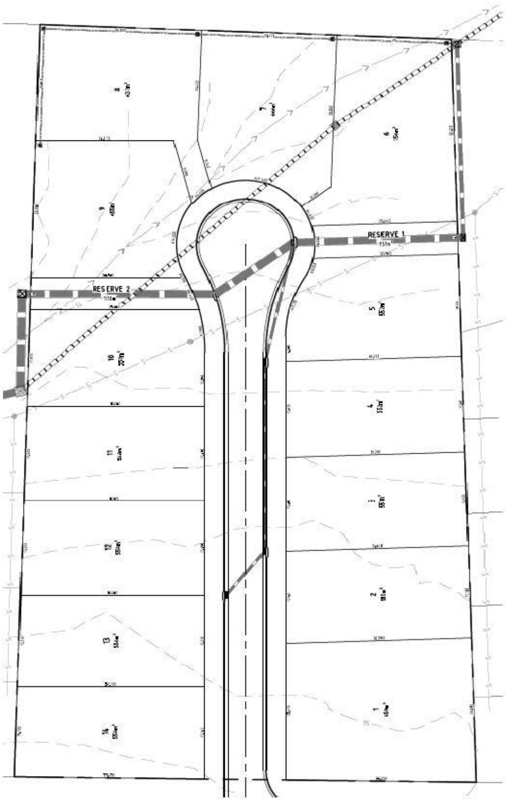

94-100 EXPLORERS WAY, ST CLAIR

Flood Study Report

Prepared for Silky Property Group

June 2015

Revision A

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Document Status

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			Author	Approved by	Date
A	5/06/2015	Issued for DA Submission	B.Badek	P. Diversi	5/06/2015

TABLE OF CONTENTS

LIST OF APPENDICIES

1 INTRODUCTION

1.1 General

Diversi Consulting have been engaged by Silky Property Group to undertake a Flood Study and concept design for the overland flow path through the proposed residential development at 94 -100 Explorers Way, St Clair.

1.2 Purpose of this report

The purpose of this report is to describe the analysis undertaken and resulting flooding experienced on the site as well as demonstrate the performance of the proposed solution for the overland flow path through the site.

1.3 The Site

The subject development area is located in the suburb of St Clair in the Penrith City Council (PCC) Local Government Area (LGA). It is located at 94-100 Explorers Way, St Clair, adjacent to the M4 Western Motorway. The site is bounded by Explorers Way to the south, residential houses to the east and west, adjoins road reserve along part of the western boundary and adjoins the drainage reserve along the M4 Western Motorway. **Figure 1** below shows the location and boundary of the proposed site.

***Figure 1:** Locality Plan*

The site is approximately 1.057ha and generally falls at approximately 2-3% north east towards the M4 Western Motorway. The site currently comprises of a single two-storey dwelling, with a number of small sheds/cottages and sparse vegetation. The rear of the site had previously been classed as undevelopable due to an existing gully through the site draining waters from Ashwick Circuit to a headwall in the M4 Western Motorway drainage reserve.

The drainage through the site consists of a defined gully/overland flow path and piped drainage system comprising of a 600mm DIA pipe. Please refer to **Appendix B** for survey plans showing the existing drainage system. Further details on the street drainage system draining to the gully at the rear of the site is provided in Section 2. The location of the existing overland flow path can be seen in **Photo 1** which is an easterly view from the western boundary of the subject site.

Photo 1: *View along northern boundary of subject site*

1.4 Proposed Development

The site has recently been re-zoned as residential allowing for residential subdivision of the rear portion of the site that has previously been classified as un-developable.

The proposed development consists of a 14 lot residential subdivision with associated road and stormwater drainage infrastructure. A copy of the subdivision plan is included in **Appendix A**.

In order to convey the upstream stormwater catchment runoff through the site, we have proposed an overland flow path and upgraded piped system through the site. The existing 600 diameter pipe through the site has been upgraded to a box culvert system to reduce overland flows to a safe level to ensure safe vehicle and pedestrian access to all lots. The flow path will be 6m wide and will be designed to safely convey waters to the drainage reserve along the M4 Western Motorway.

It is expected that some minor re-shaping earthworks will be required within the drainage reserves on either side of the development in combination with some retaining walls to protect future dwellings from the overland flows. Concept drawings of the proposed treatment is included in **Appendix A**.

2 PIPED DRAINAGE ANALYSIS

2.1 General

In order to determine and model the proposed stormwater overland flow path and site flooding, the hydrological and hydraulic study of the piped drainage system was developed using a stormwater computer program called DRAINS by Watercom Pty Ltd which was developed for the design and analysis of urban stormwater drainage.

DRAINS is a simulation program which converts rainfall patterns in stormwater runoff and routes flows through networks of pipes and channels. It develops hydrographs and calculates hydraulic grade lines throughout drainage systems, enabling the users to determine the sizes and positions of pipes in new systems and to analyse the magnitude of overland flows and stored water for established drainage systems.

DRAINS draws on parts of the PIPES and ILSAX programs developed by Watercom Pty Ltd and Geoffrey O'Loughlin (formerly of the University of Technology, Sydney). In particular DRAINS uses the ILSAX hydrological model but substantially improves on ILSAX's hydraulic methods.

In designing the post-developed piped network through the site we have ensured that peak overland flows upstream and downstream of the site have not been increased in both the 20% AEP and 1% AEP. The peak 1% AEP flows has been used for the hydraulic analysis in Section 3 of this report.

2.2 Stormwater Model

2.2.1 General

The model was constructed using a detailed pit and pipe model. Nodes were added to represent the pits or the confluence of channels or flow paths which were then connected by links, channels or pipes to the existing street drainage in Ashwick Circuit in order to determine preliminary flows and link sizes.

The drainage network through the site and in the surrounding road network has been determined through a combination of field observation, survey and GIS data provided by Penrith Council. Whilst the model is of a fairly uncomplicated structure, it provides a sound indication of the stormwater run-off storage requirements as well as the pre-development and post-development stormwater flow conditions.

Due to the high number of pit inlets within the catchment it is safe to assume that the pipes are acting as the hydraulic control (not the pits) in determining the likely overland flows through the site. The models (pre-development and post-development) have therefore been set up with the pipe network extended upstream of the site with headwall inlets to ensure the pipes run at full capacity in the 1% AEP event (i.e. the pipes are the hydraulic control).

A blockage factor of 50% has been applied to all sag pits within the model, and a 20% blockage factor applied to all on-grade pits.

2.2.2 Pre-developed Model

The existing model has been created to replicate the existing drainage system through the site. The upstream catchment drains to sag pits in Ashwick Circuit before draining through the site to a headwall along the M4 Western Motorway drainage reserve. The main trunk line runs along Denver Road in a northerly direction towards Ashwick Circuit, with pipe sizes increasing from 900mm DIA to 1200mm DIA in the last few reaches.

The sag pits within Ashwick Circuit then drain to a surcharge pit approximately 17m west of the western boundary of the site. The inlet pipe to this surcharge pit is 1200mm DIA while the outlet pipe is a 600mm DIA pipe, hence during periods of heavy rainfall this pit surcharges with overland flows directed through the site in a north easterly direction. The 600mm DIA pipe continues from the surcharge pit in a north easterly direction diagonally through the site to a headwall outlet located on RMS land. There is minimal cover over the 1200mm DIA pipe approaching the surcharge pit. It is assumed this was one of the contributing reasons that a smaller diameter pipe (600mm DIA pipe) was constructed downstream of this in the gully.

2.2.3 Post-developed Model

The post-developed model is similar to the existing model with additional pits and changed pipes to replicate the proposed drainage system through the site up to the headwall outlet. As previously mentioned in Section 2.1, the post-developed pipe system through the site has been designed to ensure that the peak overland flow upstream and downstream of the site is not increased in both the 20% AEP and 1% AEP events. The pipe system through the site has been designed to minimise overland flows to ensure water depths and velocities along the channel and across the road are within safe limits. It is expected that the upgraded pipe system through the site will significantly improve the HGL of the existing pipe system upstream of the site.

As the site is located at the downstream end of the overall drainage system draining to the M4 it is expected that the peak from the site will pass before the peak from the upstream contributing catchments occurs, therefore it is expected that peak flows downstream of the site will generally remain the same. Further details are provided in Section 2.5 of this report.

2.3 DRAINS Hydrological Model data

The model for the Chatswood project was based on the ILSAX submodule and on the following characteristics:

- Soil type = 3
- Antecedents rainfall (AMC) = 3
- Depression storage:
  - Paved areas = 1 mm
  - Supplementary areas = 1 mm
  - Grassed areas = 5 mm

Rainfall was based on the Intensity Frequency Duration (IFD) data provided by Penrith City Council. Further details regarding the catchment, pit and pipe data is attached in **Appendix C**.

2.4 Catchment Areas

In order to determine catchment areas for the model a review of available cadastral and imagery data was undertaken as well as a detailed ground survey and site inspection on 22 December 2014. The following sources were utilised to undertake the catchment analysis;

- NSW Department of Finance and Services (Land Property Information) "Six Maps" online mapping tool (2m existing contours, cadastral data, aerial photography).
- Penrith City Council's GIS data, 0.5m existing contours cadastral data as provided by Council.
- Detailed ground survey undertaken by Warren Eldridge Consulting Surveyor (existing surface levels and drainage infrastructure).

A copy of the Survey Plan is attached in **Appendix B**. Based on these plans and our site inspection we estimate that there is about 17.9 hectares draining through the site. Most of this catchment is heavily developed with low to medium density residential housing. The contributing catchment for the proposed development site drains largely from the south and west. This contributing catchment has been split into sub-catchments of varying size to replicate the existing flow regime, with each catchment draining to a pit, node or headwall in DRAINS. A copy of the catchment plan is attached in **Appendix C**.

2.5 Results

2.5.1 Pre-developed

The peak discharges have been calculated using DRAINS with the catchment discharge analysed over a range of storm durations from 5 minutes to 4.5 hours. The duration producing the peak 1% AEP pre-development overland flow through the site was found to be the 20 minute duration storm resulting in a discharge of 3.85m^3/s. Similarly the peak pre-development discharge for the 20% AEP was found to be the 25 minute duration storm resulting in an overland flow rate of 2.14m^3/s. An image of the DRAINS schematic with the 1% and 20% AEP results are located within **Appendix C.**

It can be seen that the existing piped system has insufficient capacity to cater for the 20% AEP event, with the HGL being well above the pit surface levels and significant pit bypass flows. The estimated capacity of the street drainage system upstream of the site is in the order of the 100% AEP event, however with the limited 600mm DIA pipe through the site overland flows occur. The 600mm DIA pipe through the site has an estimated capacity of just the 3 to 6 month ARI event. A copy of the proposed development model data and results is included in **Appendix C**.

2.5.2 Post developed

The peak discharges have been calculated using DRAINS with the catchment discharge analysed over a range of storm durations from 5 minutes to 4.5 hours. To restrict overland flows through the site it is proposed to install twin 1500 x 900mm box culverts through the site, moving the surcharge pit to the north eastern corner of the site before connecting to the existing 600mm DIA pipe draining to the M4 western motorway.

The proposed culvert arrangement has near capacity to cater for the 1% AEP event in comparison to the existing piped system with only 3 to 6 month ARI event. As previously mentioned in Section 2.23 the pipe system through the site has been designed to minimise overland flows to ensure water depths and velocities along the overland flow path and across the road are within safe limits for pedestrian and vehicle access. By limiting the height of the culverts to 900mm sufficient cover through the site is provided for service crossings while also significantly increasing the capacity of the piped system through the site.

The duration producing the peak 1% AEP post developed overland flow through the site was found to be the 20 minute duration storm resulting in an overland flow discharge of .115m^3/s. Not only has the increased pipe size drastically reduced overland flows through the site in comparison to the pre-development scenario, the additional pits allows more water to enter the pipe system further reducing the overland flows through the site. Similarly the peak post development discharge for the 20% AEP was found to be the 25 minute duration storm resulting in an overland flow rate of 0.053m^3/s. An image of the DRAINS schematic with the 1% and 20% AEP results are located within **Appendix C.**

Comparing the results between the pre-developed and post developed scenarios it can be seen that in both the 20% and 1% AEP events the proposed box culvert through the site generally improves the HGL upstream of the site, alleviating overland flows in Ashwick Circuit.

In the 20% AEP event there is;

- A minor increase in overland flows at the southern end of Ashwick circuit, with overland flows increasing from 1l/s to 6l/s. This increase is considered negligible as flows are still wholly contained within the kerb and gutter and well under the maximum Vd of 0.4m^2/s.

- A marginal increase in overland flows downstream of the site discharging to the headwall along the M4, with overland flows increasing from 2.14m^3/s to 2.49m^3/s. The overall discharge to the headwall in the post developed case is increased from 3.02m^3/s to 3.39m^3/s, an increase of 0.37m^3/s.

This increase in flows in the 20% AEP event has been assessed in Section 3 to determine whether the downstream stormwater system has adequate capacity to accommodate stormwater flows generated from the development. In the 1% AEP event there is;

- Significant reductions in overland flows throughout the upstream street network,

- A minor increase in overland flows at the southern end of Ashwick circuit, with overland flows increasing from 49l/s to 134/s. This increase is considered negligible as flows are still wholly contained within the kerb and gutter, with a maximum depth of 98mm and maximum Vd of $0.1m^2/s$.

- A minor increase in overland flows downstream of the site discharging to the headwall along the M4, with overland flows increasing from $3.85m^3/s$ to $4.0m^3/s$. The overall discharge to the headwall in the post developed case is also increased from $4.73m^3/s$ to $4.9m^3/s$, an increase of $0.17m^3/s$.

As previously mentioned in Section 2.3.3 as the site is located at the downstream end of the overall drainage system draining to the M4. The post developed peak 1% AEP event from the site has a lower time of concentration to that of the upstream catchment, hence the peak discharge downstream is only marginally increased.

It is further noted that the proposed WSUD treatment measures for the site (including rainwater tanks and raingardens) will provide some onsite detention and therefore the increase in peak flows is likely to be reduced significantly. We have taken a conservative approach and assessed the impacts of the additional flow without taking into account any WSUD measures.

A copy of the proposed development model data and results is included in **Appendix C**.

3 HYDRAULIC ANALYSIS

3.1 General

The hydraulic analysis of the existing overland flow path through the site and the proposed overland flow path was undertaken using HEC-RAS. HEC-RAS is a 1 dimensional simulation program, developed by the US Army Corps of Engineers, which analyses steady and unsteady flow characteristics for water flows within rivers and channels. Both the pre-developed and post developed scenarios have been assessed using HEC RAS.

3.2 Hydraulic Model Characteristics

To model both the pre-developed and post developed overland flow path through the site a number of cross sections were used at critical locations to define the flow path and hydraulic controls. Through the combination of available survey data provided by Warren Eldridge Consulting Surveyor and observations made onsite, cross sections have been interpolated through the site to define the existing overland flow path from Ashwick Circuit to the drainage reserve along the M4. Both models share section locations upstream and downstream of the site, while sections through the site have been changed to replicate the existing and proposed overland flow paths. A copy of the HEC RAS layout is contained within Appendix D.

3.3 Parameters

A site inspection was undertaken to provide a visual indication of the appropriate roughness coefficients and boundary conditions to be adopted for the hydraulic modelling. Through this visual inspection and in accordance with the parameters set-out in AR&R, a manning's 'n' value of **0.05, 0.035** and **0.015** were adopted for the landscaped, grassed and paved areas respectively. Based on the flat grade of the drainage reserve along the M4 we have adopted a **normal depth** boundary condition with a **0.5%** downstream slope.

3.4 Channel Geometry

The post developed overland flow path through the site has been designed to safely convey waters through the site to the drainage reserve along the M4. Survey information of the site shows that overland flows enter the site along the western boundary and continue in a north easterly direction. There is a reasonably defined gully through the site, being well grassed with some scattered trees. There is an existing chain wire fence along the northern boundary of the site (along the boundary with the M4).

The preferred option for the proposed overland flow path has been assessed, as shown in the concept design plans in **Appendix A**. Waters will enter the site along the western boundary of the site and be re-directed to a new low point along the western boundary to contain flows within an easement wholly contained within two lots to convey waters to the drainage reserve to the north east of the site. To ensure a minimum 1% fall along the overland flow path is achieved levels within the road reserve of Ashwick Circuit have been moderately increased by up to 0.15m.

Once waters have entered the site it is proposed to convey waters via a 6m wide dedicated channel along the alignment of the proposed easement. This channel will consist of a grassed base width of 3.5m, with a retaining wall along one side and 1:5 landscaped batters on the other side.

3.5 Channel Flows

The table below summarises the channel flows for both the pre-developed and post developed scenarios adopted from the piped drainage analysis described in Section 2 of this report.

Table 3.1 *– Summary of Channel Flows*

Section	1% AEP Event		20% AEP Event	
	Pre-Development	Post-Development	Pre-Development	Post-Development
CH 195.56	3.53	0.717	1.93	0.086
CH 177.38	-	0.01	-	0.01
CH 141	-	0.105	-	0.053
CH 115	-	0.115	-	0.035
CH 90.26	3.85	-	2.14	-
CH 52	-	4.0	-	2.49
CH 37.64	4.73	4.9	3.02	3.39

Please note that HEC RAS does not allow $0m^3/s$ along any reaches in the overland flow path, therefore where there is a calculated peak flow of $0m^3/s$ (as per DRAINS calculations in Section 2) we have adopted a flow rate of $0.01m^3/s$ in HEC RAS.

3.6 Results

Tabulated results along with long section profile and cross section information for both the pre-developed and post developed scenarios are contained within **Appendix D**. The results for the 1% AEP pre-development scenario shows that waters are relatively moderate across the entire length of the flow path, with depths in the range of 0.14-0.63m and an average depth of 0.36m. Similarly velocities in the pre-development case are moderate, within the range of 0.82-1.4m/s with the exception of Section 0 (approximately 38m downstream of the headwall in RMS land) with a velocity of 0.45m/s (due to the flat grade of the ground surface).

The corresponding Vd products are variable, with multiple locations exceeding the maximum recommended $0.4m^2/s$ for safe pedestrian access as outlined in ARR. The worst case Vd product occurs at Section 30 just downstream of the existing headwall in RMS land where the Vd product is $0.79m^2/s$, which corresponds to a high hydraulic hazard as categorised using figures L1 and L2 in the NSW Floodplain Development Manual 2005.

In comparison the results for the post development case show significantly lower water depths and corresponding Vd products due to the significant reduction of flows through the site. In the 1% AEP post development scenario the average depth of water through the site is 100mm, with a maximum depth of 0.64m occurring at section 0. The maximum velocity through the site is restricted to 0.82m/s, with the Vd product through the site well below the recommended 0.4m2/s. The worst case Vd once again occurs at Section 30 downstream of the site with a Vd of $0.79m^2/s$, the same as the pre-developed case. This was expected as the ground surface downstream of the site has not changed and the flow regime has only been changed very slightly as previously mentioned in Section 2.5 of this report.

Water levels upstream and downstream of the site have generally remained the same between the pre-developed and post developed scenarios for both the 1% and 20% AEP events.

Table 3.2 below summaries the pre-developed and post developed water levels upstream and downstream of the site.

***Table 3.2** – Summary of Water Surface Elevations*

Section	1% AEP W.S Elev (m)			20% AEP W.S Elev (m)		
	Pre	Post	Difference	Pre	Post	Difference
195.56	55.53	55.45	-0.08	55.49	55.41	-0.08
188	55.39	55.29	-0.1	55.33	55.24	-0.09
180.56	55.26	55.12	-0.14	55.2	55.05	-0.15
177.38	55.18	54.91	-0.27	55.11	54.91	-0.2
37.64	52.73	52.73	0	52.68	52.7	0.02
30	52.63	52.64	0.01	52.55	52.56	0.01
14.99	52.57	52.58	0.01	52.47	52.49	0.02
0	52.56	52.57	0.01	52.46	52.49	0.03

Table 3.2 above shows that water levels upstream of the site (sections 177.38 to 195.56) are all reduced in both the 1% AEP and 20% AEP as expected due to the increased culvert capacity through the site alleviating flooding in Ashwick Circuit. Downstream of the site in the 1% AEP event water levels remain generally the same as the pre-development scenario, with a very slight increase of 0.01m or 10mm. The M4 Western Motorway is approximately 1.5m above the invert of the overland flow path downstream of the headwall. The road RL at section 37.64 is approximately RL 53.5, therefore with a calculated 1% AEP water RL of 52.73m there is over 0.77m freeboard to the road. The very slight increase of 0.01m in the 1% AEP event is therefore considered acceptable.

In the 20% AEP event there is a slight increase in flood levels downstream of the site of 0.01m to 0.03m in comparison to the pre-developed scenario. Using the approximate road RL of 53.5 at Section 37.64 the freeboard to the 20% AEP event is over 0.8m. The slight increase of up to 0.03m in the 20% AEP event is therefore considered negligible. In accordance with Councils Development Control Plan Section C3- Water Management (2014) flood levels are not to be increased by more than 0.1m, therefore the proposed development complies.

The following tables 3.3 and 3.4 on the following page summarise the velocities and Vd products for the pre-developed and post developed scenarios in both the 1% and 20% AEP events.

***Table 3.3**– Summary of Velocities*

Section	1% AEP Velocities (m/s)			20% AEP Velocities (m/s)		
	Pre	Post	Difference (%)	Pre	Post	Difference (%)
195.56	0.97	0.64	-34.0	0.9	0.34	-62.2
188	0.82	0.48	-41.5	0.7	0.27	-61.4
180.56	1.06	0.82	-22.6	0.93	0.51	-45.2
177.38	1.24	0.3	-75.8	1.1	0.3	-72.7
37.64	1.19	1.22	2.5	0.99	1.0	1.0
30	1.31	1.3	-0.8	1.37	1.42	3.6
14.99	0.82	0.82	0	0.74	0.75	1.4
0	0.45	0.46	2.2	0.4	0.41	2.5

***Table 3.4**– Summary of Vd Products*

Section	1% AEP Vd Products (m^2/s)			20% AEP Vd Products (m^2/s)		
	Pre	Post	Difference	Pre	Post	Difference
195.56	0.14	0.04	-0.10	0.09	0.01	-0.08
188	0.16	0.04	-0.11	0.09	0.01	-0.08
180.56	0.25	0.08	-0.17	0.17	0.02	-0.15
177.38	0.36	0.01	-0.35	0.24	0.01	-0.23
37.64	0.63	0.65	0.02	0.48	0.50	0.02
30	0.79	0.79	0	0.71	0.75	0.04
14.99	0.5	0.51	0.01	0.38	0.40	0.02
0	0.28	0.29	0.01	0.21	0.23	0.02

Table 3.3 shows that all velocities upstream of the site are reduced in the post development case significantly. Downstream of the site velocities generally remain the same in the 1% AEP event, while there is a slight increase in velocities in the 20% AEP event up to 3.6%. In accordance with Councils Development Control Plan Section C3- Water Management (2014) downstream velocities are not to be increased by more than 10%, therefore the proposed development complies.

As expected, with reduced flood levels upstream of the site the corresponding Vd product upstream of the site in both the 1% and 20% AEP events are also reduced. Downstream of the site there is minimal to no impact on the Vd product in the 1% AEP event. In the 20% AEP event there is a slight increase in the Vd product across sections 37.64 to 0. Table 3.5 on the following page summarises the provisional hydraulic hazard category downstream of the site in both the 1% and 20% AEP event.

***Table 3.5**– Hydraulic Hazard Category*

Section	20% AEP Event		1% AEP Event	
	Pre-Development	Post Development	Pre-Development	Post Development
37.64	LOW	LOW	HIGH	HIGH
30	HIGH	HIGH	HIGH	HIGH
14.99	LOW	LOW	HIGH	HIGH
0	LOW	LOW	LOW	LOW

Table 3.5 shows that the provisional hydraulic hazard category has not changed from the pre-developed to post developed scenario downstream of the site. The slight increase in velocity (and corresponding Vd product) due to marginally increased flows downstream of the site in both the 1% and 20% AEP events are therefore considered acceptable. The hydraulic hazard category through the site in the post developed scenario is low, with the calculated Vd being well below the maximum recommended of $0.4m^2/s$. For full HEC RAS results including the depth and Vd product refer to **Appendix D**.

3.7 Building Constraints

The location and geometry of the proposed overland flow channel will necessitate a number of constraints to the proposed subdivision. The overland flow channel must remain clear of obstructions, therefore building envelopes and any other structures must be located outside the easement. The floor level of any dwelling and garages must provide freeboard to the calculated water levels in this report in accordance with Penrith City Council requirements.

An open style pool fence will be required from the ground up to an RL of 100mm above the calculated 100yr water level along the rear of lot 5 and lot 10 within the easement to allow waters to drain freely.

4 CONCLUSION AND RECOMMENDATIONS

Based on the proposed stormwater channel design shown in **Appendix A** we note the following:

- The overland flow path safely conveys the post developed catchment flows for events up to the 1% AEP.

- Flows through the site are significantly improved by providing an upgraded culvert system, limiting overland flows to have a $Vd<0.4m^2/s$.

- The hydraulic hazard category upstream and downstream of the site has not changed, therefore the proposed subdivision is not negatively impacting neighbouring properties.

- Velocities downstream of the site are not increased by more than 10% in accordance with Penrith City Council requirements, with a maximum increase downstream of 3.6%.

- Flood levels are not increased more than 0.1m upstream or downstream of the site, with a marginal increase of just 0.03m downstream of the site in the 20% AEP event.

Accordingly this report is submitted for Council's review and approval and should be read in conjunction with the engineering plans submitted for the Development Application for the proposed development.

Appendix A

Concept Engineering Design Plans

REV	DATE	AMENDMENT / DESCRIPTION	BY	APP'D
A	5/06/2015	ISSUED FOR DA APPROVAL	RLP	DLG

NOT FOR CONSTRUCTION

DRAWING DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE

DESIGNED R.L.P.	DATE 15/05/2015	CHECKED D.L.G.	DATE 25/05/2015
APPROVED P.G.D.	DATE 26/05/2015	SCALE 1:250 (A1)	

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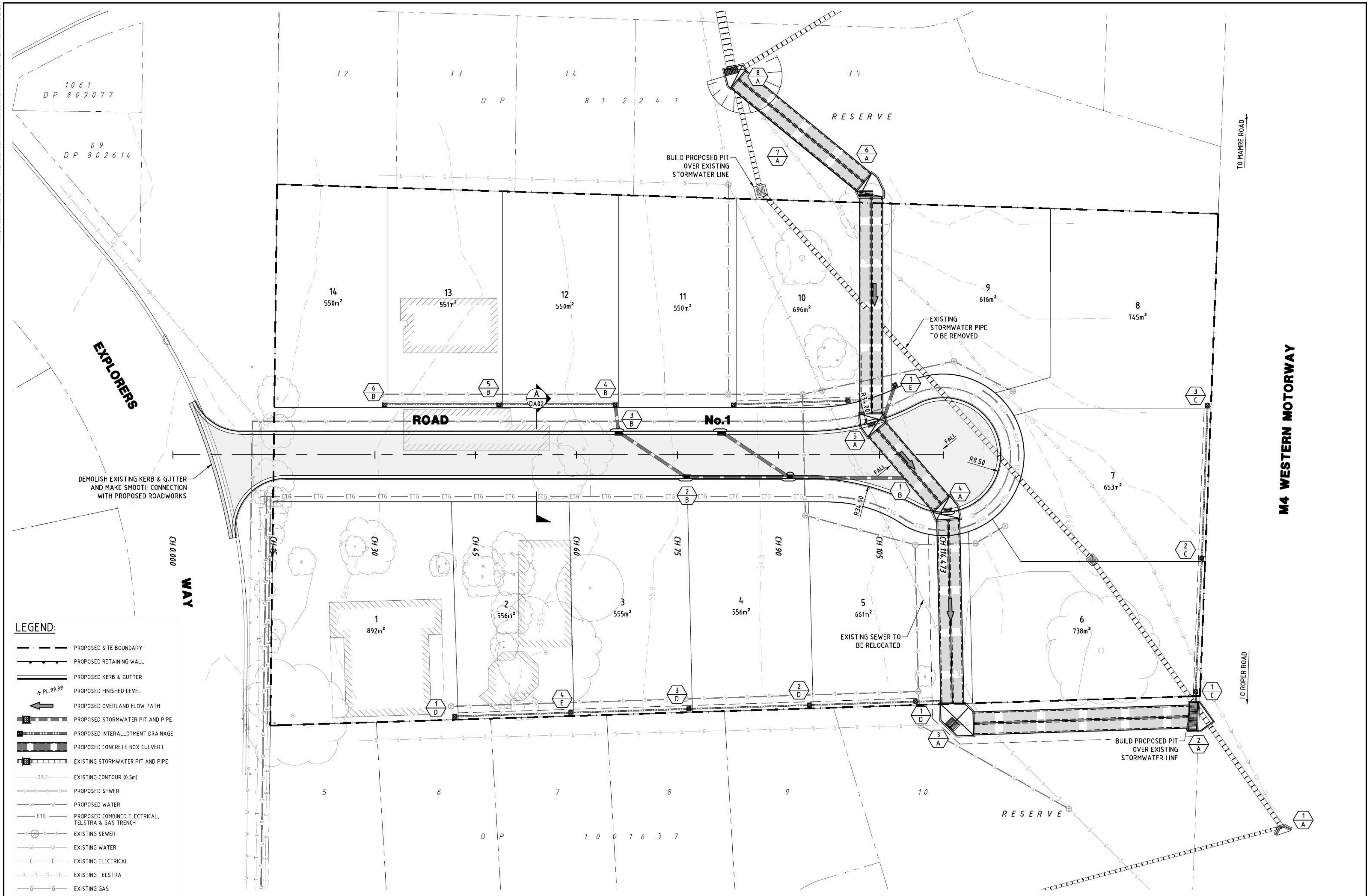
CLIENT: SILKY PROPERTY GROUP

PROJECT: PROPOSED RESIDENTIAL SUBDIVISION
94-100 EXPLORERS WAY, ST. CLAIR

TITLE: PLAN OF SUBDIVISION

PROJECT No.: 14140 | DRG No.: DA01 | Rev.: A



REV	DATE	AMENDMENT / DESCRIPTION	BY	APP'D	REV	DATE	AMENDMENT / DESCRIPTION	BY	APP'D
A	5/06/2015	ISSUED FOR DA APPROVAL	RLP	DLG					

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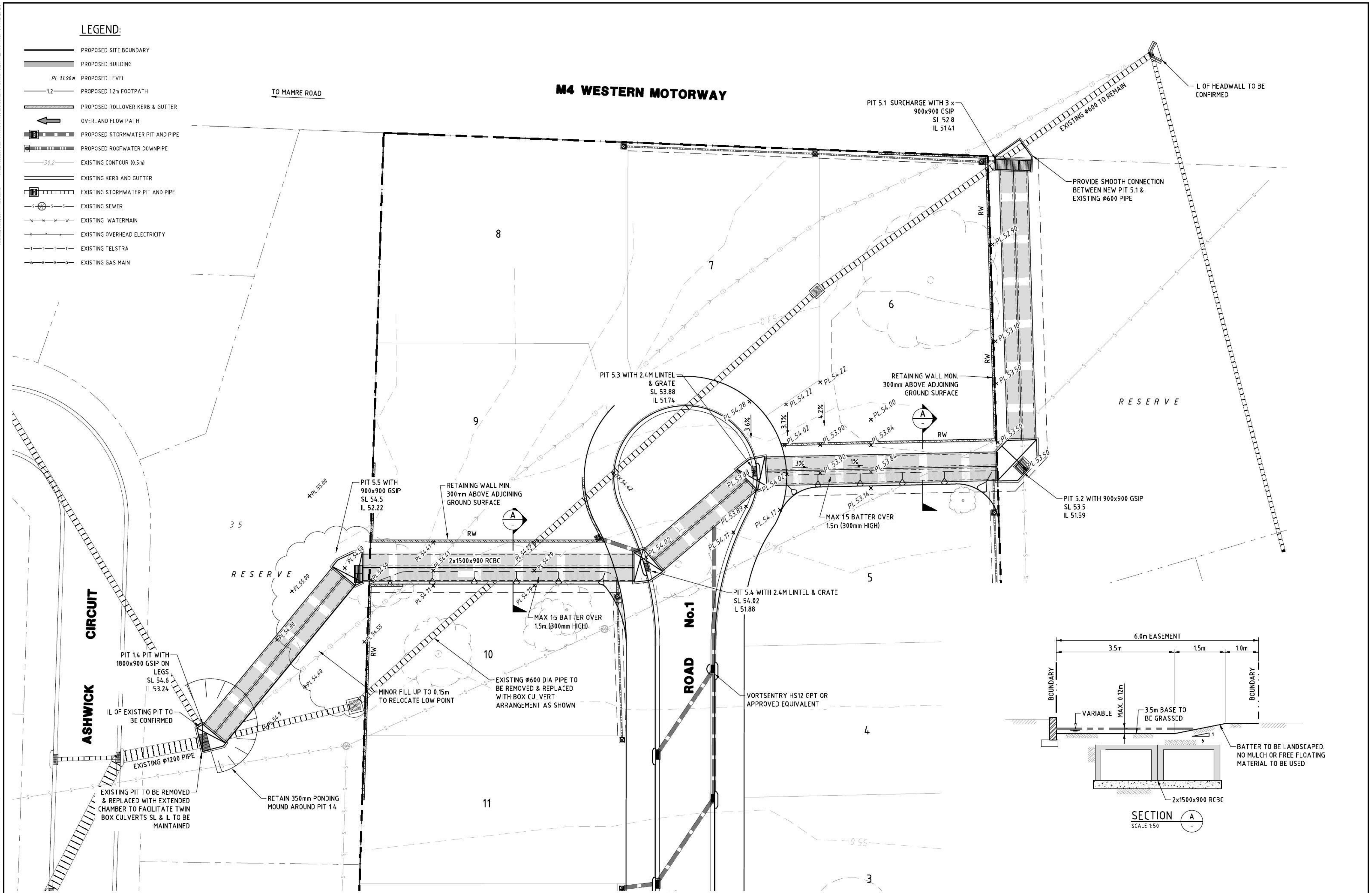
CLIENT: SILKY PROPERTY GROUP

PROJECT: PROPOSED RESIDENTIAL SUBDIVISION 94-100 EXPLORERS WAY, ST. CLAIR

TITLE: ROADWORKS AND STORMWATER DRAINAGE LAYOUT PLAN

PROJECT No.: 14140 | DRG No.: DA03 | Rev.: A

Document Set ID: 6654719
Version: 1, Version Date: 11/06/2015



REV	DATE	AMENDMENT / DESCRIPTION	BY	APP'D
A	5/06/2015	ISSUED FOR DA APPROVAL	RLP	DLG

NOT FOR CONSTRUCTION

DRAWING DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE

DESIGNED: R.L.P.	DATE: 15/05/2015	
CHECKED: D.L.G.	DATE: 25/05/2015	
APPROVED: P.G.D.	DATE: 26/05/2015	
SCALE: 1:200 (A1)		

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CLIENT: SILKY PROPERTY GROUP

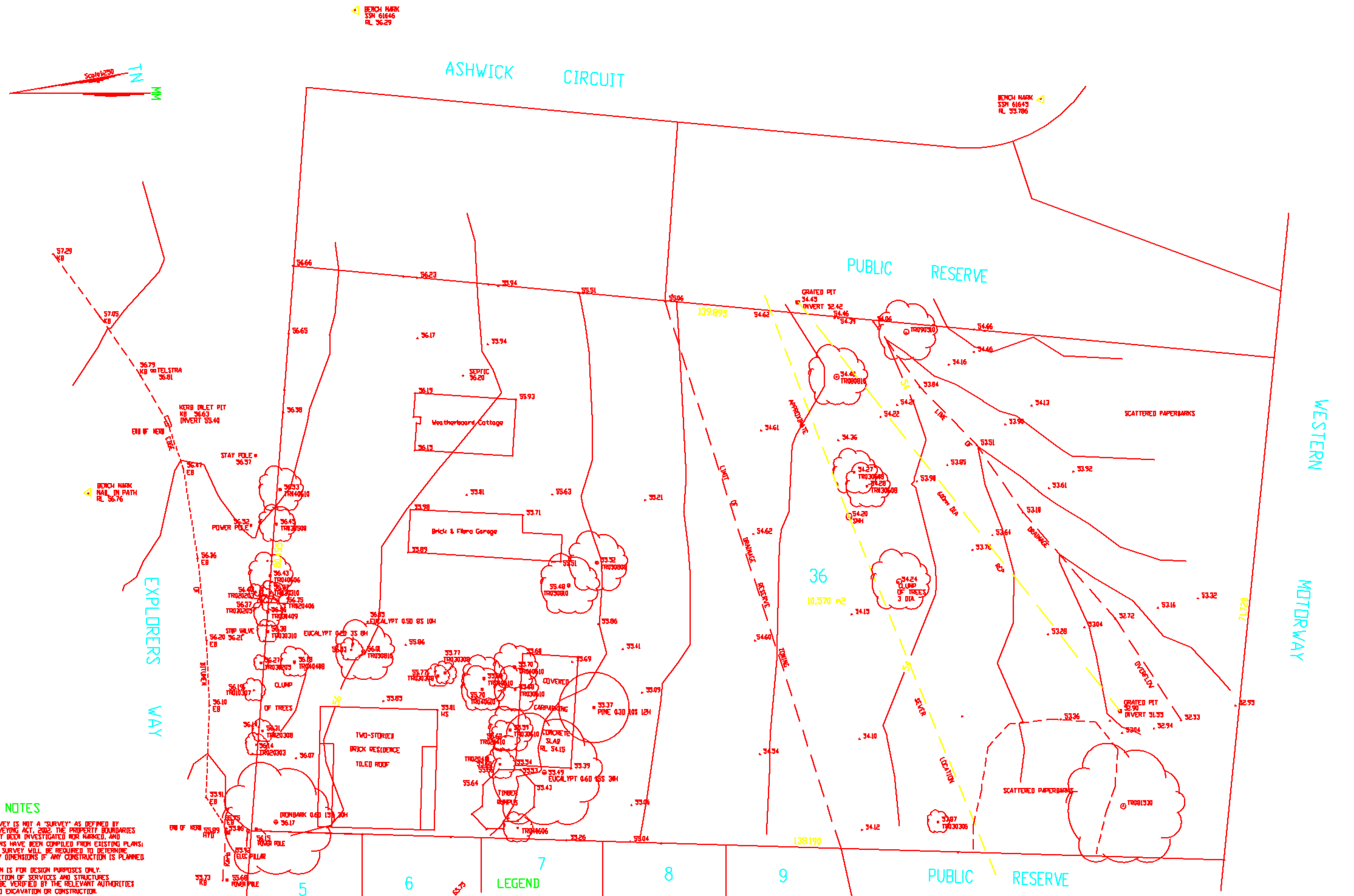
PROJECT: PROPOSED RESIDENTIAL SUBDIVISION 94-100 EXPLORERS WAY, ST. CLAIR

TITLE: STORMWATER MANAGEMENT PLAN

PROJECT No.: 14140 DRG No.: DA06 Rev.: A

Appendix B

Survey Plans



NOTES

1. THIS SURVEY IS NOT A "SURVEY" AS DEFINED BY THE SURVEYING ACT, 2002. THE PROPERTY BOUNDARIES HAVE NOT BEEN INVESTIGATED NOR MARKED, AND DIMENSIONS HAVE BEEN COMPILED FROM EXISTING PLANS; FURTHER SURVEY WILL BE REQUIRED TO DETERMINE BOUNDARY DIMENSIONS IF ANY CONSTRUCTION IS PLANNED.
2. THIS PLAN IS FOR DESIGN PURPOSES ONLY. THE POSITION OF SERVICES AND STRUCTURES SHOULD BE VERIFIED BY THE RELEVANT AUTHORITIES PRIOR TO EXCAVATION OR CONSTRUCTION.
3. THE BENCH MARK SHOULD BE VERIFIED PRIOR TO COMMENCEMENT OF ANY EXCAVATION OR CONSTRUCTION.
4. THE POSITION OF FEATURES RELATIVE TO BOUNDARIES IS DIAGRAMMATIC ONLY & ANY OFFSETS SHOWN ARE APPROXIMATE PENDING FURTHER SURVEY DEFINITION.
5. ORIGIN OF LEVELS - SYDNEY WATER SEWER

LEGEND

- SPOT HEIGHTS SHOWN THUS
- TREES SHOWN THUS WITH APPROXIMATE HEIGHT OF CANOPY TRUNK & SPREAD SHOWN TO SCALE
TR 081030 DENOTES TREE 0.80,10S,30H
TR denotes Paperbark Tree unless noted otherwise

PROJECT	CLIENT	WARREN ELDRIDGE	LEVELS ON AUSTRALIAN HEIGHT DATUM CONTOUR INTERVAL 0.5 METRES
DETAIL & CONTOUR SURVEY AT No.94-100 EXPLORERS WAY, ST CLAIR BEING LOT 36 IN D.P. 239502 PENRITH L.G.A.	MR D. FINIANOS	B Surv M.I.S. Aust CONSULTING SURVEYOR & REAL ESTATE VALUER P.O. Box 477, PENNANT HILLS 2120 Ph. 9481 9831 Fax. 9980 8931	SCALES PLAN 1:250 @A1 LONGITUDINAL SECTION HOR. 1:500 VERT. 1:100 CROSS SECTIONS 1:100 DATE 6-4-11 PLAN NO. 167-1

Appendix C

Catchment Plan, DRAINS Model Data and Results

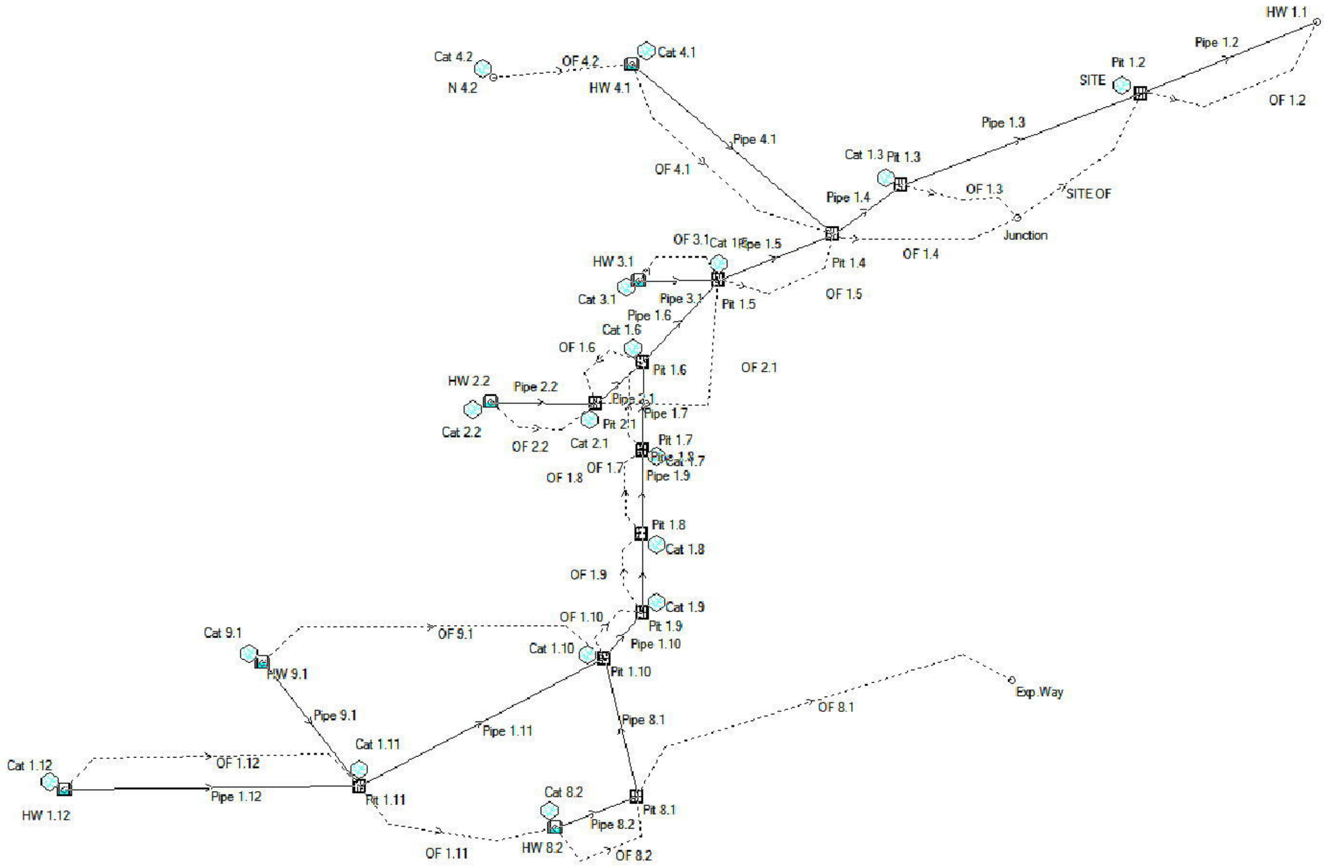


Figure C1 – PRE-DEVELOPED DRAINS Network

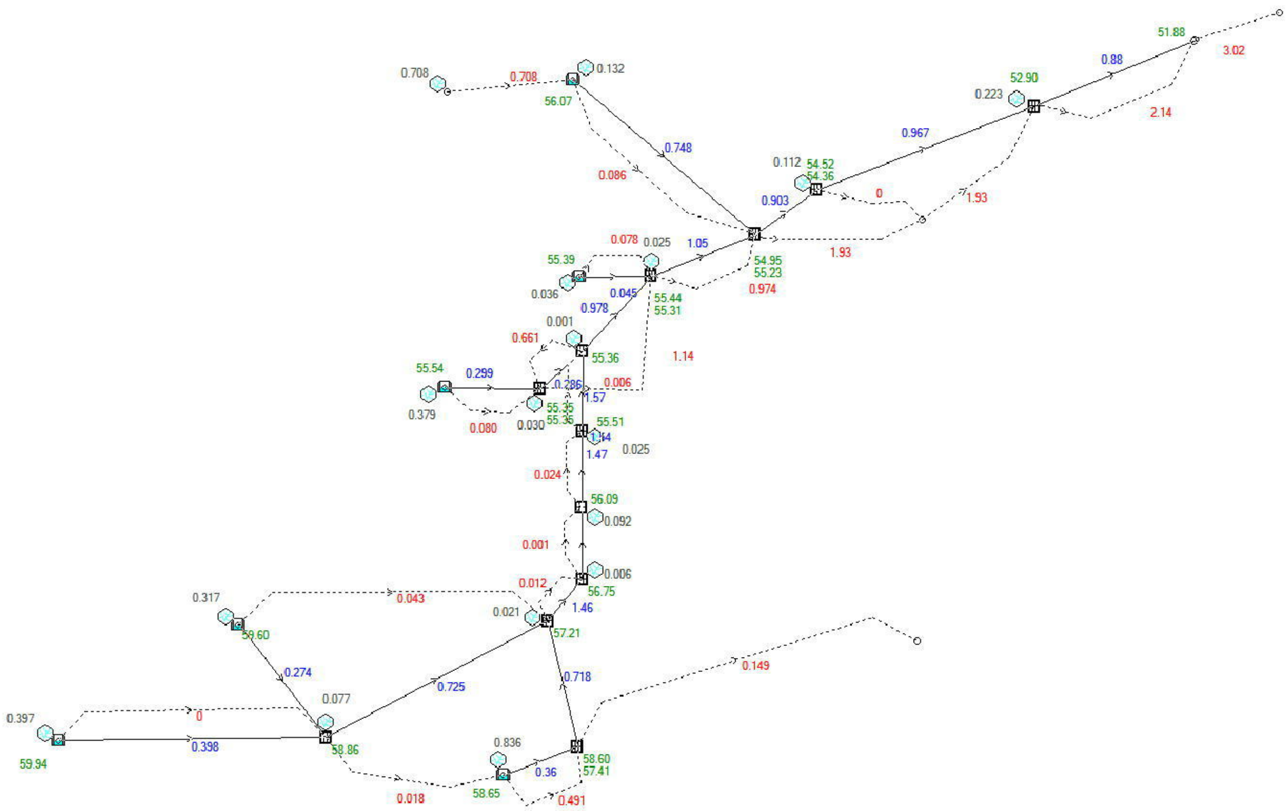


Figure C2 – PRE-DEVELOPED DRAINS 20% AEP RESULTS

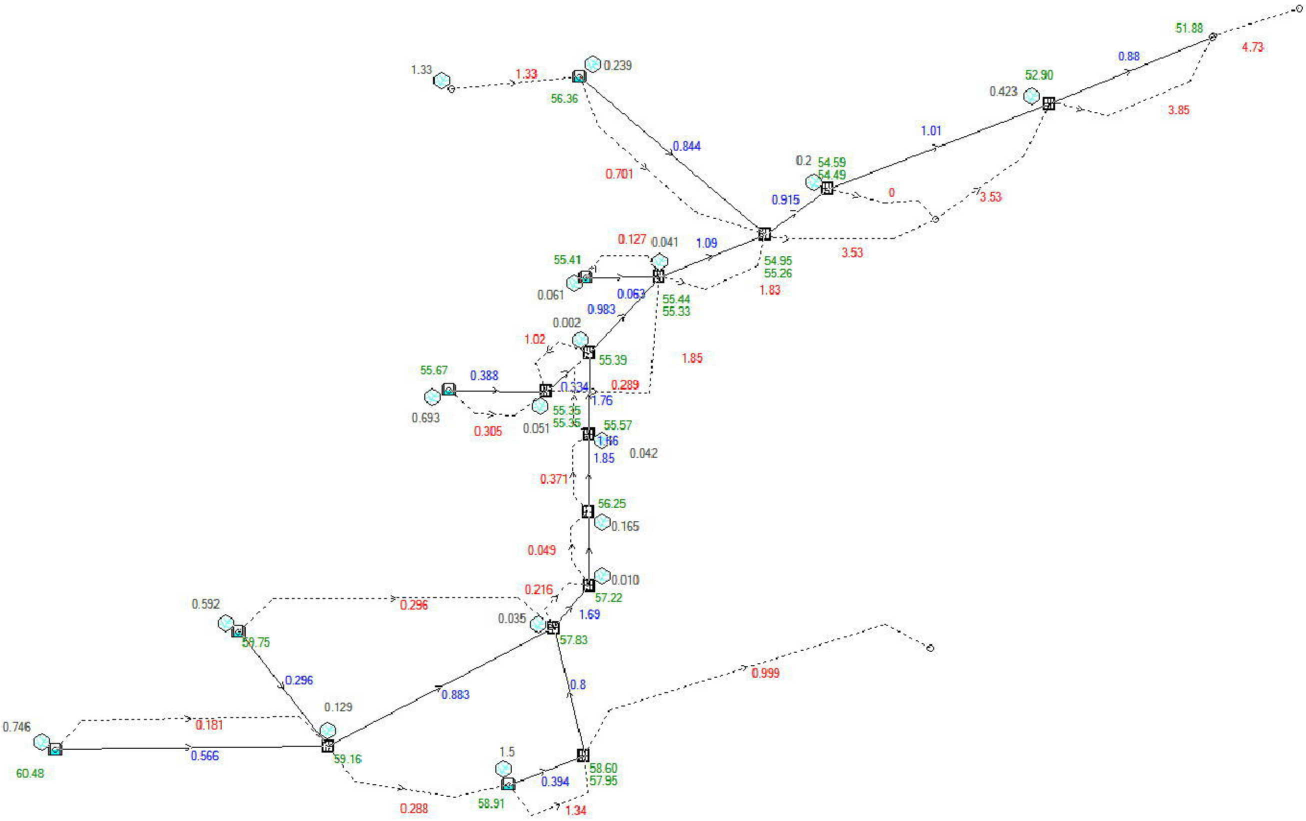


Figure C3 – PRE-DEVELOPED DRAINS 1% AEP RESULTS

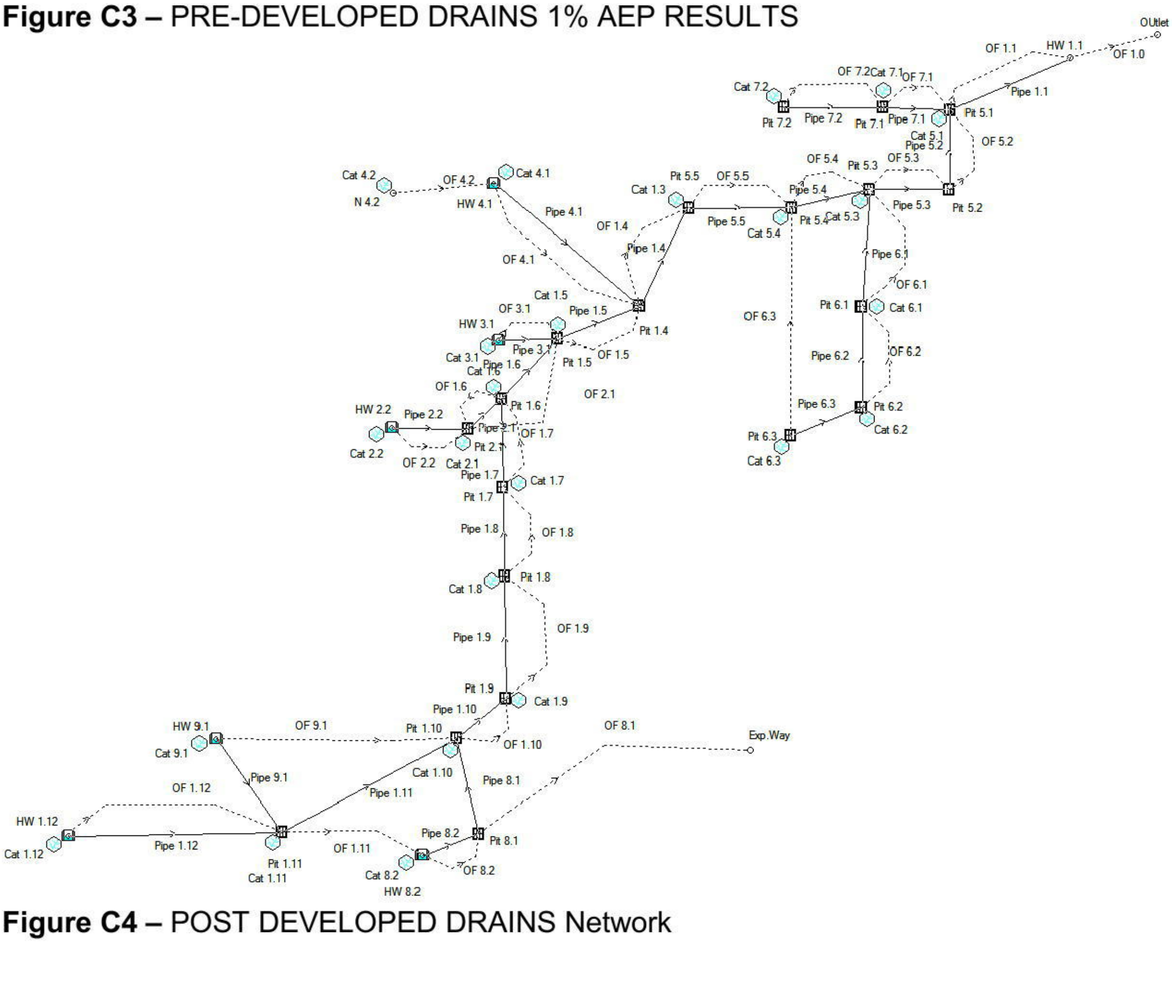


Figure C4 – POST DEVELOPED DRAINS Network

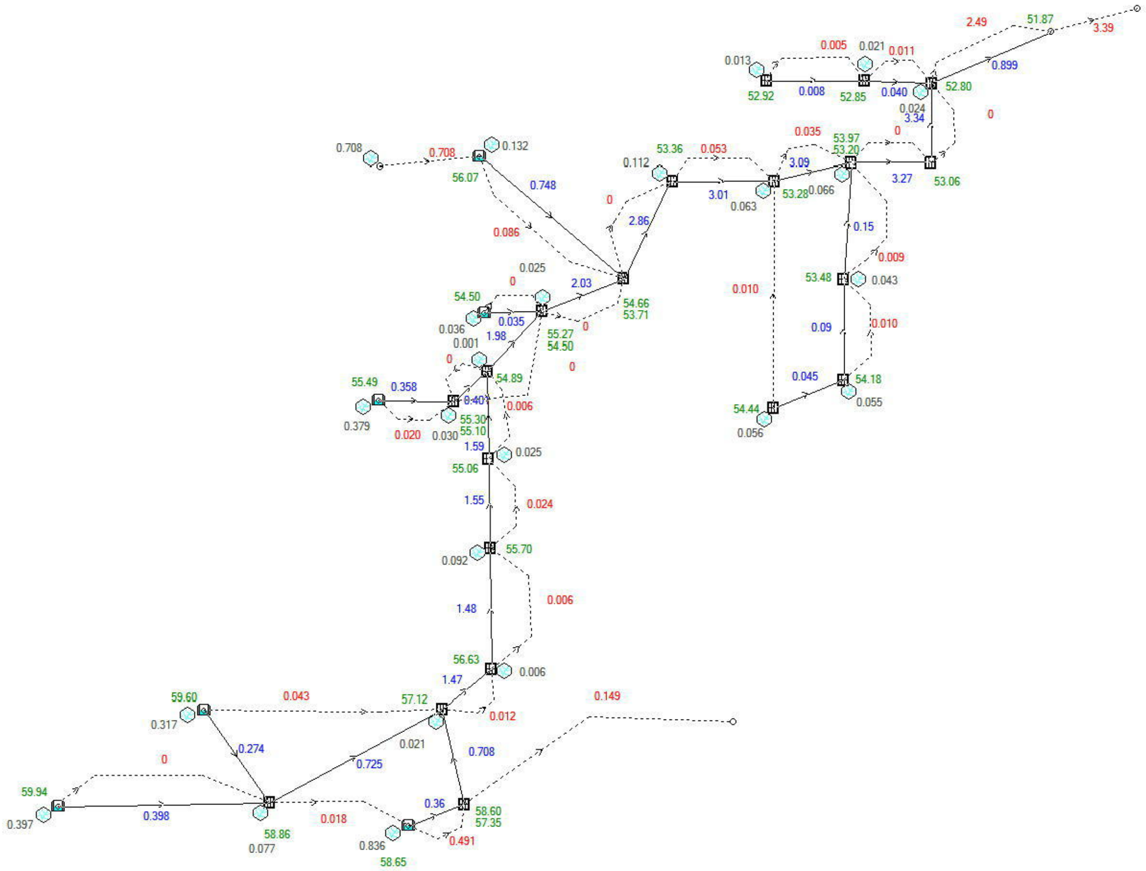


Figure C5 – POST DEVELOPED DRAINS 20% AEP RESULTS

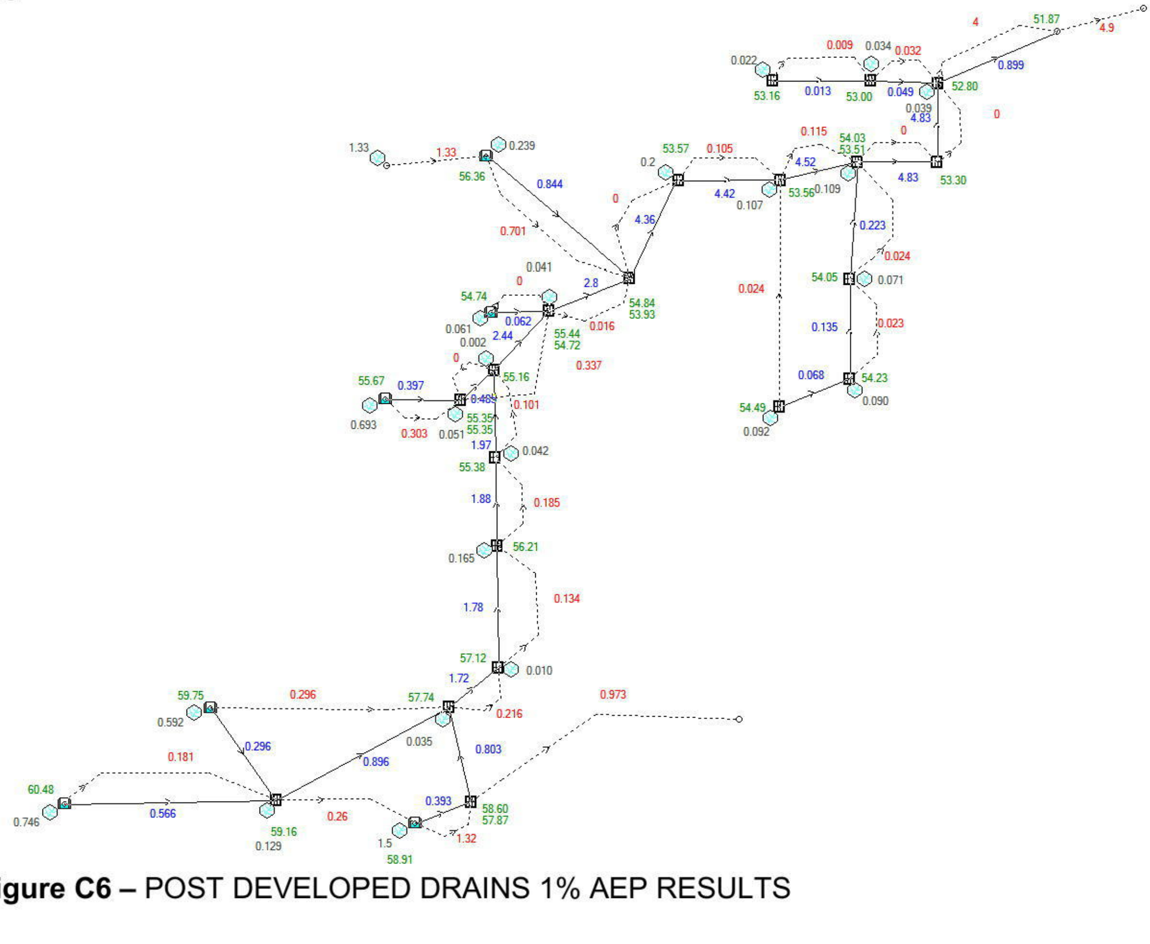


Figure C6 – POST DEVELOPED DRAINS 1% AEP RESULTS

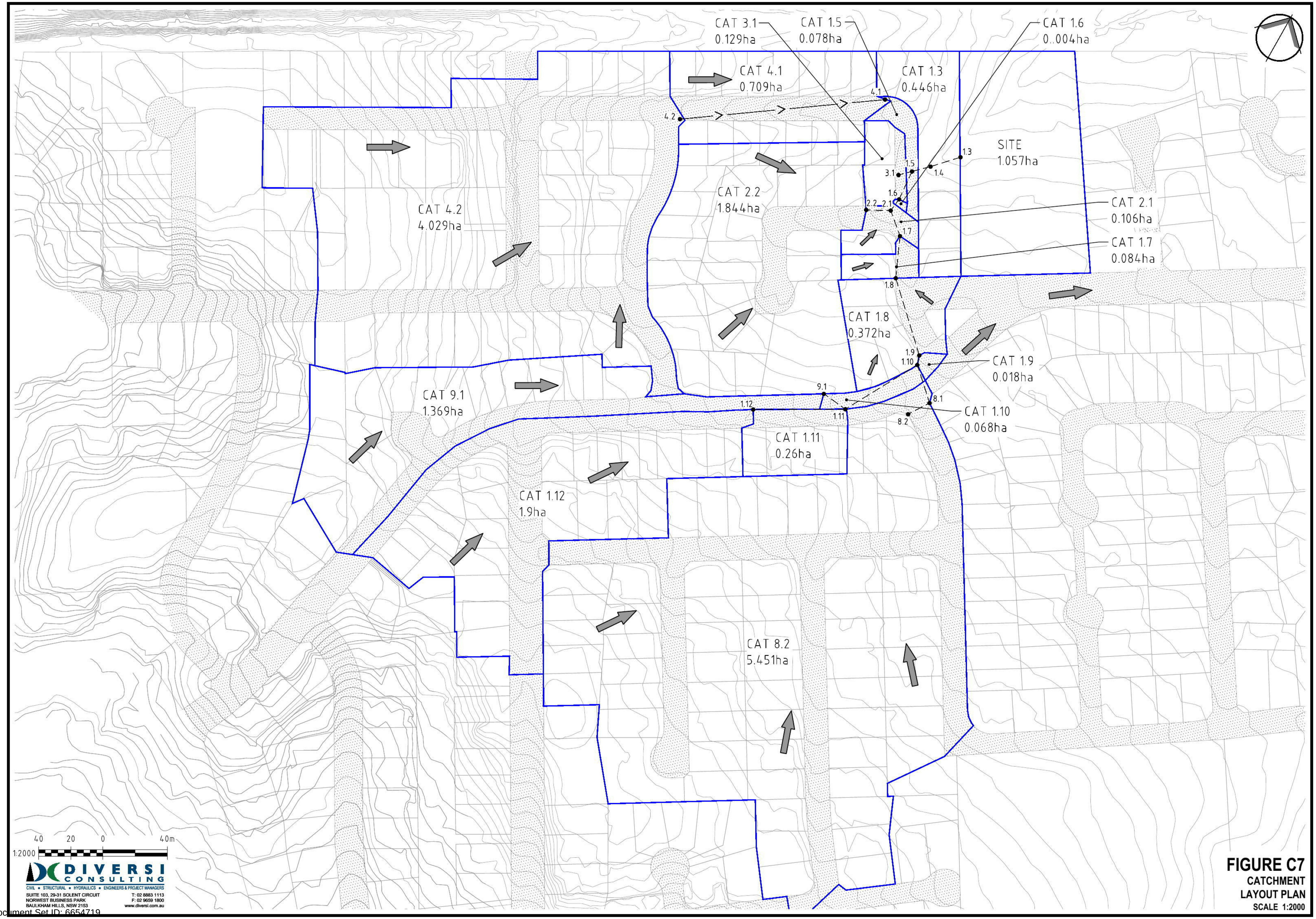


FIGURE C7
CATCHMENT LAYOUT PLAN
SCALE 1:2000

Table C1 – Pre-developed DRAINS Data

PIT / NODE DETAILS Version 12

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Blocking Factor
N 4.2	Node					56.5		
HW 4.1	Headwall				0.5	55.98		
Pit 1.4	Sag	WELDLOC	0.9 x 0.9	3	1.4	54.6	0.35	0.5
Pit 1.3	Sag	WELDLOC	0.9 x 0.9	3	0.4	54.45	0.4	0.5
Pit 1.2	OnGrade	WELDLOC	0.9 x 0.9		0.7	52.9		0.2
HW 1.1	Node					52.5		
HW 3.1	Headwall				0.5	55.27		
Pit 1.5	Sag	(Kl+grate), 3% crossfall	2.4 m lintel	3	1.7	55.24	0.2	0.5
HW 2.2	Headwall				0.5	55.45		
Pit 2.1	Sag	(Kl+grate), 3% crossfall	2.4 m lintel	1	0.9	55.25	0.1	0.5
Pit 1.6	OnGrade	grated sag pit (sags only)	0.9 m x 0.45 m		1.7	55.26		0.2
Junction	Node					54.45		
HW 9.1	Headwall				0.5	59.55		
Pit 1.11	OnGrade	(Kl+grate), 3% crossfall	1.8 m lintel		1.5	59.15		0.2
Pit 1.10	OnGrade	(Kl+grate), 3% crossfall	1.8 m lintel		1.5	58.02		0.2
Pit 1.9	OnGrade	WELDLOC	.6 x .6		1.5	57.64		0.2
Pit 1.8	OnGrade	(Kl+grate), 3% crossfall	1.8 m lintel		1.5	56.22		0.2
Pit 1.7	OnGrade	(Kl+grate), 3% crossfall	1.8 m lintel		0.6	55.71		0.2
HW 1.12	Headwall				0.5	60.34		
Exp.Way	Node					56.8		
HW 8.2	Headwall				0.5	58.37		
Pit 8.1	Sag	(Kl+grate), 3% crossfall	2.4 m lintel	2	1.5	58.4	0.2	0.5
M4	Node					52.4		

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)
Cat 4.2	N 4.2	4.0290	50.0	50.0	0.0	13	17.4	0
Cat 4.1	HW 4.1	0.7090	50.0	50.0	0.0	9	21.2	0
Cat 1.3	Pit 1.3	0.4460	60.0	40.0	0.0	7	10	0
SITE	Pit 1.2	1.0570	0.0	100.0	0.0	5	10	0
Cat 3.1	HW 3.1	0.1290	50.0	50.0	0.0	6	7	0
Cat 1.5	Pit 1.5	0.0780	70.0	30.0	0.0	5	5	0
Cat 2.2	HW 2.2	1.8440	50.0	50.0	0.0	9	14.2	0
Cat 2.1	Pit 2.1	0.1060	50.0	50.0	0.0	6	6	0
Cat 1.6	Pit 1.6	0.0040	70.0	30.0	0.0	5	5	0
Cat 9.1	HW 9.1	1.3690	50.0	50.0	0.0	9	10	0
Cat 1.11	Pit 1.11	0.2600	50.0	50.0	0.0	5	6	0
Cat 1.10	Pit 1.10	0.0680	90.0	10.0	0.0	6	6	0
Cat 1.9	Pit 1.9	0.0180	90.0	10.0	0.0	5	5	0
Cat 1.8	Pit 1.8	0.3722	50.0	50.0	0.0	7	9	0
Cat 1.7	Pit 1.7	0.0840	50.0	50.0	0.0	5	6	0
Cat 1.12	HW 1.12	1.9000	50.0	50.0	0.0	11	12.3	0
Cat 8.2	HW 8.2	5.4510	50.0	50.0	0.0	13	33	0

Table C1 – Pre-developed DRAINS Data (continued)

PIPE DETAILS

Name	From	To	Length	U/S IL	D/S IL	Slope	Type	Dia	Rough
			(m)	(m)	(m)	(%)		(mm)	
Pipe 4.1	HW 4.1	Pit 1.4	48.09	54.740	53.920	1.71	Concrete	600	0.3
Pipe 1.4	Pit 1.4	Pit 1.3	16.66	53.240	52.420	4.92	Concrete	600	0.3
Pipe 1.3	Pit 1.3	Pit 1.2	72.68	52.420	51.550	1.20	Concrete	600	0.3
Pipe 1.2	Pit 1.2	HW 1.1	48.29	51.550	51.309	0.50	Concrete	600	0.3
Pipe 3.1	HW 3.1	Pit 1.5	7.18	54.110	53.690	5.85	Concrete	375	0.3
Pipe 1.5	Pit 1.5	Pit 1.4	9.64	53.640	53.240	4.15	Concrete	1200	0.3
Pipe 2.2	HW 2.2	Pit 2.1	13.57	54.510	54.290	1.62	Concrete	450	0.3
Pipe 2.1	Pit 2.1	Pit 1.6	10	54.190	54.190	0.00	Concrete	525	0.3
Pipe 1.6	Pit 1.6	Pit 1.5	18.56	53.850	53.690	0.86	Concrete	1200	0.3
Pipe 9.1	HW 9.1	Pit 1.11	16	58.510	58.110	2.50	Concrete	375	0.3
Pipe 1.11	Pit 1.11	Pit 1.10	53.5	58.000	56.790	2.26	Concrete	600	0.3
Pipe 1.10	Pit 1.10	Pit 1.9	11.91	56.240	55.740	4.20	Concrete	900	0.3
Pipe 1.9	Pit 1.9	Pit 1.8	47.39	55.770	54.730	2.19	Concrete	900	0.3
Pipe 1.8	Pit 1.8	Pit 1.7	27.3	54.690	54.220	1.72	Concrete	900	0.3
Pipe 1.7	Pit 1.7	Pit 1.6	22.89	54.180	53.910	1.18	Concrete	1050	0.3
Pipe 1.12	HW 1.12	Pit 1.11	59	59.210	58.110	1.86	Concrete	525	0.3
Pipe 8.2	HW 8.2	Pit 8.1	8	56.964	56.800	2.05	Concrete	375	0.3
Pipe 8.1	Pit 8.1	Pit 1.10	20.88	56.760	56.260	2.39	Concrete	900	0.3

OVERFLOW ROUTE DETAILS

Name	From	To	Travel	Spill	Crest	Weir	Cross	Safe Depth	SafeDepth	Safe	Bed
			Time	Level	Length	Coeff. C	Section	Major Storms	Minor Storms	DxV	Slope
			(min)	(m)	(m)			(m)	(m)	(sq.m/sec)	(%)
OF 4.2	N 4.2	HW 4.1	1				7.5 m roadway	0.3	0.15	0.4	1
OF 4.1	HW 4.1	Pit 1.4	1	55.980	1.8	1.67	7.5 m roadway	0.3	0.15	0.4	1
OF 1.4	Pit 1.4	Junction	1				4 m wide pathway	0.3	0.15	0.4	1
OF 1.3	Pit 1.3	Junction	1				4 m wide pathway	0.3	0.15	0.4	1
OF 1.2	Pit 1.2	HW 1.1	1				4 m wide pathway	0.3	0.15	0.4	1
OF 1.1	HW 1.1	M4	1				Dummy	0.3	0.15	0.4	1
OF 3.1	HW 3.1	Pit 1.5	1	55.270	1.8	1.67	7.5 m roadway	0.3	0.15	0.4	1
OF 1.5	Pit 1.5	Pit 1.4	1				7.5 m roadway	0.3	0.15	0.4	1
OF 2.2	HW 2.2	Pit 2.1	1	55.450	1.8	1.67	7.5 m roadway	0.3	0.15	0.4	1
OF 2.1	Pit 2.1	Pit 1.5	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.6	Pit 1.6	Pit 2.1	1				7.5 m roadway	0.3	0.15	0.4	1
SITE OF	Junction	Pit 1.2	1				Dummy	0.3	0.15	0.4	1
OF 9.1	HW 9.1	Pit 1.10	1	59.550	2	1.67	10 m roadway	0.3	0.15	0.6	2.1
OF 1.11	Pit 1.11	HW 8.2	1				10 m roadway	0.3	0.15	0.6	1.89
OF 1.10	Pit 1.10	Pit 1.9	1				10 m roadway	0.3	0.15	0.6	2.97
OF 1.9	Pit 1.9	Pit 1.8	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.8	Pit 1.8	Pit 1.7	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.7	Pit 1.7	Pit 1.6	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.12	HW 1.12	Pit 1.11	1	60.340	2	1.67	10 m roadway	0.3	0.15	0.6	1.8
OF 8.2	HW 8.2	Pit 8.1	1	58.370	2	1.67	Dummy	0.3	0.15	0.4	1
OF 8.1	Pit 8.1	Exp.Way	1				10 m roadway	0.3	0.15	0.6	2.6

Table C2 – Post developed DRAINS Data

PIT / NODE DETAILS Version 12

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Blocking Factor
N 4.2	Node					56.5		
HW 4.1	Headwall				0.5	55.98		
Pit 1.4	Sag	WELDLOC	0.9 x 0.9	3	1.4	54.6	0.35	0.5
Pit 5.5	OnGrade	WELDLOC	0.9 x 0.9		1.7	54.5		0.2
Pit 5.4	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		0.9	54.02		0.2
Pit 5.3	Sag	(KI+grate), 3% crossfall	2.4 m lintel	1	0.9	53.88	0.15	0.5
Pit 5.2	OnGrade	WELDLOC	0.9 x 0.9		2.0	53.5		0.2
Pit 5.1	OnGrade	WELDLOC	0.9 x 0.9		1.2	52.8		0.2
HW 1.1	Node					52.5		
HW 3.1	Headwall				0.5	55.27		
Pit 1.5	Sag	(KI+grate), 3% crossfall	2.4 m lintel	3	1.7	55.24	0.2	0.5
HW 2.2	Headwall				0.5	55.45		
Pit 2.1	Sag	(KI+grate), 3% crossfall	2.4 m lintel	1	0.9	55.25	0.1	0.5
Pit 1.6	OnGrade	grated sag pit (sags only)	0.9 m x 0.45 m		1.7	55.26		0.2
Pit 6.3	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		3.5	55.65		0.2
Pit 6.2	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		0.7	55.55		0.2
Pit 6.1	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		0.5	54.3		0.2
Pit 7.2	OnGrade	WELDLOC	0.6 x 0.6		3.5	54		0.2
Pit 7.1	OnGrade	WELDLOC	0.6 x 0.6		0.5	53		0.2
HW 9.1	Headwall				0.5	59.55		
Pit 1.11	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		1.5	59.15		0.2
Pit 1.10	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		1.5	58.02		0.2
Pit 1.9	OnGrade	WELDLOC	0.6 x 0.6		1.5	57.64		0.2
Pit 1.8	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		1.5	56.22		0.2
Pit 1.7	OnGrade	(KI+grate), 3% crossfall	1.8 m lintel		0.6	55.71		0.2
HW 1.12	Headwall				0.5	60.34		
Exp.Way	Node					56.8		
HW 8.2	Headwall				0.5	58.37		
Pit 8.1	Sag	(KI+grate), 3% crossfall	2.4 m lintel	2	1.5	58.4	0.2	0.5
OUtlet	Node					52		

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)
Cat 4.2	N 4.2	4.0290	50.0	50.0	0.0	13	17.4	0
Cat 4.1	HW 4.1	0.7090	50.0	50.0	0.0	9	21.2	0
Cat 1.3	Pit 5.5	0.4460	60.0	40.0	0.0	7	10	0
Cat 5.4	Pit 5.4	0.2200	50.0	50.0	0.0	5	7	0
Cat 5.3	Pit 5.3	0.2110	75.0	25.0	0.0	5	7	0
Cat 5.1	Pit 5.1	0.0740	75.0	25.0	0.0	5	5	0
Cat 3.1	HW 3.1	0.1290	50.0	50.0	0.0	6	7	0
Cat 1.5	Pit 1.5	0.0780	70.0	30.0	0.0	5	5	0
Cat 2.2	HW 2.2	1.8440	50.0	50.0	0.0	9	14.2	0

Table C2 – Post developed DRAINS Data (continued)

Cat 2.1	Pit 2.1	0.1060	50.0	50.0	0.0	6	6	0
Cat 1.6	Pit 1.6	0.0040	70.0	30.0	0.0	5	5	0
Cat 6.3	Pit 6.3	0.1740	75.0	25.0	0.0	5	5	0
Cat 6.2	Pit 6.2	0.1710	75.0	25.0	0.0	5	5	0
Cat 6.1	Pit 6.1	0.1350	75.0	25.0	0.0	5	5	0
Cat 7.2	Pit 7.2	0.0410	75.0	25.0	0.0	5	5	0
Cat 7.1	Pit 7.1	0.0650	75.0	25.0	0.0	5	5	0
Cat 9.1	HW 9.1	1.3690	50.0	50.0	0.0	9	10	0
Cat 1.11	Pit 1.11	0.2600	50.0	50.0	0.0	5	6	0
Cat 1.10	Pit 1.10	0.0680	90.0	10.0	0.0	6	6	0
Cat 1.9	Pit 1.9	0.0180	90.0	10.0	0.0	5	5	0
Cat 1.8	Pit 1.8	0.3722	50.0	50.0	0.0	7	9	0
Cat 1.7	Pit 1.7	0.0840	50.0	50.0	0.0	5	6	0
Cat 1.12	HW 1.12	1.9000	50.0	50.0	0.0	11	12.3	0
Cat 8.2	HW 8.2	5.4510	50.0	50.0	0.0	13	33	0

PIPE DETAILS

Name	From	To	Length	U/S IL	D/S IL	Slope	Type	Dia	Rough
			(m)	(m)	(m)	(%)		(mm)	
Pipe 4.1	HW 4.1	Pit 1.4	48.09	54.740	53.920	1.71	Concrete	600	0.3
Pipe 1.4	Pit 1.4	Pit 5.5	26.88	53.240	52.220	3.79	Box culverts	1.5W x 0.9H	0.3
Pipe 5.5	Pit 5.5	Pit 5.4	33.74	52.220	51.880	1.01	Box culverts	1.5W x 0.9H	0.3
Pipe 5.4	Pit 5.4	Pit 5.3	17.5	51.880	51.740	0.80	Box culverts	1.5W x 0.9H	0.3
Pipe 5.3	Pit 5.3	Pit 5.2	30.3	51.740	51.590	0.50	Box culverts	1.5W x 0.9H	0.3
Pipe 5.2	Pit 5.2	Pit 5.1	34.7	51.590	51.410	0.52	Box culverts	1.5W x 0.9H	0.3
Pipe 1.1	Pit 5.1	HW 1.1	21.54	51.410	51.300	0.51	Concrete	600	0.3
Pipe 3.1	HW 3.1	Pit 1.5	7.18	54.110	53.690	5.85	Concrete	375	0.3
Pipe 1.5	Pit 1.5	Pit 1.4	9.64	53.640	53.240	4.15	Concrete	1200	0.3
Pipe 2.2	HW 2.2	Pit 2.1	13.57	54.510	54.290	1.62	Concrete	450	0.3
Pipe 2.1	Pit 2.1	Pit 1.6	10	54.190	54.190	0.00	Concrete	525	0.3
Pipe 1.6	Pit 1.6	Pit 1.5	18.56	53.850	53.690	0.86	Concrete	1200	0.3
Pipe 6.3	Pit 6.3	Pit 6.2	10.5	54.240	54.030	2.00	Concrete	375	0.3
Pipe 6.2	Pit 6.2	Pit 6.1	35.26	53.980	52.400	4.48	Concrete	375	0.3
Pipe 6.1	Pit 6.1	Pit 5.3	24.11	52.350	51.870	1.99	Concrete	375	0.3
Pipe 7.2	Pit 7.2	Pit 7.1	22.72	52.800	51.650	5.06	uPVC	150	0.03
Pipe 7.1	Pit 7.1	Pit 5.1	20	51.610	51.410	1.00	uPVC	225	0.03
Pipe 9.1	HW 9.1	Pit 1.11	16	58.510	58.110	2.50	Concrete	375	0.3
Pipe 1.11	Pit 1.11	Pit 1.10	53.5	58.000	56.790	2.26	Concrete	600	0.3
Pipe 1.10	Pit 1.10	Pit 1.9	11.91	56.240	55.740	4.20	Concrete	900	0.3
Pipe 1.9	Pit 1.9	Pit 1.8	47.39	55.770	54.730	2.19	Concrete	900	0.3
Pipe 1.8	Pit 1.8	Pit 1.7	27.3	54.690	54.220	1.72	Concrete	900	0.3
Pipe 1.7	Pit 1.7	Pit 1.6	22.89	54.180	53.910	1.18	Concrete	1050	0.3
Pipe 1.12	HW 1.12	Pit 1.11	59	59.210	58.110	1.86	Concrete	525	0.3
Pipe 8.2	HW 8.2	Pit 8.1	8	56.964	56.800	2.05	Concrete	375	0.3
Pipe 8.1	Pit 8.1	Pit 1.10	20.88	56.760	56.260	2.39	Concrete	900	0.3

Table C2 – Post developed DRAINS Data (continued)

OVERFLOW ROUTE DETAILS

Name	From	To	Travel	Spill	Crest	Weir	Cross	Safe Depth	SafeDepth	Safe	Bed
			Time	Level	Length	Coeff. C	Section	Major Storms	Minor Storms	DxV	Slope
			(min)	(m)	(m)			(m)	(m)	(sq.m/sec)	(%)
OF 4.2	N 4.2	HW 4.1	1				7.5 m roadway	0.3	0.15	0.4	1
OF 4.1	HW 4.1	Pit 1.4	1	55.980	1.8	1.67	7.5 m roadway	0.3	0.15	0.4	1
OF 1.4	Pit 1.4	Pit 5.5	1				4 m wide pathway	0.3	0.15	0.4	1
OF 5.5	Pit 5.5	Pit 5.4	1				Dummy	0.3	0.15	0.4	1
OF 5.4	Pit 5.4	Pit 5.3	1				Dummy	0.3	0.15	0.4	1
OF 5.3	Pit 5.3	Pit 5.2	1				Dummy	0.3	0.15	0.4	1
OF 5.2	Pit 5.2	Pit 5.1	1				Dummy	0.3	0.15	0.4	1
OF 1.1	Pit 5.1	HW 1.1	1				Dummy	0.3	0.15	0.4	1
OF 1.0	HW 1.1	OUtlet	1				Dummy	0.3	0.3	0.6	1
OF 3.1	HW 3.1	Pit 1.5	1	55.270	1.8	1.67	7.5 m roadway	0.3	0.15	0.4	1
OF 1.5	Pit 1.5	Pit 1.4	1				7.5 m roadway	0.3	0.15	0.4	1
OF 2.2	HW 2.2	Pit 2.1	1	55.450	1.8	1.67	7.5 m roadway	0.3	0.15	0.4	1
OF 2.1	Pit 2.1	Pit 1.5	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.6	Pit 1.6	Pit 2.1	1				7.5 m roadway	0.3	0.15	0.4	1
OF 6.3	Pit 6.3	Pit 5.4	2				10 m roadway	0.3	0.15	0.6	1
OF 6.2	Pit 6.2	Pit 6.1	1				10 m roadway	0.3	0.15	0.6	1
OF 6.1	Pit 6.1	Pit 5.3	1				10 m roadway	0.3	0.15	0.6	1
OF 7.2	Pit 7.2	Pit 7.1	1				Dummy	0.3	0.15	0.4	1
OF 7.1	Pit 7.1	Pit 5.1	1				Dummy	0.3	0.15	0.4	1
OF 9.1	HW 9.1	Pit 1.10	1	59.550	2	1.67	10 m roadway	0.3	0.15	0.6	2.1
OF 1.11	Pit 1.11	HW 8.2	1				10 m roadway	0.3	0.15	0.6	1.89
OF 1.10	Pit 1.10	Pit 1.9	1				10 m roadway	0.3	0.15	0.6	2.97
OF 1.9	Pit 1.9	Pit 1.8	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.8	Pit 1.8	Pit 1.7	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.7	Pit 1.7	Pit 1.6	1				7.5 m roadway	0.3	0.15	0.4	1
OF 1.12	HW 1.12	Pit 1.11	1	60.340	2	1.67	10 m roadway	0.3	0.15	0.6	1.8
OF 8.2	HW 8.2	Pit 8.1	1	58.370	2	1.67	Dummy	0.3	0.15	0.4	1
OF 8.1	Pit 8.1	Exp.Way	1				10 m roadway	0.3	0.15	0.6	2.6
OF 8.2	HW 8.2	Pit 8.1	1	58.370	2	1.67	Dummy	0.3	0.15	0.4	1
OF 8.1	Pit 8.1	Exp.Way	1				10 m roadway	0.3	0.15	0.6	2.6

Table C3 – Pre-developed DRAINS Results

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
HW 4.1	56.36		1.562		-0.38	0.701	Headwall height/system capacity
Pit 1.4	55.26	54.95	2.523	2.6	-0.66	3.528	Outlet System
Pit 1.3	54.49	54.59	0.200	0.5	-0.04	0.000	Outlet System
Pit 1.2	52.90		3.808		0.00	3.850	Outlet System
HW 1.1	51.88		3.850				
HW 3.1	55.41		0.061		-0.14	0.127	Headwall height/system capacity
Pit 1.5	55.33	55.44	1.987	2.6	-0.09	1.835	Outlet System
HW 2.2	55.67		0.693		-0.22	0.305	Headwall height/system capacity
Pit 2.1	55.35	55.35	1.311	0.9	-0.10	1.850	Outlet System
Pit 1.6	55.39		0.290		-0.13	1.015	Outlet System
HW 9.1	59.75		0.592		-0.20	0.296	Headwall height/system capacity
Pit 1.11	59.16		0.289		-0.01	0.288	Outlet System
Pit 1.10	57.83		0.325		0.19	0.216	Inlet Capacity
Pit 1.9	57.22		0.223		0.42	0.049	Inlet Capacity
Pit 1.8	56.25		0.192		-0.03	0.371	Outlet System
Pit 1.7	55.57		0.400		0.14	0.289	Inlet Capacity
HW 1.12	60.48		0.746		-0.14	0.181	Headwall height/system capacity
HW 8.2	58.91		1.760		-0.54	1.341	Headwall height/system capacity
Pit 8.1	57.95	58.60	1.341	1.7	0.45	0.999	Inlet Capacity

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat 4.2	1.329	0.857	0.516	13.00	17.40	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 4.1	0.239	0.152	0.093	9.00	21.20	0.00	AR&R 100 year, 2 hours storm, average 44.2 mm/h, Zone 1
Cat 1.3	0.200	0.131	0.069	7.00	10.00	0.00	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
SITE	0.423	0.000	0.423	5.00	10.00	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 3.1	0.061	0.034	0.027	6.00	7.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.5	0.041	0.030	0.011	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 2.2	0.693	0.442	0.283	9.00	14.20	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 2.1	0.051	0.028	0.023	6.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.6	0.002	0.002	0.001	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 9.1	0.592	0.328	0.274	9.00	10.00	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 1.11	0.129	0.071	0.057	5.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.10	0.035	0.032	0.003	6.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.9	0.010	0.009	0.001	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.8	0.165	0.091	0.074	7.00	9.00	0.00	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Cat 1.7	0.042	0.023	0.019	5.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.12	0.746	0.431	0.325	11.00	12.30	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 8.2	1.496	1.159	0.368	13.00	33.00	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1

Table C3 – Pre-developed DRAINS Results (continued)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
Pipe 4.1	0.844	2.99	55.901	55.259	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.4	0.915	3.23	54.678	54.485	AR&R 100 year, 10 minutes storm, average 168 mm/h, Zone 1
Pipe 1.3	1.006	3.56	54.227	52.900	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Pipe 1.2	0.880	3.18	52.729	51.875	AR&R 100 year, 5 minutes storm, average 206.1 mm/h, Zone 1
Pipe 3.1	0.063	0.57	55.323	55.332	AR&R 100 year, 10 minutes storm, average 168 mm/h, Zone 1
Pipe 1.5	1.090	0.96	55.264	55.259	AR&R 100 year, 1.5 hours storm, average 52.6 mm/h, Zone 1
Pipe 2.2	0.388	2.44	55.516	55.350	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 2.1	0.334	1.54	55.350	55.388	AR&R 100 year, 5 minutes storm, average 206.1 mm/h, Zone 1
Pipe 1.6	0.983	0.87	55.338	55.332	AR&R 100 year, 10 minutes storm, average 168 mm/h, Zone 1
Pipe 9.1	0.296	2.68	59.448	59.160	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.11	0.883	3.63	58.482	57.827	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.10	1.694	2.66	57.297	57.224	AR&R 100 year, 2 hours storm, average 44.2 mm/h, Zone 1
Pipe 1.9	1.849	3.07	56.579	56.248	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.8	1.657	2.60	55.942	55.568	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.7	1.762	1.96	55.514	55.388	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.12	0.566	2.61	59.878	59.160	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 8.2	0.394	3.57	58.216	57.954	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 8.1	0.800	1.26	57.852	57.827	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF 4.2	1.329	1.329	1.484	0.212	0.37	7.04	1.75	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 4.1	0.701	0.701	1.484	0.172	0.24	6.03	1.42	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.4	3.528	3.528	1.479	0.330	0.92	4.00	2.80	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.3	0	0	1.479	0	0	0	0	
OF 1.2	3.850	3.850	1.479	0.348	1.01	4.00	2.89	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.1	4.730	4.730	3.629	0.332	0.29	33.15	0.86	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 3.1	0.127	0.127	1.484	0.097	0.09	3.08	0.96	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.5	1.835	1.835	1.484	0.238	0.46	7.69	1.93	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 2.2	0.305	0.305	1.484	0.134	0.14	5.09	1.07	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 2.1	1.850	1.850	1.484	0.239	0.46	7.70	1.94	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.6	1.015	1.015	1.484	0.194	0.31	6.58	1.60	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
SITE OF	3.528	3.528	3.629	0.296	0.24	29.64	0.80	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 9.1	0.296	0.296	2.340	0.136	0.19	3.69	1.42	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.11	0.288	0.288	2.415	0.138	0.18	3.75	1.34	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.10	0.216	0.216	2.115	0.117	0.18	3.03	1.51	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.9	0.049	0.049	1.484	0.070	0.05	2.11	0.78	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.8	0.371	0.371	1.484	0.142	0.16	5.28	1.15	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.7	0.289	0.289	1.484	0.131	0.14	4.96	1.07	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.12	0.181	0.181	2.422	0.119	0.14	3.11	1.21	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 8.2	1.341	1.341	3.629	0.207	0.13	20.65	0.63	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 8.1	0.999	0.999	2.211	0.198	0.37	6.81	1.86	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1

Table C4 – Post developed DRAINS Results

PIT / NODE DETAILS

Name	Max HGL	Max Pond	Max Surface	Max Pond	Min	Overflow	Constraint
		HGL	Flow Arriving	Volume	Freeboard	(cu.m/s)	
			(cu.m/s)	(cu.m)	(m)		
HW 4.1	56.36		1.562		-0.38	0.701	Headwall height/system capacity
Pit 1.4	53.93	54.84	0.712	1.3	0.67	0.000	Inlet Capacity
Pit 5.5	53.57		0.200		0.93	0.105	Inlet Capacity
Pit 5.4	53.56		0.232		0.46	0.115	Inlet Capacity
Pit 5.3	53.51	54.03	0.243	0.8	0.37	0.000	Inlet Capacity
Pit 5.2	53.30		0.000		0.20	0.000	None
Pit 5.1	52.80		0.065		0.00	4.001	Outlet System
HW 1.1	51.87		4.001				
HW 3.1	54.74		0.061		0.53	0.000	None
Pit 1.5	54.72	55.44	0.363	2.6	0.52	0.016	Inlet Capacity
HW 2.2	55.67		0.693		-0.22	0.303	Headwall height/system capacity
Pit 2.1	55.35	55.35	0.345	0.9	-0.10	0.337	Outlet System
Pit 1.6	55.16		0.102		0.10	0.000	None
Pit 6.3	54.49		0.092		1.16	0.024	Inlet Capacity
Pit 6.2	54.23		0.090		1.32	0.023	Inlet Capacity
Pit 6.1	54.05		0.094		0.25	0.024	Inlet Capacity
Pit 7.2	53.16		0.022		0.84	0.009	Inlet Capacity
Pit 7.1	53.00		0.043		0.00	0.032	Inlet Capacity
HW 9.1	59.75		0.592		-0.20	0.296	Headwall height/system capacity
Pit 1.11	59.16		0.289		-0.01	0.260	Outlet System
Pit 1.10	57.74		0.325		0.28	0.216	Inlet Capacity
Pit 1.9	57.12		0.223		0.52	0.134	Inlet Capacity
Pit 1.8	56.21		0.275		0.01	0.185	Inlet Capacity
Pit 1.7	55.38		0.212		0.33	0.101	Inlet Capacity
HW 1.12	60.48		0.746		-0.14	0.181	Headwall height/system capacity
HW 8.2	58.91		1.733		-0.54	1.315	Headwall height/system capacity
Pit 8.1	57.87	58.60	1.315	1.7	0.53	0.973	Inlet Capacity

SUB-CATCHMENT DETAILS

Name	Max	Paved	Grassed	Paved	Grassed	Supp.	Due to Storm
	Flow Q	Max Q	Max Q	Tc	Tc	Tc	
	(cu.m/s)	(cu.m/s)	(cu.m/s)	(min)	(min)	(min)	
Cat 4.2	1.329	0.857	0.516	13.00	17.40	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 4.1	0.239	0.152	0.093	9.00	21.20	0.00	AR&R 100 year, 2 hours storm, average 44.2 mm/h, Zone 1
Cat 1.3	0.200	0.131	0.069	7.00	10.00	0.00	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Cat 5.4	0.107	0.060	0.046	5.00	7.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 5.3	0.109	0.087	0.022	5.00	7.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 5.1	0.039	0.030	0.009	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 3.1	0.061	0.034	0.027	6.00	7.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.5	0.041	0.030	0.011	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 2.2	0.693	0.442	0.283	9.00	14.20	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1

Table C4 – Post developed DRAINS Results (continued)

Cat 2.1	0.051	0.028	0.023	6.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.6	0.002	0.002	0.001	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 6.3	0.092	0.071	0.020	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 6.2	0.090	0.070	0.020	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 6.1	0.071	0.055	0.016	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 7.2	0.022	0.017	0.005	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 7.1	0.034	0.027	0.008	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 9.1	0.592	0.328	0.274	9.00	10.00	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 1.11	0.129	0.071	0.057	5.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.10	0.035	0.032	0.003	6.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.9	0.010	0.009	0.001	5.00	5.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.8	0.165	0.091	0.074	7.00	9.00	0.00	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Cat 1.7	0.042	0.023	0.019	5.00	6.00	0.00	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Cat 1.12	0.746	0.431	0.325	11.00	12.30	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Cat 8.2	1.496	1.159	0.368	13.00	33.00	0.00	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1

PIPE DETAILS

Name	Max Q	Max V	Max U/S	Max D/S	Due to Storm
	(cu.m/s)	(m/s)	HGL (m)	HGL (m)	
Pipe 4.1	0.844	3.87	55.173	54.357	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.4	4.359	3.93	53.610	53.565	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 5.5	4.420	1.64	53.454	53.563	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 5.4	4.516	1.67	53.526	53.515	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 5.3	4.831	1.79	53.481	53.297	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Pipe 5.2	4.834	1.79	53.188	52.800	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Pipe 1.1	0.899	3.24	52.316	51.869	AR&R 100 year, 5 minutes storm, average 206.1 mm/h, Zone 1
Pipe 3.1	0.062	0.56	54.719	54.715	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Pipe 1.5	2.796	6.59	54.122	53.925	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 2.2	0.397	2.50	55.514	55.350	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Pipe 2.1	0.485	2.24	55.213	55.164	AR&R 100 year, 1.5 hours storm, average 52.6 mm/h, Zone 1
Pipe 1.6	2.441	2.63	54.768	54.715	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 6.3	0.068	2.24	54.360	54.227	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Pipe 6.2	0.135	3.63	54.119	54.045	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Pipe 6.1	0.223	2.02	53.986	53.515	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 7.2	0.013	0.85	52.922	52.997	AR&R 100 year, 10 minutes storm, average 168 mm/h, Zone 1
Pipe 7.1	0.049	1.07	52.994	52.800	AR&R 100 year, 10 minutes storm, average 168 mm/h, Zone 1
Pipe 9.1	0.296	2.68	59.449	59.159	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.11	0.896	3.96	58.448	57.740	AR&R 100 year, 2 hours storm, average 44.2 mm/h, Zone 1
Pipe 1.10	1.715	2.70	57.197	57.124	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
Pipe 1.9	1.784	3.14	56.523	56.212	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 1.8	1.876	2.97	55.571	55.385	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Pipe 1.7	1.969	2.19	55.250	55.164	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
Pipe 1.12	0.566	2.61	59.887	59.159	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 8.2	0.393	3.56	58.128	57.867	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
Pipe 8.1	0.803	1.26	57.765	57.740	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1

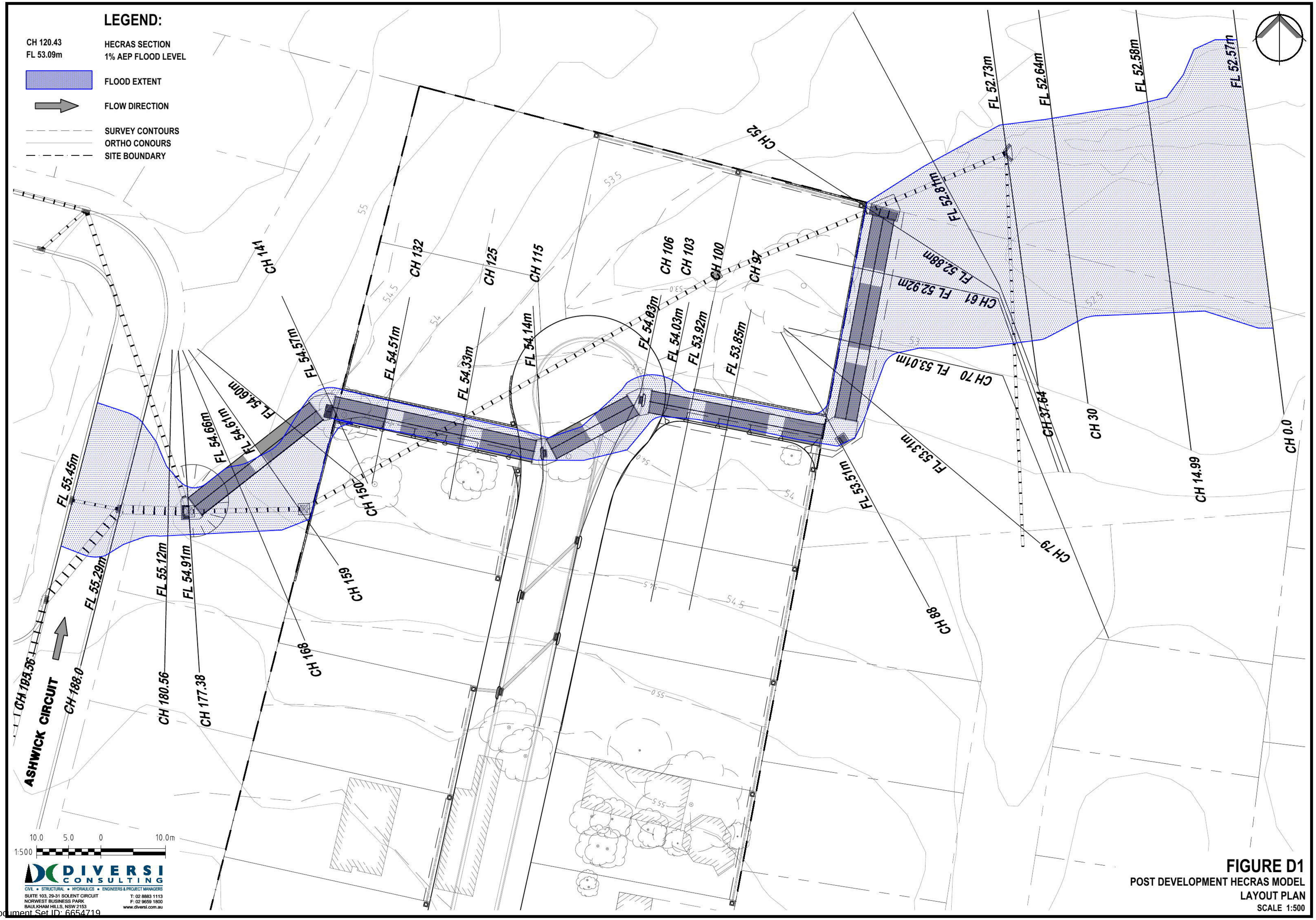
Table C4 – Post developed DRAINS Results (continued)

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF 4.2	1.329	1.329	1.484	0.212	0.37	7.04	1.75	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 4.1	0.701	0.701	1.484	0.172	0.24	6.03	1.42	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.4	0	0	1.479	0	0	0	0	
OF 5.5	0.105	0.105	3.629	0.080	0.03	7.96	0.33	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 5.4	0.115	0.115	3.629	0.083	0.03	8.25	0.34	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 5.3	0	0	3.629	0	0	0	0	
OF 5.2	0	0	3.629	0	0	0	0	
OF 1.1	4.001	4.001	3.629	0.311	0.26	31.10	0.83	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.0	4.899	4.899	3.629	0.335	0.29	33.54	0.87	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 3.1	0	0	1.484	0	0	0	0	
OF 1.5	0.016	0.016	1.484	0.048	0.03	1.31	0.63	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 2.2	0.303	0.303	1.484	0.134	0.14	5.07	1.08	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 2.1	0.337	0.337	1.484	0.138	0.15	5.18	1.11	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.6	0	0	1.484	0	0	0	0	
OF 6.3	0.024	0.024	2.459	0.068	0.05	1.41	0.67	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
OF 6.2	0.023	0.023	2.459	0.067	0.05	1.37	0.68	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
OF 6.1	0.024	0.024	2.459	0.068	0.05	1.41	0.67	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
OF 7.2	0.009	0.009	3.629	0.032	0.01	3.17	0.17	AR&R 100 year, 15 minutes storm, average 139.7 mm/h, Zone 1
OF 7.1	0.032	0.032	3.629	0.051	0.01	5.13	0.24	AR&R 100 year, 10 minutes storm, average 168 mm/h, Zone 1
OF 9.1	0.296	0.296	2.340	0.136	0.19	3.69	1.42	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.11	0.260	0.260	2.415	0.133	0.17	3.60	1.31	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.10	0.216	0.216	2.115	0.117	0.18	3.03	1.51	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 1.9	0.134	0.134	1.484	0.098	0.10	3.14	0.97	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.8	0.185	0.185	1.484	0.112	0.11	3.87	0.99	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.7	0.101	0.101	1.484	0.089	0.08	2.81	0.91	AR&R 100 year, 25 minutes storm, average 108.5 mm/h, Zone 1
OF 1.12	0.181	0.181	2.422	0.119	0.14	3.11	1.21	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 8.2	1.315	1.315	3.629	0.205	0.13	20.46	0.63	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1
OF 8.1	0.973	0.973	2.211	0.197	0.36	6.78	1.84	AR&R 100 year, 20 minutes storm, average 121.4 mm/h, Zone 1

Appendix D

HEC-RAS Layout and Results


LEGEND:
CH 120.43
FL 53.09m
HECRAS SECTION
1% AEP FLOOD LEVEL
FLOOD EXTENT
FLOW DIRECTION
SURVEY CONTOURS
ORTHO CONOURS
SITE BOUNDARY
CH 0.0
CH 14.99
CH 30
CH 37.64
CH 52
CH 61
CH 70
CH 79
CH 88
CH 97
CH 100
CH 103
CH 106
CH 115
CH 125
CH 132
CH 141
CH 150
CH 159
CH 168
CH 177.38
CH 180.56
CH 188.0
CH 195.56
FL 52.57m
FL 52.58m
FL 52.64m
FL 52.73m
FL 52.81m
FL 52.88m
FL 52.92m
FL 53.01m
FL 53.31m
FL 53.51m
FL 53.85m
FL 53.92m
FL 54.03m
FL 54.03m
FL 54.14m
FL 54.33m
FL 54.51m
FL 54.57m
FL 54.60m
FL 54.61m
FL 54.66m
FL 54.91m
FL 55.12m
FL 55.29m
FL 55.45m
ASHWICK CIRCUIT
10.0 5.0 0 10.0m
1:500
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F: 02 9659 1800
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FIGURE D1
POST DEVELOPMENT HECRAS MODEL
LAYOUT PLAN
SCALE 1:500

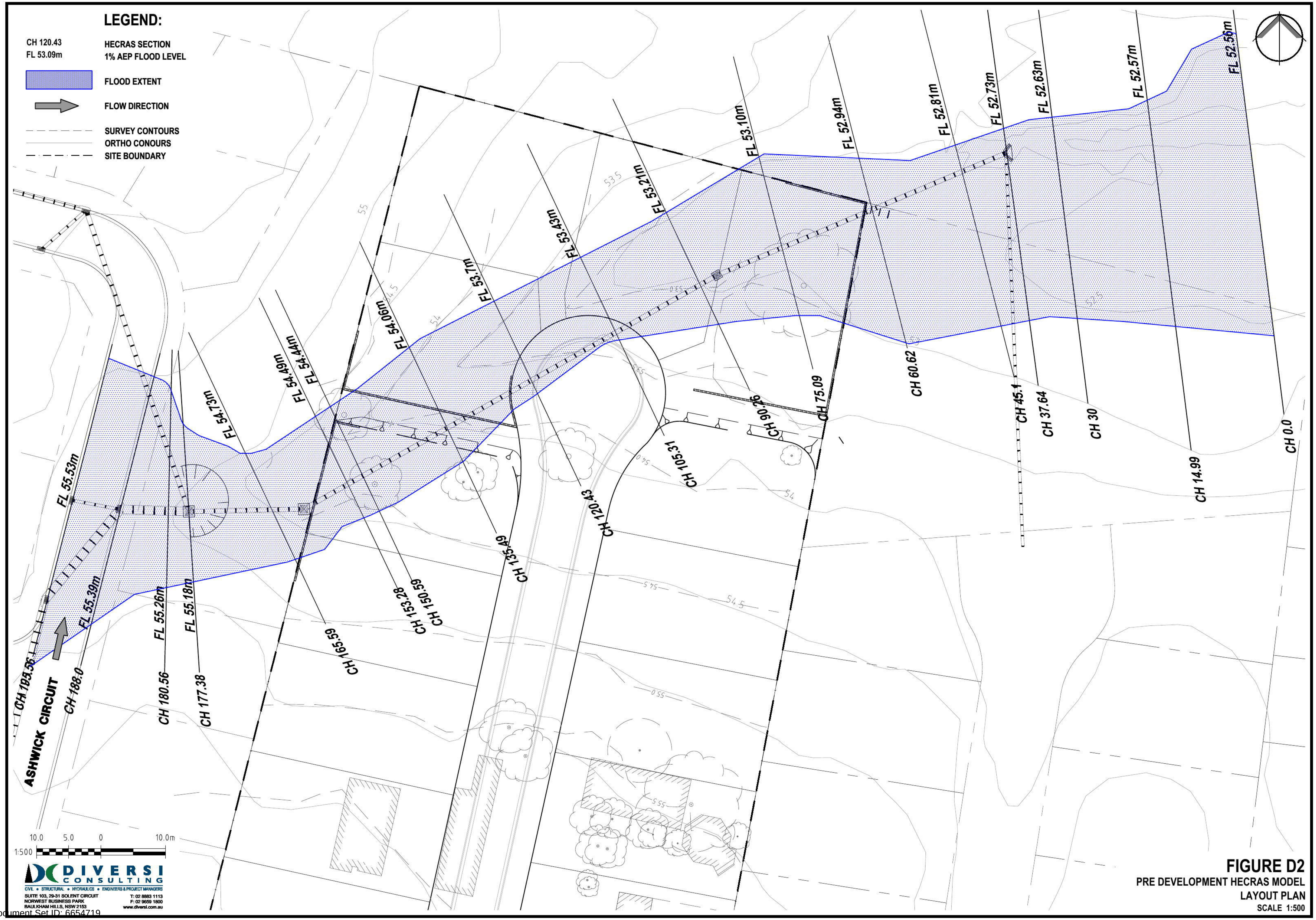


FIGURE D2
PRE DEVELOPMENT HECRAS MODEL
LAYOUT PLAN
SCALE 1:500

Results

Table D1 – Pre-developed HEC RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Flow Area	Top Width	Froude # Chl	Depth	Vd
			(m3/s)	(m)	(m)	(m)	(m/s)	(m2)	(m)		(m)	(m2/s)
0	195.6	20% AEP	1.93	55.39	55.49	55.49	0.9	2.3	39.65	1.03	0.1	0.09
0	188	20% AEP	1.93	55.2	55.33		0.7	2.89	32.14	0.7	0.13	0.09
0	180.6	20% AEP	1.93	55.02	55.2	55.19	0.93	2.07	17.83	0.87	0.18	0.17
0	177.4	20% AEP	1.93	54.89	55.11	55.11	1.1	1.76	14.45	1	0.22	0.24
0	165.6	20% AEP	1.93	54.45	54.65	54.65	1.15	1.68	12.77	1.01	0.2	0.23
0	153.3	20% AEP	1.93	54.18	54.42		0.91	2.11	13.62	0.74	0.24	0.22
0	150.6	20% AEP	1.93	54.12	54.36		0.98	1.97	13.18	0.81	0.24	0.24
0	135.5	20% AEP	1.93	53.68	53.97	53.97	1.23	1.57	10.57	1.01	0.29	0.36
0	120.4	20% AEP	1.93	53.33	53.62	53.6	1.09	1.82	11.92	0.85	0.29	0.32
0	105.3	20% AEP	1.93	53.05	53.34	53.34	1.23	1.66	11.44	0.95	0.29	0.36
0	90.26	20% AEP	2.14	52.89	53.14		0.73	2.98	19.09	0.57	0.25	0.18
0	75.09	20% AEP	2.14	52.77	53.03		0.67	3.2	19.39	0.53	0.26	0.17
0	60.62	20% AEP	2.14	52.64	52.88		0.83	2.88	25.08	0.66	0.24	0.20
0	45.1	20% AEP	2.14	52.5	52.76		0.67	3.87	28.35	0.49	0.26	0.17
0	37.64	20% AEP	3.02	52.2	52.68		0.99	4.48	29.96	0.59	0.48	0.48
0	30	20% AEP	3.02	52.03	52.55	52.55	1.37	3.28	26.29	0.92	0.52	0.71
0	14.99	20% AEP	3.02	51.96	52.47		0.74	5.74	26.62	0.39	0.51	0.38
0	0	20% AEP	3.02	51.93	52.46	52.2	0.4	11.58	40.71	0.18	0.53	0.21

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Flow Area	Top Width	Froude # Chl	Depth	Vd
			(m3/s)	(m)	(m)	(m)	(m/s)	(m2)	(m)		(m)	(m2/s)
0	195.56	1% AEP	3.53	55.39	55.53	55.53	0.97	4.07	46.69	0.91	0.14	0.14
0	188	1% AEP	3.53	55.2	55.39		0.82	4.66	36.07	0.67	0.19	0.16
0	180.56	1% AEP	3.53	55.02	55.26		1.06	3.33	21.35	0.86	0.24	0.25
0	177.38	1% AEP	3.53	54.89	55.18	55.18	1.24	2.85	18.74	1.01	0.29	0.36
0	165.59	1% AEP	3.53	54.45	54.73	54.73	1.28	2.77	17.07	1.01	0.28	0.36
0	153.28	1% AEP	3.53	54.18	54.49		1.08	3.27	16.77	0.78	0.31	0.33
0	150.59	1% AEP	3.53	54.12	54.44		1.13	3.12	17	0.84	0.32	0.36
0	135.49	1% AEP	3.53	53.68	54.06	54.06	1.33	2.65	15.11	1.01	0.38	0.51
0	120.43	1% AEP	3.53	53.33	53.7	53.69	1.3	2.85	15.08	0.9	0.37	0.48
0	105.31	1% AEP	3.53	53.05	53.43	53.43	1.4	2.72	14.73	0.96	0.38	0.53
0	90.26	1% AEP	3.85	52.89	53.21		0.9	4.45	22.51	0.6	0.32	0.29
0	75.09	1% AEP	3.85	52.77	53.1		0.87	4.51	23.8	0.59	0.33	0.29
0	60.62	1% AEP	3.85	52.64	52.94		0.98	4.52	28.55	0.66	0.3	0.29
0	45.1	1% AEP	3.85	52.5	52.81		0.85	5.48	30.65	0.54	0.31	0.26
0	37.64	1% AEP	4.73	52.2	52.73		1.19	5.74	31.48	0.67	0.53	0.63
0	30	1% AEP	4.73	52.03	52.63		1.31	5.71	35.03	0.76	0.6	0.79
0	14.99	1% AEP	4.73	51.96	52.57		0.82	8.89	35.86	0.38	0.61	0.50
0	0	1% AEP	4.73	51.93	52.56	52.25	0.45	15.94	45.26	0.19	0.63	0.28

Table D2 – Post developed HEC RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Flow Area	Top Width	Froude # Chl	Depth (m)	Vd
			(m3/s)	(m)	(m)	(m)	(m/s)	(m2)	(m)			
0	195.56	20% AEP	0.09	55.39	55.41	55.41	0.34	0.25	16.29	0.88	0.02	0.01
0	188	20% AEP	0.09	55.2	55.24	55.23	0.27	0.32	15.6	0.59	0.04	0.01
0	180.56	20% AEP	0.09	55.02	55.05	55.05	0.51	0.17	6.52	1.01	0.03	0.02
0	177.38	20% AEP	0.01	54.89	54.91	54.91	0.3	0.03	2.62	0.86	0.02	0.01
0	168	20% AEP	0.01	54.63	54.66	54.66	0.13	0.08	3.79	0.29	0.03	0.00
0	159	20% AEP	0.01	54.6	54.61	54.61	0.13	0.07	11.79	0.54	0.01	0.001
0	150	20% AEP	0.01	54.55	54.59		0.06	0.17	5.02	0.1	0.04	0.00
0	141	20% AEP	0.05	54.5	54.54		0.43	0.14	4.38	0.66	0.04	0.02
0	132	20% AEP	0.05	54.41	54.47	54.44	0.23	0.24	3.82	0.28	0.06	0.01
0	125	20% AEP	0.05	54.29	54.32		0.46	0.12	3.66	0.81	0.03	0.01
0	115	20% AEP	0.03	54.01	54.09	54.09	0.58	0.06	1.71	0.99	0.08	0.05
0	106	20% AEP	0.01	53.88	54.03		0.01	0.86	8.47	0.01	0.15	0.001
0	103	20% AEP	0.01	54.02	54.03	54.03	0.29	0.03	3.89	0.98	0.01	0.00
0	100	20% AEP	0.01	53.9	53.92	53.91	0.15	0.06	4	0.37	0.02	0.00
0	97	20% AEP	0.01	53.84	53.85	53.85	0.22	0.04	3.56	0.64	0.01	0.00
0	88	20% AEP	0.01	53.5	53.51	53.51	0.2	0.05	4.8	0.61	0.01	0.00
0	79	20% AEP	0.01	53.3	53.31		0.25	0.04	3.83	0.73	0.01	0.00
0	70	20% AEP	0.01	53	53.01	53.01	0.34	0.03	4.35	1.3	0.01	0.00
0	61	20% AEP	0.01	52.65	52.87		0	3.07	28.35	0	0.22	0.000
0	52	20% AEP	2.49	52.6	52.83		0.57	4.39	31.27	0.48	0.23	0.13
0	43	20% AEP	2.49	52.55	52.77		0.57	4.67	29.14	0.43	0.22	0.13
0	37.64	20% AEP	3.39	52.2	52.7		1	4.92	30.51	0.58	0.5	0.50
0	30	20% AEP	3.39	52.03	52.56	52.56	1.42	3.56	27.73	0.94	0.53	0.75
0	14.99	20% AEP	3.39	51.96	52.49		0.75	6.41	27.95	0.38	0.53	0.40
0	0	20% AEP	3.39	51.93	52.49	52.21	0.41	12.61	42.1	0.18	0.56	0.23

Table D2 – Post developed HEC RAS Results (continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Flow Area	Top Width	Froude # Chl	Depth (m)	Vd
			(m3/s)	(m)	(m)	(m)	(m/s)	(m2)	(m)			
0	195.56	1% AEP	0.7	55.39	55.45	55.45	0.64	1.12	27.68	0.99	0.06	0.04
0	188	1% AEP	0.72	55.2	55.29	55.28	0.48	1.51	28.23	0.64	0.09	0.04
0	180.56	1% AEP	0.72	55.02	55.12	55.12	0.82	0.88	13.26	1.01	0.1	0.08
0	177.38	1% AEP	0.01	54.89	54.91	54.91	0.3	0.03	2.62	0.86	0.02	0.01
0	168	1% AEP	0.01	54.63	54.66	54.66	0.13	0.07	3.75	0.3	0.03	0.00
0	159	1% AEP	0.01	54.6	54.61		0.13	0.08	11.8	0.49	0.01	0.00
0	150	1% AEP	0.01	54.55	54.6		0.04	0.27	5.23	0.05	0.05	0.00
0	141	1% AEP	0.11	54.5	54.57		0.5	0.25	5	0.63	0.07	0.04
0	132	1% AEP	0.11	54.41	54.51		0.29	0.36	3.99	0.3	0.1	0.03
0	125	1% AEP	0.11	54.29	54.33	54.33	0.66	0.16	3.72	1.01	0.04	0.03
0	115	1% AEP	0.12	54.01	54.14	54.14	0.75	0.15	2.75	1.01	0.13	0.10
0	106	1% AEP	0.01	53.88	54.03		0.01	0.86	8.47	0.01	0.15	0.00
0	103	1% AEP	0.01	54.02	54.03	54.03	0.29	0.03	3.89	0.98	0.01	0.00
0	100	1% AEP	0.01	53.9	53.92	53.91	0.15	0.07	4.01	0.36	0.02	0.00
0	97	1% AEP	0.01	53.84	53.85	53.85	0.24	0.04	3.56	0.72	0.01	0.00
0	88	1% AEP	0.01	53.5	53.51	53.51	0.19	0.05	4.82	0.55	0.01	0.00
0	79	1% AEP	0.01	53.3	53.31	53.31	0.27	0.04	3.79	0.83	0.01	0.00
0	70	1% AEP	0.01	53	53.01	53.01	0.29	0.03	4.71	1.06	0.01	0.00
0	61	1% AEP	0.01	52.65	52.92		0	4.79	33.08	0	0.27	0.00
0	52	1% AEP	4	52.6	52.88		0.66	6.1	33.24	0.49	0.28	0.18
0	43	1% AEP	4	52.55	52.81		0.72	6.06	31.58	0.49	0.26	0.19
0	37.64	1% AEP	4.9	52.2	52.73		1.22	5.84	31.58	0.68	0.53	0.65
0	30	1% AEP	4.9	52.03	52.64		1.3	5.97	35.43	0.74	0.61	0.79
0	14.99	1% AEP	4.9	51.96	52.58		0.82	9.21	36.53	0.38	0.62	0.51
0	0	1% AEP	4.9	51.93	52.57	52.26	0.46	16.34	45.6	0.19	0.64	0.29

Profiles

Pre-Development

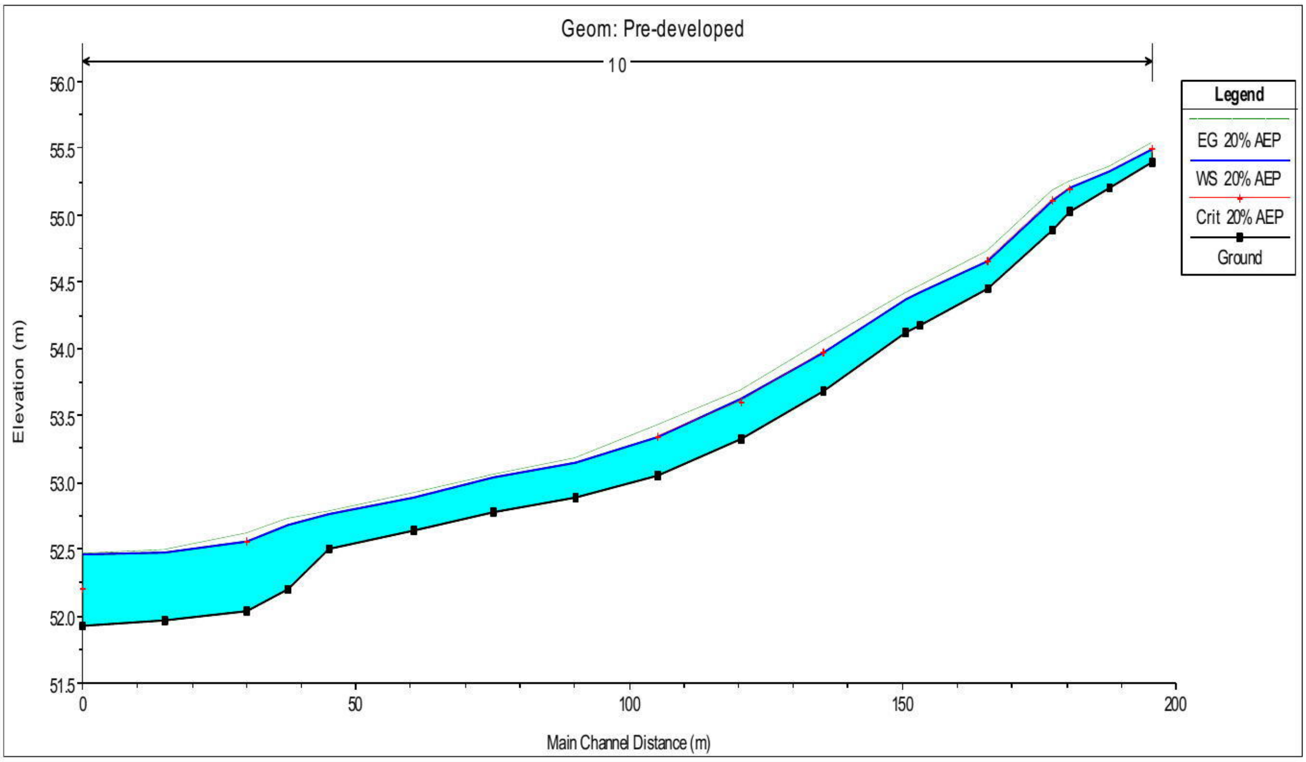


Figure D3 – Pre-developed 20% AEP Profile

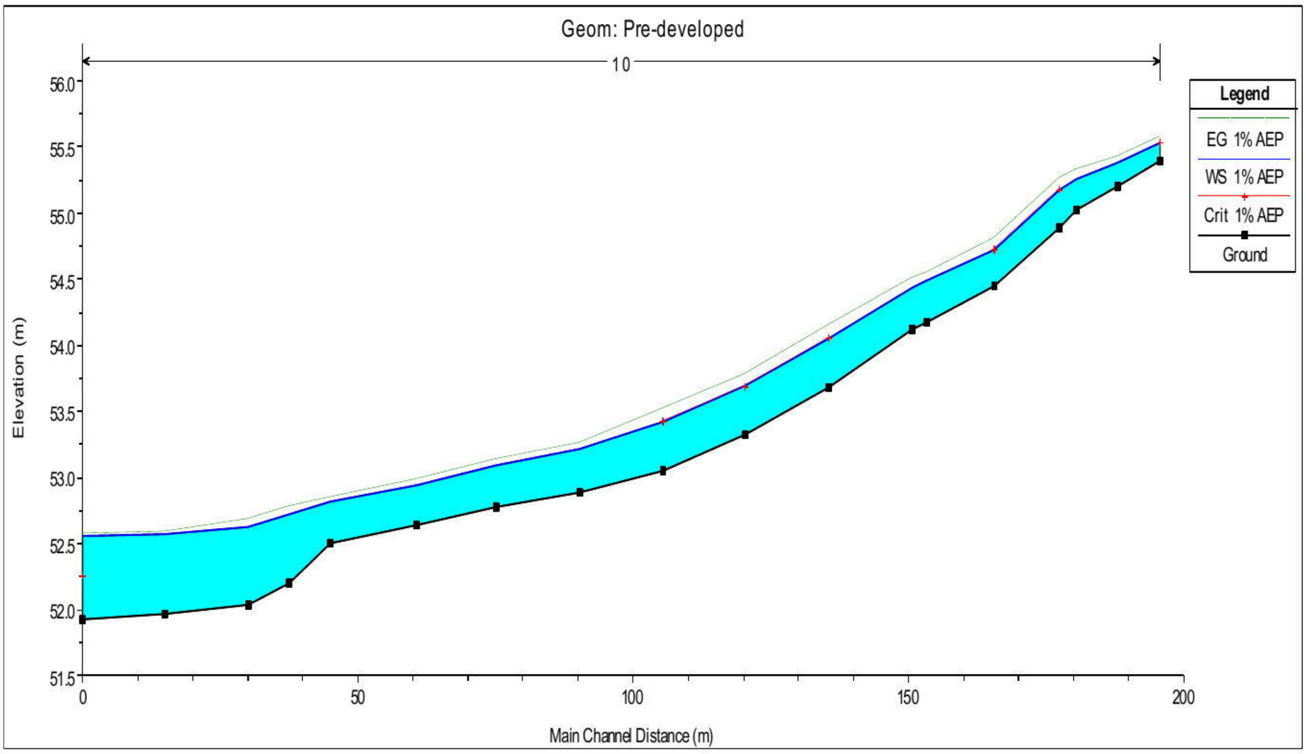


Figure D4 – Pre-developed 1% AEP Profile

Post Development

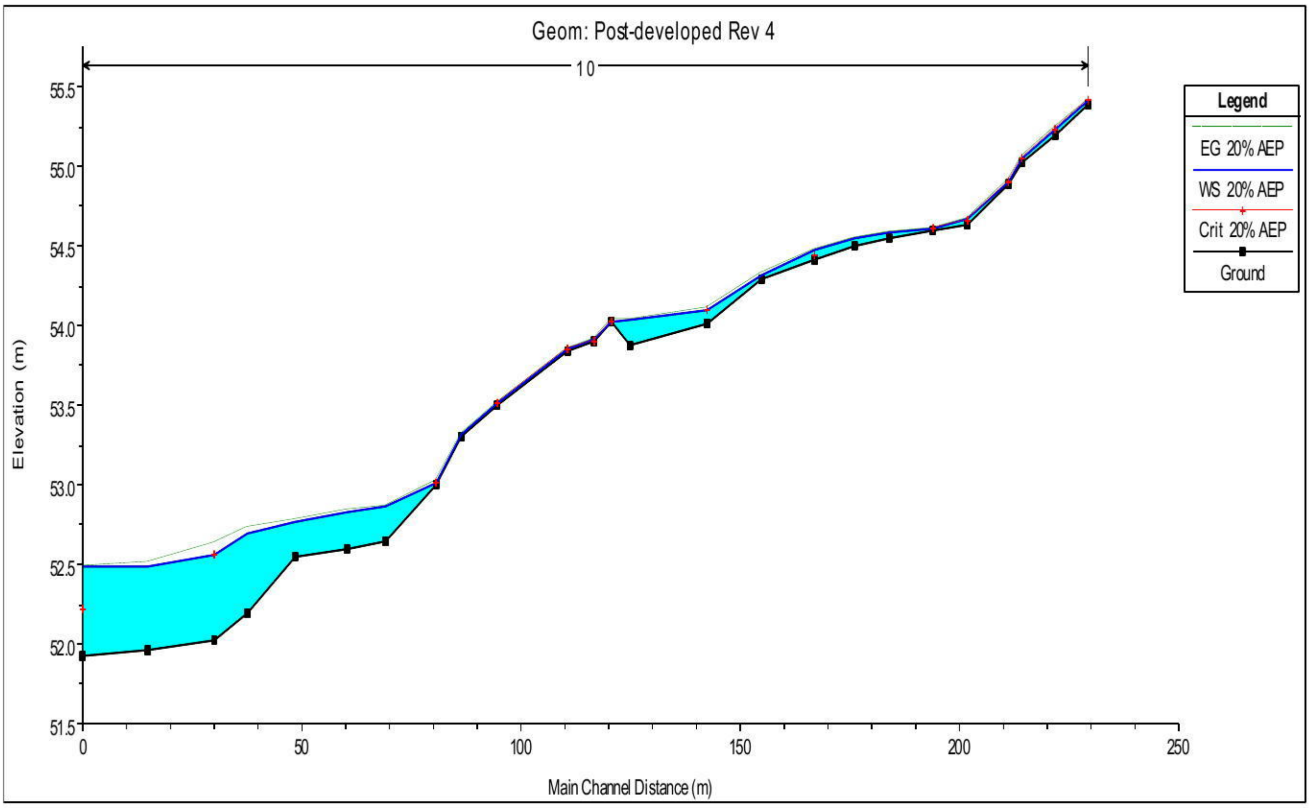


Figure D5 – Post developed 20% AEP Profile

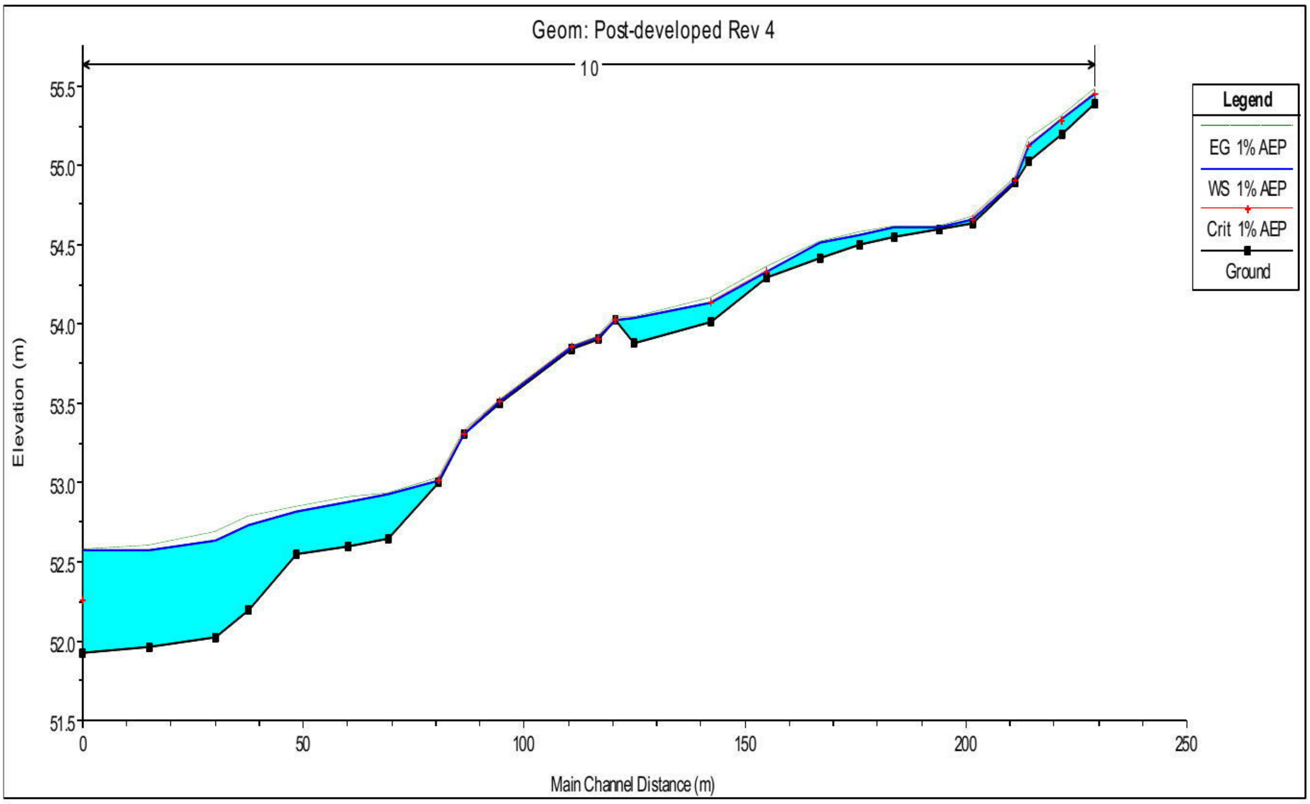
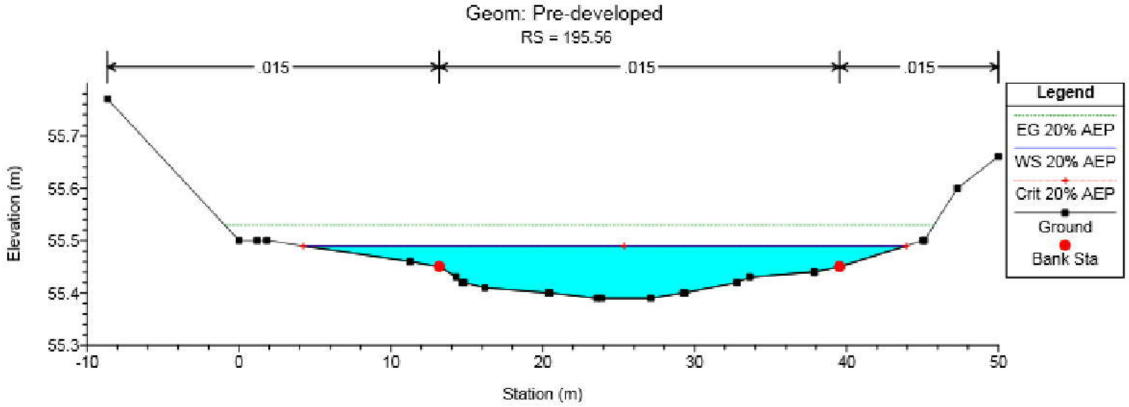
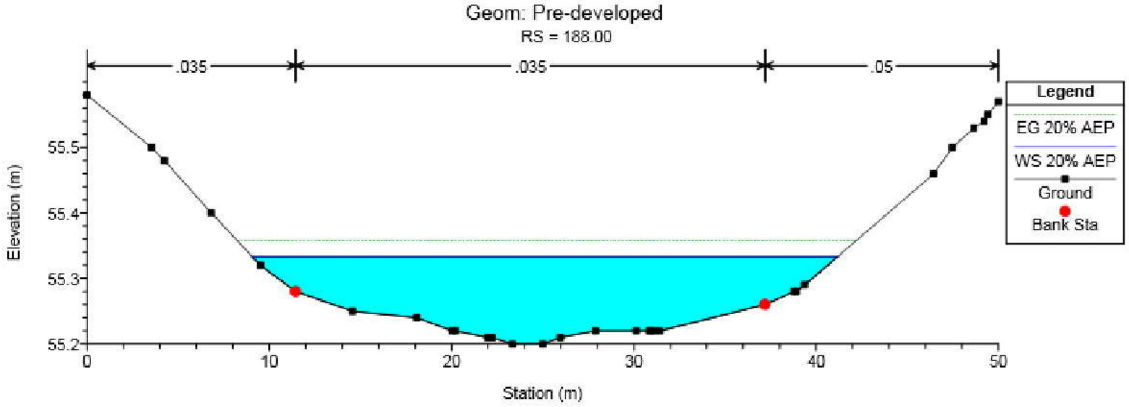


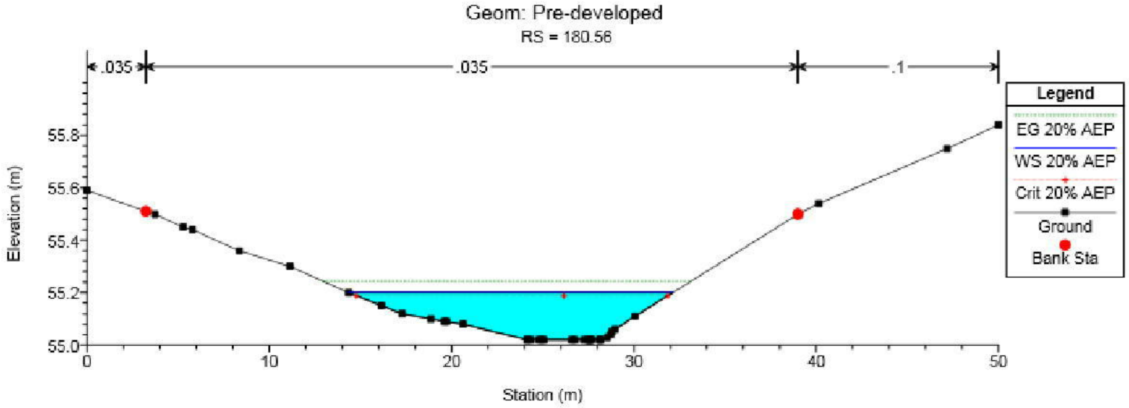
Figure D6 – Post developed 1% AEP Profile

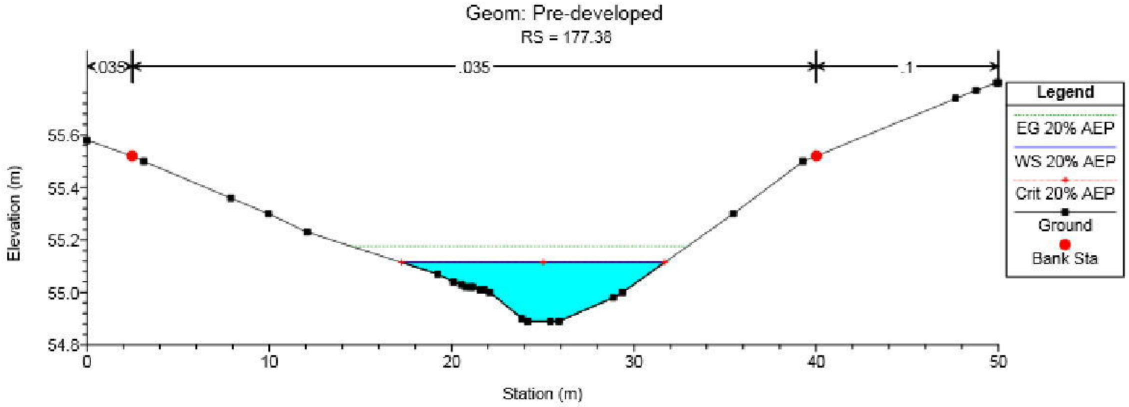
Cross Sections

Pre-Development 20% AEP

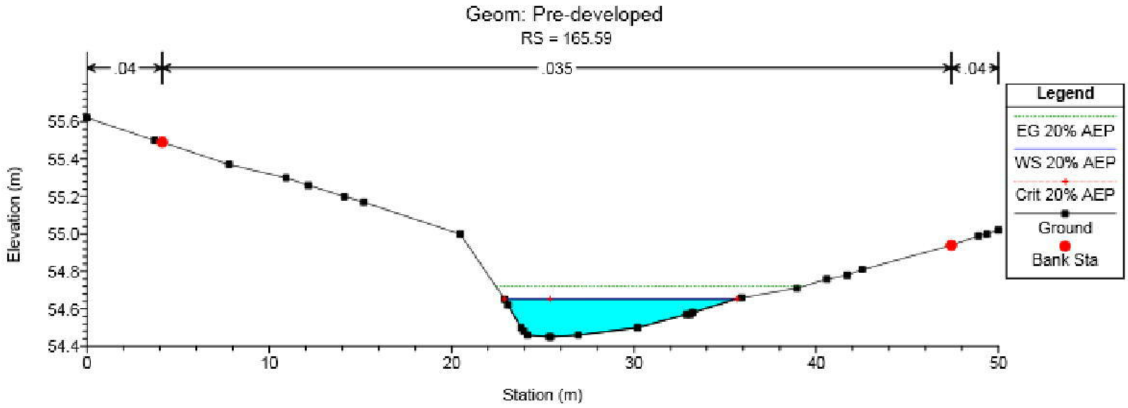


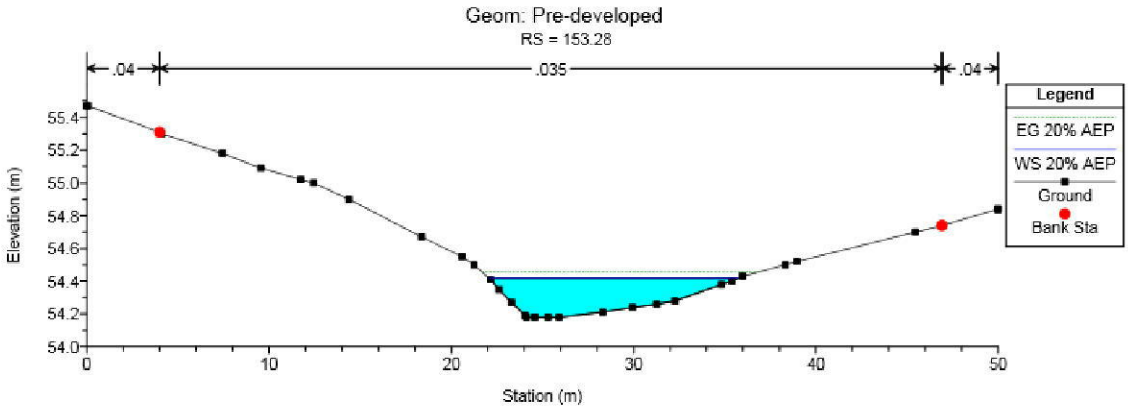


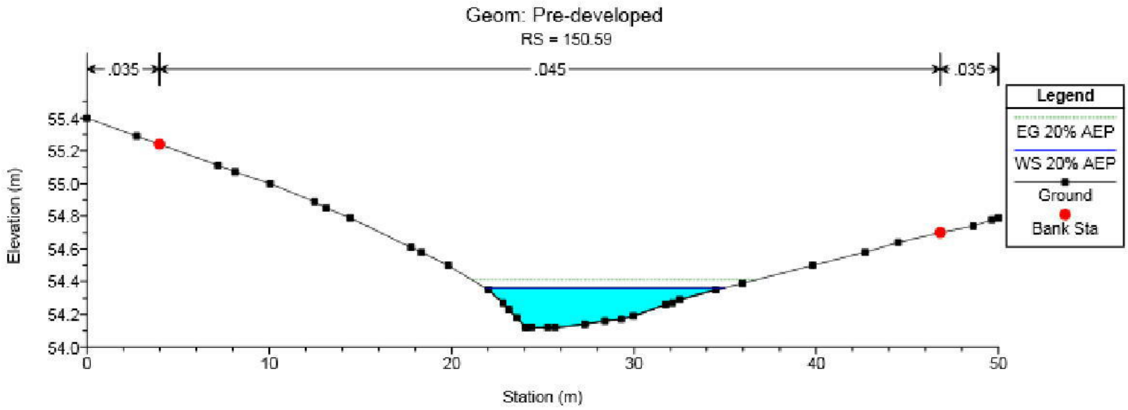


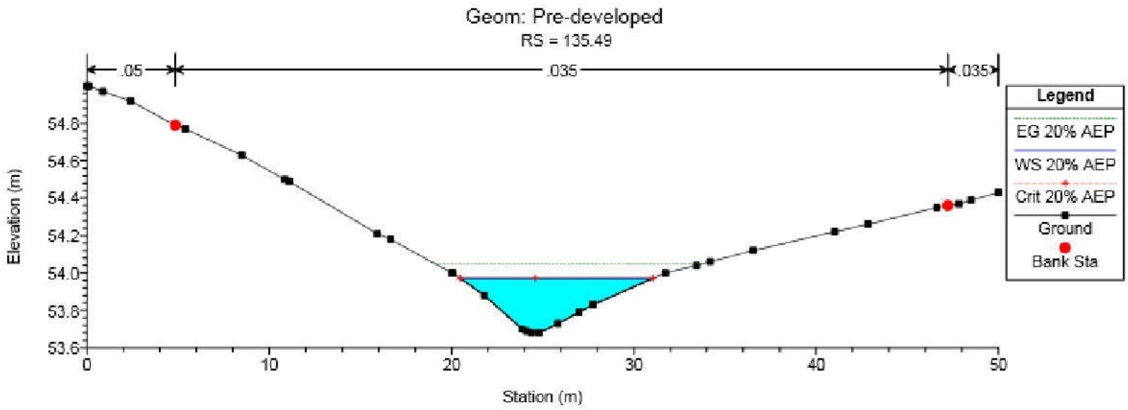


Pre-Development 20% AEP (continued)

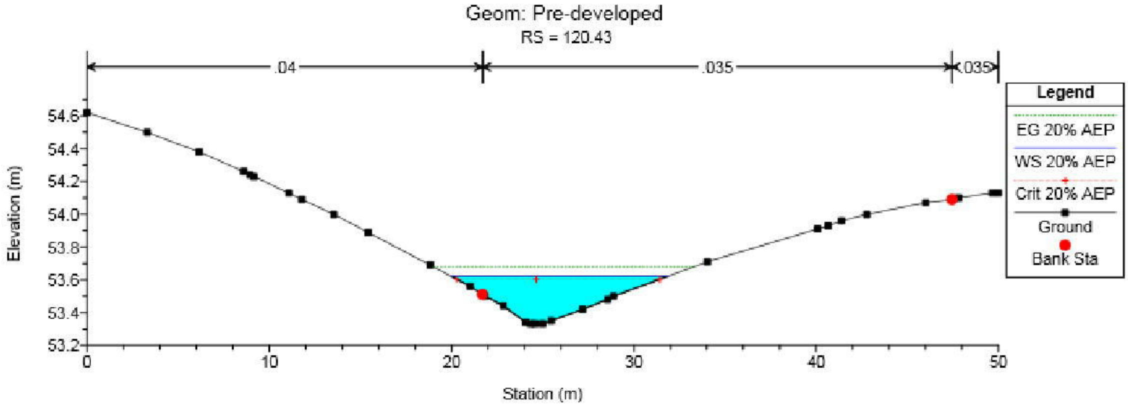


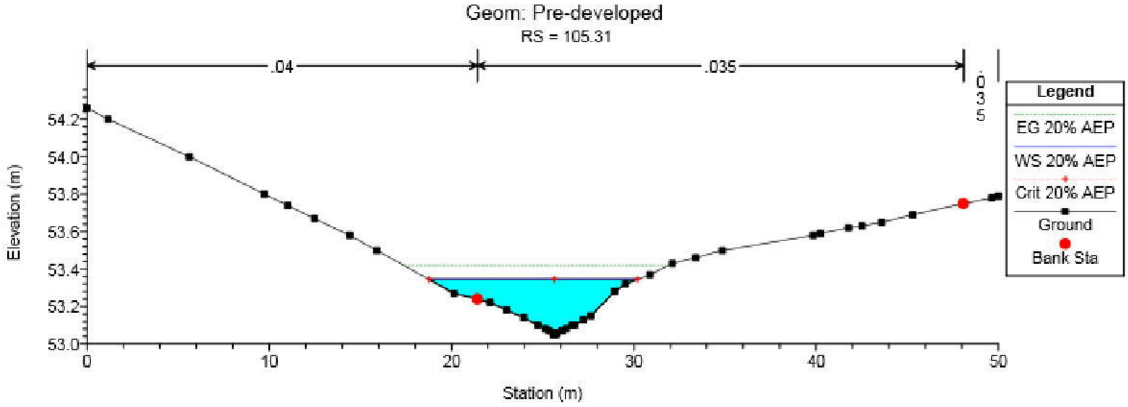


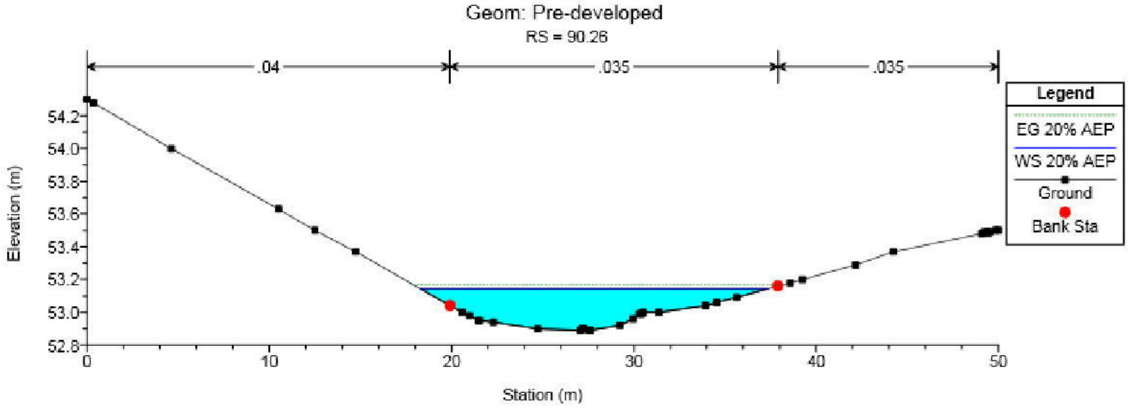


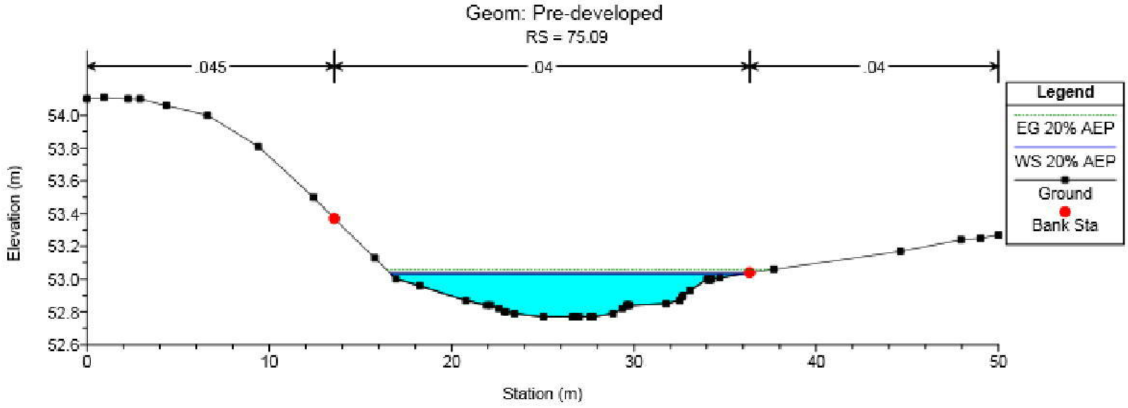


Pre-Development 20% AEP (continued)

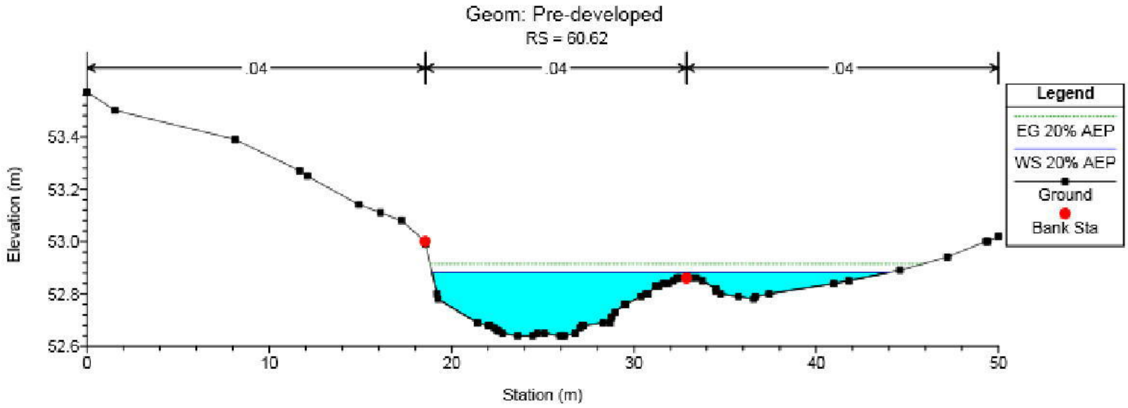


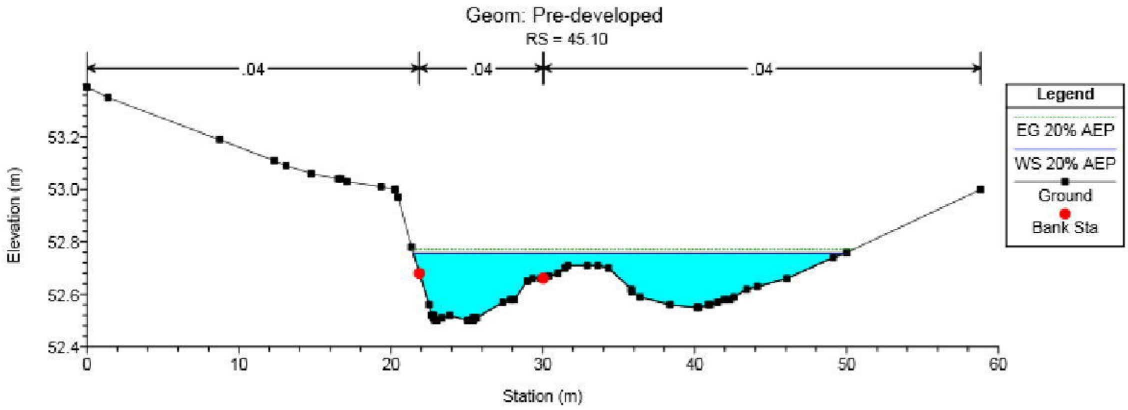


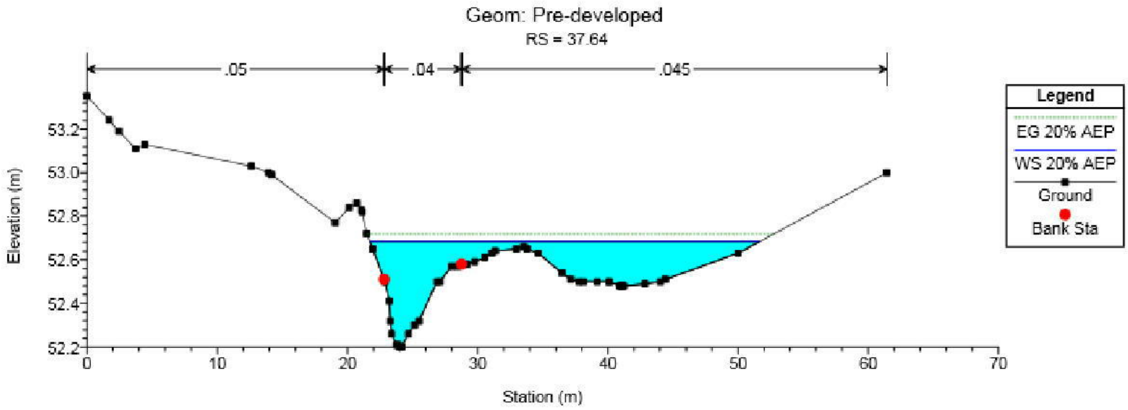


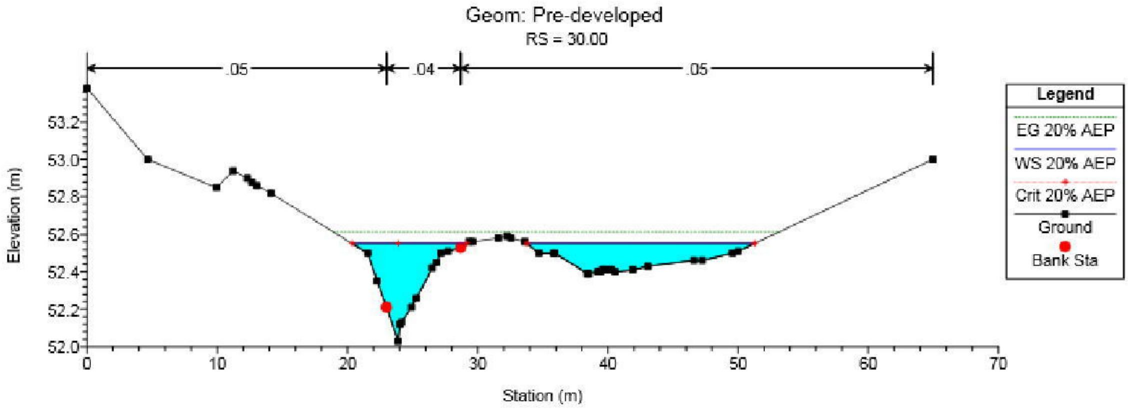


Pre-Development 20% AEP (continued)

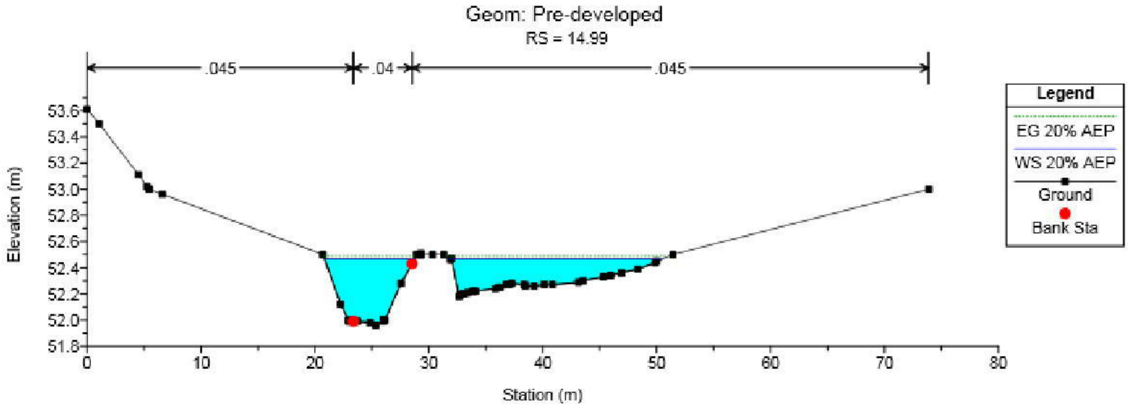


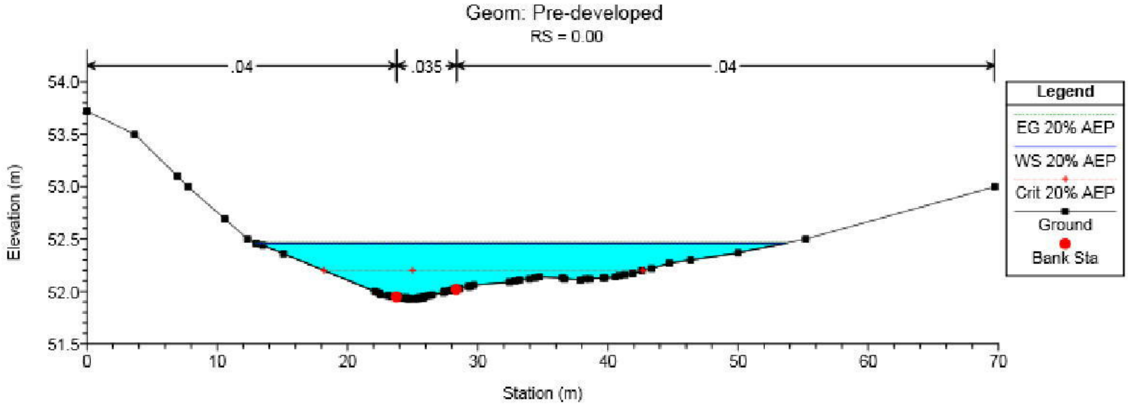




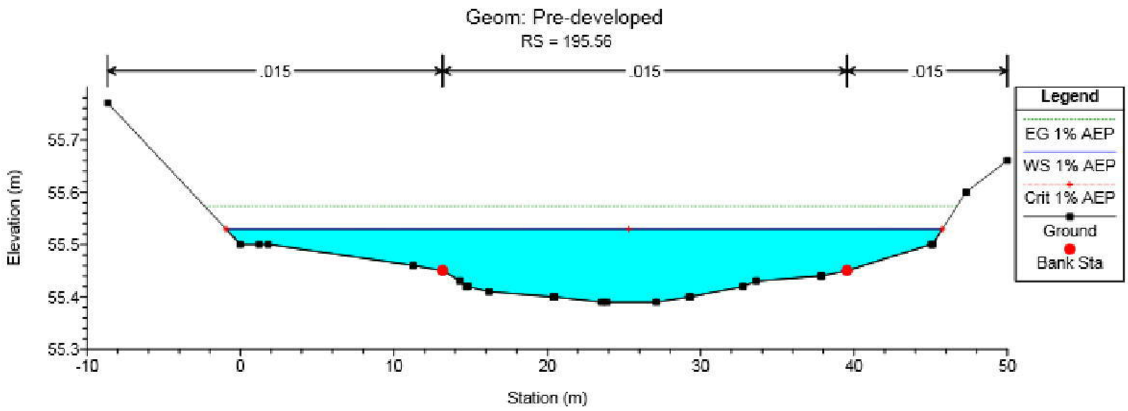


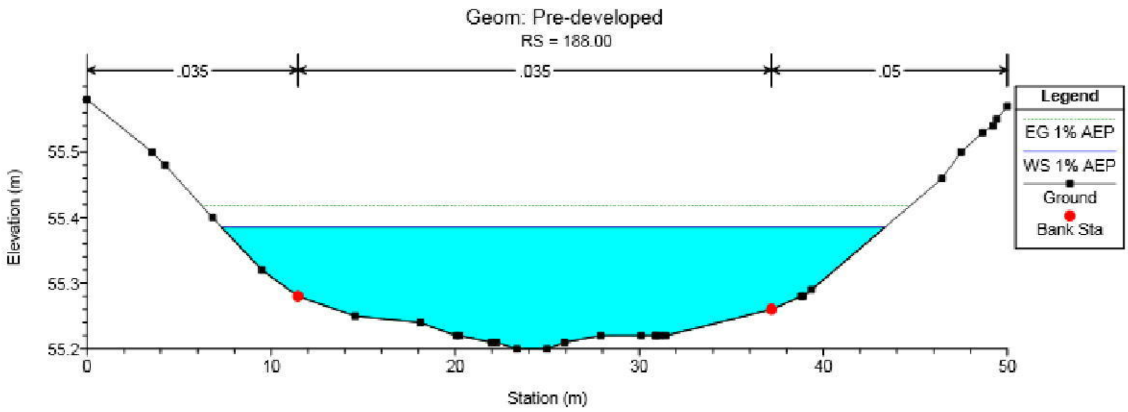
Pre-Development 20% AEP (continued)

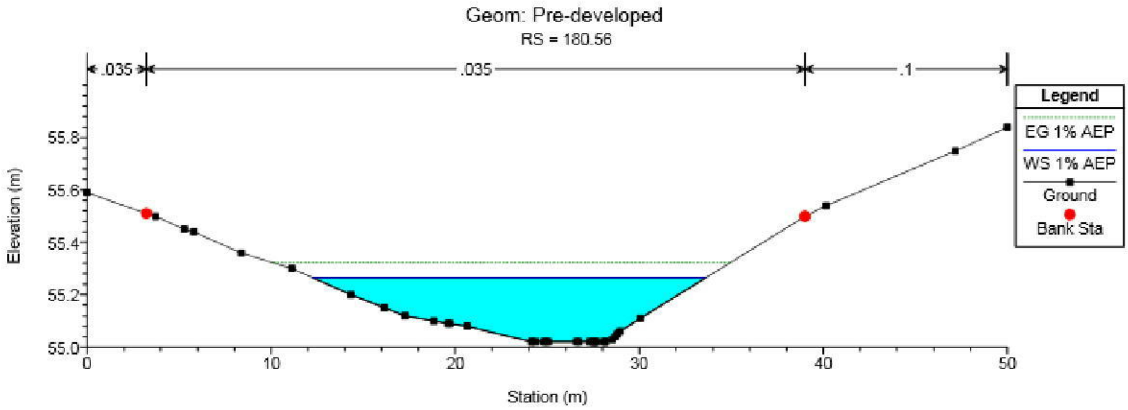


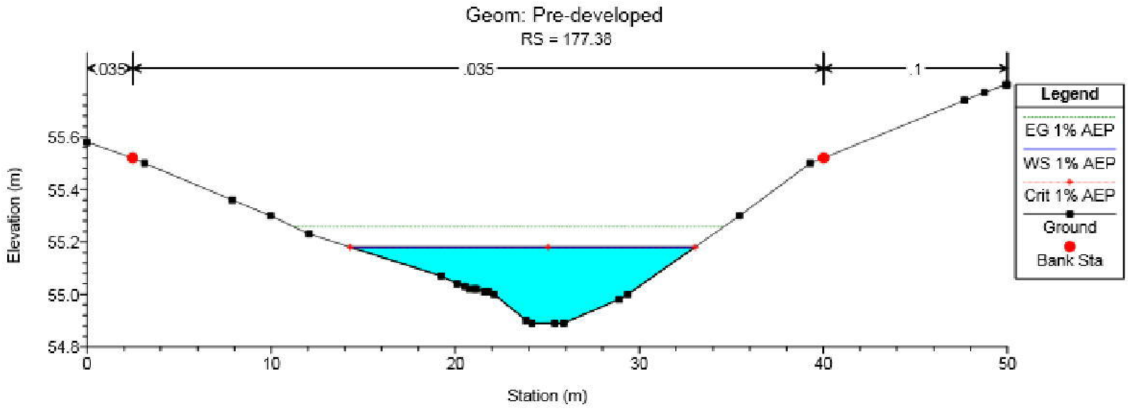


Pre-Development 1% AEP

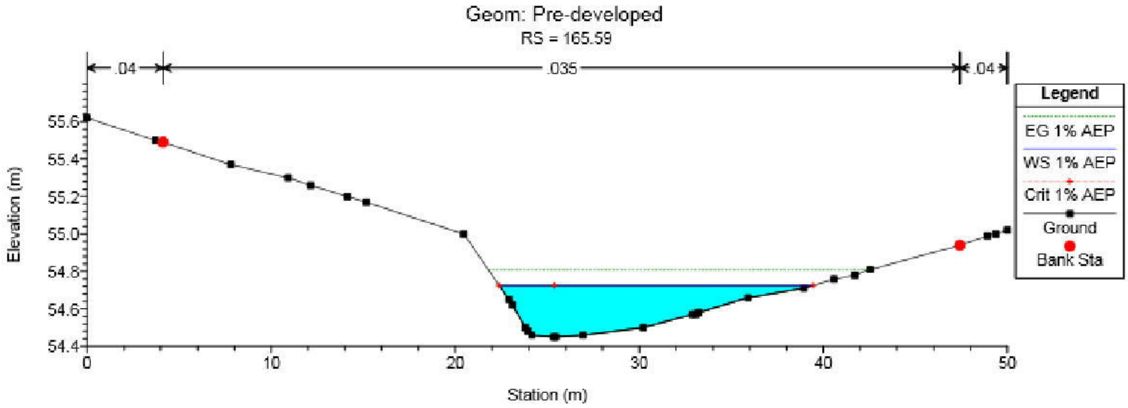


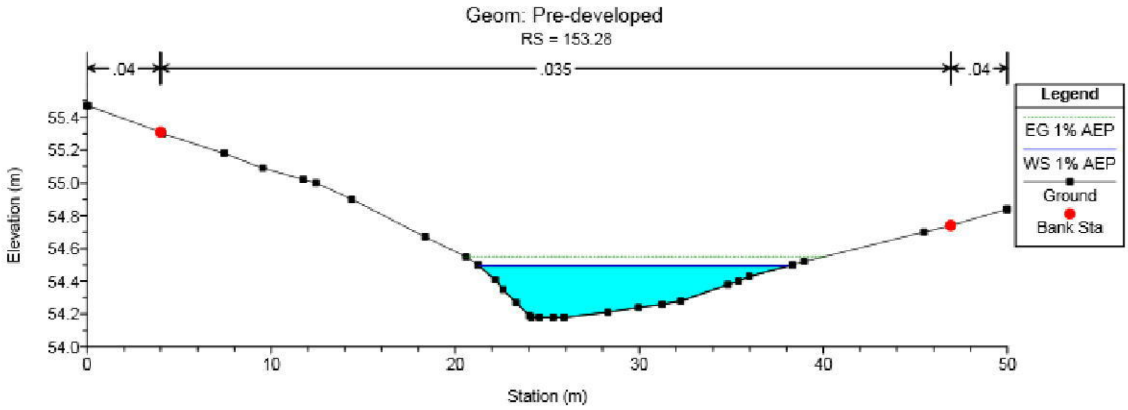


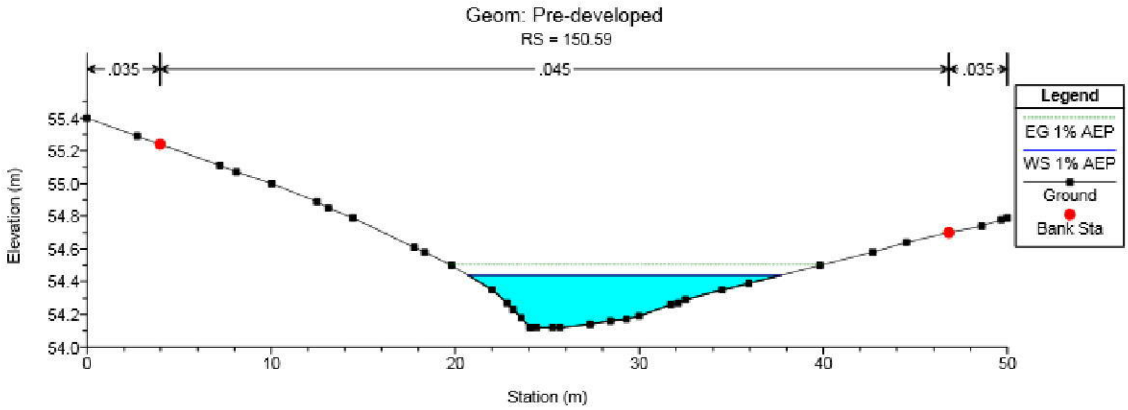


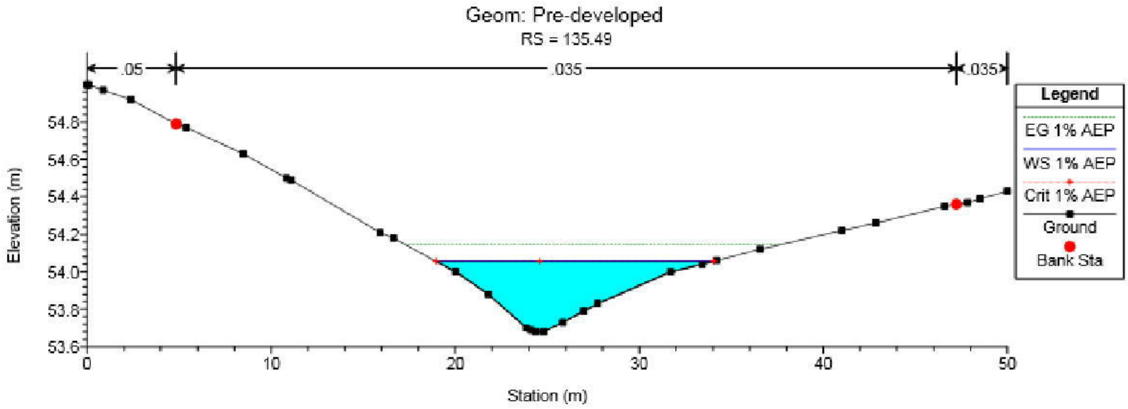


Pre-Development 1% AEP (continued)

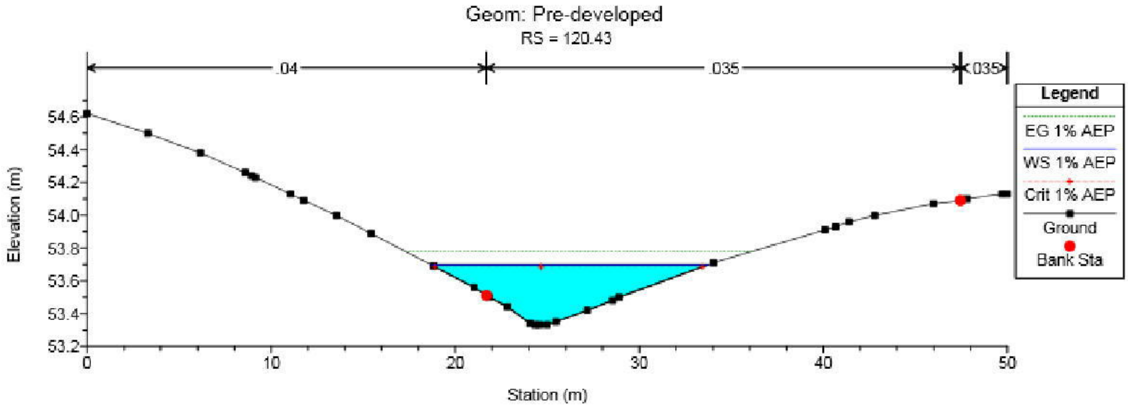


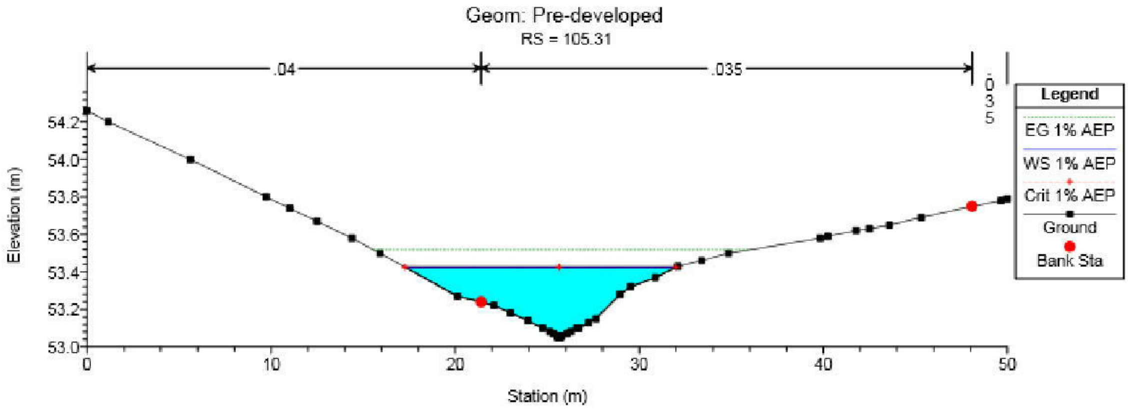


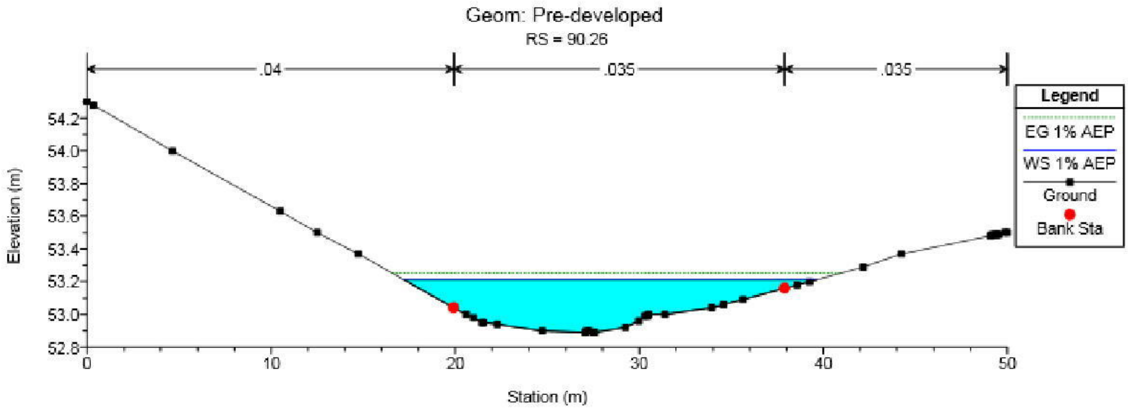


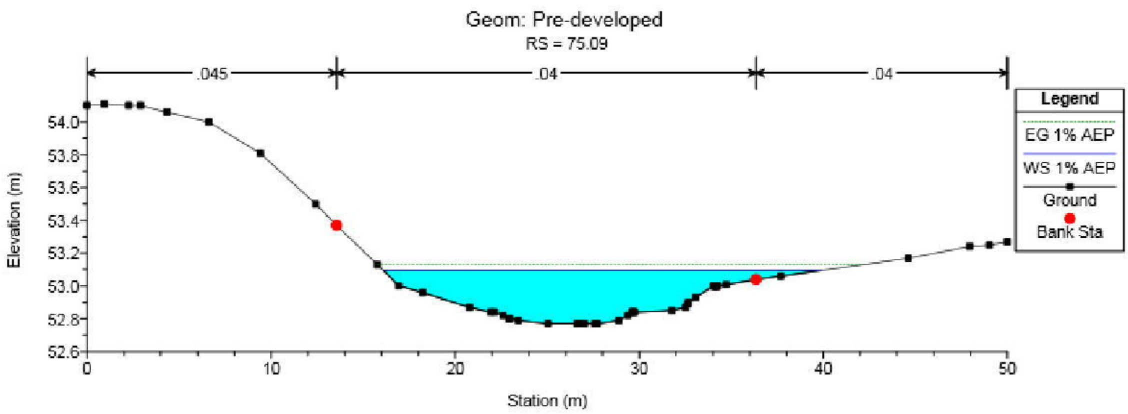


Pre-Development 1% AEP (continued)

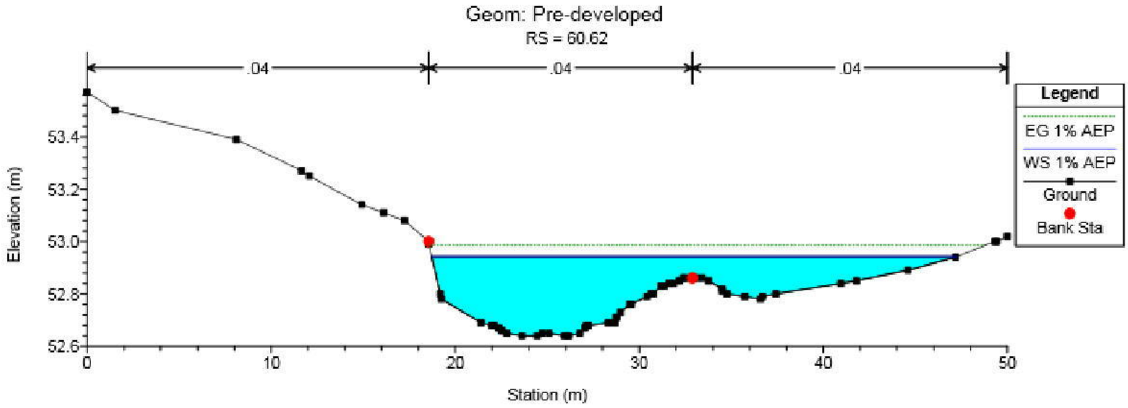


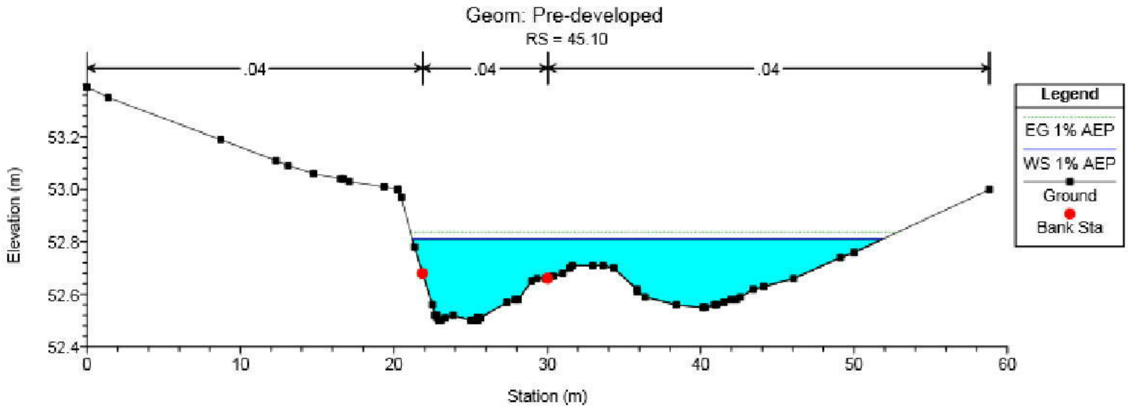


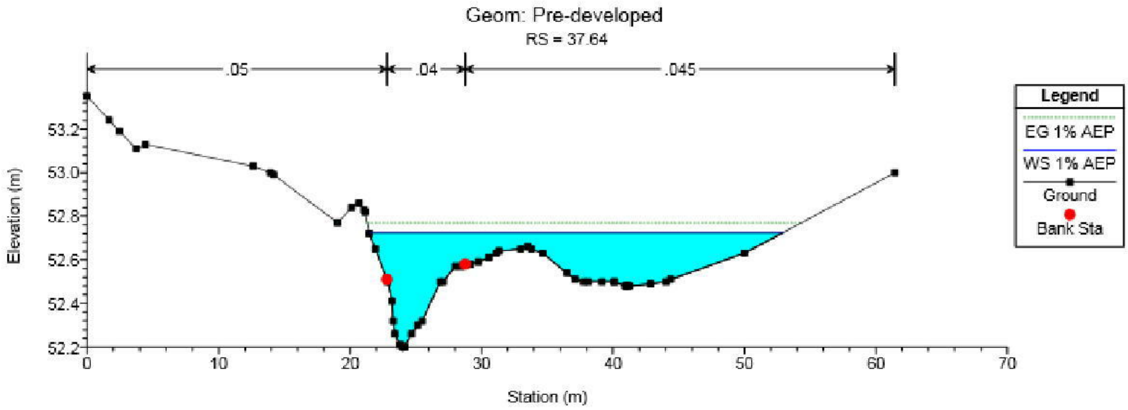


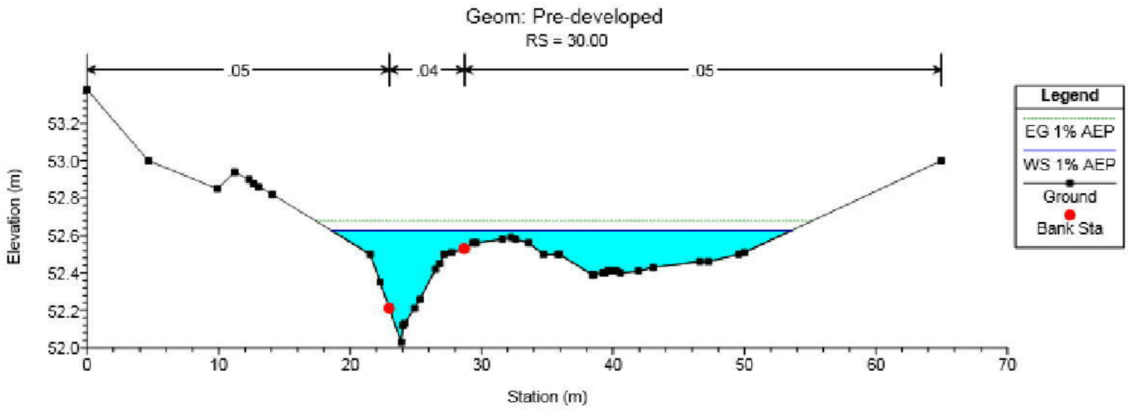


Pre-Development 1% AEP (continued)

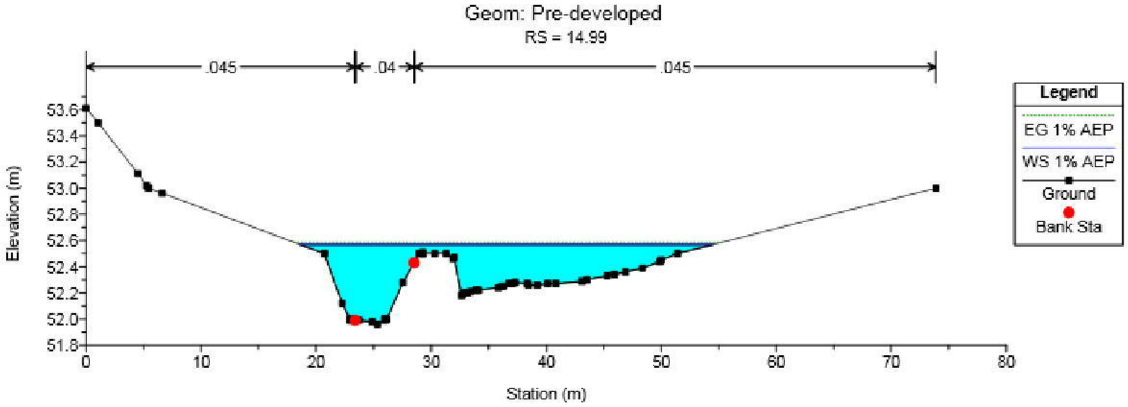


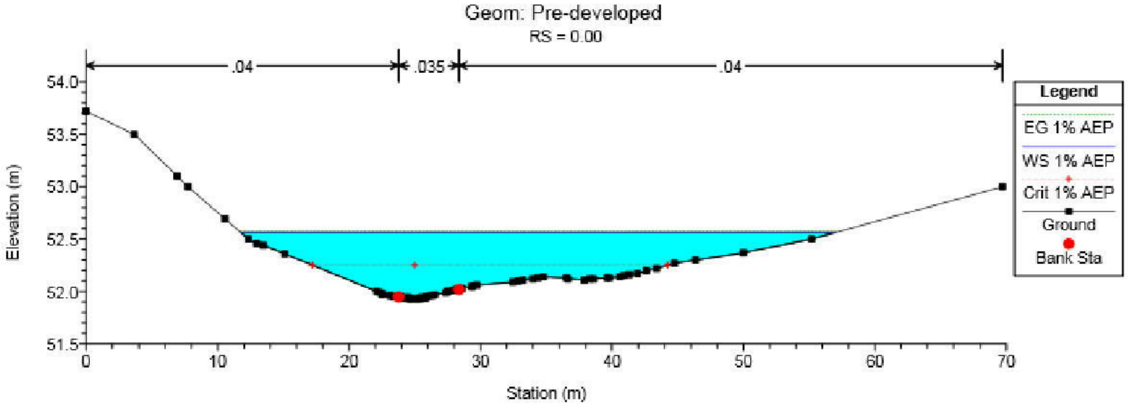




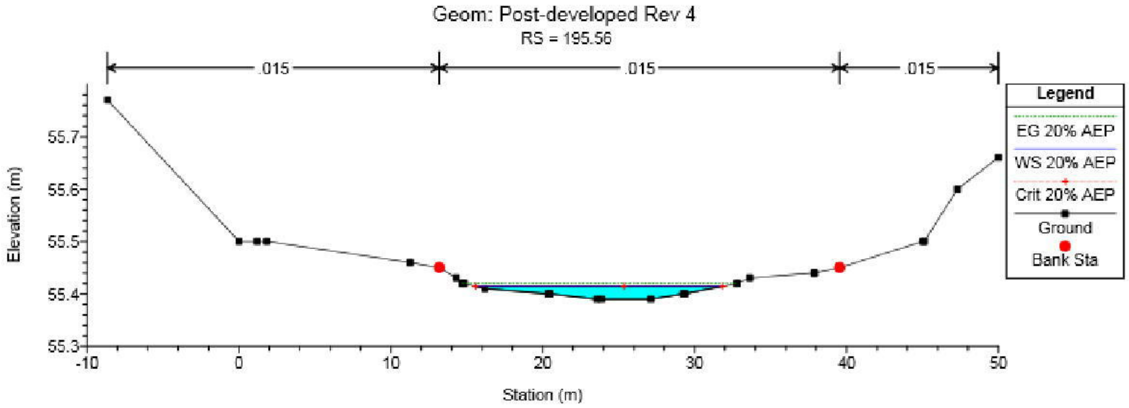


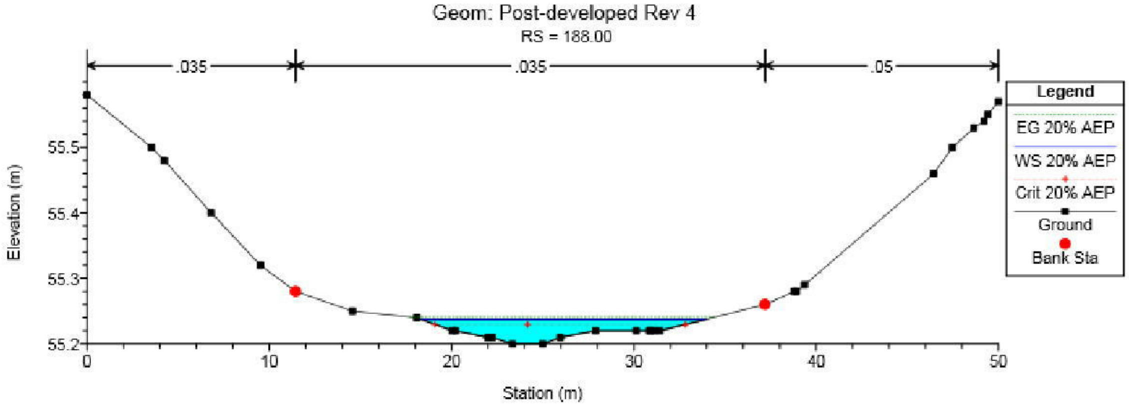
Pre-Development 1% AEP (continued)

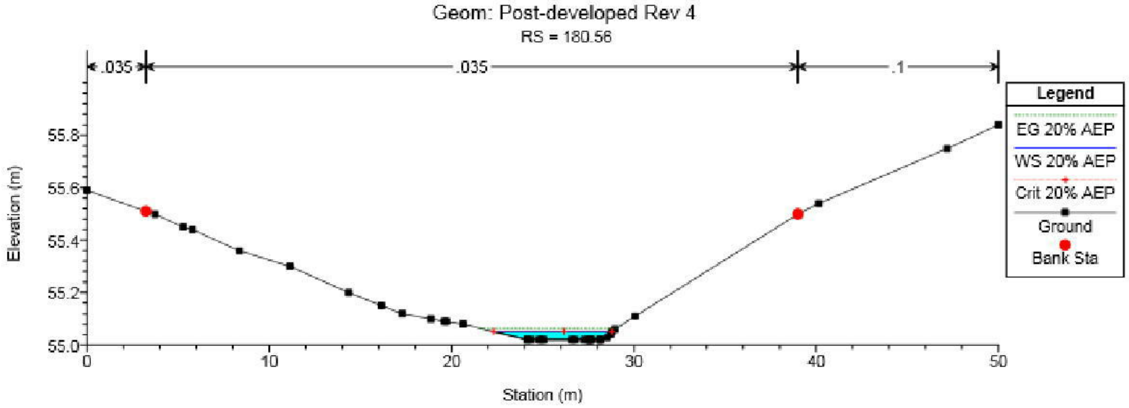


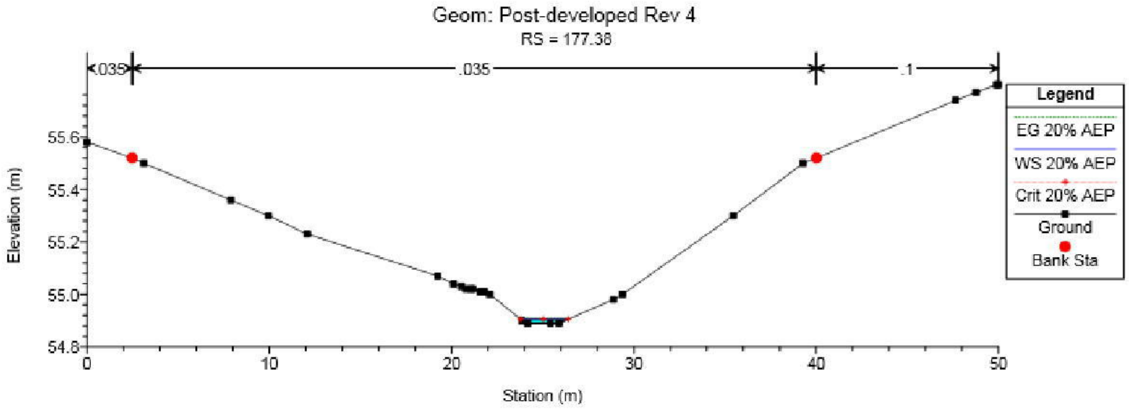


Post Development 20% AEP

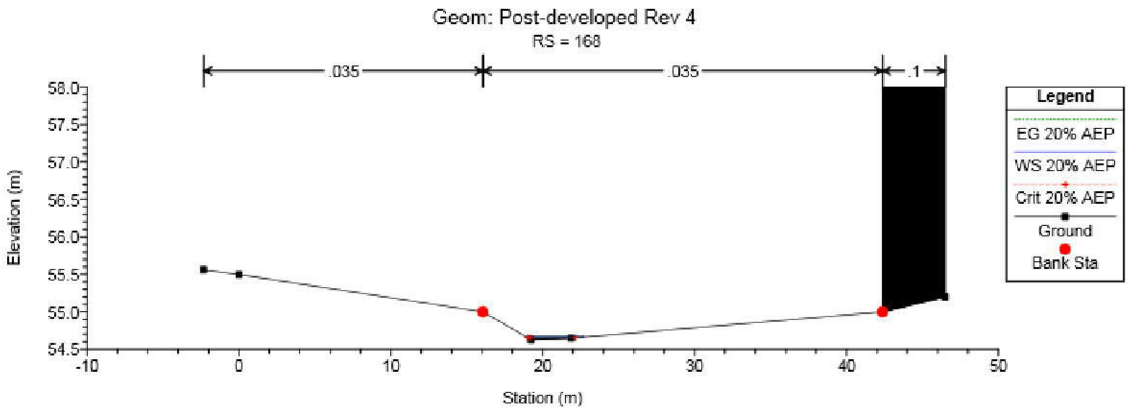


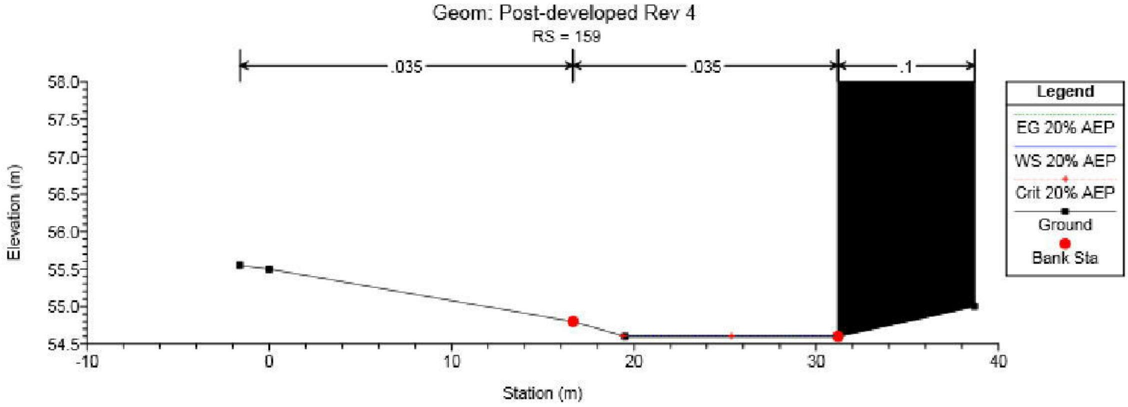


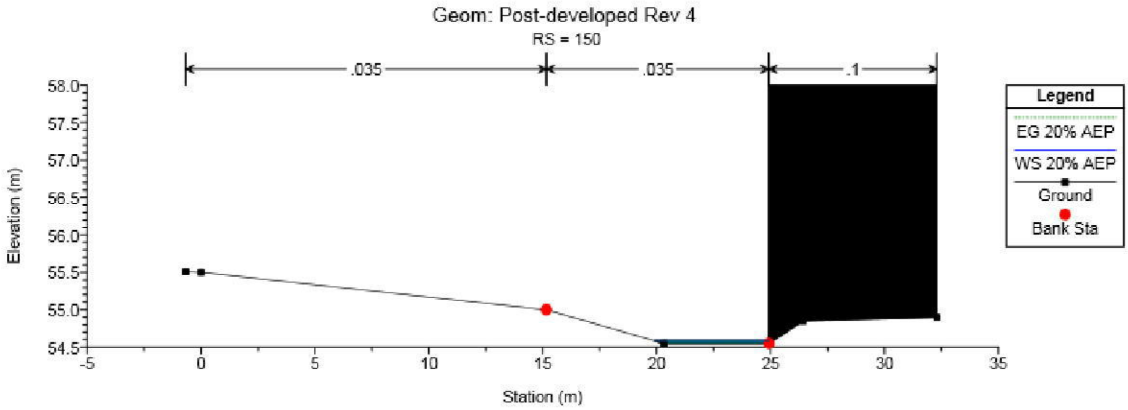


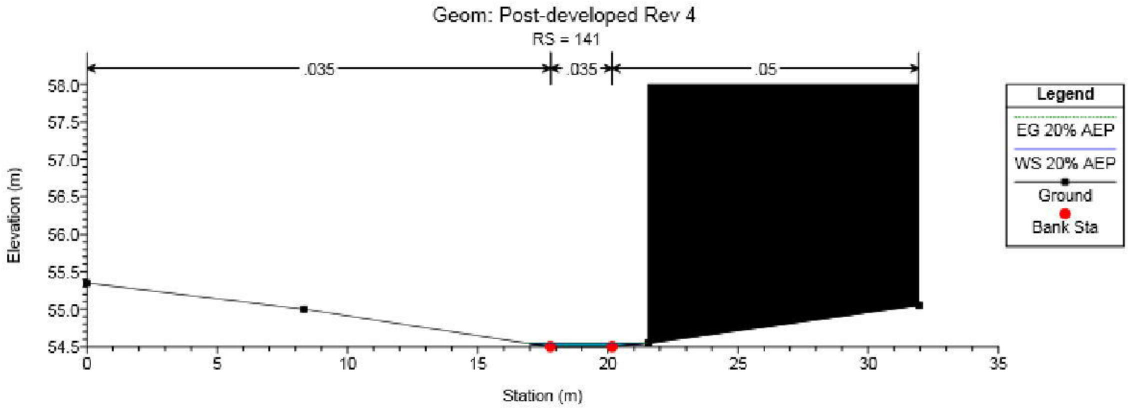


Post Development 20% AEP (continued)

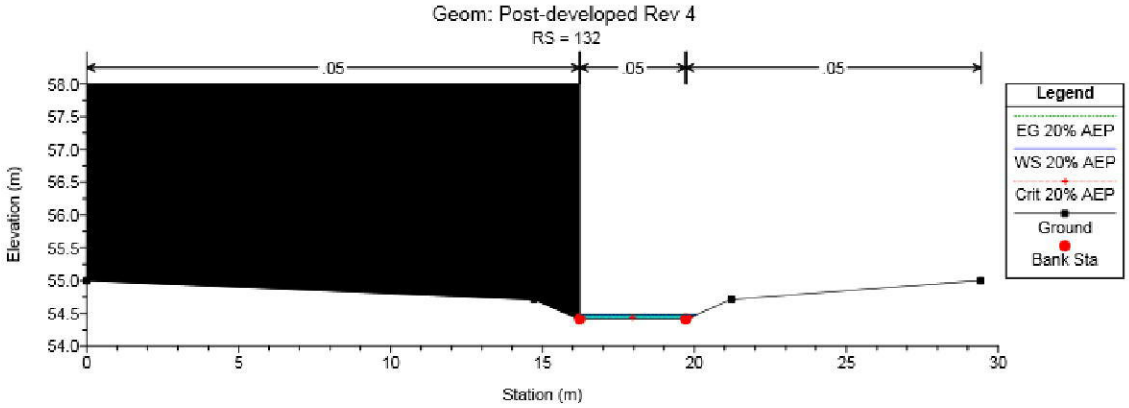


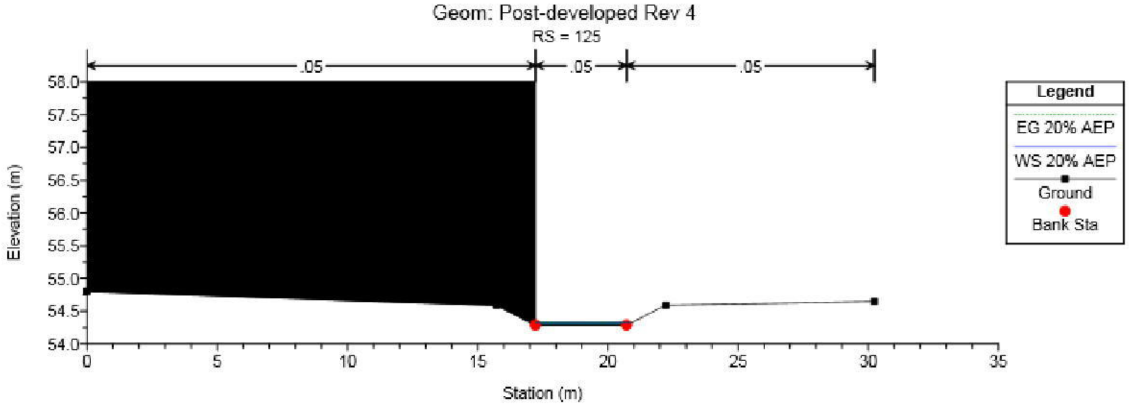


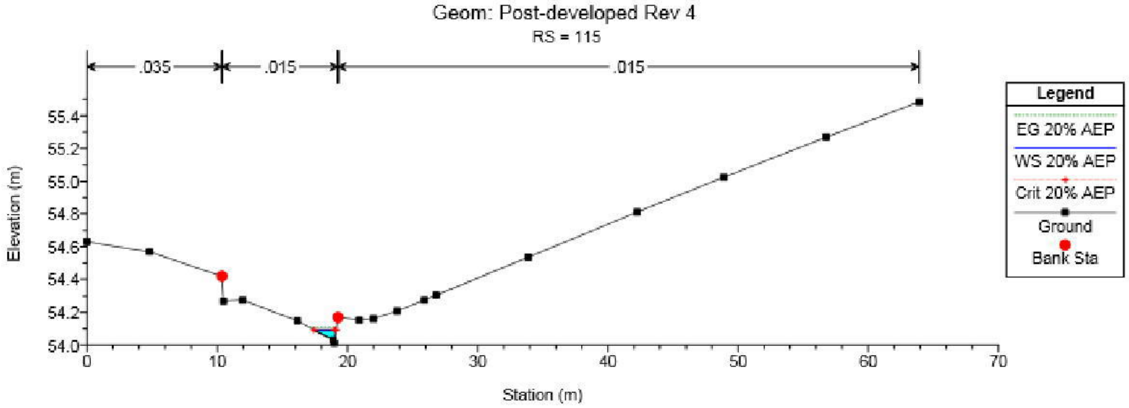


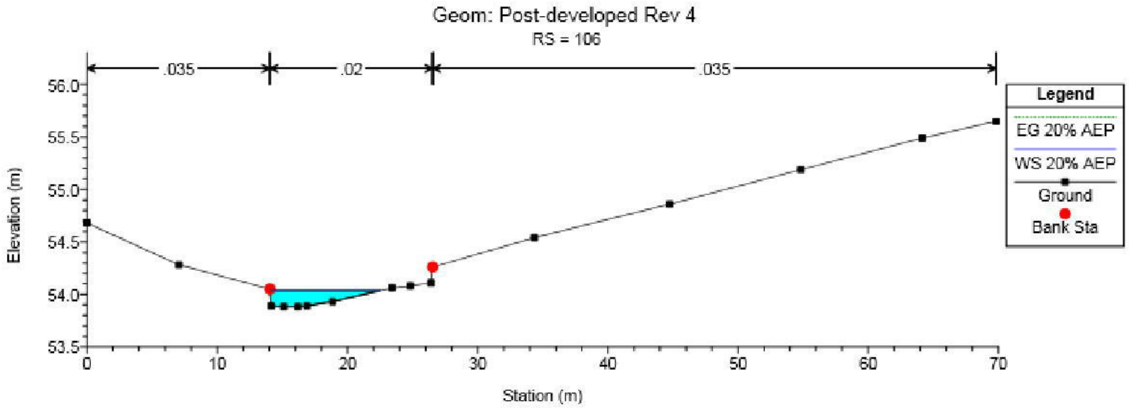


Post Development 20% AEP (continued)

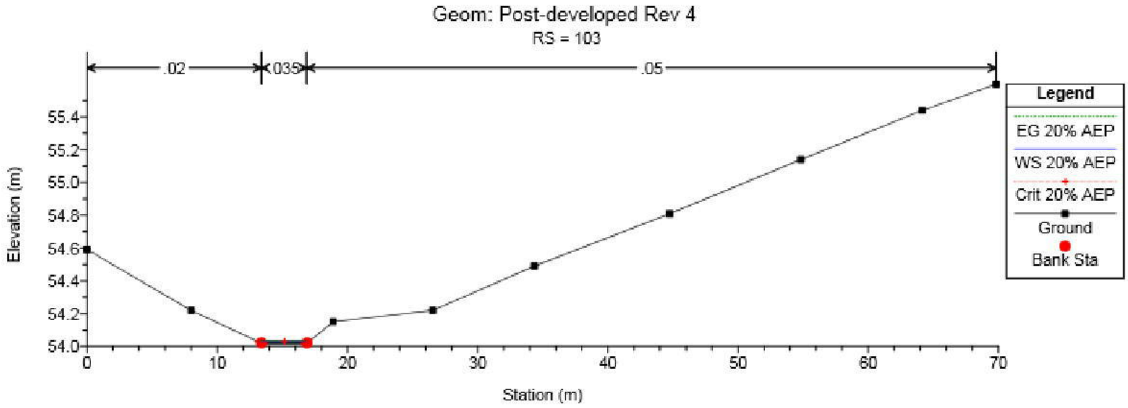


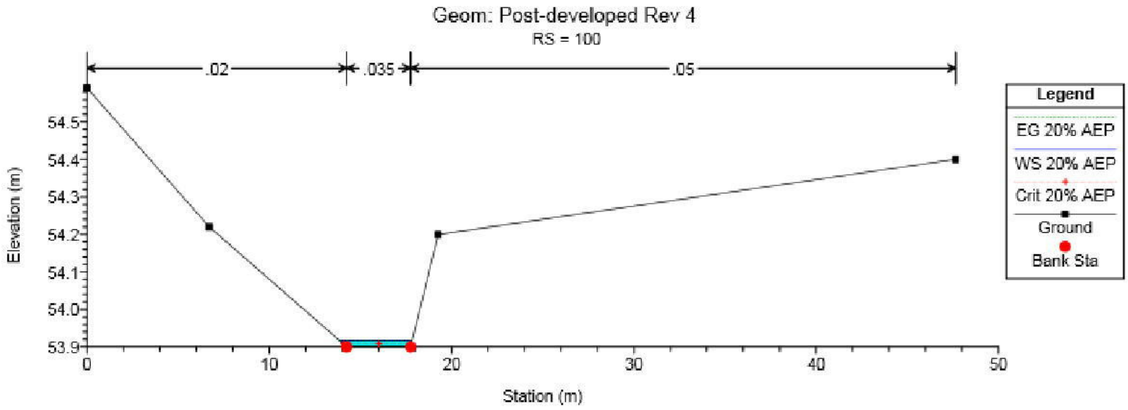


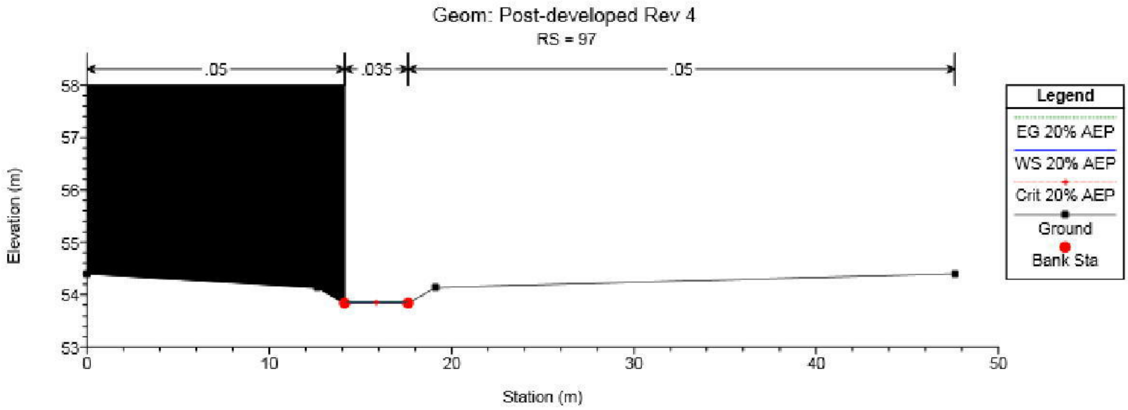


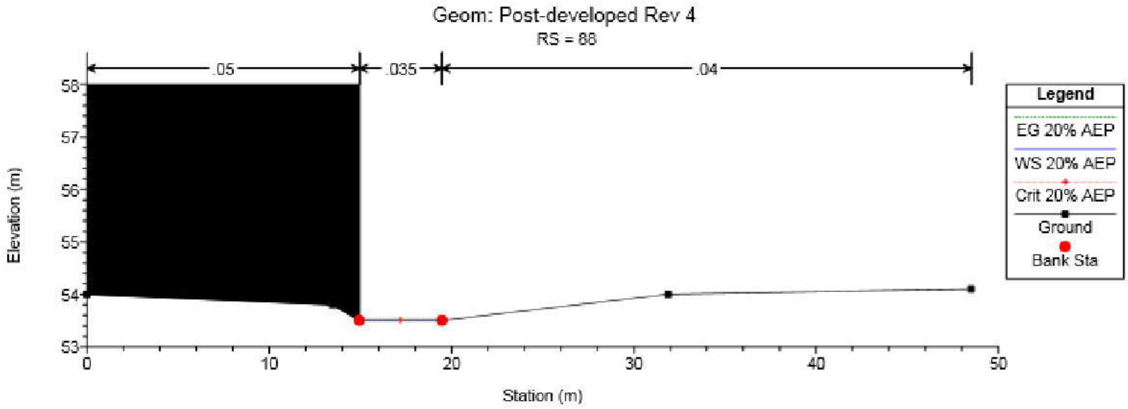


Post Development 20% AEP (continued)

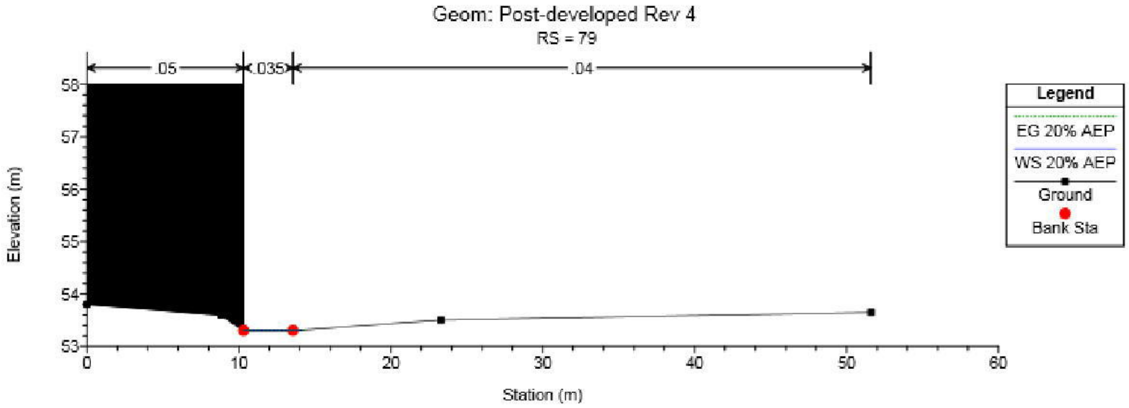


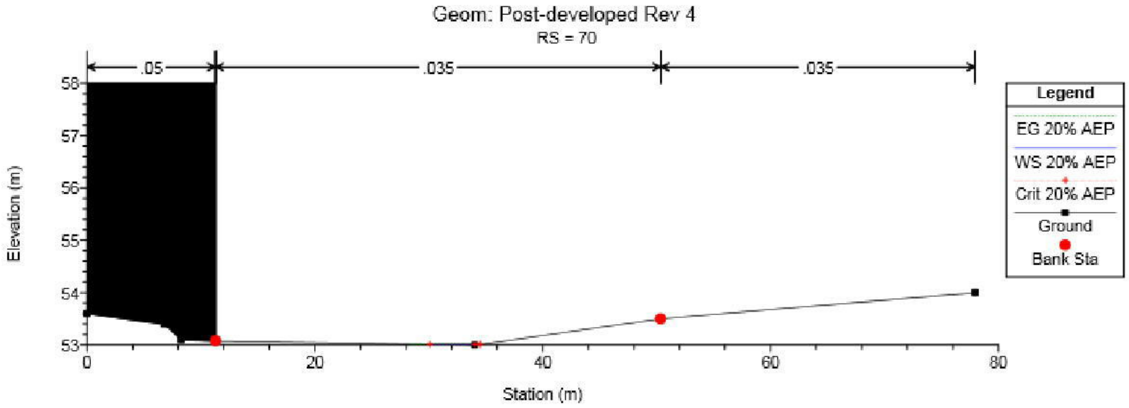


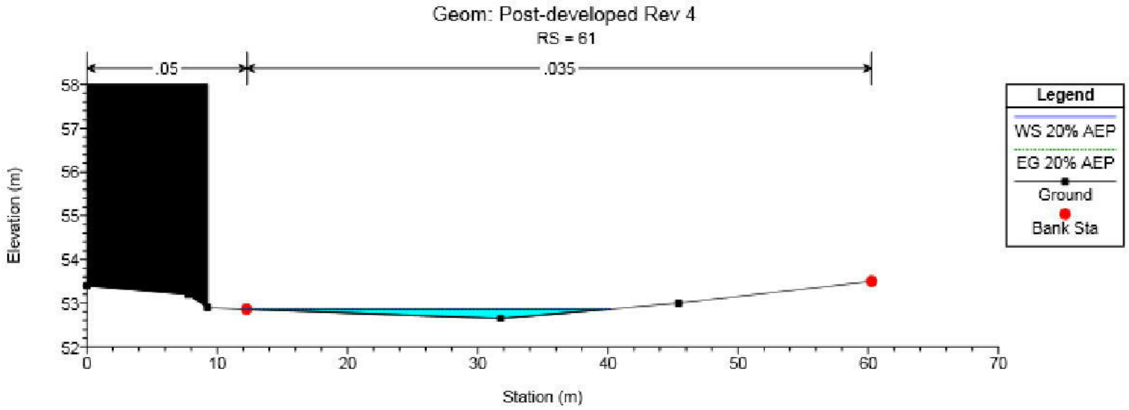


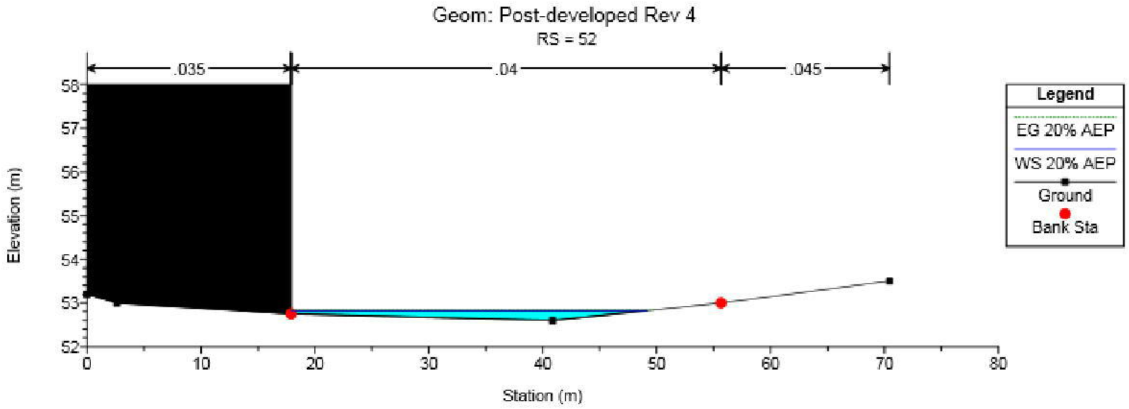


Post Development 20% AEP (continued)

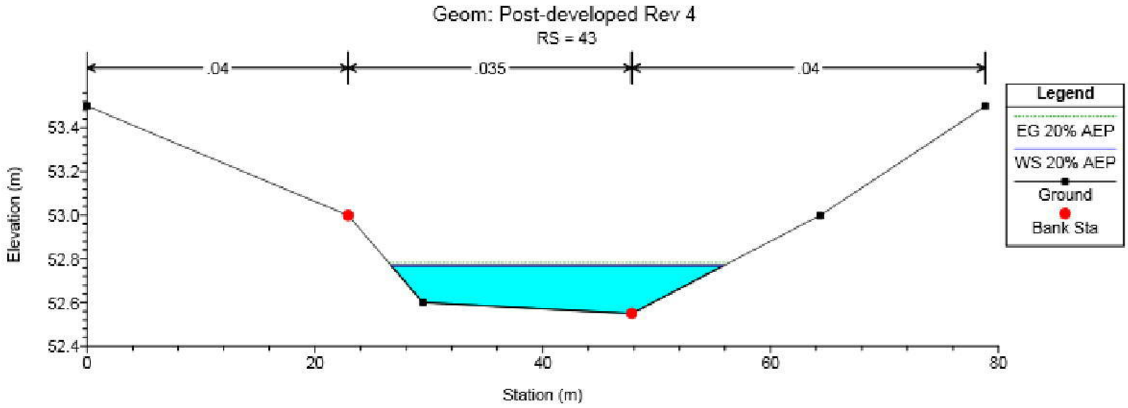


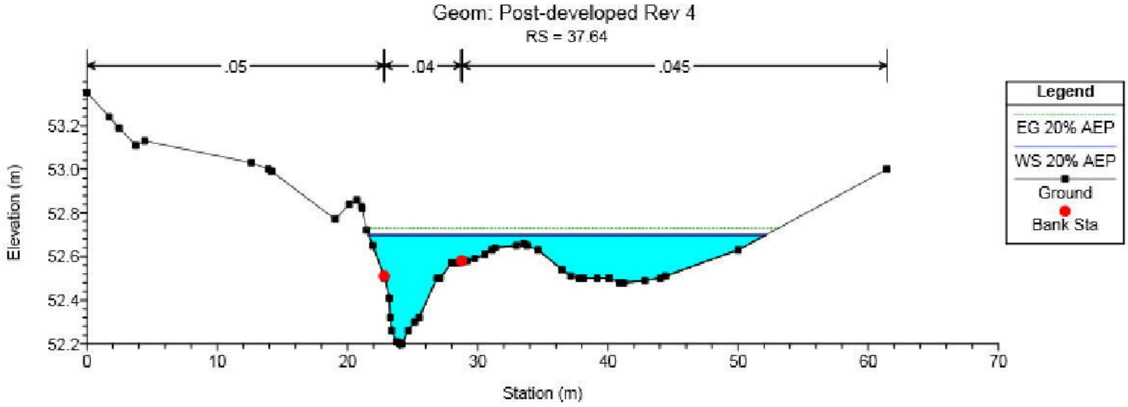


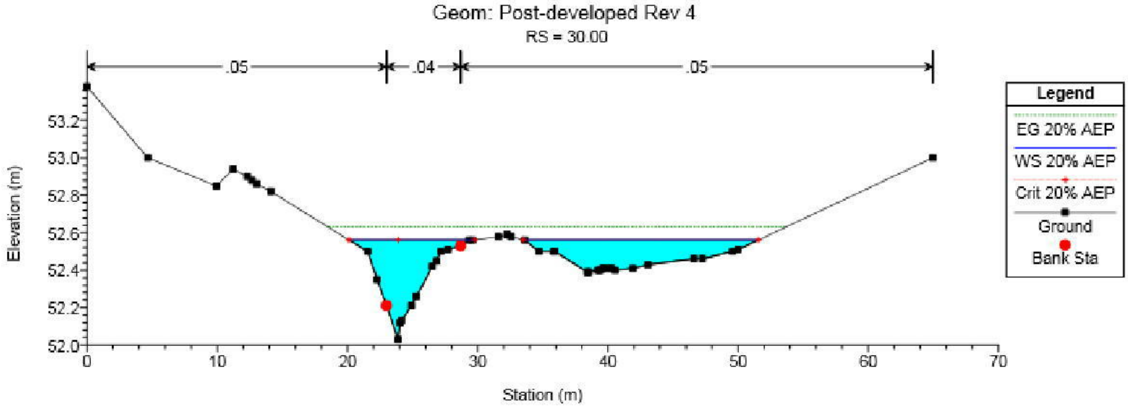


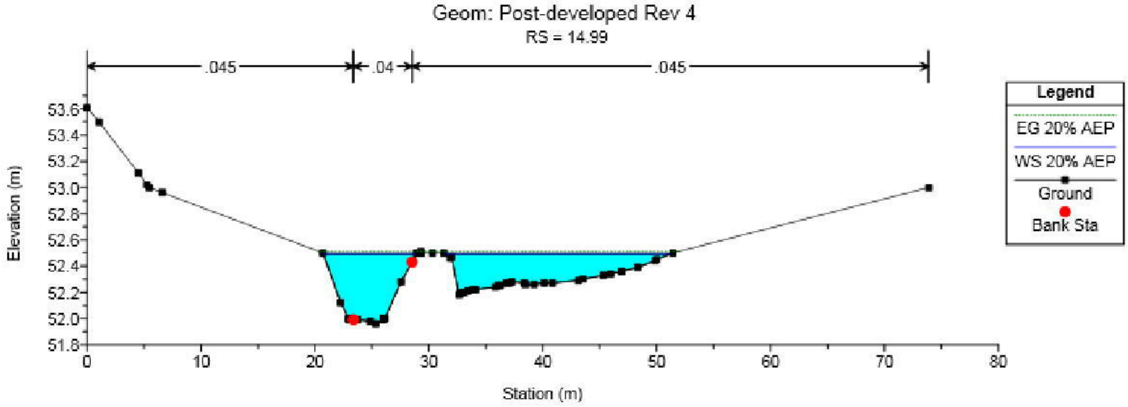


Post Development 20% AEP (continued)

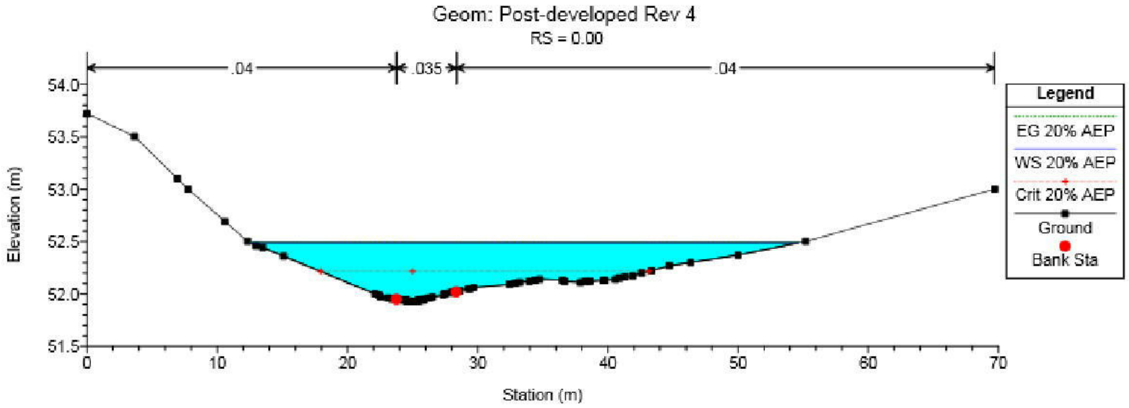




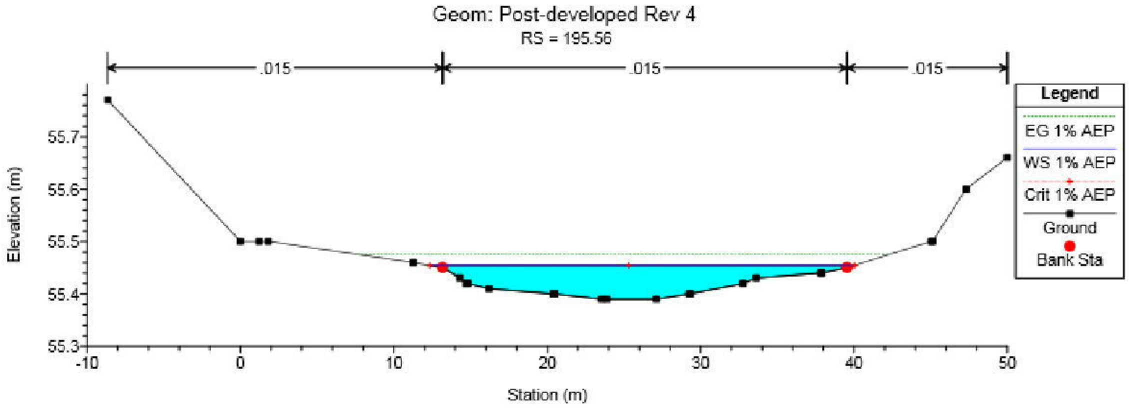


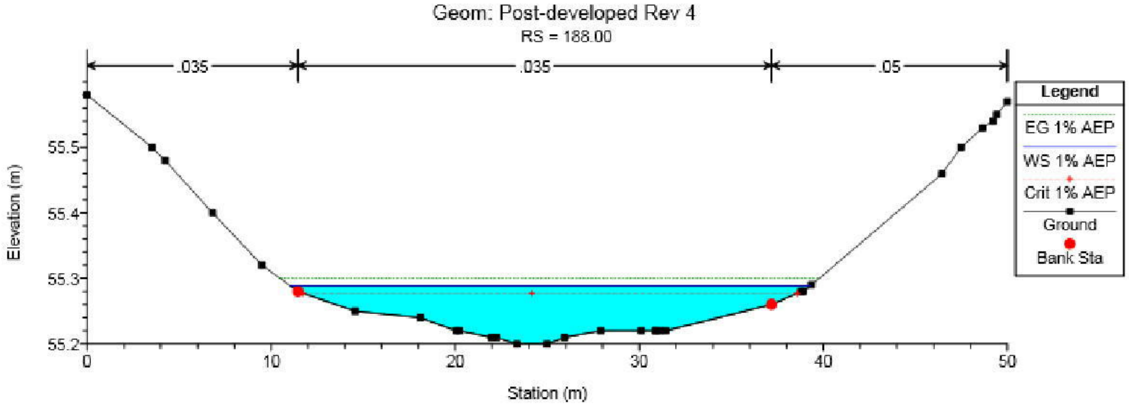


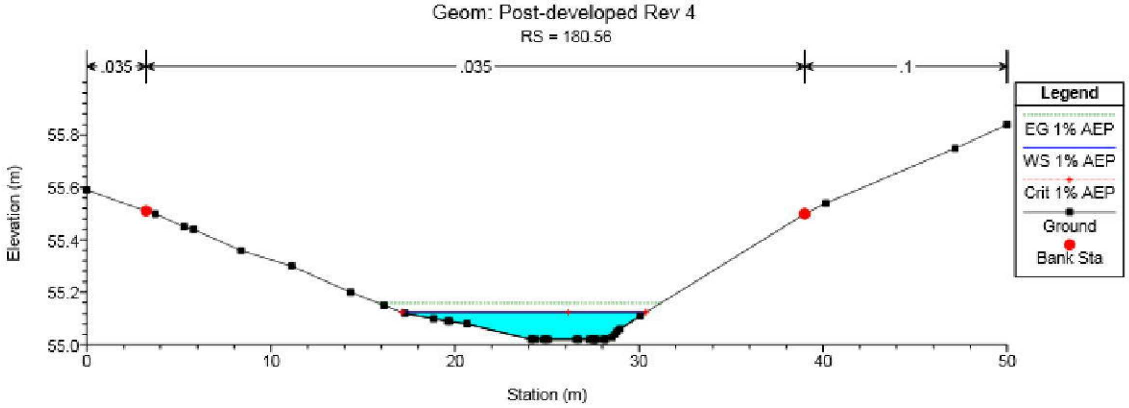
Post Development 20% AEP (continued)

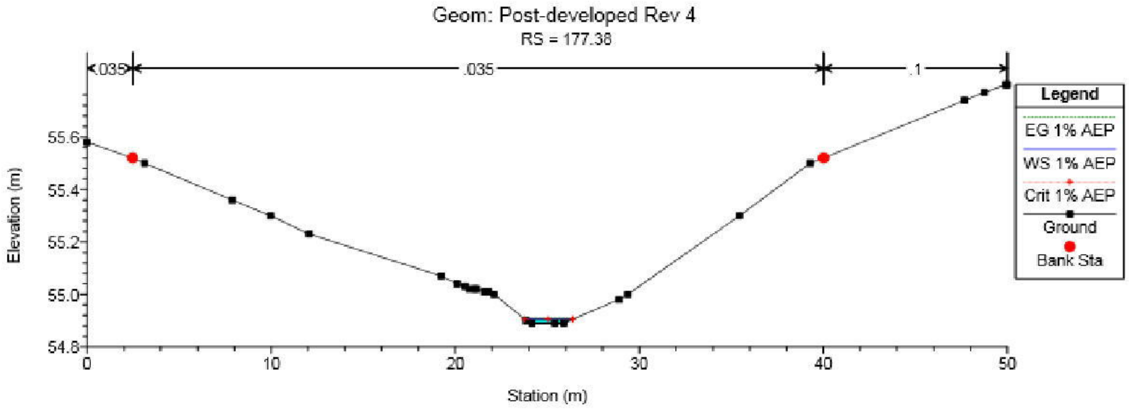


Post Development 1% AEP

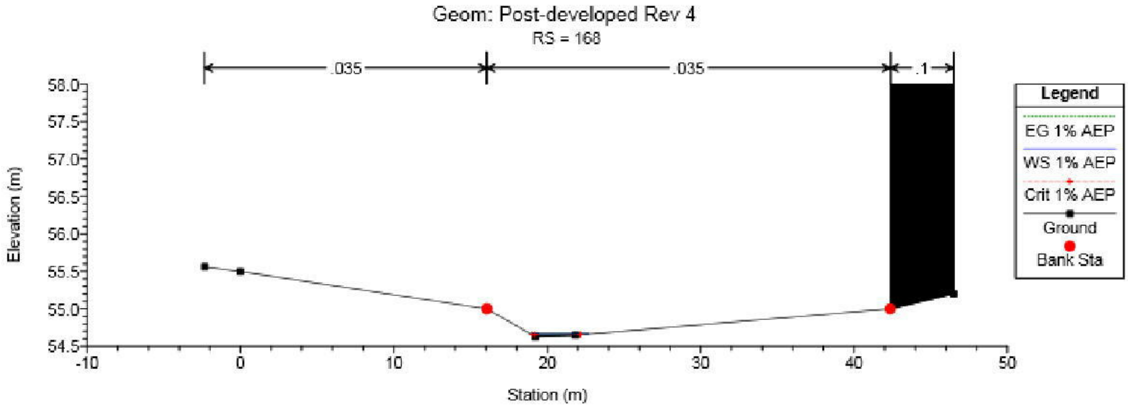


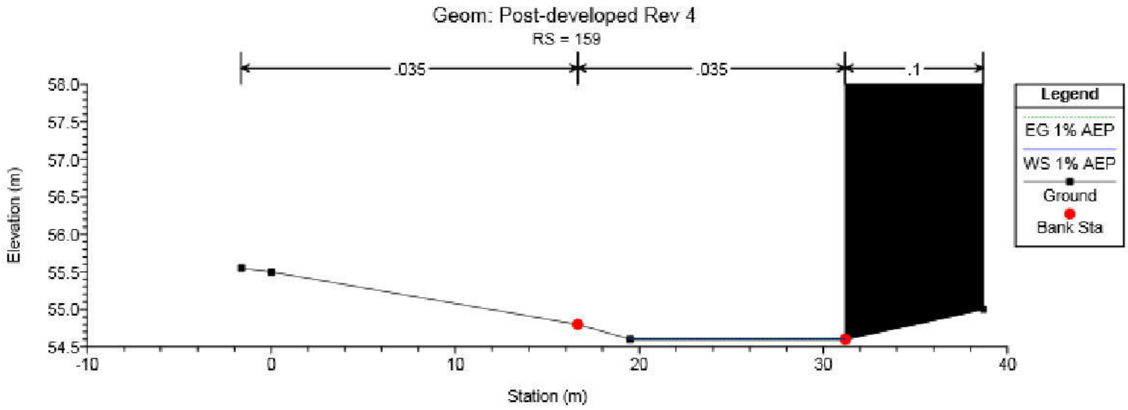


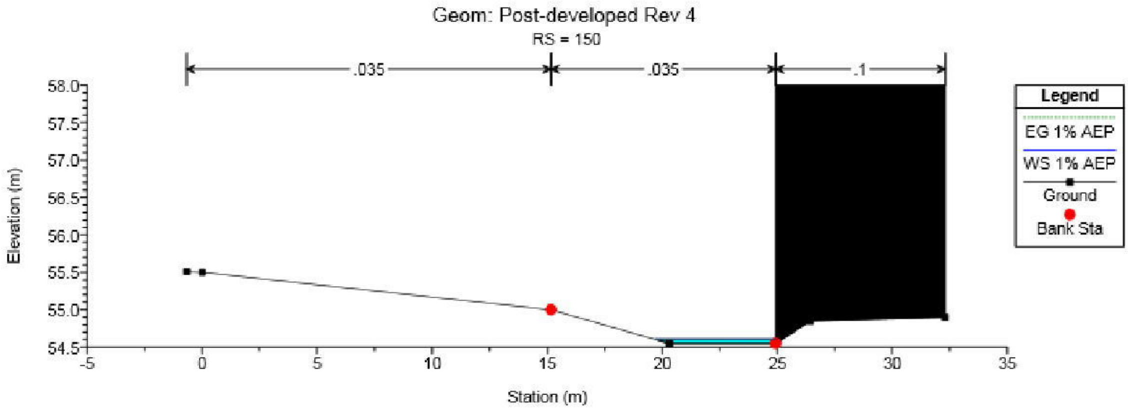


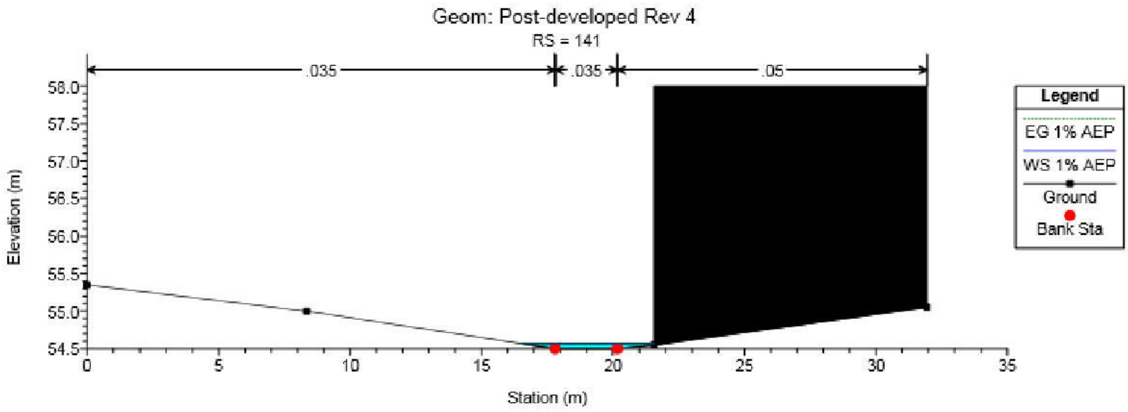


Post Development 1% AEP (continued)

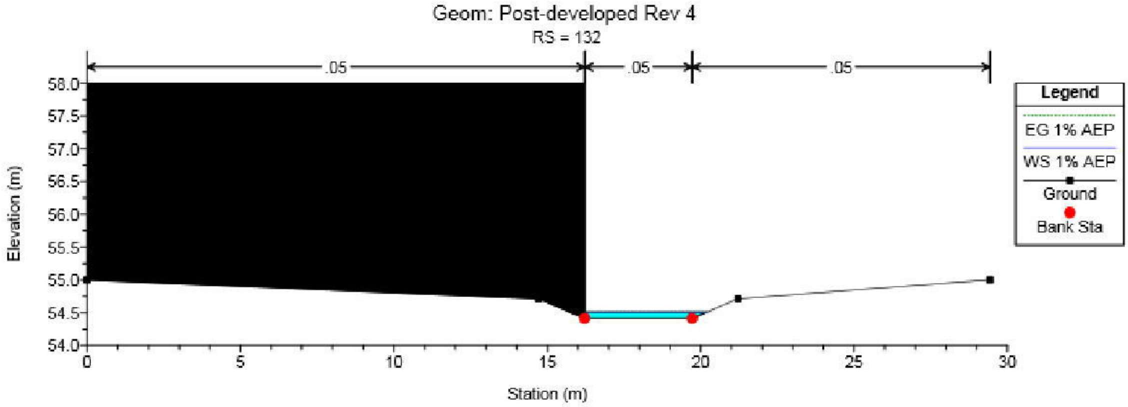


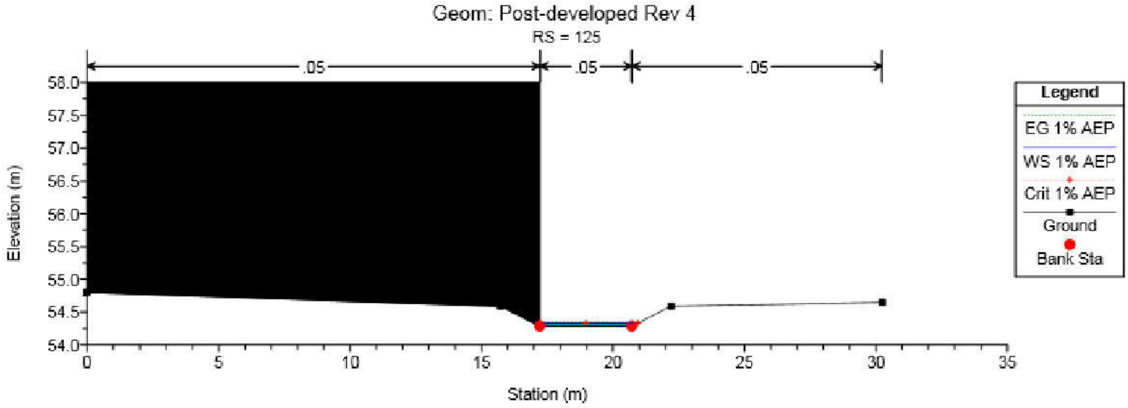


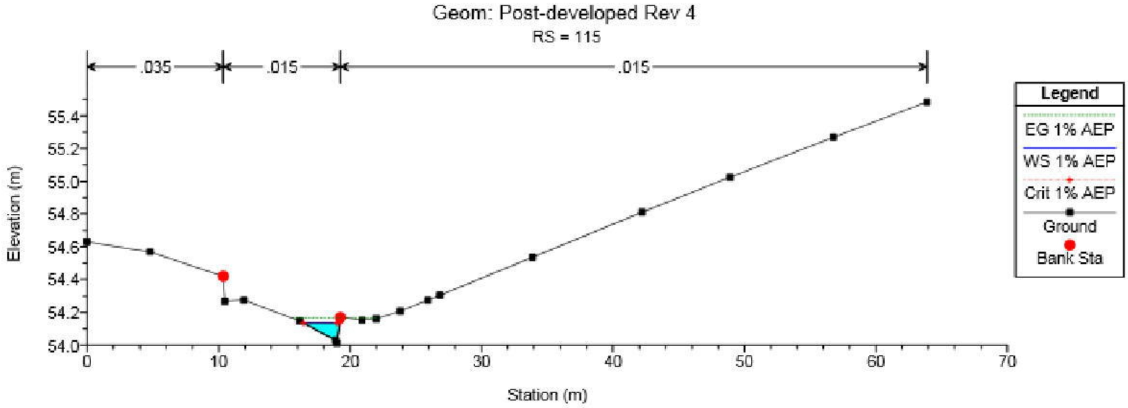


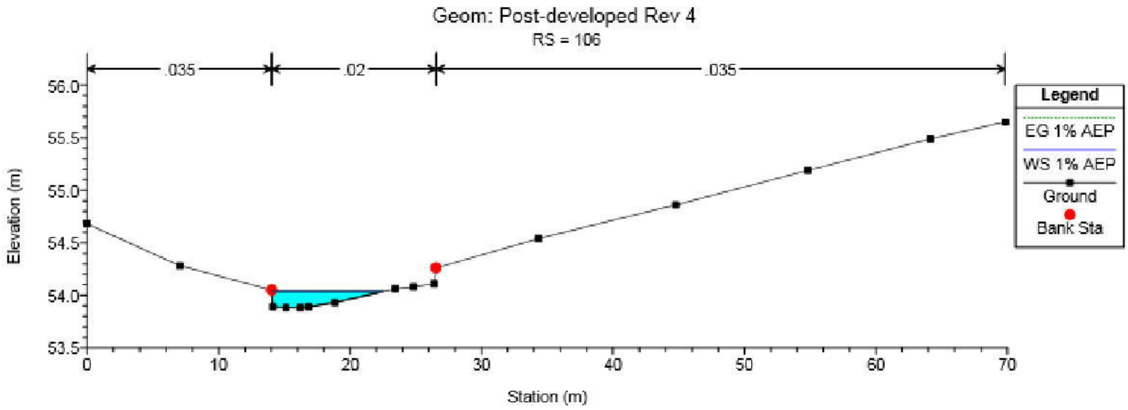


Post Development 1% AEP (continued)

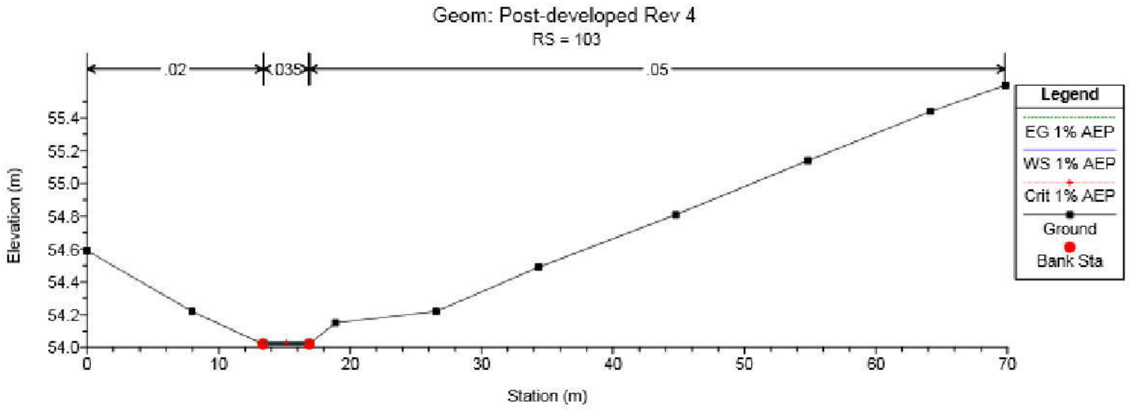


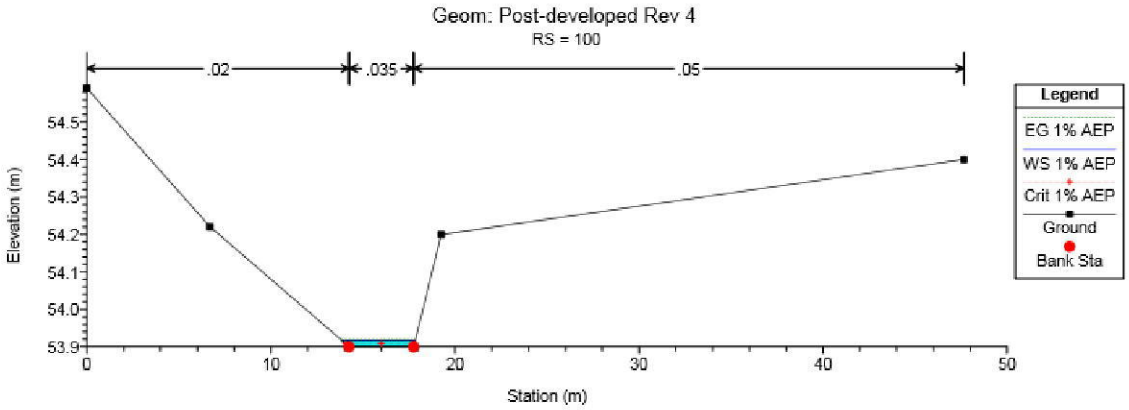


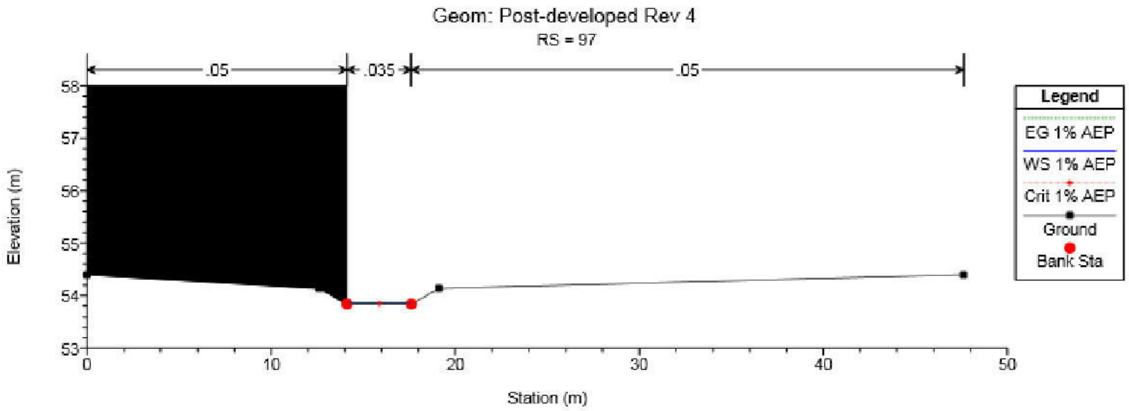


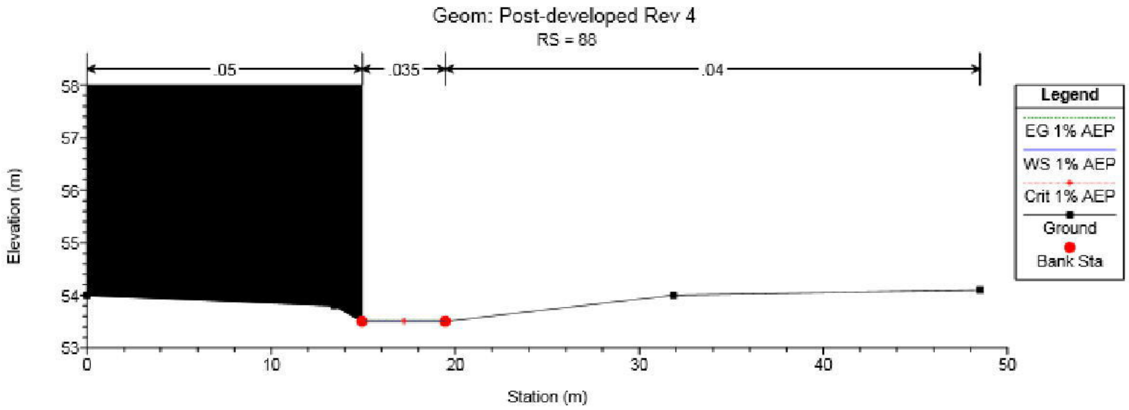


Post Development 1% AEP (continued)

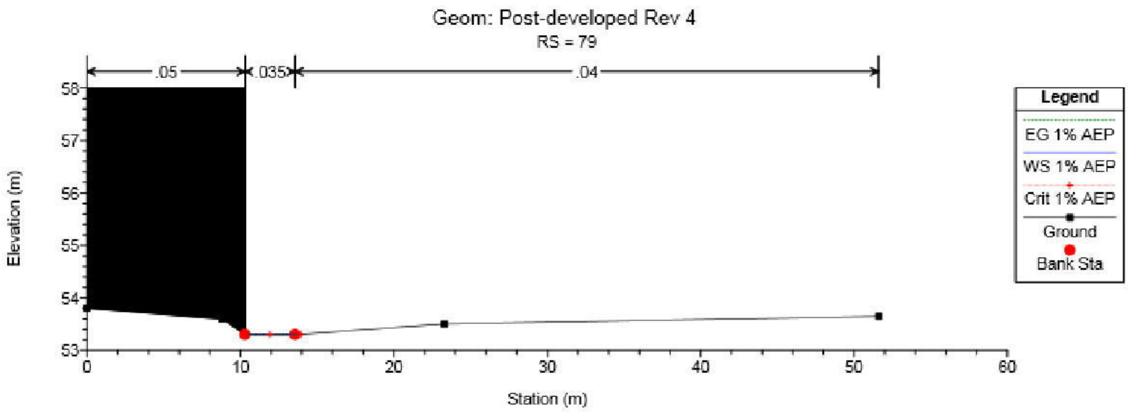


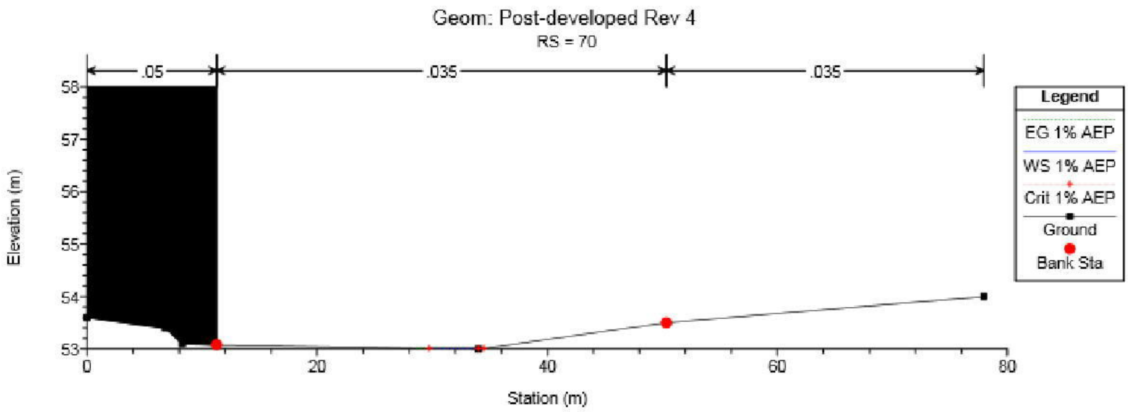


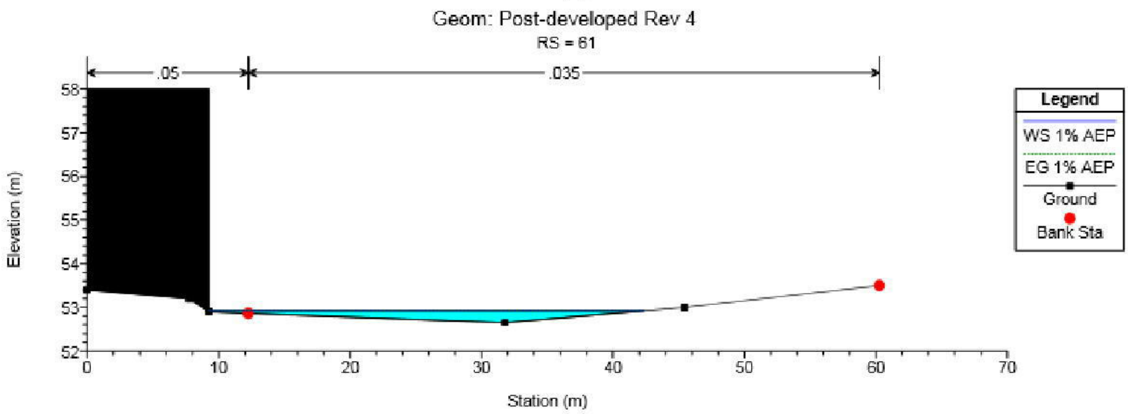


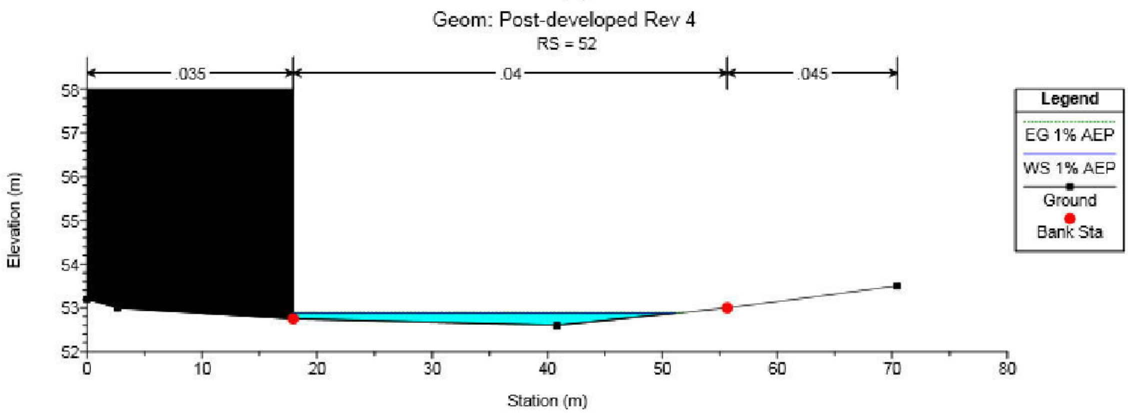


Post Development 1% AEP (continued)









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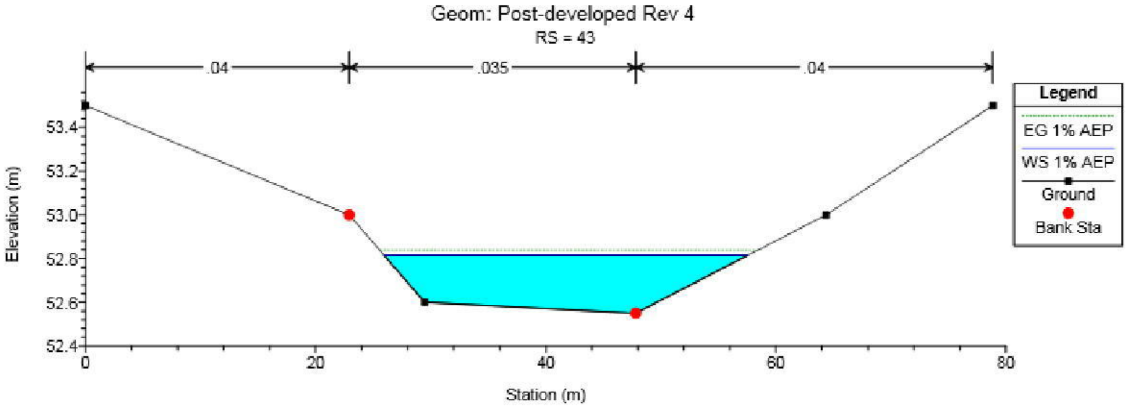

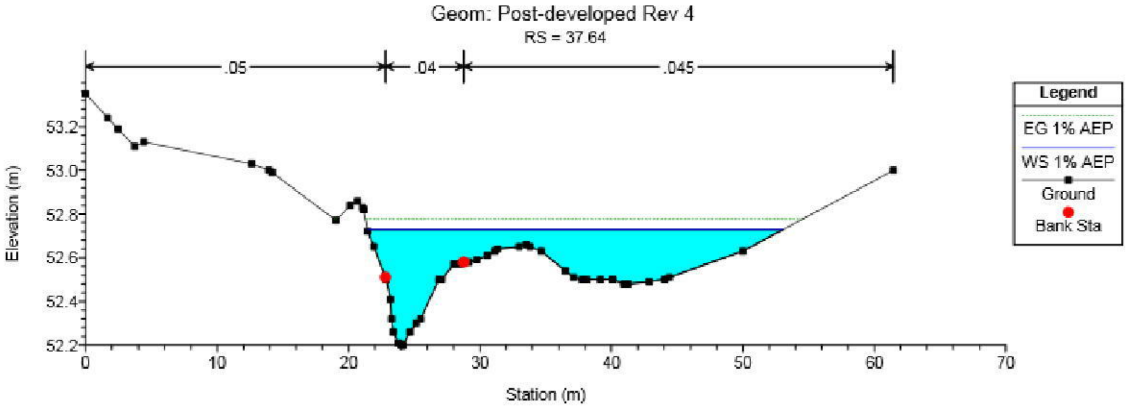

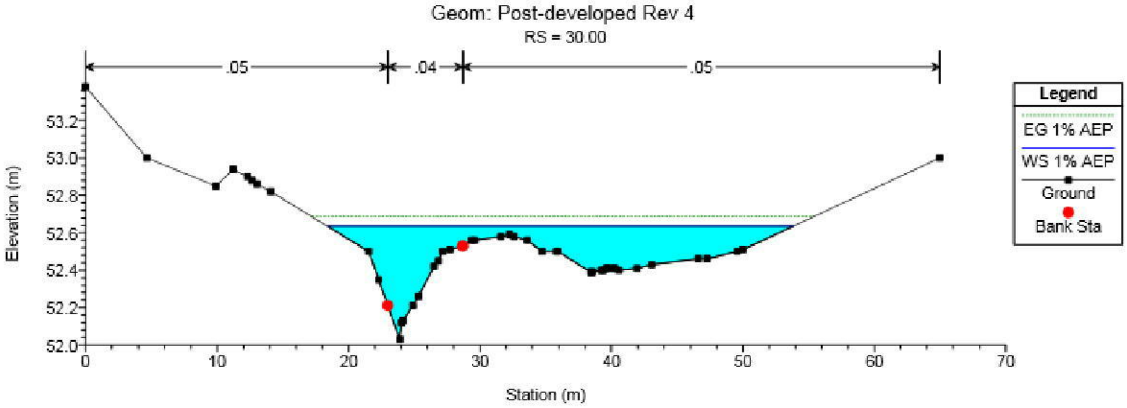

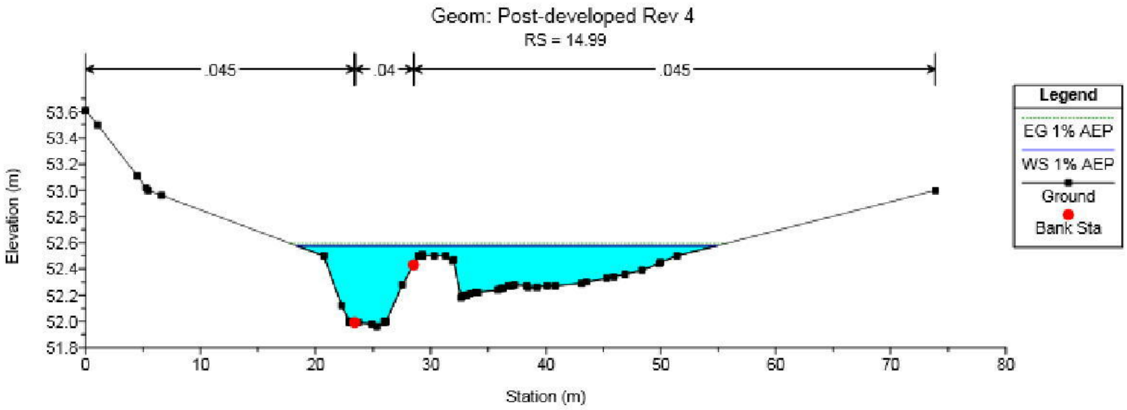

Post Development 1% AEP (continued)