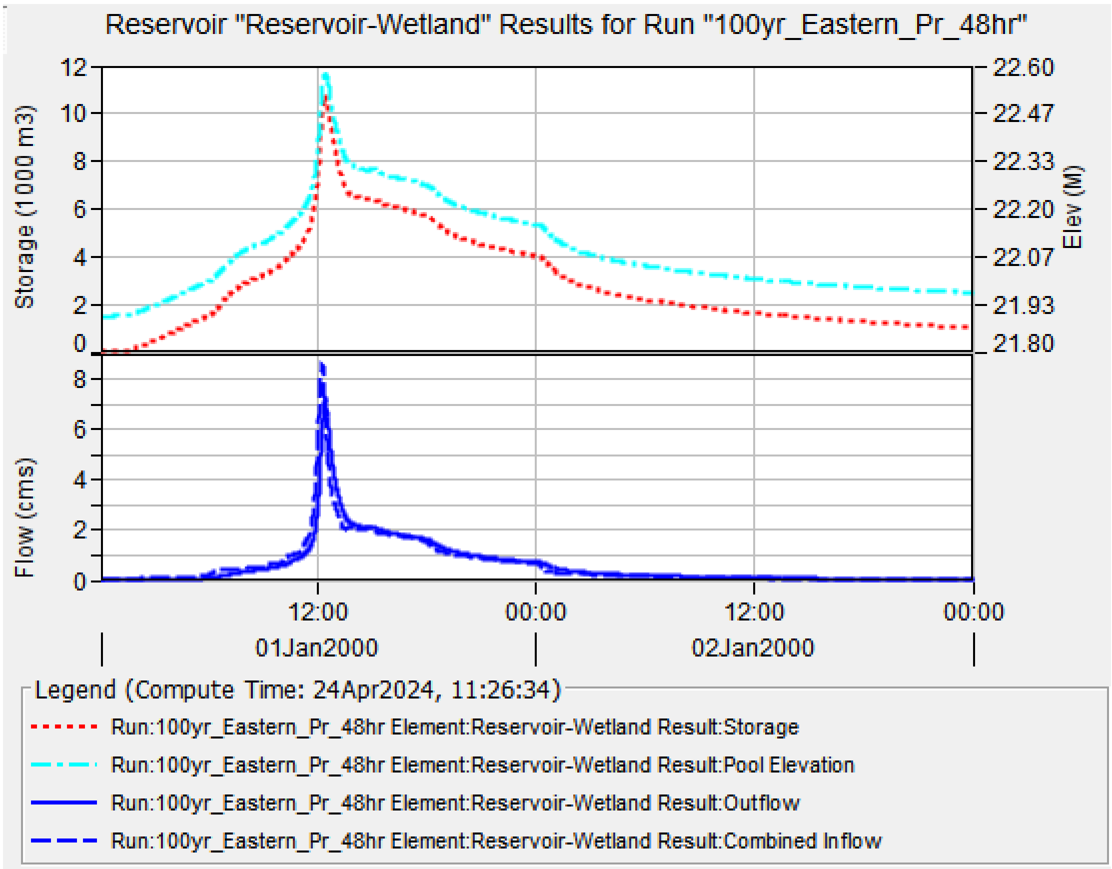
Project: Eastern_Catchment Simulation Run: 100yr_Eastern_Pr_48hr
Reservoir: Reservoir-Wetland

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_100yr_v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	100yr 24hr TP108CC_Pr
Compute Time:	24Apr2024, 11:26:34	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflo...	8.59653 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:11
Peak Dischar...	7.09467 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 12:21
Inflow Volu...	106.43197 (1000 M3)	Peak Storage:	10.74213 (1000 M3
Discharge Volu...	105.40476 (1000 M3)	Peak Elevation:	22.58750 (M)



Summary Results for Reservoir "Reservoir-Main_Northern_Chan"

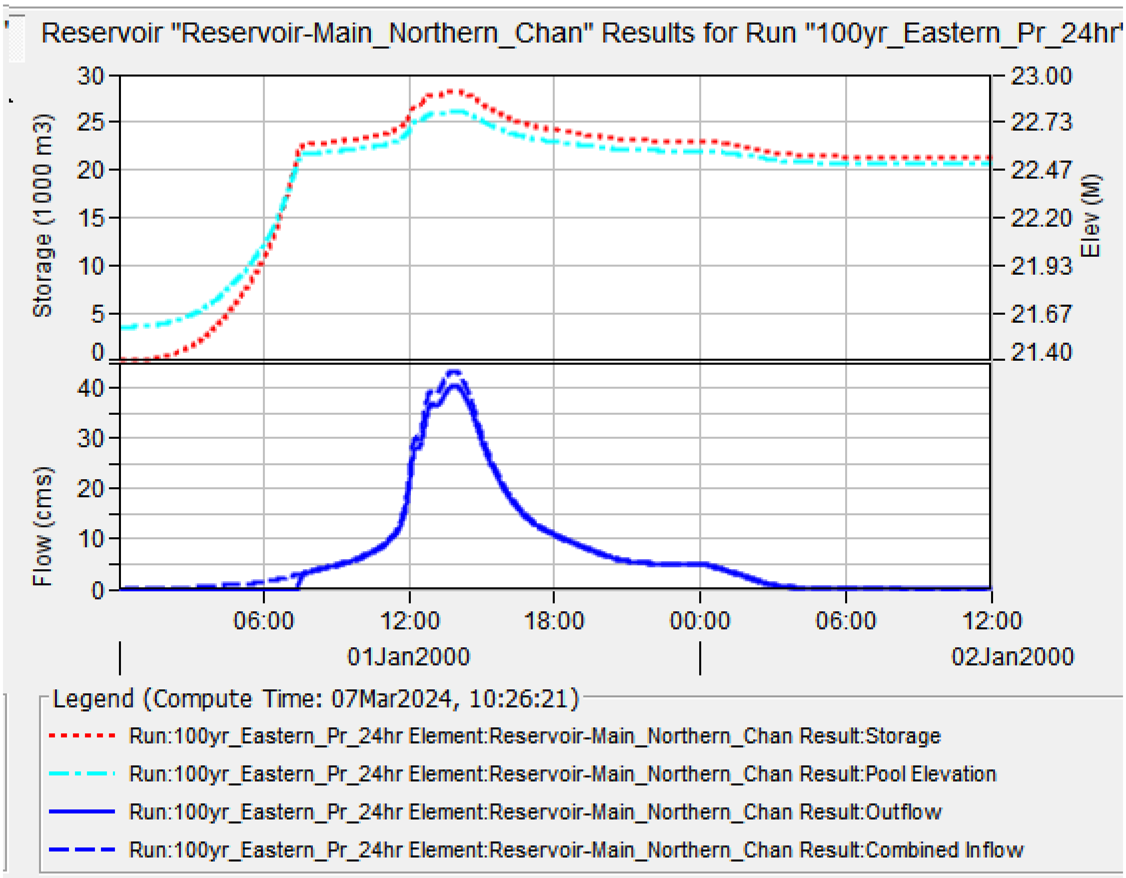
Project: Eastern_Catchment Simulation Run: 100yr_Eastern_Pr_48hr
Reservoir: Reservoir-Main_Northern_Chan

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_100yr_v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	100yr 24hr TP108CC_Pr
Compute Time:	24Apr2024, 11:26:34	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

Computed Results

Peak Inflow:	43.23831 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 13:50
Peak Discharge:	40.32569 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 13:52
Inflow Volume:	908.54126 (1000 M3)	Peak Storage:	28.25158 (1000 M3
Discharge Volume:	854.05035 (1000 M3)	Peak Elevation:	22.79711 (M)



Summary Results for Reservoir "Reservoir-Dry Pond"

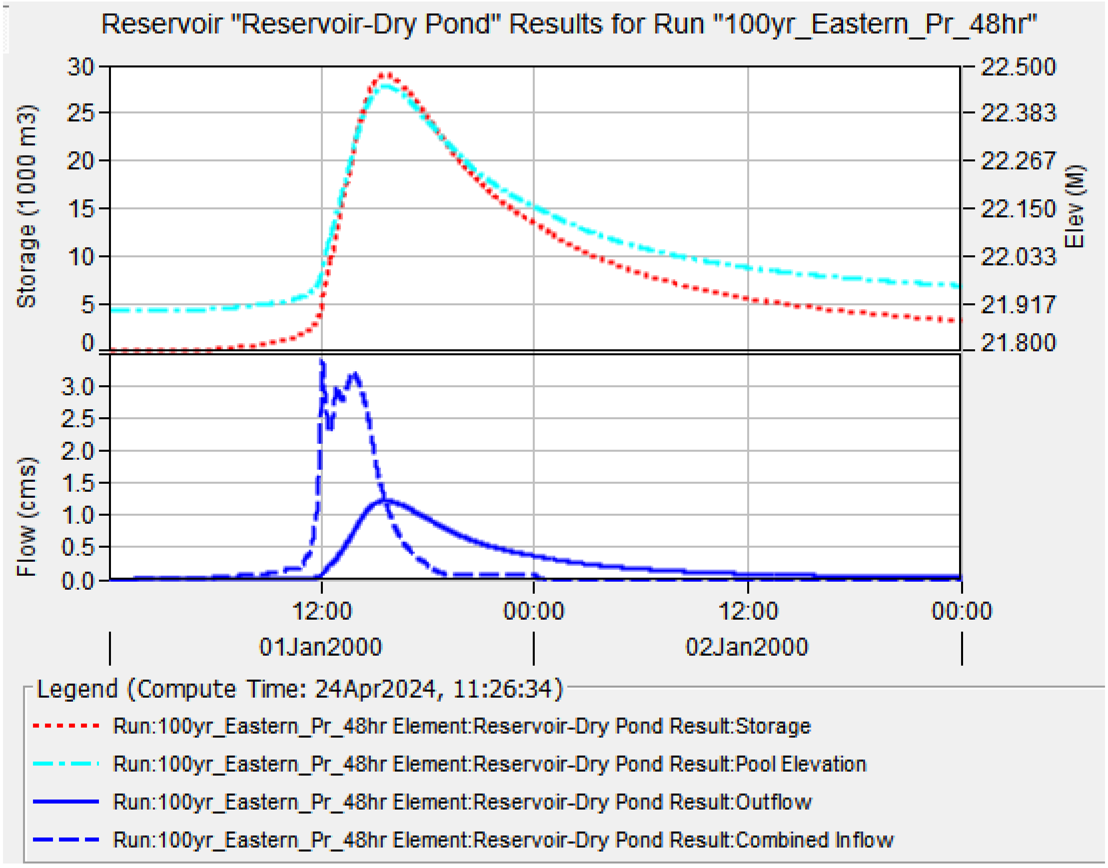
Project: Eastern_Catchment   Simulation Run: 100yr_Eastern_Pr_48hr
Reservoir: Reservoir-Dry Pond

Start of Run:	01Jan2000, 00:01	Basin Model:	Pr_100yr_v2
End of Run:	03Jan2000, 00:00	Meteorologic Model:	100yr 24hr TP108CC_Pr
Compute Time:	24Apr2024, 11:26:34	Control Specifications:	48hr (1min)

Volume Units: ○ MM ◉ 1000 M3

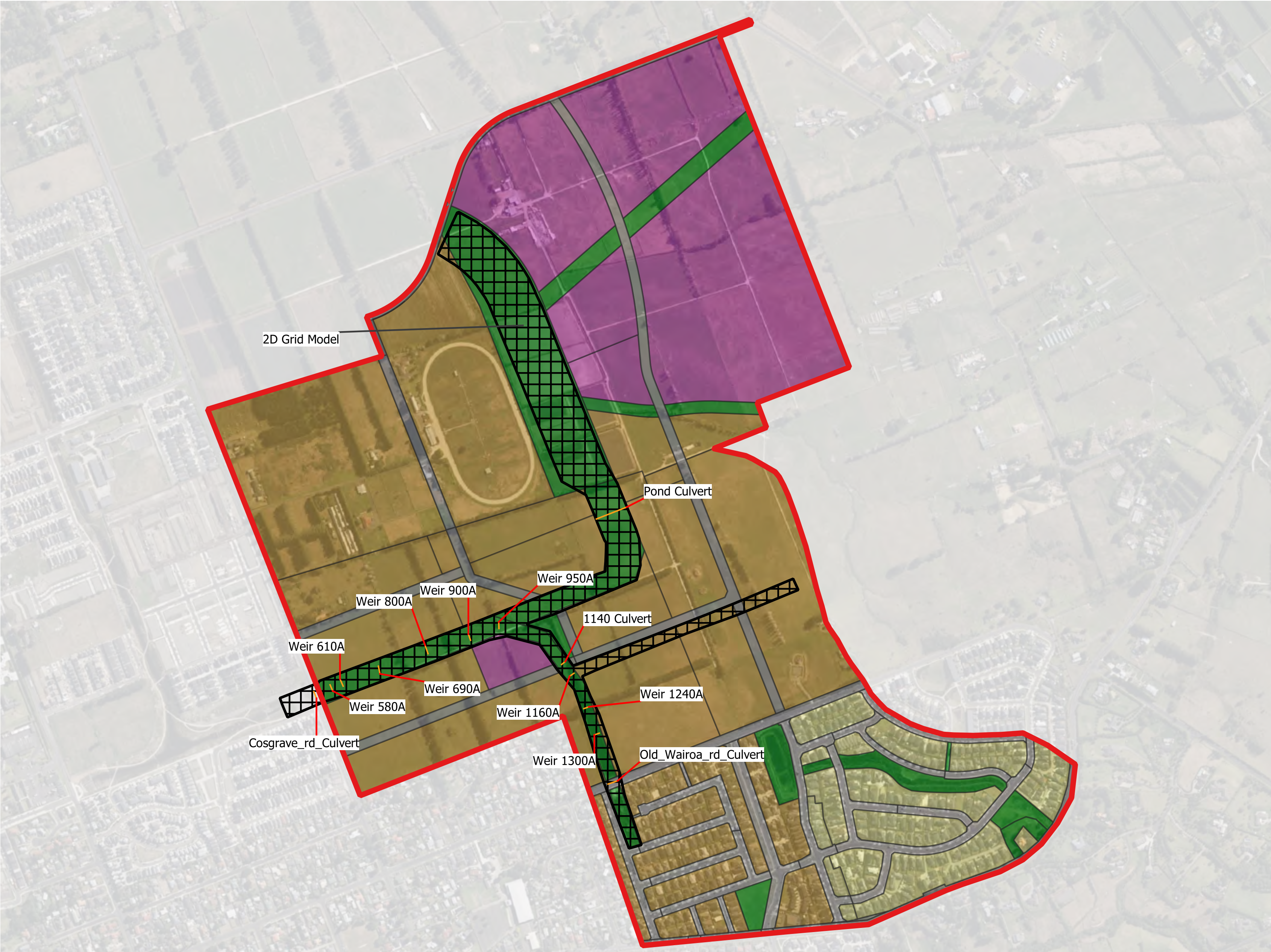
Computed Results

Peak Inflow:	3.36696 (M3/S)	Date/Time of Peak Inflow:	01Jan2000, 12:04
Peak Discharge:	1.22173 (M3/S)	Date/Time of Peak Discharge:	01Jan2000, 15:36
Inflow Volume:	45.25249 (1000 M3)	Peak Storage:	29.04481 (1000 M3)
Discharge Volume:	42.03753 (1000 M3)	Peak Elevation:	22.44862 (M)



APPENDIX H – RAS MODEL

Western Catchment Model - Hydraulic Structures



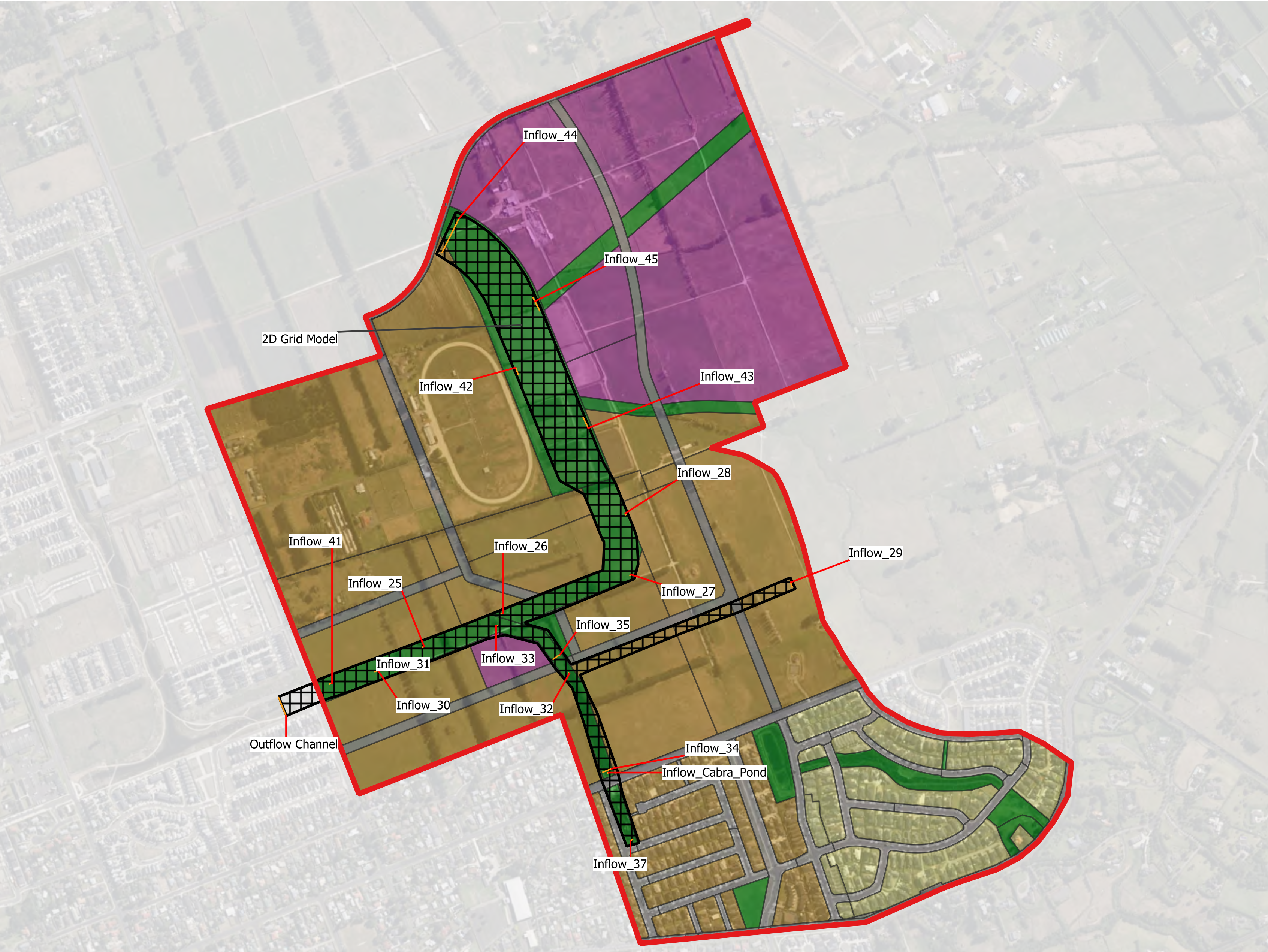
Legend

Model_Western

Perimeter

SK015
REV 001

Western Catchment Model - Boundary Conditions

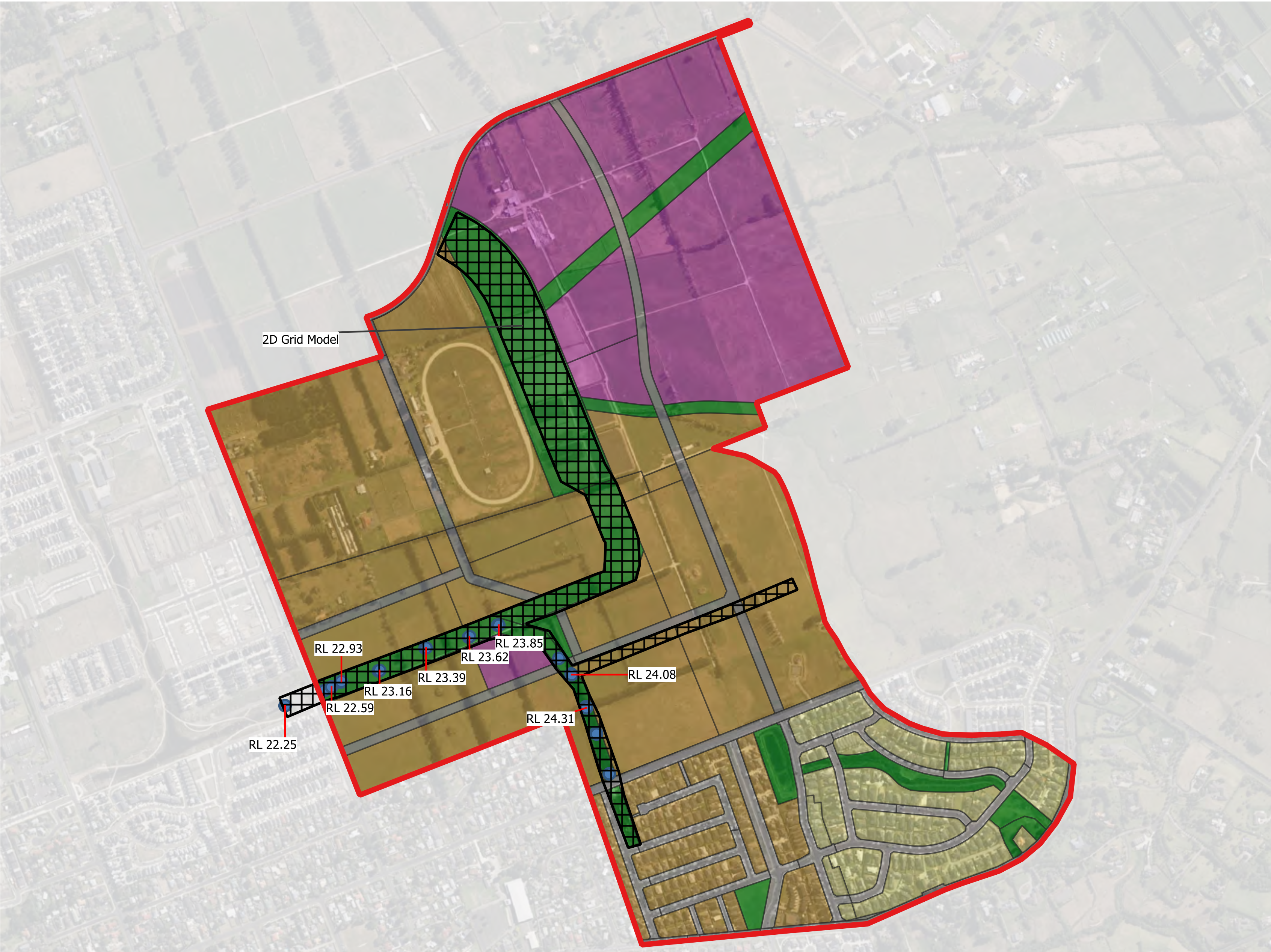


Legend

- Model_Western
- Boundary Conditions
- Perimeter

SK016
REV 001

Western Catchment Model - Initial Water level (Permanent Water Level)



Legent

- Model_Western
- Initial_Conditions
- Perimeter

SK 017
REV 001

100yr Post development Western Catchment HEC RAS Model results

Legend

Model_Western

Perimeter

100yr Post Development Depths

<= 0.50000

0.50000 - 1.00000

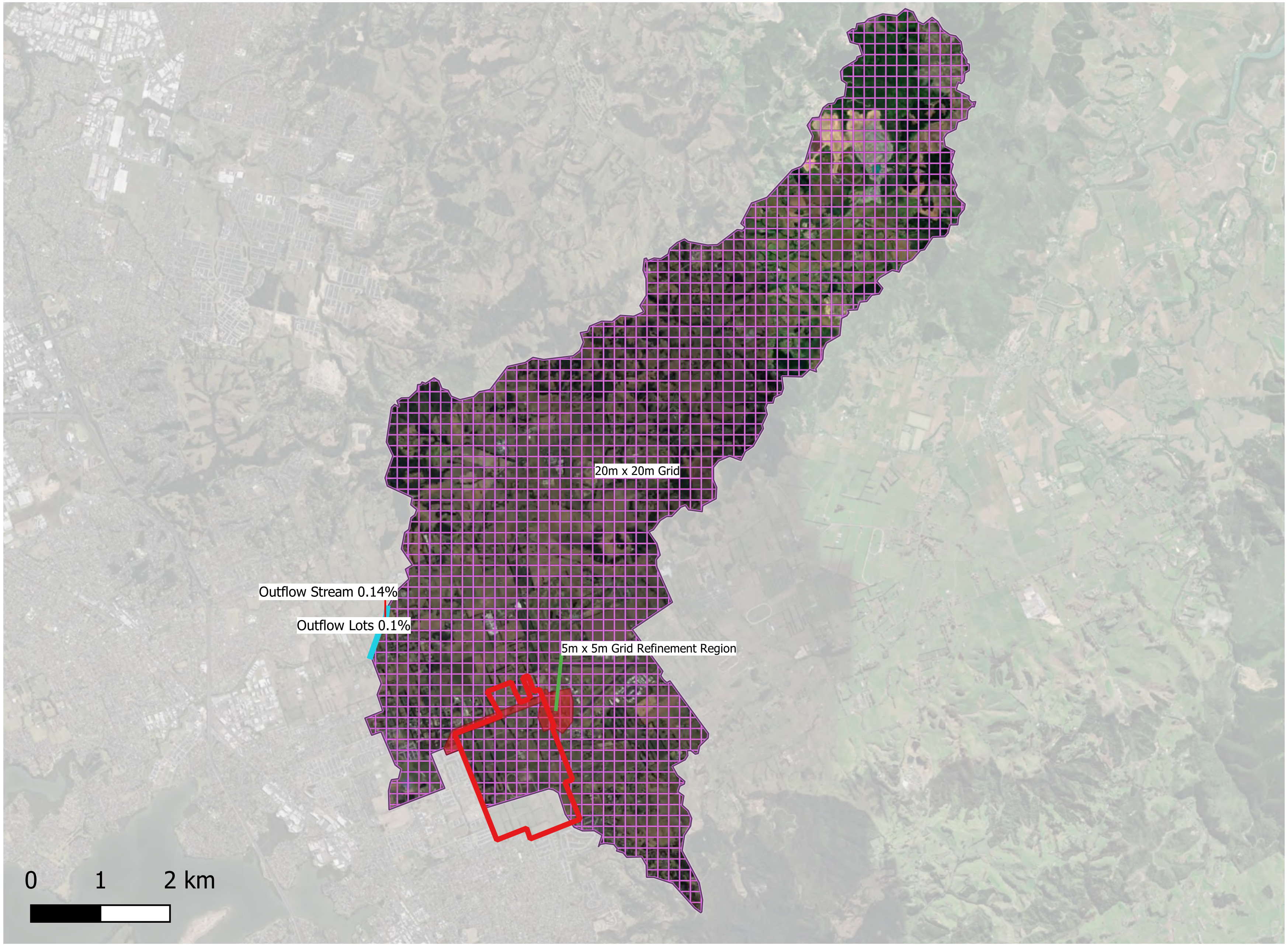
1.00000 - 1.50000

1.50000 - 2.00000

> 2.00000

SK021
REV001

Predeveloped Eastern Catchments HEC RAS model



Legend

Pr-Bdy

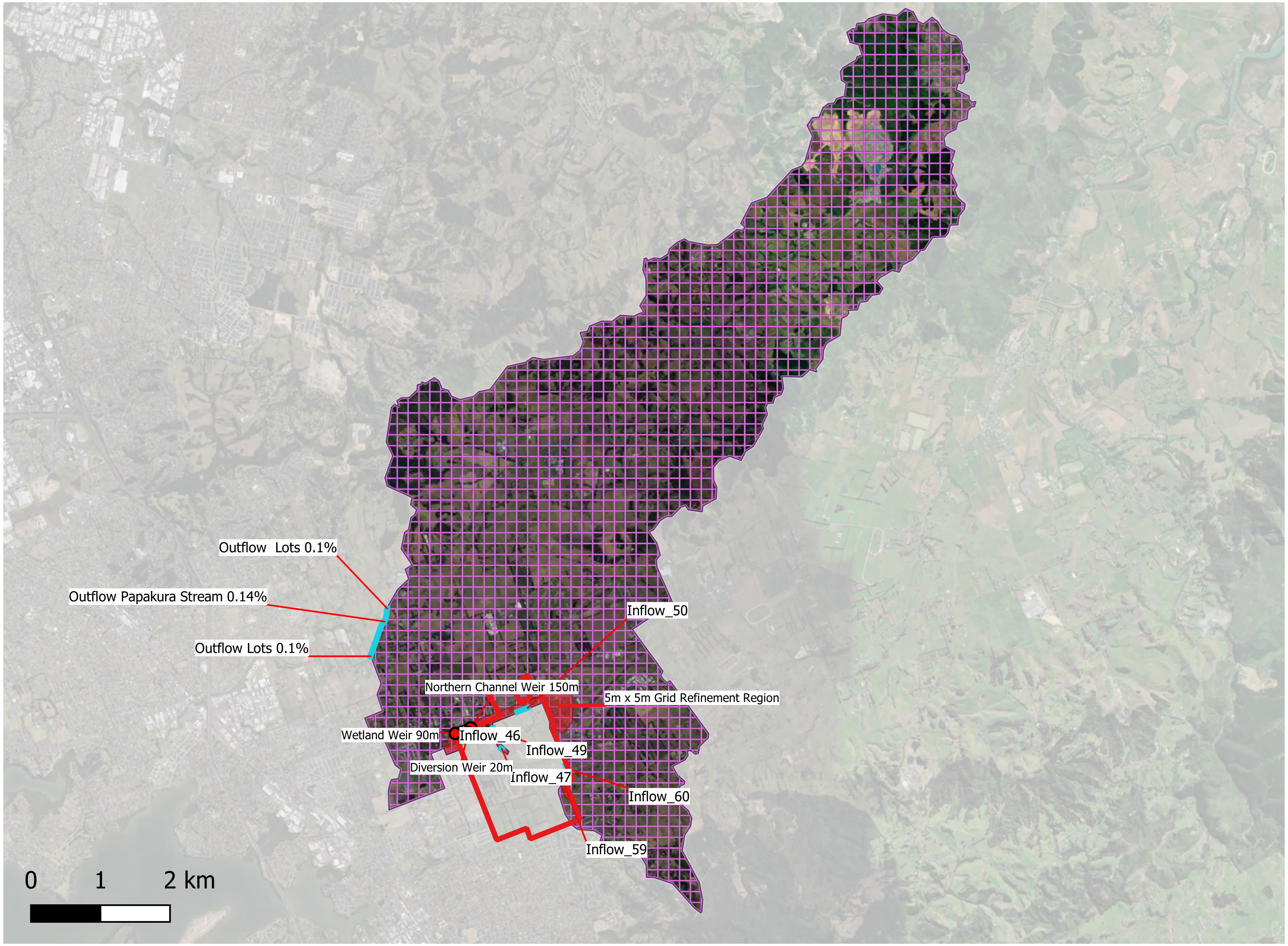
Predeveloped Eastern Catchment RAS model

Boundary Conditions

Refinement Region

SK018
REV001

Postdevelopment Eastern Catchments HEC RAS model

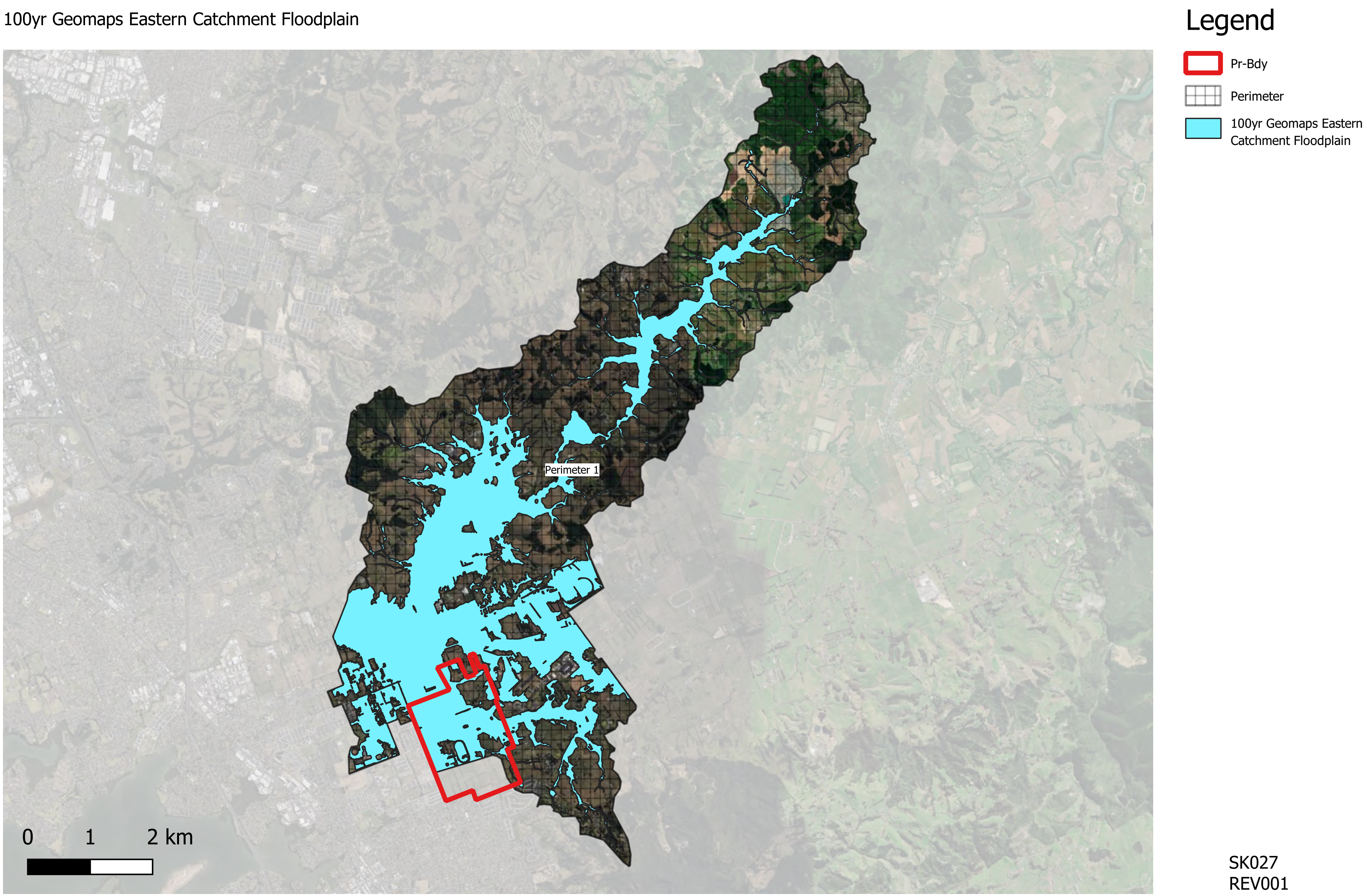


Legend

- Pr-Bdy
- Boundary Conditions
- Refinement Region
- Postdevelopment Eastern Catchment RAS model

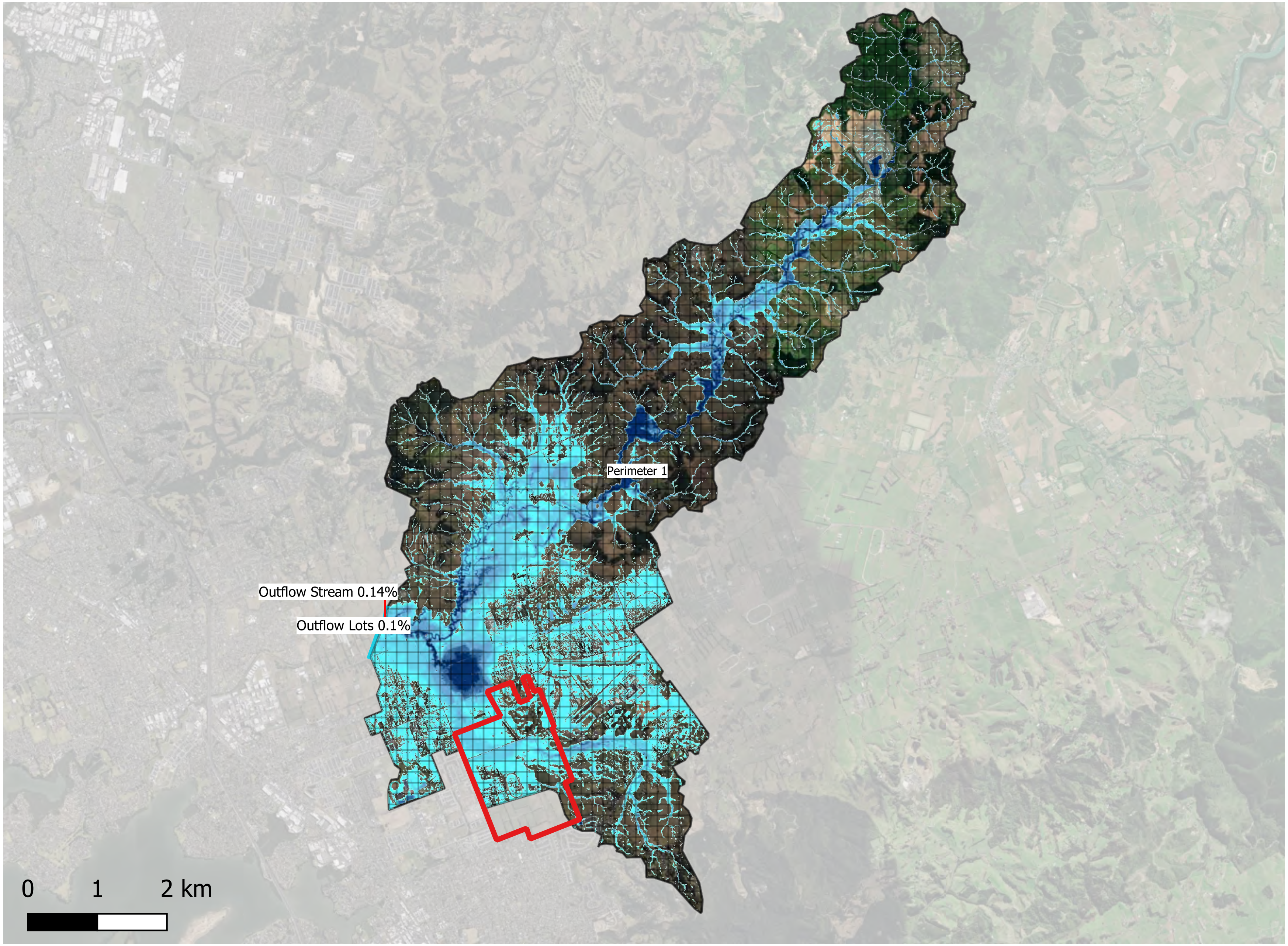
SK019
REV001

100yr Geomaps Eastern Catchment Floodplain



SK027
REV001

100yr Eastern Catchment Predevelopment HEC RAS Model results



Legend

Pr-Bdy

Outflow Boundary Conditions

Perimeter

Eastern catchment
Pre development
1% AEP peak flow depths

<= 0.50000

0.50000 - 1.00000

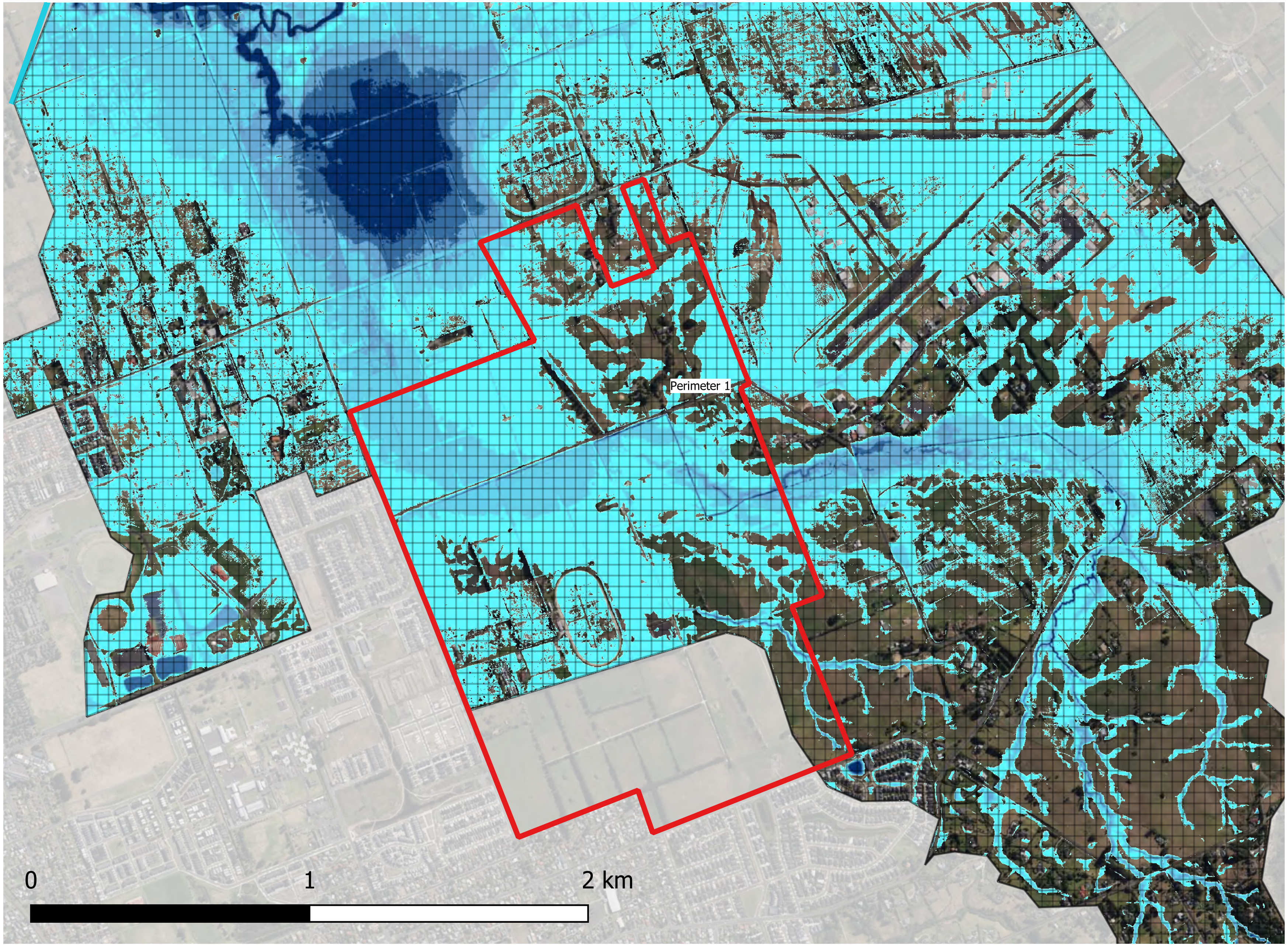
1.00000 - 1.50000

1.50000 - 2.00000

> 2.00000

SK023
REV001

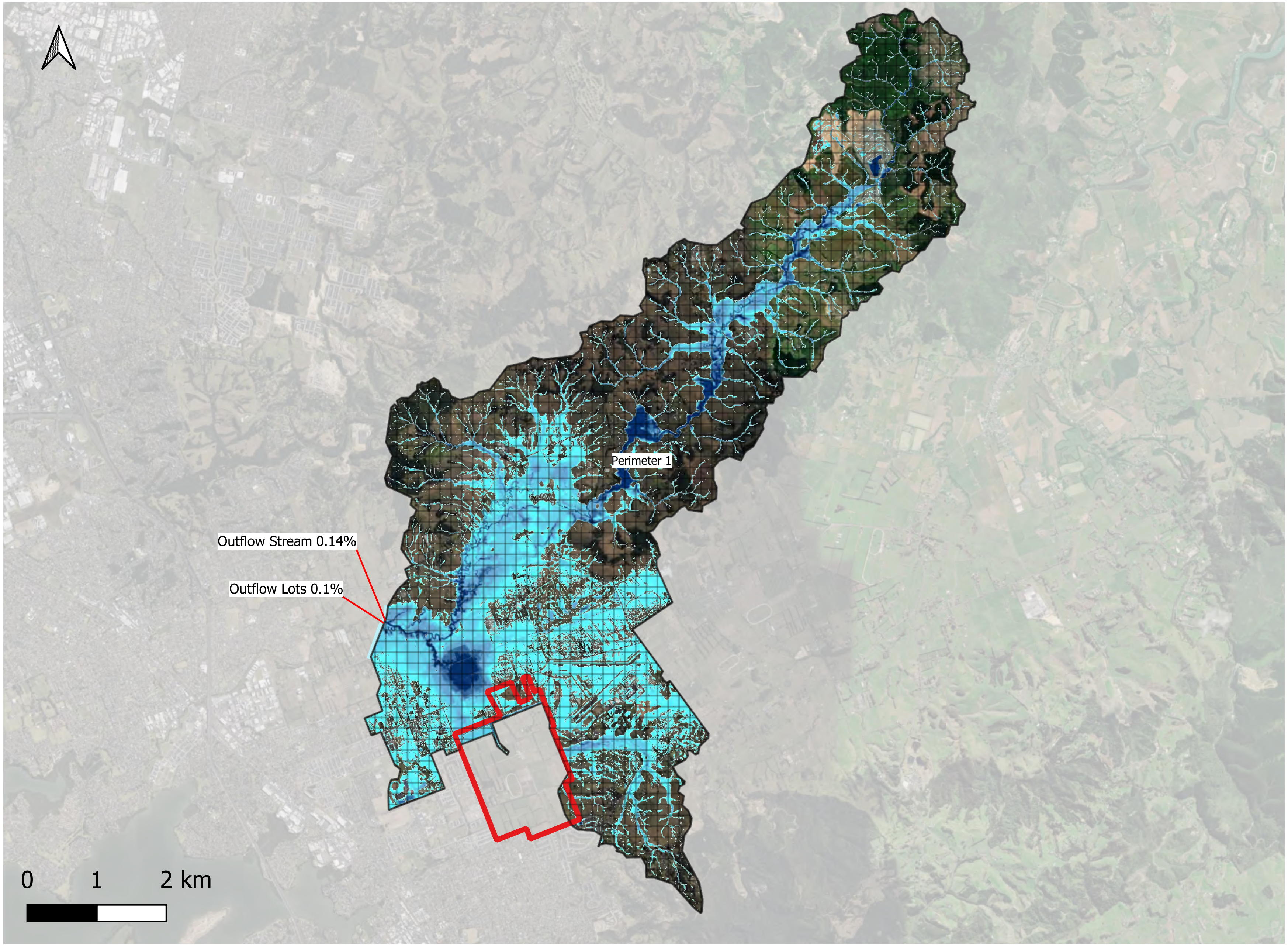
100yr Eastern Catchment Predevelopment HEC RAS Model results



Legend

SK023B
REV001

100yr Eastern Catchment Post development HEC RAS Model results



Legend

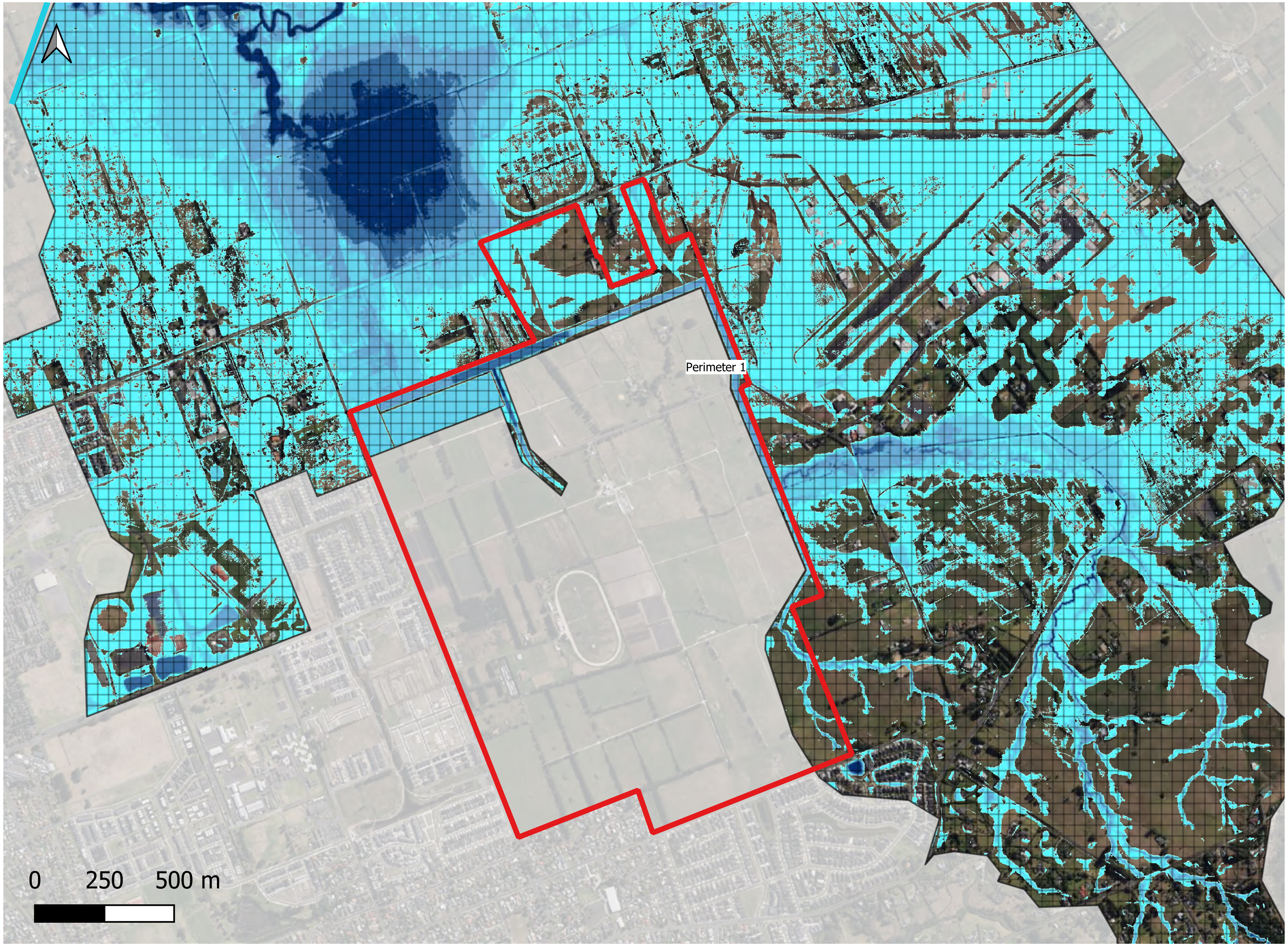
- Pr-Bdy
- Outflow Boundary Conditions
- Perimeter

Eastern catchment
Post development
1% AEP peak flow depths

- <= 0.50000
- 0.50000 - 1.00000
- 1.00000 - 1.50000
- 1.50000 - 2.00000
- > 2.00000

SK024
REV001

100yr Eastern Catchment Post development HEC RAS Model results



Legend

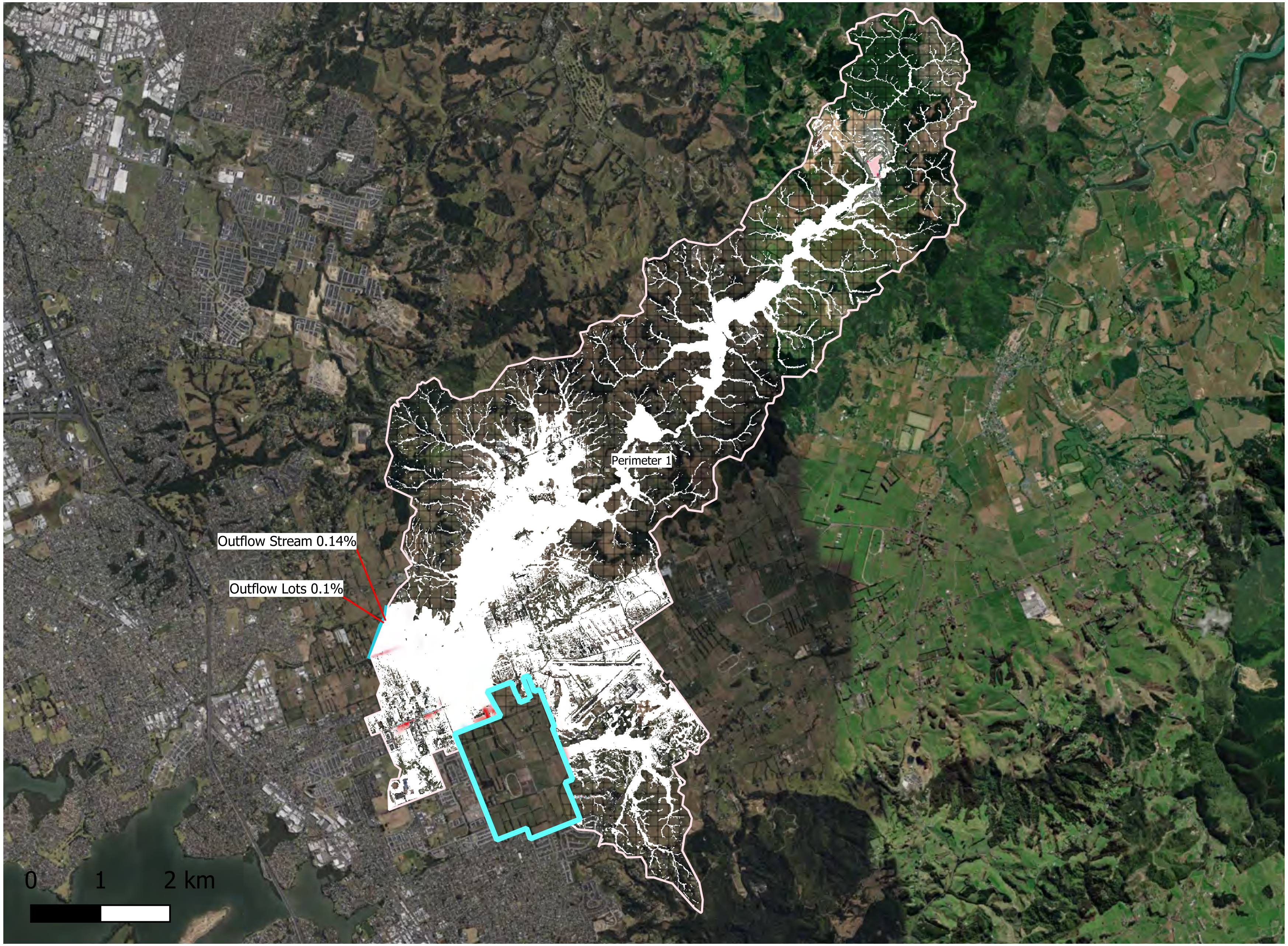
- Pr-Bdy
- Outflow Boundary Conditions
- Postdeveloped Eastern Catchment RAS model

Eastern catchment
Post development
1% AEP peak flow depths

- <= 0.50000
- 0.50000 - 1.00000
- 1.00000 - 1.50000
- 1.50000 - 2.00000
- > 2.00000

SK024B
REV001

100yr Eastern Catchment HEC RAS Model results Comparison



Legend

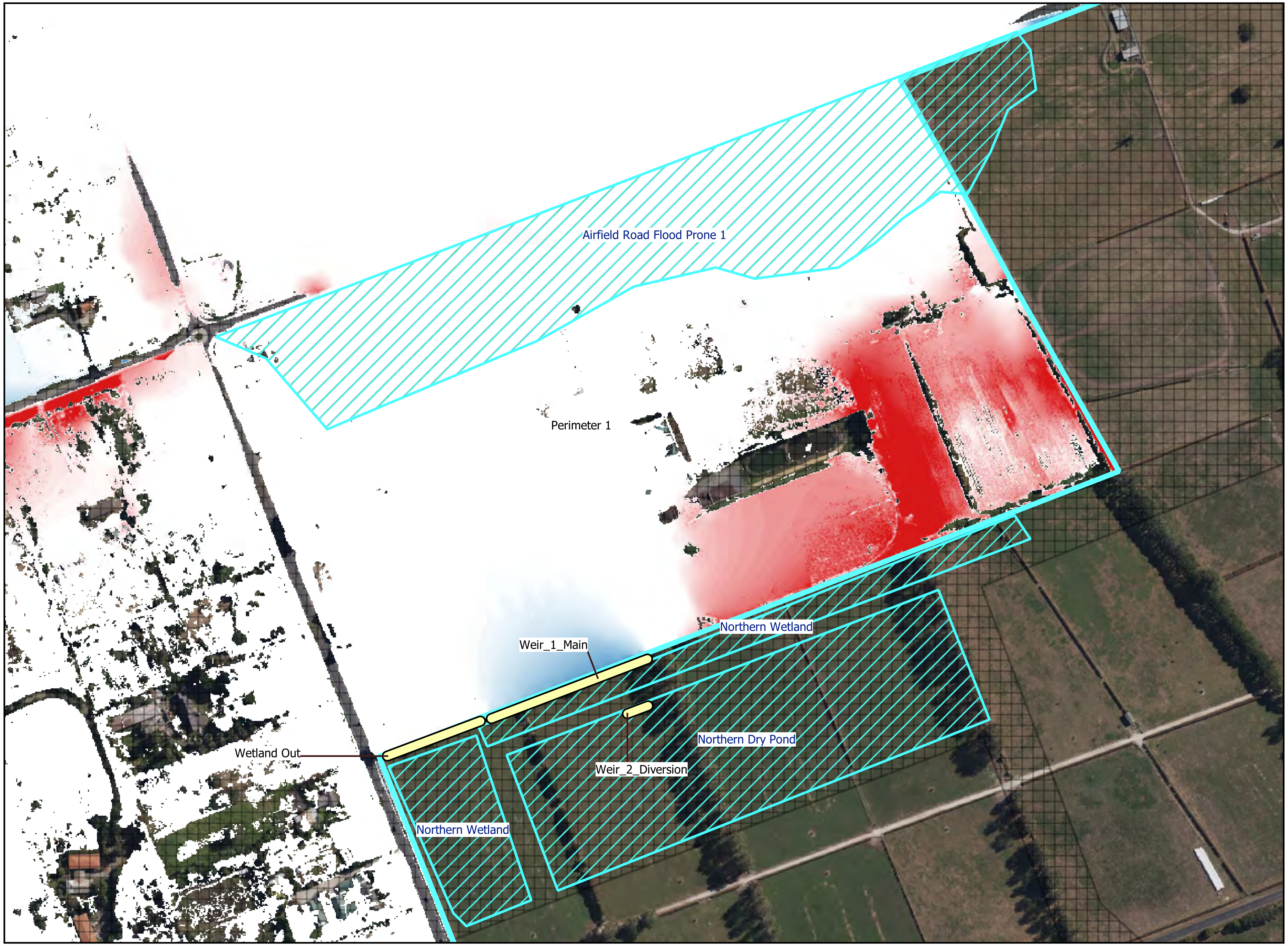
- Pr-Bdy
- Outflow Boundary Conditions
- Postdeveloped Eastern Catchment RAS model

100yr WSE Comparison Postdevelopment minus predevelopment

- -0.2500
- -0.2000
- -0.1500
- -0.1000
- -0.0500
- 0.0000
- 0.0500
- 0.1000
- 0.1500
- 0.2000
- 0.2500

SK025
REV001

100yr Eastern Catchment HEC RAS Model results Comparison



Legend

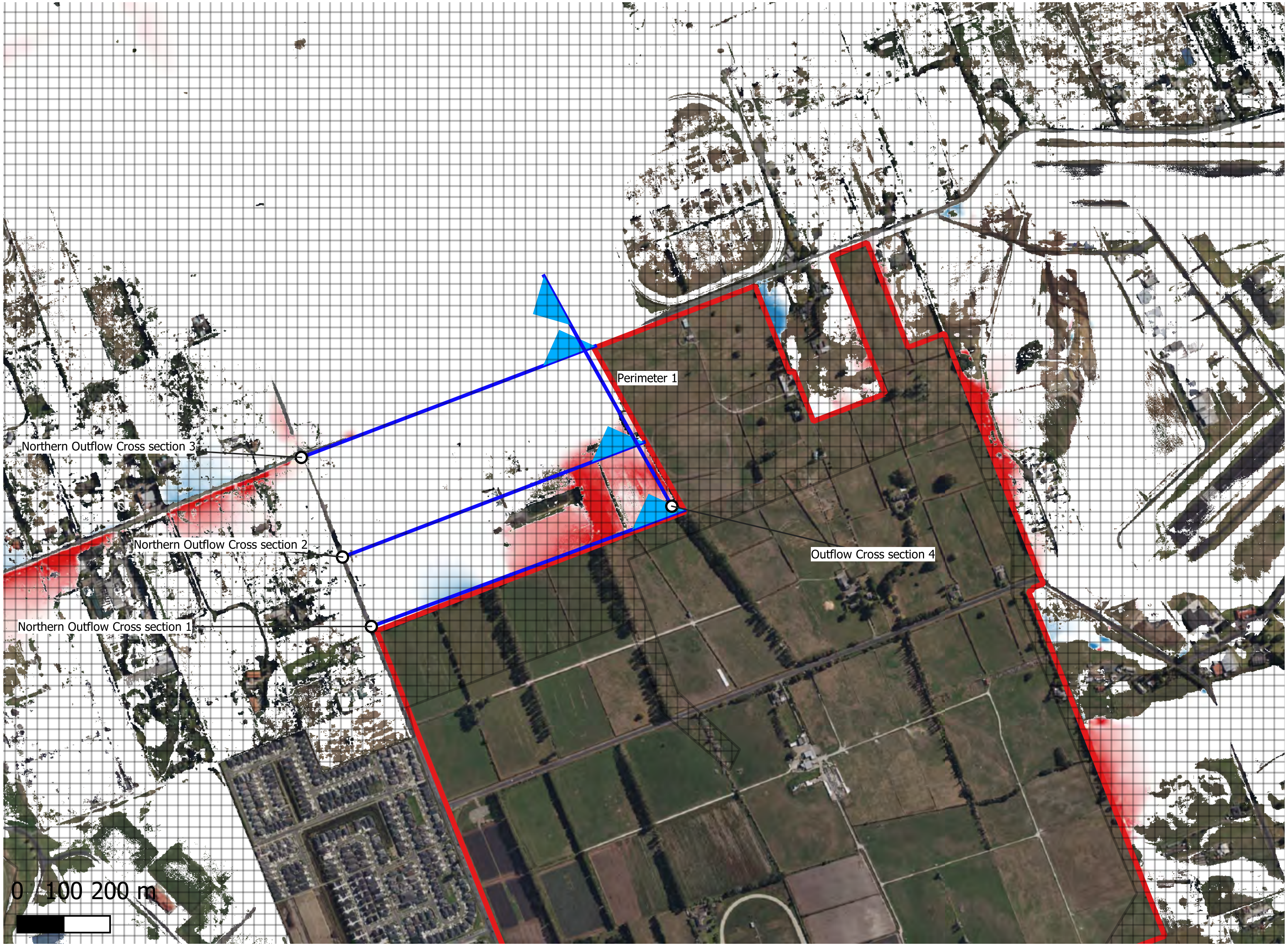
- Pr-Bdy
- Outflow Boundary Conditions
- Postdeveloped Eastern Catchment RAS model

100yr WSE Comparison Postdevelopment minus predevelopment

- -0.2500
- -0.2000
- -0.1500
- -0.1000
- -0.0500
- 0.0000
- 0.0500
- 0.1000
- 0.1500
- 0.2000
- 0.2500

SK025B
REV001

100yr Eastern Catchment Post vs Pre development comparisons sections



Legend

Pr-Bdy

Sections for Pre Post hydrograph comparison

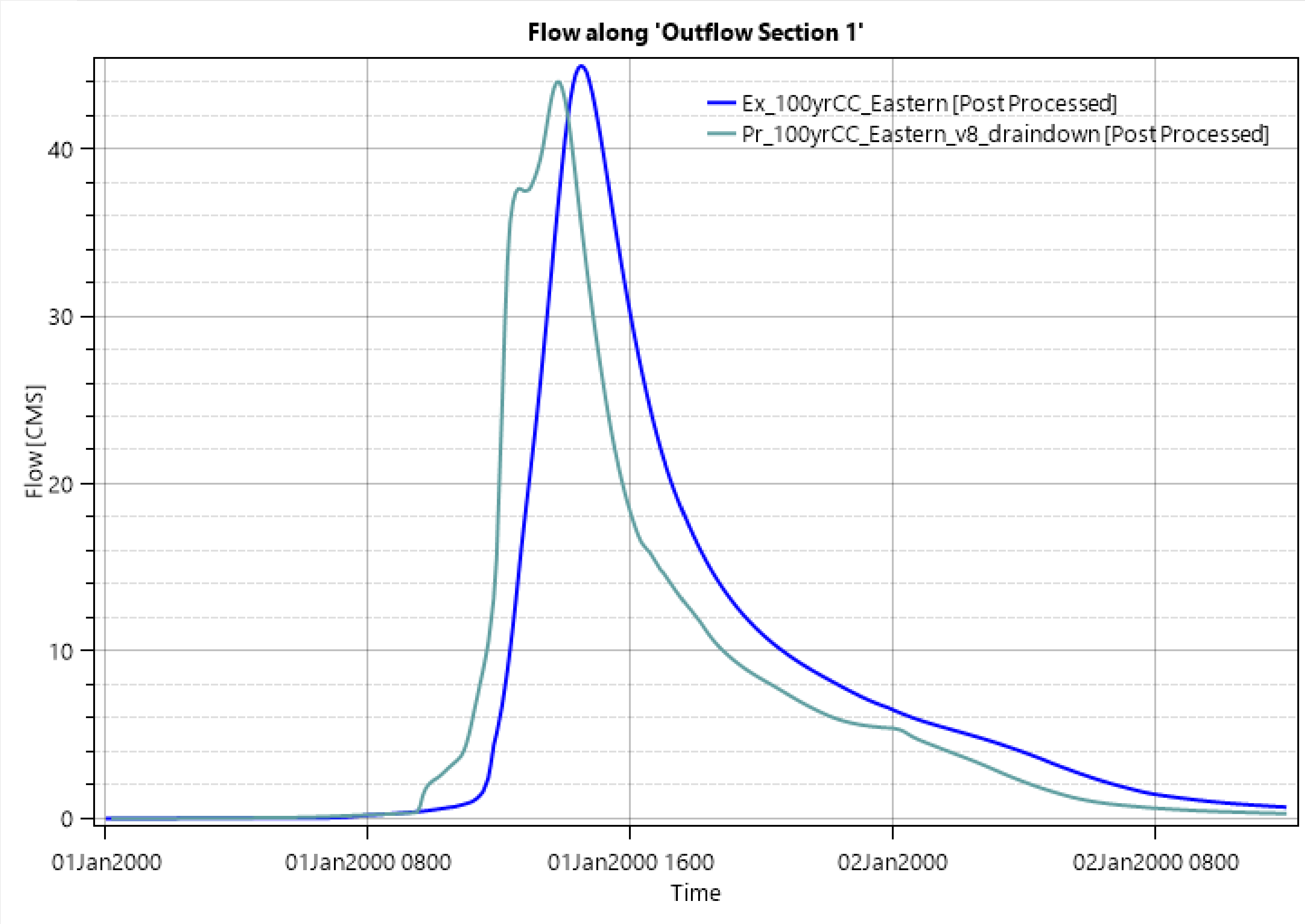
Postdeveloped Eastern Catchment RAS model

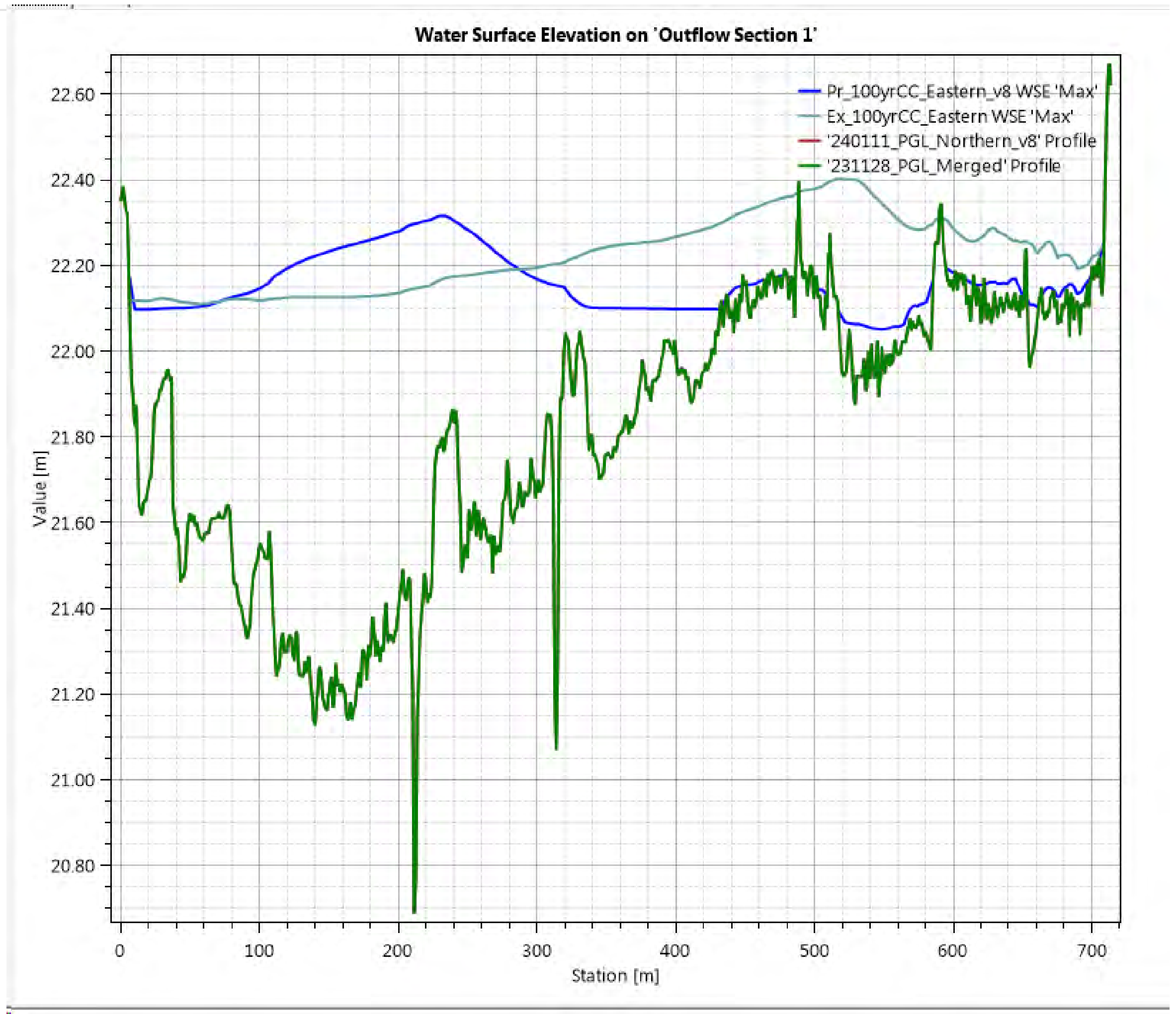
100yr Post vs Pre Comparison

-0.6000
-0.5000
-0.4000
-0.3000
-0.2000
-0.1000
0.1000
0.2000
0.3000
0.4000
0.5000

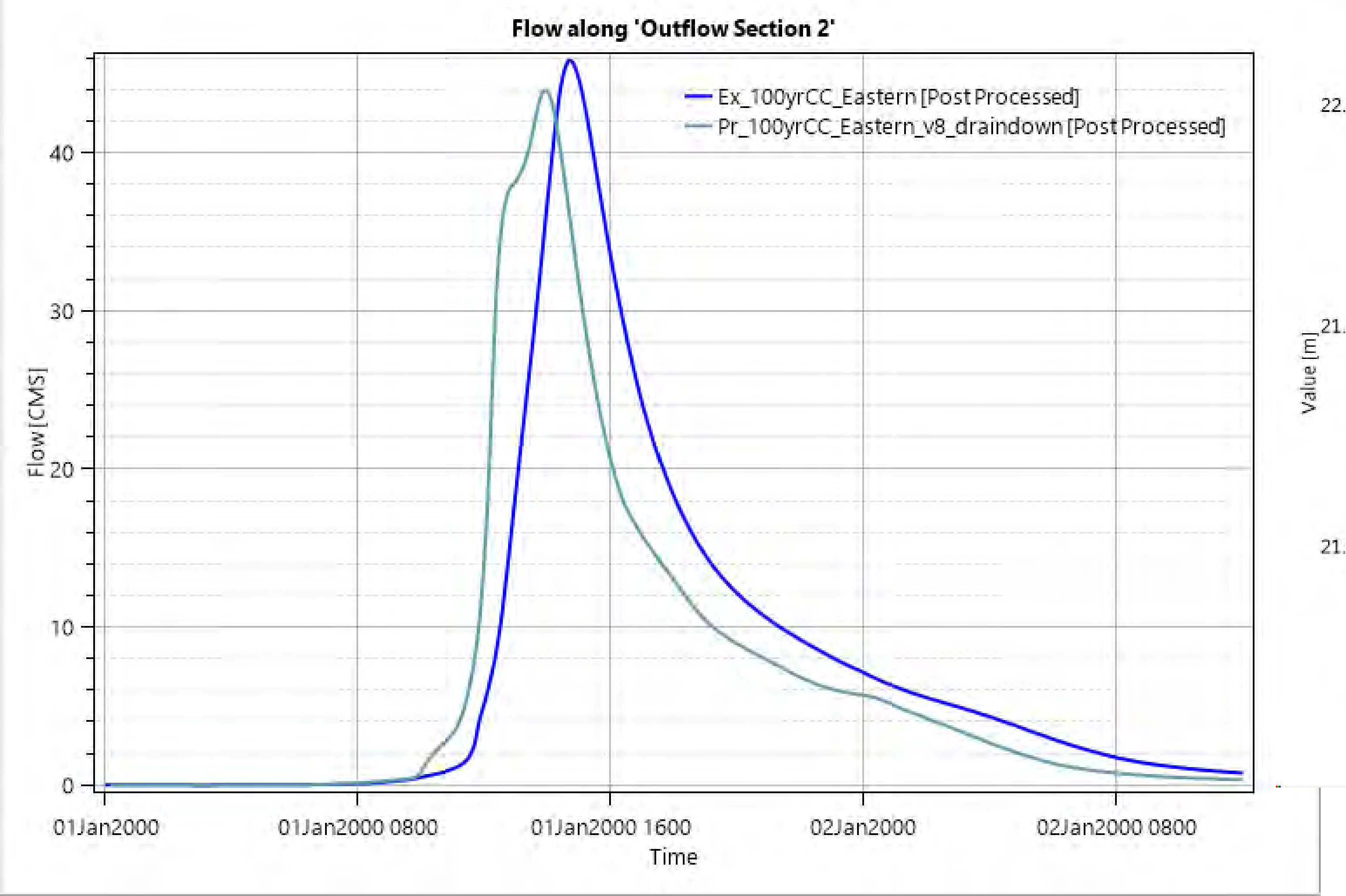
SK026
REV001

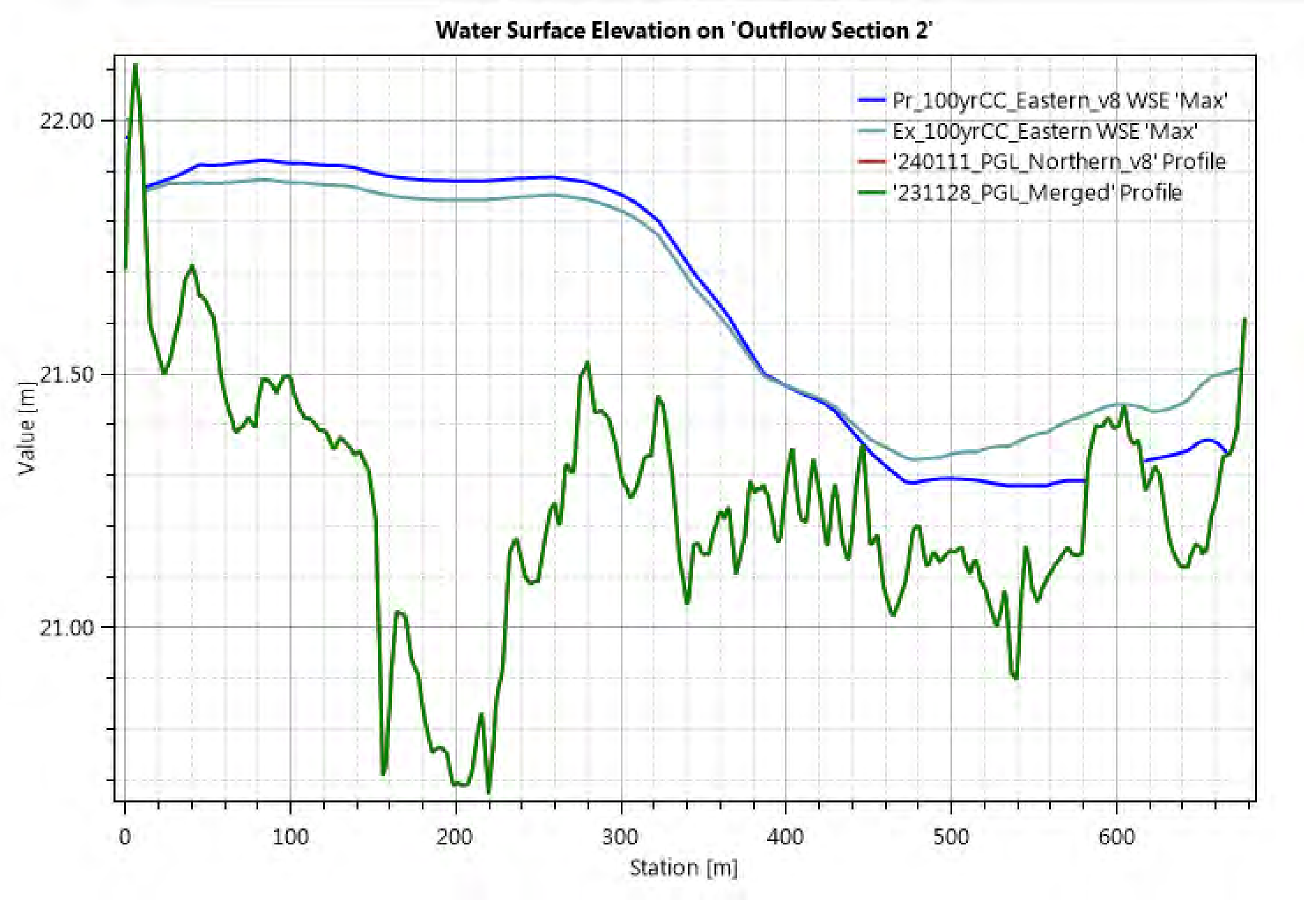
Flow Cross section 1



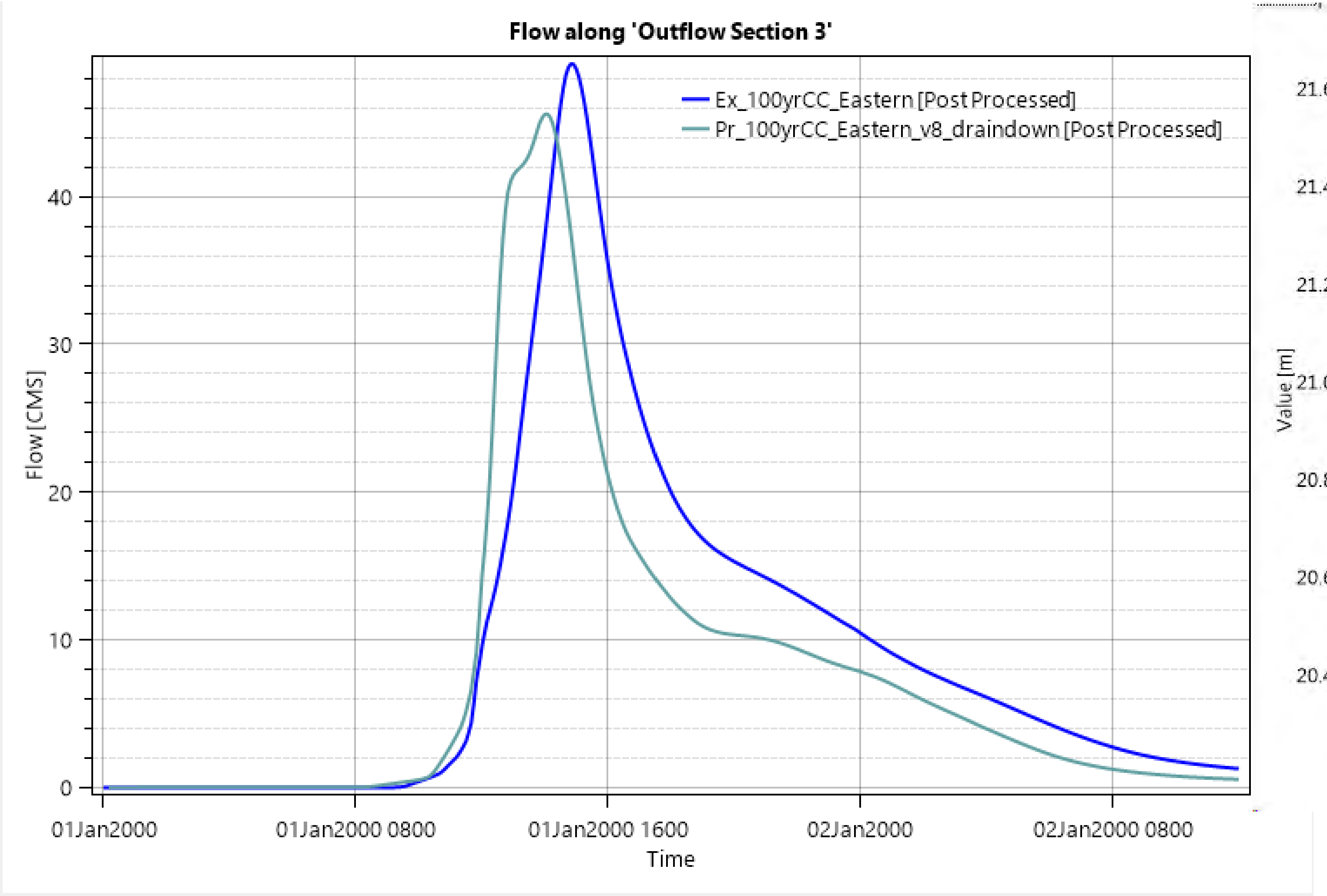


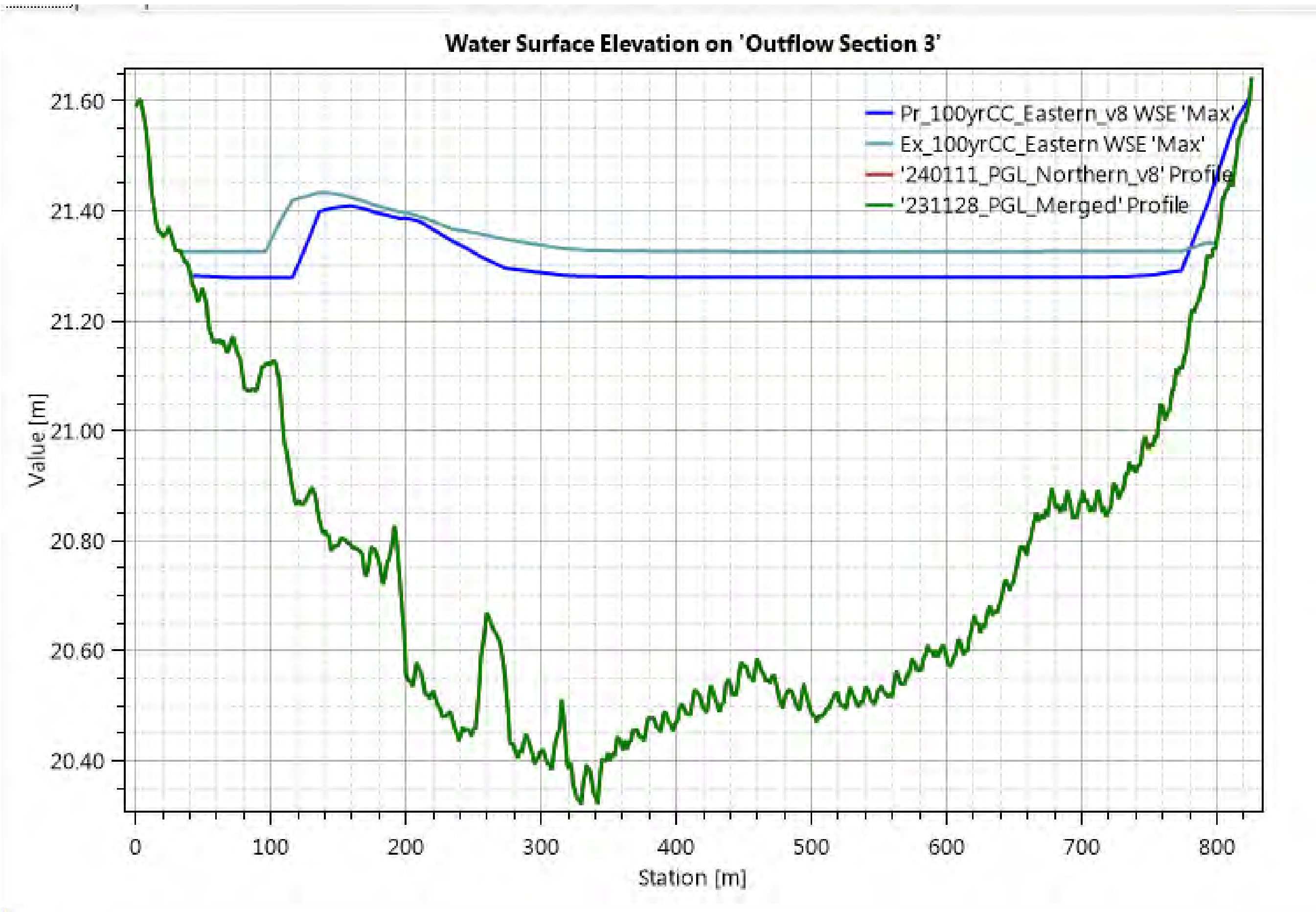
Flow Cross section 2



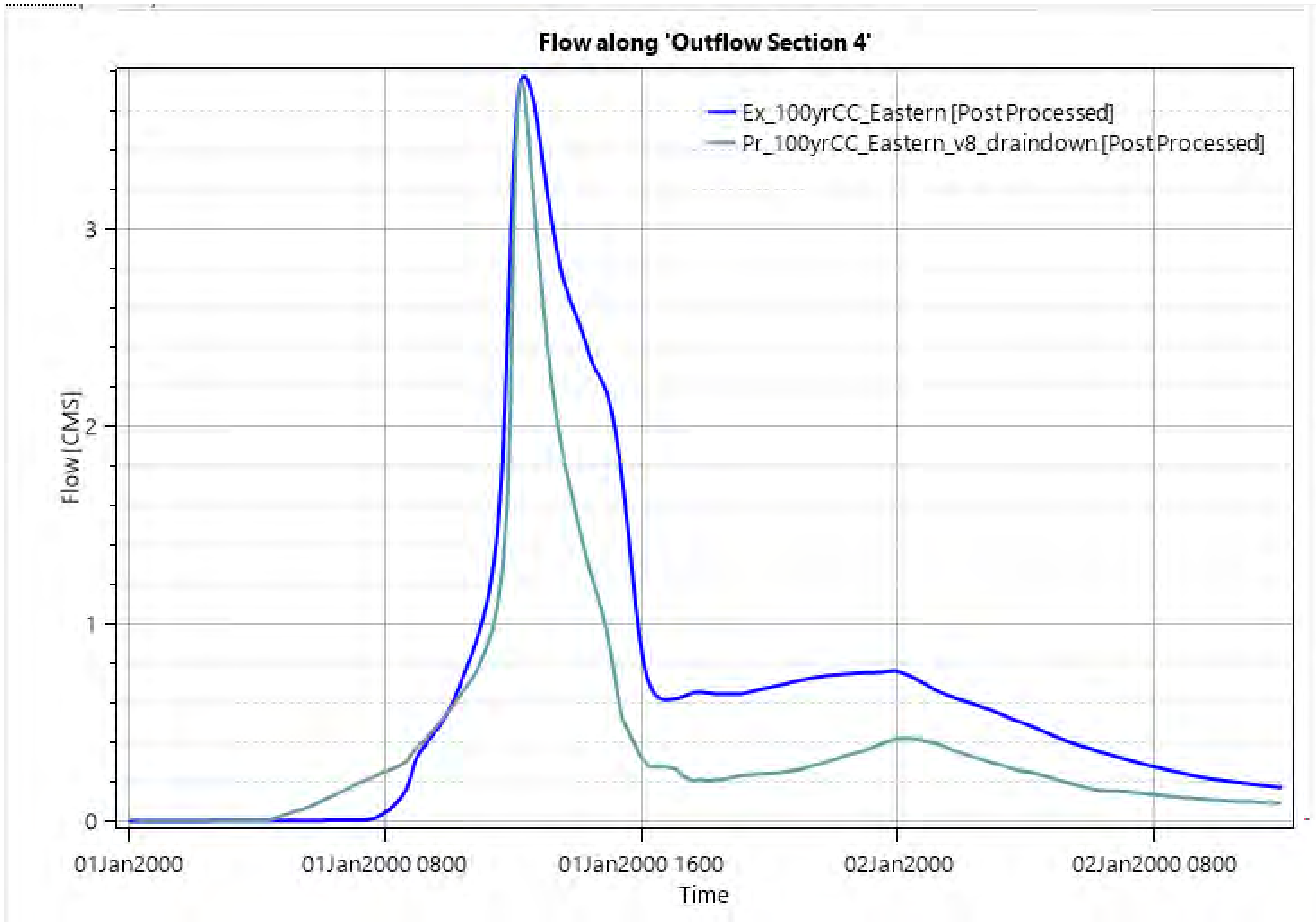


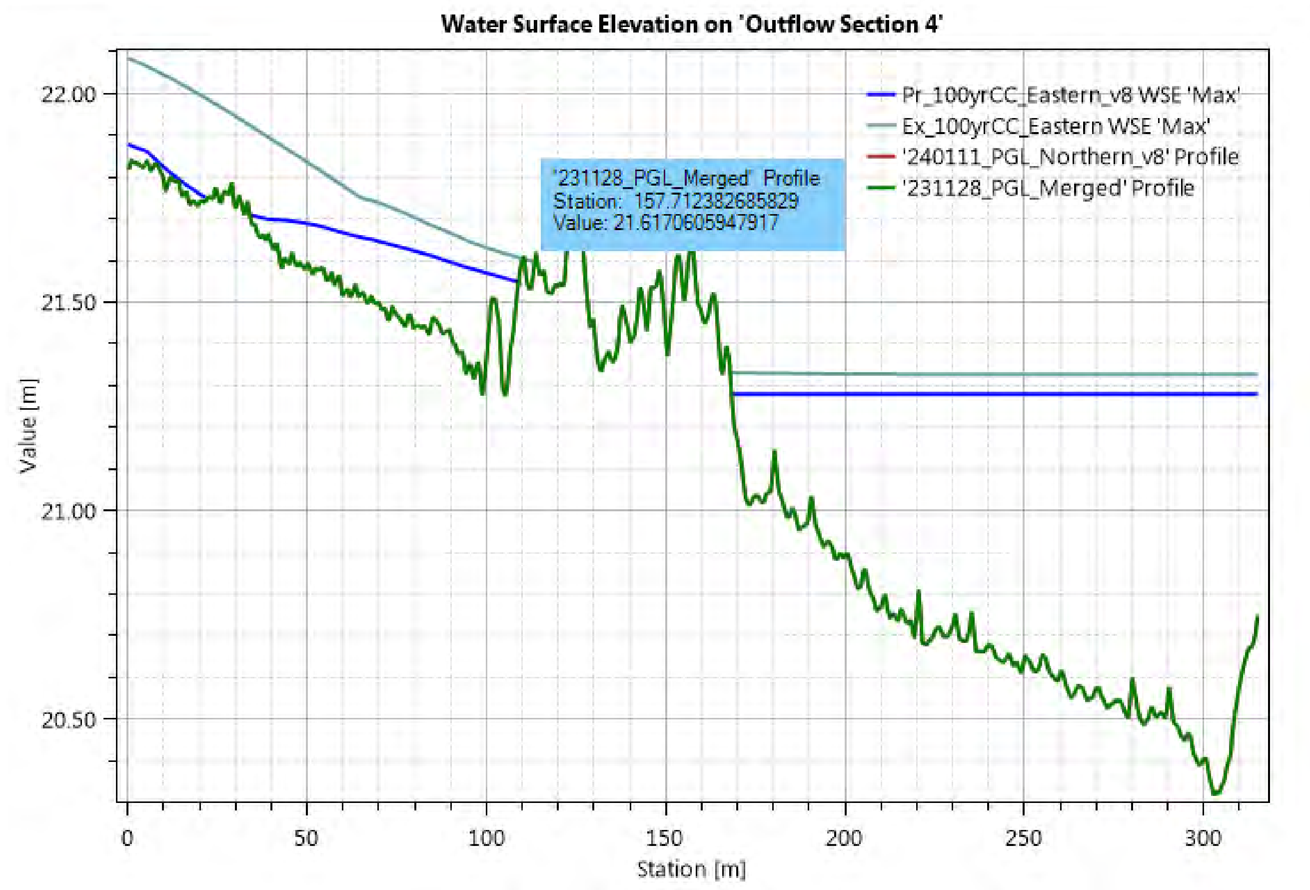
Flow Cross section 3



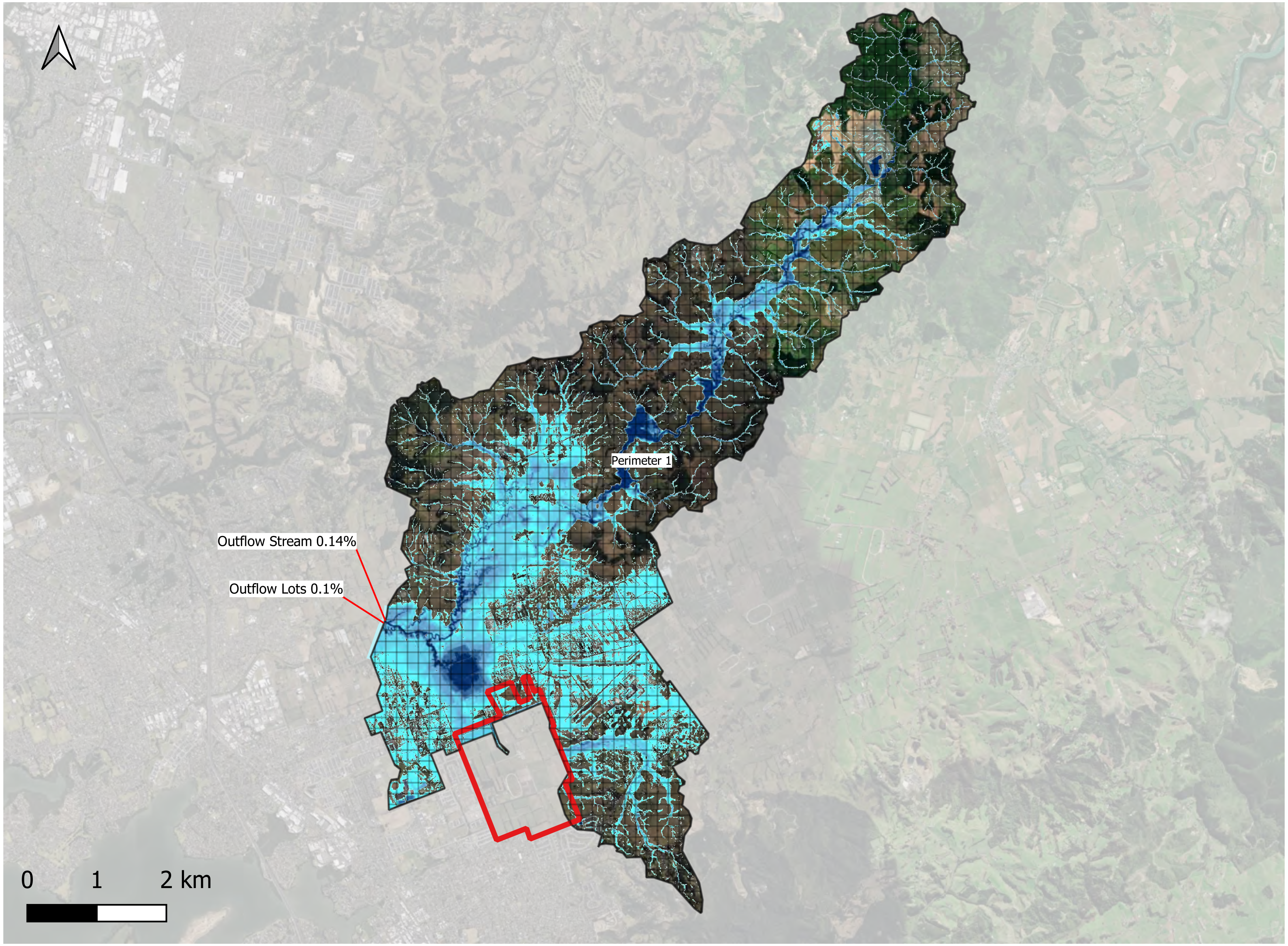


Flow Cross section 4





100yr Eastern Catchment Post development HEC RAS Model results



Legend

Pr-Bdy

Outflow Boundary Conditions

Perimeter

Eastern catchment
Post development
1% AEP peak flow depths

<= 0.50000

0.50000 - 1.00000

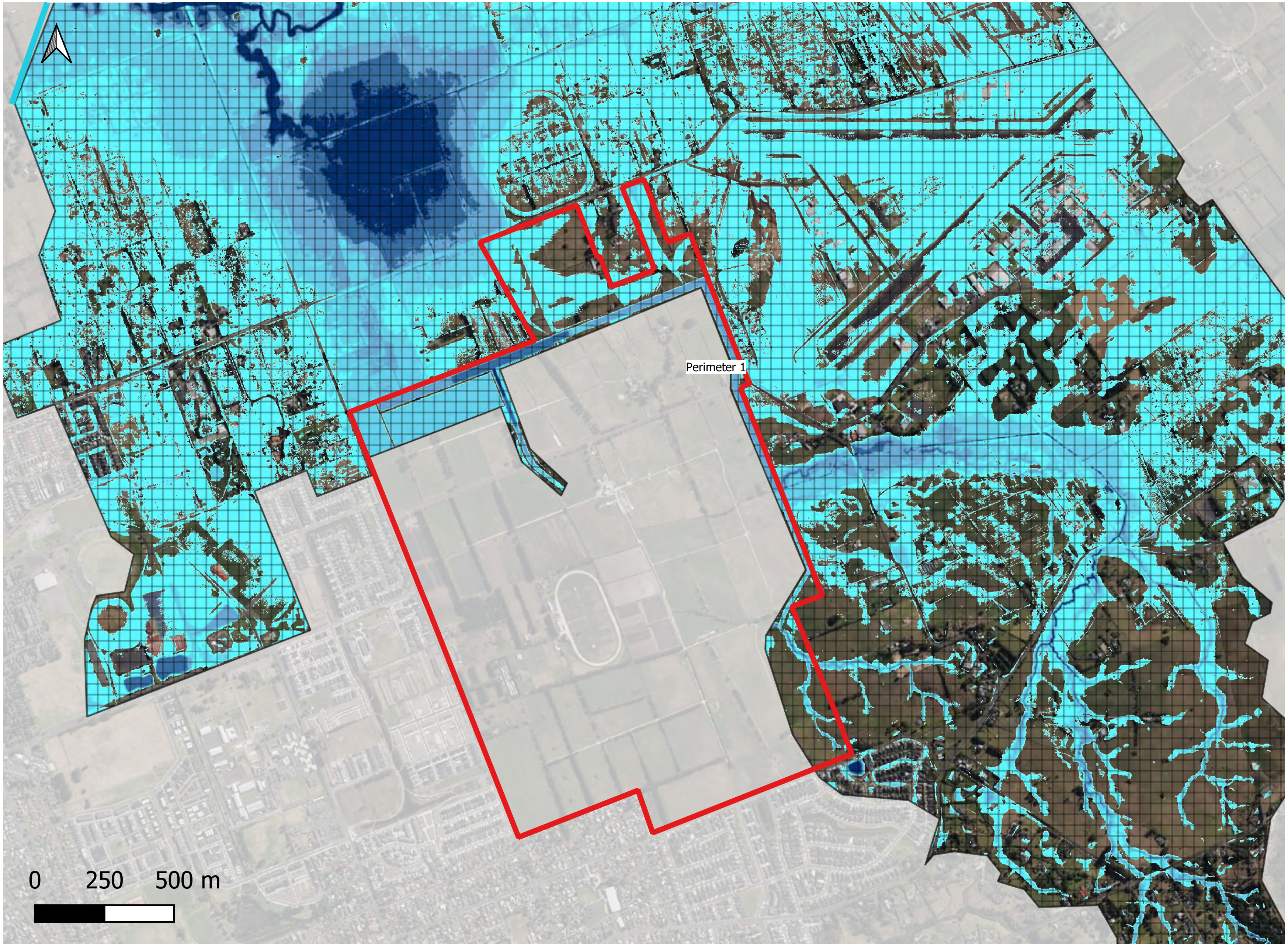
1.00000 - 1.50000

1.50000 - 2.00000

> 2.00000

SK024
REV001

100yr Eastern Catchment Post development HEC RAS Model results



Legend

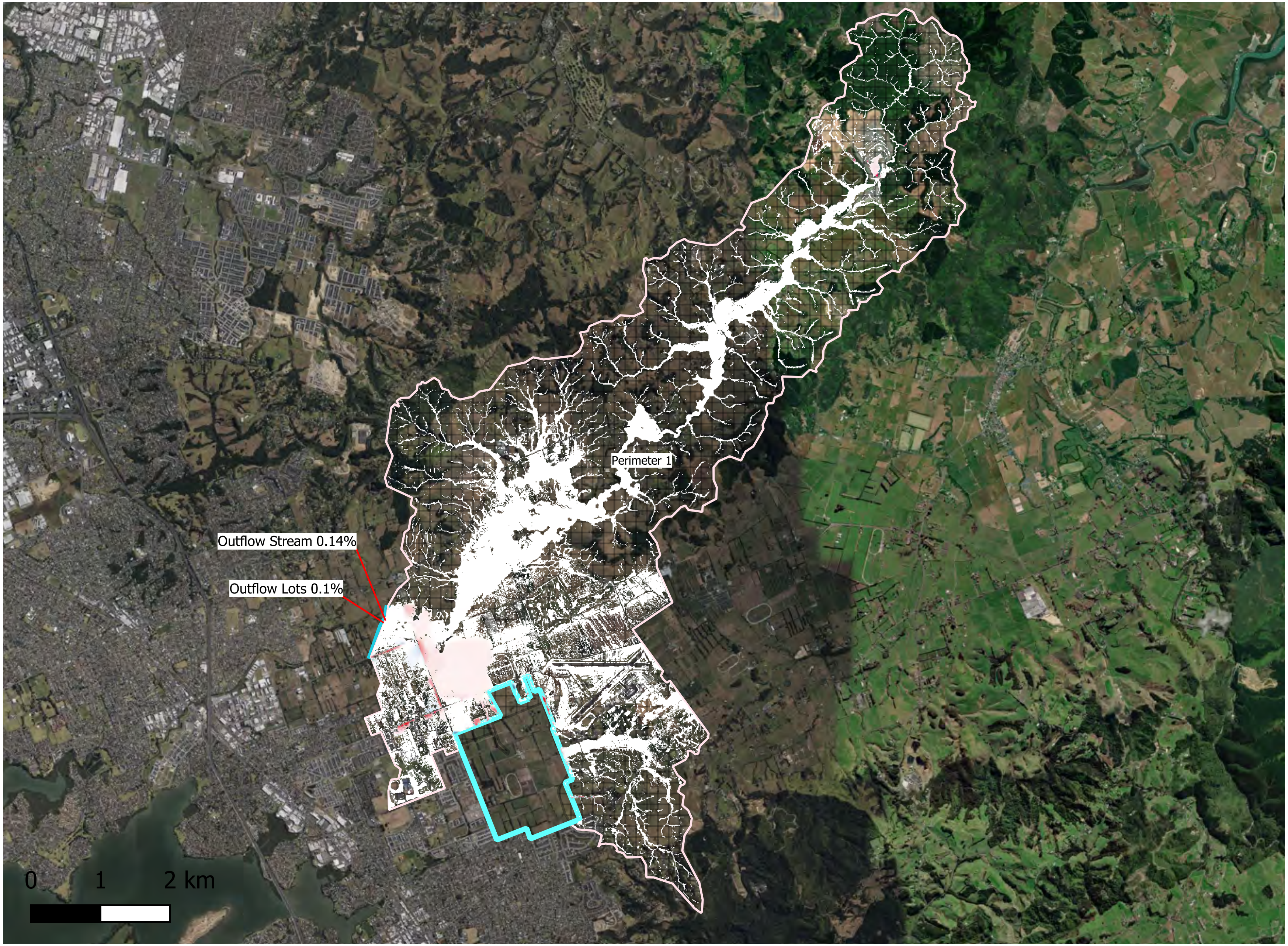
- Pr-Bdy
- Outflow Boundary Conditions
- Postdeveloped Eastern Catchment RAS model

Eastern catchment
Post development
1% AEP peak flow depths

- <= 0.50000
- 0.50000 - 1.00000
- 1.00000 - 1.50000
- 1.50000 - 2.00000
- > 2.00000

SK024B
REV001

10yr Eastern Catchment HEC RAS Model results Comparison



Legend

- Pr-Bdy
- Outflow Boundary Conditions
- Postdeveloped Eastern Catchment RAS model

10yr WSE Comparison Postdevelopment minus predevelopment

- -0.2500
- -0.2000
- -0.1500
- -0.1000
- -0.0500
- 0.0000
- 0.0500
- 0.1000
- 0.1500
- 0.2000
- 0.2500

SK029
REV001

10yr Eastern Catchment HEC RAS Model results Comparison

Legend

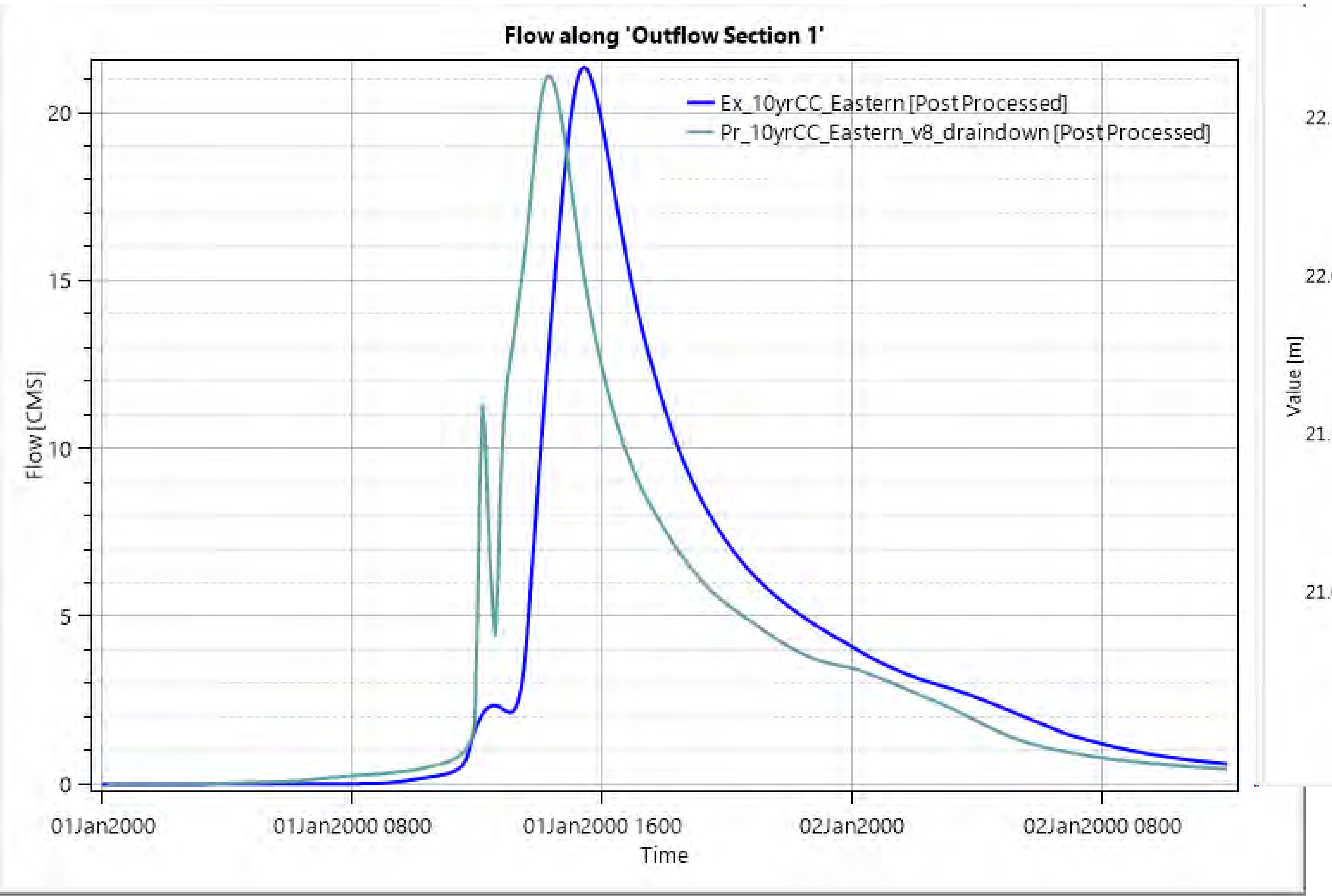
- Pr-Bdy
- Outflow Boundary Conditions
- Postdeveloped Eastern Catchment RAS model

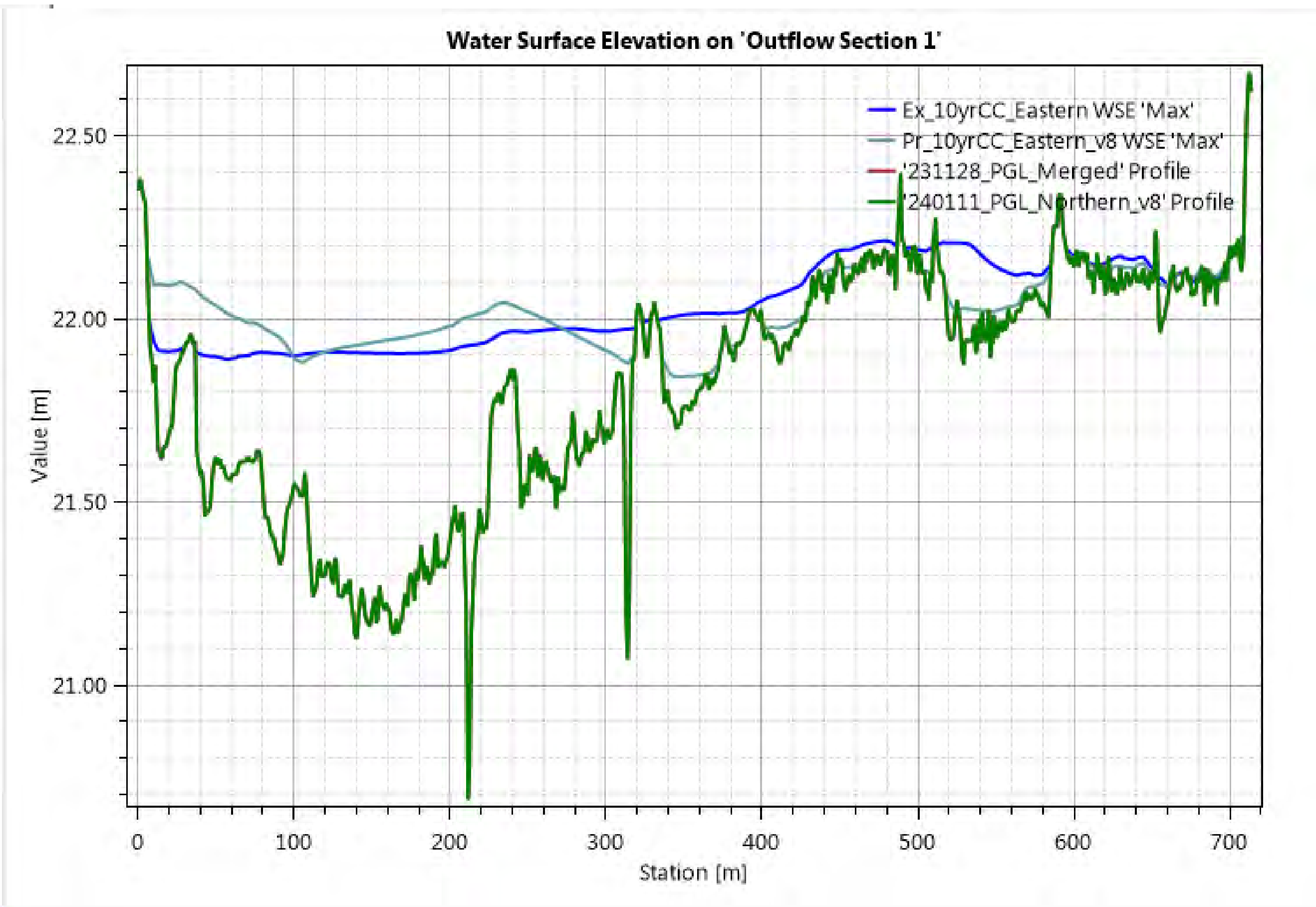
10yr WSE Comparison Postdevelopment minus predevelopment

- -0.2500
- -0.2000
- -0.1500
- -0.1000
- -0.0500
- 0.0000
- 0.0500
- 0.1000
- 0.1500
- 0.2000
- 0.2500

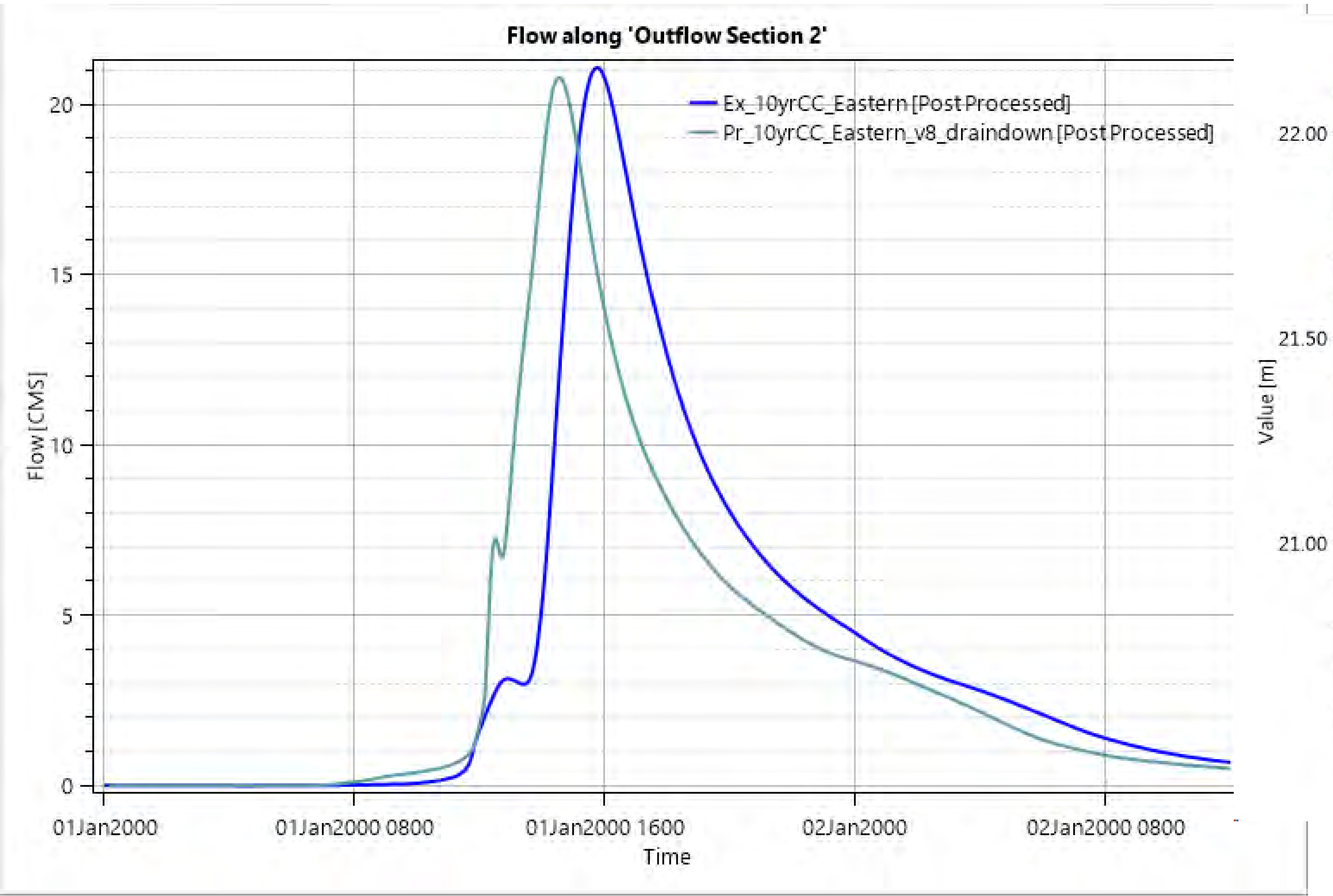
SK029B
REV001

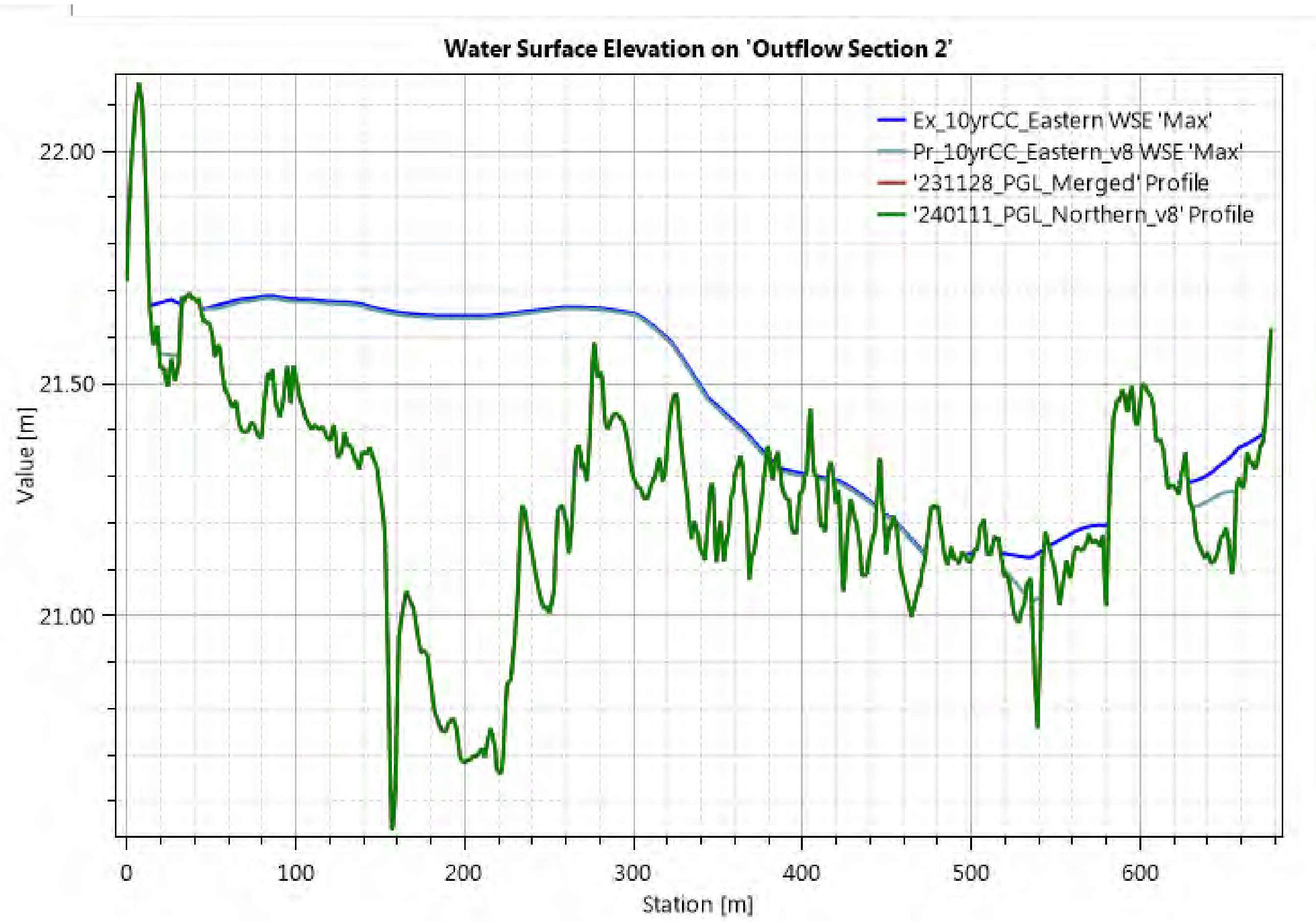
Flow Cross section 1



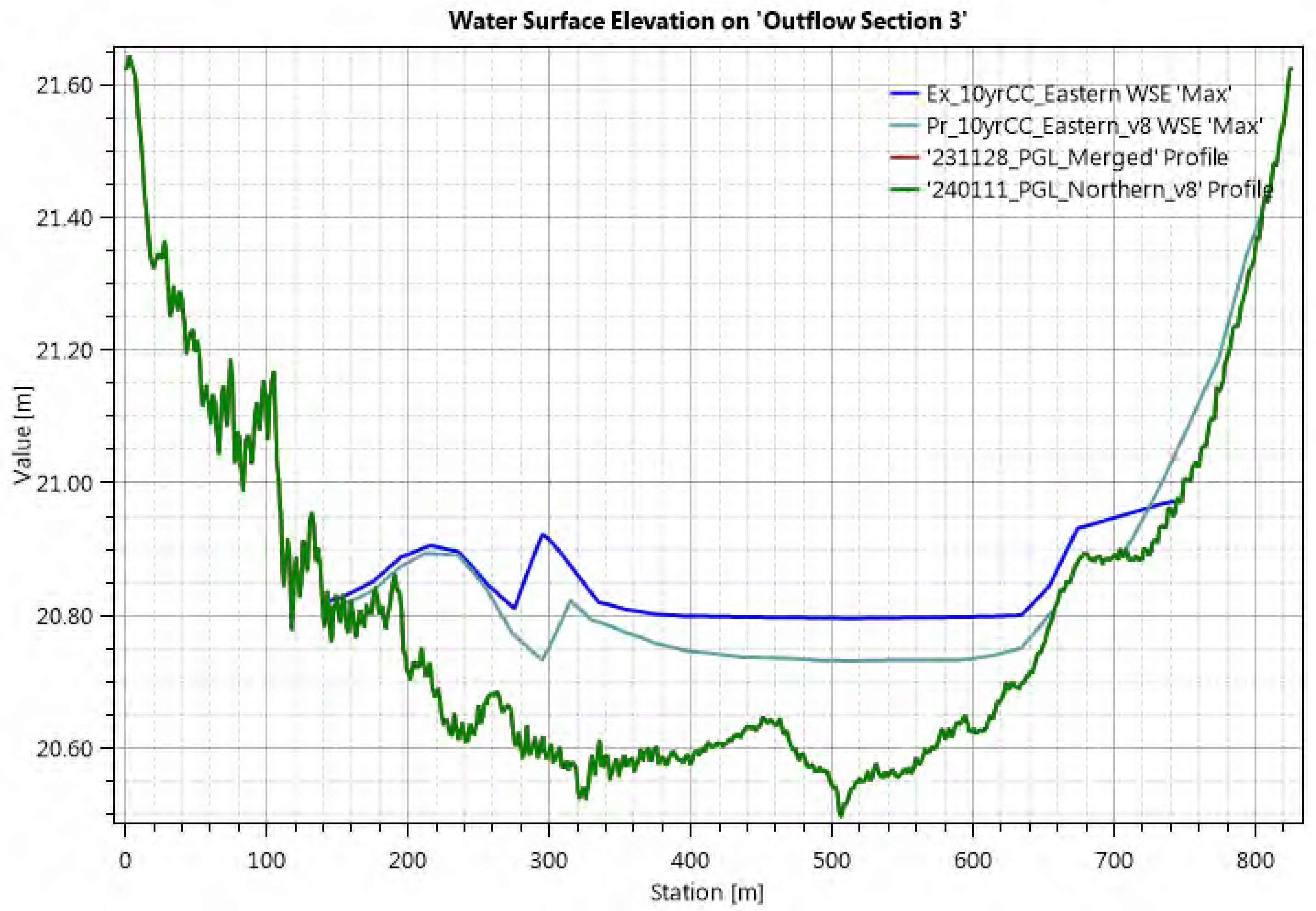


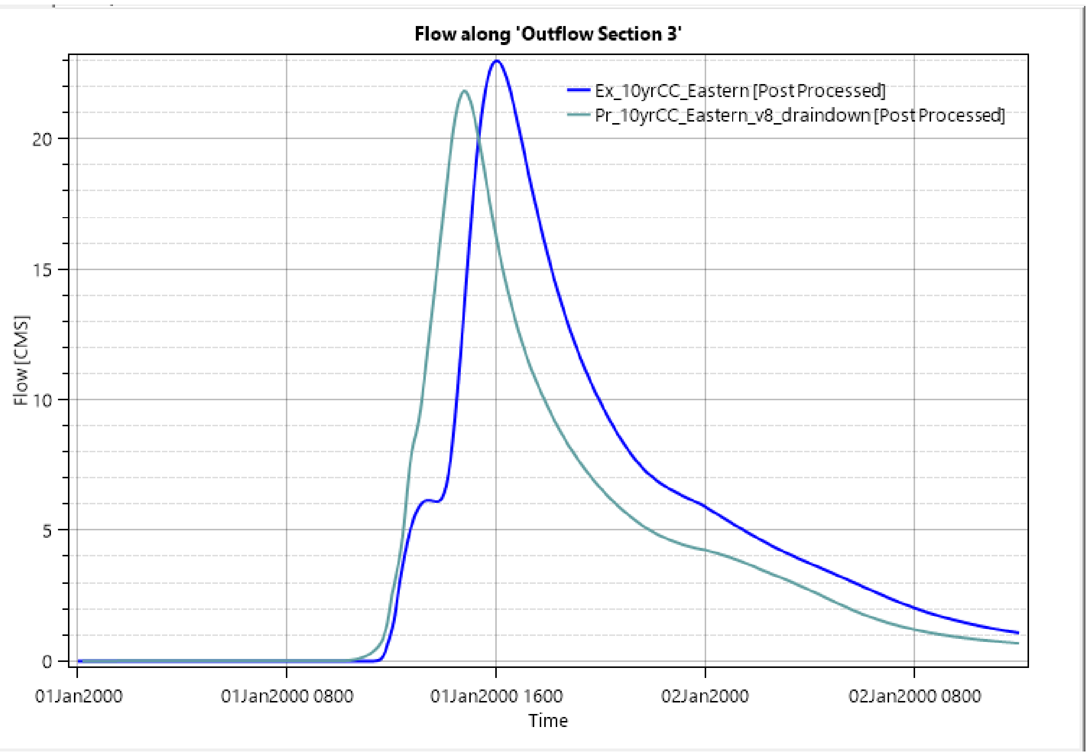
Flow Cross section 2



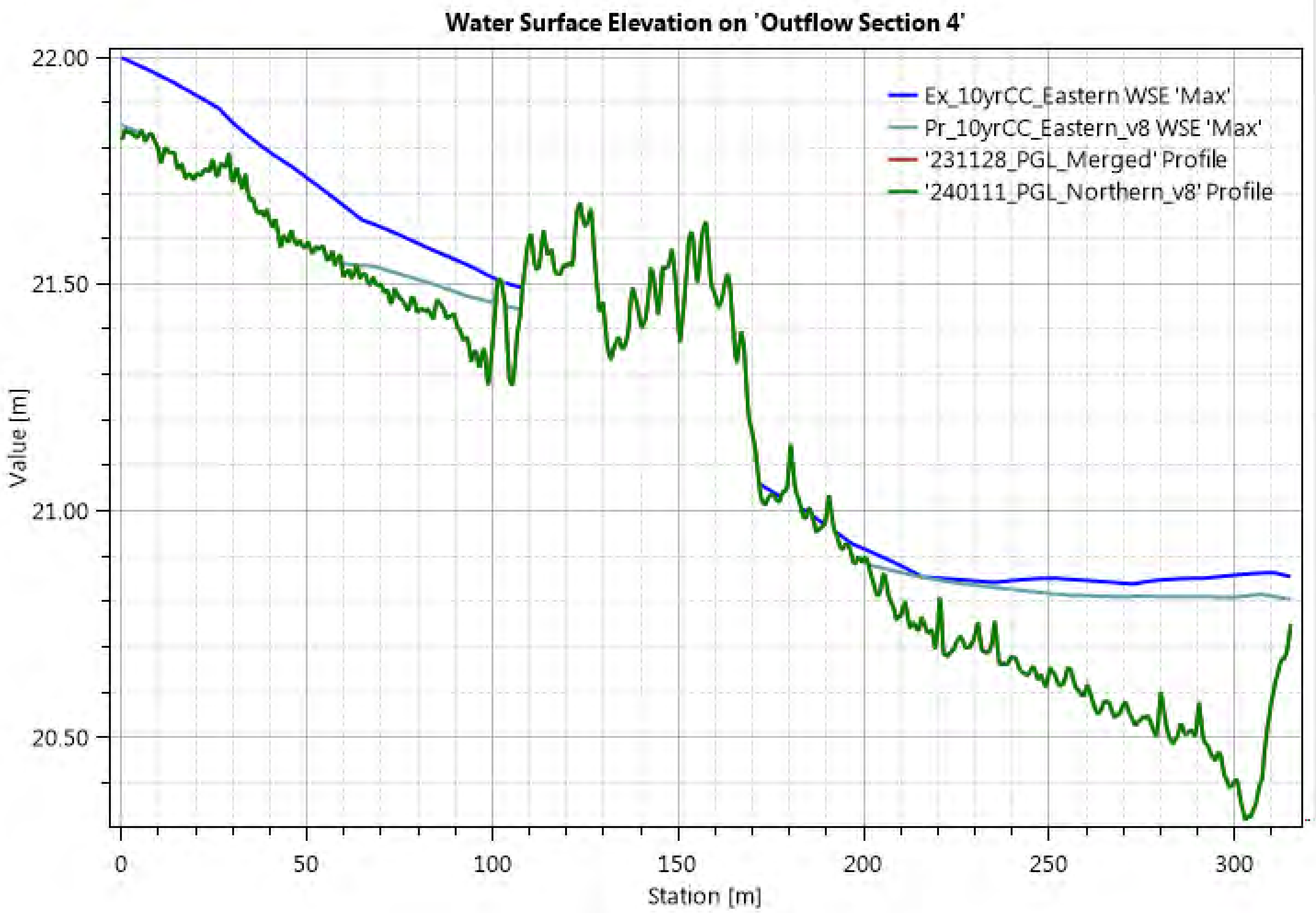


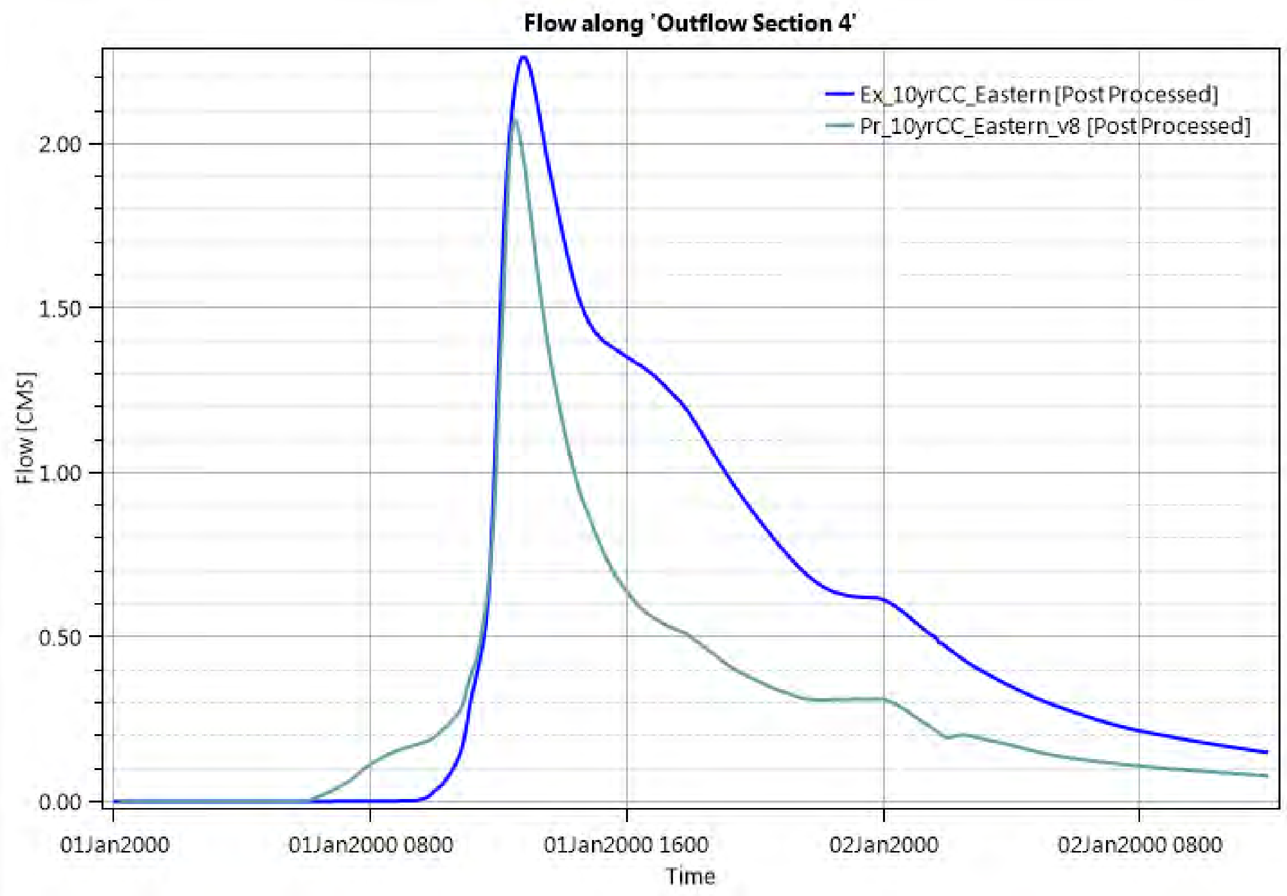
Flow Cross section 3





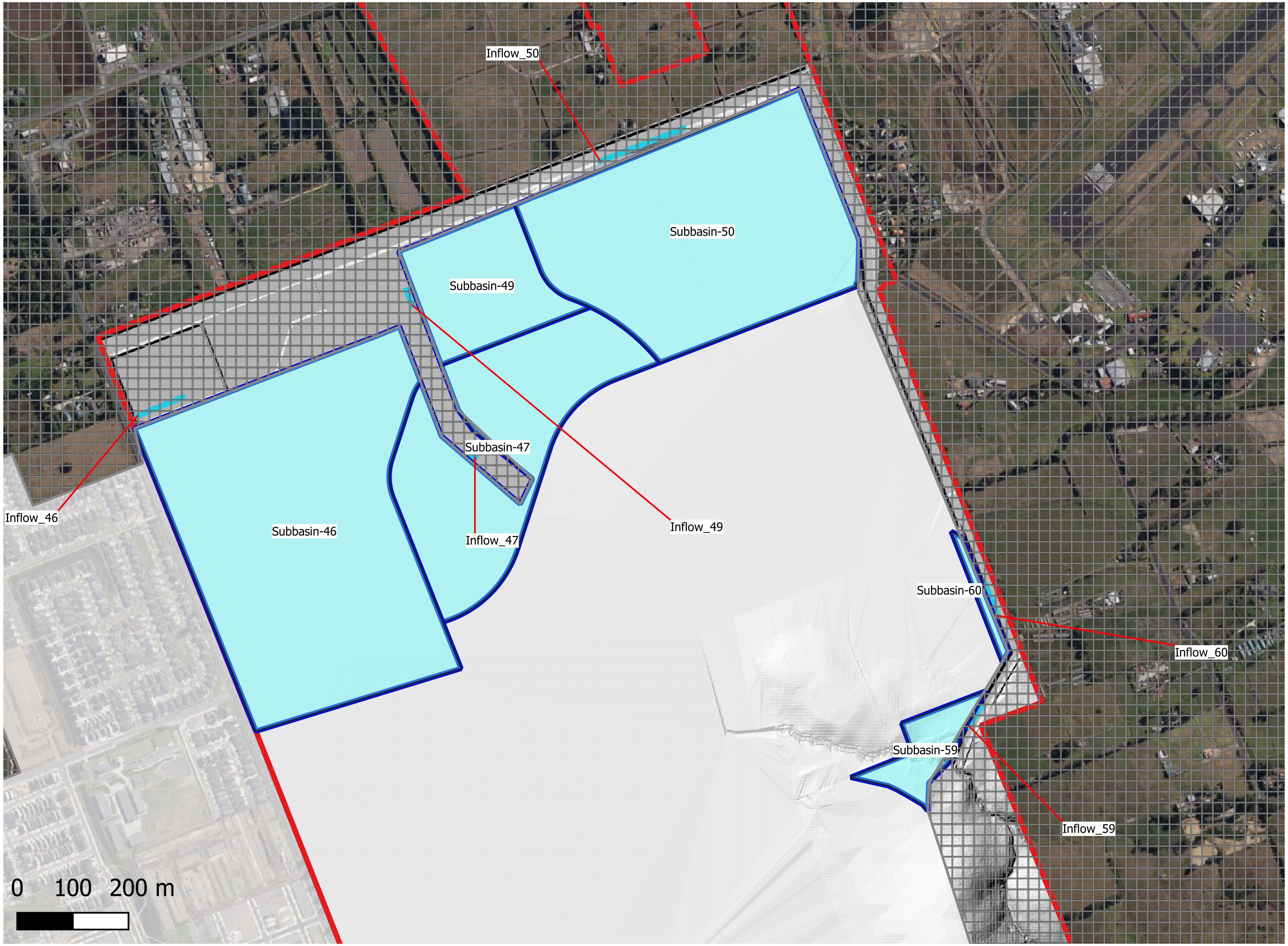
Flow Cross section 4





APPENDIX I – RAS EASTERN CATCHMENT SUBBASIN INFLOWS

100yr Postdeveloped Eastern Catchments HMS Subbasins for Inflows



Legend

- Pr-Bdy
- Boundary Conditions
- Postdeveloped Eastern Catchment RAS model
- 100yr HMS Subbasin for RAS inflows

SK020A
REV001

Proposed 100yr Eastern

Catchment	Area Ha	Area km2	Imper %		Impervious Total (Ha)	Pervious Total (Ha)	Impervious CN	Pervious CN	Weighted CN	Ia (average)	100 year C factor	Slope	Length	Tc	Tp	tp min
Subbasin-46	25.17506	0.251750615	0.61	61%	15.4361	9.7389	98	74	88.7	1.9	0.8	0.005	562.7	0.425	0.3	17.0
Subbasin-47	11.45268	0.114526767	0.63	63%	7.2379	4.2147	98	74	89.2	1.8	0.8	0.008	948.3	0.519	0.3	20.8
Subbasin-49	5.138035	0.051380347	0.63	63%	3.2133	1.9247	98	74	89.0	1.9	0.8	0.009	338.3	0.254	0.2	10.2
Subbasin-50	18.16128	0.181612766	0.87	87%	15.7841	2.3771	98	74	94.9	0.7	0.8	0.007	452.3	0.311	0.2	12.4
Subbasin-59	1.656435	0.01656435	0.27	27%	0.4486	1.2078	98	74	80.5	3.6	0.8	0.01	100.0	0.121	0.1	4.8
Subbasin-60	0.365404	0.003654041	0.50	50%	0.1827	0.1827	98	74	86.0	2.5	0.8	0.01	100.0	0.114	0.1	4.6

Project: Eastern_Catchment
Simulation Run: 100yr_Eastern_Pr_24hr_To_RAS
Simulation Start: 1 January 2000, 00:01
Simulation End: 2 January 2000, 12:00

HMS Version: 4.11
Executed: 06 March 2024, 21:15

Global Parameter Summary - Subbasin

Area (KM2)

Element Name	Area (KM2)
Subbasin - 46	0.25
Subbasin - 49	0.05
Subbasin - 50	0.18
Subbasin - 47	0.11
Subbasin - 59	0.02
Subbasin - 60	0

Downstream

Element Name	Downstream
Subbasin - 46	Junction - 1
Subbasin - 49	Junction - 1

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number	Initial Abstraction
Subbasin - 46	0	88.7	1.9
Subbasin - 49	0	89	1.9
Subbasin - 50	0	94.9	0.7
Subbasin - 47	0	89.2	1.8
Subbasin - 59	0	80.5	3.6
Subbasin - 60	0	86	2.5

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 46	17	Standard
Subbasin - 49	10.2	Standard
Subbasin - 50	12.4	Standard
Subbasin - 47	20.8	Standard
Subbasin - 59	4.8	Standard
Subbasin - 60	4.6	Standard

Global Results Summary

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin - 46	0.25	7.99	01Jan2000, 12:12	234.92
Subbasin - 49	0.05	2	01Jan2000, 12:05	236.65
Junction - 1	0.3	9.69	01Jan2000, 12:10	235.22
Subbasin - 50	0.18	6.84	01Jan2000, 12:07	254.73
Subbasin - 47	0.11	3.36	01Jan2000, 12:15	237.62
Subbasin - 59	0.02	0.74	01Jan2000, 12:01	218.46
Subbasin - 60	0	0.17	01Jan2000, 12:01	233.5

Subbasin: Subbasin-46

Area (KM2) : 0.25
Latitude Degrees : -37.04
Longitude Degrees : 174.95
Downstream : Junction - 1

Loss Rate: Scs

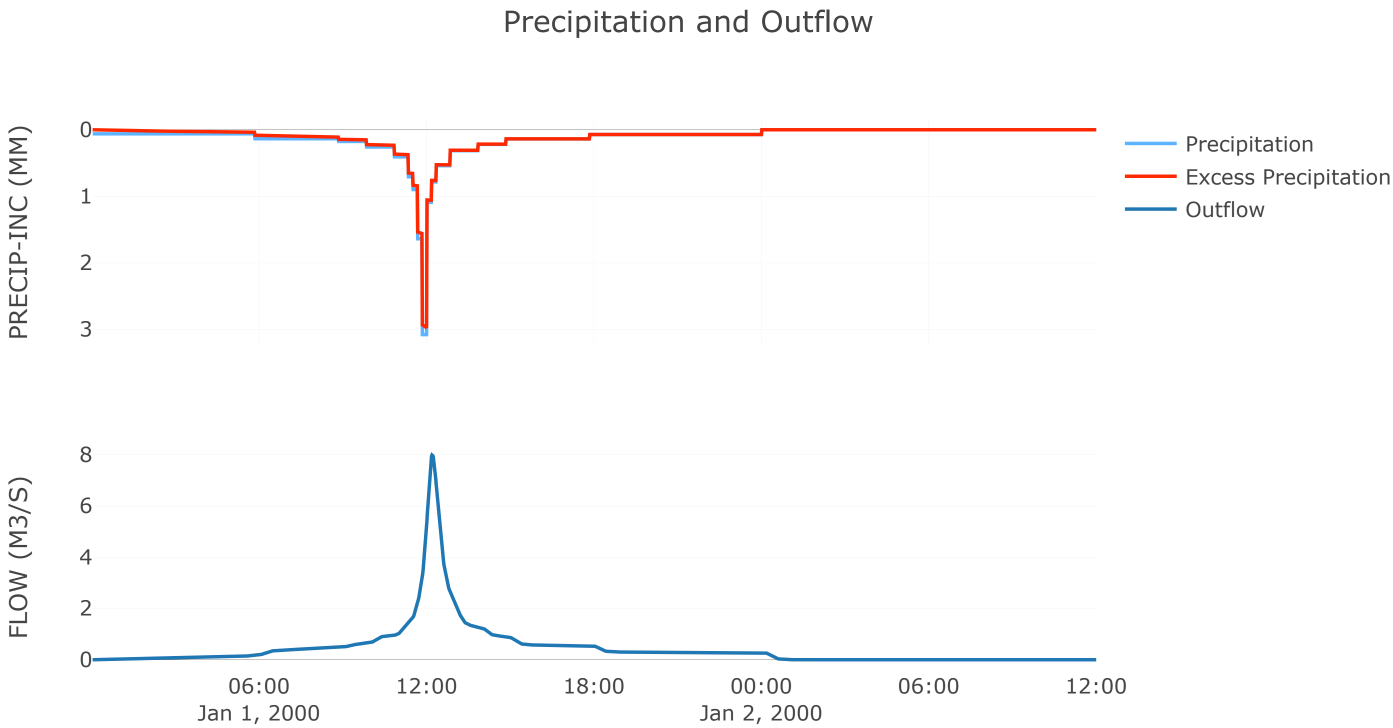
Percent Impervious Area	0
Curve Number	88.7
Initial Abstraction	1.9

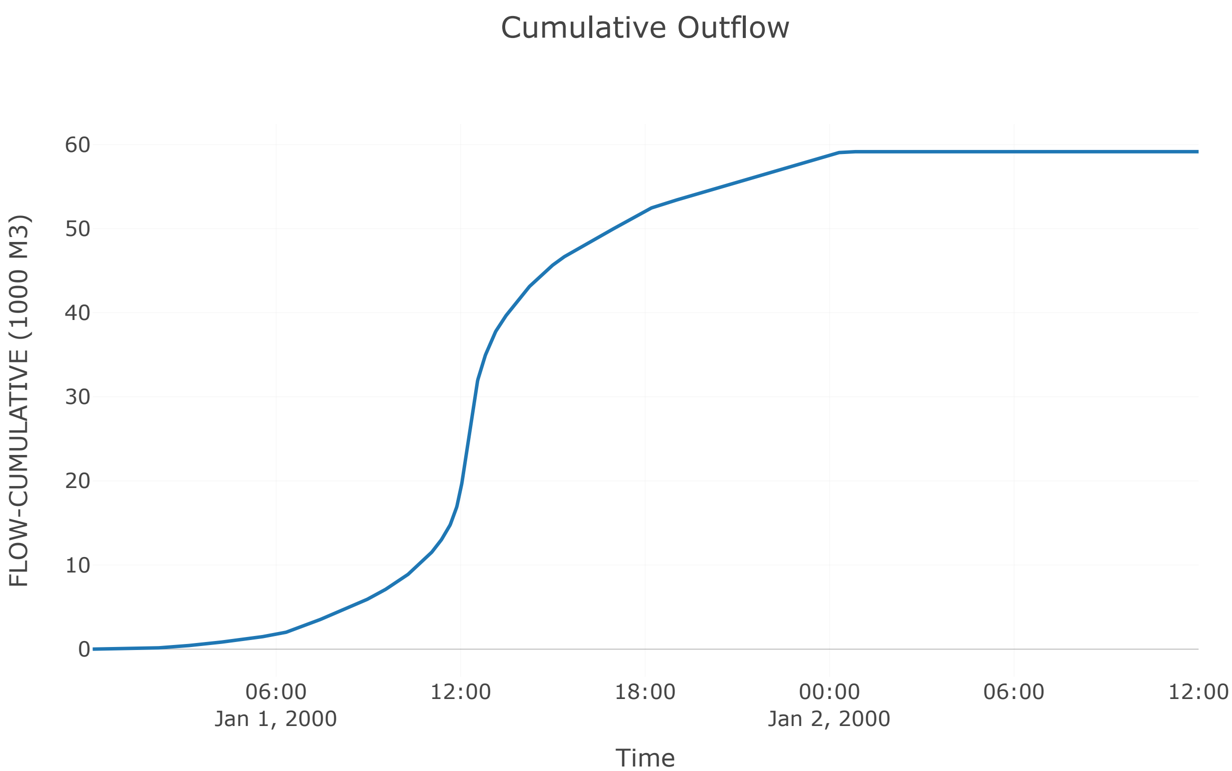
Transform: Scs

Lag	17
Unitgraph Type	Standard

Results: Subbasin-46

Peak Discharge (M3/S)	7.99
Time of Peak Discharge	01Jan2000, 12:12
Volume (MM)	234.92
Precipitation Volume (M3)	66889.97
Loss Volume (M3)	7735.89
Excess Volume (M3)	59154.08
Direct Runoff Volume (M3)	59154.08
Baseflow Volume (M3)	0


Precipitation and Outflow
PRECIP-INC (MM)
0
1
2
3
FLOW (M3/S)
8
6
4
2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Precipitation
Excess Precipitation
Outflow


Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
60
50
40
30
20
10
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-49

Area (KM2) : 0.05
Latitude Degrees : -37.04
Longitude Degrees : 174.96
Downstream : Junction - 1

Loss Rate: Scs

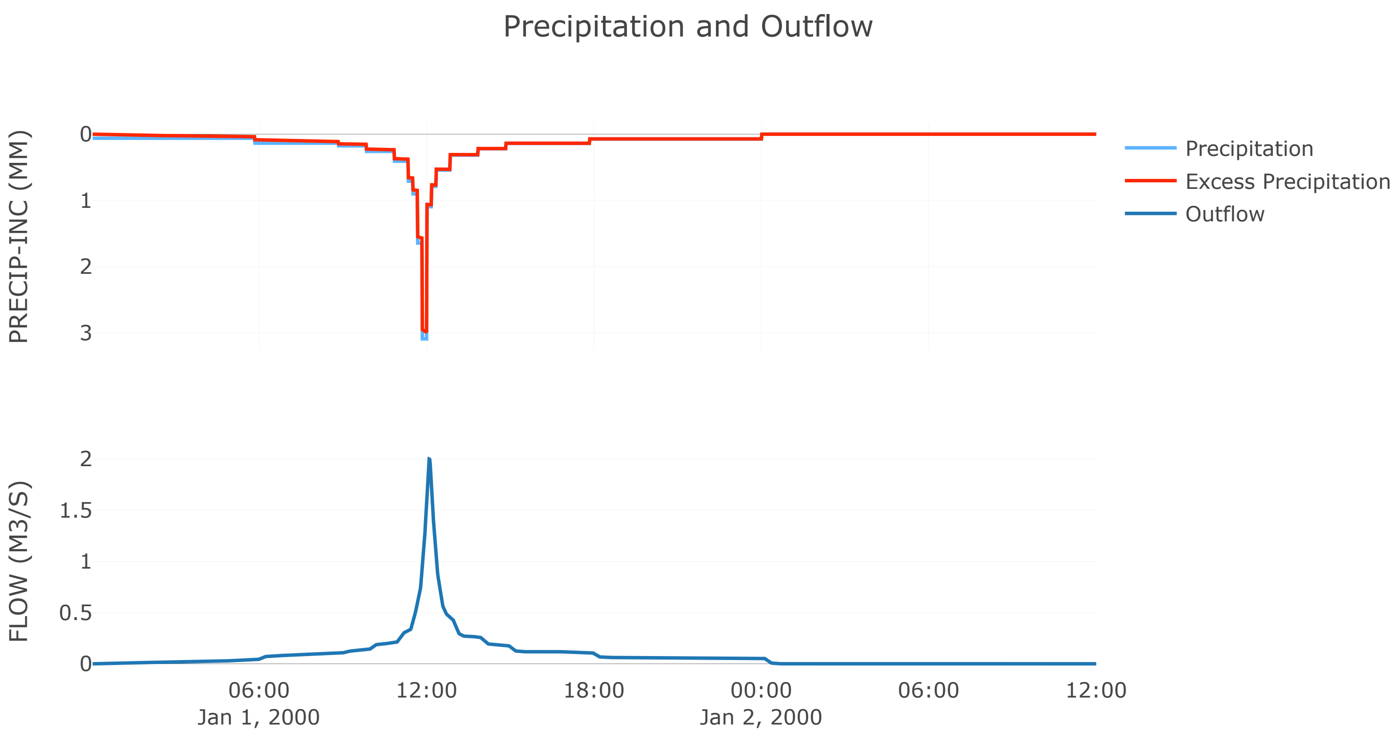
Percent Impervious Area	0
Curve Number	89
Initial Abstraction	1.9

Transform: Scs

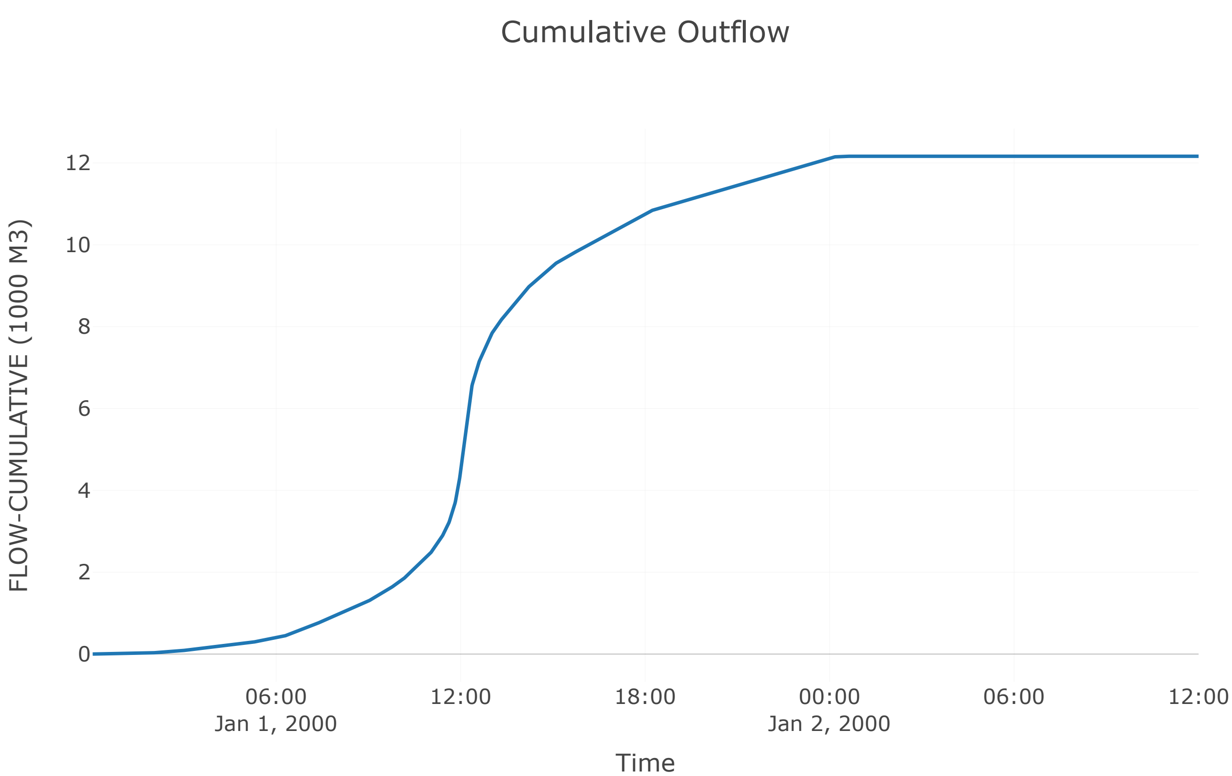
Lag	10.2
Unitgraph Type	Standard

Results: Subbasin-49

Peak Discharge (M3/S)	2
Time of Peak Discharge	01Jan2000, 12:05
Volume (MM)	236.65
Precipitation Volume (M3)	13704.22
Loss Volume (M3)	1540.2
Excess Volume (M3)	12164.02
Direct Runoff Volume (M3)	12164.02
Baseflow Volume (M3)	0



Precipitation and Outflow
PRECIP-INC (MM)
0
1
2
3
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
2
1.5
1
0.5
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00



Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
12
10
8
6
4
2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-50

Area (KM2) : 0.18
Latitude Degrees : -37.04
Longitude Degrees : 174.96

Loss Rate: Scs

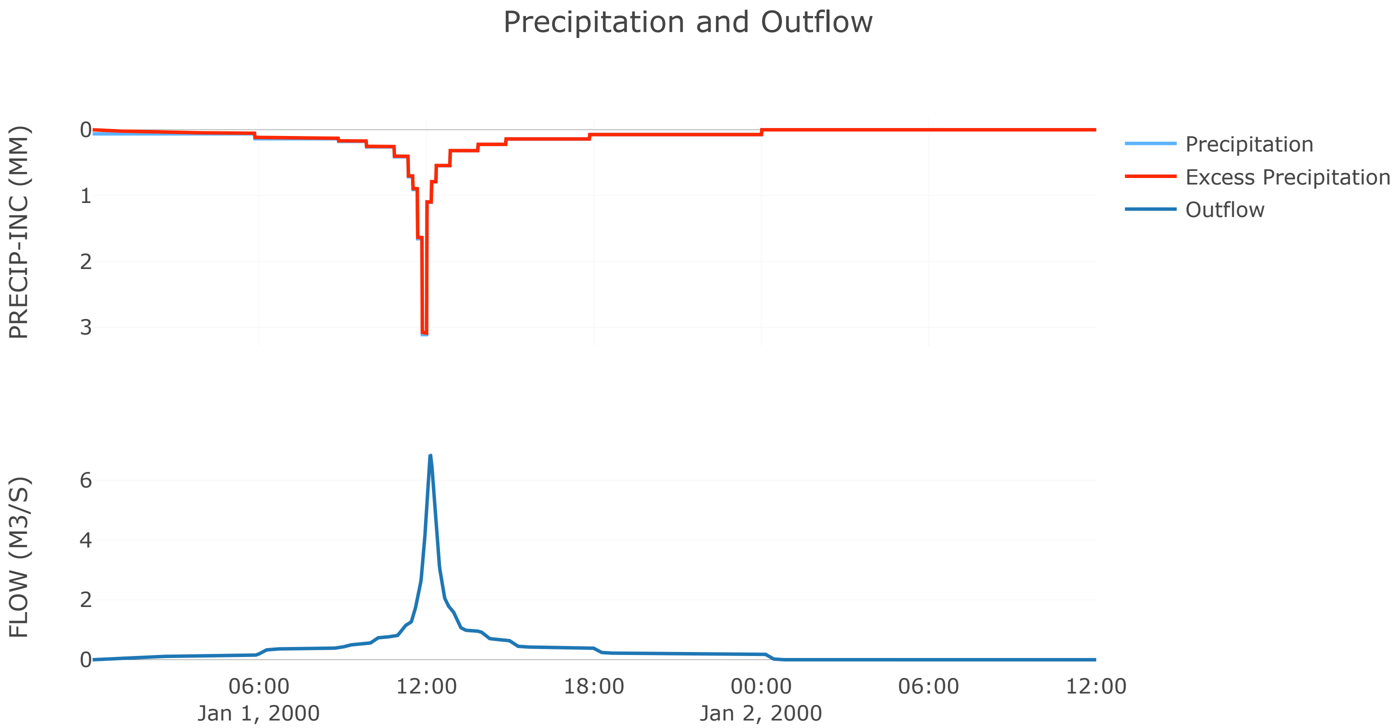
Percent Impervious Area	0
Curve Number	94.9
Initial Abstraction	0.7

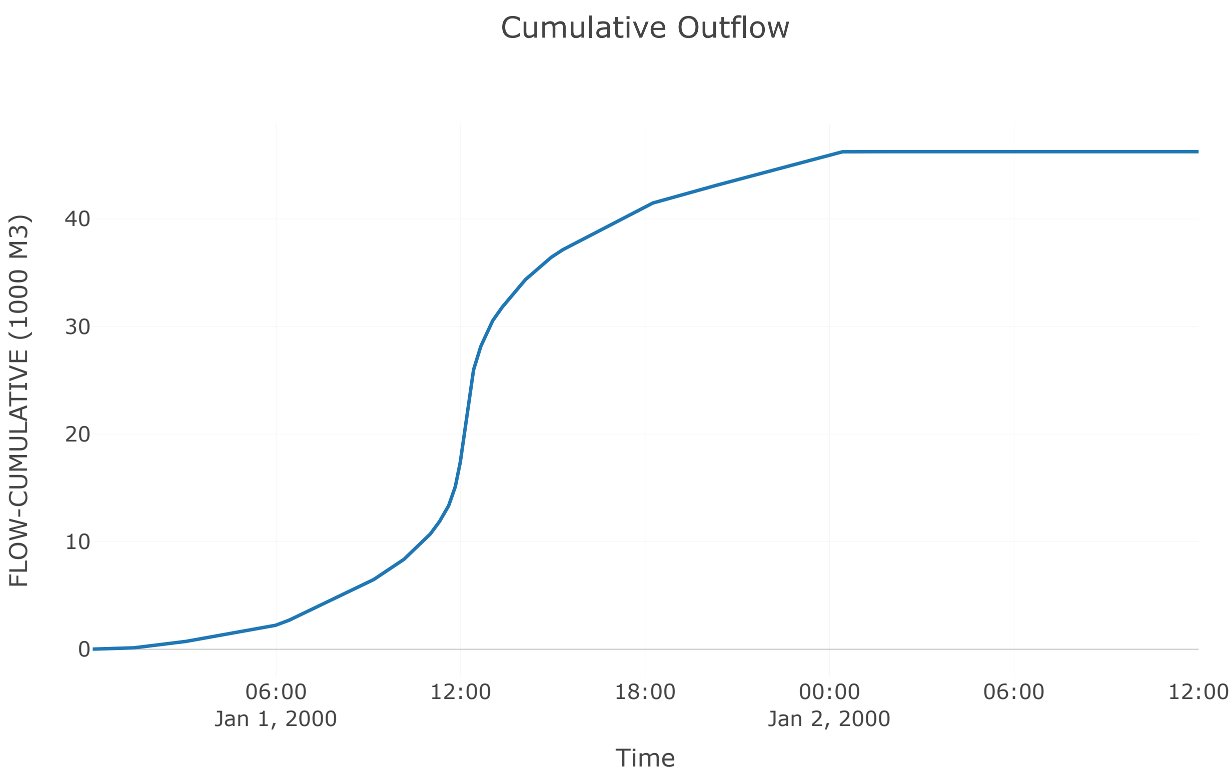
Transform: Scs

Lag	12.4
Unitgraph Type	Standard

Results: Subbasin-50

Peak Discharge (M3/S)	6.84
Time of Peak Discharge	01Jan2000, 12:07
Volume (MM)	254.73
Precipitation Volume (M3)	48743.94
Loss Volume (M3)	2485.73
Excess Volume (M3)	46258.21
Direct Runoff Volume (M3)	46258.21
Baseflow Volume (M3)	0


Precipitation and Outflow
PRECIP-INC (MM)
0
1
2
3
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
6
4
2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00


Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
40
30
20
10
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-47

Area (KM2) : 0.11
Latitude Degrees : -37.04
Longitude Degrees : 174.96

Loss Rate: Scs

Percent Impervious Area	0
Curve Number	89.2
Initial Abstraction	1.8

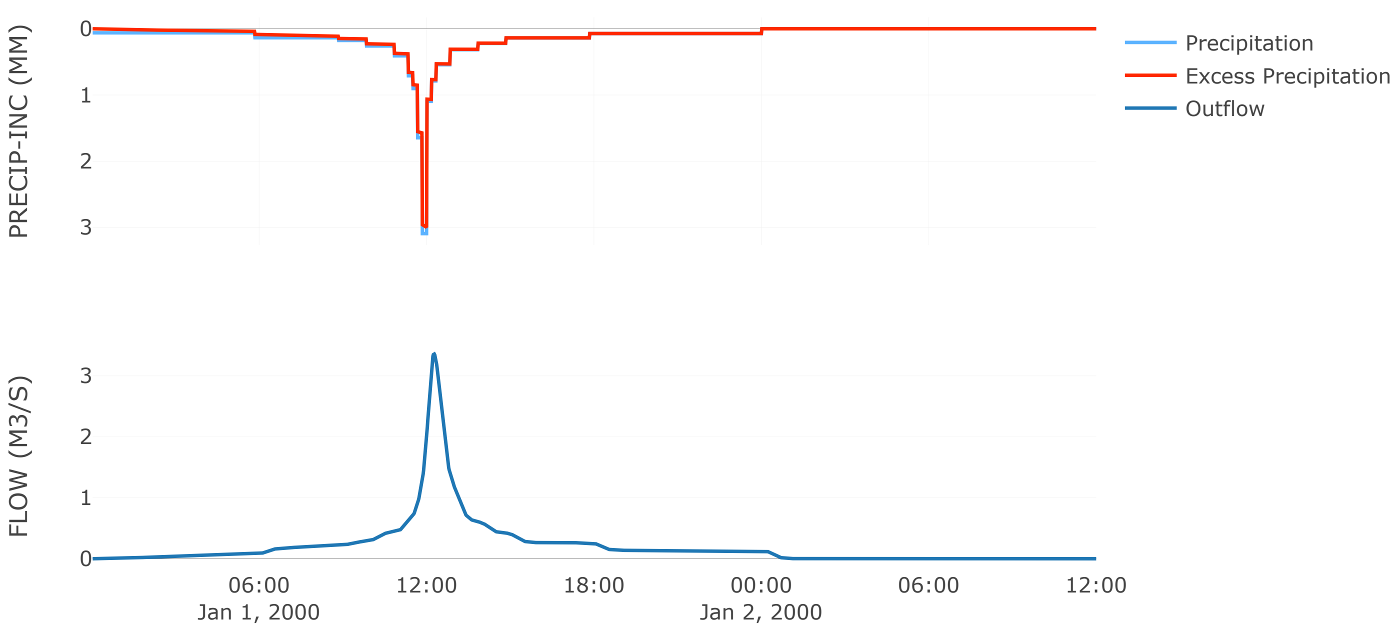
Transform: Scs

Lag	20.8
Unitgraph Type	Standard

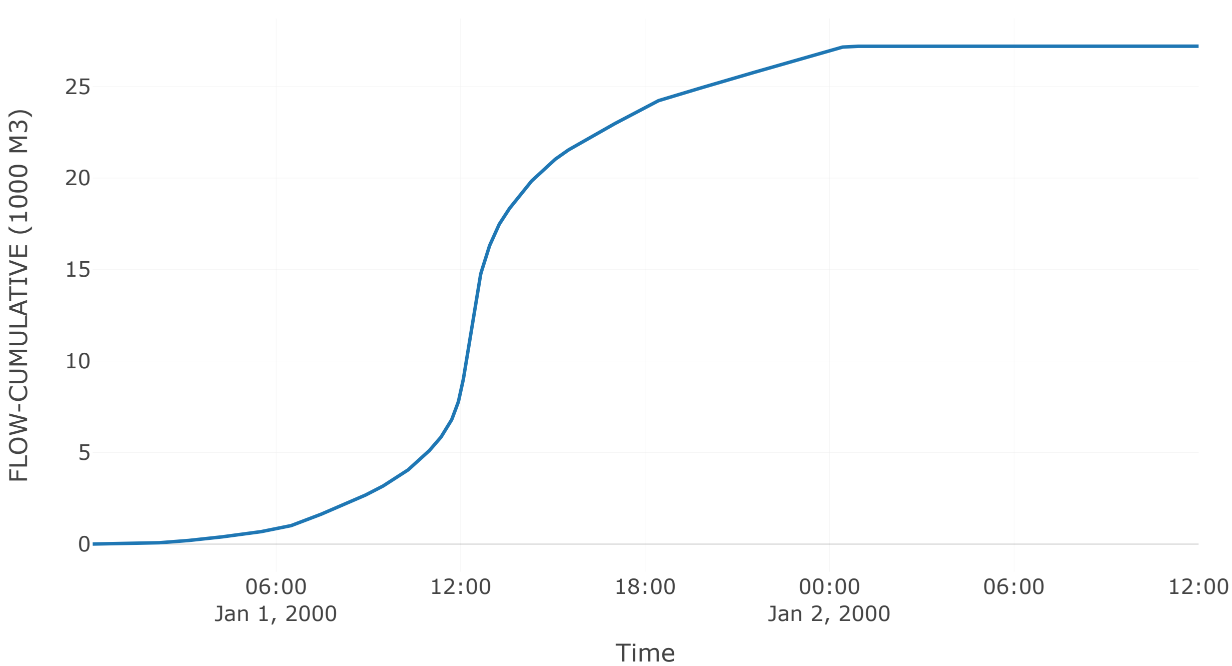
Results: Subbasin-47

Peak Discharge (M3/S)	3.36
Time of Peak Discharge	01Jan2000, 12:15
Volume (MM)	237.62
Precipitation Volume (M3)	30568.99
Loss Volume (M3)	3361.43
Excess Volume (M3)	27207.56
Direct Runoff Volume (M3)	27207.56
Baseflow Volume (M3)	0

Precipitation and Outflow



Cumulative Outflow



Subbasin: Subbasin-59

Area (KM2) : 0.02
Latitude Degrees : -37.04
Longitude Degrees : 174.97

Loss Rate: Scs

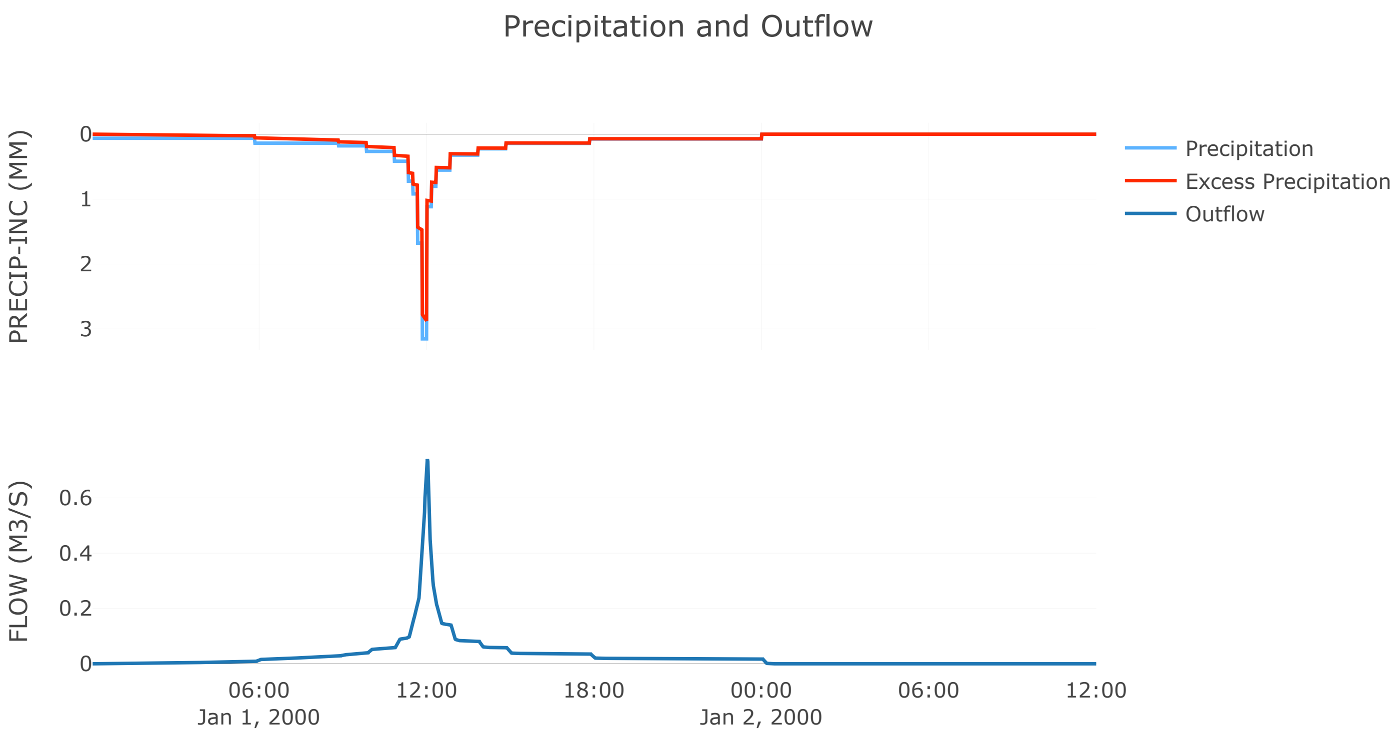
Percent Impervious Area	0
Curve Number	80.5
Initial Abstraction	3.6

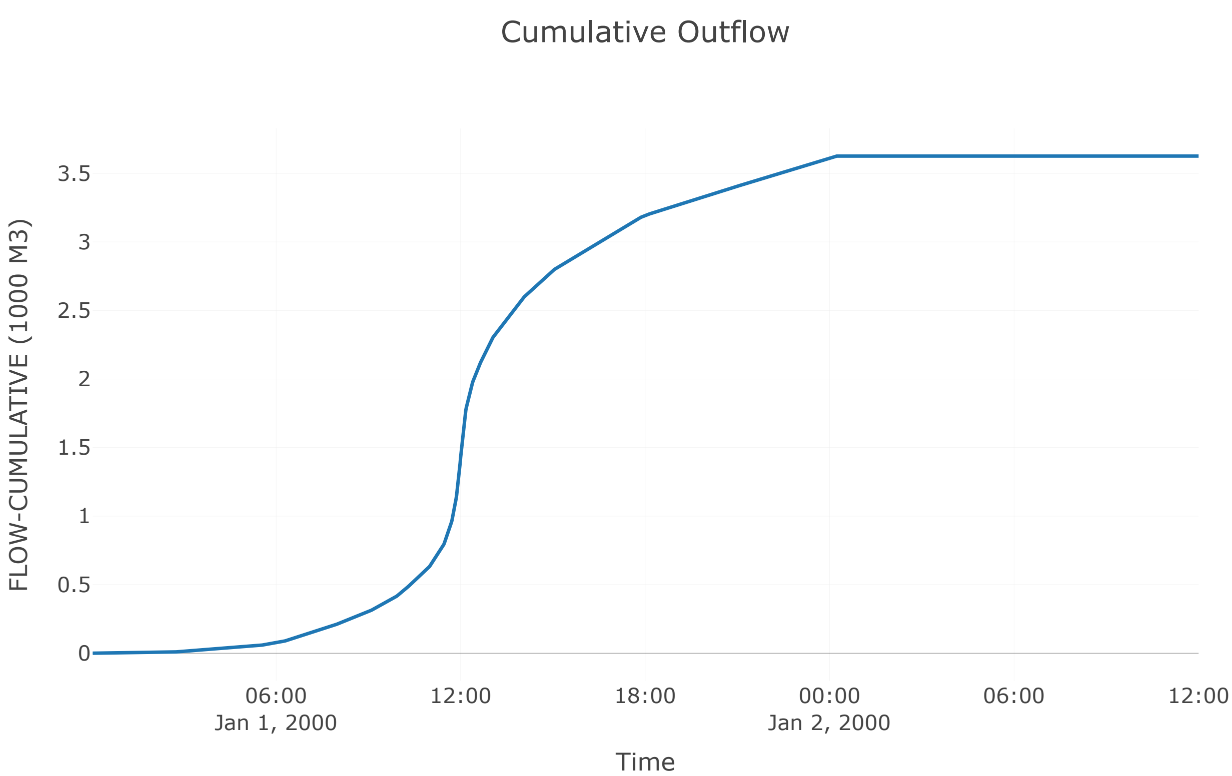
Transform: Scs

Lag	4.8
Unitgraph Type	Standard

Results: Subbasin-59

Peak Discharge (M3/S)	0.74
Time of Peak Discharge	01Jan2000, 12:01
Volume (MM)	218.46
Precipitation Volume (M3)	4517.1
Loss Volume (M3)	890.72
Excess Volume (M3)	3626.39
Direct Runoff Volume (M3)	3626.39
Baseflow Volume (M3)	0


Precipitation and Outflow
PRECIP-INC (MM)
0
1
2
3
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
0.6
0.4
0.2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00


Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
3.5
3
2.5
2
1.5
1
0.5
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-60

Area (KM2) : 0
Latitude Degrees : -37.04
Longitude Degrees : 174.97

Loss Rate: Scs

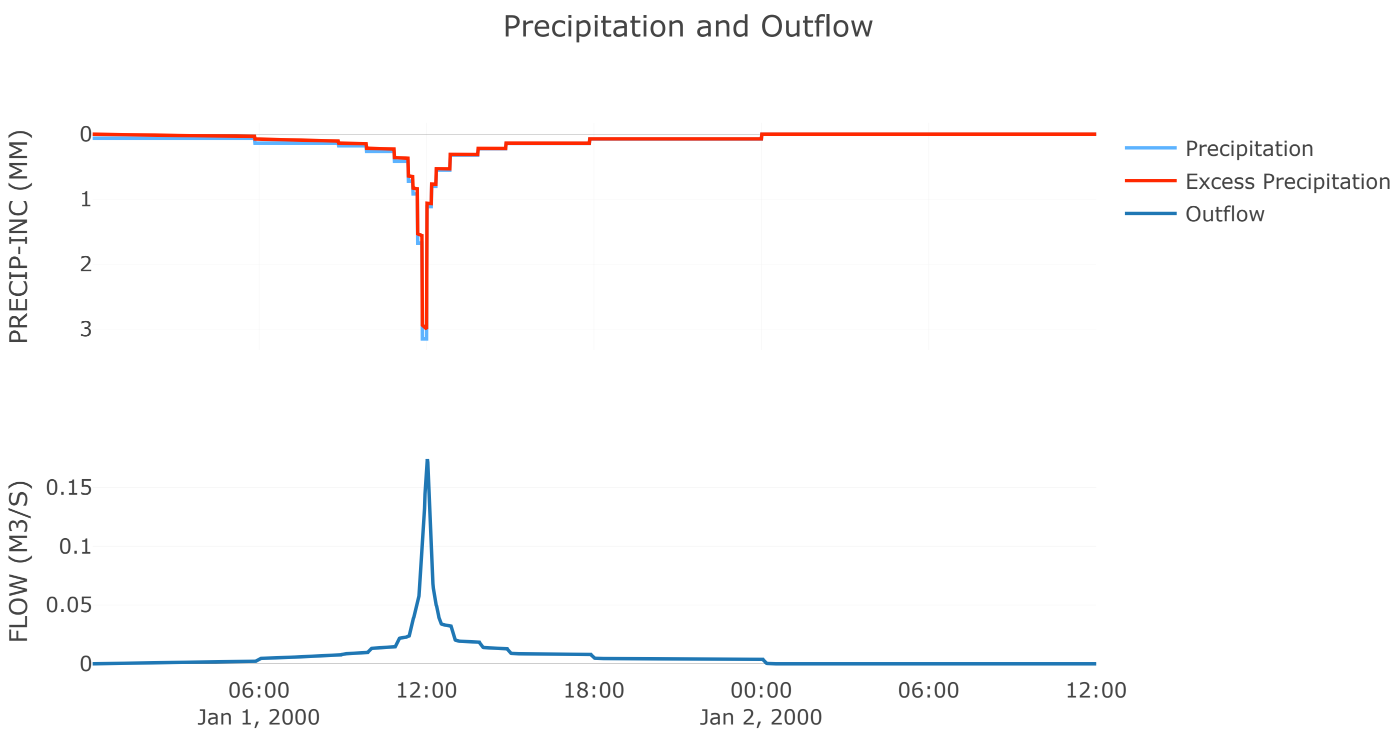
Percent Impervious Area	0
Curve Number	86
Initial Abstraction	2.5

Transform: Scs

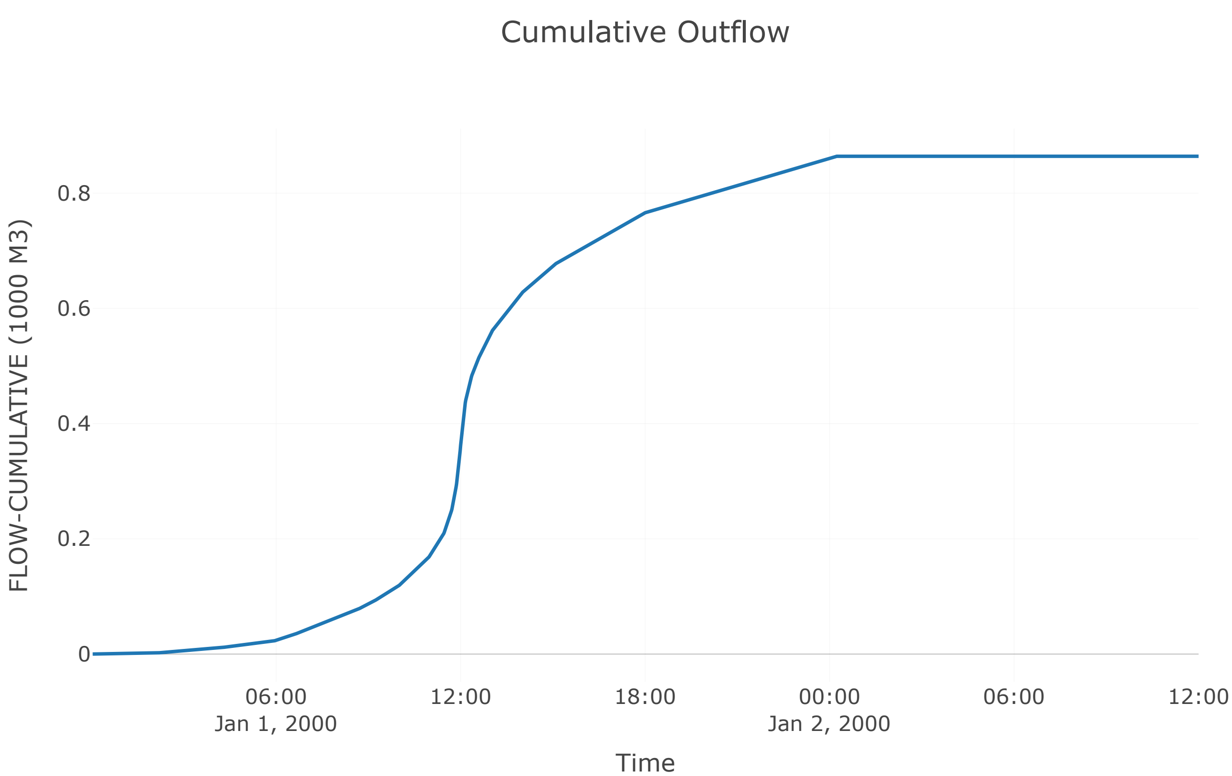
Lag	4.6
Unitgraph Type	Standard

Results: Subbasin-60

Peak Discharge (M3/S)	0.17
Time of Peak Discharge	01Jan2000, 12:01
Volume (MM)	233.5
Precipitation Volume (M3)	1005.83
Loss Volume (M3)	141.88
Excess Volume (M3)	863.95
Direct Runoff Volume (M3)	863.95
Baseflow Volume (M3)	0

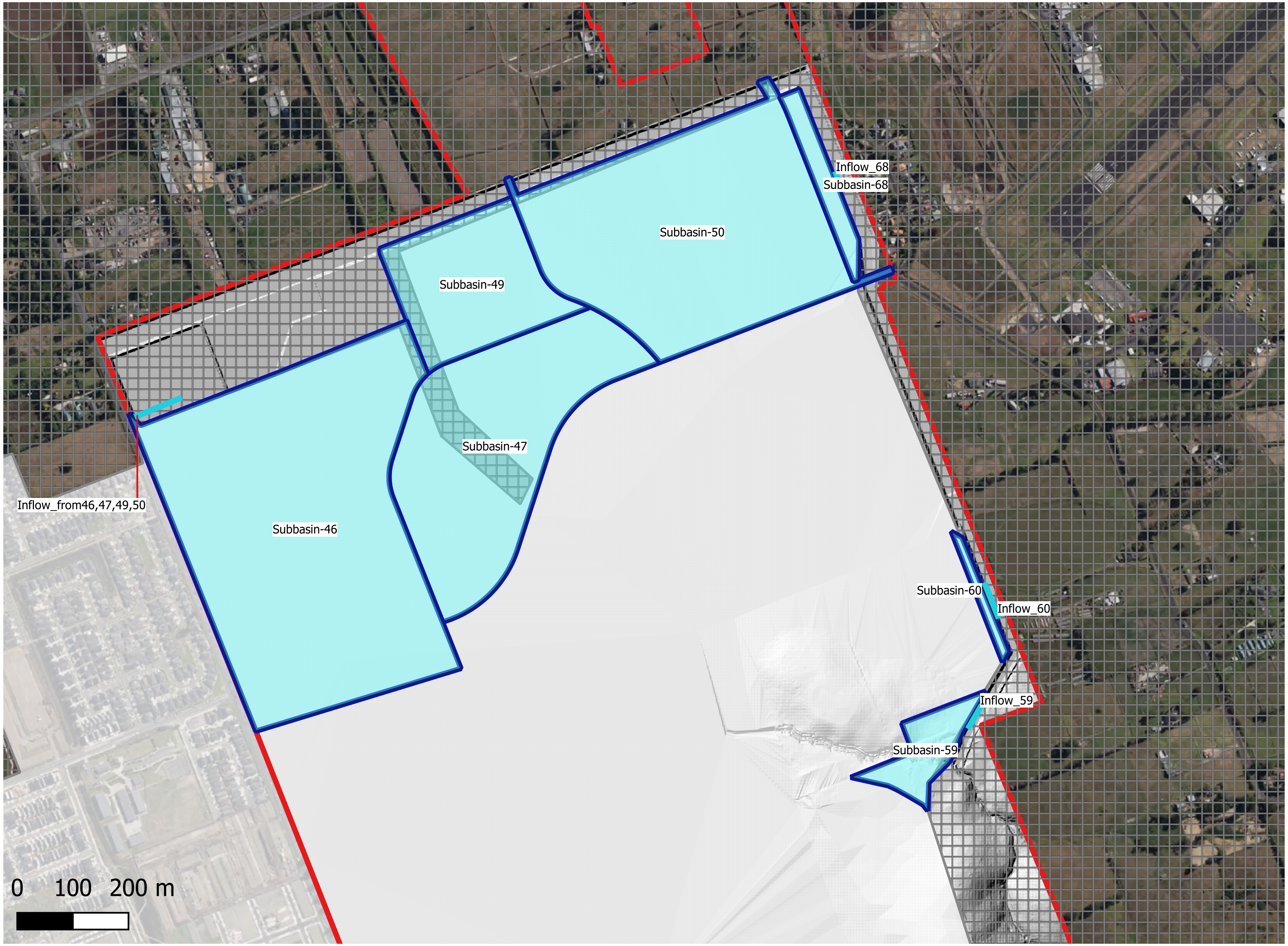


Precipitation and Outflow
PRECIP-INC (MM)
0
1
2
3
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
0.15
0.1
0.05
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00



Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
0.8
0.6
0.4
0.2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

10yr Postdeveloped Eastern Catchments HMS Subbasins for Inflows



Legend

- Pr-Bdy
- Boundary Conditions
- Postdeveloped Eastern Catchment RAS model
- 10yr HMS Subbasin for RAS inflows

SK020B
REV001

Proposed 10yr Eastern

Catchment	Area Ha	Area km2	Imper %		Impervious Total (Ha)	Pervious Total (Ha)	Impervious CN	Pervious CN	Weighted CN	Ia (average)	C factor	Slope	Length	Tc	Tp	tp min
											10 year					
Subbasin-46	25.4827	0.254826996	0.61	61%	15.6236	9.8591	98	74	88.7	1.9	0.6	0.005	562.7	0.3	0.2	12.8
Subbasin-47	12.78057	0.12780566	0.62	62%	7.8897	4.8909	98	74	88.8	1.9	0.6	0.008	325.7	0.2	0.1	7.7
Subbasin-48	2.373507	0.02373507	0.30	30%	0.7117	1.6618	98	74	81.2	3.5	0.6	0.01	100.0	0.1	0.1	3.6
Subbasin-49	6.234005	0.062340052	0.60	60%	3.7465	2.4875	98	74	88.4	2.0	0.6	0.009	338.3	0.2	0.1	7.7
Subbasin-50	17.69748	0.176974836	0.90	90%	15.8396	1.8579	98	74	95.5	0.5	0.6	0.007	452.3	0.2	0.2	9.3
Subbasin-59	1.656435	0.01656435	0.27	27%	0.4486	1.2078	98	74	80.5	3.6	0.6	0.01	100.0	0.1	0.1	6.7
Subbasin-60	0.365404	0.003654041	0.50	50%	0.1827	0.1827	98	74	86.0	2.5	0.6	0.01	100.0	0.1	0.1	6.7
Subbasin-68	1.215259	0.012152585	0.30	30%	0.3646	0.8507	98	74	81.2	3.5	0.6	0.01	100.0	0.1	0.1	6.7

Project: Eastern_Catchment
Simulation Run: 10yr_Eastern_Pr_24hr_To_RAS
Simulation Start: 1 January 2000, 00:01
Simulation End: 2 January 2000, 12:00

HMS Version: 4.11
Executed: 04 March 2024, 22:01

Global Parameter Summary - Subbasin

Area (KM2)

Element Name	Area (KM2)
Subbasin - 50	0.18
Subbasin - 47	0.13
Subbasin - 49	0.06
Subbasin - 46	0.25
Subbasin - 59	0.02
Subbasin - 60	0
Subbasin - 68	0.01

Downstream

Element Name	Downstream
Subbasin - 50	Junction - 13
Subbasin - 47	Junction - 47
Subbasin - 49	Junction - 47
Subbasin - 46	Junction - 11

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number	Initial Abstraction
Subbasin - 50	0	95.5	0.5
Subbasin - 47	0	88.8	1.9
Subbasin - 49	0	88.4	2
Subbasin - 46	0	88.7	1.9
Subbasin - 59	0	80.5	3.6
Subbasin - 60	0	86	2.5
Subbasin - 68	0	81.2	3.5

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 50	9.3	Standard
Subbasin - 47	7.7	Standard
Subbasin - 49	7.7	Standard
Subbasin - 46	12.8	Standard
Subbasin - 59	6.7	Standard
Subbasin - 60	6.7	Standard
Subbasin - 68	6.7	Standard

Global Results Summary

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin - 50	0.18	4.49	01Jan2000, 12:05	152.98
Junction - 13	0.18	4.49	01Jan2000, 12:05	152.98
Reach - 10	0.18	4.49	01Jan2000, 12:05	152.98
Subbasin - 47	0.13	3.17	01Jan2000, 12:03	134.92
Subbasin - 49	0.06	1.53	01Jan2000, 12:03	133.75
Junction - 47	0.37	9.15	01Jan2000, 12:04	143.43
Reach - 6	0.37	9.15	01Jan2000, 12:07	143.43
Subbasin - 46	0.25	5.28	01Jan2000, 12:08	133.83
Junction - 11	0.62	14.42	01Jan2000, 12:07	139.49
Reach - 9	0.62	14.42	01Jan2000, 12:07	139.49
Sink - 1	0.62	14.42	01Jan2000, 12:07	139.49
Subbasin - 59	0.02	0.38	01Jan2000, 12:03	118.24
Subbasin - 60	0	0.09	01Jan2000, 12:03	130.98
Subbasin - 68	0.01	0.28	01Jan2000, 12:03	118.75

Subbasin: Subbasin-50

Area (KM2) : 0.18
Latitude Degrees : -37.04
Longitude Degrees : 174.96
Downstream : Junction - 13

Loss Rate: Scs

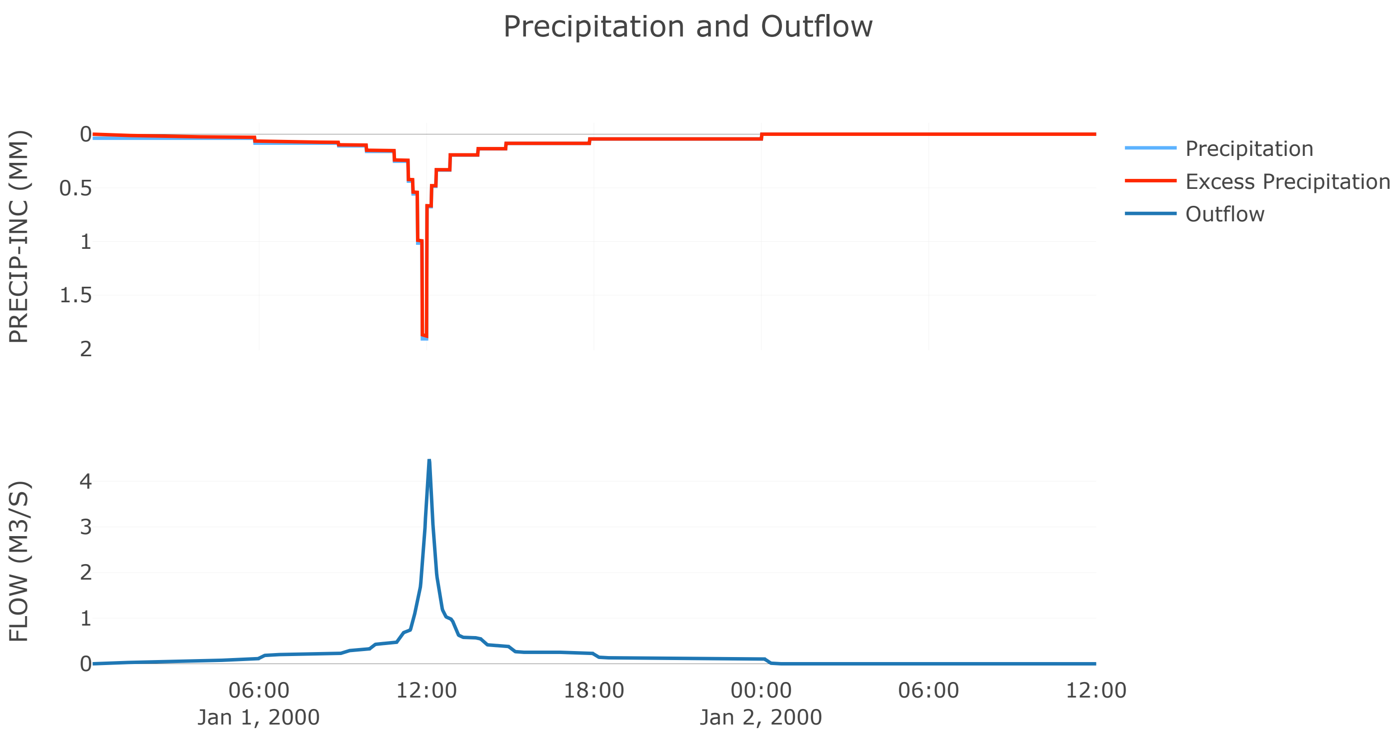
Percent Impervious Area	0
Curve Number	95.5
Initial Abstraction	0.5

Transform: Scs

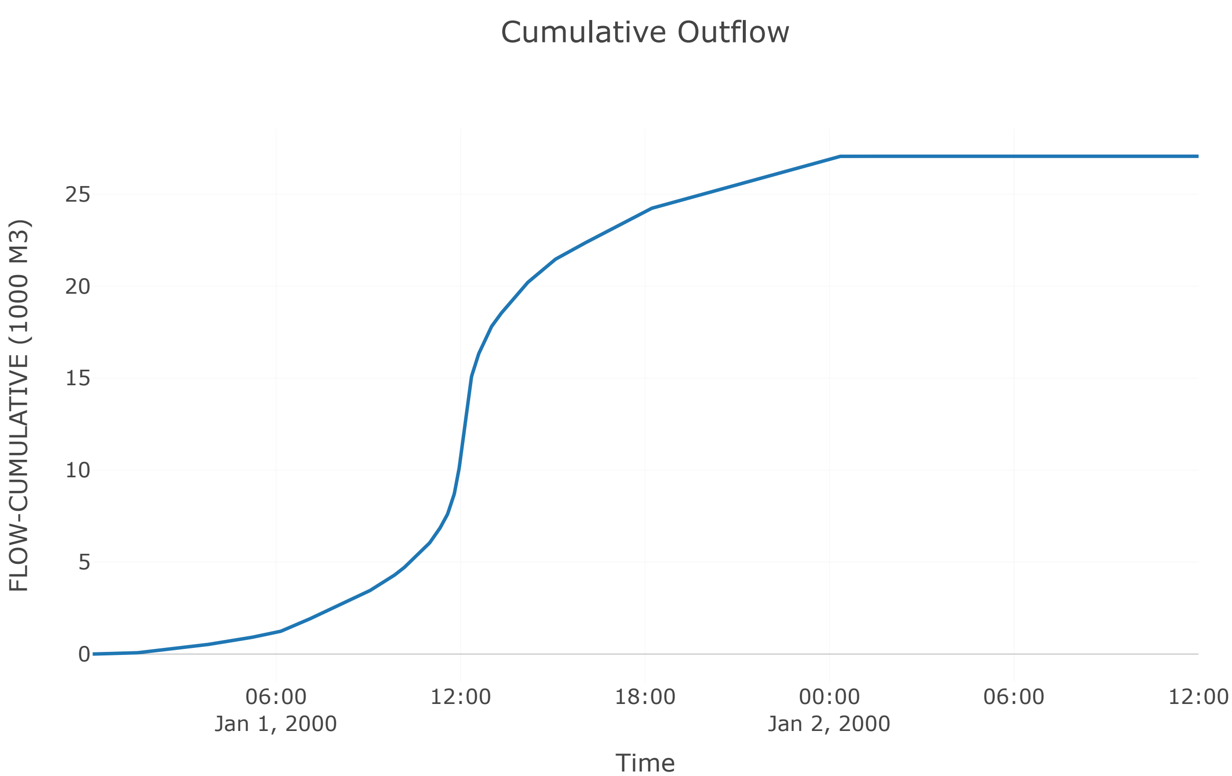
Lag	9.3
Unitgraph Type	Standard

Results: Subbasin-50

Peak Discharge (M3/S)	4.49
Time of Peak Discharge	01Jan2000, 12:05
Volume (MM)	152.98
Precipitation Volume (M3)	29123.79
Loss Volume (M3)	2061.8
Excess Volume (M3)	27062
Direct Runoff Volume (M3)	27062
Baseflow Volume (M3)	0



Precipitation and Outflow
PRECIP-INC (MM)
0
0.5
1
1.5
2
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
4
3
2
1
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00



Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
25
20
15
10
5
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-47

Area (KM2) : 0.13
Latitude Degrees : -37.04
Longitude Degrees : 174.96
Downstream : Junction - 47

Loss Rate: Scs

Percent Impervious Area	0
Curve Number	88.8
Initial Abstraction	1.9

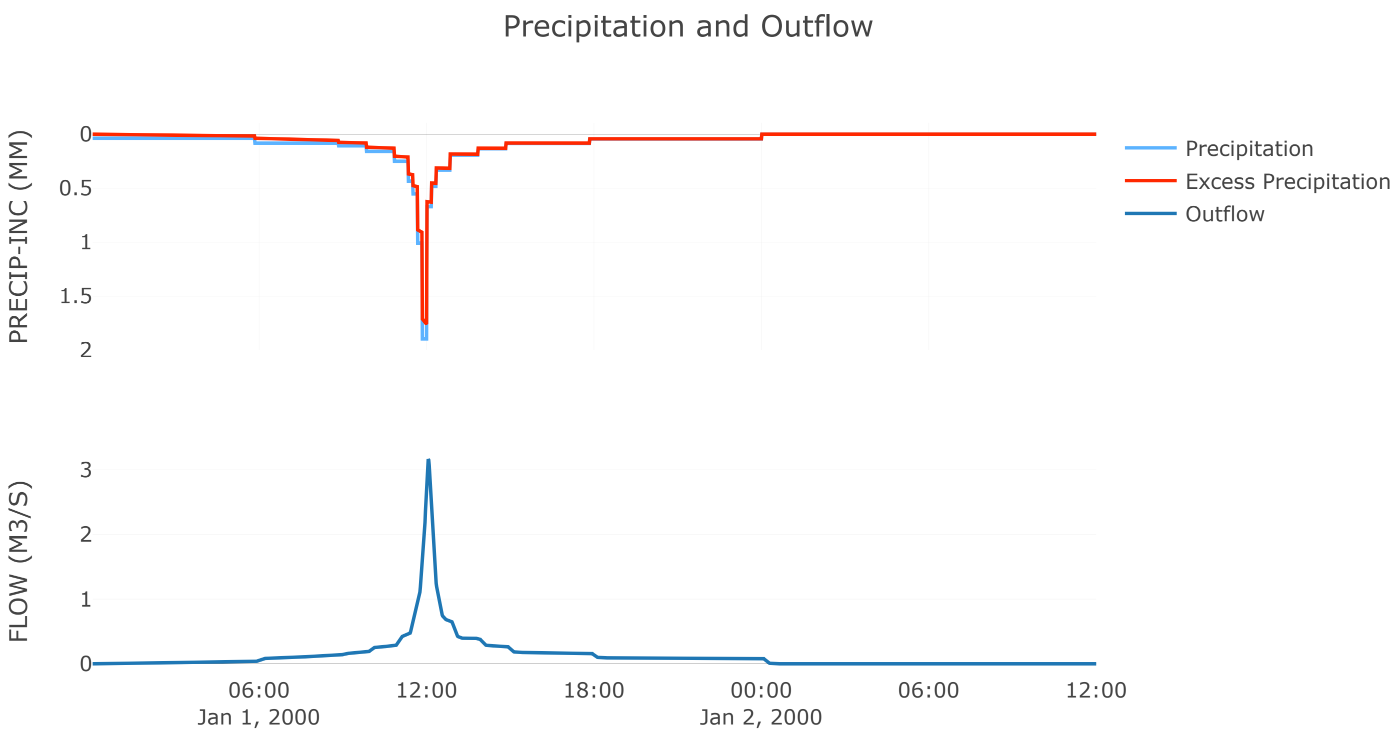
Transform: Scs

Lag	7.7
Unitgraph Type	Standard

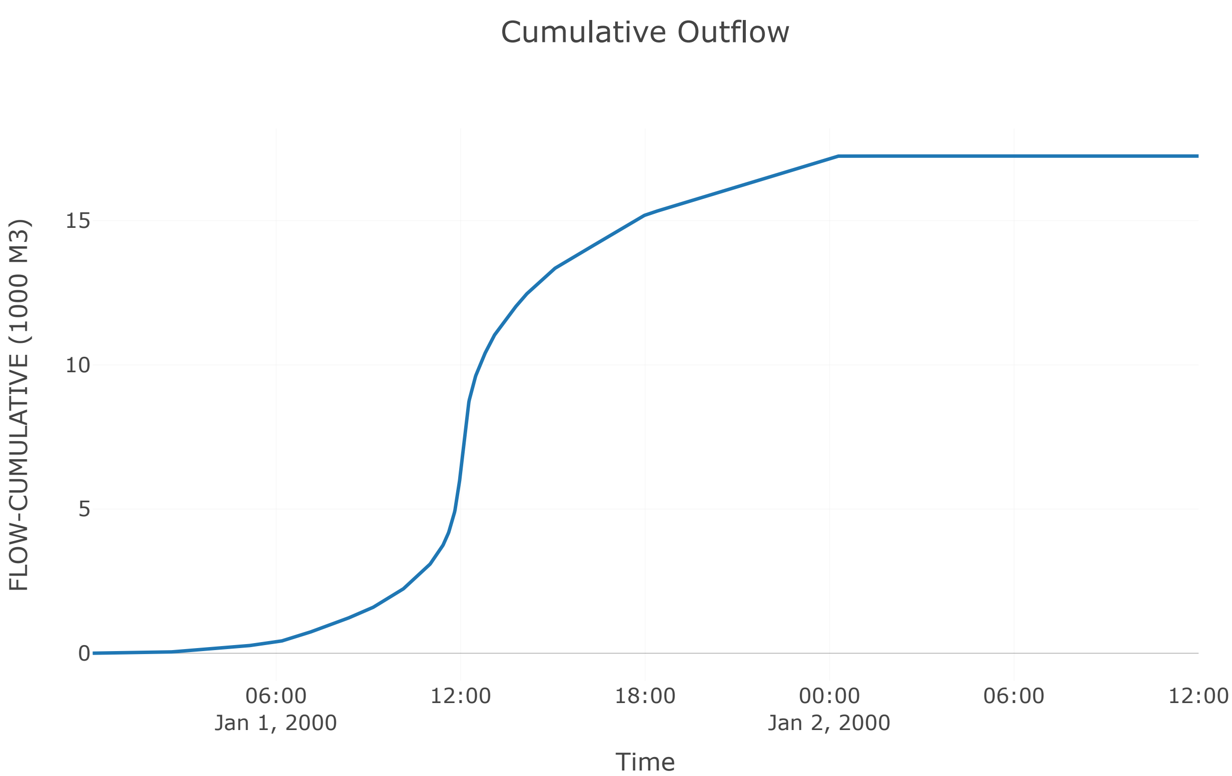
Results: Subbasin-47

Peak Discharge (M3/S)	3.17
Time of Peak Discharge	01Jan2000, 12:03
Volume (MM)	134.92
Precipitation Volume (M3)	20903.25
Loss Volume (M3)	3659.88
Excess Volume (M3)	17243.37
Direct Runoff Volume (M3)	17243.37
Baseflow Volume (M3)	0

Precipitation and Outflow



Cumulative Outflow



Subbasin: Subbasin-49

Area (KM2) : 0.06
Latitude Degrees : -37.04
Longitude Degrees : 174.96
Downstream : Junction - 47

Loss Rate: Scs

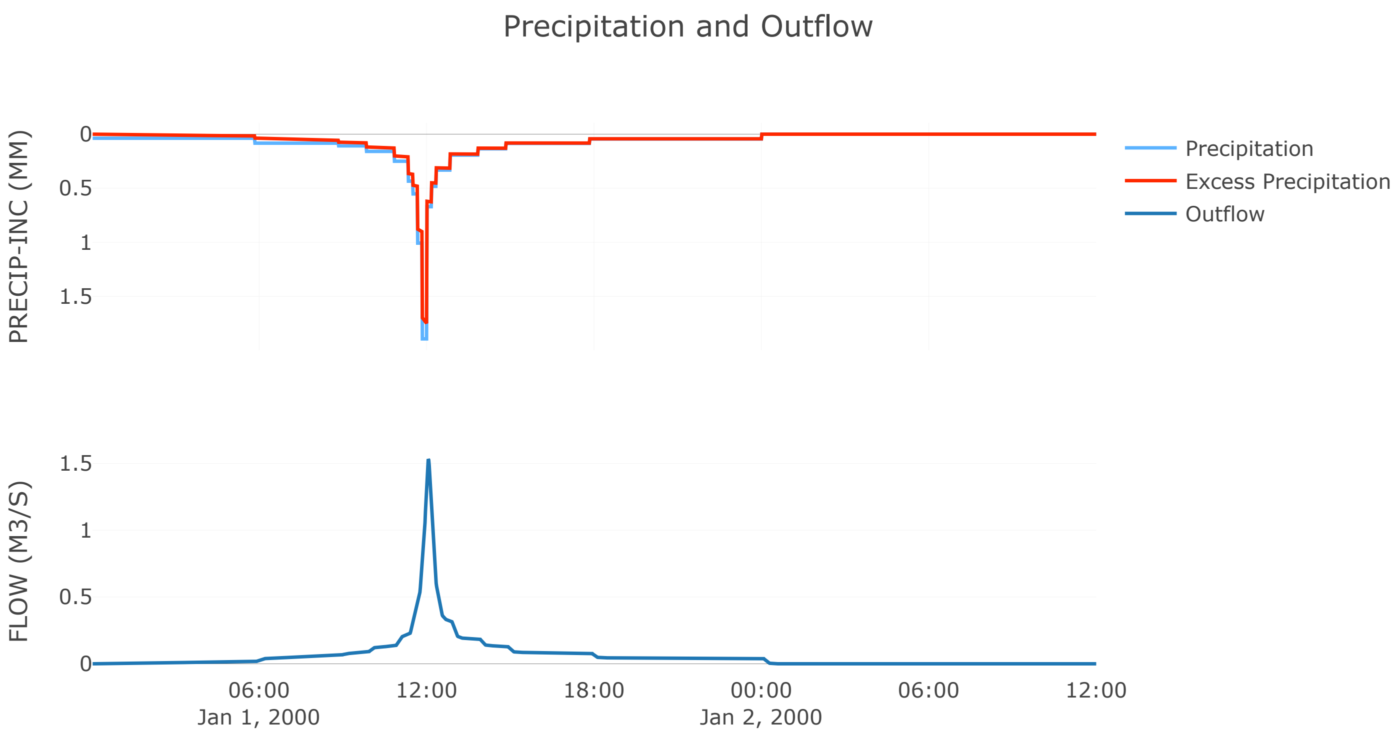
Percent Impervious Area	0
Curve Number	88.4
Initial Abstraction	2

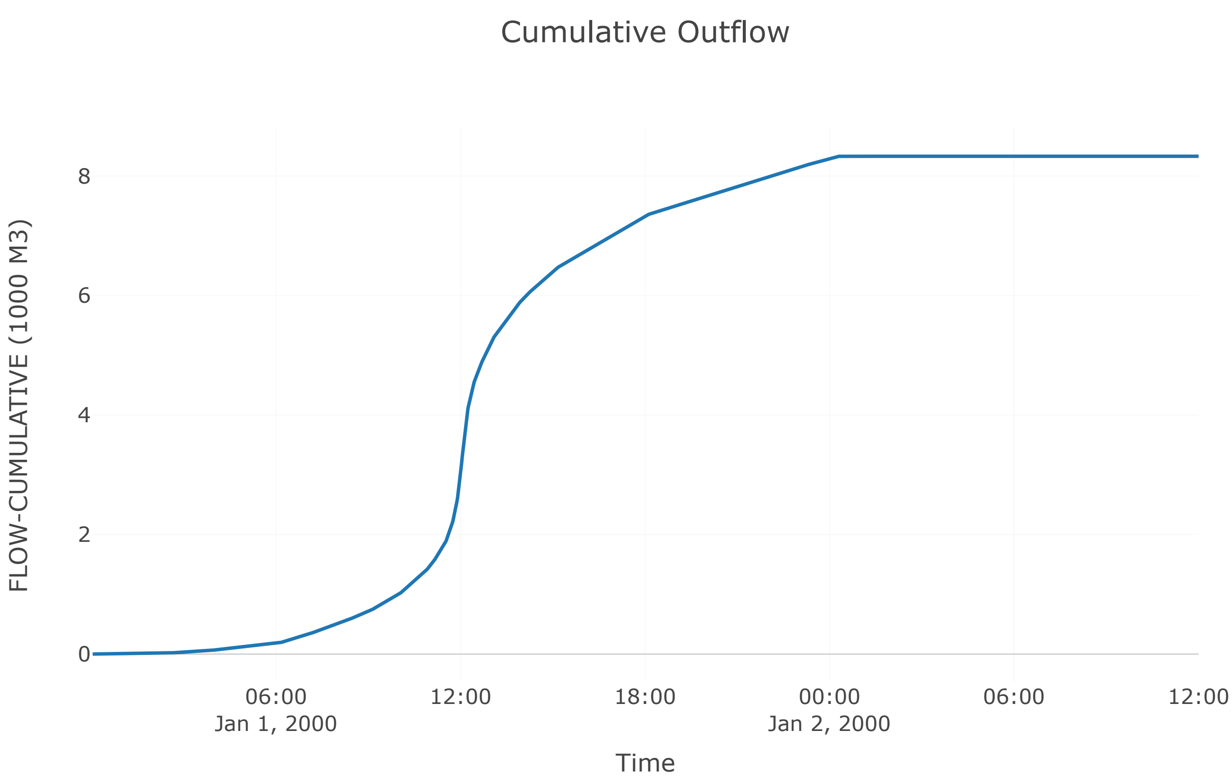
Transform: Scs

Lag	7.7
Unitgraph Type	Standard

Results: Subbasin-49

Peak Discharge (M3/S)	1.53
Time of Peak Discharge	01Jan2000, 12:03
Volume (MM)	133.75
Precipitation Volume (M3)	10178.13
Loss Volume (M3)	1845.62
Excess Volume (M3)	8332.51
Direct Runoff Volume (M3)	8332.51
Baseflow Volume (M3)	0


Precipitation and Outflow
PRECIP-INC (MM)
0
0.5
1
1.5
FLOW (M3/S)
1.5
1
0.5
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Precipitation
Excess Precipitation
Outflow


Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
8
6
4
2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-46

Area (KM2) : 0.25
Latitude Degrees : -37.04
Longitude Degrees : 174.95
Downstream : Junction - 11

Loss Rate: Scs

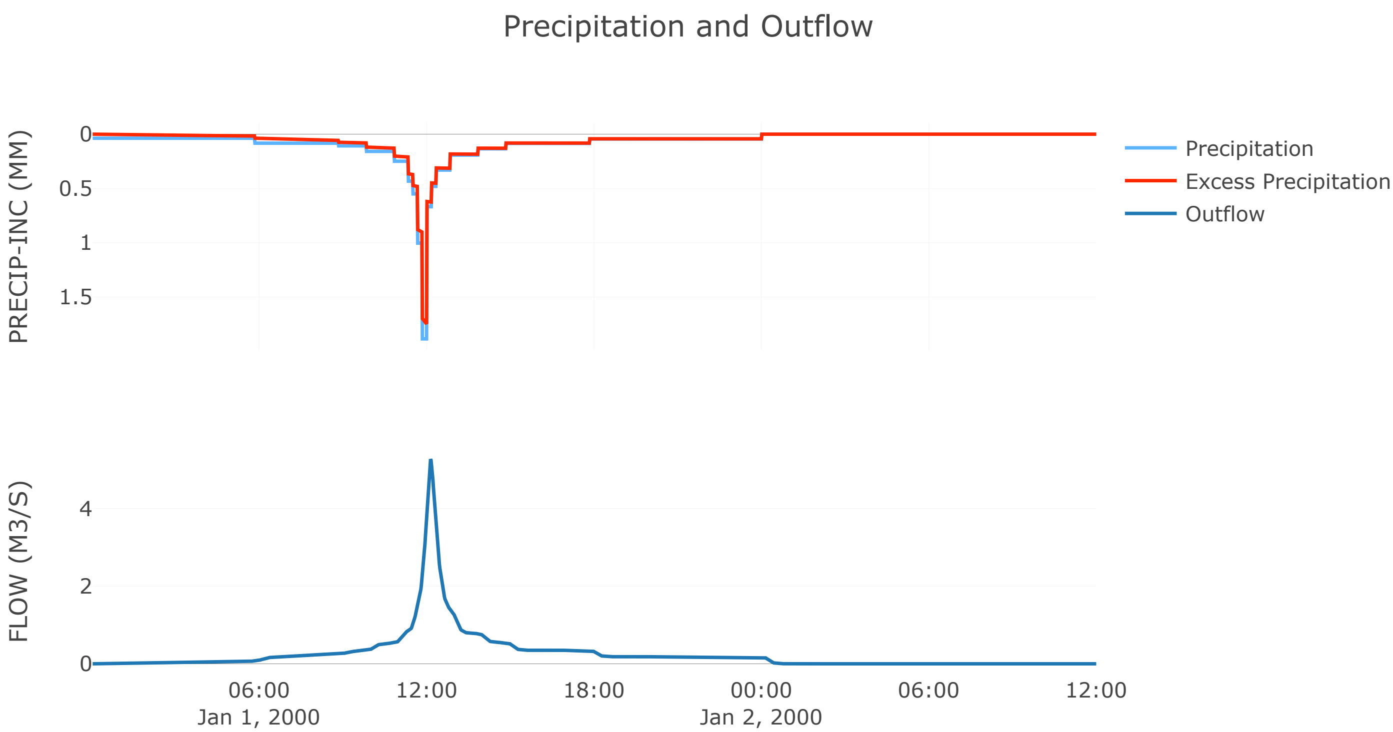
Percent Impervious Area	0
Curve Number	88.7
Initial Abstraction	1.9

Transform: Scs

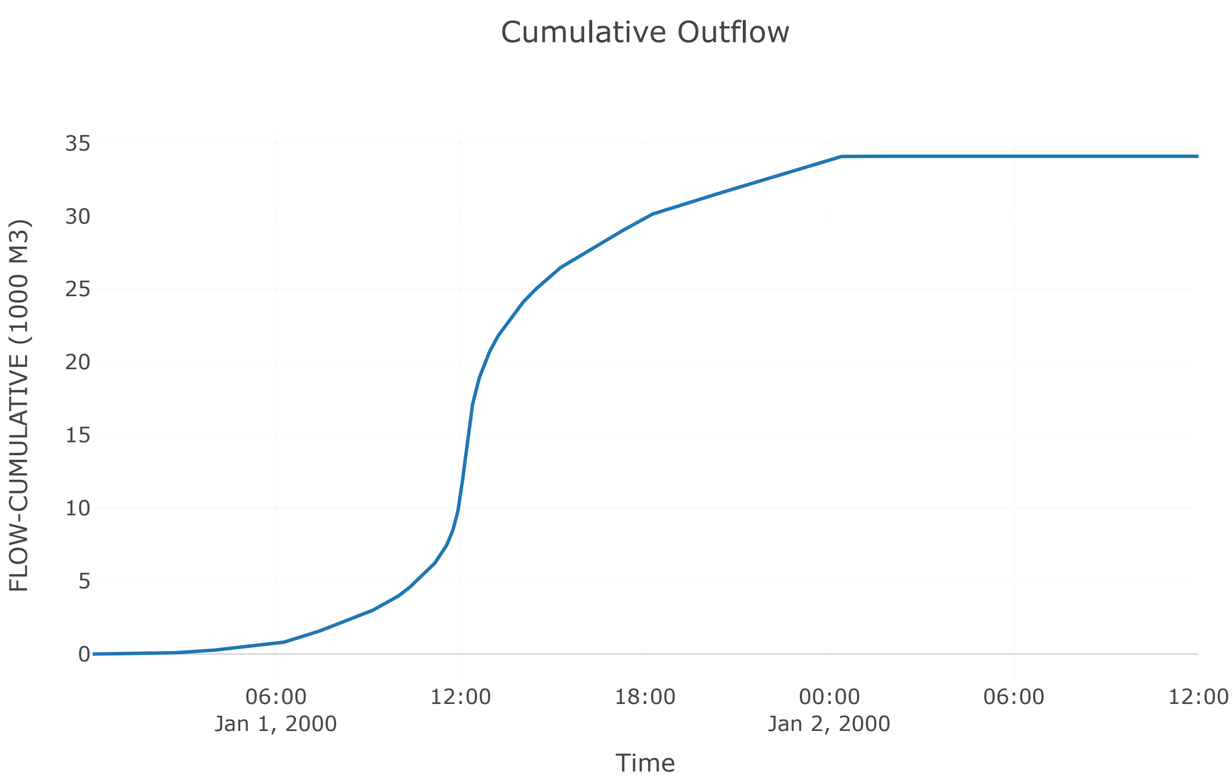
Lag	12.8
Unitgraph Type	Standard

Results: Subbasin-46

Peak Discharge (M3/S)	5.28
Time of Peak Discharge	01Jan2000, 12:08
Volume (MM)	133.83
Precipitation Volume (M3)	41447.68
Loss Volume (M3)	7347.62
Excess Volume (M3)	34100.06
Direct Runoff Volume (M3)	34100.06
Baseflow Volume (M3)	0



Precipitation and Outflow
PRECIP-INC (MM)
0
0.5
1
1.5
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
4
2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00



Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
35
30
25
20
15
10
5
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-59

Area (KM2) : 0.02
Latitude Degrees : -37.04
Longitude Degrees : 174.97

Loss Rate: Scs

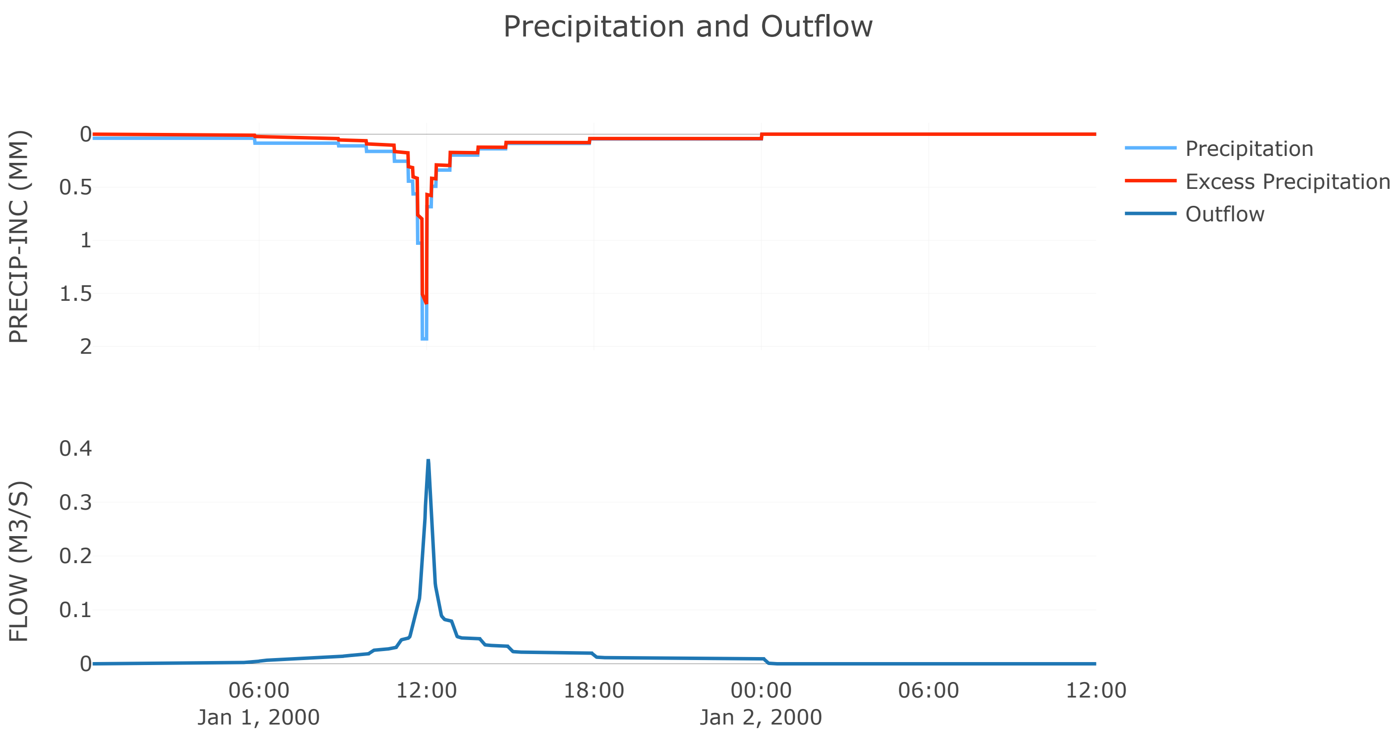
Percent Impervious Area	0
Curve Number	80.5
Initial Abstraction	3.6

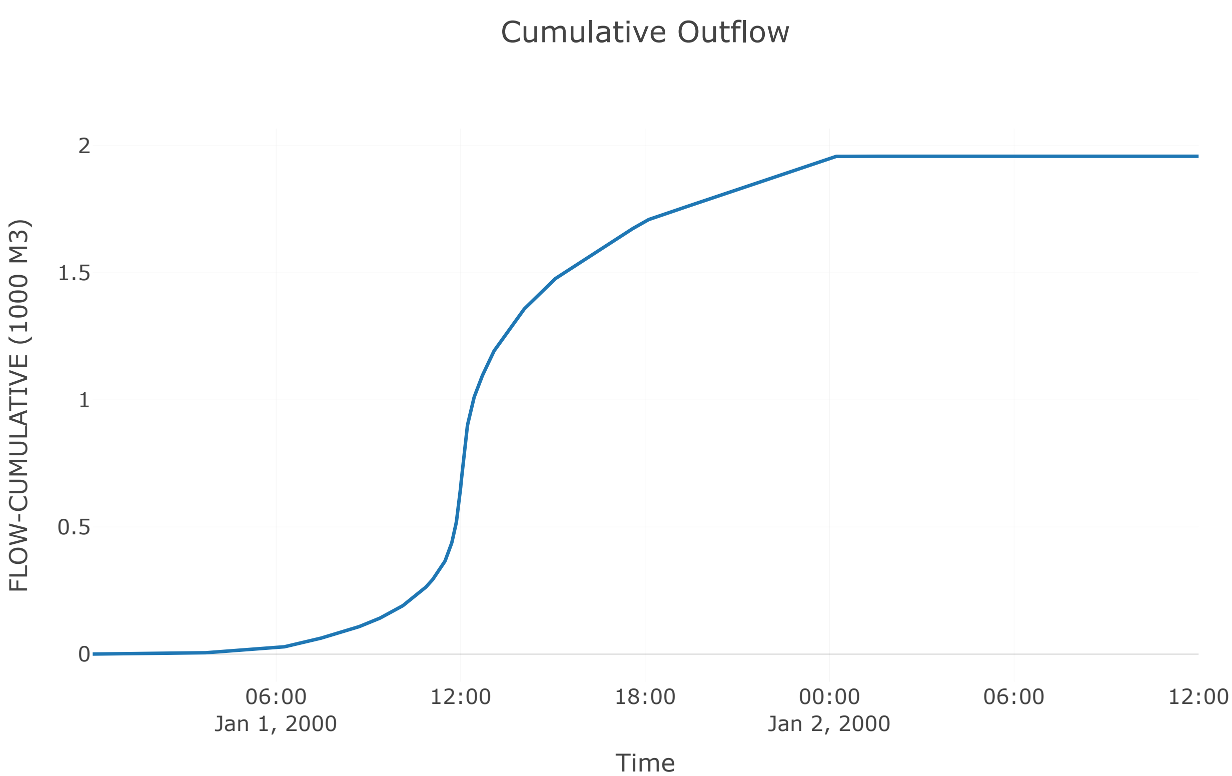
Transform: Scs

Lag	6.7
Unitgraph Type	Standard

Results: Subbasin-59

Peak Discharge (M3/S)	0.38
Time of Peak Discharge	01Jan2000, 12:03
Volume (MM)	118.24
Precipitation Volume (M3)	2757.93
Loss Volume (M3)	799.39
Excess Volume (M3)	1958.54
Direct Runoff Volume (M3)	1958.54
Baseflow Volume (M3)	0


Precipitation and Outflow
PRECIP-INC (MM)
0
0.5
1
1.5
2
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
0.4
0.3
0.2
0.1
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00


Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
2
1.5
1
0.5
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-60

Area (KM2) : 0
Latitude Degrees : -37.04
Longitude Degrees : 174.97

Loss Rate: Scs

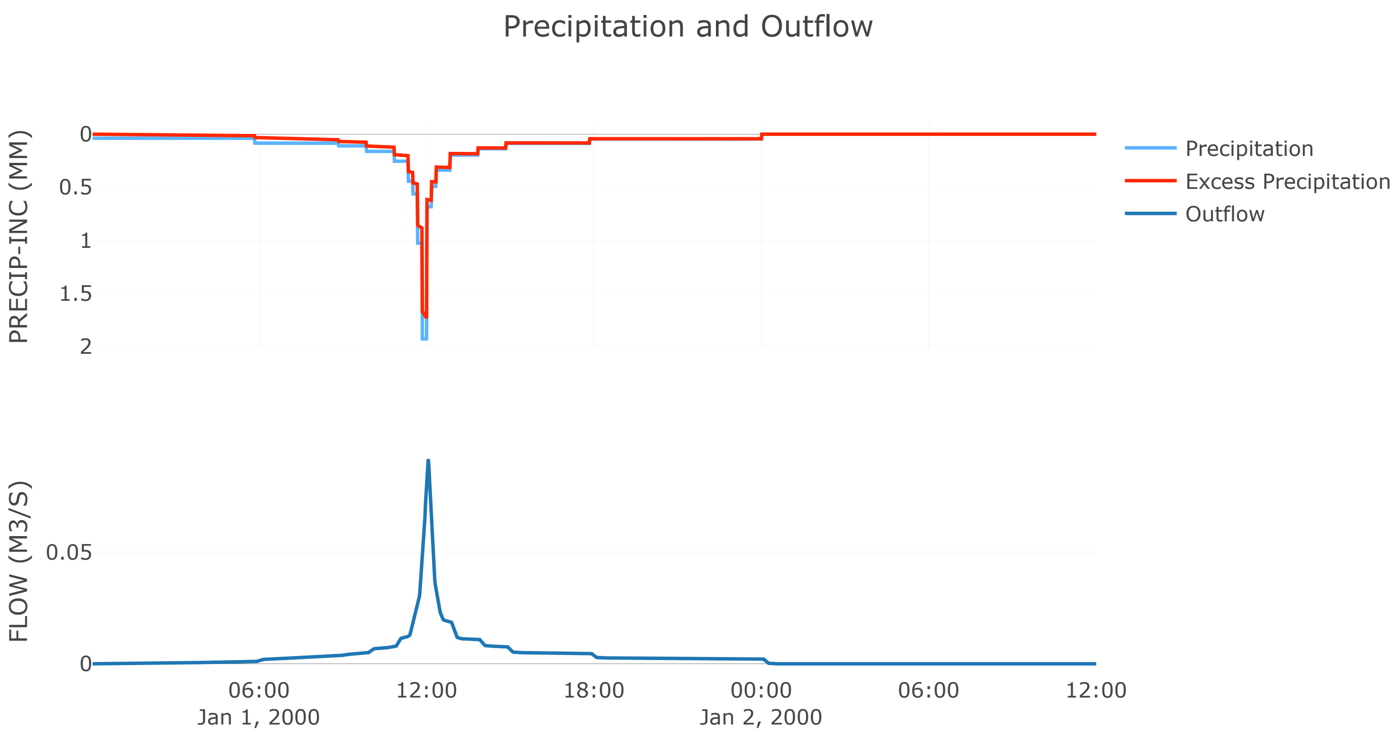
Percent Impervious Area	0
Curve Number	86
Initial Abstraction	2.5

Transform: Scs

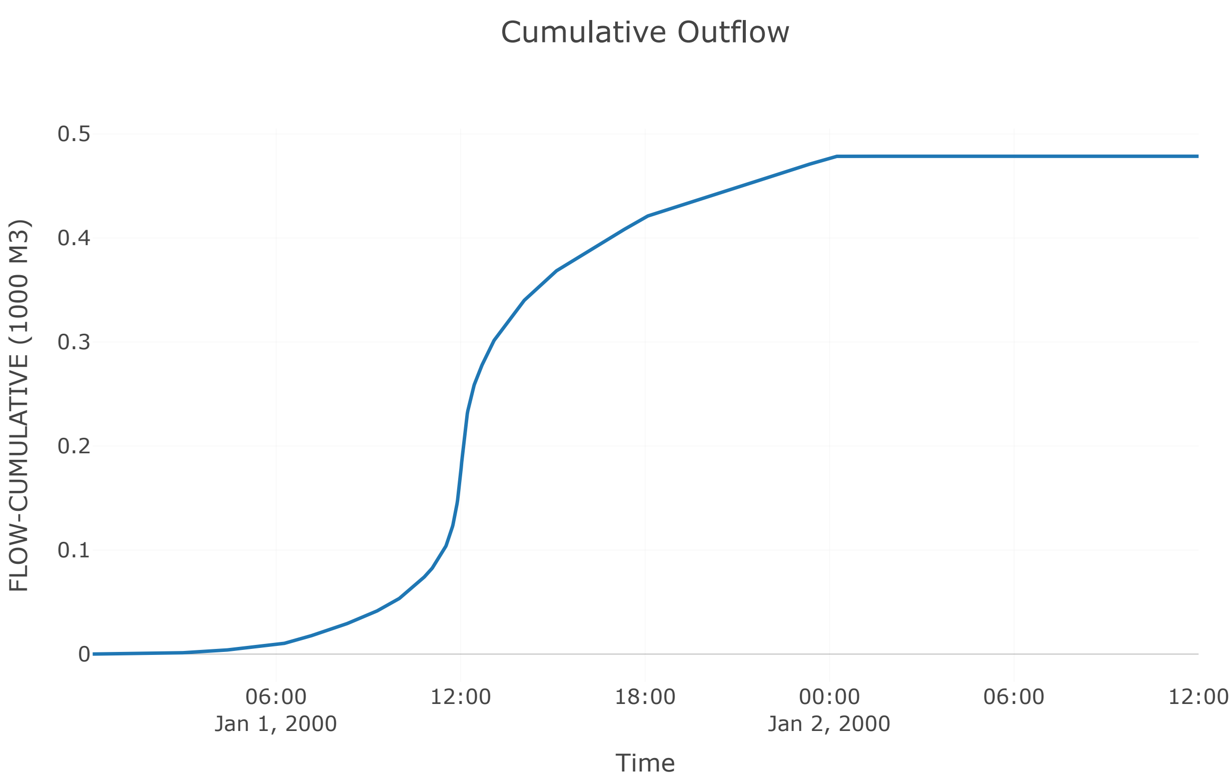
Lag	6.7
Unitgraph Type	Standard

Results: Subbasin-60

Peak Discharge (M3/S)	0.09
Time of Peak Discharge	01Jan2000, 12:03
Volume (MM)	130.98
Precipitation Volume (M3)	608.4
Loss Volume (M3)	129.8
Excess Volume (M3)	478.6
Direct Runoff Volume (M3)	478.6
Baseflow Volume (M3)	0



Precipitation and Outflow
PRECIP-INC (MM)
0
0.5
1
1.5
2
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
0.05
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00



Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
0.5
0.4
0.3
0.2
0.1
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

Subbasin: Subbasin-68

Area (KM2) : 0.01
Latitude Degrees : -37.03
Longitude Degrees : 174.96

Loss Rate: Scs

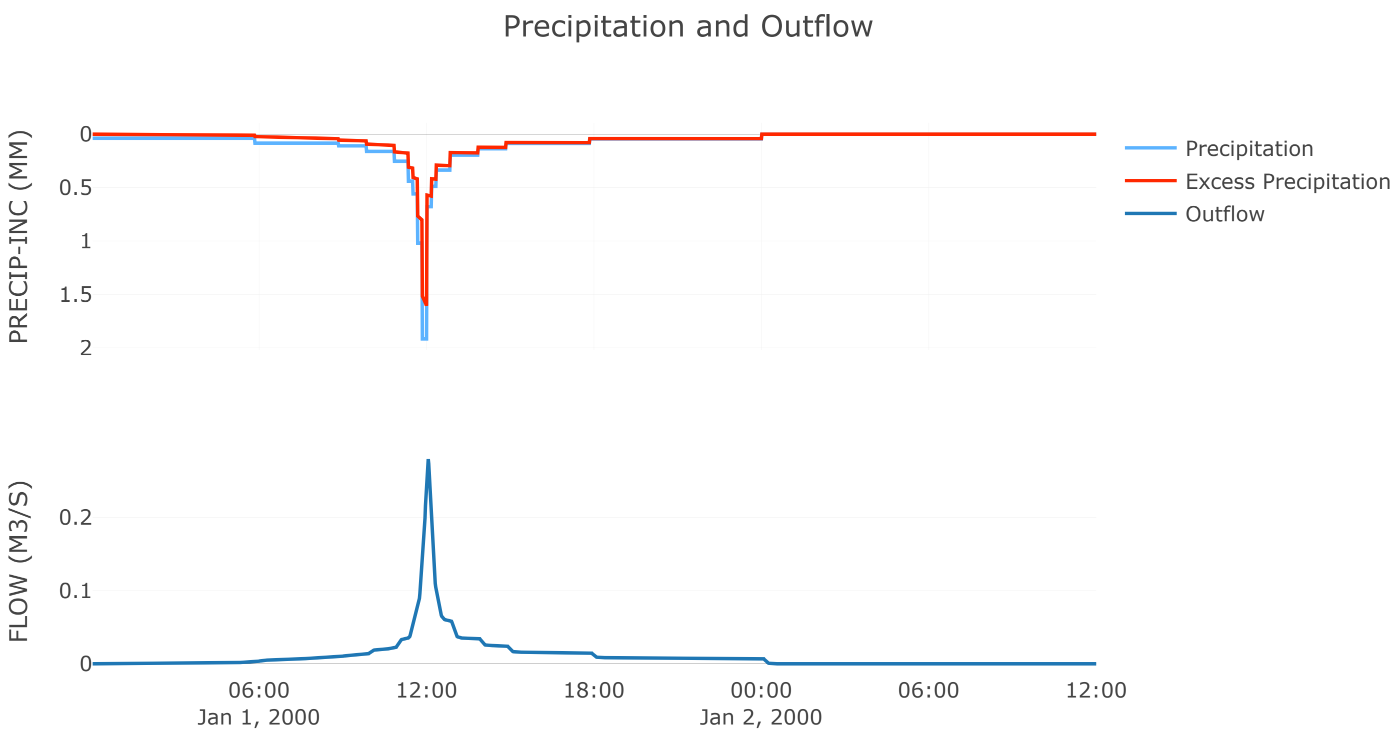
Percent Impervious Area	0
Curve Number	81.2
Initial Abstraction	3.5

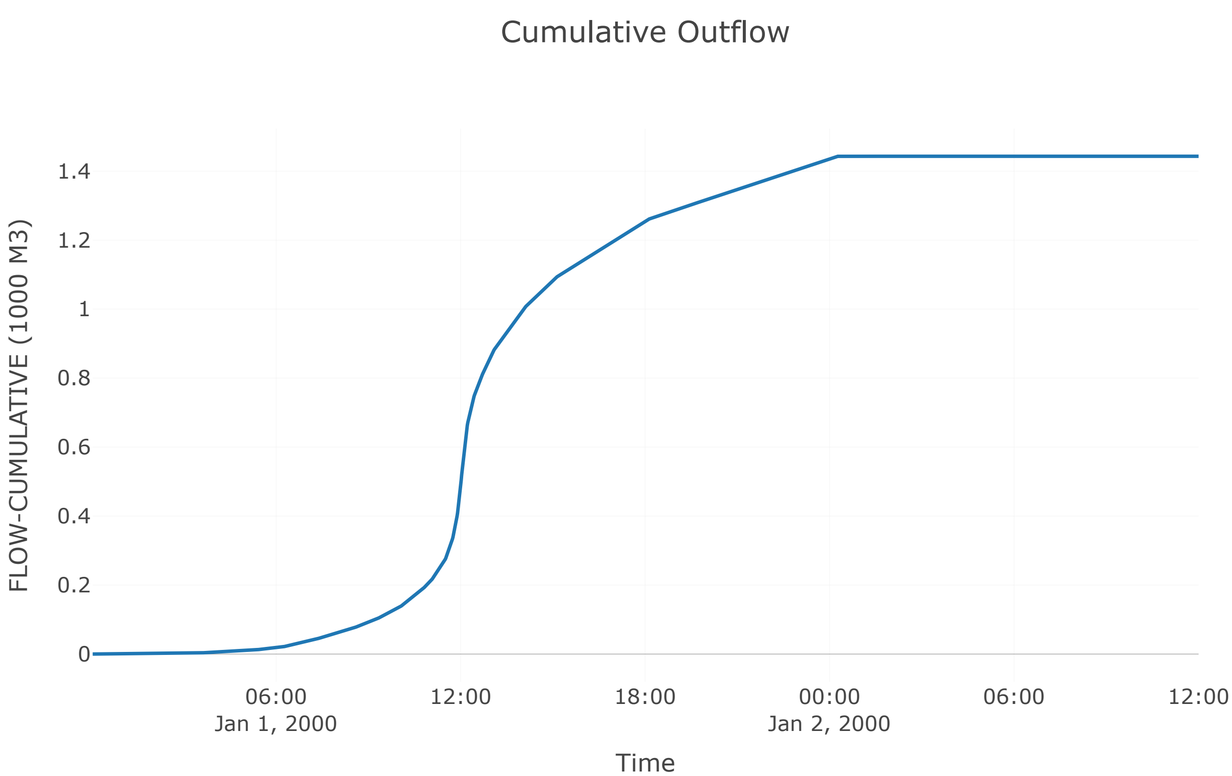
Transform: Scs

Lag	6.7
Unitgraph Type	Standard

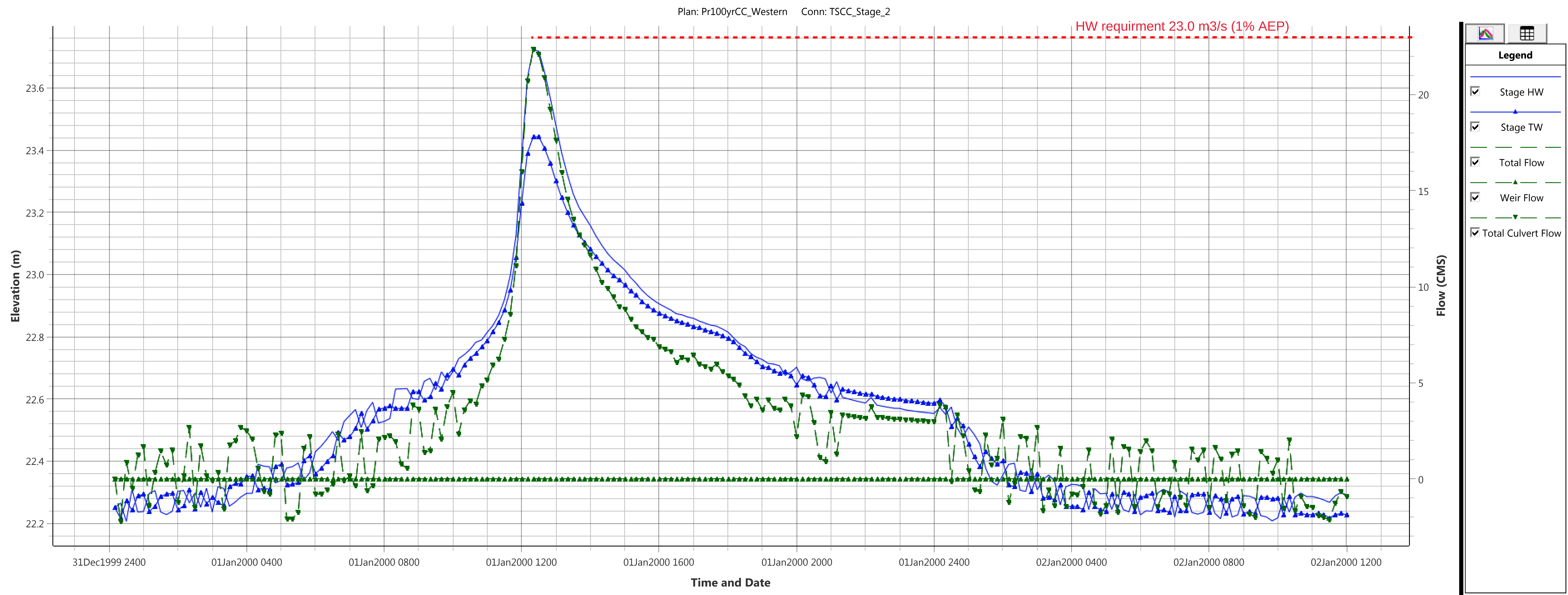
Results: Subbasin-68

Peak Discharge (M3/S)	0.28
Time of Peak Discharge	01Jan2000, 12:03
Volume (MM)	118.75
Precipitation Volume (M3)	2009.93
Loss Volume (M3)	566.77
Excess Volume (M3)	1443.16
Direct Runoff Volume (M3)	1443.16
Baseflow Volume (M3)	0

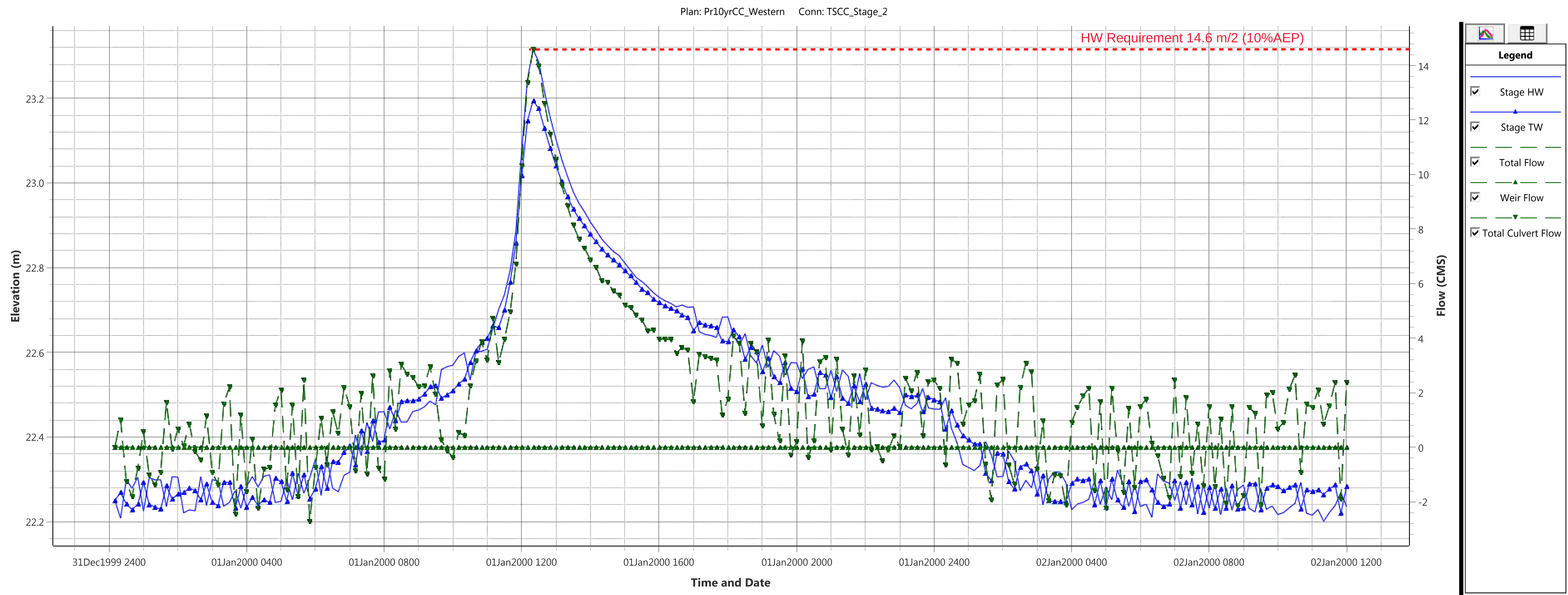

Precipitation and Outflow
PRECIP-INC (MM)
0
0.5
1
1.5
2
Precipitation
Excess Precipitation
Outflow
FLOW (M3/S)
0.2
0.1
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00


Cumulative Outflow
FLOW-CUMULATIVE (1000 M3)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
06:00
Jan 1, 2000
12:00
18:00
00:00
Jan 2, 2000
06:00
12:00
Time

APPENDIX J – RAS WEST CATCHMENT HYDROGRAPHS



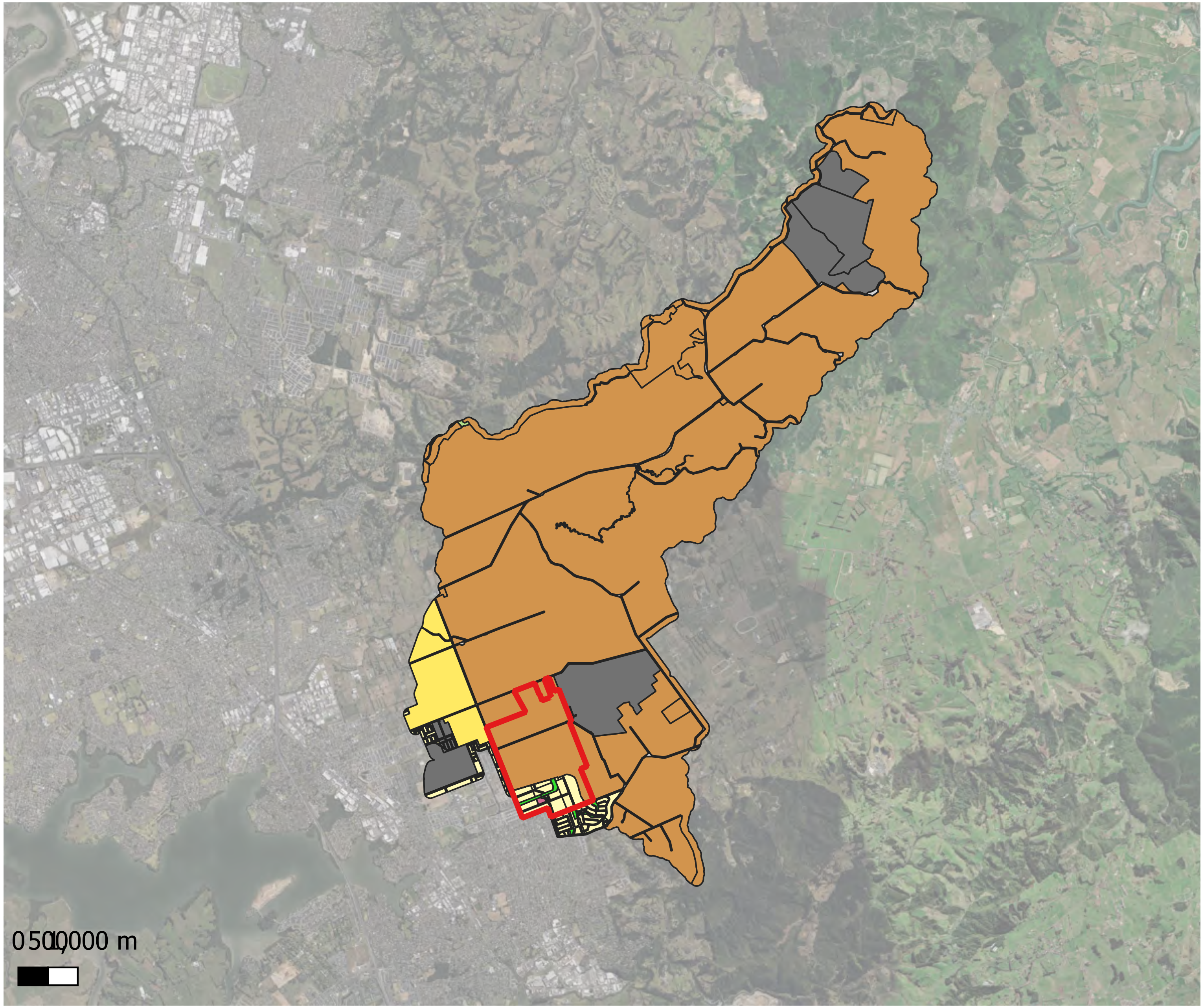
Plan: Pr100yrCC_Western
Conn: TSCC_Stage_2
HW requirment 23.0 m3/s (1% AEP)
Elevation (m)
23.6
23.4
23.2
23.0
22.8
22.6
22.4
22.2
Flow (CMS)
20
15
10
5
0
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Time and Date
Legend
Stage HW
Stage TW
Total Flow
Weir Flow
Total Culvert Flow



Plan: Pr10yrCC_Western Conn: TSCC_Stage_2
HW Requirement 14.6 m/2 (10%AEP)
Elevation (m)
Flow (CMS)
Time and Date
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Legend
Stage HW
Stage TW
Total Flow
Weir Flow
Total Culvert Flow

APPENDIX K – ZONING

Pre development Zoning



Legend

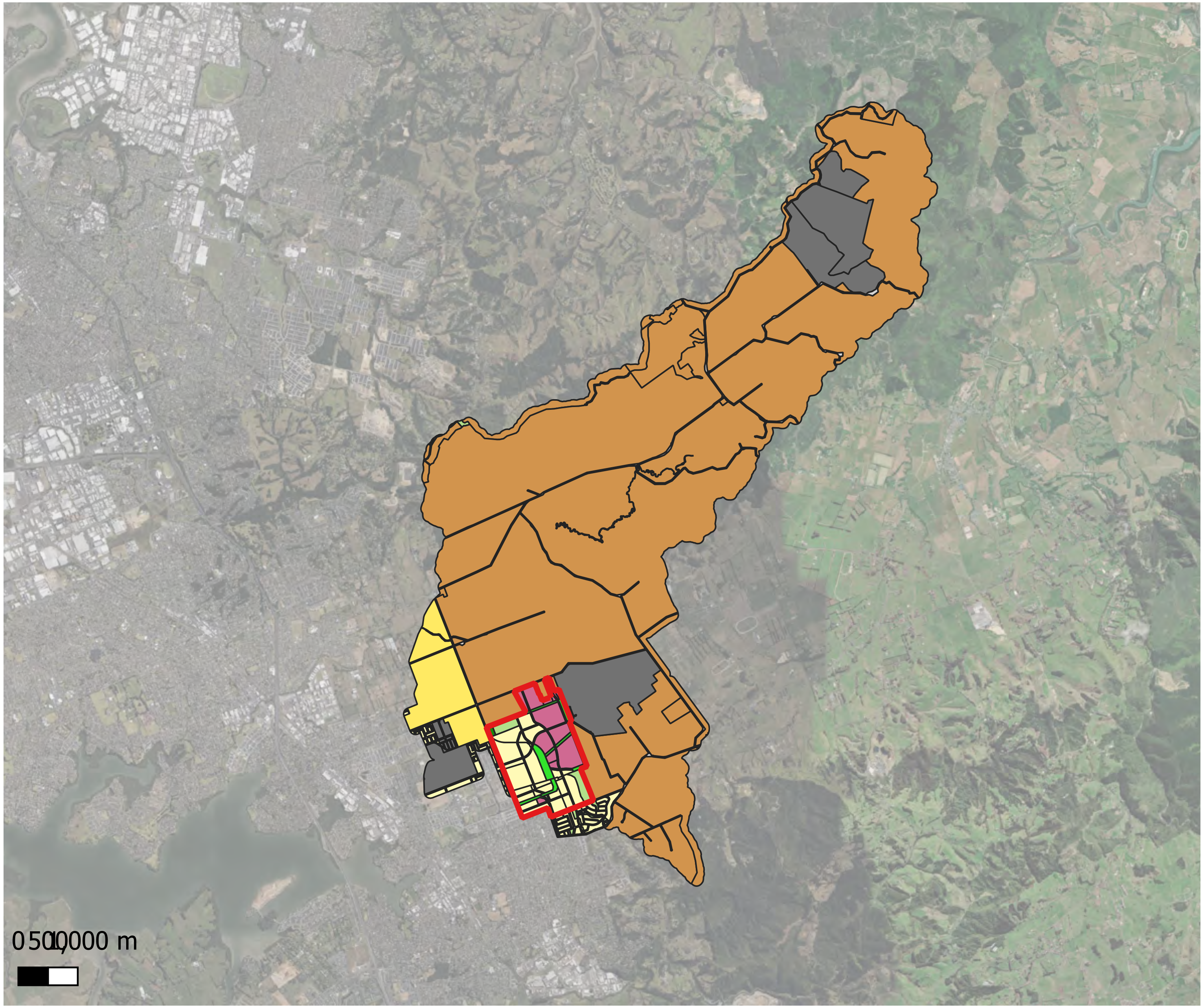
Pr-Bdy

Pre development Zoning

- Business - General Business Zone
- Business - Town Centre Zone
- Future Urban Zone
- Residential - Mixed Housing Suburban Zone
- Residential - Mixed Housing Urban Zone
- Residential - Single House Zone
- Road
- Rural - Countryside Living Zone
- Rural - Mixed Rural Zone
- Special Purpose - Airports and Airfields Zone
- Special Purpose - Major Recreation Facility Zone
- Special Purpose - Quarry Zone
- Special Purpose - School Zone
- Water
- Open Space - 10% Imp
- Open Space - 30% Imp
- Open Space - Wetland (100% Imp)

SK033
REV 001

Post development Zoning



Legend

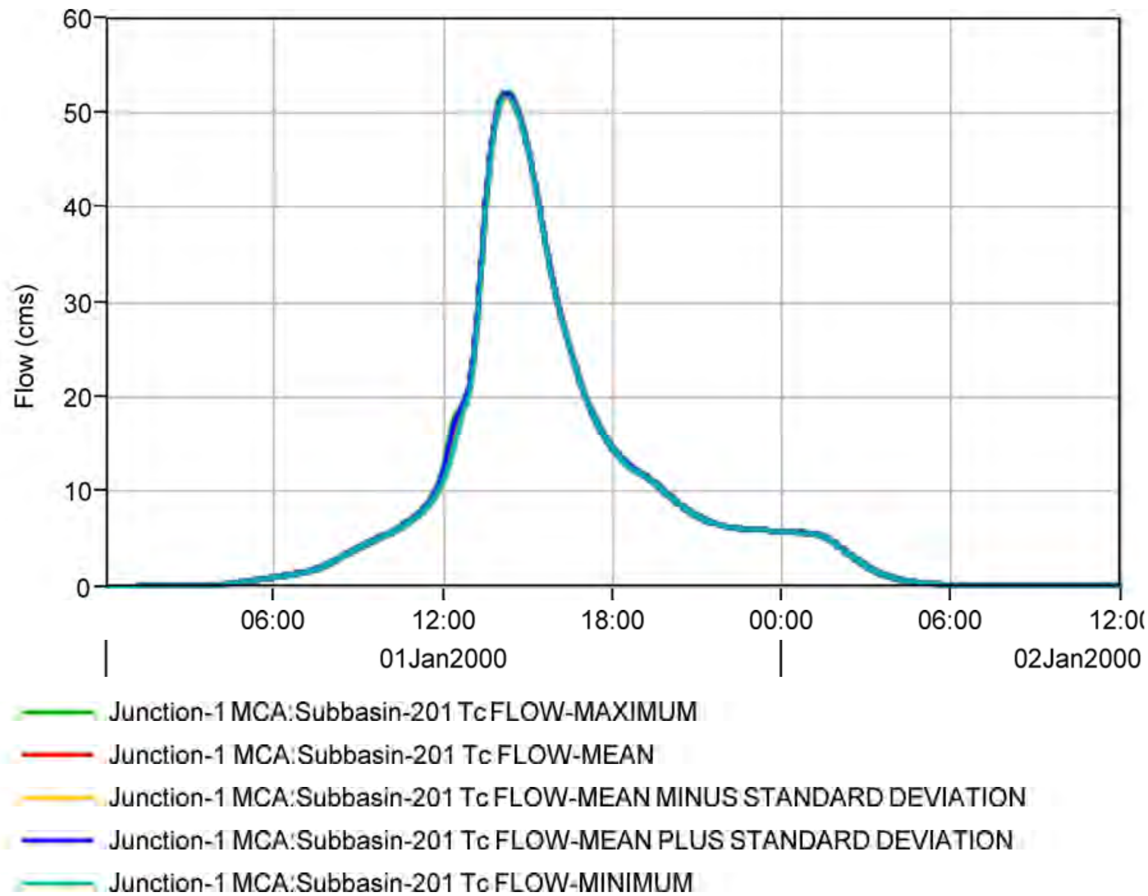
- Pr-Bdy

Post development Zoning

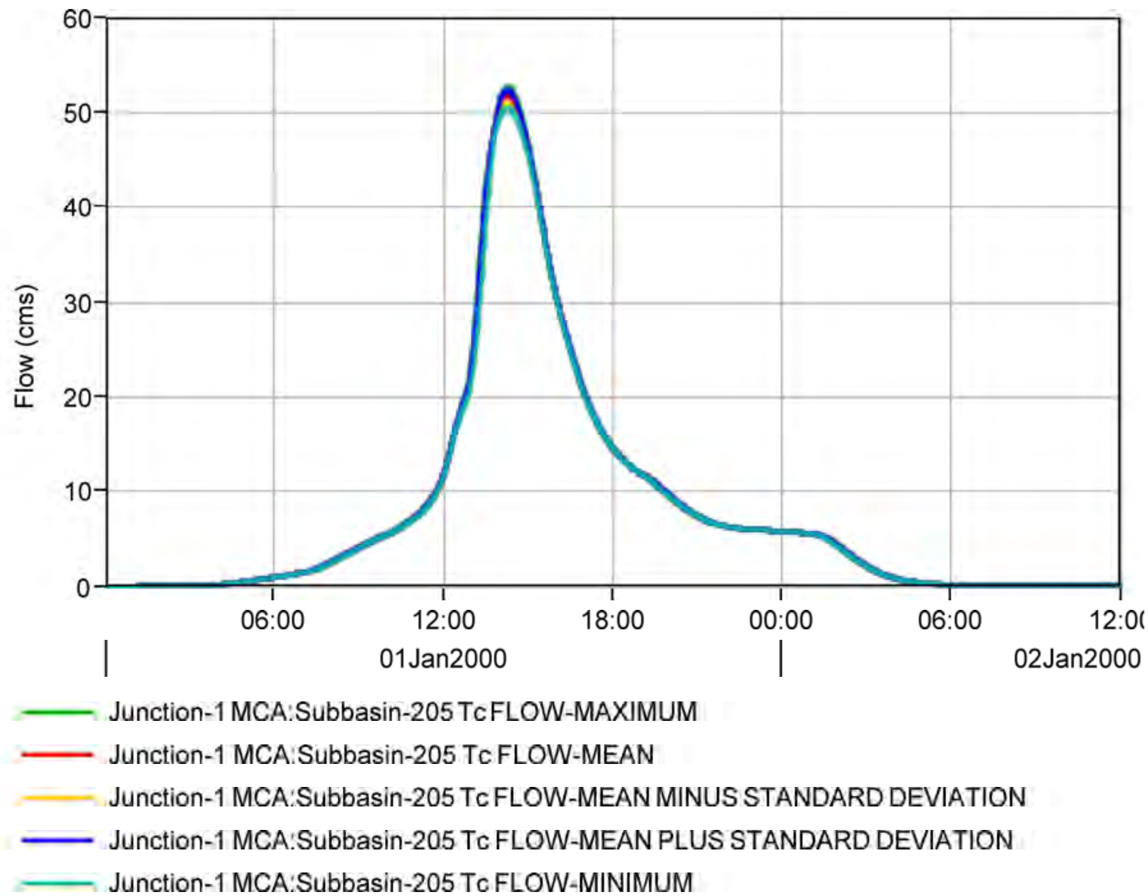
- Business - General Business Zone
- Business - Town Centre Zone
- Future Urban Zone
- Residential - Mixed Housing Suburban Zone
- Residential - Mixed Housing Urban Zone
- Residential - Single House Zone
- Road
- Rural - Countryside Living Zone
- Rural - Mixed Rural Zone
- Special Purpose - Airports and Airfields Zone
- Special Purpose - Major Recreation Facility Zone
- Special Purpose - Quarry Zone
- Special Purpose - School Zone
- Water
- Open Space - 10% Imp
- Open Space - 30% Imp
- Open Space - Wetland (100% Imp)

SK032
REV 001

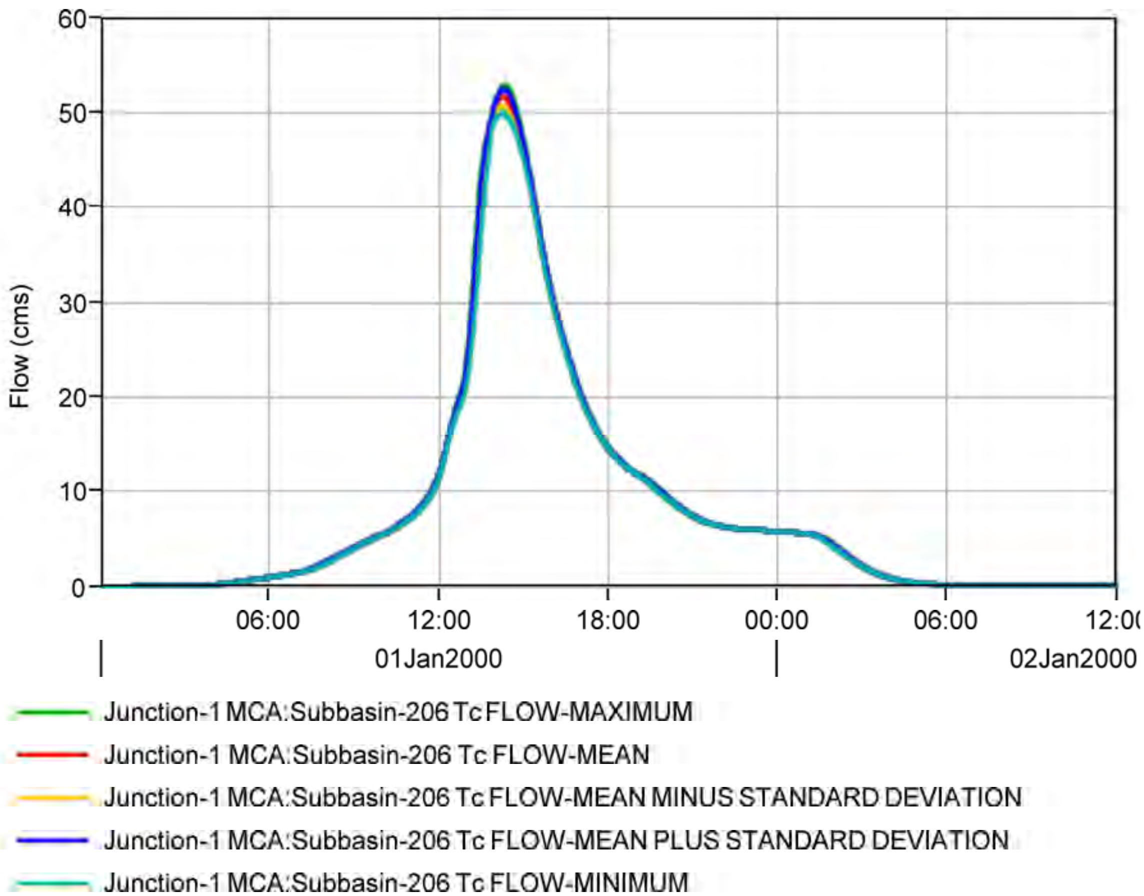
APPENDIX L – HMS Tc Sensitivity anaylysis (Junction-1)



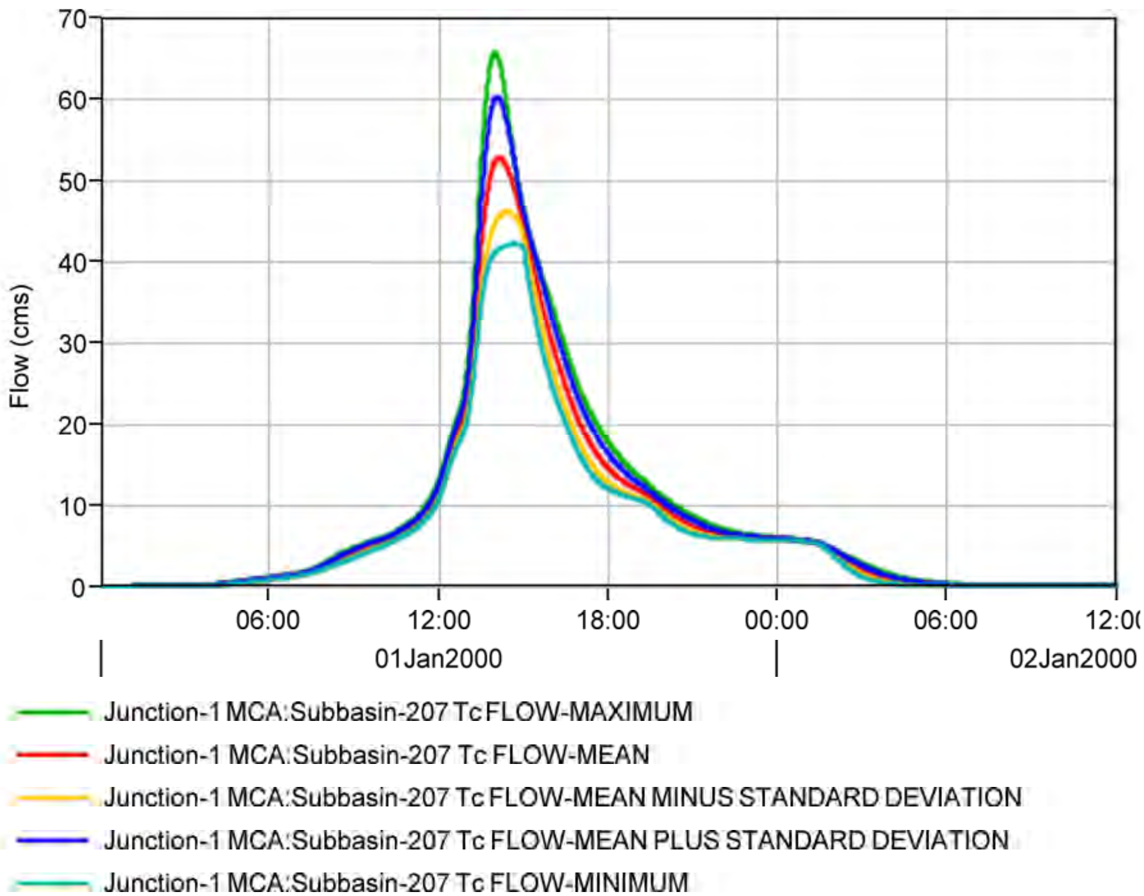
60
50
40
30
20
10
0
Flow (cms)
06:00
12:00
18:00
00:00
06:00
01Jan2000
02Jan2000
Junction-1 MCA:Subbasin-201 Tc FLOW-MAXIMUM
Junction-1 MCA:Subbasin-201 Tc FLOW-MEAN
Junction-1 MCA:Subbasin-201 Tc FLOW-MEAN MINUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-201 Tc FLOW-MEAN PLUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-201 Tc FLOW-MINIMUM



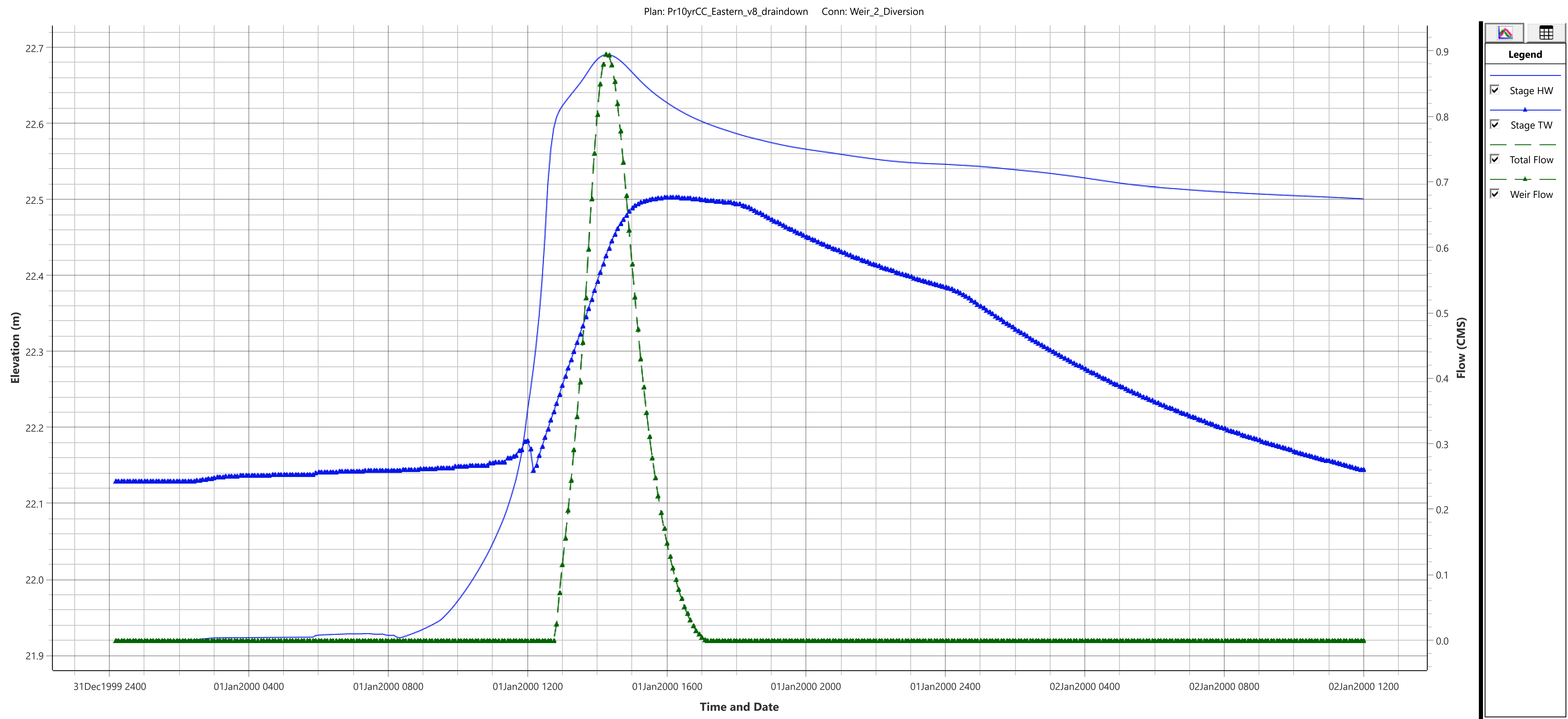
60
50
40
30
20
10
0
Flow (cms)
06:00
12:00
18:00
00:00
06:00
01Jan2000
02Jan2000
Junction-1 MCA:Subbasin-205 Tc FLOW-MAXIMUM
Junction-1 MCA:Subbasin-205 Tc FLOW-MEAN
Junction-1 MCA:Subbasin-205 Tc FLOW-MEAN MINUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-205 Tc FLOW-MEAN PLUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-205 Tc FLOW-MINIMUM



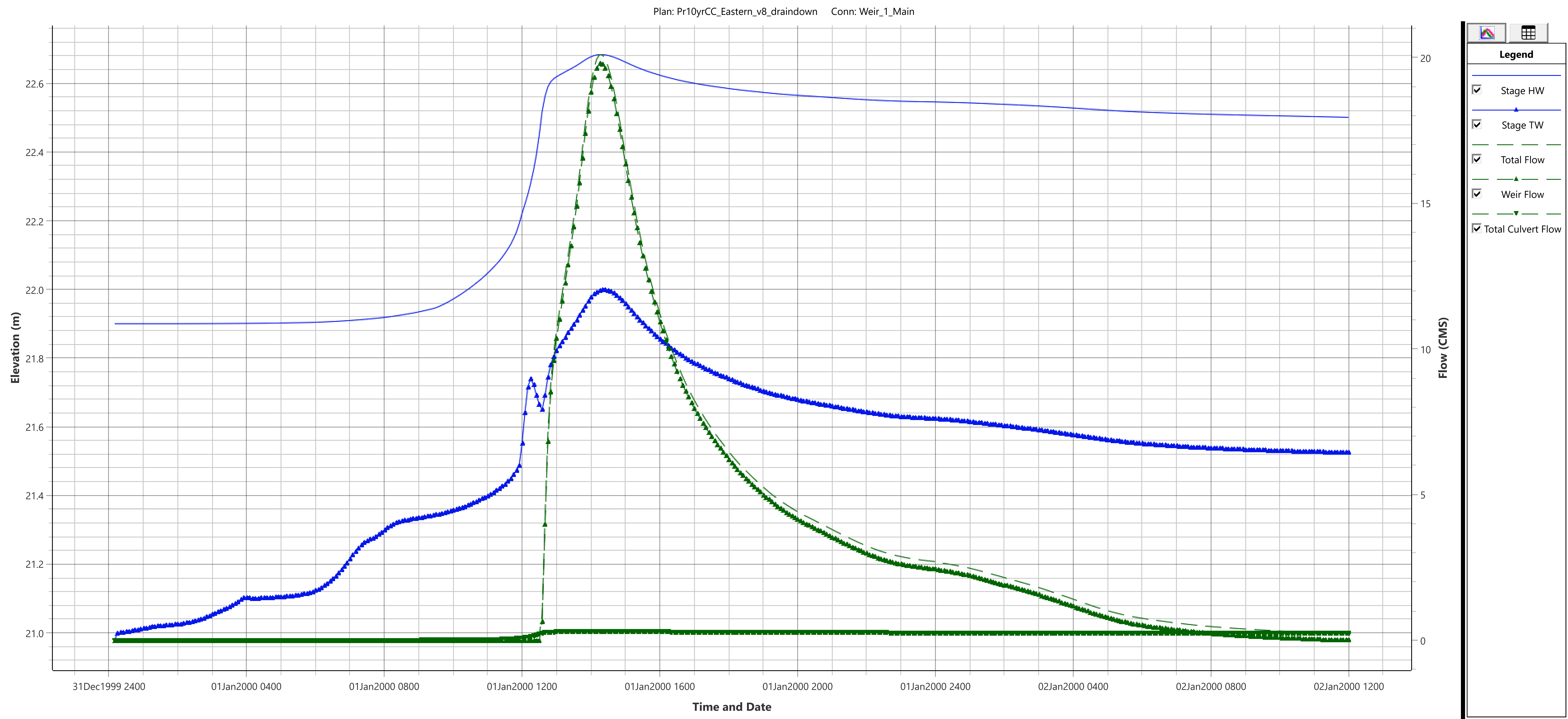
Flow (cms)
60
50
40
30
20
10
0
06:00
12:00
18:00
00:00
06:00
12:00
01Jan2000
02Jan2000
Junction-1 MCA:Subbasin-206 Tc FLOW-MAXIMUM
Junction-1 MCA:Subbasin-206 Tc FLOW-MEAN
Junction-1 MCA:Subbasin-206 Tc FLOW-MEAN MINUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-206 Tc FLOW-MEAN PLUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-206 Tc FLOW-MINIMUM

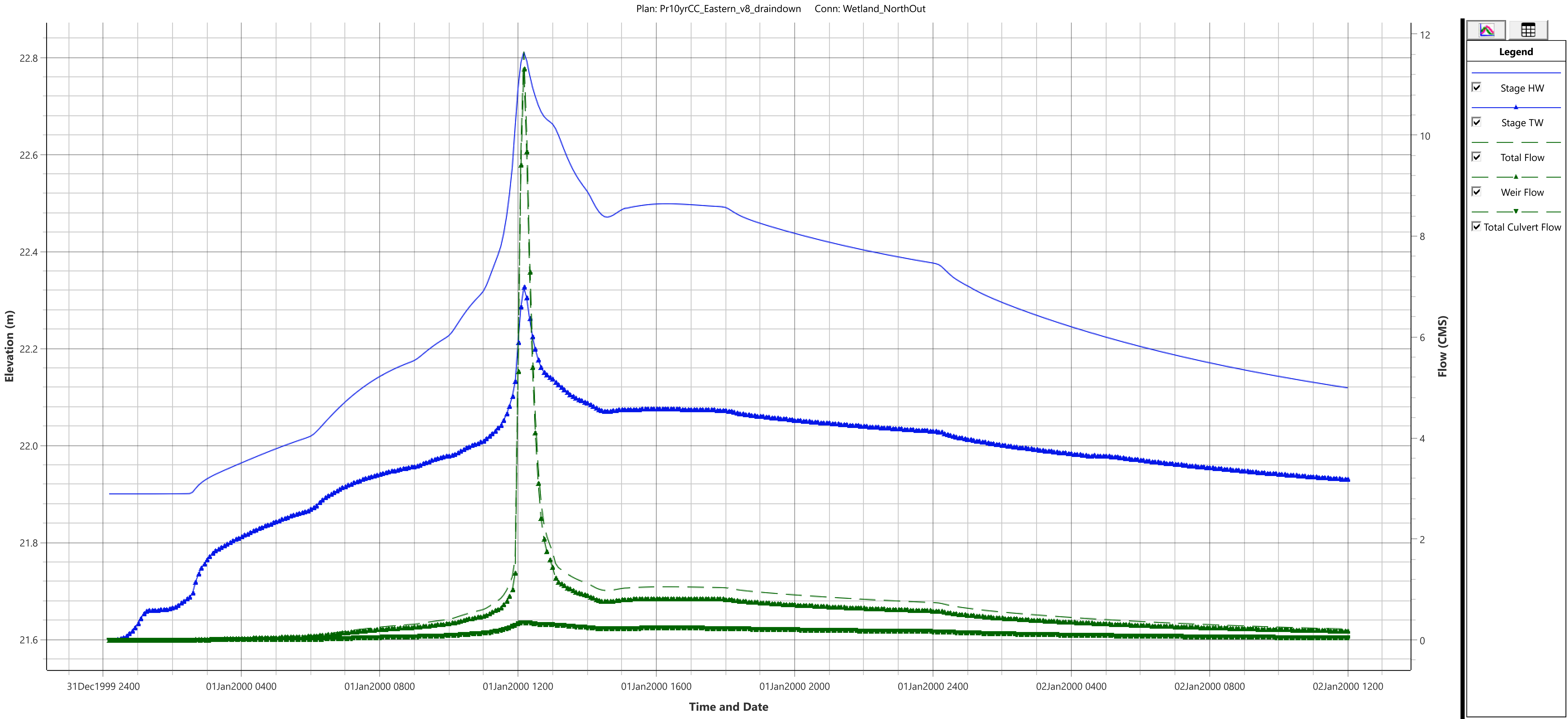

Flow (cms)
70
60
50
40
30
20
10
0
06:00
12:00
18:00
00:00
06:00
12:0(
01Jan2000
02Jan2000
Junction-1 MCA:Subbasin-207 Tc FLOW-MAXIMUM
Junction-1 MCA:Subbasin-207 Tc FLOW-MEAN
Junction-1 MCA:Subbasin-207 Tc FLOW-MEAN MINUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-207 Tc FLOW-MEAN PLUS STANDARD DEVIATION
Junction-1 MCA:Subbasin-207 Tc FLOW-MINIMUM

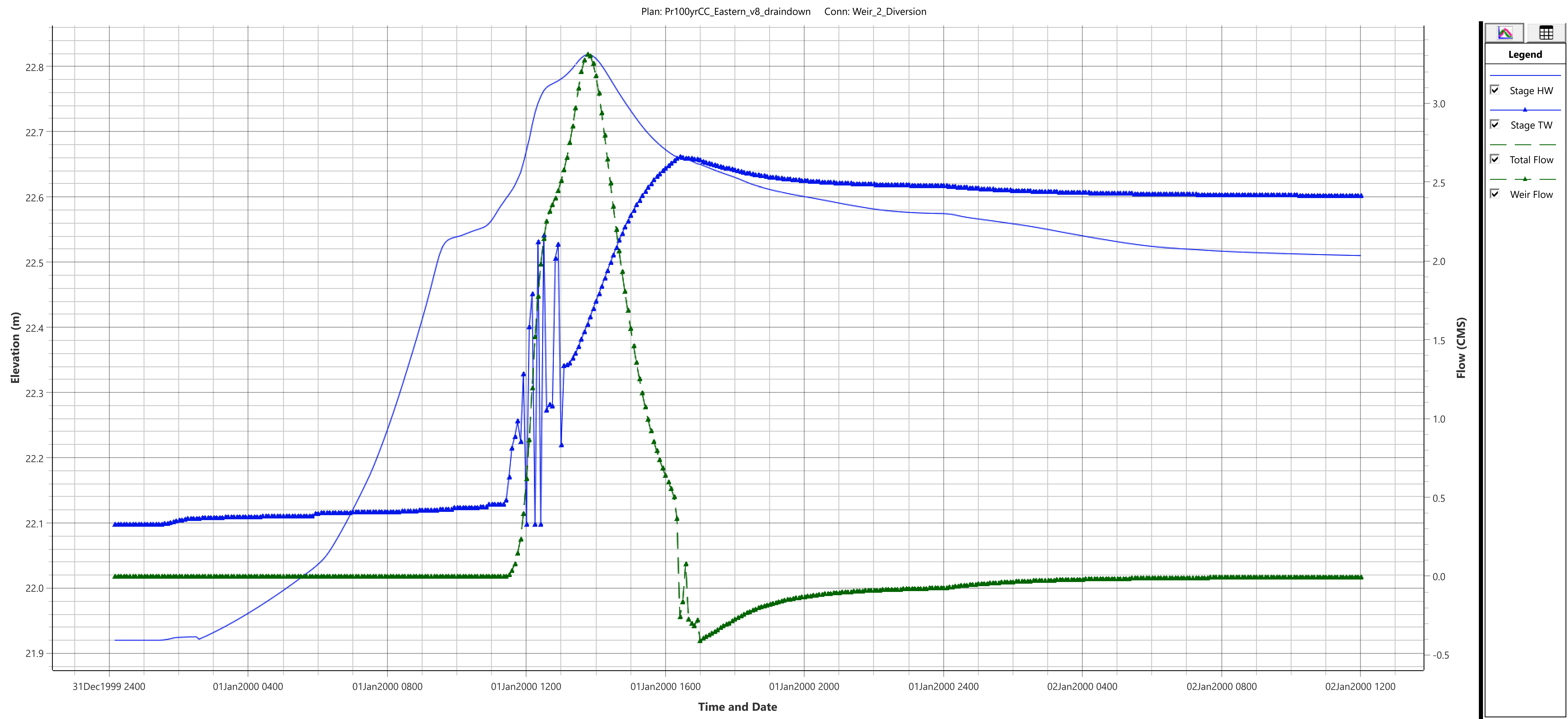
APPENDIX M – Eastern catchment RAS weir hydrographs

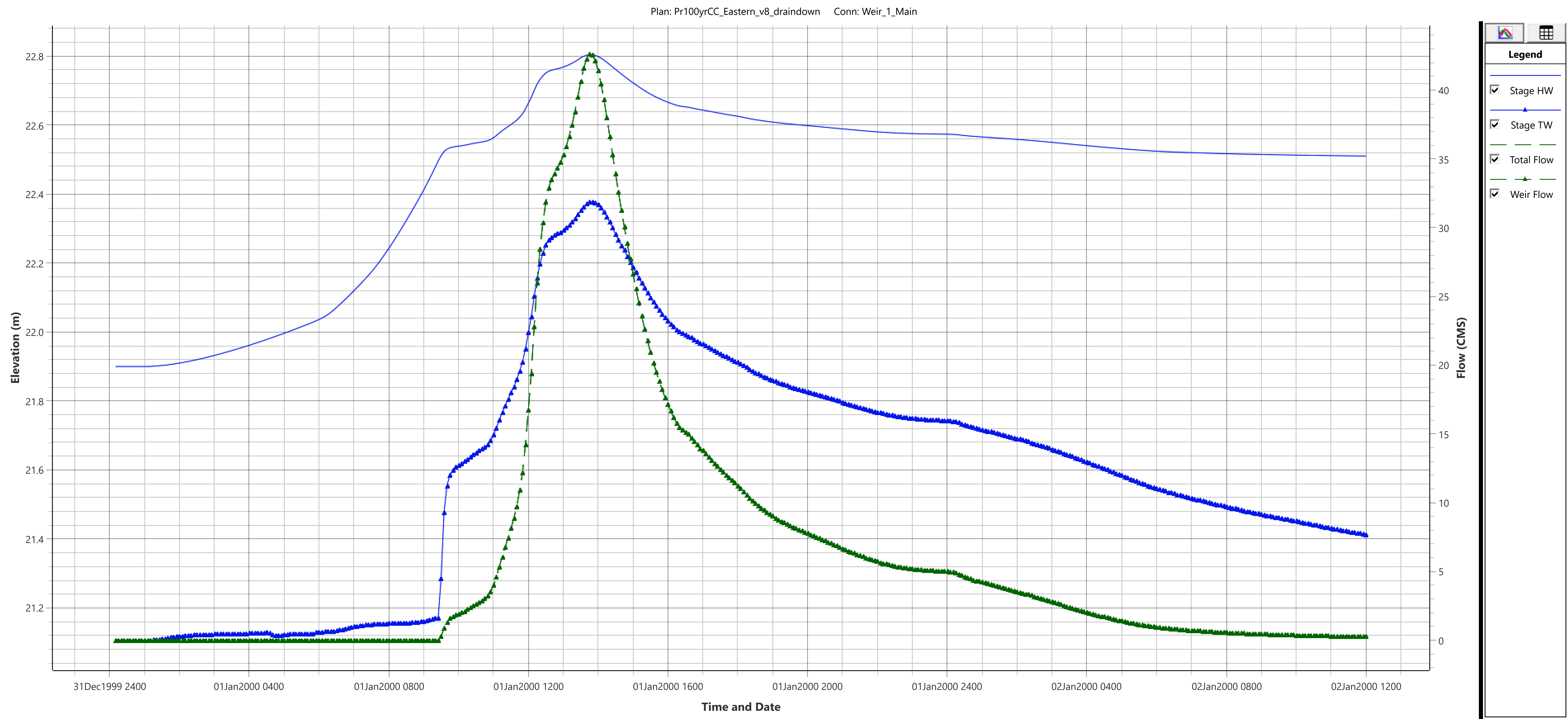


Plan: Pr10yrCC_Eastern_v8_draindown Conn: Weir_2_Diversion
Elevation (m)
22.7
22.6
22.5
22.4
22.3
22.2
22.1
22.0
21.9
Flow (CMS)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Time and Date
Legend
Stage HW
Stage TW
Total Flow
Weir Flow

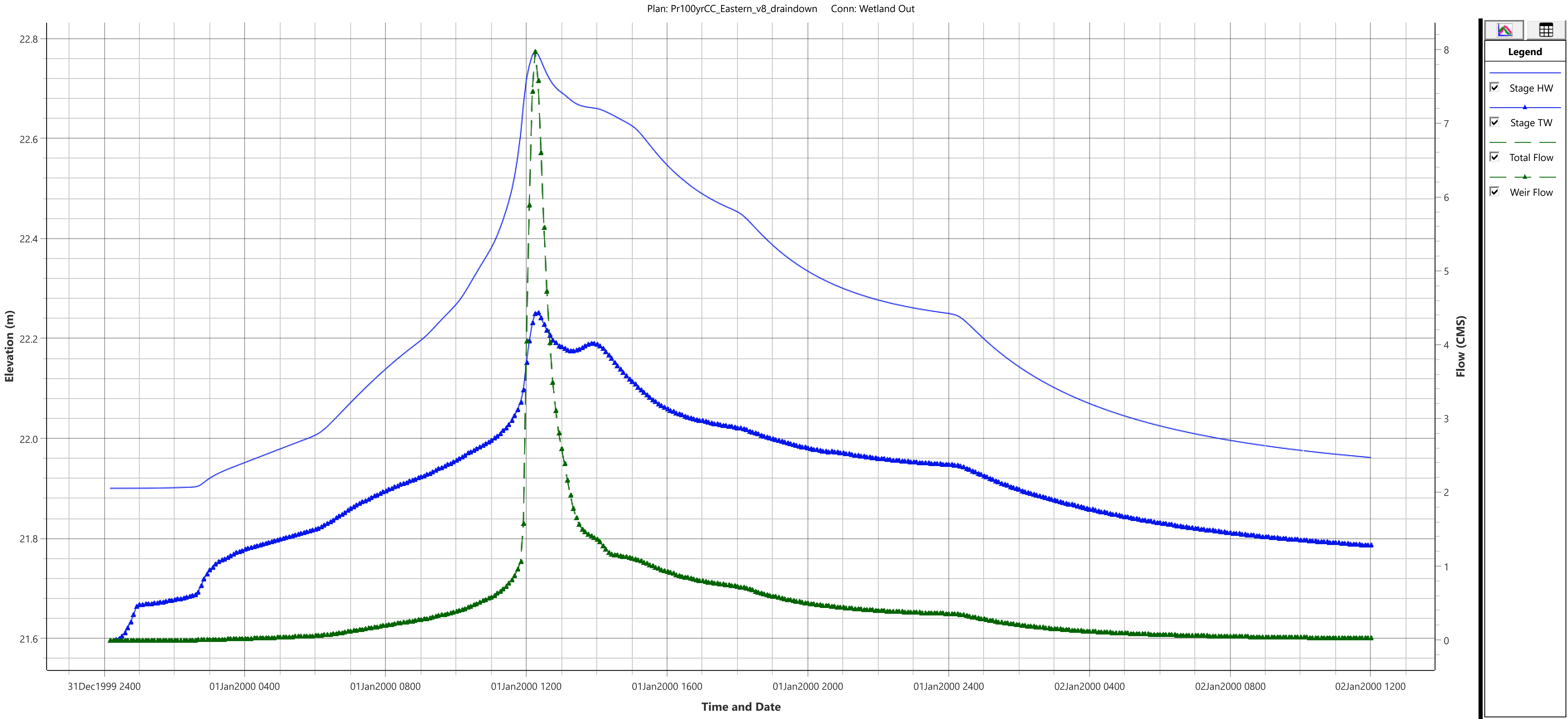

Plan: Pr10yrCC_Eastern_v8_draindown Conn: Weir_1_Main
Elevation (m)
22.6
22.4
22.2
22.0
21.8
21.6
21.4
21.2
21.0
Flow (CMS)
20
15
10
5
0
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Time and Date
Legend
Stage HW
Stage TW
Total Flow
Weir Flow
Total Culvert Flow


Plan: Pr10yrCC_Eastern_v8_draindown Conn: Wetland_NorthOut
Elevation (m)
22.8
22.6
22.4
22.2
22.0
21.8
21.6
Flow (CMS)
12
10
8
6
4
2
0
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Time and Date
Legend
Stage HW
Stage TW
Total Flow
Weir Flow
Total Culvert Flow


Plan: Pr100yrCC_Eastern_v8_draindown Conn: Weir_2_Diversion
Elevation (m)
Flow (CMS)
Time and Date
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
21.9
22.0
22.1
22.2
22.3
22.4
22.5
22.6
22.7
22.8
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Legend
Stage HW
Stage TW
Total Flow
Weir Flow



Plan: Pr100yrCC_Eastern_v8_draindown Conn: Weir_1_Main
Elevation (m)
22.8
22.6
22.4
22.2
22.0
21.8
21.6
21.4
21.2
Flow (CMS)
40
35
30
25
20
15
10
5
0
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Time and Date
Legend
Stage HW
Stage TW
Total Flow
Weir Flow



Plan: Pr100yrCC_Eastern_v8_draindown Conn: Wetland Out
Elevation (m)
22.8
22.6
22.4
22.2
22.0
21.8
21.6
Flow (CMS)
8
7
6
5
4
3
2
1
0
31Dec1999 2400
01Jan2000 0400
01Jan2000 0800
01Jan2000 1200
01Jan2000 1600
01Jan2000 2000
01Jan2000 2400
02Jan2000 0400
02Jan2000 0800
02Jan2000 1200
Time and Date
Legend
Stage HW
Stage TW
Total Flow
Weir Flow

APPENDIX D – WATER DEMAND CALCULATIONS

Development Application Form – Water Supply/Wastewater Planning Assessment		
Date of Application	**13/11/2023**	
Address of Development	**55 Cosgrave Road, Ardmore**	
Layout Plan of Proposed Development clearly showing: • Aerial photograph • Road names • Boundary of development • Preferred point of connection to existing water supply and wastewater asset	Refer to supplied Engineering documentation	
	Description	**Comment**
Current Land Use	Future Urban & Mixed Rural	
Proposed Land Use	Residential & Commercial	
Total Development Area (Ha.)	*244 Ha*	
Number of Residential Households (Consent & Ultimate)	Refer to attached Calculations	

Refer to Water and Wastewater Code of Practice for Land Development and Subdivision Section 6 Water Supply

Water Supply Development Assessment		
Average and Peak Residential Demand (L/s)	Average = 30.56 L/s, Peak = 114.58 L/s	
Average and Peak Non-Residential Demand (L/s)	40.01 L/s	
Non Residential Demand Typical Daily Consumption Profile / Trend	TBC	
Fire- fighting Classification required by the proposed site	TBC	*As per New Zealand Standard SNZ PAS 4509:2008*
Hydrant Flow Test Results	☐ Yes ☒ No	*To be Attached*

MAVEN Maven Associates	Job Number 215001		Sheet 1	Rev B
Job Title: Sunfield Calc Title: Site Water Demand	Author JP		Date 10/09/2021	Checked WM

Proposed Development Site

Residential/Retirement	Dwellings 5000	People 3	Ocupancy 15000
Demand		Rate (L/p/d)	Flow/s
Average Daily Demand (AD)		220	38.19
Peak Day Demand (PF =1.5)		330	57.29
Peak Hourly Demand (PD) (PF =1.5x2)		825	**143.23**
Light Industrial	Area (Ha) 40.5		
Demand		Rate (L/m2/d)	Flow/s
Peak Day Demand (as per WCOP)		4.5	**21.09**
Retail (Wet)	Net Floor Area (Ha) 8.2		
Demand		Rate (L/m2/d) 15	Flow/s **14.24**
Schools	Students 2,000		
Demand		Rate (L/p/d) 25	Flow/s **0.58**

	Flow/s
Total Average Daily Demand =	**74.10**
Total Peak Day Demand =	**93.20**
Total Peak Hourly Demand =	**179.14**