management consultants &
project managers

npc

Proposed Residential Apartment Development
Avon Road, Pymble

Part 3A Concept Plan and Stage 1 Project Application
MP08_0207 and MP10_0219

Stormwater Management and Riparian Issues

November 2012
Job No. 2514

TABLE OF CONTENTS

Executive Summary

JW Neale Pty Ltd (Receivers and Managers Appointed) propose to submit a Part 3A Concept Plan (MP08_0207) and Stage 1 Project Application (MP10_0219) for a residential development on a site fronting Avon and Beechworth Roads in Pymble. The Concept Plan includes four apartment buildings while the Stage 1 Project Application is for Building 1 fronting Avon Road.

NPC has been engaged to address the stormwater related issues, to prepare a Stormwater Drainage Concept Plan and a Soil and Erosion Control Plan and to address the riparian issues associated with the site.

The existing site encompasses part of a heavily weed infested valley bounded to the north by the North Shore rail line and with access from both Avon and Beechworth Roads (refer Figure 2). It slopes steeply down to the south over the upper third of the site with the lower two thirds of the site relatively flat. At the southern boundary, there are two rows of houses with access to Arilla Road.

The site is located near to the top of the catchment. Runoff flows onto the site from the north are controlled by the rail line embankment and a 900mm diameter pipe culvert through the embankment. At the site's southern boundary, flows enter a culvert and are directed to the culvert under Arilla Road to discharge to a stream downstream of Arilla Road.

The proposed development consists of four apartment buildings located as shown on Figure 3. Other than Building 3, the buildings are located a significant height above the drainage line through the site. A best practice Water Sensitive Urban Design (WSUD) approach has been adopted in the formulation of the water management for the development. The Stormwater Drainage Concept Plan has been derived incorporating WSUD features and formulated in concert with the Landscape Plan (refer Figure 4) in order to create a natural environment along the drainage line through the site which uses water and vegetation to enhance habitats and water quality. This will form an environment which will contribute to the long term improvement in water quality and environmental quality of the streams downstream of the site. It will also provide a significant passive recreational feature for the local residents.

The proposed Stormwater Drainage Concept Plan would incorporate the following WSUD features and achieve the following results:

1. Roof runoff capture in rainwater tanks and reuse within the buildings for non potable flushing of toilets, laundries and outdoors irrigation – this will reduce the runoff volumes, runoff pollutant load and potable water usage;
2. Inclusion of water saving appliances within the apartments;
3. Detention of runoff from impermeable surfaces to ensure peak flow rates remain at existing levels and do not impact the flooding behaviour on adjacent properties;
4. Incorporation of erosion and sediment control features during the construction stage as proposed in the Erosion and Sediment Control Plan;
5. Treatment of runoff in the post development stage to maintain pollutant loads at or below existing levels as proposed in the Stormwater Drainage Concept Plan;

6. Enhancement of the blue gum forest and habitat, stabilisation of surfaces and improvement in runoff water quality along the watercourse; and
7. Use of endemic vegetation in landscaping to reduce water demand.

Based on the NSW Office of Water policy, as the drainage line through the site is not shown as a blue line on the 1:25,000 Topographic Map for the area, it is not defined as a river under the Water Management Act 2000 and does not require a riparian corridor. A detailed site inspection has confirmed that the drainage line is not a river. Notwithstanding this, the proposed Landscape Plan (Figure 4) demonstrates significant works will be undertaken to re establish the Blue Gum forest and understorey along with natural features and ponds to embellish the habitat quality (both terrestrial and aquatic). It will create a significant endemic bushland corridor through the site to the benefit of the environment and local residents.

As this drainage line does not have banks and is not classified as a river, the Ku ring gai Council's Category 3 classification of the drainage line in its Riparian Policy is not considered appropriate. Notwithstanding this, the Landscape Plan proposes works which meet the objectives of Council's Riparian Policy for such a Category 3 stream and would create a significant bushland corridor through the site.

A Sediment and Erosion Control Plan has been formulated for the construction phase of the project to control the quality of runoff from the site (refer Figure 8). This plan has been designed based on the industry best practice "Blue Book" guidelines.

The Stage 1 Project Application is for Building 1 fronting Avon Road. The Stormwater Drainage Concept Plan (refer Figure 9) for Building 1 includes a 20kL rainwater tank for reuse of roof runoff, a 125m3 detention tank to maintain peak flow rates below existing rates, discharge to a constructed wetland for water quality control and landscaping to clear weeds and re establish a stabilised and landscape area downslope of Building 1. This will achieve the pollutant reduction in the site runoff and contribute to the long term improvement in water quality in downstream water courses.

The Erosion and Sediment Control Plan (refer Figure 10) provides works for the Stage 1 Project Application to stabilise the site during construction of Building 1 and to minimise the discharge of sediment in runoff to areas downstream of the site. The design conforms to the requirements of the Blue Book.

The proposed stormwater management for the proposed development in both the Concept Plan and the Stage 1 Project Application conforms to the requirements of the Ku ring gai Council Water Management Development Control Plan – DCP 47 and the Riparian Policy.

1. Introduction

JW Neale Pty Ltd (Receivers and Managers Appointed) propose to submit a Part 3A Concept Plan (MP08_0207) and Stage 1 Project Application (MP10_0219) for a residential development on a site fronting Avon and Beechworth Roads in Pymble. The Concept Plan includes four apartment buildings while the Stage 1 Project Application is for Building 1 with a frontage to Avon Road.

NPC has been engaged to address the stormwater related issues, to prepare a Stormwater Drainage Concept Plan and a Soil and Erosion Control Plan and to address the riparian issues associated with the site.

This report deals with the following issues:

1. Water sensitive urban design;
2. Riparian issues;
3. Flooding and minimum habitable floor levels;
4. Stormwater detention;
5. Stormwater water quality measures; and
6. Rainwater reuse.

2. Existing Site

The site has an area of approximately 2.4ha and is generally a T plan shape with the northern boundary adjacent to the North Shore rail line and accesses to both Avon and Beechworth Roads. The site is in the general form of a valley extending from the rail line in the north southwards to backing onto two rows of existing residential properties with frontage and access to Arilla Road (refer to the survey plan at Figure 1).

The site is sited near the top end of the catchment. The catchment which encompasses the site extends to the ridge line which is the Pacific Highway just to the north of the site. The catchment above the site has a small area of approximately 5 ha.

Stormwater runoff from the upstream catchment flows onto the site from a 900mm diameter pipe culvert located under the rail corridor. It appears that this pipe was not located in the original low point at the top end of the site nor aligned to the low point. As such, these flows have eroded this area at the top end of the site.

The site falls north to south with the upper third of the site being relatively steep leading to a generally lower slope over the lower two thirds of the site. There is evidence of formal gardens and a tennis court in these lower areas of the site especially on the eastern side.

The site is heavily overgrown with weeds hiding what was once a Blue Gum forest (Figure 2).

A house has been recently constructed adjacent to the southern boundary of the site which is a battleaxe lot with access to Arilla Road. At the site southern boundary, there is a drainage culvert leading along the driveway of this battleaxe block to the culvert under Arilla Road. The culvert is approximately 0.7m high and 1.2m wide. There is an overland flow route over the top of the culvert along the driveway of this property leading to Arilla Road.

3. Proposed Development

The proposed development consists of four apartment buildings as depicted on Figure 3.

Building 1 has a frontage to Avon Road with a ground floor level of RL 138m AHD. Runoff from this building will, after reuse, detention and treatment, mostly discharge to the drainage line through the site.

There is no Building 2.

Building 3 is located in the south eastern corner of the site and would have a ground floor level of RL 126m AHD. This building is adjacent to the drainage line and will need to have a minimum freeboard of 500mm from the habitable floor level to the 100 year ARI flood level at this section of the site. The driveway to Building 3 would enter from Avon Road and pass around Building 4. This driveway would incorporate kerbs to control surface runoff and permit treatment and detention to trap pollutants and reduce flow velocities prior to discharge. Drainage from the building would discharge to the watercourse after reuse and detention.

Building 4 is located in the north eastern section of the property with a driveway access from Avon Road. Its proposed ground floor level is RL 144m AHD. It is located considerably above the drainage line through the centre of the site. Drainage from this building will discharge to the drainage line on the site after part of it is reused from the rainwater tanks, and all discharges would be detained prior to discharge.

Building 5 would be located in the north western portion of the site with driveway access to Beechworth Road. Drainage from this building will discharge to the drainage line on the site after part of it being reused, and the remainder would be detained prior to discharge. The proposed ground floor level for this building would be RL 148m AHD which is considerably above the drainage line.

The Landscape Plan for the development has been formulated in workshop with the ecologist, bushfire, arborist and hydrologist specialists to create a natural and stable environment which maximises the ecological and water sensitive design outcomes as well as being an attractive area for passive recreation (refer Figure 4).

The Landscape Plan would involve clearing all the weeds and regeneration of the Blue Gum High Forest understorey to stabilise the valley floor. The steep upper third of the site would incorporate an intermittent cascading pool system in the drainage line to slow down the runoff and create aquatic habitat features with macrophyte planting to improve water quality. The lower two thirds of the site would incorporate a vegetated and rocky drainage line to further enhance habitats and a pond with a macrophyte upper third to provide diversity of habitat and water quality treatment. The pond would be designed as a wet and dry feature to accommodate variations in rainfall patterns. The Landscape Plan would provide a valuable environmental outcome for this valley and the local residents.

4. Water Sensitive Urban Design

A water sensitive urban design (WSUD) approach has been adopted for all elements of the project. Within the area of stormwater management, the proposed WSUD features include:

1. Roof runoff capture in rainwater tanks and reuse within the buildings for non potable flushing of toilets, laundries and outdoors irrigation – this will reduce the runoff volumes, runoff pollutant load and potable water usage;
2. Detention of runoff from impermeable surfaces to ensure peak flow rates remain at existing levels and do not impact flooding behaviour on adjacent properties;
3. Incorporation of erosion and sediment control features during the construction stage as proposed in the Erosion and Sediment Control Plan;
4. Treatment of runoff in the post development stage to maintain pollutant loads at or below existing levels as proposed in the Stormwater Drainage Concept Plan;
5. Enhancement of the blue gum forest and habitat, stabilisation of surfaces and improvement in runoff water quality along the drainage line; and
6. Use of endemic vegetation in landscaping to reduce water demand.

Detailed hydrologic and hydraulic modelling was undertaken by CivilCert to determine the quantitative controls required for this development to achieve the above objectives. The results for the Concept Plan are in Appendix A while the results for the Stage 1 Project Application are at Appendix B.

5. Riparian Issues

On the 1 July, 2012, the NSW Office of Water (NOW) introduced new procedures for identifying waterfront land under the Water Management Act 2000. Waterfront land identifies where controlled activities occur under this Act. This applies to riparian corridors.

The NOW specifies the need for a vegetated riparian corridor for the “rivers” shown as blue lines on the 1:25,000 topographic maps. The widths of the corridor vary according to the stream order as classified under the Strahler System.

The 1:25,000 topographic map covering the subject site shows a blue line starting downstream of the culvert under Arilla Road south of the site. There is no blue line shown on the site. The blue line starts about 70m south of the site and heads downstream (further south). As such, no riparian corridor is required on the site (refer Figure 5). Also, no approval is required under the Water Management Act 2000 for works in the drainage line.

A detailed site inspection was undertaken of the drainage line to ascertain its classification as a “river” under the Water Management Act 2000. This inspection identified that the drainage line was heavily modified due to weed invasion and the concentration of flows from the upstream urban catchment at the pipe culvert under the railway corridor. Due to the limited upstream catchment of 5 ha, the drainage corridor does not exhibit bank features other than at the railway culvert outlet which because of its concentration of flows and its location away from the natural low point has eroded a small area around the pipe culvert outlet. This is a limited and obviously not a natural feature. In the lower two thirds of the site there is a broad area through which the flows pass. The site inspection confirmed that a riparian corridor was not required through the site.

The Landscape Plan indicates that the removal of the weeds and embellishment of the Blue Gum forest understorey with endemic species will create a broad vegetated corridor with sympathetic treatment of the drainage line which will provide significant improvements in the flora and fauna habitats of this area for the local residents to enjoy. The width of this corridor would vary from about 30m to 55m wide.

Ku ring gai Council formulated their Riparian Policy in 2003 and 2004. The policy aims to ensure the long term viability and sustainability of the creeks and riparian zones. Under this policy, the Council categorised its creeks into three categories and specifies riparian corridor widths measured from the top of bank. For the site, the Council has nominated it as the lowest importance category – Category 3. This category is primarily concerned with providing basic bank stability and protection and enhancement of water quality. The nominated riparian corridor width is 10m from top of bank on each side with no buffer width requirement.

The drainage line on the site does not have banks and as such, the policy is not relevant to the site. However, the outcomes of the proposed development as demonstrated through the Landscape Plan and the WSUD features would mean that the Council’s Riparian Policy objectives for a Category 3 watercourse would be satisfied in any case.

The objectives of the Category 3 watercourses in Council's policy are:

- Providing bank protection and bed stability;
- Protecting water quality;
- Protecting native vegetation; and
- Protecting in stream aquatic vegetation.

Council suggests that these objectives be achieved by:

- Emulating where possible a naturally functioning stream;
- Ensuring channel stability;
- Protecting the natural values within the channel;
- Providing lateral connectivity for in-stream function;
- Using pipes or other engineering devices as a last resort; and
- Ensuring all stormwater discharge is treated before it enters the stream.

The development proposes to reduce the runoff volume from the site as well detain and treat runoff to control peak flow rates and pollutant load. The Landscape Plan demonstrates that the drainage line will have a natural and stable form with significant enhancement of flora and fauna habitats. The width of landscaping corridor through the site will vary from 30m to 55m which is very generous for a site at the top end of a catchment.

It is therefore considered that the proposed development readily achieves the objectives of Council's Riparian Policy even though this Policy and the Water Management Act are not relevant to the site.

6. Flooding

6.1 Flood Levels

Hydrological and hydraulic modelling was undertaken for the site to determine the 100 year ARI and Probably Maximum Flood levels for the site. Flows through the site are unconstrained for the upper third of the site as there are no obstructions to flows. Also, the buildings in line with this section of the site are elevated a significant distance above the drainage line and would be unaffected by flood flows. The 100 year ARI flows are typically 0.5m deep along the drainage line.

At the lower end of the site, the Council culvert at the southern boundary has sufficient capacity for the 100 year ARI floods. However, when partially blocked, this restricted capacity would cause floodwaters backup behind the culvert until flows can overtop it and flow overland down the driveway to Arilla Road. The predicted existing flood levels in this area as they relate to Building 3 assuming a 50% blockage of the culvert downstream of the site are:

Location on Bldg 3	Model Chainage	100 yr flood	PMF flood
Downstream end (southern)	40m	RL 121.9m AHD	RL 122.4 m, AHD
Upstream end (northern)	80m	RL 124.6 m AHD	RL 124.9 m AHD

The 100 year ARI flood extents on the site are presented in Figure 6.

In the post development conditions, a pond/wetland is proposed near to Building 3. This pond/wetland will have stepped water levels with the upstream weir (crest level RL 125.2m AHD) located upstream of Building 3 at Chainage 82m. The lower weir located at Chainage 67m would have a weir crest of RL 124.7m AHD. The predicted post development flood levels in this area as they relate to Building 3 assuming a 50% blockage of the culvert downstream of the site are:

Location on Bldg 3	Model Chainage	100 yr flood	PMF flood
Downstream end (southern)	40m	RL 121.8m AHD	RL 122.4 m, AHD
Upstream end (northern)	80m	RL 125.3 m AHD	RL 125.5 m AHD

The 100 year ARI flood level is the flood standard for setting minimum habitable floor levels with the addition of a minimum freeboard of 500mm. The minimum habitable floor level set for Building 3 is RL 126 m AHD which satisfies the flood freeboard requirements.

The PMF flood level is used to assess the risk to personal safety in an extreme flood event (it is not used to set floor levels). All residents and habitable floors will be above the PMF level and as such, are not posed with significant risk to personal safety. Also, emergency vehicles could access all buildings along driveways unaffected during a PMF event.

6.2 Climate Change Impact on Flood Levels

It is predicted that climate change has the potential to cause decreases and increases in the long term rainfall intensities in Sydney. These changes could lead to decreases or increases in flood levels in Sydney. Given the uncertainty of the extent of this change, it is recommended that sensitivity testing be undertaken to assess the possible extent of increase in 100 year ARI flood levels due to an anticipated increase in rainfall intensity.

The flood modelling was undertaken with a 15% increase in rainfall intensity and the 100 year ARI flood levels at Building 3 would increase by around 40mm.

Even with this increase in rainfall intensity, the proposed minimum habitable floor level in Building 3 is still more than 500mm above the predicted 100 year ARI flood level. As such, the proposed minimum floor level has an appropriate freeboard to minimise the potential for flood damages even in the event climate change increases rainfall intensities. The development conforms to the NSW Floodplain Management Manual.

7. Stormwater Peak Flows

Development without suitable controls can lead to higher peak flows and velocities leading to erosion of drainage lines and watercourses and possible increased flood levels on adjacent properties downstream. The objective in development is to ensure that runoff from the site is maintained at or below the existing peak flows. This is typically achieved by detaining flows and releasing them at or below existing peak flow rates. Hydrologic modelling is undertaken to determine the detention storage volume required to achieve this objective.

All runoff from the driveways and paved areas of the development will be directed to stormwater detention tanks (refer to the Stormwater Drainage Concept Plan at Figure 7). Runoff from the building roofs will be firstly directed to rainwater tanks and then if necessary to detention tanks. The rainwater tanks will trap some of the runoff and effectively reduce flows in the low severity storms. In larger storms, this effect is less as the rainwater tanks would fill readily and then flows would bypass the tanks. Ku ring gai Council permits 25% of the rainwater tank volume to be counted as detention storage for this reason.

Each building would have detention storage of 125m3 and a rainwater tank volume of 20m3 (20 kL). This would provide the required detention storage of 520m3. This conforms to the Ku ring gai Council's requirements in the Water Management Development Control Plan – DCP 47.

The detailed hydrologic and hydraulic modelling is detailed in Appendix A.

The runoff from the buildings up to the 20 year ARI storm would be piped from the detention basin to the drainage line through the site to a scour protected outlet designed to complement the flora and habitat goals of the Landscape Plan. The area between the proposed buildings and the stormwater drainage line outlet would be stabilised with vegetation as detailed in the Landscape Plan such that overland flows from the development would not cause erosion and deposition in the rehabilitated drainage line.

Ku ring gai Council adopted in April 2005 the Water Management Development Control Plan – DCP 47. Under this plan the proposed development is categorised as a Type 5 development in a Location B which discharges directly to a natural waterbody. The proposed management of peak runoff flows for the subject development conform to the requirements of DCP 47.

8. Stormwater Water Quality

The management of stormwater runoff water quality covers two phases:

- During construction; and
- Post development.

8.1 During Construction

The objectives during construction are to minimise the erosion caused by runoff over the site and maximise the sediment and pollutant control on the site, thereby minimising the sediment load and any pollutant load in runoff which discharges off the site. The controls proposed on the subject site conform to the industry best practice guidelines in the "Blue Book".

The main principles of erosion and sediment control are to:

- Minimise the extent of site disturbance;
- Rapidly stabilise disturbed areas;
- Divert clean runoff around work areas; and
- Trap eroded sediment prior to discharging to a drainage line or natural waterbody.

The proposed Erosion and Sediment Control Plan for the site is detailed in Figure 8. The detailed calculations for this plan are presented in Appendix A.

The Plan conforms to the requirements of the Ku ring gai Council Water Management DCP 47.

8.2 Post Development

Stormwater runoff from development sites typically contain elevated levels of suspended solids, nutrients and debris/trash and can contribute to the pollution of receiving waters. Industry best practice in urban development is to introduce WSUD features in the development which reduce the runoff annual pollutant load by the following percentages:

- Gross pollutants 90%
- Total suspended solids 80%
- Total phosphorus 60%
- Total nitrogen 45%

The WSUD features proposed for the subject development to achieve these reductions in runoff pollutant loads are:

- Debris baskets in all drainage inlet pits;
- 20 kL rainwater tank in each building for reuse of roof runoff;
- 125 m3 detention tank in each building;
- Water efficient fittings in the buildings to minimise potable water use
- 200 m2 surface area of constructed wetland/pond;
- Use of vegetation to stabilise the site; and
- Vegetation and ponds along the drainage line through the site to provide habitat and remove pollutants.

The location of these proposed controls are presented on Figure 7.

The proposed runoff water quality control system was modelled using the industry best practice program MUSIC and the pollutant reductions achieved would be:

- Gross pollutants 99%
- Total suspended solids 83%
- Total phosphorus 61%
- Total nitrogen 51%

This exceeds the industry best practice requirements for runoff water quality control.

The requirements of the Ku ring gai Council DCP 47 are less than the adopted standards and as such, the proposed runoff water quality controls for the development readily exceed the Council requirements.

9. Stormwater Drainage Concept Plan

Rainfall and runoff on the proposed development would be managed in a pipe system for storms up to a 20 year ARI event and then as overland flow for storms of greater severity. The stormwater drainage system will also include a range of water sensitive urban design features to ensure that rainwater is reused for non potable water uses, peak flows are not increased above existing rates, runoff pollutant loads are reduced substantially and that runoff from the site can contribute to the long term improvement in water quality in the natural streams downstream of the site. The details of this WSUD system is presented in the Stormwater Drainage Concept Plan (refer Figure 7).

The Stormwater Drainage Concept Plan is complemented by the Landscape Plan which removes the extensive weeds, embellishes the Blue Gum Forest and understorey and establishes habitat for a range of fauna. The Plan uses natural features such as pools, ponds and vegetation to slow flows and improve the water quality of flows from areas upstream of the site. This would further enhance the habitat quality through the site as well as contribute to the long term improvement in water quality in streams downstream of the site. This enhanced natural valley forest setting can then be an important component of the local environment to be enjoyed by the local residents.

A maintenance regime would be implemented for all the proposed stormwater pipe and treatment infrastructure which would be the responsibility of the body corporate. This would comprise:

- Periodic (6 monthly) inspection and removal of any gross pollutants or coarse sediment that is deposited in the stormwater pipe system and constructed wetland;
- Periodic (3 monthly) and episodic (post severe storms) inspection and if required, removal of trapped pollutants from the GPT and litter baskets; and
- Periodic (annually) inspection of the rainwater tanks.

10. Stage 1 Project Application

10.1 Stormwater Drainage Concept Plan

The stormwater controls for Building 1 conform to those adopted for the Concept Plan.

10.1.1 Stormwater Peak Flows

Runoff peak flows from the site would be maintained at or below existing rates with the installation of a 20kL rainwater tank for reuse and a 125m3 detention tank within the building. Roof runoff would be firstly directed to the rainwater tank and then overflows directed to the detention tank. The detention tank would have an orifice to control flows so that the combined flows from the site at the southern boundary do not increase above existing rates.

Stormwater flows would be conveyed from the detention tank via pipes with a capacity for the 20 year ARI storm. Flows would discharge via a natural rock headwall and scour protected outlet into the proposed constructed wetland (refer Figure 9). The area between Building 1 and the constructed wetland would be cleared of weeds and stabilised with vegetation. Any overland flows from Building 1 would be dissipated by the vegetation and would not cause scour.

10.1.2 Stormwater Quality

10.1.2.1 Construction Phase

The objectives during construction For Building 1 are to minimise the erosion caused by runoff over the site and maximise the sediment and pollutant control on the site, thereby minimising the sediment load and any pollutant load in runoff which discharges off the site. The controls proposed on the subject site conform to the industry best practice guidelines in the “Blue Book”.

The main principles of erosion and sediment control are to:

- Minimise the extent of site disturbance;
- Rapidly stabilise disturbed areas;
- Divert clean runoff around work areas; and
- Trap eroded sediment prior to discharging to a drainage line or natural waterbody.

The proposed Erosion and Sediment Control Plan for Building 1 is detailed in Figure 10. The detailed calculations for this plan are presented in Appendix B.

The Plan conforms to the requirements of the Ku ring gai Council Water Management DCP 47.

10.1.2.2 Post Development

Stormwater runoff from development sites typically contain elevated levels of suspended solids, nutrients and debris/trash and can contribute to the pollution of receiving waters. Industry best practice in urban development is to introduce WSUD features in the development which reduce the runoff annual pollutant load by the following percentages:

- Gross pollutants 90%
- Total suspended solids 80%
- Total phosphorus 60%
- Total nitrogen 45%

The WSUD features proposed for Building 1 to achieve these reductions in runoff pollutant loads are:

- 20 kL rainwater tank in each building for reuse of roof runoff;
- 125 m3 detention tank in each building;
- Water efficient fittings in the buildings to minimise potable water use
- 200 m2 surface area of constructed wetland/pond; and
- Use of vegetation to stabilise the site.

The location of these proposed controls are presented on Figure 9.

The proposed runoff water quality control system was modelled using the industry best practice program MUSIC and the pollutant reductions achieved would be:

- Gross pollutants 99%
- Total suspended solids 91%
- Total phosphorus 87%
- Total nitrogen 83%

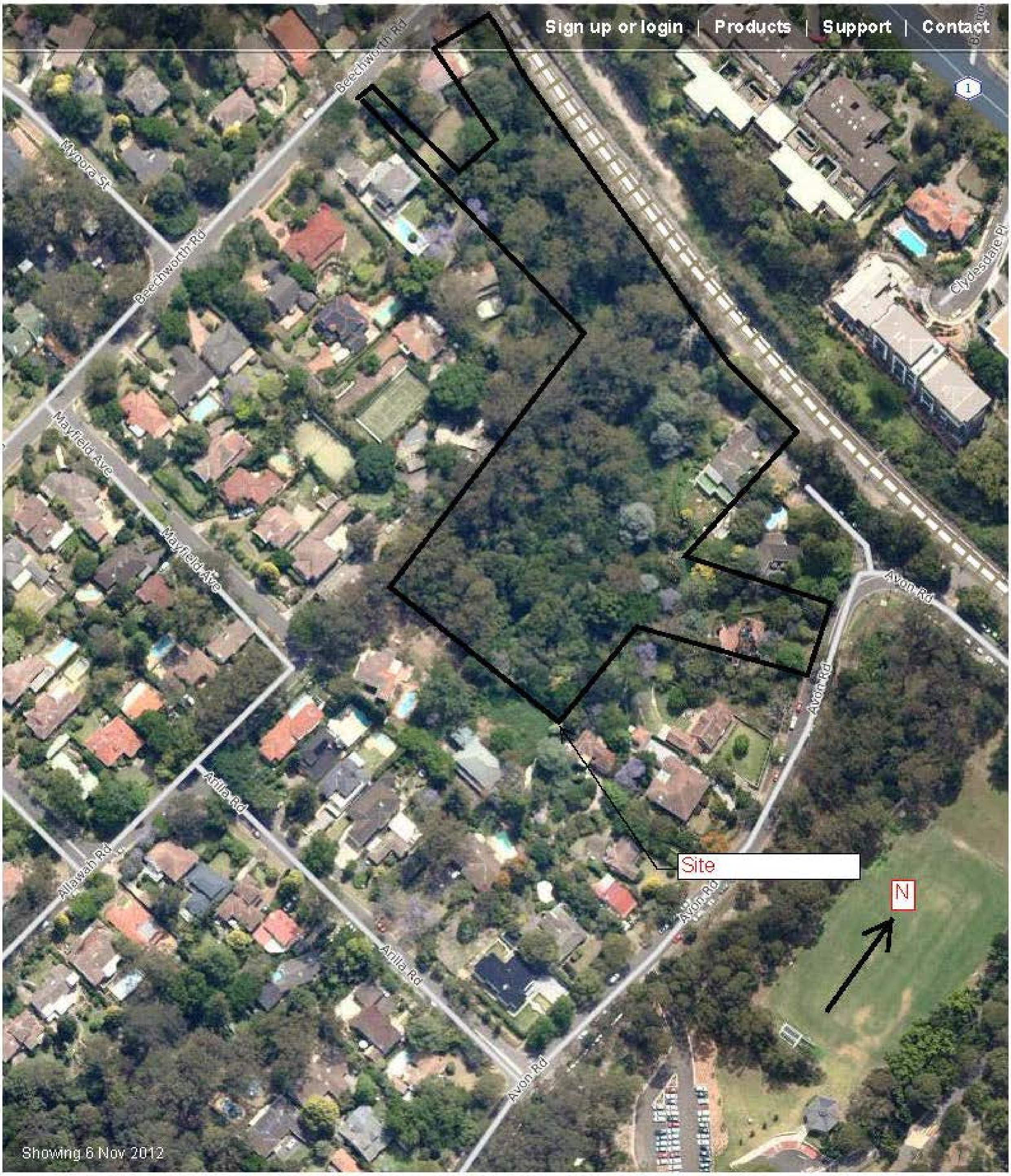
This exceeds the industry best practice requirements for runoff water quality control.

The requirements of the Ku ring gai Council DCP 47 are less than the adopted standards and as such, the proposed runoff water quality controls for the development readily exceed the Council requirements.

FIGURES

Figure 1

Figure 2



http://www.nearmap.com/[12/11/2012 4:51:55 PM]

Figure 3

Figure 4

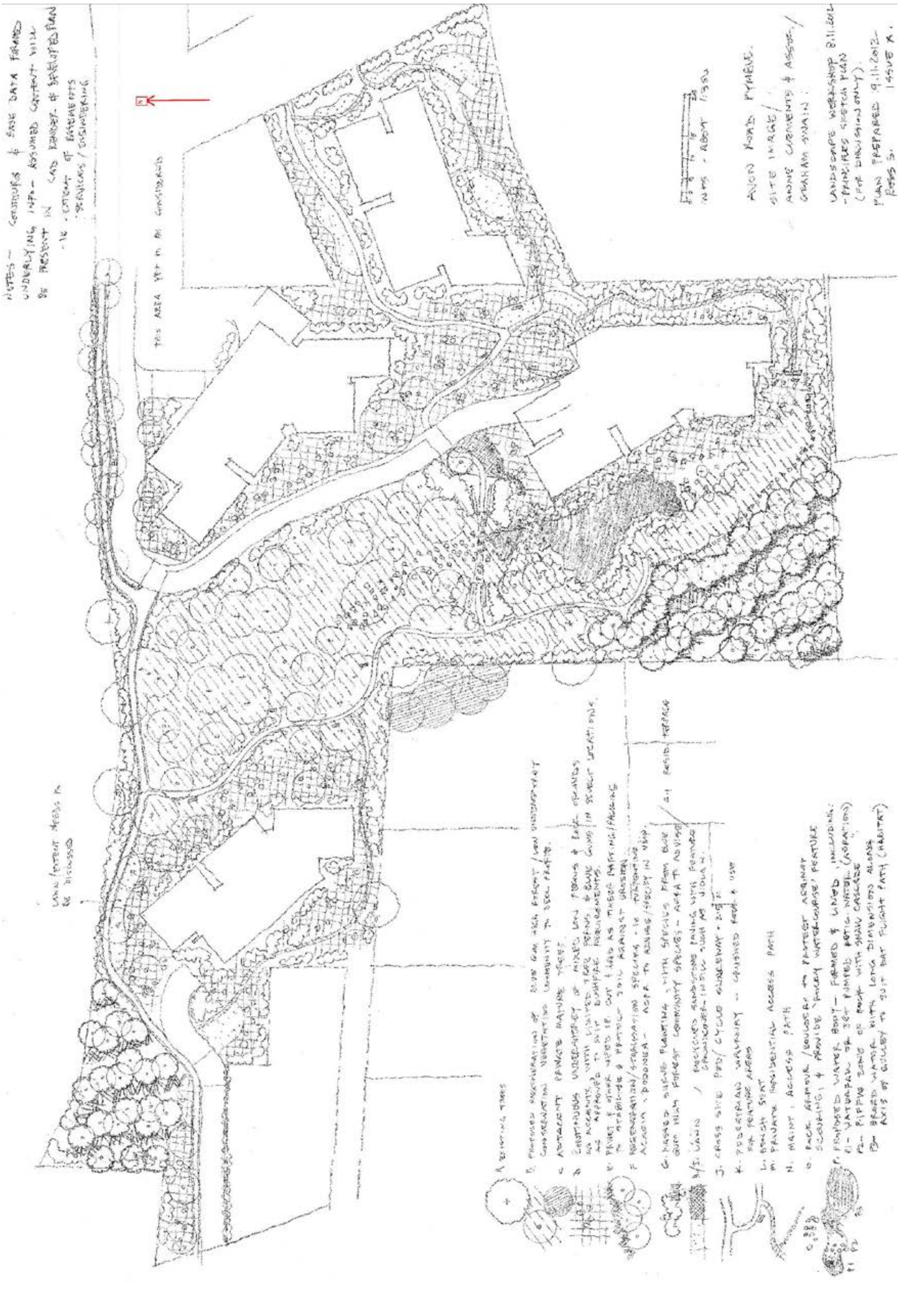
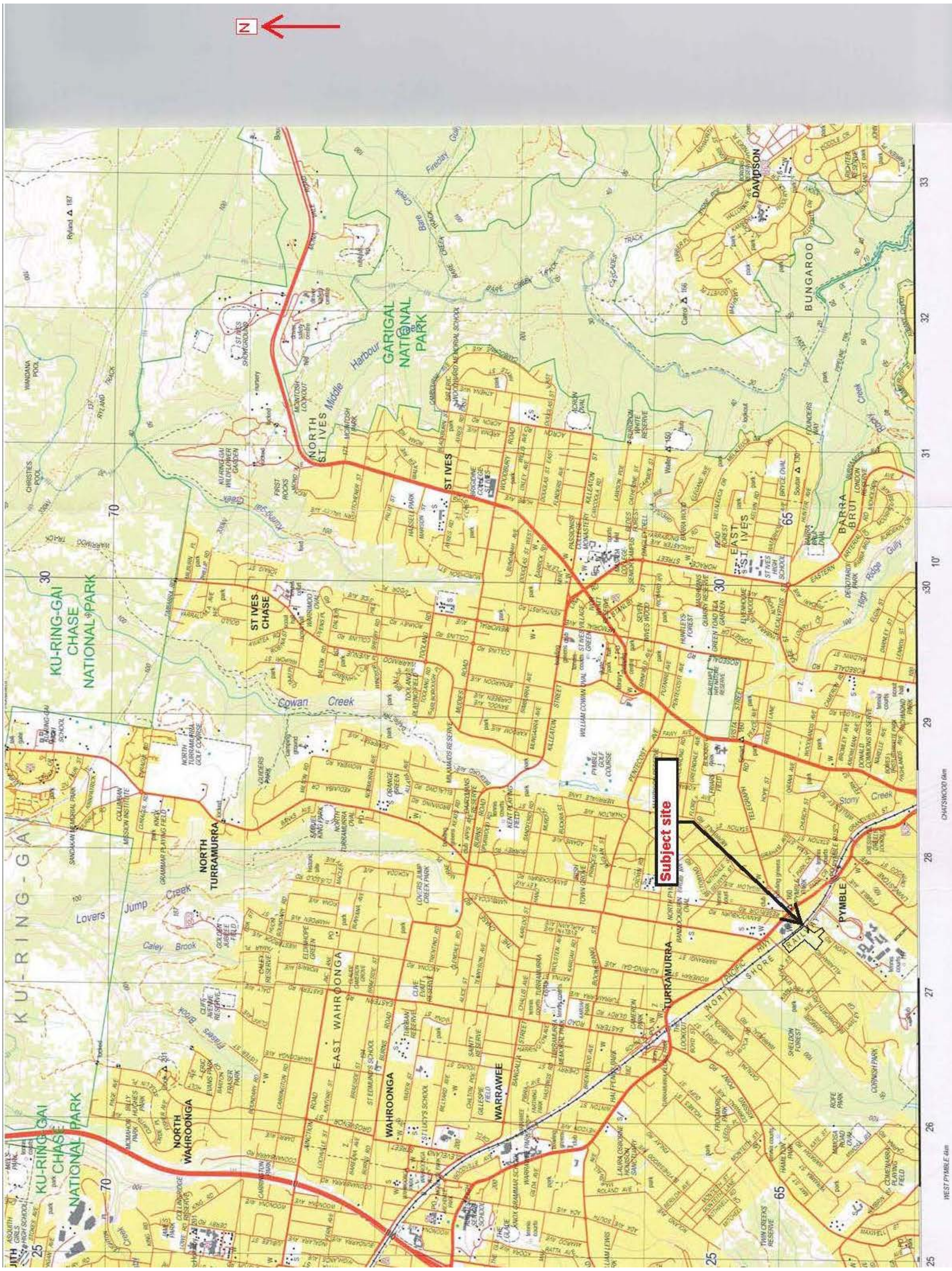


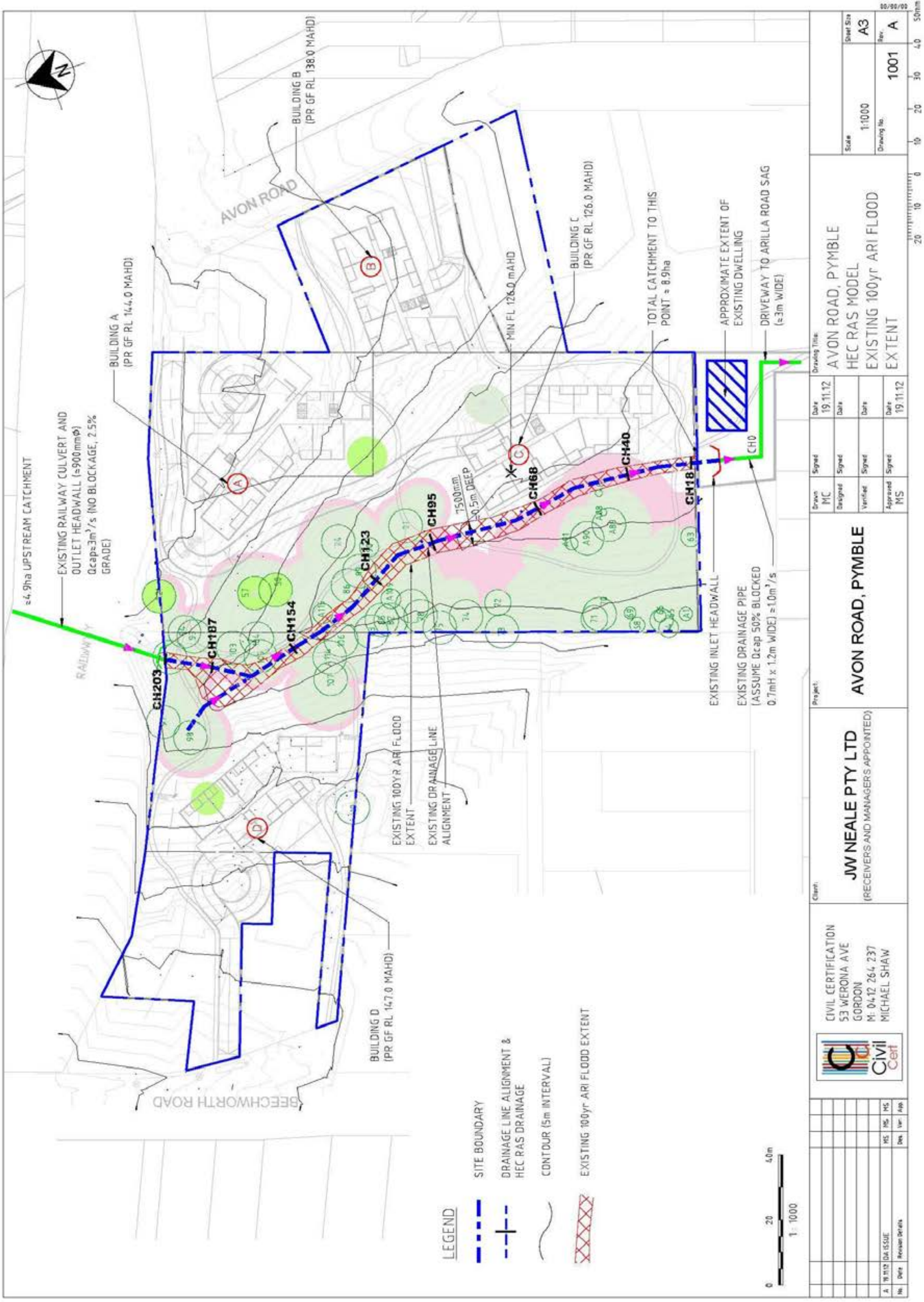
Figure 5



N
Subject site
KU-RING-GAI CHASE NATIONAL PARK
GARIGAL NATIONAL PARK
ST IVES
NORTH ST IVES
ST IVES CHASE
EAST ST IVES
DAVIDSON
BUNGAROO
BARRA BRUI
NORTH TURRAMURRA
TURRAMURRA
PYMBLE
WARRAWEE
WAHROONGA
EAST WAHROONGA
NORTH WAHROONGA
Cowan Creek

npc

Figure 6



AVON ROAD, PYMBLE
HEC RAS MODEL
EXISTING 100yr ARI FLOOD EXTENT
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)
AVON ROAD, PYMBLE
CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW
Scale 1:1000
Sheet Size A3
Drawing No. 1001
Rev. A
LEGEND
SITE BOUNDARY
DRAINAGE LINE ALIGNMENT & HEC RAS DRAINAGE
CONTOUR (5m INTERVAL)
EXISTING 100yr ARI FLOOD EXTENT
AVON ROAD
BEECHWORTH ROAD
RAILWAY
BUILDING A (PR GF RL 144.0 MAHD)
BUILDING B (PR GF RL 138.0 MAHD)
BUILDING C (PR GF RL 126.0 MAHD)
BUILDING D (PR GF RL 147.0 MAHD)
≈4.9ha UPSTREAM CATCHMENT
EXISTING RAILWAY CULVERT AND OUTLET HEADWALL (≈900mmφ)
MIN FL 126.0 mAHD
TOTAL CATCHMENT TO THIS POINT ≈ 8.9ha
APPROXIMATE EXTENT OF EXISTING DWELLING
DRIVEWAY TO ARILLA ROAD SAG (≈3m WIDE)
EXISTING INLET HEADWALL
EXISTING DRAINAGE PIPE
EXISTING 100YR ARI FLOOD EXTENT
EXISTING DRAINAGE LINE ALIGNMENT
CH203
CH187
CH154
CH123
CH95
CH68
CH40
CH18
CH0

Figure 7

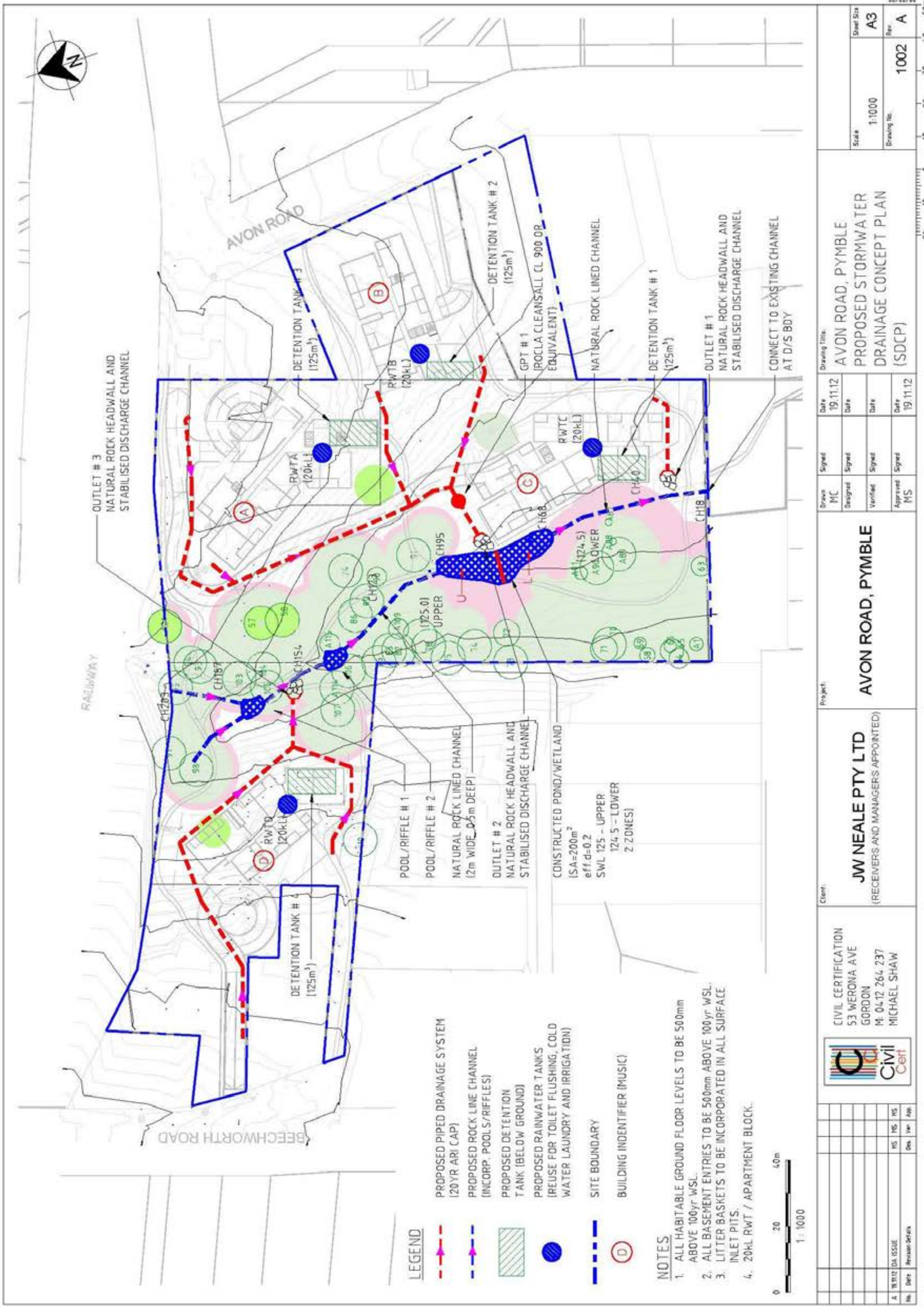

AVON ROAD, PYMBLE
PROPOSED STORMWATER
DRAINAGE CONCEPT PLAN
(SDCP)
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)
CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW
Scale 1:1000
Sheet Size A3
Drawing No. 1002
Rev. A
AVON ROAD
BEECHWORTH ROAD
RAILWAY
LEGEND
PROPOSED PIPED DRAINAGE SYSTEM (20YR ARI CAP)
PROPOSED ROCK LINE CHANNEL (INCORP. POOLS/RIFFLES)
PROPOSED DETENTION TANK (BELOW GROUND)
PROPOSED RAINWATER TANKS (REUSE FOR TOILET FLUSHING, COLD WATER LAUNDRY AND IRRIGATION)
SITE BOUNDARY
BUILDING INDENTIFIER (MUSIC)
NOTES
1. ALL HABITABLE GROUND FLOOR LEVELS TO BE 500mm ABOVE 100yr WSL.
2. ALL BASEMENT ENTRIES TO BE 500mm ABOVE 100yr WSL.
3. LITTER BASKETS TO BE INCORPORATED IN ALL SURFACE INLET PITS.
4. 20kL RWT / APARTMENT BLOCK.
OUTLET # 3
NATURAL ROCK HEADWALL AND STABILISED DISCHARGE CHANNEL
DETENTION TANK # 3 (125m³)
DETENTION TANK # 2 (125m³)
GPT # 1 (ROCLA CLEANSALL CL 900 OR EQUIVALENT)
NATURAL ROCK LINED CHANNEL
DETENTION TANK # 1 (125m³)
OUTLET # 1
NATURAL ROCK HEADWALL AND STABILISED DISCHARGE CHANNEL
CONNECT TO EXISTING CHANNEL AT D/S BDY
POOL/RIFFLE # 1
POOL/RIFFLE # 2
NATURAL ROCK LINED CHANNEL (2m WIDE 0.5m DEEP)
OUTLET # 2
NATURAL ROCK HEADWALL AND STABILISED DISCHARGE CHANNEL
CONSTRUCTED POND/WETLAND
(SA=200m²
eff d=0.2
SWL 125 - UPPER
124.5 - LOWER
2 ZONES)
DETENTION TANK # 4 (125m³)
RWTA (20kL)
RWTB (20kL)
RWTC (20kL)
RWTD (20kL)
(125.0) UPPER
(124.5) LOWER
1:1000

Figure 8

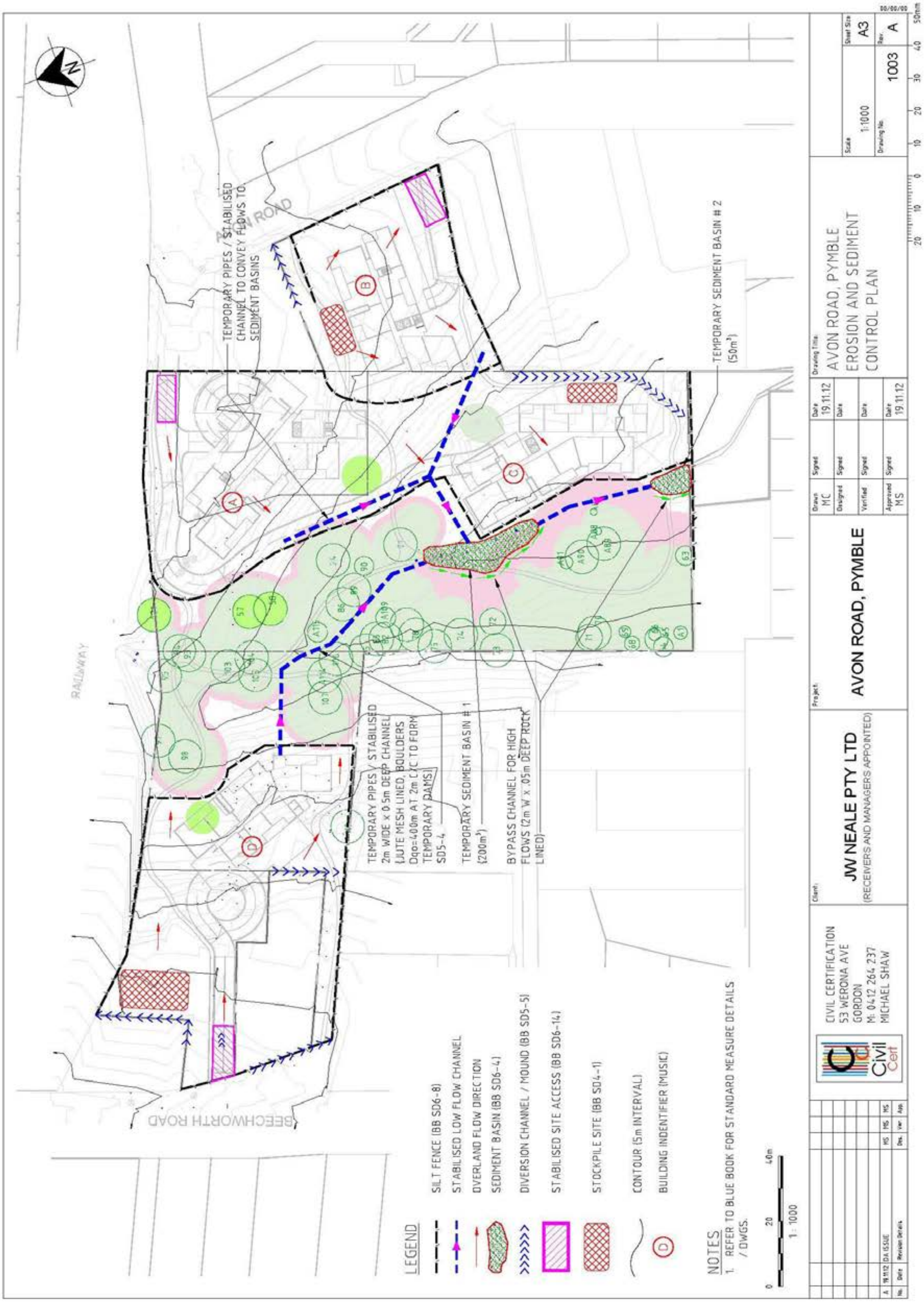

LEGEND
SILT FENCE (BB SD6-8)
STABILISED LOW FLOW CHANNEL
OVERLAND FLOW DIRECTION
SEDIMENT BASIN (BB SD6-4)
DIVERSION CHANNEL / MOUND (BB SD5-5)
STABILISED SITE ACCESS (BB SD6-14)
STOCKPILE SITE (BB SD4-1)
CONTOUR (5m INTERVAL)
BUILDING INDENTIFIER (MUSIC)
NOTES
1. REFER TO BLUE BOOK FOR STANDARD MEASURE DETAILS / DWGS.
1:1000
BEECHWORTH ROAD
RAILWAY
AVON ROAD
TEMPORARY PIPES / STABILISED CHANNEL TO CONVEY FLOWS TO SEDIMENT BASINS
TEMPORARY SEDIMENT BASIN # 2 (50m³)
TEMPORARY PIPES / STABILISED 2m WIDE x 0.5m DEEP CHANNEL (JUTE MESH LINED, BOULDERS D50=400m AT 2m C/C TO FORM TEMPORARY DAMS) SD5-4
TEMPORARY SEDIMENT BASIN # 1 (200m³)
BYPASS CHANNEL FOR HIGH FLOWS (2m W x 0.5m DEEP ROCK LINED)
CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)
AVON ROAD, PYMBLE
AVON ROAD, PYMBLE
EROSION AND SEDIMENT CONTROL PLAN
Scale 1:1000
Sheet Size A3
Drawing No. 1003
Rev. A
Drawn MC
Approved MS
19.11.12
A 19.11.12 DA ISSUE

Figure 9

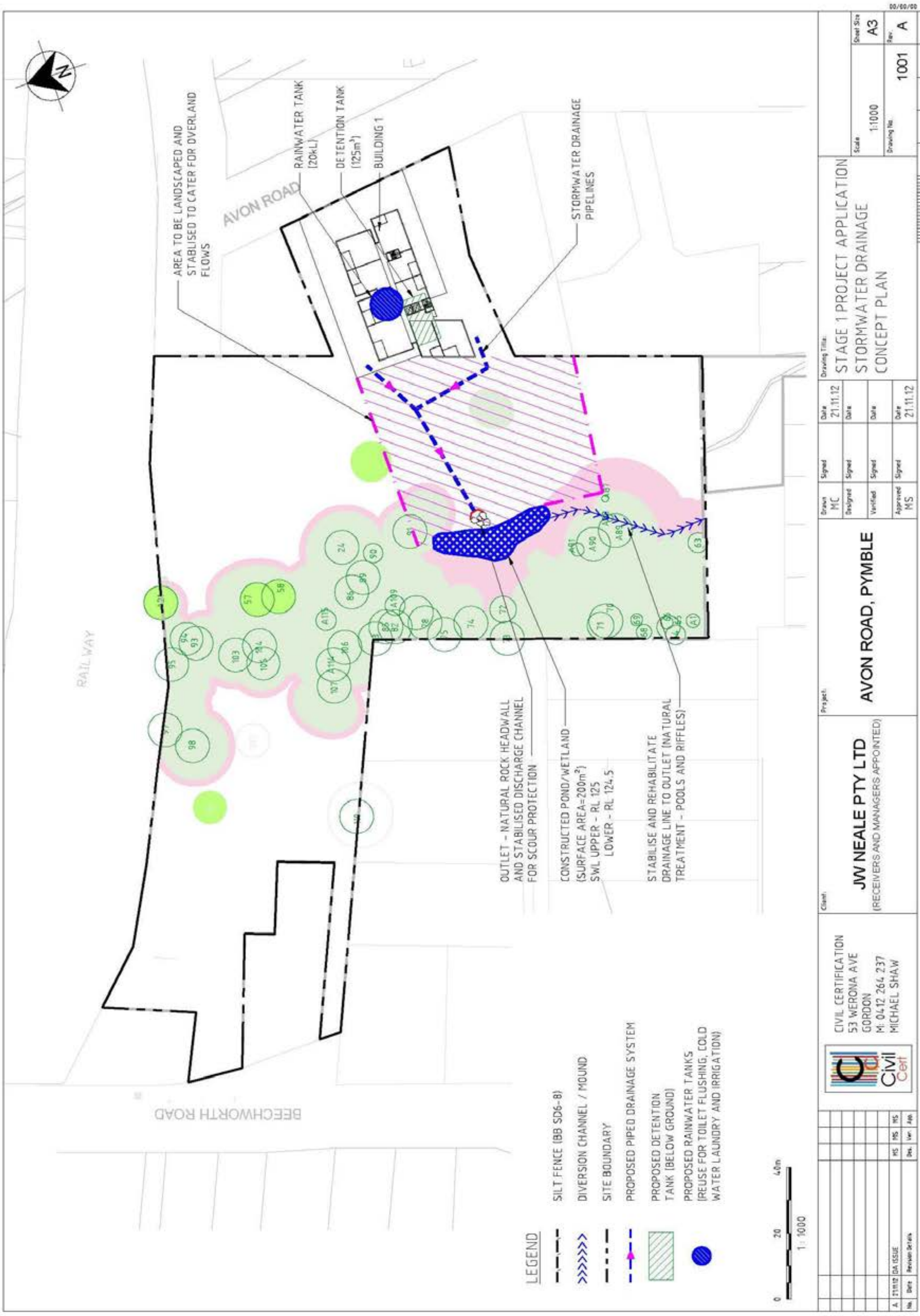
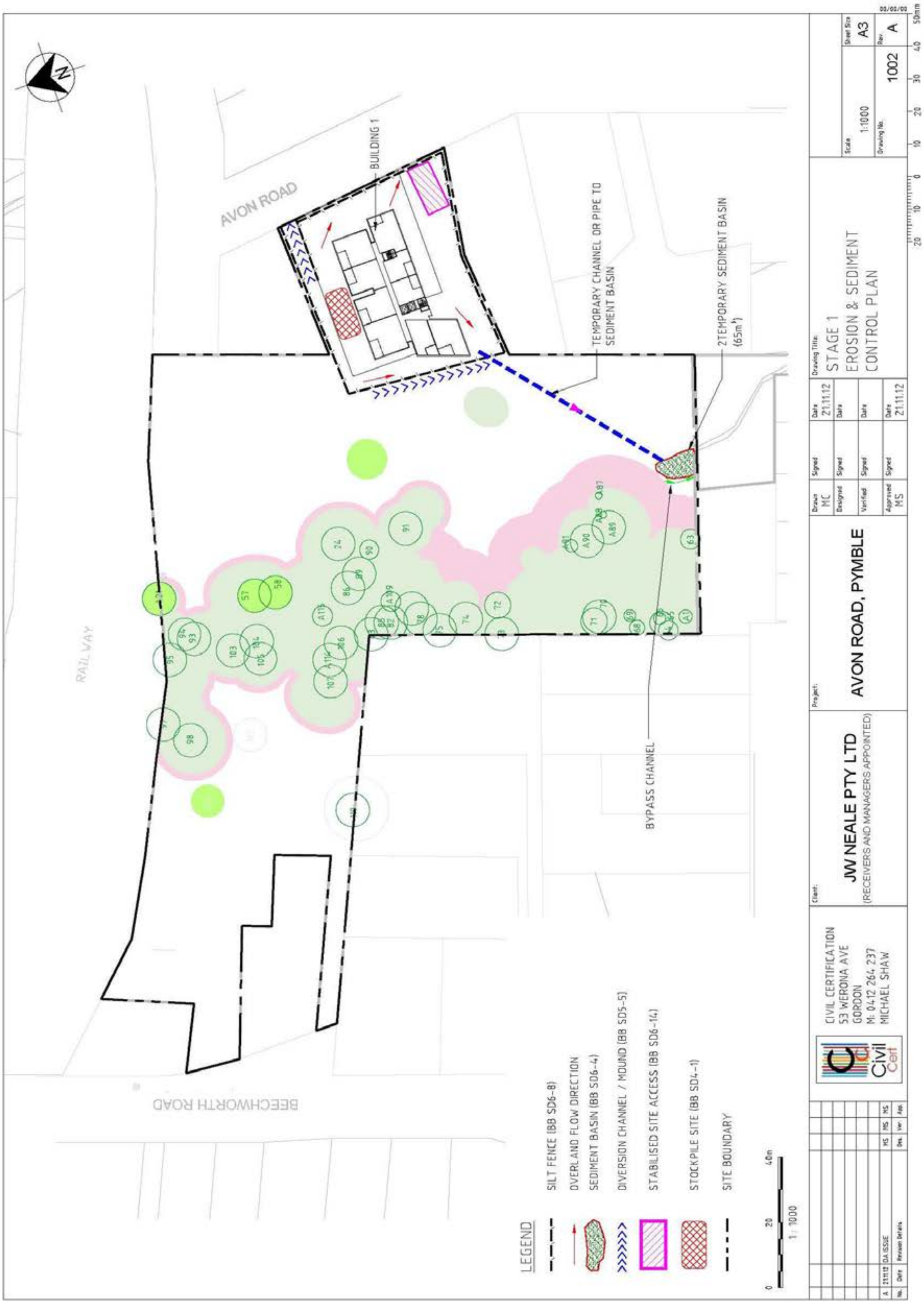

AREA TO BE LANDSCAPED AND STABILISED TO CATER FOR OVERLAND FLOWS
AVON ROAD
RAINWATER TANK (20kL)
DETENTION TANK (125m³)
BUILDING 1
STORMWATER DRAINAGE PIPELINES
RAILWAY
BEECHWORTH ROAD
OUTLET - NATURAL ROCK HEADWALL AND STABILISED DISCHARGE CHANNEL FOR SCOUR PROTECTION
CONSTRUCTED POND/WETLAND (SURFACE AREA=200m²) SWL UPPER - RL 125 LOWER - RL 124.5
STABILISE AND REHABILITATE DRAINAGE LINE TO OUTLET (NATURAL TREATMENT - POOLS AND RIFFLES)
LEGEND
SILT FENCE (BB SD6-8)
DIVERSION CHANNEL / MOUND
SITE BOUNDARY
PROPOSED PIPED DRAINAGE SYSTEM
PROPOSED DETENTION TANK (BELOW GROUND)
PROPOSED RAINWATER TANKS (REUSE FOR TOILET FLUSHING, COLD WATER LAUNDRY AND IRRIGATION)
1:1000
CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)
AVON ROAD, PYMBLE
STAGE 1 PROJECT APPLICATION
STORMWATER DRAINAGE
CONCEPT PLAN
1:1000
A3
1001
A
21.11.12
DA ISSUE

Figure 10


AVON ROAD
BUILDING 1
TEMPORARY CHANNEL OR PIPE TO SEDIMENT BASIN
2TEMPORARY SEDIMENT BASIN (65m³)
BYPASS CHANNEL
RAILWAY
BEECHWORTH ROAD
LEGEND
SILT FENCE (BB SD6-8)
OVERLAND FLOW DIRECTION
SEDIMENT BASIN (BB SD6-4)
DIVERSION CHANNEL / MOUND (BB SD5-5)
STABILISED SITE ACCESS (BB SD6-14)
STOCKPILE SITE (BB SD4-1)
SITE BOUNDARY
1:1000
CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)
AVON ROAD, PYMBLE
STAGE 1
EROSION & SEDIMENT
CONTROL PLAN
1:1000
A3
1002
A

Appendix A – CIVILCERT REPORT - CONCEPT PLAN

Civil Certification
Accredited Certifiers
Civil Engineering

53 Werona Avenue
Gordon, NSW, 2072
0412 264 237

ABN 87 532 718 229

lr095mjs-16-11-12-avon rd pymble (v2 final site wide).doc

JW Neale Pty Ltd (*Receivers and Managers Appointed*)
C/O NPC Pty Ltd
Level 4, 10 Clarke Street
Crows Nest, NSW, 2059

Friday, 16 November 2012

Attention: Mark Tooker

Dear Mark,

AVON AND BEECHWORTH RD, PYMBLE
MAJOR PROJECT APPLICATION (MP10-0219)
STORMWATER AND DRAINAGE MANAGEMENT CONCEPT PLAN

1. INTRODUCTION

Civil Certification has been engaged by NPC on behalf of JW Neale Pty Ltd (*Receivers and Managers Appointed*) to carry out a stormwater and drainage management assessment for the proposed residential development at the above site.

The aim of the report is to provide a background to existing flooding and drainage constraints at the site and to develop a conceptual stormwater and drainage management plan for the proposed major project application.

Our concept plan has been formulated to align with best practice, Ku-ring-gai Council standards and meet the additional information requirements stipulated by NSW Planning and Infrastructure in their letter dated 19/4/11 (*MP10-0219*).

The areas of stormwater management that are covered by this report are summarised as follows:

- Flooding;
- Drainage;
- Stormwater Quality;
- Erosion and Sediment Control'
- Stormwater Quantity/Detention; and
- Water Sensitive Urban Design (*WSUD*).

2. SITE

The site is located between Avon Rd and Beechworth Road, Pymble in the local government area of Ku-ring-gai. It is approximately 2.5ha in area and is currently a mix of low density residential development and open space/bushland. The developable portion of the site is estimated to be approximately 1.31ha.

The site has moderate slopes to a central valley which falls in a south west direction from approximately RL 140mAHD adjacent to the low point along the northern boundary with the railway corridor down to RL 119mAHD at the downstream low point of the site. Refer to **Appendix B** for more details of the existing levels across the site.

It is proposed that the land be redeveloped to contain four new apartment buildings served by new internal roads/driveways and all required servicing infrastructure. The open space at the centre of the site is also proposed to be enhanced by removal of existing noxious vegetation and replacement with indigenous species.

Refer to **Appendix A** for photographs of the site.

Diagram 1 shows the site and surrounding areas.

Diagram 1 – Locality Plan (*Courtesy of NearMap*)

3. RELEVANT POLICY/GUIDELINE DOCUMENTS

A summary of the relevant policy and guideline documents regarding stormwater management at the site and surrounding areas is provided below:

- "*Ku-ring-gai LEP (Local Centres) 2012"* KC, July 2012;
- "*Development Control Plan 47 2011* "KC, April, 2005;
- "Draft MUSIC Modelling Guidelines" KC, 2010;
- "*Floodplain Management Manual*" NSW Government, January 2001;
- "*ARQ*" Engineers Australia, 2006; and
- "*ARR*" Engineers Australia, 1987.

Previous reports which were generated for the site and reviewed as part of the current assessment are also provided below:

- "*Stormwater and Flood Study Report for Residential Development at Avon Road, Pymble*" MYD Consulting Engineers, 17 December, 2009; and
- "*Geotechnical Assessment for Proposed Multi Storey development – 1, 1A and 5 Avon Road and 4 & 8 Beechworth Road, Pymble*" Jeffery & Katauskaus, 19 November, 2010;

4. EXISTING DRAINAGE

The site is located in the upper reaches of a small tributary of Lane Cove River. The tributary starts at the North Shore railway line, runs through Avondale Golf Course/Rolf Park and eventually joins the Lane Cove River (*over 3km to the south west of the site*).

A minor drainage line/overland flow path currently traverses the centre of the site (*ie at the base of the valley*). But this drainage line does not sustain a permanent presence of water. At the upstream end of the site a 900mm dia. railway culvert discharges into the drainage line. At the downstream end of the site the drainage line joins a 0.75m high x 1.2m wide box culvert. Flows in excess of the downstream culvert capacity flow overland to Arilla Road.

Council classify the drainage line running through the subject site as a Category 3 riparian zone (*refer to map at **Appendix F***). It is not considered that this section of watercourse is a "*River*" as defined by the Water Management Act 2000. Nor is it considered that any development in the vicinity of the drainage line would require referral to the NSW Office of Water for a controlled activity approval.

The upstream railway culvert has good capacity, estimated to be capable of conveying the full 100yr ARI flow generated by the 4.9ha catchment draining to it. The downstream culvert is likely to be susceptible to blockage and based on its current size is estimated to have a capacity of between 5-10yr ARI (*assuming 50% blockage*). Based on this, flows are expected to overtop the culvert and run overland to Arilla via the driveway to #1 Arilla Road at an occasional frequency (*ie at least once every 5-10 years*).

The central drainage line has a moderate slope of approximately 10% draining south towards Arilla Road.

A small sub-catchment exists upstream of the site (*approximately 4.9ha*). The total catchment to the downstream end of the site has been estimated at 8.9ha.

The existing drainage connection point for the site is the central drainage line.

The existing local catchment for the site, adjoining sites and the small upstream catchment primarily consists of residential landuse and open space, with an estimated impervious fraction of approximately 65% (*average*).

5. HYDROLOGY

A preliminary RAFTS model was setup to predict the flows generated by the development, neighbouring sites and the upstream sub-catchment. A summary of the resultant peak flows at the upstream end of the site and discharge point from the site (*ie at the downstream boundary of the site*) is provided below:

Upstream end of site

- 20yr ARI Peak Q (*Ex.*) = 1.46m^3/s;
- 100yr ARI Peak Q (*Ex.*) = 2.14m^3/s;
- 100yr ARI 15% Increase in Intensity Due to CC Peak Q (Ex.) = 2.47m^3/s; and
- PMF Peak Q (*Ex.*) = 8.77m^3/s.

Downstream end of site (ie Discharge Point)

- 20yr ARI Peak Q (*Ex.*) = 2.14m^3/s;
- 100yr ARI Peak Q (*Ex.*) = 3.18m^3/s;
- 100yr ARI 15% Increase in Intensity Due to CC Peak Q (Ex.) = 3.61m^3/s; and
- PMF Peak Q (*Ex.*) = 15.24m^3/s.

The peak flows generated by RAFTS compared well with those calculated using the Rational Method and the previously reported MYD December 2009 predicted flows.

6. FLOODING

The hydraulic behaviour of the drainage line/overland flow path running along the centre of the site was assessed using the software package HEC RAS.

6.1. HEC RAS

HEC-RAS is a water surface profile program capable of analysing steady, gradually varied channel flow. Subcritical, supercritical and mixed flow water surface profile computations are possible. It is based on the industry standard Corps of Engineers HEC-2 program.

The program can account for backwater effects created by bridges, culverts, weirs and other floodplain structures. The program can be used to evaluate floodway encroachments, identify flood hazard zones manage floodplains and design and evaluate channel improvements. Water surface profiles with different discharges or initial water surface elevations can be analysed at one time.

The program allows Manning's roughness coefficients to be varied in either horizontal or vertical directions.

6.2. MODEL DESCRIPTION

A HEC RAS model was assembled for the section of the overland flow path running through the centre of the subject site. A model was constructed for both existing and proposed conditions. The model starts just downstream of the site (*Chainage 0*) and extends to the upstream site boundary (*Chainage 203*). Refer to **Figure 1** for details of the flow path alignment and cross section locations.

An illustration of the model geometry is contained in **Diagram 1**.

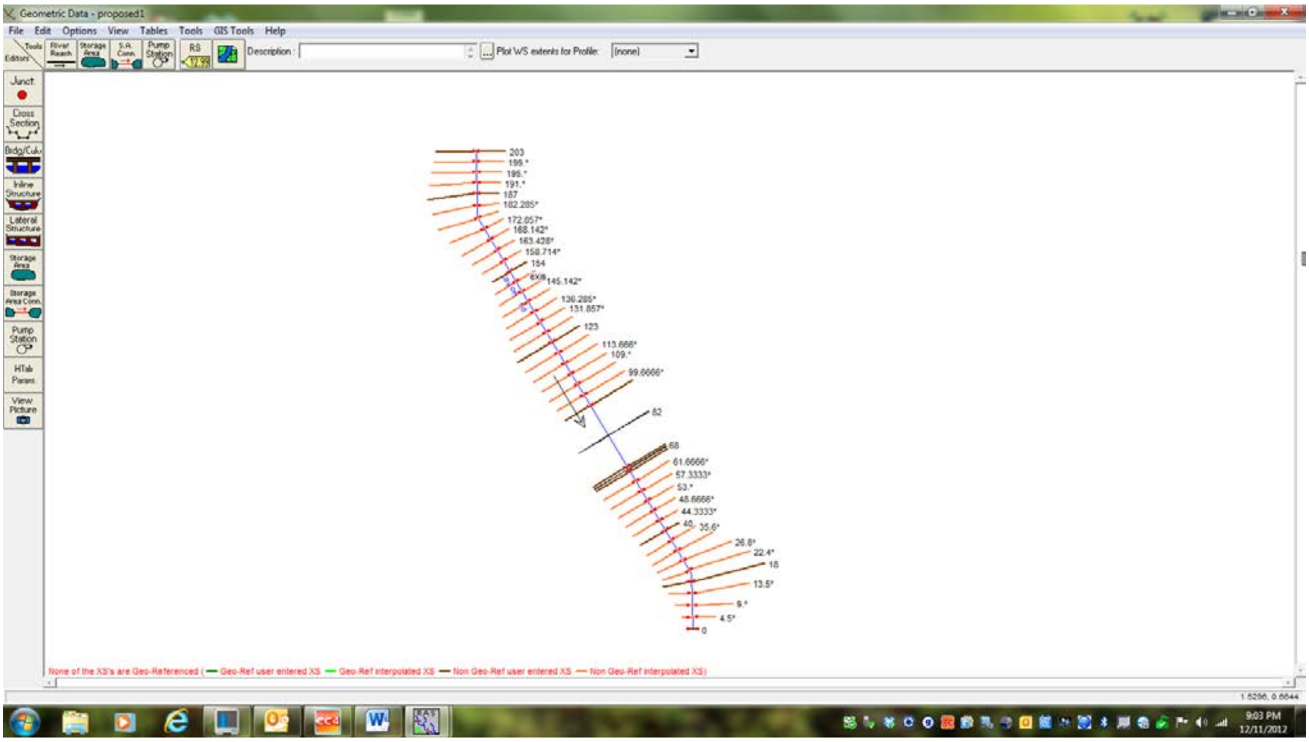


Diagram 1 – HEC RAS Model Geometry (*Proposed Conditions*)

6.3. MODELPARAMETERS

Cross Sections

Cross section data was based on the detailed survey completed for the site by Higgins Surveyors (*refer to **Appendix B***).

Steady State Flows

The steady state flows derived as part of this study (*refer to **Section 5***) were adopted for the HEC RAS modelling.

It has been assumed that flows under proposed conditions would be maintained at existing levels (ie *due to implementation of the proposed detention measures*).

The presence of the box culvert at the downstream end of the site was incorporated in the model by subtracting its capacity from the total flow at this location.

The overland flow path downstream of the site (*ie driveway of No. 1 Arilla Rd*) was replicated by implementation of a typical 4m wide bitumen driveway. It must be noted that the culvert/driveway combination located downstream of the site is sufficiently lower than the subject site to have any significant control on flooding within the proposed development site.

Boundary Conditions

Normal depth was set for the upstream boundary conditions at a slope of 0.001, whilst critical depth was utilised as the downstream boundary condition.

Roughness Co-Efficient's

Roughness co-efficient's were estimated based on visual inspection and the anticipated ultimate conditions.

The adopted Manning's n value for the main channel and overbank were generally set at 0.07 and 0.09 respectively.

Bridges/Weirs/Obstructions

No bridges or weirs were utilised in the existing condition model

Two weirs were implemented in the proposed condition model to represent the weirs to be incorporated as part of the proposed online wetland/pond works.

Flow obstructions were incorporated within the model to represent any proposed buildings/encroachments to the floodway.

6.4 MODEL RESULTS

Full details of all the HEC RAS modelling results are included at **Appendix G**.

The modelling demonstrates that the 100 year ARI flood extent under proposed conditions is fully contained within the central open space and is well below the required 500mm freeboard to habitable ground floor levels/basement entries for all proposed buildings.

The lowest proposed building ground floor level on the site has also been shown to be above both the 100yr ARI event incorporating a 15% increase in rainfall intensity (*ie to represent a possible future climate change scenario*) as well as the PMF.

100yr ARI flooding under proposed conditions does not impact on any adjoining properties.

7. FLOOD EMERGENCY/EVACUATION

As the proposed habitable dwellings are all set at an appropriate flood planning level (*ie greater than 500mm above the central 100yr ARI overland flow path*) and in fact are also above the PMF level no special flood emergency/evacuation measures would be required.

8. STORMWATER QUALITY/WSUD

As part of the development of the site, implementation of best practice stormwater treatment measures will be required to minimise any detrimental impact on water quality.

This will involve implementation of both short term controls during the construction phase and long term controls as part of the ultimate development.

8.1. CONSTRUCTION PHASE

Prior to executing the construction phase of the development, a detailed erosion and sediment control plan would be developed for the site in accordance with Ku-ring-gai Councils guidelines and the NSW Blue Book (*NSW DECC publication titled "Managing Urban Stormwater – Soils and Construction" January 2008*).

The erosion and sediment control plan will outline the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction (*ie primarily as a result of erosion*).

A summary of the principal elements of a preferred erosion and sediment control plan for the site is summarised below:

- Minimising the extent of disturbed surfaces at any one time (*i.e. staging of earthworks etc*);
- Stabilising disturbed surfaces immediately upon completion of works (*i.e. hydromulch or vegetation*);
- Diverting clean runoff around disturbed work areas (*i.e. using earth bunds/diversion mounds/channels*);
- Protecting stockpiles (*i.e. using silt fence, diversion bunds, temporary vegetative cover etc*);
- Implementation of dust control/suppression measures during works(*i.e. perimeter fencing, wind velocity monitoring, cessation of earthworks activities during high wind conditions, watering down disturbed areas, setup of recycled water irrigation sprays etc*);
- Use of sediment basins;
- Use of silt fencing downslope of disturbed surfaces;

- Use of silt socks or equivalent around existing drainage structures;
- Use of rock /haybale/mulch check dams along designated overland flow paths;
- Protection of exposed slopes;
- Restriction of vehicle entry/exit points to construction zones;
- Setup of stabilised site access points; and
- Setup of vehicle washdown/wheel wash baths at exit points of disturbed areas.

An illustration of the conceptual erosion and sediment control plan for the site is contained in **Figure 3.** Sediment basin sizing calculations are included at **Appendix I**.

8.2. OPERATIONAL PHASE

As part of the ultimate development proposal a number of Water Sensitive Urban Design (*WSUD*) measures are proposed as follows:

- Lot based rainwater reuse/recycling systems (*min 20KL tank per apartment block with water being reused for toilet flushing, cold water laundry and garden irrigation*);
- Litter baskets installed in all pits within the new internal roads/driveways (*ie Ecosol RSF100 or equivalent*);l
- A below ground GPT at the main discharge point into drainage line (*east side*);
- An online constructed wetland/pond;
- Minimisation of impervious surfaces; and
- Use of water efficient fixtures for each new dwelling.

These measures will control urban generated pollutants at the source and minimise the export of suspended solids, nutrients and litter from the site.

The software package developed by the CRC for Catchment Hydrology termed "MUSIC" (*Model for Urban Stormwater Improvement Conceptualisation*) was used to assess the effectiveness of the proposed "*treatment train*".

Details of the MUSIC modelling exercise (*including results*) are included at **Appendix D** and summarised in the following sections.

8.2.1 TREATMENT TARGETS

The treatment targets as recommended by DECCW, SWC and Ku-ring-gai Council will be adopted for the proposed development. These targets presented in **Table 1**

Table 1 – Treatment Targets (*DECCW, SWC and Council*)

	WATER QUALITY % reduction in pollutant load			
	Gross Pollutants GP (> 5mm)	Total suspended solids (TSS)	Total Phosphorus (TP)	Total Nitrogen (TN)
Treatment Targets	90	80	60	45

8.2.2 MUSIC

To ensure the objectives outlined in **Section 8.2.2** can be achieved, a MUSIC model has been established for the proposed development.

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. It is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

MUSIC was chosen for this investigation because it has the following attributes:

- It can account for the temporal variation in storm rainfall throughout the year;
- Modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- It can model a range of treatment devices;
- It can be used to estimate pollutant loads at any location within the catchment; and
- It is based on logical and accepted algorithms.

Where appropriate we have utilised the recommendations of Ku-ring-gai Councils 2010 MUSIC modelling guidelines in compiling the MUSIC model for the subject site.

Rainfall

Rainfall data adopted in the MUSIC modelling exercise was sourced from the Bureau of Meteorology (*BOM*). A rainfall range over a number of years (*1996 to 1999 inclusive*) was selected to exceed the annual average for the region. In addition, a mix of dry, average and wet years was included in the selected range.

Evaporation

Monthly areal Potential Evapotranspiration values were obtained for the site from the 'Climate Atlas of Australia, Evapotranspiration' (*Bureau of Meteorology, 2001*) and are shown in **Table 2**.

Table 2 – Adopted Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	170
February	145
March	130
April	80
May	61
June	45
July	45
August	60
September	90
October	130
November	151
December	165

Sub Catchment Areas

The total site was broken into a number of sub catchments in accordance with the proposed development layout and proposed treatment measure locations. Details of the sub catchment area characteristics are provided in **Table 3**.

Both the net developable area and resulting impervious fractions were conservatively set higher than the expected values for this early assessment (*ie to yield a conservative result*). The actual developable area and impervious fraction within these developable areas is expected to be around 1.3ha and 65% respectively.

Table 3 – Sub catchment Characteristics

Sub catchment Name	Area (m^2)	% Impervious
Building D Roof	900	100
Building D Non Roof	3,700	75
Building A Roof	1,100	100
Building A Non Roof	2,650	75
Building B Roof	800	100
Building B Non Roof	2,950	75
Building C Roof	1,100	100
Building C Non Roof	1,600	75
TOTAL Developable Area (Net)	**14,800**	**81.5%**
Upper Forest	5,000	0
Lower Forest	5,000	0
TOTAL Site (Gross)	**24,700**	**49%av**

Soil Data / Characteristics

For this study the MUSIC soil properties as stipulated in Ku-ring-gai's 2010 MUSIC guidelines have been adopted. This data is summarised in **Table 4.**

Table 4 – Adopted Soil Data

	Units	Post Development	Pre Development
Impervious area parameters			
Rainfall threshold	mm/day	1.5	1.5
Pervious area parameters			
Soil storage capacity	mm	300	300
Initial storage	% of capacity	20	20
Field capacity	mm	172	172
Infiltration capacity coefficient – a		200	200
Infiltration capacity coefficient – b		1	1
Groundwater properties			
Initial depth	mm	1	1
Daily recharge rate	%	25	25
Daily base flow rate	%	5	5
Daily deep seepage rate	%	4	4

EMC Values

The EMC values as stipulated in Ku-ring-gai's 2010 MUSIC guidelines have been adopted (*refer to **Table 5***).

Table 5 – EMC Values

	Storm Flow						**Base Flow**					
	TSS		**TP**		**TN**		**TSS**		**TP**		**TN**	
	Mn	**SD**	**Mn**	**SD**	**Mn**	**SD**	**Mn**	**SD**	**Mn**	**SD**	**Mn**	**SD**
Land use	*(all values expressed as log_{10} mg/l)*											
General urban	2.20	0.32	-0.45	0.25	0.42	0.19	1.10	0.17	-0.82	0.19	0.32	0.12
Roof	1.55	0.39	-0.92	0.29	0.42	0.19	1.10	0.17	-0.82	0.19	0.32	0.12
Forest /Natural	1.90	0.20	-1.10	0.22	-0.075	0.24	0.9	0.13	-1.50	0.13	-0.14	0.13

8.2.3 PROPOSED TREATMENT TRAIN

An illustration of the MUSIC network constructed to represent the site under developed conditions is contained at **Diagram 2**. The treatment train consists of rainwater tanks collecting roof runoff for reuse, GPTs/Litter Baskets and a constructed wetland.

Further details of the individual components of the proposed treatment system are provided below.

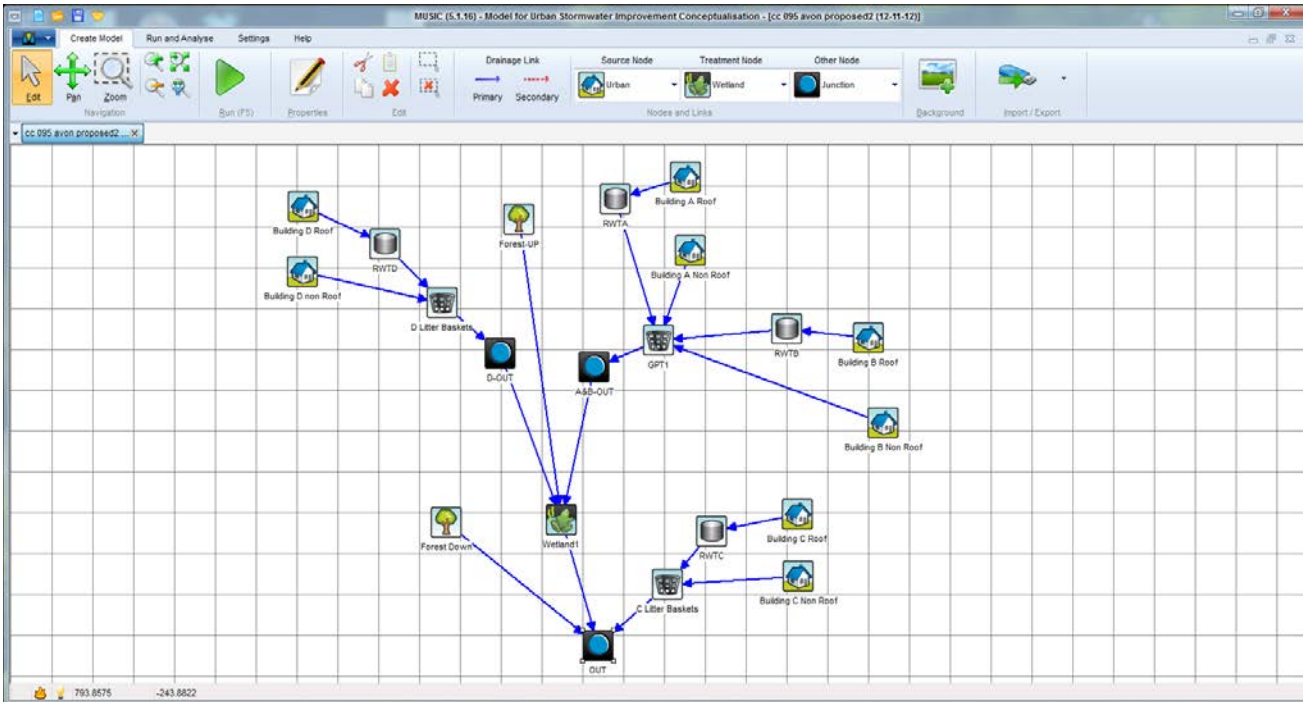


Diagram 2 - Post Development MUSIC Network Diagram

Rainwater Tanks

Rainwater tanks indirectly reduce pollutant load by collecting and storing rainwater for reuse in non-potable applications. If the annual volume of water discharged from the site is reduced then in theory the annual pollutant load carried by this water is also reduced. Rainwater tanks also assist in the reduction of potable water demand. For this site we have assumed adoption of a 20KL storage volume and a reuse rate of 4KL/day per building (*Total volume for site 80KL*). Water collected from the building roofs will be reused internally for toilet flushing, cold water laundry, car washing and garden irrigation.

Gross Pollutant Traps (*GPT's*) and Litter Baskets

Gross Pollutant Traps (GPT's) and litter baskets are a form of primary stormwater treatment designed to capture litter, debris and coarse sediment.

A below ground GPT is proposed to be constructed at the main discharge point from the eastern part of the site into the central drainage line. For ease of maintenance the GPT will be constructed at the same level as the internal driveway Based on the size of the total sub catchment draining to this line the GPT will be a Rocla CL900 or equivalent treating a minimum of the 3 month ARI peak flow (*approx. 90% of the annual flow volume*).

The inlet pits serving the remainder of the site will be fitted with litter baskets (similar to GPTs but on a smaller scale and close to the source), as convenient and accessible maintenance points are not available near the main drainage outlets serving these areas. The proposed litter baskets will be Ecosol RSF 100 or equivalent.

While the pollutant capture efficiency of various traps may vary from model to model, the following generic capture rates have been adopted as a reasonable middle ground for this study:

- Gross pollutants majority (95%);
- Total suspended sediments up to 80%;
- Total phosphorous up to 30%; and
- Total nitrogen 13%.

Constructed Wetland

Constructed wetlands are water bodies with a deep central zone and shallow edge zones with fringing macrophyte vegetation. The primary treatment mechanisms are detention/settling, take up of nutrients by plants, filtering treatment and other biological and chemical process. They are a demonstrated natural treatment system.

For this site an online wetland is proposed to be constructed in the lower reaches of the site, where the drainage line transitions to a gentler grade (*ie adjacent to the old tennis courts*). A large open/flat area currently exists at the proposed wetland location, which appears to have previously contained a small waterbody.

The wetland will be divided into two zones by a central weir. The upper pond will have a Stillwater level of RL125.0mAHD and lower pond RL124.5mAHD. Both ponds will be contained by weirs. These weirs will allow for an extended detention depth of 0.2m. Above this level water will overtop and continue downstream. Note that the ground floor level of the nearest building is RL126.0mAHD (*ie 1.0m above the highest weir level*).

The proposed wetland properties are summarised below in **Table 6**

Table 6 – Wetland Properties

	Wetland #1
Inlet Pond Volume (m3)	10
Extended Detention Depth	0.2
Surface Area (m^2)	200
Perm. Pool Volume (m3)	200
Seepage Loss (mm/hr)	4
Equiv. Outlet pipe dia. (mm)	50

	Wetland #1
Overflow Weir Width (m)	2
Notional Detention Time (hrs)	4.27

8.2.4 MUSIC MODELLING RESULTS

The post development MUSIC modelling results are summarised in **Table 7**.

The results illustrate the following:

- Implementation of WSUD features as proposed readily allows achievement of the stated treatment targets; and
- Proposed roof water capture and reuse provides a substantial effect on reducing the quantity of flows discharging from the site (*Total annual flow reduced by up to 35%).*

Table 7 – MUSIC MODELLING RESULTS

Music model	**Location**	**Annual Flow and Pollutant Load Results**				
		Flow	**TSS**	**TP**	**TN**	**GP**
		(ML/yr)	**(kg/yr)**	**(kg/yr)**	**(kg/yr)**	**(kg/yr)**
Developed (With Treatment)						
	All Source Nodes	19.0	2,820	5.65	48.2	386
	Residual Load at Outlet	12.3	479	2.18	23.7	4.03
% Treat Train Effectiveness		**35.5**	**83.0**	**61.4**	**50.8**	**99.0**
Achieve Objectives			>80%	>60%	>45%	>90%
			Yes	Yes	Yes	Yes

8.2.5 MAINTENANCE OF TREATMENT MEASURES

To maintain effectiveness, a maintenance regime would be implemented for all proposed treatment measures. Maintenance would be the responsibility of the community. This would typically consist of the following:

- Periodic (*6 monthly*) inspection and removal of any gross pollutants & coarse sediment that is deposited in the wetland and replacement of vegetation as necessary;
- Periodic (*3 monthly*) and episodic (*post storm greater than 1 yr ARI*) inspection and if required removal of trapped pollutants from all GPTs/litter baskets; and
- Periodic (*annually)* inspection (*and flushing if required*) of the rainwater tanks.

9. STORMWATER QUANTITY/DETENTION

As the development will result in an increase in impervious fraction compared to existing conditions, stormwater detention is proposed to mitigate any increase in flows.

Ku-ring-gai Councils DCP47 stipulates a detention rate for the subject site as follows:

- Catchment AC1 (refer to Map at **Appendix E**) ;
- PSD – 102L/s/ha
- SSR - 398m^3/ha.

Based on the developable area for the site (*ie 1.3ha*) this translates to a permitted site discharge (PSD) of 132.6L/s and a total detention storage of 517.4m^3.

It is proposed that each of the four proposed building complexes will include a 125m3 below ground detention tank to temporarily detain site generated flows. These tanks are likely to be constructed within the basement areas of each building. The total detention volume provided by these measures equals 500m3.

The remaining detention will be provided within the sites rainwater tanks. Large rainwater tanks as proposed (*ie 20KL*), particularly those with high reuse rates, have been shown to have an effective detention component of up to 50% of the total storage volume. For this site we are assuming a modest 25% effective detention rate, yielding a total detention volume of 20m^3.

The proposed total detention volume of 520m^3 exceeds the minimum required by Councils DCP.

Preliminary RAFTS modellings shows that this volume combined with the allowable PSD will reduce site discharges below existing conditions, leading to a reduction in total peak flows experienced downstream of the site.

10. STORMWATER DRAINAGE CONCEPT PLAN (SDCP)

Detailed design of the major/minor drainage system within the site would ensure 20yr ARI flows are fully contained within the internal piped drainage system and localised 100yr ARI flooding will be confined to the roadways /driveways/pathways/designated overland flow paths.

Minor flows generated by the developable areas of the site (ie *driveways, landscaped areas, rainwater tank overflow etc*) would be conveyed in internal pipelines which would ultimately discharge to the central drainage line. All new lines would be accompanied by sufficient inlet pits.

All outlets into the central drainage line would be constructed of natural rock and contain energy dissipation/outlet stabilisation.

The existing drainage line running through the centre of the site is proposed to be enhanced by construction of a dry rocky creek bed. This will not only stabilise the drainage line but provide habitat and treatment. Pools and riffles will be constructed along the drainage line to further enhance these functions.

Refer to **Figure 2** for an illustration of the proposed stormwater drainage concept plan.

11. PRELIMINARY CIVIL DESIGN

A preliminary civil design has been developed to address concerns related to possible batters extending into the central open space of the site.

An illustration of this design is contained in **Figure 4**.

It is proposed that the bulk of the level differences across the site will be taken up by construction of retaining walls. This will mean that virtually no batters will encroach into the central open space areas of the site.

Most retaining walls are required downslope of the proposed building's, however a retaining wall will also be required downslope of the proposed driveway/internal road leading to the lower building.

12. CONCLUSIONS

The following conclusions have been derived from this water management assessment:

- 100yr ARI and PMF flooding does not currently inundate the proposed building locations;
- The proposed development will manage water quality by implementing best practice WSUD treatment facilities. The treatment rates achieved align with best practice and Councils minimum requirements *;*
- On Site detention is proposed in accordance with Councils requirements to mitigate any increase in flows generated by the development. Preliminary modelling has shown that peak flows experienced downstream of the site will be reduced;
- New site drainage will be implemented to prevent nuisance flooding and protect the central drainage line;
- The use of extensive retaining systems to take up levels differences across the site will mean that no batters will encroach into the central open space of the site.

13. QUALIFIERS

This report has been prepared by Mr Michael John Shaw. A copy of Michael's CV is included at **Appendix G**.

This report has been prepared for the benefit of JW Neale Pty Ltd (*Receivers and Managers Appointed*) with relation to the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Civil Certification. In preparing this report I have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended.

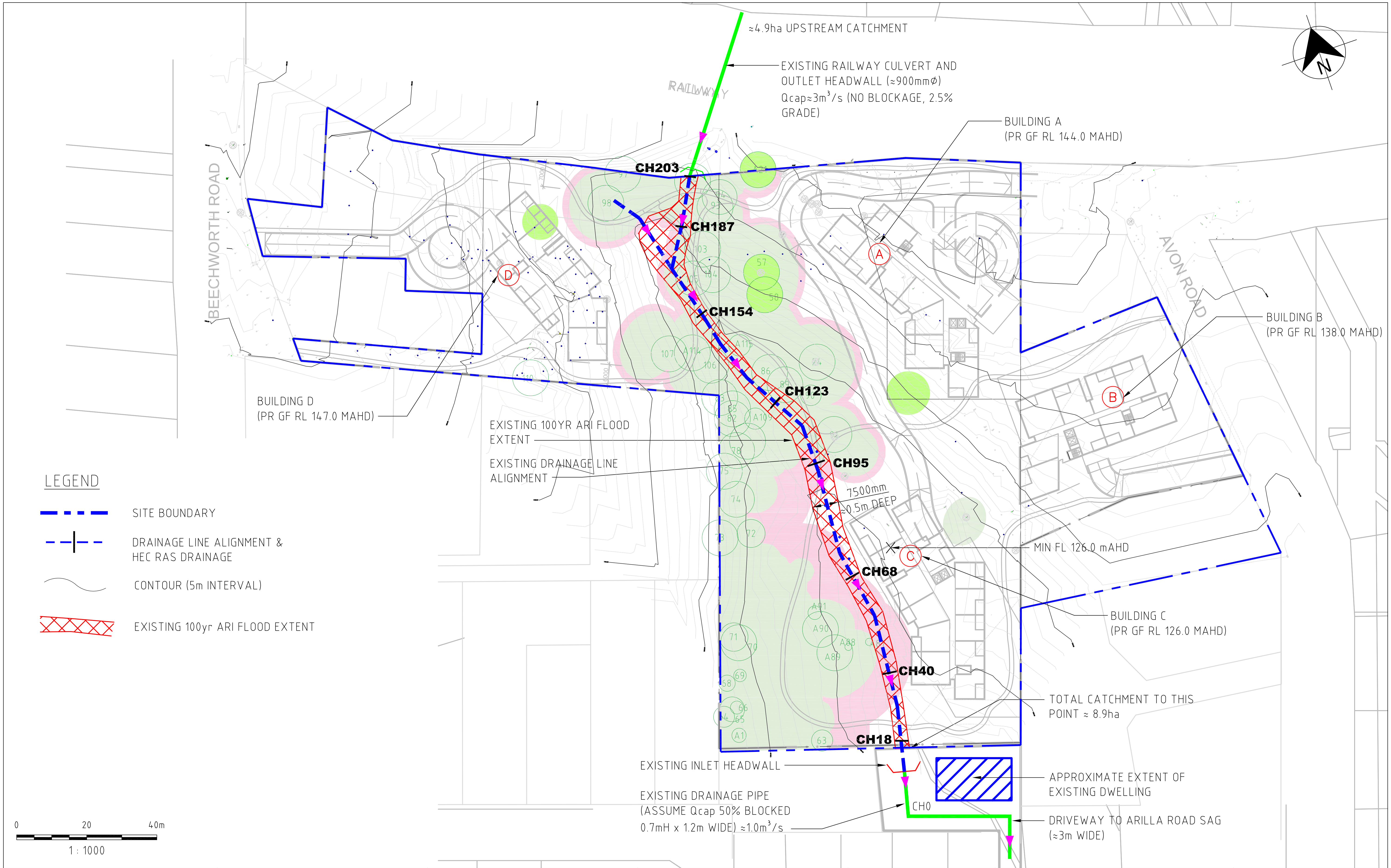
We trust this report is satisfactory. Should you have any further queries, please do not hesitate to contact me on 0412 264 237.

Yours faithfully

CIVIL CERTIFICATION

Michael Shaw
BE(Civil) MIEAust CPEng NPER(Civil)
Accredited Certifier (BPB 0816)
Principal
0412 264 237
michael.shaw@civilcertification.com

FIGURES



Rev.	Date	Revision Details	Des.	Ver.	App.
A	19.11.12	DA ISSUE	MS	MS	MS

Civil Cert

CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW

Client:
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)

Project:
AVON ROAD, PYMBLE

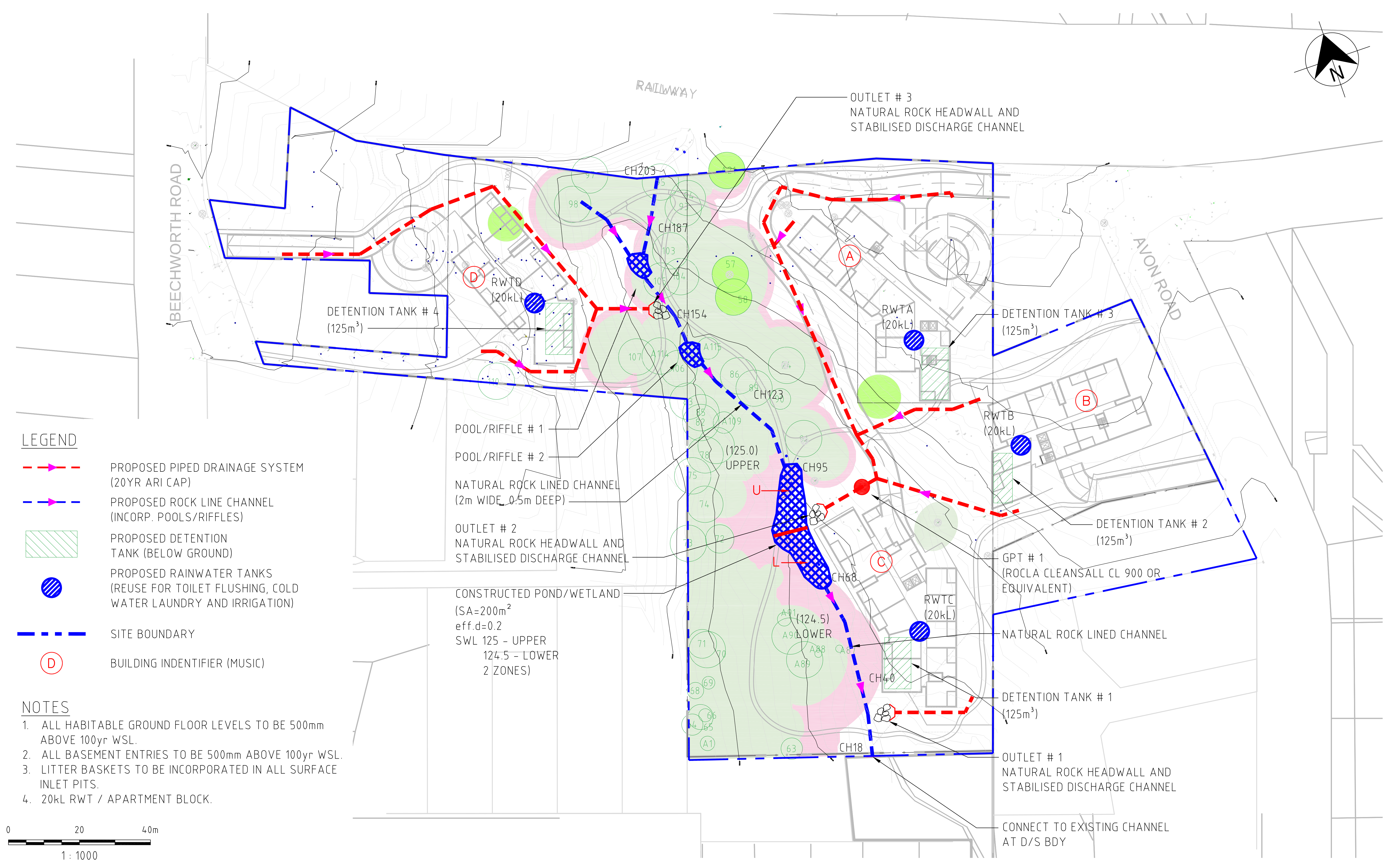
	Signed	Date
Drawn MC	Signed	19.11.12
Designed	Signed	Date
Verified	Signed	Date
Approved MS	Signed	19.11.12

Drawing Title:
AVON ROAD, PYMBLE
HEC RAS MODEL
EXISTING 100yr ARI FLOOD EXTENT

FIGURE 1

Scale 1:1000
Sheet Size A3
Drawing No. 1001
Rev. A

20 10 0 10 20 30 40 50mm



LEGEND

- PROPOSED PIPED DRAINAGE SYSTEM (20YR ARI CAP)
- PROPOSED ROCK LINE CHANNEL (INCORP. POOLS/RIFFLES)
- PROPOSED DETENTION TANK (BELOW GROUND)
- PROPOSED RAINWATER TANKS (REUSE FOR TOILET FLUSHING, COLD WATER LAUNDRY AND IRRIGATION)
- SITE BOUNDARY
- (D) BUILDING INDENTIFIER (MUSIC)

NOTES

1. ALL HABITABLE GROUND FLOOR LEVELS TO BE 500mm ABOVE 100yr WSL.
2. ALL BASEMENT ENTRIES TO BE 500mm ABOVE 100yr WSL.
3. LITTER BASKETS TO BE INCORPORATED IN ALL SURFACE INLET PITS.
4. 20kL RWT / APARTMENT BLOCK.

0 20 40m

1 : 1000

No.	Date	Revision Details	Des.	Ver.	App.
A	19.11.12	DA ISSUE	MS	MS	MS

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AVON ROAD, PYMBLE

Drawn MC	Signed	Date 19.11.12
Designed	Signed	Date
Verified	Signed	Date
Approved MS	Signed	Date 19.11.12

Drawing Title:
AVON ROAD, PYMBLE
PROPOSED STORMWATER
DRAINAGE CONCEPT PLAN
(SDCP)

FIGURE 2

Scale 1:1000 | Sheet Size A3

Drawing No. 1002 | Rev. A

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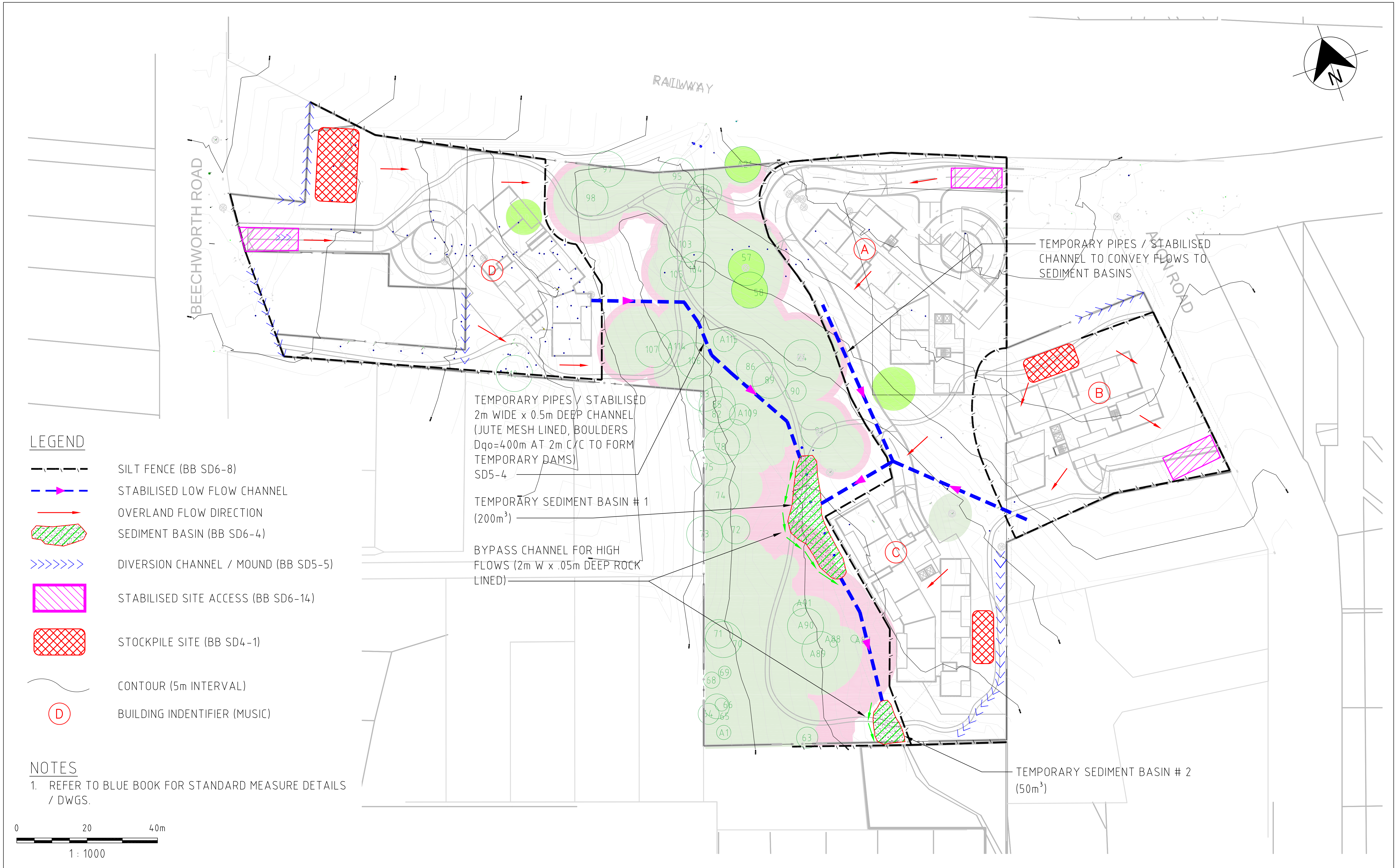

No.	Date	Revision Details	Des.	Ver.	App.
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GORDON
M: 0412 264 237
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Project:
AVON ROAD, PYMBLE

	Signed	Date
Drawn MC		19.11.12
Designed		
Verified		
Approved MS		19.11.12

Drawing Title:
AVON ROAD, PYMBLE
EROSION AND SEDIMENT CONTROL PLAN

FIGURE 3

Scale 1:1000
Sheet Size A3
Drawing No. 1003
Rev. A

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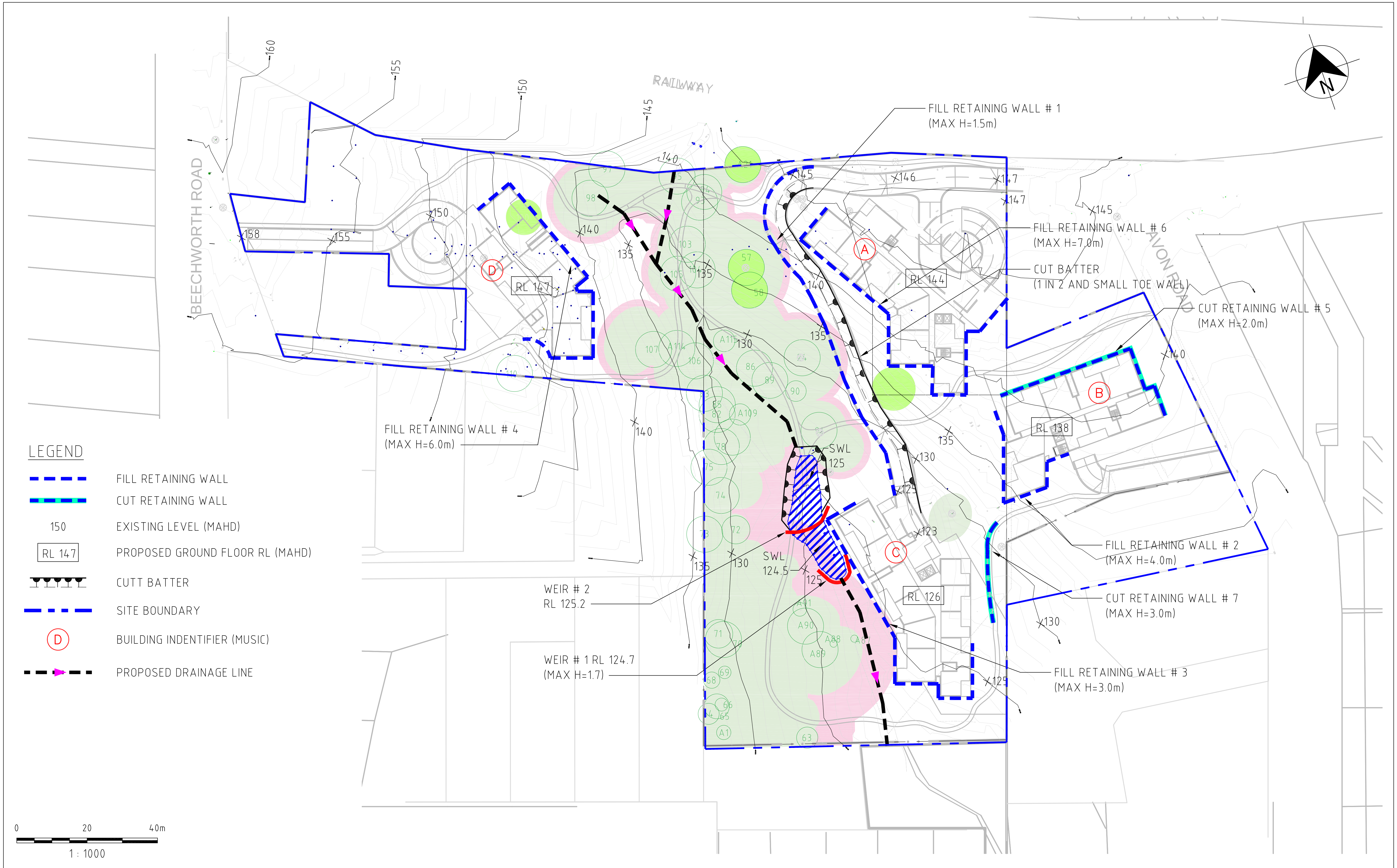

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Drawn MC	Signed	Date 19.11.12
Designed	Signed	Date
Verified	Signed	Date
Approved MS	Signed	Date 19.11.12

Drawing Title:
AVON ROAD, PYMBLE
CONCEPT CIVIL DESIGN

FIGURE 4

Scale 1:1000	Sheet Size A3
Drawing No. 1004	Rev. A

20 10 0 10 20 30 40 50mm

APPENDIX A (Photos)

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

Plate 6

Plate 7

Plate 8


Plate 9


Plate 10


Plate 11


Plate 12


Plate 13


Plate 14


Plate 15


Plate 16


Plate 17


Plate 18


Plate 19


Plate 20


Plate 21


Plate 22


Plate 23


Plate 24


Plate 25

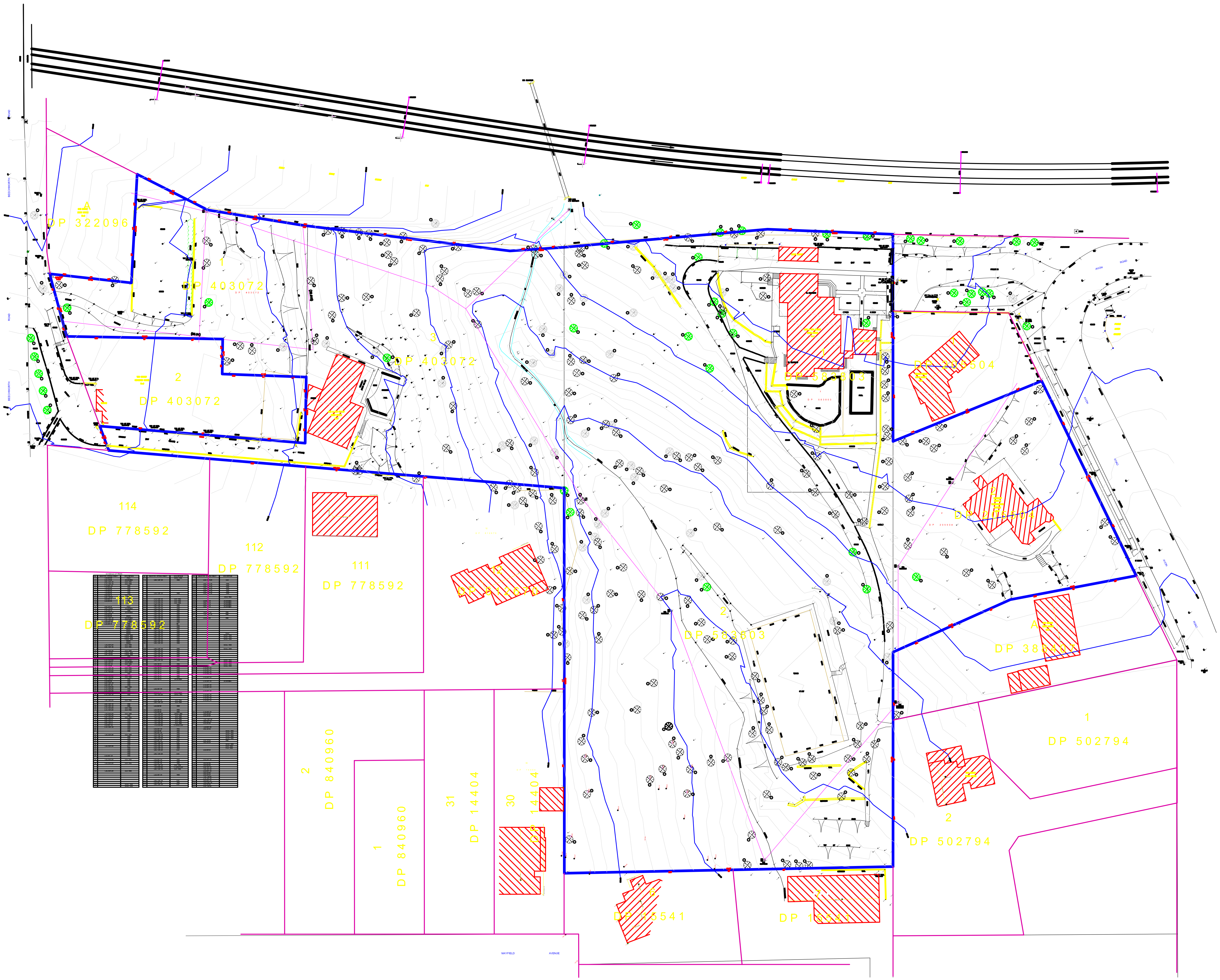

Plate 26


Plate 27


Plate 28


Plate 29

APPENDIX B (Survey Plan)



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1
DP 403072
2
DP 403072
114
DP 778592
112
DP 778592
111
DP 778592
2
DP 840960
1
DP 840960
31
DP 14404
30
1
DP 502794
2
DP 502794

APPENDIX C (Proposed Subdivision Layout)


RAILWAY
BEECHWORTH ROAD
AVON ROAD
RL 147
RL 144
RL 138
RL 126

APPENDIX D (*MUSIC*)

Source nodes

Location,Building D non Roof,Building D Roof,Building A Non Roof,Building A Roof,Building B Roof,Building B Non Roof,Building C Roof,Building C Non Roof,Forest-UP,Forest Down
ID,1,2,5,6,10,12,14,15,19,20
Node Type,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,ForestSourceNode,ForestSourceNode
Total Area (ha),0.37,0.09,0.265,0.11,0.08,0.295,0.11,0.16,0.5,0.5
Area Impervious (ha),0.278101730103806,0.09,0.198254844290657,0.11,0.08,0.220698788927336,0.109204498269896,0.120260207612457,0,0
Area Pervious (ha),0.0918982698961938,0,0.0667451557093426,0,0,0.0743012110726643,0.000795501730103829,0.0397397923875433,0.5,0.5
Field Capacity (mm),172,50,172,50,50,172,50,172,172,172
Pervious Area Infiltration Capacity coefficient - a,200,50,200,50,50,200,50,200,200,200
Pervious Area Infiltration Capacity exponent - b,1,2,1,2,2,1,2,1,1,1
Impervious Area Rainfall Threshold (mm/day),1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5
Pervious Area Soil Storage Capacity (mm),300,150,300,150,150,300,150,300,300,300
Pervious Area Soil Initial Storage (% of Capacity),20,25,20,25,25,20,25,20,20,20
Groundwater Initial Depth (mm),1,50,1,50,50,1,50,1,1,1
Groundwater Daily Recharge Rate (%),0.25,0.65,0.25,0.65,0.65,0.25,0.65,0.25,0.25,0.25
Groundwater Daily Baseflow Rate (%),0.05,0.85,0.05,0.85,0.85,0.05,0.85,0.05,0.05,0.05
Groundwater Daily Deep Seepage Rate (%),0.04,0,0.04,0,0,0.04,0,0.04,0.04,0.04
Stormflow Total Suspended Solids Mean (log mg/L),2.2,1.55,2.2,1.55,1.55,2.2,1.55,2.2,1.9,1.9
Stormflow Total Suspended Solids Standard Deviation (log mg/L),0.32,0.39,0.32,0.39,0.39,0.32,0.39,0.32,0.2,0.2
Stormflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0,0
Stormflow Total Phosphorus Mean (log mg/L),-0.45,-0.92,-0.45,-0.92,-0.92,-0.45,-0.92,-0.45,-1.1,-1.1
Stormflow Total Phosphorus Standard Deviation (log mg/L),0.25,0.29,0.25,0.29,0.29,0.25,0.29,0.25,0.22,0.22
Stormflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0,0
Stormflow Total Nitrogen Mean (log mg/L),0.42,0.42,0.42,0.42,0.42,0.42,0.42,0.42,-0.075,-0.075
Stormflow Total Nitrogen Standard Deviation (log mg/L),0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.24,0.24
Stormflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0,0
Baseflow Total Suspended Solids Mean (log mg/L),1.1,1.1,1.1,1.1,1.1,1.1,1.1,1.1,0.9,0.9
Baseflow Total Suspended Solids Standard Deviation (log mg/L),0.17,0.17,0.17,0.17,0.17,0.17,0.17,0.17,0.13,0.13
Baseflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0,0
Baseflow Total Phosphorus Mean (log mg/L),-0.82,-0.82,-0.82,-0.82,-0.82,-0.82,-0.82,-0.82,-1.5,-1.5
Baseflow Total Phosphorus Standard Deviation (log mg/L),0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.13,0.13
Baseflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0,0
Baseflow Total Nitrogen Mean (log mg/L),0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,-0.14,-0.14
Baseflow Total Nitrogen Standard Deviation (log mg/L),0.12,0.12,0.12,0.12,0.12,0.12,0.12,0.12,0.13,0.13
Baseflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0,0
OUT - Mean Annual Flow (ML/yr),3.70,1.10,2.65,1.34,0.978,2.95,1.34,1.60,1.68,1.68
OUT - TSS Mean Annual Load (kg/yr),762,58.0,528,70.4,52.9,623,71.0,333,148,153
OUT - TP Mean Annual Load (kg/yr),1.50,0.164,1.11,0.195,0.145,1.26,0.196,0.666,0.152,0.143
OUT - TN Mean Annual Load (kg/yr),10.8,3.18,7.57,3.90,2.87,8.50,3.87,4.64,1.65,1.55
OUT - Gross Pollutant Mean Annual Load (kg/yr),93.2,25.8,66.8,31.6,23.0,74.3,31.4,40.3,0.00,0.00
Rain In (ML/yr),5.18694,1.26169,3.71497,1.54206,1.1215,4.13553,1.54206,2.243,7.00937,7.00937
ET Loss (ML/yr),1.43916,0.161324,1.03075,0.197174,0.1434,1.14744,0.204054,0.622337,5.09048,5.09048
Deep Seepage Loss (ML/yr),0.007831,0,0.00560875,0,0,0.00624375,0,0.0033865,0.04233,0.04233
Baseflow Out (ML/yr),0.009785,0,0.007008,0,0,0.0078015,0.0006695,0.00423125,0.0528913,0.0528913

Imp. Stormflow Out (ML/yr),3.39279,1.10036,2.42996,1.34489,0.9781,2.70506,1.33144,1.46715,0,0
Perv. Stormflow Out (ML/yr),0.301031,0,0.215604,0,0,0.240011,0.00576,0.130176,1.62719,1.62719
Total Stormflow Out
(ML/yr),3.69382,1.10036,2.64557,1.34489,0.9781,2.94507,1.3372,1.59733,1.62719,1.62719
Total Outflow (ML/yr),3.7036,1.10036,2.65258,1.34489,0.9781,2.95287,1.33787,1.60156,1.68009,1.68009
Change in Soil Storage (ML/yr),0.036348,0,0.026033,0,0,0.02898,0.0001405,0.015718,0.196475,0.196475
TSS Baseflow Out (ML/yr),0.132846,0,0.0955462,0,0,0.10618,0.00910125,0.0575825,0.438936,0.438454
TSS Total Stormflow Out
(ML/yr),762.117,58.033,528.189,70.4023,52.8747,623.195,71.0022,332.731,147.77,152.386
TSS Total Outflow (ML/yr),762.25,58.033,528.285,70.4023,52.8747,623.301,71.0113,332.788,148.209,152.825
TP Baseflow Out (ML/yr),0.00162575,0,0.00116725,0,0,0.0012995,0.0001115,0.00070425,0.0017475,0.0017495
TP Total Stormflow Out
(ML/yr),1.49955,0.16413,1.11023,0.194635,0.144903,1.25975,0.196276,0.665107,0.150732,0.140897
TP Total Outflow
(ML/yr),1.50118,0.16413,1.1114,0.194635,0.144903,1.26105,0.196388,0.665812,0.15248,0.142647
TN Baseflow Out (ML/yr),0.0212407,0,0.0152292,0,0,0.0169387,0.00145,0.0091965,0.0400527,0.03997
TN Total Stormflow Out
(ML/yr),10.7386,3.18352,7.55258,3.90301,2.87236,8.48065,3.86572,4.62972,1.6091,1.50832
TN Total Outflow
(ML/yr),10.7598,3.18352,7.56781,3.90301,2.87236,8.49759,3.86717,4.63892,1.64915,1.54829
GP Total Outflow (ML/yr),93.2277,25.8381,66.7712,31.58,22.9673,74.3301,31.445,40.3146,0,0

No Imported Data Source nodes

USTM treatment nodes

Location,RWTD,RWTA,RWTB,RWTC,Wetland1
ID,3,7,11,16,21
Node Type,RainWaterTankNode,RainWaterTankNode,RainWaterTankNode,RainWaterTankNode,WetlandNode
Lo-flow bypass rate (cum/sec),0,0,0,0,0
Hi-flow bypass rate (cum/sec),1,1,1,1,1
Inlet pond volume,0,0,0,0,15
Area (sqm),10,10,10,10,200
Extended detention depth (m),0.05,0.05,0.05,0.05,0.2
Permanent Pool Volume (cubic metres),20,20,20,20,200
Proportion vegetated,0,0,0,0,0.5
Equivalent Pipe Diameter (mm),50,50,50,50,50
Overflow weir width (m),10,10,10,10,3
Notional Detention Time (hrs),0.107,0.107,0.107,0.107,4.27
Orifice Discharge Coefficient,0.6,0.6,0.6,0.6,0.6
Weir Coefficient,1.7,1.7,1.7,1.7,1.7
Number of CSTR Cells,2,2,2,2,5
Total Suspended Solids - k (m/yr),400,400,400,400,5000
Total Suspended Solids - C* (mg/L),12,12,12,12,6
Total Suspended Solids - C** (mg/L),12,12,12,12,6
Total Phosphorus - k (m/yr),300,300,300,300,2800
Total Phosphorus - C* (mg/L),0.13,0.13,0.13,0.13,0.09
Total Phosphorus - C** (mg/L),0.13,0.13,0.13,0.13,0.09
Total Nitrogen - k (m/yr),40,40,40,40,500
Total Nitrogen - C* (mg/L),1.4,1.4,1.4,1.4,1.3
Total Nitrogen - C** (mg/L),1.4,1.4,1.4,1.4,1.3
Threshold Hydraulic Loading for C** (m/yr),3500,3500,3500,3500,3500
Horizontal Flow Coefficient, , , , ,
Extraction for Re-use,On,On,On,On,Off
Annual Re-use Demand - scaled by daily PET (ML),0,0,0,0,
Annual Re-use Demand - scaled by daily PET - Rain (ML),0,0,0,0,
Constant Daily Re-use Demand (kL),5,5,5,5,
User-defined Annual Re-use Demand (ML),0,0,0,0,
Percentage of User-defined Annual Re-use Demand
Jan,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Feb,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Mar,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Apr,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
May,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Jun,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Jul,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Aug,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,

```
Percentage of User-defined Annual Re-use Demand
Sep,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Oct,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Nov,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
Percentage of User-defined Annual Re-use Demand
Dec,8.33333333333333,8.33333333333333,8.33333333333333,8.33333333333333,
User-defined Re-use File, , , , ,
Filter area (sqm), , , , ,
Filter perimeter (m), , , , ,
Filter depth (m), , , , ,
Filter Median Particle Diameter (mm), , , , ,
Saturated Hydraulic Conductivity (mm/hr), , , , ,
Infiltration Media Porosity, , , , ,
Length (m), , , , ,
Bed slope, , , , ,
Base Width (m), , , , ,
Top width (m), , , , ,
Vegetation height (m), , , , ,
Vegetation Type, , , , ,
Total Nitrogen Content in Filter (mg/kg), , , , ,
Orthophosphate Content in Filter (mg/kg), , , , ,
Is Base Lined?, , , , ,
Is Underdrain Present?, , , , ,
Is Submerged Zone Present?, , , , ,
Submerged Zone Depth (m), , , , ,
B for Media Soil Texture,-9999,-9999,-9999,-9999,-9999
Proportion of upstream impervious area treated, , , , ,
Exfiltration Rate (mm/hr),0,0,0,0,4
Evap Loss as proportion of PET,0,0,0,0,1.25
Depth in metres below the drain pipe, , , , ,
TSS A Coefficient, , , , ,
TSS B Coefficient, , , , ,
TP A Coefficient, , , , ,
TP B Coefficient, , , , ,
TN A Coefficient, , , , ,
TN B Coefficient, , , , ,
Sfc, , , , ,
S*, , , , ,
Sw, , , , ,
Sh, , , , ,
Emax (m/day), , , , ,
Ew (m/day), , , , ,
IN - Mean Annual Flow (ML/yr),1.10,1.34,0.978,1.34,12.6
IN - TSS Mean Annual Load (kg/yr),58.0,70.4,52.9,71.0,545
IN - TP Mean Annual Load (kg/yr),0.164,0.195,0.145,0.196,3.03
IN - TN Mean Annual Load (kg/yr),3.18,3.90,2.87,3.87,29.0
IN - Gross Pollutant Mean Annual Load (kg/yr),25.8,31.6,23.0,31.4,23.4
OUT - Mean Annual Flow (ML/yr),0.501,0.693,0.410,0.688,8.30
OUT - TSS Mean Annual Load (kg/yr),21.3,31.4,18.3,30.5,265
OUT - TP Mean Annual Load (kg/yr),74.5E-3,98.8E-3,60.9E-3,98.7E-3,1.48
OUT - TN Mean Annual Load (kg/yr),1.41,1.97,1.22,1.99,16.7
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00,0.00,0.00,0.00
Flow In (ML/yr),1.10035,1.34488,0.978101,1.33735,12.5969
ET Loss (ML/yr),0,0,0,0,0.176512
Infiltration Loss (ML/yr),0,0,0,0,4.12752
Low Flow Bypass Out (ML/yr),0,0,0,0,0
High Flow Bypass Out (ML/yr),0,0,0,0,0
Orifice / Filter Out (ML/yr),0.305651,0.387076,0.264096,0.383661,2.4455
Weir Out (ML/yr),0.195668,0.306375,0.145408,0.304735,5.85163
Transfer Function Out (ML/yr),0,0,0,0,0
Reuse Supplied (ML/yr),0.601812,0.654124,0.571416,0.651977,0
Reuse Requested (ML/yr),1.82472,1.82472,1.82472,1.82472,0
% Reuse Demand Met,32.981,35.8479,31.3153,35.7303,0
% Load Reduction,54.44,48.4375,58.1328,48.5255,34.1337
TSS Flow In (kg/yr),58.0331,70.4024,52.8746,71.003,544.888
TSS ET Loss (kg/yr),0,0,0,0,0
TSS Infiltration Loss (kg/yr),0,0,0,0,25.6835
TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0
TSS High Flow Bypass Out (kg/yr),0,0,0,0,0
TSS Orifice / Filter Out (kg/yr),12.795,17.635,12.1819,16.7958,15.1857
TSS Weir Out (kg/yr),8.51531,13.7991,6.13355,13.7423,249.549
TSS Transfer Function Out (kg/yr),0,0,0,0,0
TSS Reuse Supplied (kg/yr),14.6997,15.8451,13.9168,16.3149,0
```

TSS Reuse Requested (kg/yr),0,0,0,0,0
TSS % Reuse Demand Met,0,0,0,0,0
TSS % Load Reduction,63.2791,55.3509,65.3606,56.9905,51.4148
TP Flow In (kg/yr),0.16413,0.194635,0.144903,0.196304,3.02708
TP ET Loss (kg/yr),0,0,0,0,0
TP Infiltration Loss (kg/yr),0,0,0,0,0.379416
TP Low Flow Bypass Out (kg/yr),0,0,0,0,0
TP High Flow Bypass Out (kg/yr),0,0,0,0,0
TP Orifice / Filter Out (kg/yr),0.0454867,0.0554147,0.0390675,0.0560153,0.226829
TP Weir Out (kg/yr),0.0289635,0.0433917,0.0217892,0.0427177,1.25458
TP Transfer Function Out (kg/yr),0,0,0,0,0
TP Reuse Supplied (kg/yr),0.0819475,0.0887205,0.0775302,0.0887745,0
TP Reuse Requested (kg/yr),0,0,0,0,0
TP % Reuse Demand Met,0,0,0,0,0
TP % Load Reduction,54.6395,49.235,58.0018,49.704,51.0614
TN Flow In (kg/yr),3.18352,3.90301,2.87236,3.86595,28.99
TN ET Loss (kg/yr),0,0,0,0,0
TN Infiltration Loss (kg/yr),0,0,0,0,5.73771
TN Low Flow Bypass Out (kg/yr),0,0,0,0,0
TN High Flow Bypass Out (kg/yr),0,0,0,0,0
TN Orifice / Filter Out (kg/yr),0.852171,1.12291,0.783225,1.08052,3.78323
TN Weir Out (kg/yr),0.559954,0.848242,0.433751,0.904921,12.9114
TN Transfer Function Out (kg/yr),0,0,0,0,0
TN Reuse Supplied (kg/yr),1.56527,1.70421,1.469,1.66491,0
TN Reuse Requested (kg/yr),0,0,0,0,0
TN % Reuse Demand Met,0,0,0,0,0
TN % Load Reduction,55.6427,49.4968,57.6315,48.6429,42.4123
GP Flow In (kg/yr),25.8381,31.58,22.9672,31.444,23.4292
GP ET Loss (kg/yr),0,0,0,0,0
GP Infiltration Loss (kg/yr),0,0,0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0,0,0
GP High Flow Bypass Out (kg/yr),0,0,0,0,0
GP Orifice / Filter Out (kg/yr),0,0,0,0,0
GP Weir Out (kg/yr),0,0,0,0,0
GP Transfer Function Out (kg/yr),0,0,0,0,0
GP Reuse Supplied (kg/yr),0,0,0,0,0
GP Reuse Requested (kg/yr),0,0,0,0,0
GP % Reuse Demand Met,0,0,0,0,0
GP % Load Reduction,100,100,100,100,100

Generic treatment nodes

Location,GPT1,D Litter Baskets,C Litter Baskets
ID,9,13,17
Node Type,GPTNode,GPTNode,GPTNode
Lo-flow bypass rate (cum/sec),0,0,0
Hi-flow bypass rate (cum/sec),1,1,1
Flow Transfer Function
Input (cum/sec),0,0,0
Output (cum/sec),0,0,0
Input (cum/sec),10,10,10
Output (cum/sec),10,10,10
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Input (cum/sec), , ,
Output (cum/sec), , ,
Gross Pollutant Transfer Function
Input (kg/ML),0,0,0
Output (kg/ML),0,0,0
Input (kg/ML),100,100,100
Output (kg/ML),10,10,10
Input (kg/ML), , ,
Output (kg/ML), , ,

```
Input (kg/ML), , ,
Output (kg/ML), , ,
Input (kg/ML), , ,
Output (kg/ML), , ,
Input (kg/ML), , ,
Output (kg/ML), , ,
Input (kg/ML), , ,
Output (kg/ML), , ,
Input (kg/ML), , ,
Output (kg/ML), , ,
Input (kg/ML), , ,
Output (kg/ML), , ,
Input (kg/ML), , ,
Output (kg/ML), , ,
Total Nitrogen Transfer Function
Input (mg/L),0,0,0
Output (mg/L),0,0,0
Input (mg/L),100,100,100
Output (mg/L),87,87,87
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Total Phosphorus Transfer Function
Input (mg/L),0,0,0
Output (mg/L),0,0,0
Input (mg/L),10,10,10
Output (mg/L),7,7,7
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Total Suspended Solids Transfer Function
Input (mg/L),0,0,0
Output (mg/L),0,0,0
Input (mg/L),1000,1000,1000
Output (mg/L),200,200,200
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
Input (mg/L), , ,
Output (mg/L), , ,
```

```
Input (mg/L), , ,
Output (mg/L), , ,
IN - Mean Annual Flow (ML/yr),6.71,4.20,2.29
IN - TSS Mean Annual Load (kg/yr),1.20E3,784,363
IN - TP Mean Annual Load (kg/yr),2.53,1.58,0.765
IN - TN Mean Annual Load (kg/yr),19.3,12.2,6.62
IN - Gross Pollutant Mean Annual Load (kg/yr),141,93.2,40.3
OUT - Mean Annual Flow (ML/yr),6.71,4.20,2.29
OUT - TSS Mean Annual Load (kg/yr),240,157,72.7
OUT - TP Mean Annual Load (kg/yr),1.77,1.10,0.535
OUT - TN Mean Annual Load (kg/yr),16.8,10.6,5.76
OUT - Gross Pollutant Mean Annual Load (kg/yr),14.1,9.32,4.03
Flow In (ML/yr),6.71241,4.20667,2.28946
ET Loss (ML/yr),0,0,0
Infiltration Loss (ML/yr),0,0,0
Low Flow Bypass Out (ML/yr),0,0,0
High Flow Bypass Out (ML/yr),0,0,0
Orifice / Filter Out (ML/yr),0,0,0
Weir Out (ML/yr),0,0,0
Transfer Function Out (ML/yr),6.71241,4.20667,2.28946
Reuse Supplied (ML/yr),0,0,0
Reuse Requested (ML/yr),0,0,0
% Reuse Demand Met,0,0,0
% Load Reduction,0,0,0
TSS Flow In (kg/yr),1201.15,783.435,363.272
TSS ET Loss (kg/yr),0,0,0
TSS Infiltration Loss (kg/yr),0,0,0
TSS Low Flow Bypass Out (kg/yr),0,0,0
TSS High Flow Bypass Out (kg/yr),0,0,0
TSS Orifice / Filter Out (kg/yr),0,0,0
TSS Weir Out (kg/yr),0,0,0
TSS Transfer Function Out (kg/yr),240.229,156.687,72.6544
TSS Reuse Supplied (kg/yr),0,0,0
TSS Reuse Requested (kg/yr),0,0,0
TSS % Reuse Demand Met,0,0,0
TSS % Load Reduction,80,80,80
TP Flow In (kg/yr),2.53086,1.57482,0.764136
TP ET Loss (kg/yr),0,0,0
TP Infiltration Loss (kg/yr),0,0,0
TP Low Flow Bypass Out (kg/yr),0,0,0
TP High Flow Bypass Out (kg/yr),0,0,0
TP Orifice / Filter Out (kg/yr),0,0,0
TP Weir Out (kg/yr),0,0,0
TP Transfer Function Out (kg/yr),1.7715,1.10244,0.534925
TP Reuse Supplied (kg/yr),0,0,0
TP Reuse Requested (kg/yr),0,0,0
TP % Reuse Demand Met,0,0,0
TP % Load Reduction,30.0038,29.9955,29.9961
TN Flow In (kg/yr),19.2521,12.1717,6.62262
TN ET Loss (kg/yr),0,0,0
TN Infiltration Loss (kg/yr),0,0,0
TN Low Flow Bypass Out (kg/yr),0,0,0
TN High Flow Bypass Out (kg/yr),0,0,0
TN Orifice / Filter Out (kg/yr),0,0,0
TN Weir Out (kg/yr),0,0,0
TN Transfer Function Out (kg/yr),16.7526,10.5888,5.76047
TN Reuse Supplied (kg/yr),0,0,0
TN Reuse Requested (kg/yr),0,0,0
TN % Reuse Demand Met,0,0,0
TN % Load Reduction,12.9828,13.0055,13.0183
GP Flow In (kg/yr),141.079,93.2127,40.3083
GP ET Loss (kg/yr),0,0,0
GP Infiltration Loss (kg/yr),0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0
GP High Flow Bypass Out (kg/yr),0,0,0
GP Orifice / Filter Out (kg/yr),0,0,0
GP Weir Out (kg/yr),0,0,0
GP Transfer Function Out (kg/yr),14.1079,9.32127,4.03082
GP Reuse Supplied (kg/yr),0,0,0
GP Reuse Requested (kg/yr),0,0,0
GP % Reuse Demand Met,0,0,0
GP % Load Reduction,100,100,100
```

Other nodes

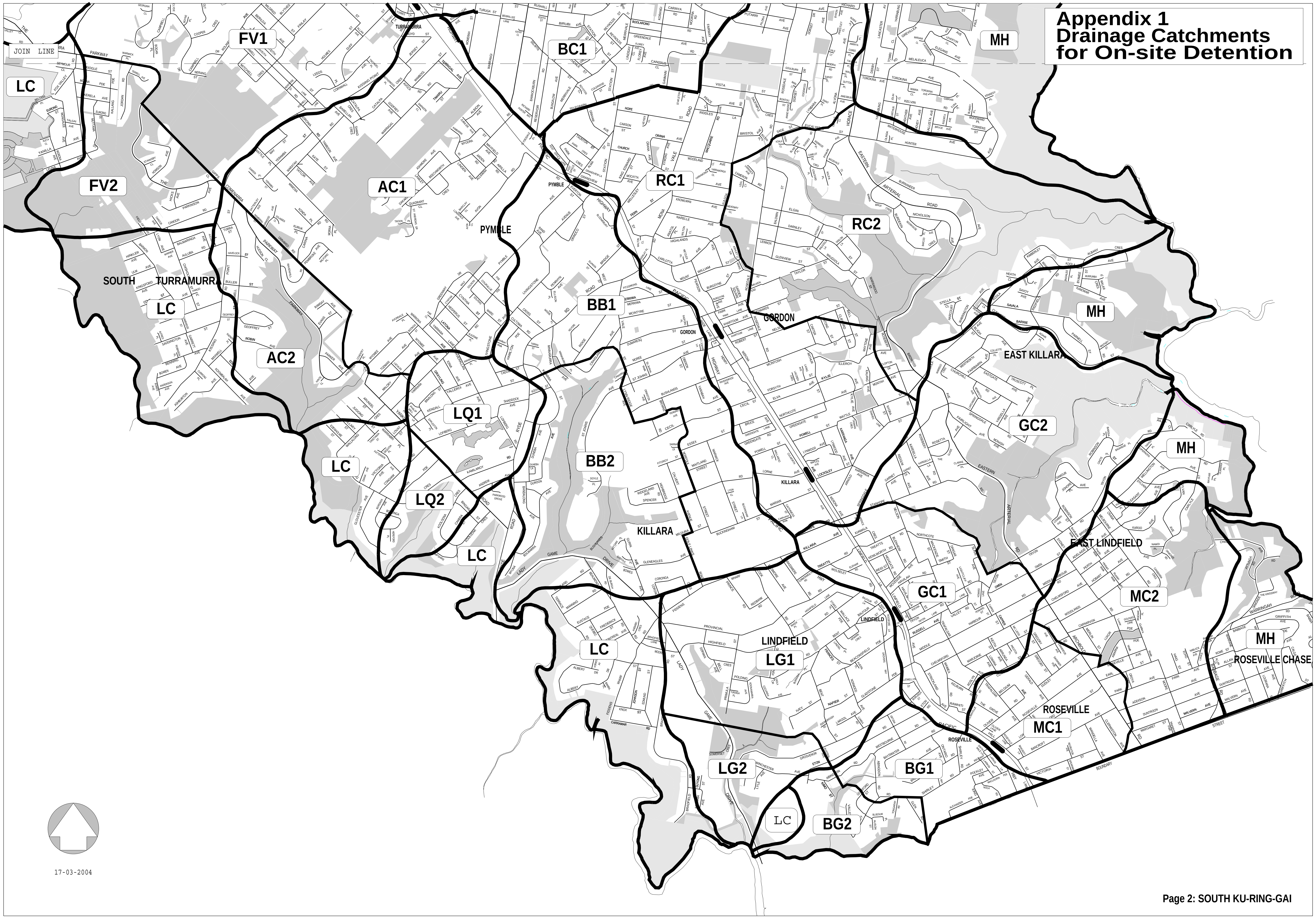
```
Location,D-OUT,A&B-OUT,OUT
ID,4,8,18
Node Type,JunctionNode,JunctionNode,JunctionNode
IN - Mean Annual Flow (ML/yr),4.20,6.71,12.3
IN - TSS Mean Annual Load (kg/yr),157,240,490
IN - TP Mean Annual Load (kg/yr),1.10,1.77,2.16
IN - TN Mean Annual Load (kg/yr),10.6,16.8,24.0
IN - Gross Pollutant Mean Annual Load (kg/yr),9.32,14.1,4.03
OUT - Mean Annual Flow (ML/yr),4.20,6.71,12.3
OUT - TSS Mean Annual Load (kg/yr),157,240,490
OUT - TP Mean Annual Load (kg/yr),1.10,1.77,2.16
OUT - TN Mean Annual Load (kg/yr),10.6,16.8,24.0
OUT - Gross Pollutant Mean Annual Load (kg/yr),9.32,14.1,4.03
```

Links

```
Location,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage
Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage
Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link
Source node ID,2,6,9,7,5,10,11,12,1,3,13,14,16,15,17,4,8,21,19,20
Target node ID,3,7,8,9,9,11,9,9,13,13,4,16,17,17,18,21,21,18,21,18
Muskingum-Cunge Routing,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not
Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed,Not
Routed,Not Routed,Not Routed,Not Routed,Not Routed
Muskingum K, , , , , , , , , , , , , , , , , , , ,
Muskingum theta, , , , , , , , , , , , , , , , , , , ,
IN - Mean Annual Flow
(ML/yr),1.10,1.34,6.71,0.693,2.65,0.978,0.410,2.95,3.70,0.501,4.20,1.34,0.688,1.60,2.29,4.20,6.71,8.30,
1.68,1.68
IN - TSS Mean Annual Load
(kg/yr),58.0,70.4,240,31.4,528,52.9,18.3,623,762,21.3,157,71.0,30.5,333,72.7,157,240,265,148,153
IN - TP Mean Annual Load (kg/yr),0.164,0.195,1.77,98.8E-3,1.11,0.145,60.9E-3,1.26,1.50,74.5E-
3,1.10,0.196,98.7E-3,0.666,0.535,1.10,1.77,1.48,0.152,0.143
IN - TN Mean Annual Load
(kg/yr),3.18,3.90,16.8,1.97,7.57,2.87,1.22,8.50,10.8,1.41,10.6,3.87,1.99,4.64,5.76,10.6,16.8,16.7,1.65,
1.55
IN - Gross Pollutant Mean Annual Load
(kg/yr),25.8,31.6,14.1,0.00,66.8,23.0,0.00,74.3,93.2,0.00,9.32,31.4,0.00,40.3,4.03,9.32,14.1,0.00,0.00,
0.00
OUT - Mean Annual Flow
(ML/yr),1.10,1.34,6.71,0.693,2.65,0.978,0.410,2.95,3.70,0.501,4.20,1.34,0.688,1.60,2.29,4.20,6.71,8.30,
1.68,1.68
OUT - TSS Mean Annual Load
(kg/yr),58.0,70.4,240,31.4,528,52.9,18.3,623,762,21.3,157,71.0,30.5,333,72.7,157,240,265,148,153
OUT - TP Mean Annual Load (kg/yr),0.164,0.195,1.77,98.8E-3,1.11,0.145,60.9E-3,1.26,1.50,74.5E-
3,1.10,0.196,98.7E-3,0.666,0.535,1.10,1.77,1.48,0.152,0.143
OUT - TN Mean Annual Load
(kg/yr),3.18,3.90,16.8,1.97,7.57,2.87,1.22,8.50,10.8,1.41,10.6,3.87,1.99,4.64,5.76,10.6,16.8,16.7,1.65,
1.55
OUT - Gross Pollutant Mean Annual Load
(kg/yr),25.8,31.6,14.1,0.00,66.8,23.0,0.00,74.3,93.2,0.00,9.32,31.4,0.00,40.3,4.03,9.32,14.1,0.00,0.00,
0.00
```

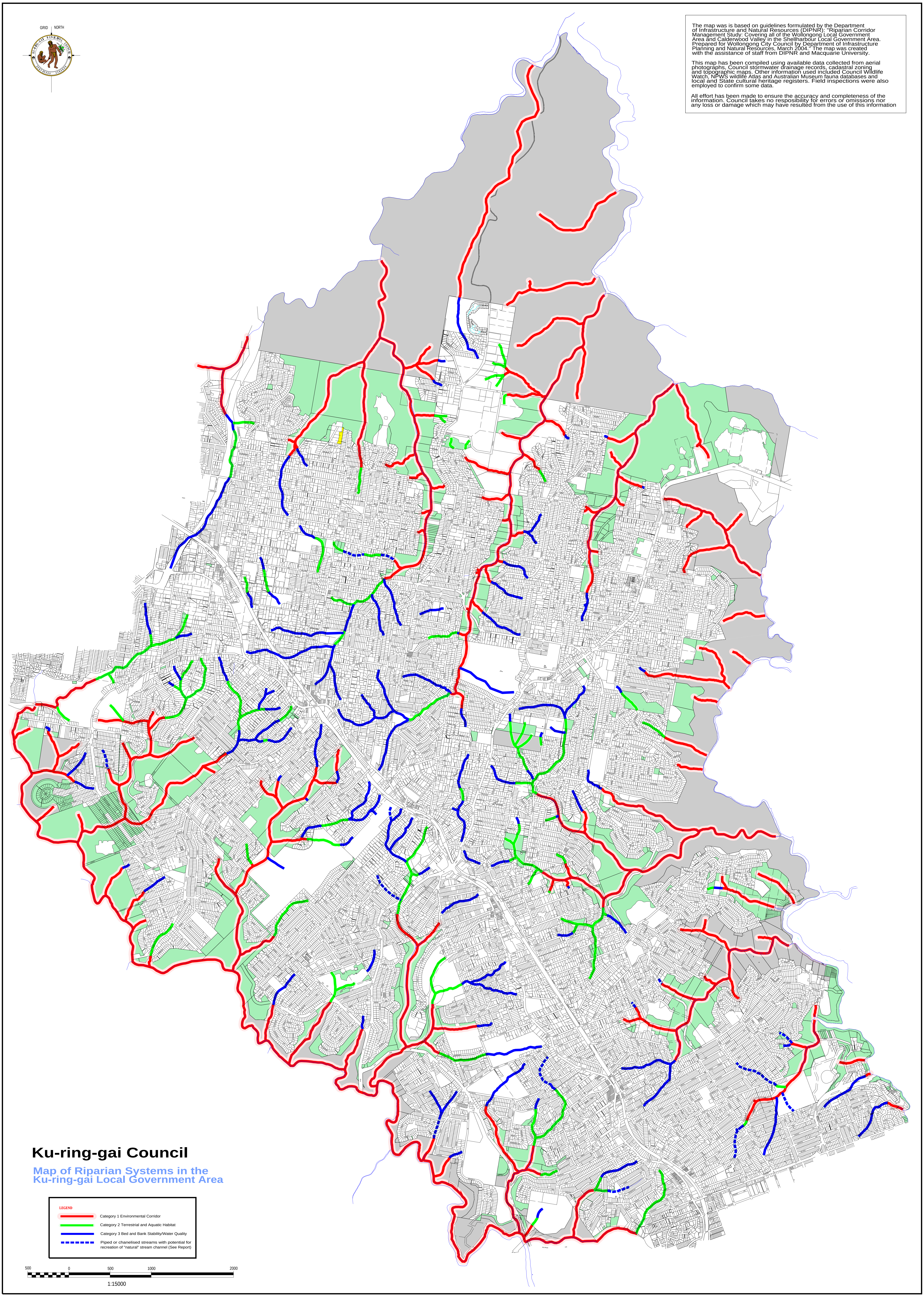
APPENDIX E (*OSD Catchments*)

Appendix 1
Drainage Catchments for On-site Detention



17-03-2004

APPENDIX F (*Riparian Zones*)



GRID
NORTH
The map was is based on guidelines formulated by the Department of Infrastructure and Natural Resources (DIPNR): "Riparian Corridor Management Study: Covering all of the Wollongong Local Government Area and Calderwood Valley in the Shellharbour Local Government Area. Prepared for Wollongong City Council by Department of Infrastructure Planning and Natural Resources, March 2004." The map was created with the assistance of staff from DIPNR and Macquarie University.
This map has been compiled using available data collected from aerial photographs, Council stormwater drainage records, cadastral zoning and topographic maps. Other information used included Council Wildlife Watch, NPWS wildlife Atlas and Australian Museum fauna databases and local and State cultural heritage registers. Field inspections were also employed to confirm some data.
All effort has been made to ensure the accuracy and completeness of the information. Council takes no resposibility for errors or omissions nor any loss or damage which may have resulted from the use of this information
Ku-ring-gai Council
Map of Riparian Systems in the Ku-ring-gai Local Government Area
LEGEND
Category 1 Environmental Corridor
Category 2 Terrestrial and Aquatic Habitat
Category 3 Bed and Bank Stability/Water Quality
Piped or chanelised streams with potential for recreation of "natural" stream channel (See Report)
500
0
500
1000
2000
1:15000

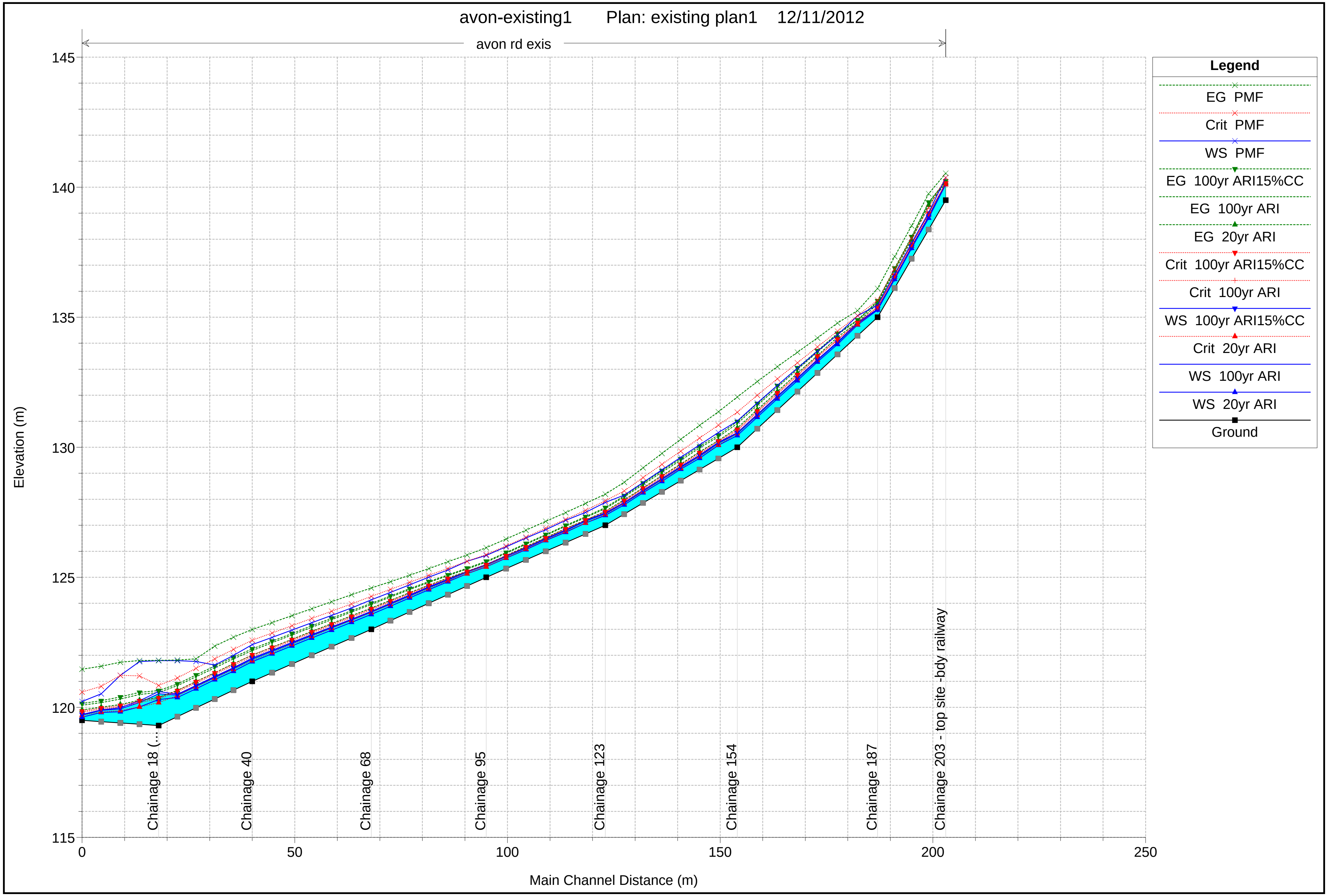
APPENDIX G (*HEC RAS*)

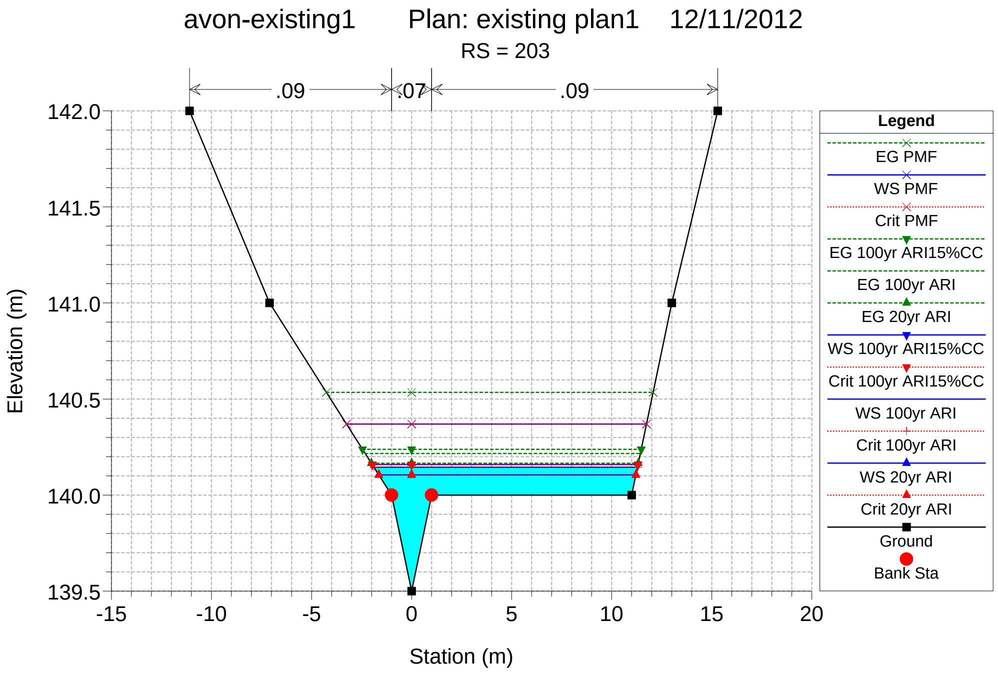
HEC-RAS Plan: p1 River: avon rd Reach: exis

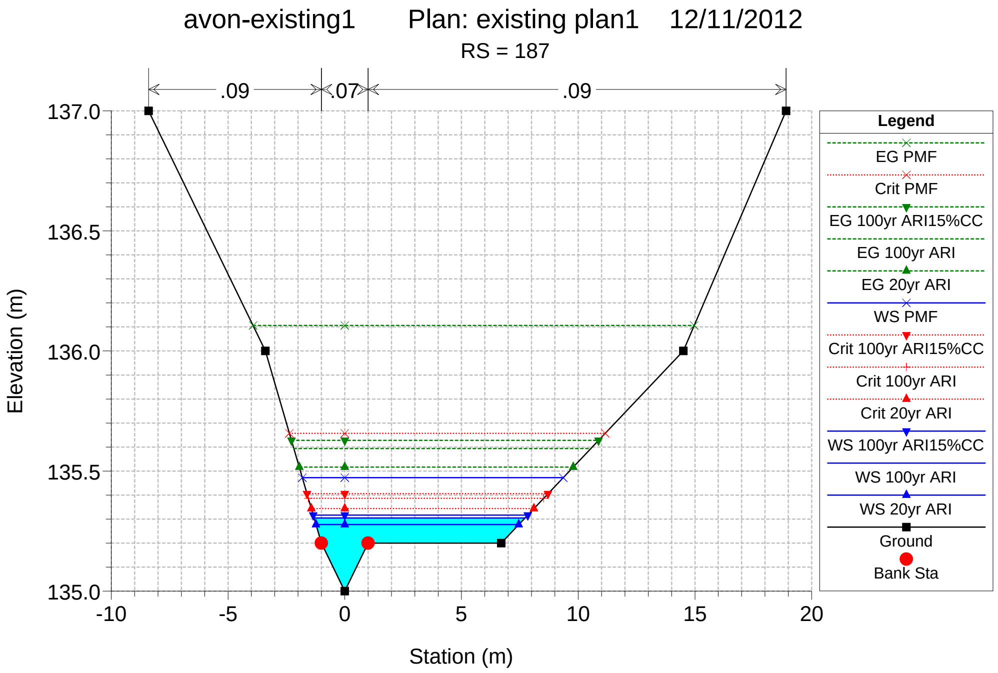
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
exis	203	100yr ARI	2.14	139.50	140.14	140.14	140.21660	0.04409	1.50	2.32	13.17	0.76
exis	203	20yr ARI	1.46	139.50	140.10	140.10	140.16570	0.03929	1.32	1.80	12.85	0.71
exis	203	100yr ARI15%CC	2.47	139.50	140.16	140.16	140.23840	0.04746	1.59	2.51	13.29	0.79
exis	203	PMF	8.77	139.50	140.37	140.37	140.53500	0.06280	2.41	5.48	14.99	0.98
exis	187	100yr ARI	2.14	135.00	135.30	135.39	135.59360	0.35586	2.92	1.08	9.04	2.06
exis	187	20yr ARI	1.46	135.00	135.28	135.34	135.51660	0.33902	2.59	0.83	8.68	1.96
exis	187	100yr ARI15%CC	2.47	135.00	135.32	135.41	135.62770	0.36145	3.06	1.18	9.19	2.10
exis	187	PMF	8.77	135.00	135.47	135.66	136.10600	0.39016	4.56	2.77	11.17	2.38
exis	154	100yr ARI	2.14	130.00	130.53	130.64	130.91040	0.14797	2.78	0.81	2.55	1.45
exis	154	20yr ARI	1.46	130.00	130.45	130.53	130.73950	0.14695	2.39	0.63	2.37	1.39
exis	154	100yr ARI15%CC	2.47	130.00	130.56	130.68	130.98460	0.14734	2.93	0.90	2.63	1.47
exis	154	PMF	8.77	130.00	131.01	131.35	131.93190	0.12729	4.48	2.34	3.84	1.54
exis	123	100yr ARI	2.66	127.00	127.45	127.50	127.64200	0.08577	2.26	1.65	6.88	1.14
exis	123	20yr ARI	1.80	127.00	127.38	127.42	127.53970	0.08549	1.99	1.21	5.93	1.11
exis	123	100yr ARI15%CC	3.04	127.00	127.47	127.53	127.68100	0.08623	2.36	1.83	7.23	1.16
exis	123	PMF	12.00	127.00	127.88	127.94	128.19790	0.06965	3.31	5.87	12.86	1.16
exis	95	100yr ARI	2.66	125.00	125.46	125.46	125.58070	0.06463	1.83	1.98	7.85	0.97
exis	95	20yr ARI	1.80	125.00	125.40	125.40	125.49560	0.06549	1.62	1.51	7.32	0.94
exis	95	100yr ARI15%CC	3.04	125.00	125.49	125.48	125.61430	0.06336	1.90	2.19	8.07	0.97
exis	95	PMF	12.00	125.00	125.84	125.87	126.14070	0.07126	3.08	5.53	11.04	1.14
exis	68	100yr ARI	2.66	123.00	123.66	123.75	123.95360	0.06230	2.56	1.37	5.57	1.21
exis	68	20yr ARI	1.80	123.00	123.57	123.65	123.81980	0.06496	2.28	0.94	4.37	1.19
exis	68	100yr ARI15%CC	3.04	123.00	123.69	123.79	124.00210	0.06134	2.66	1.56	6.02	1.21
exis	68	PMF	12.00	123.00	124.13	124.27	124.58930	0.05113	3.74	5.59	11.71	1.24
exis	40	100yr ARI	2.66	121.00	121.85	121.95	122.18310	0.06520	2.57	1.14	3.72	1.16
exis	40	20yr ARI	1.80	121.00	121.75	121.80	122.00530	0.06562	2.23	0.82	2.60	1.12
exis	40	100yr ARI15%CC	3.04	121.00	121.89	122.02	122.24710	0.06448	2.69	1.29	4.15	1.17
exis	40	PMF	12.00	121.00	122.41	122.58	122.99390	0.05588	3.92	4.51	7.76	1.21
exis	18	100yr ARI	3.18	119.30	120.52	120.33	120.57200	0.00648	1.17	4.56	13.04	0.40
exis	18	20yr ARI	2.14	119.30	120.30	120.18	120.38280	0.01399	1.41	2.17	7.94	0.56
exis	18	100yr ARI15%CC	3.61	119.30	120.61	120.36	120.64590	0.00513	1.11	5.71	14.87	0.36
exis	18	PMF	15.24	119.30	121.80	120.84	121.80870	0.00090	0.79	36.42	34.37	0.17

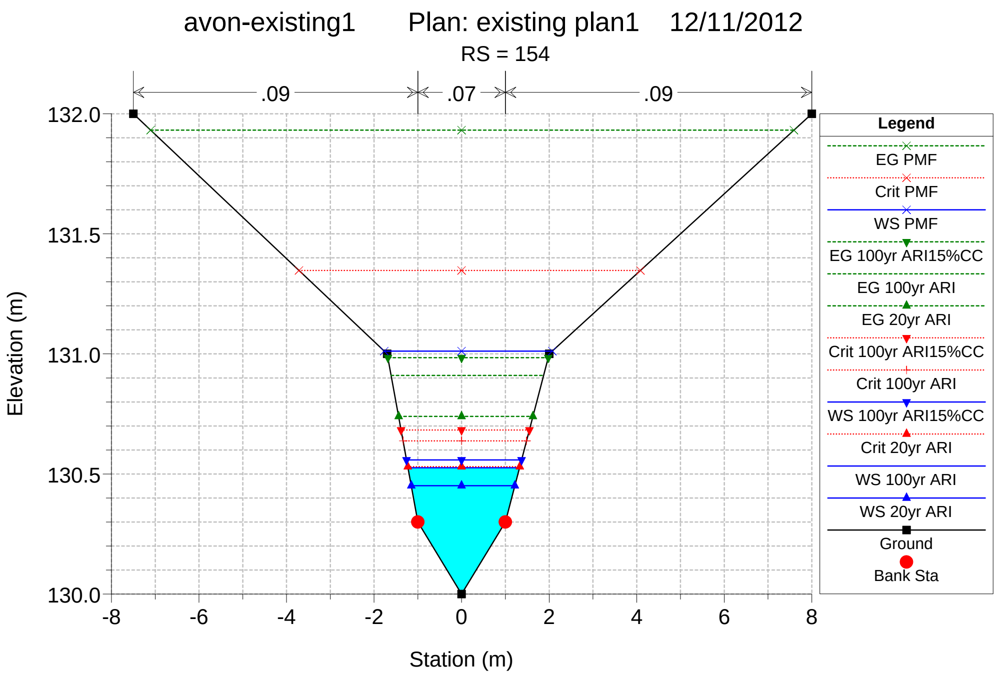
HEC-RAS Plan: p1   River: avon rd   Reach: exis (Continued)

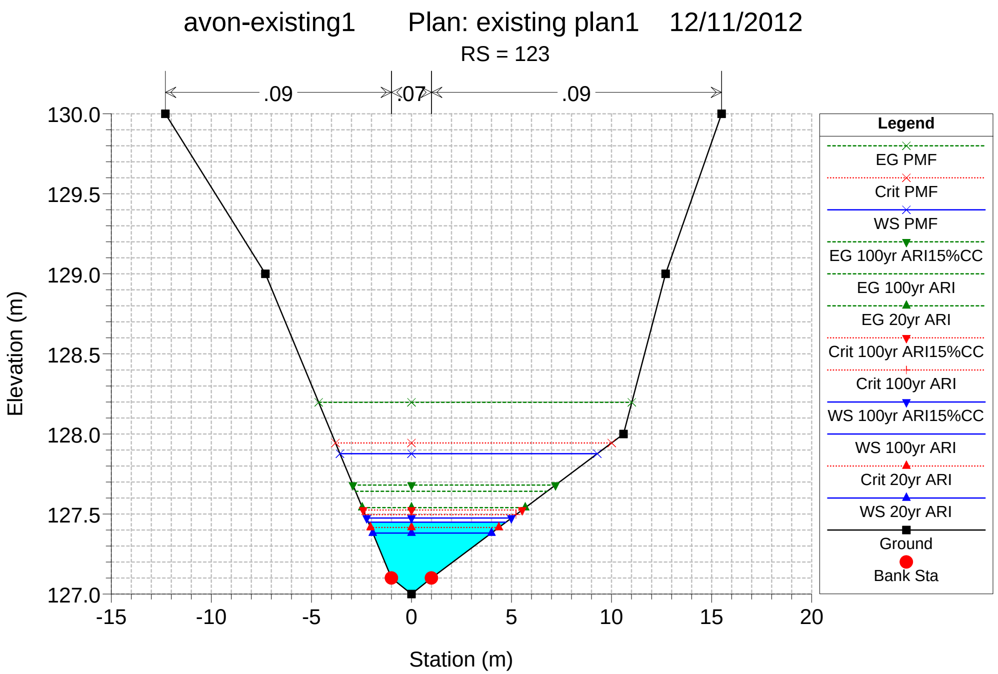
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
exis	0	100yr ARI	2.18	119.50	119.70	119.81	120.07870	0.02317	2.72	0.80	3.98	1.94
exis	0	20yr ARI	1.14	119.50	119.62	119.70	119.89750	0.03072	2.32	0.49	3.98	2.11
exis	0	100yr ARI15%CC	2.61	119.50	119.73	119.85	120.15070	0.02240	2.88	0.91	3.98	1.93
exis	0	PMF	14.24	119.50	120.22	120.59	121.46420	0.01830	4.93	2.89	3.99	1.85

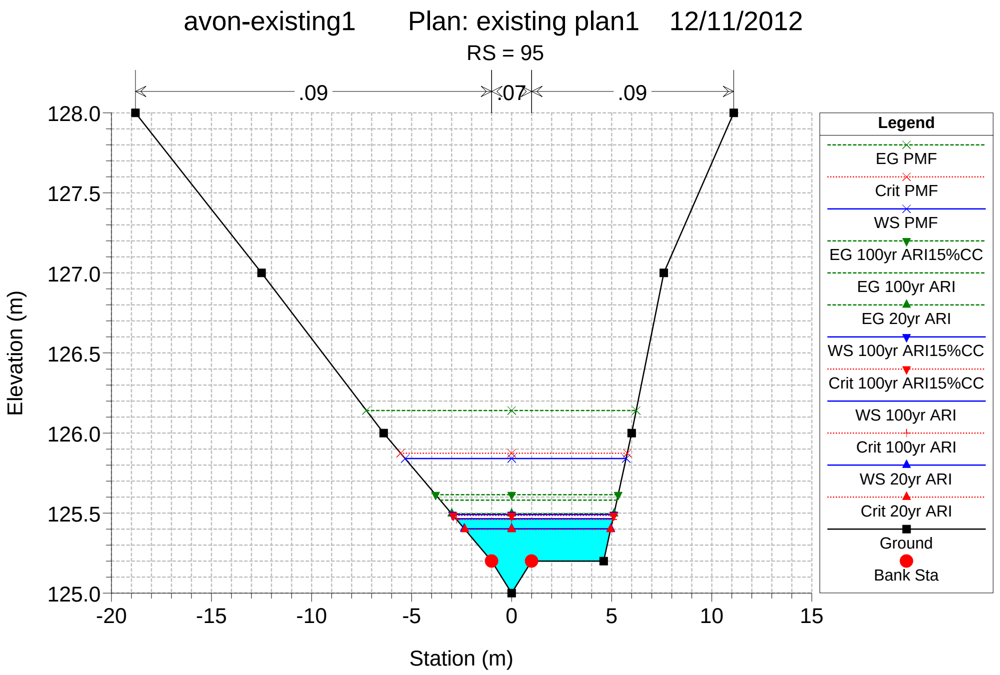

avon-existing1 Plan: existing plan1 12/11/2012
avon rd exis
Elevation (m)
145
140
135
130
125
120
115
0
50
100
150
200
250
Main Channel Distance (m)
Chainage 18 (...
Chainage 40
Chainage 68
Chainage 95
Chainage 123
Chainage 154
Chainage 187
Chainage 203 - top site -bdy railway
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
Crit 20yr ARI
WS 100yr ARI
WS 20yr ARI
Ground

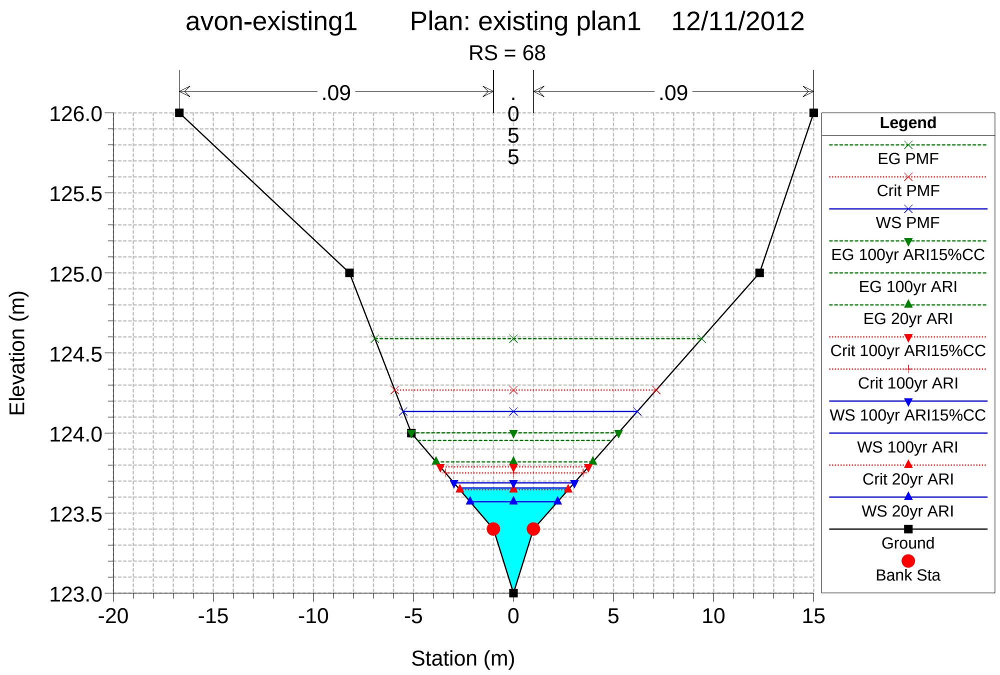

avon-existing1 Plan: existing plan1 12/11/2012
RS = 203
.09
.07
.09
Elevation (m)
Station (m)
Legend
EG PMF
WS PMF
Crit PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
WS 100yr ARI15%CC
Crit 100yr ARI15%CC
WS 100yr ARI
Crit 100yr ARI
WS 20yr ARI
Crit 20yr ARI
Ground
Bank Sta

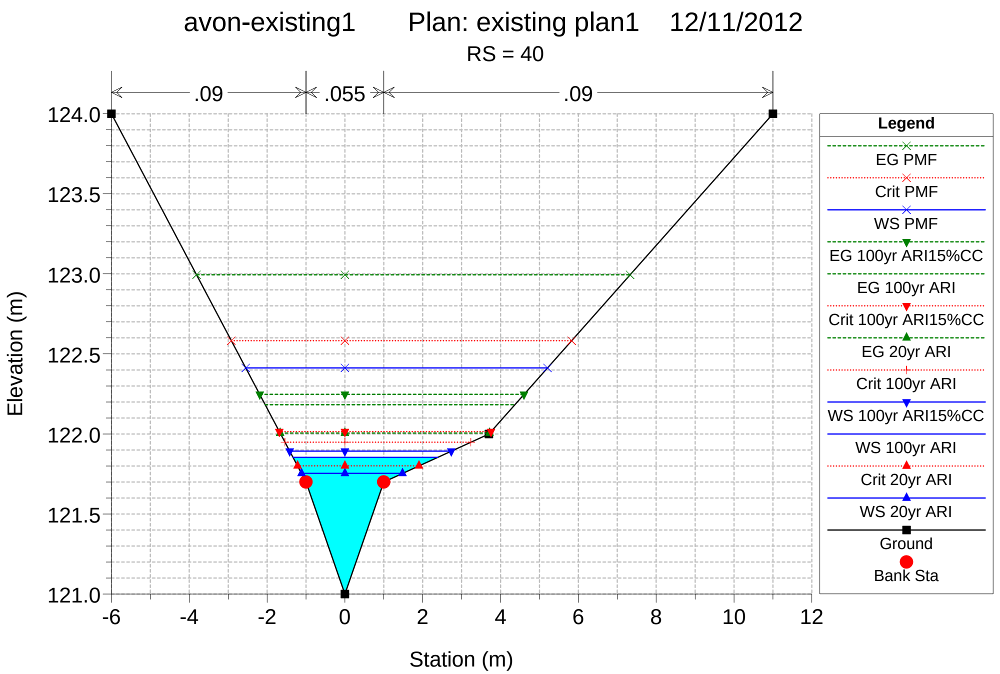

avon-existing1 Plan: existing plan1 12/11/2012
RS = 187
.09
.07
.09
Elevation (m)
Station (m)
Legend
EG PMF
Crit PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
WS PMF
Crit 100yr ARI15%CC
Crit 100yr ARI
Crit 20yr ARI
WS 100yr ARI15%CC
WS 100yr ARI
WS 20yr ARI
Ground
Bank Sta

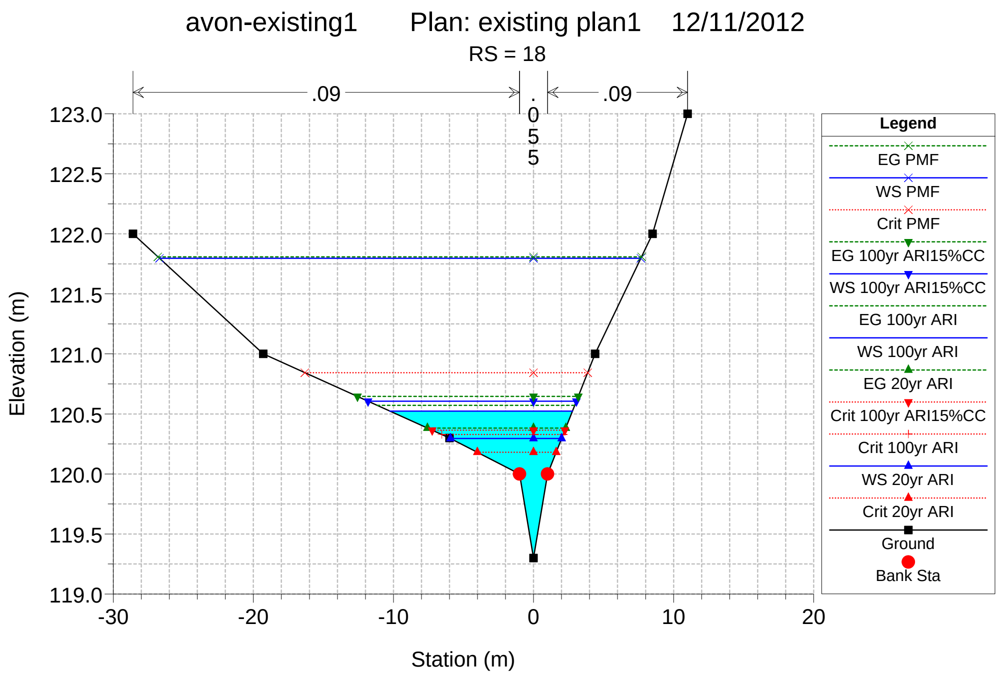

avon-existing1 Plan: existing plan1 12/11/2012
RS = 154
.09
.07
.09
Elevation (m)
Station (m)
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
Crit 20yr ARI
WS 100yr ARI
WS 20yr ARI
Ground
Bank Sta

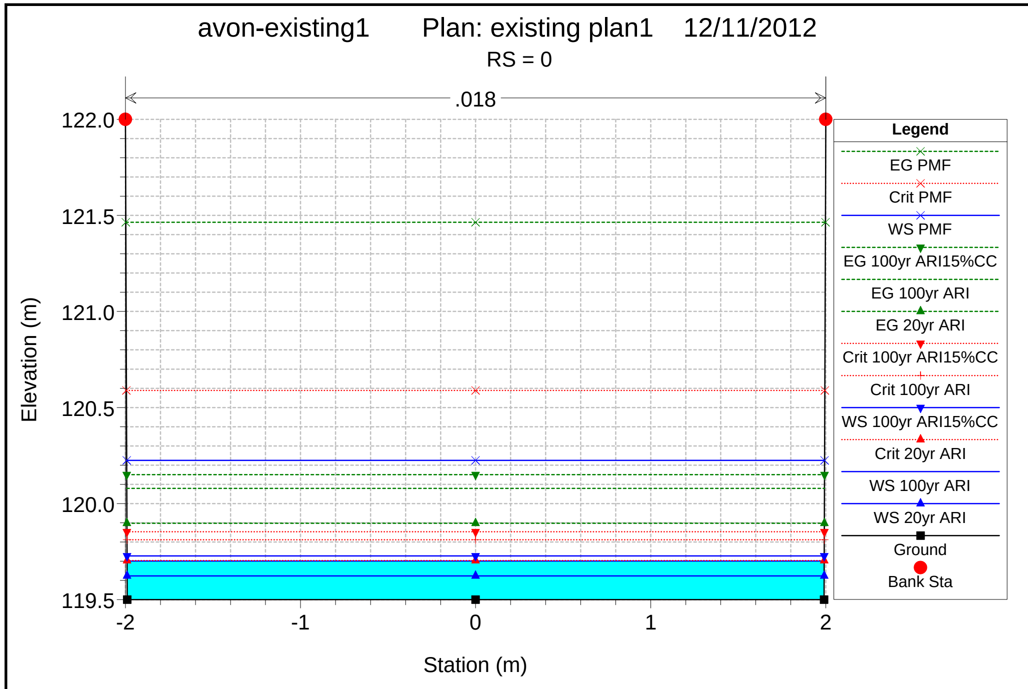

avon-existing1 Plan: existing plan1 12/11/2012
RS = 123
.09
.07
.09
Elevation (m)
Station (m)
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
WS 100yr ARI
Crit 20yr ARI
WS 20yr ARI
Ground
Bank Sta


avon-existing1 Plan: existing plan1 12/11/2012
RS = 95
.09
.07
.09
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
WS 100yr ARI15%CC
Crit 100yr ARI15%CC
WS 100yr ARI
Crit 100yr ARI
WS 20yr ARI
Crit 20yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)

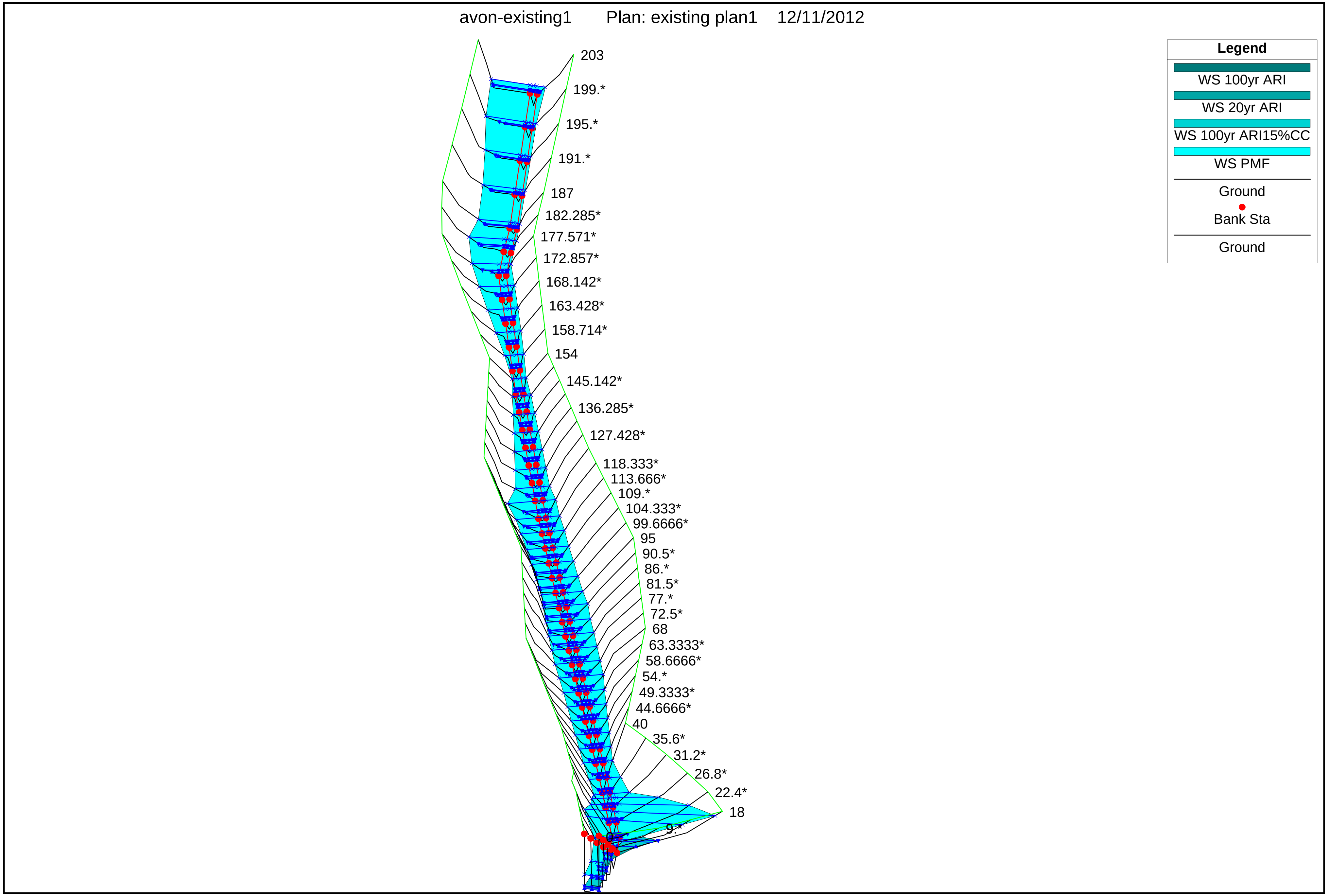

avon-existing1 Plan: existing plan1 12/11/2012
RS = 68
.09
.055
.09
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
WS 100yr ARI
Crit 20yr ARI
WS 20yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)


avon-existing1 Plan: existing plan1 12/11/2012
RS = 40
.09
.055
.09
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
Crit 100yr ARI15%CC
EG 20yr ARI
Crit 100yr ARI
WS 100yr ARI15%CC
WS 100yr ARI
Crit 20yr ARI
WS 20yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)


avon-existing1 Plan: existing plan1 12/11/2012
RS = 18
.09
.055
.09
Legend
EG PMF
WS PMF
Crit PMF
EG 100yr ARI15%CC
WS 100yr ARI15%CC
EG 100yr ARI
WS 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 20yr ARI
Crit 20yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)



avon-existing1 Plan: existing plan1 12/11/2012
RS = 0
.018
122.0
121.5
121.0
120.5
120.0
119.5
Elevation (m)
-2
-1
0
1
2
Station (m)
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
Crit 20yr ARI
WS 100yr ARI
WS 20yr ARI
Ground
Bank Sta

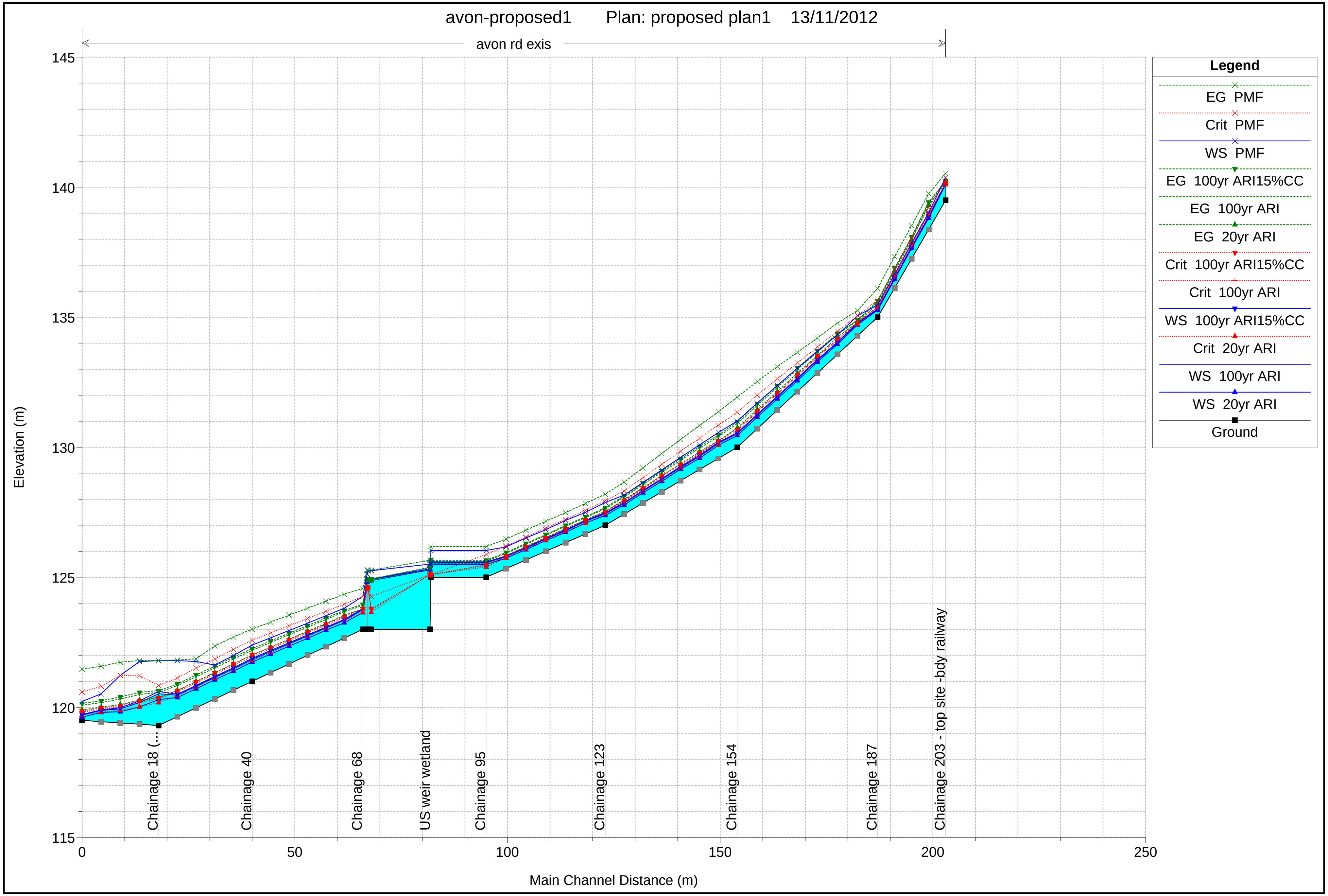

avon-existing1 Plan: existing plan1 12/11/2012
Legend
WS 100yr ARI
WS 20yr ARI
WS 100yr ARI15%CC
WS PMF
Ground
Bank Sta
Ground
203
199.*
195.*
191.*
187
182.285*
177.571*
172.857*
168.142*
163.428*
158.714*
154
145.142*
136.285*
127.428*
118.333*
113.666*
109.*
104.333*
99.6666*
95
90.5*
86.*
81.5*
77.*
72.5*
68
63.3333*
58.6666*
54.*
49.3333*
44.6666*
40
35.6*
31.2*
26.8*
22.4*
18
9.*
0

HEC-RAS Plan: p2 River: avon rd Reach: exis

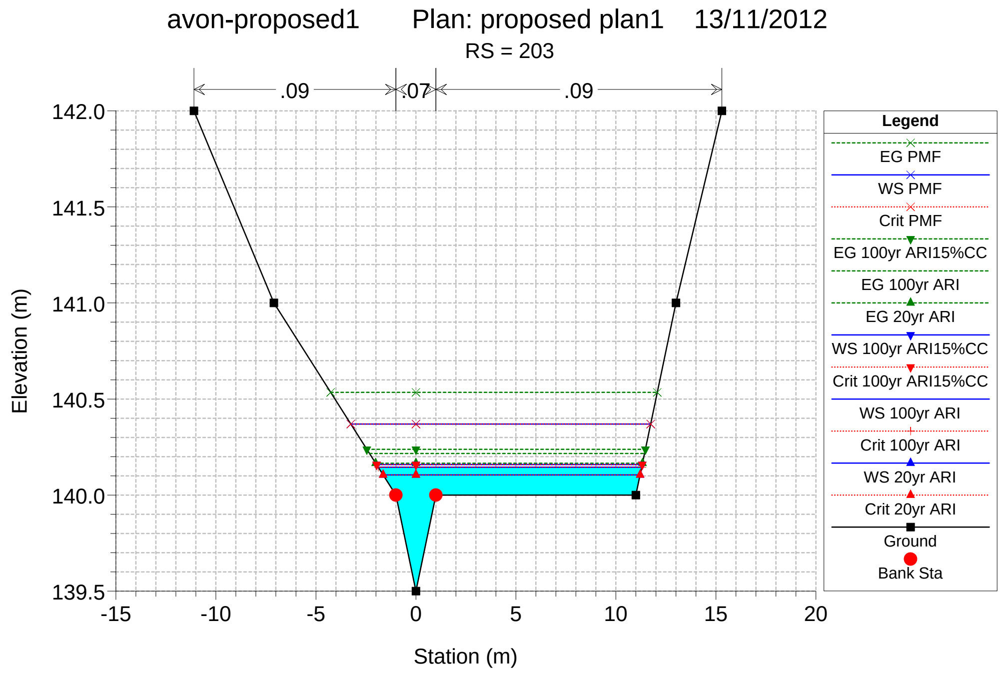
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
exis	203	100yr ARI	2.14	139.50	140.14	140.14	140.21660	0.04409	1.50	2.32	13.17	0.76
exis	203	20yr ARI	1.46	139.50	140.10	140.10	140.16570	0.03929	1.32	1.80	12.85	0.71
exis	203	100yr ARI15%CC	2.47	139.50	140.16	140.16	140.23840	0.04746	1.59	2.51	13.29	0.79
exis	203	PMF	8.77	139.50	140.37	140.37	140.53500	0.06280	2.41	5.48	14.99	0.98
exis	187	100yr ARI	2.14	135.00	135.30	135.39	135.59360	0.35586	2.92	1.08	9.04	2.06
exis	187	20yr ARI	1.46	135.00	135.28	135.34	135.51660	0.33902	2.59	0.83	8.68	1.96
exis	187	100yr ARI15%CC	2.47	135.00	135.32	135.41	135.62770	0.36145	3.06	1.18	9.19	2.10
exis	187	PMF	8.77	135.00	135.47	135.66	136.10600	0.39016	4.56	2.77	11.17	2.38
exis	154	100yr ARI	2.14	130.00	130.53	130.64	130.91040	0.14797	2.78	0.81	2.55	1.45
exis	154	20yr ARI	1.46	130.00	130.45	130.53	130.73950	0.14695	2.39	0.63	2.37	1.39
exis	154	100yr ARI15%CC	2.47	130.00	130.56	130.68	130.98460	0.14734	2.93	0.90	2.63	1.47
exis	154	PMF	8.77	130.00	131.01	131.35	131.93190	0.12729	4.48	2.34	3.84	1.54
exis	123	100yr ARI	2.66	127.00	127.45	127.50	127.64200	0.08577	2.26	1.65	6.88	1.14
exis	123	20yr ARI	1.80	127.00	127.38	127.42	127.53970	0.08549	1.99	1.21	5.93	1.11
exis	123	100yr ARI15%CC	3.04	127.00	127.47	127.53	127.68100	0.08623	2.36	1.83	7.23	1.16
exis	123	PMF	12.00	127.00	127.88	127.94	128.19790	0.06965	3.31	5.87	12.86	1.16
exis	95	100yr ARI	2.66	125.00	125.56	125.46	125.62170	0.02372	1.30	2.81	8.70	0.61
exis	95	20yr ARI	1.80	125.00	125.49	125.40	125.53500	0.02189	1.12	2.20	8.08	0.57
exis	95	100yr ARI15%CC	3.04	125.00	125.59	125.48	125.65630	0.02410	1.37	3.06	8.95	0.62
exis	95	PMF	12.00	125.00	126.03	125.87	126.18140	0.02745	2.23	7.78	12.63	0.74
exis	82		Culvert									
exis	68	100yr ARI	2.66	123.00	124.92	123.75	124.92110	0.00013	0.29	17.89	19.68	0.07
exis	68	20yr ARI	1.80	123.00	124.87	123.65	124.87110	0.00007	0.20	16.94	19.18	0.05
exis	68	100yr ARI15%CC	3.04	123.00	124.94	123.79	124.93960	0.00016	0.32	18.25	19.86	0.08
exis	68	PMF	12.00	123.00	125.25	124.27	125.27310	0.00107	0.91	25.10	23.35	0.20
exis	67		Culvert									
exis	66	100yr ARI	2.66	123.00	123.75	123.75	123.91340	0.02857	1.96	1.95	6.87	0.85
exis	66	20yr ARI	1.80	123.00	123.64	123.64	123.79220	0.03173	1.80	1.31	5.40	0.86
exis	66	100yr ARI15%CC	3.04	123.00	123.79	123.79	123.95810	0.02834	2.04	2.21	7.37	0.85
exis	66	PMF	12.00	123.00	124.27	124.27	124.56820	0.02951	3.10	6.72	11.11	0.96
exis	40	100yr ARI	2.66	121.00	121.84	121.95	122.18990	0.07013	2.63	1.10	3.61	1.20

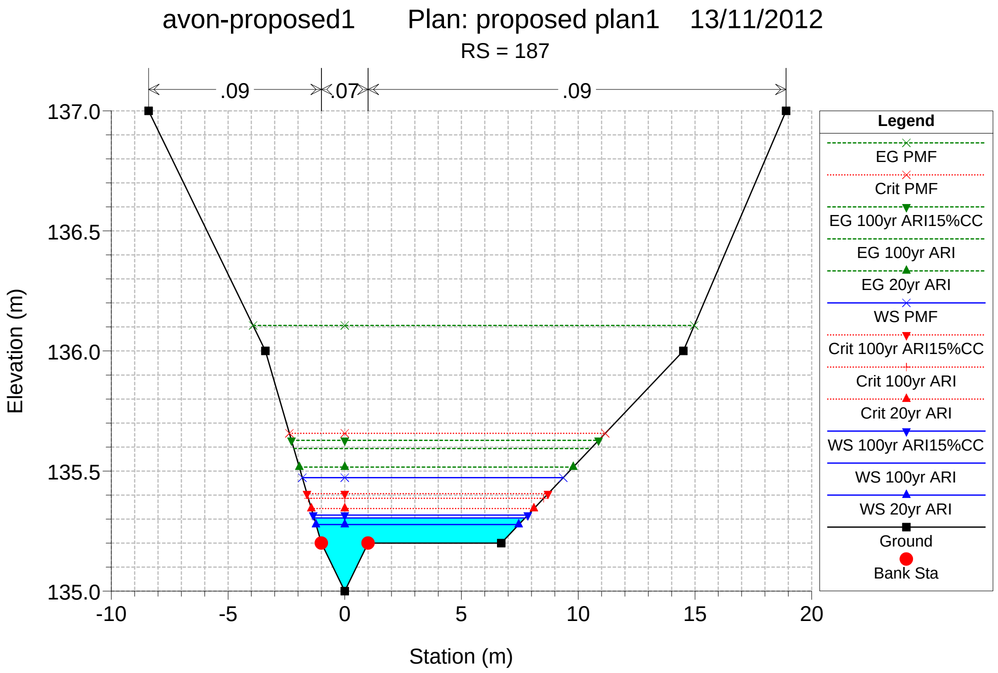
HEC-RAS Plan: p2 River: avon rd Reach: exis (Continued)

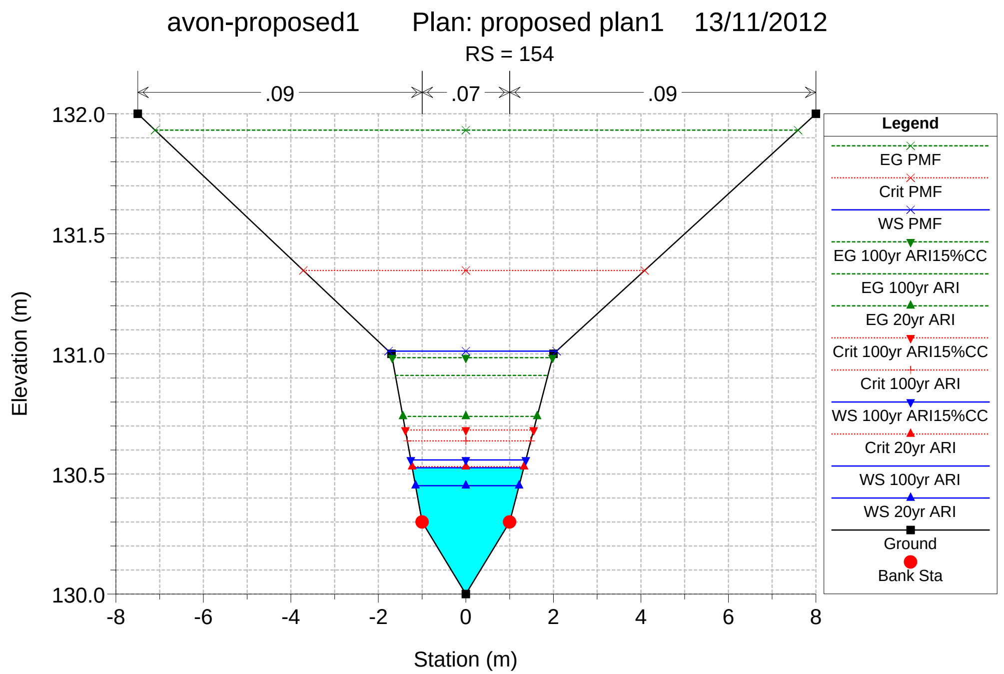
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
exis	40	20yr ARI	1.80	121.00	121.74	121.80	122.00850	0.07075	2.28	0.80	2.50	1.16
exis	40	100yr ARI15%CC	3.04	121.00	121.88	122.02	122.25430	0.06869	2.75	1.26	4.05	1.20
exis	40	PMF	12.00	121.00	122.39	122.58	123.01280	0.06040	4.03	4.37	7.65	1.26
exis	18	100yr ARI	3.18	119.30	120.52	120.33	120.57200	0.00648	1.17	4.56	13.04	0.40
exis	18	20yr ARI	2.14	119.30	120.30	120.18	120.38280	0.01399	1.41	2.17	7.94	0.56
exis	18	100yr ARI15%CC	3.61	119.30	120.61	120.36	120.64590	0.00513	1.11	5.71	14.87	0.36
exis	18	PMF	15.24	119.30	121.80	120.84	121.80870	0.00090	0.79	36.42	34.37	0.17
exis	0	100yr ARI	2.18	119.50	119.70	119.81	120.07870	0.02317	2.72	0.80	3.98	1.94
exis	0	20yr ARI	1.14	119.50	119.62	119.70	119.89750	0.03072	2.32	0.49	3.98	2.11
exis	0	100yr ARI15%CC	2.61	119.50	119.73	119.85	120.15070	0.02240	2.88	0.91	3.98	1.93
exis	0	PMF	14.24	119.50	120.22	120.59	121.46420	0.01830	4.93	2.89	3.99	1.85

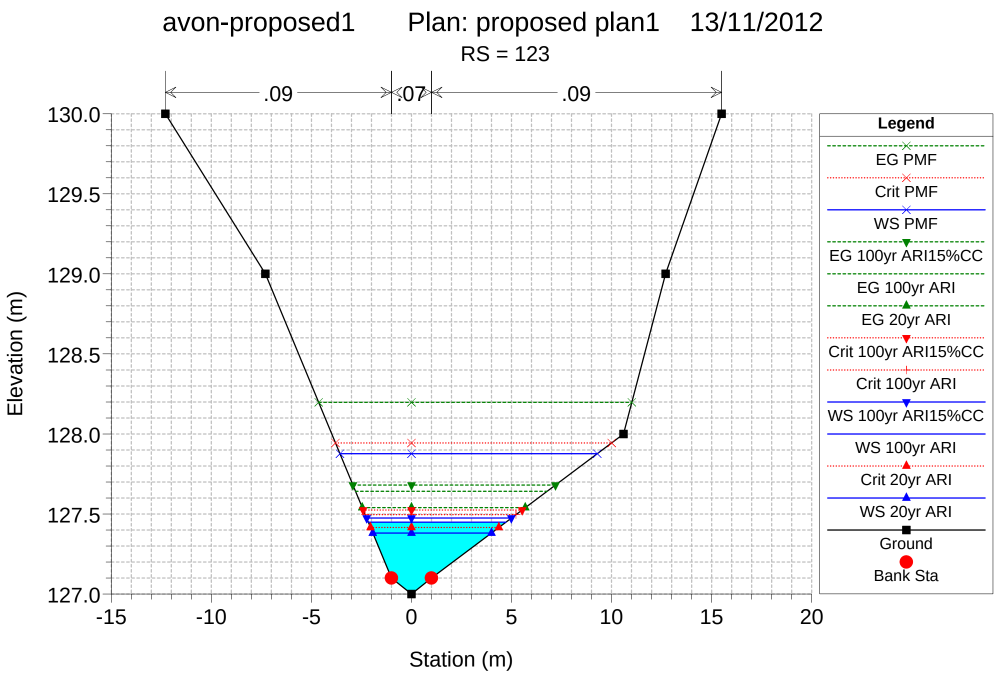


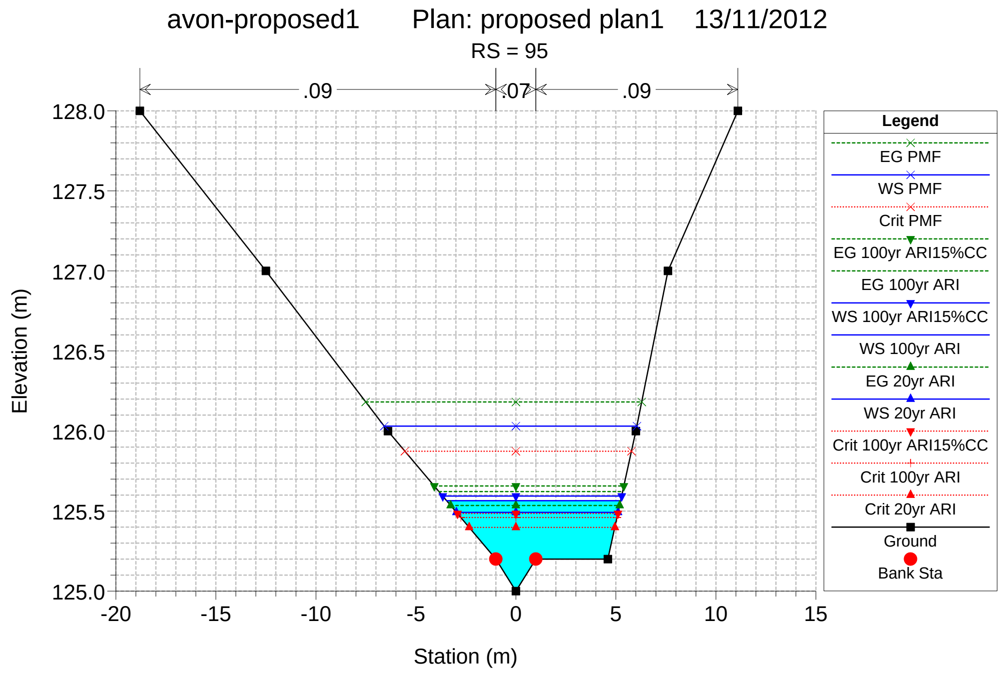
avon-proposed1 Plan: proposed plan1 13/11/2012
avon rd exis
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
Crit 20yr ARI
WS 100yr ARI
WS 20yr ARI
Ground
Elevation (m)
145
140
135
130
125
120
115
Chainage 18 (...
Chainage 40
Chainage 68
US weir wetland
Chainage 95
Chainage 123
Chainage 154
Chainage 187
Chainage 203 - top site -bdy railway
0
50
100
150
200
250
Main Channel Distance (m)


avon-proposed1 Plan: proposed plan1 13/11/2012
RS = 203
.09
.07
.09
Elevation (m)
142.0
141.5
141.0
140.5
140.0
139.5
-15
-10
-5
0
5
10
15
20
Station (m)
Legend
EG PMF
WS PMF
Crit PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
WS 100yr ARI15%CC
Crit 100yr ARI15%CC
WS 100yr ARI
Crit 100yr ARI
WS 20yr ARI
Crit 20yr ARI
Ground
Bank Sta


avon-proposed1 Plan: proposed plan1 13/11/2012
RS = 187
.09
.07
.09
Elevation (m)
137.0
136.5
136.0
135.5
135.0
-10
-5
0
5
10
15
20
Station (m)
Legend
EG PMF
Crit PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
WS PMF
Crit 100yr ARI15%CC
Crit 100yr ARI
Crit 20yr ARI
WS 100yr ARI15%CC
WS 100yr ARI
WS 20yr ARI
Ground
Bank Sta


avon-proposed1 Plan: proposed plan1 13/11/2012
RS = 154
.09
.07
.09
Elevation (m)
132.0
131.5
131.0
130.5
130.0
-8
-6
-4
-2
0
2
4
6
8
Station (m)
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
Crit 20yr ARI
WS 100yr ARI
WS 20yr ARI
Ground
Bank Sta


avon-proposed1 Plan: proposed plan1 13/11/2012
RS = 123
.09
.07
.09
Elevation (m)
130.0
129.5
129.0
128.5
128.0
127.5
127.0
-15
-10
-5
0
5
10
15
20
Station (m)
Legend
EG PMF
Crit PMF
WS PMF
EG 100yr ARI15%CC
EG 100yr ARI
EG 20yr ARI
Crit 100yr ARI15%CC
Crit 100yr ARI
WS 100yr ARI15%CC
WS 100yr ARI
Crit 20yr ARI
WS 20yr ARI
Ground
Bank Sta


avon-proposed1 Plan: proposed plan1 13/11/2012
RS = 95
.09
.07
.09
Elevation (m)
Station (m)
Legend
EG PMF
WS PMF
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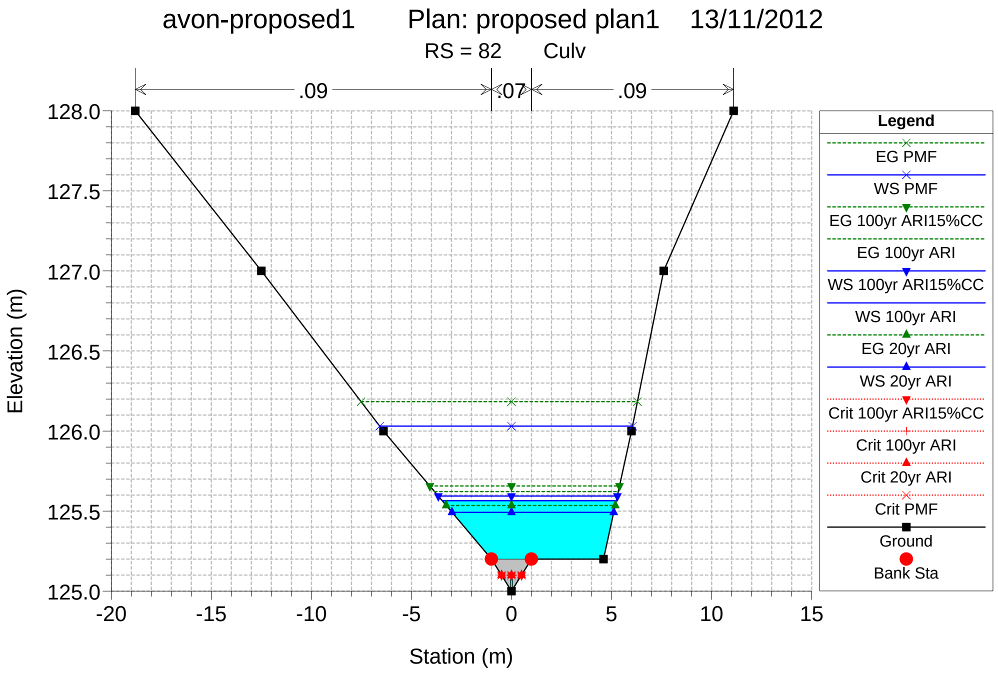
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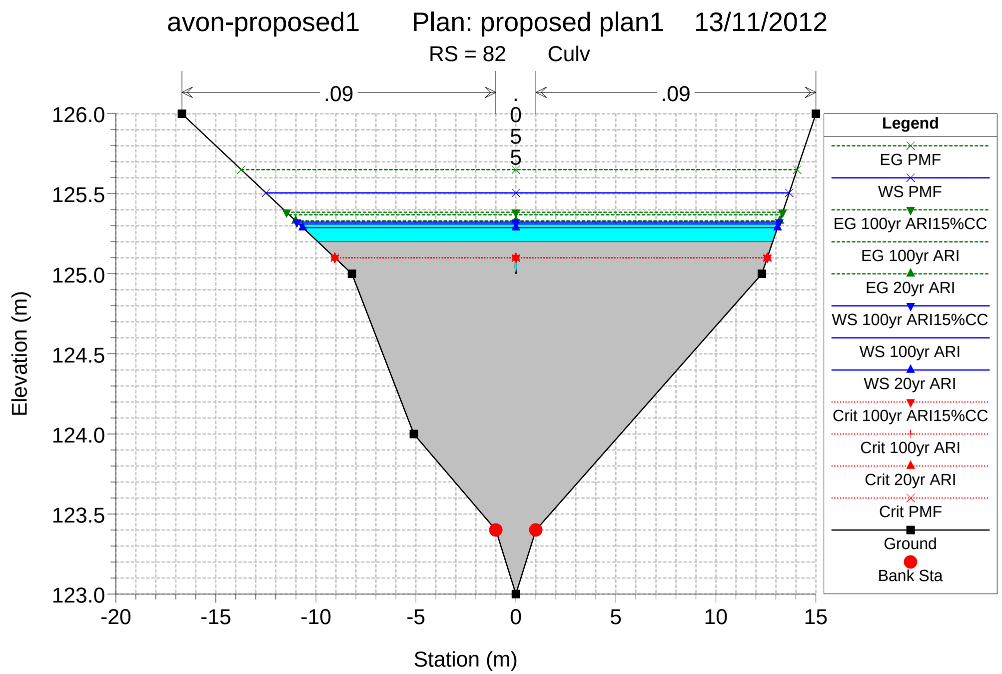
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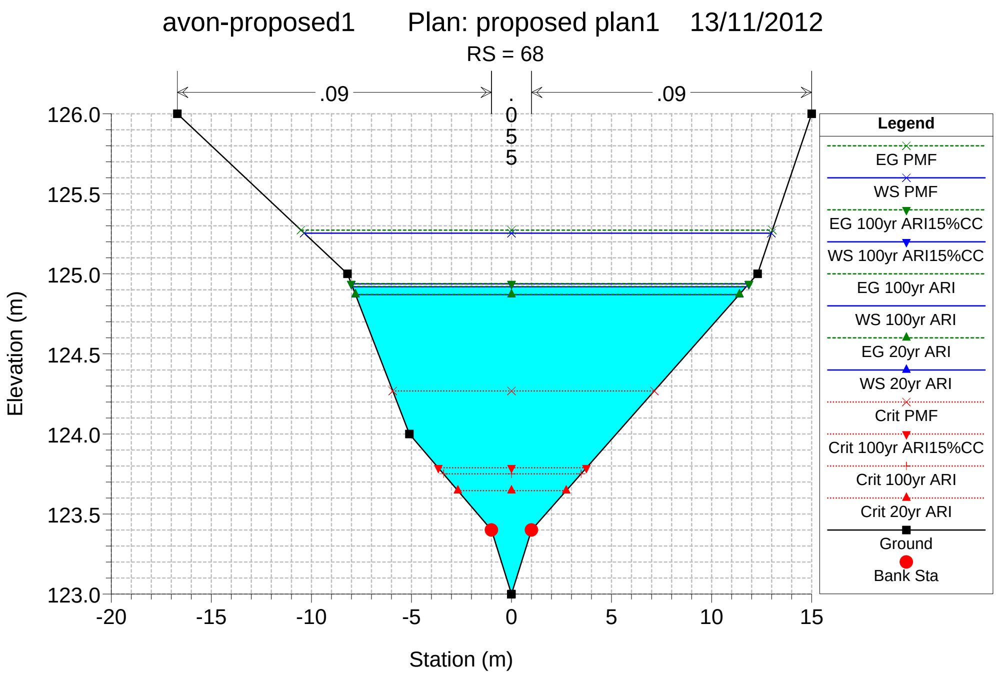
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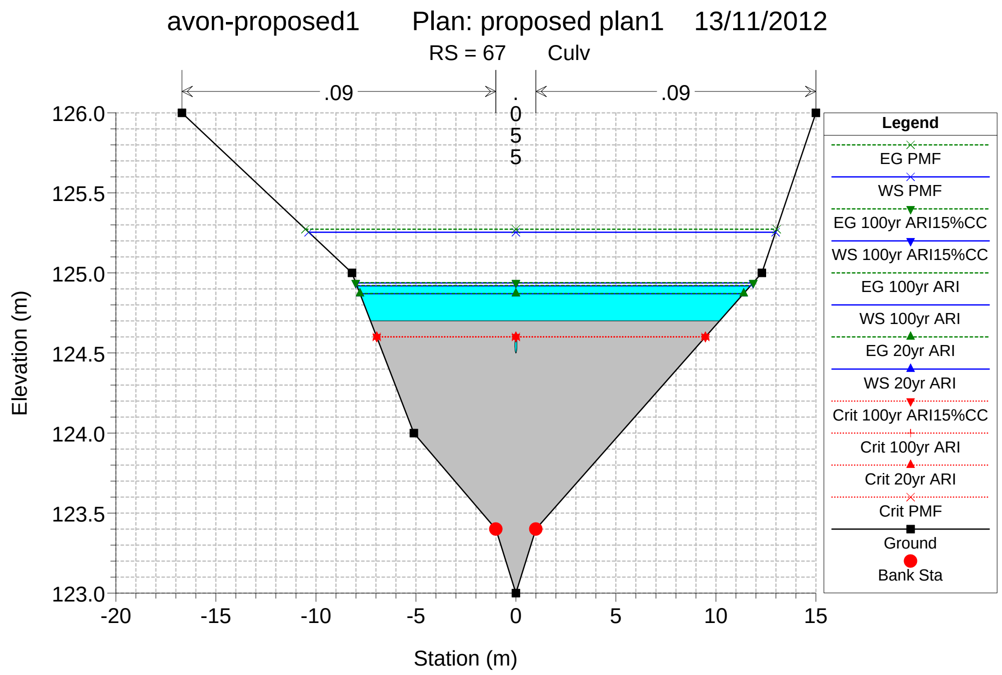
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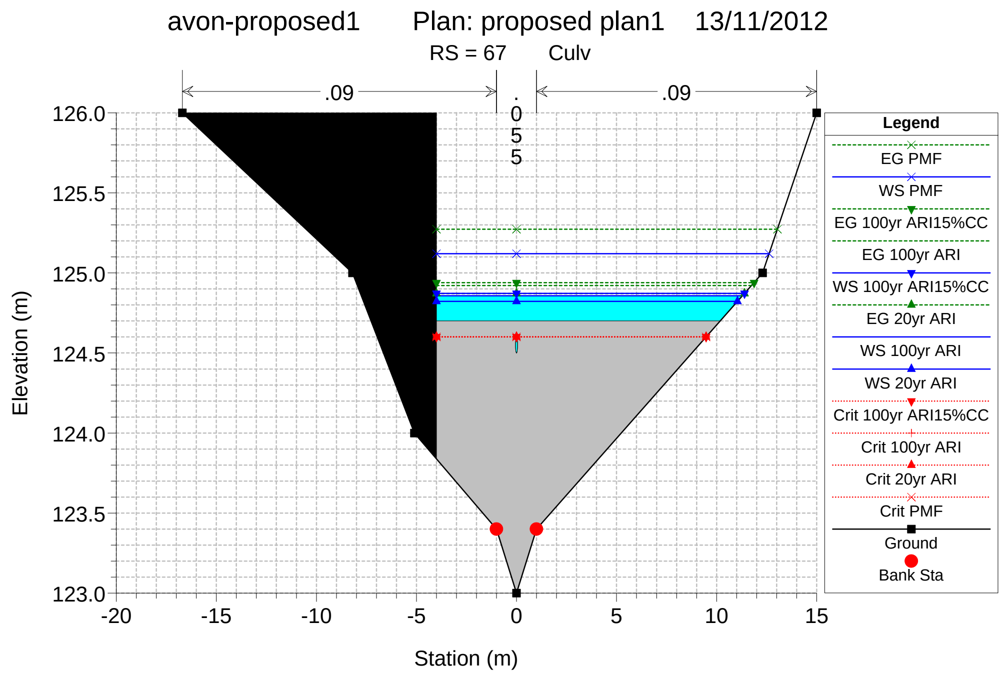
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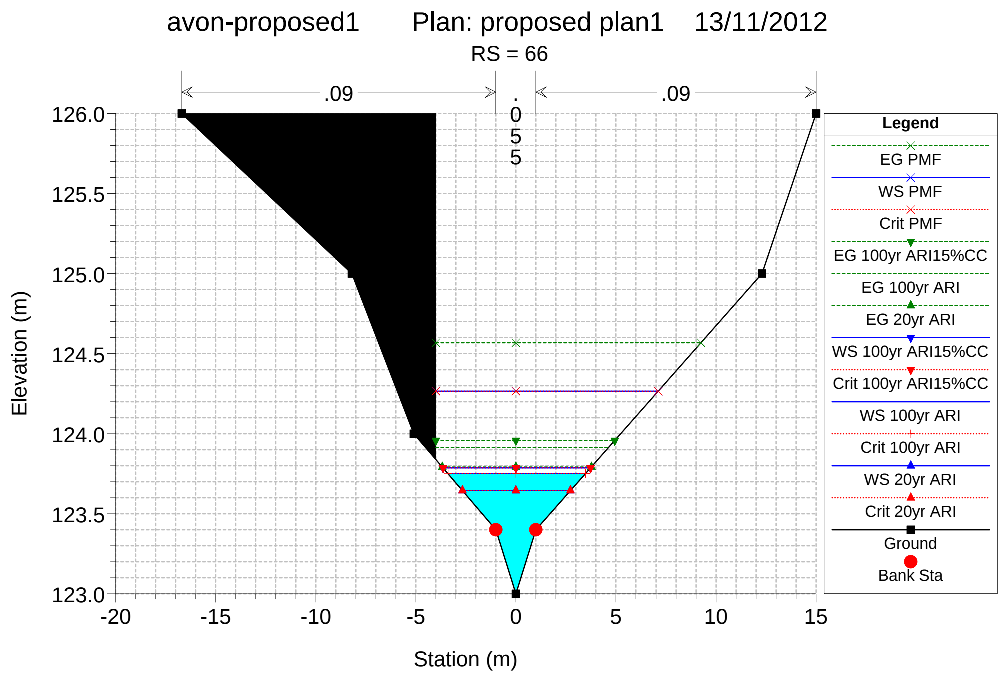
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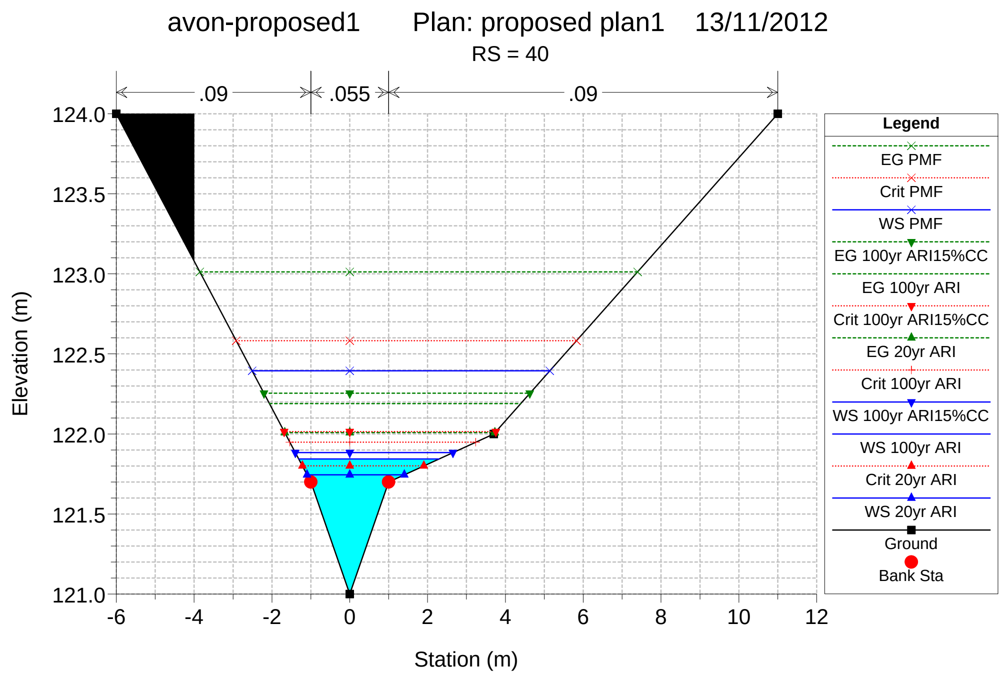
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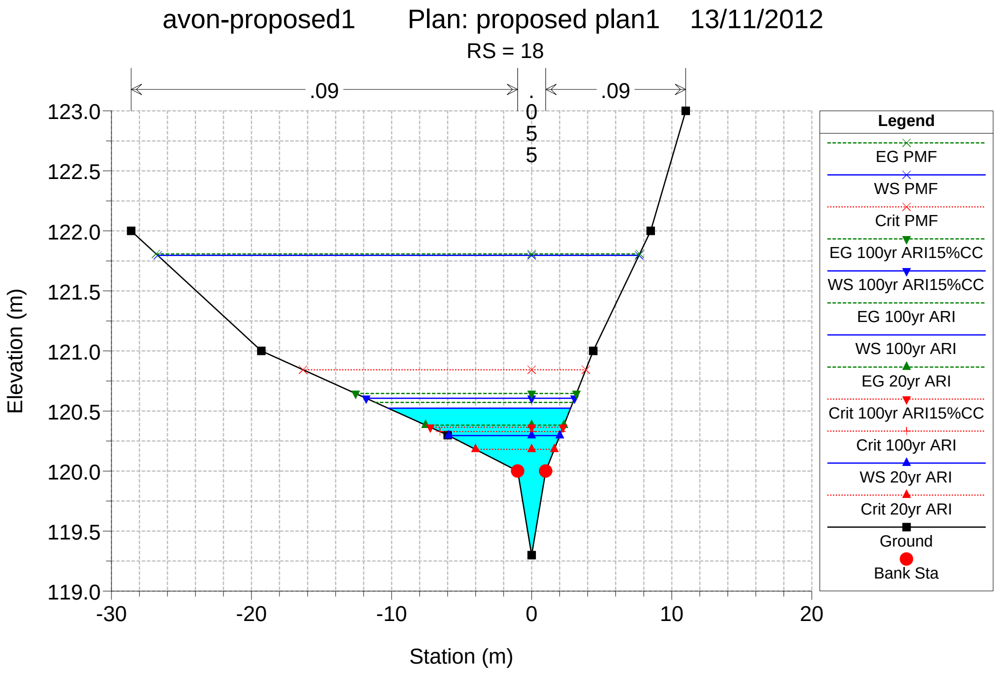
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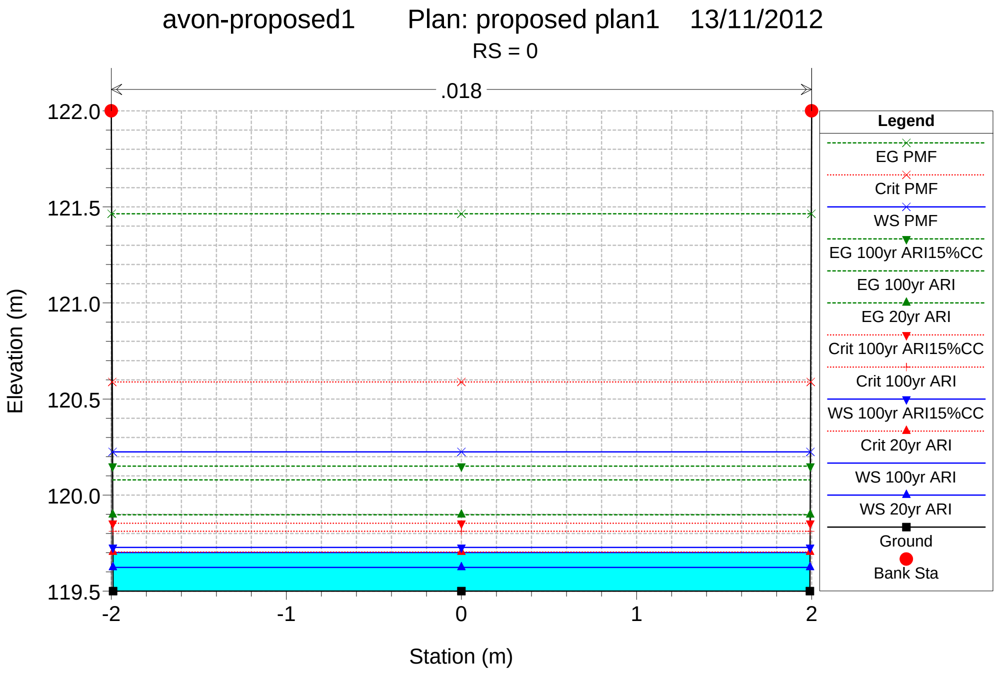
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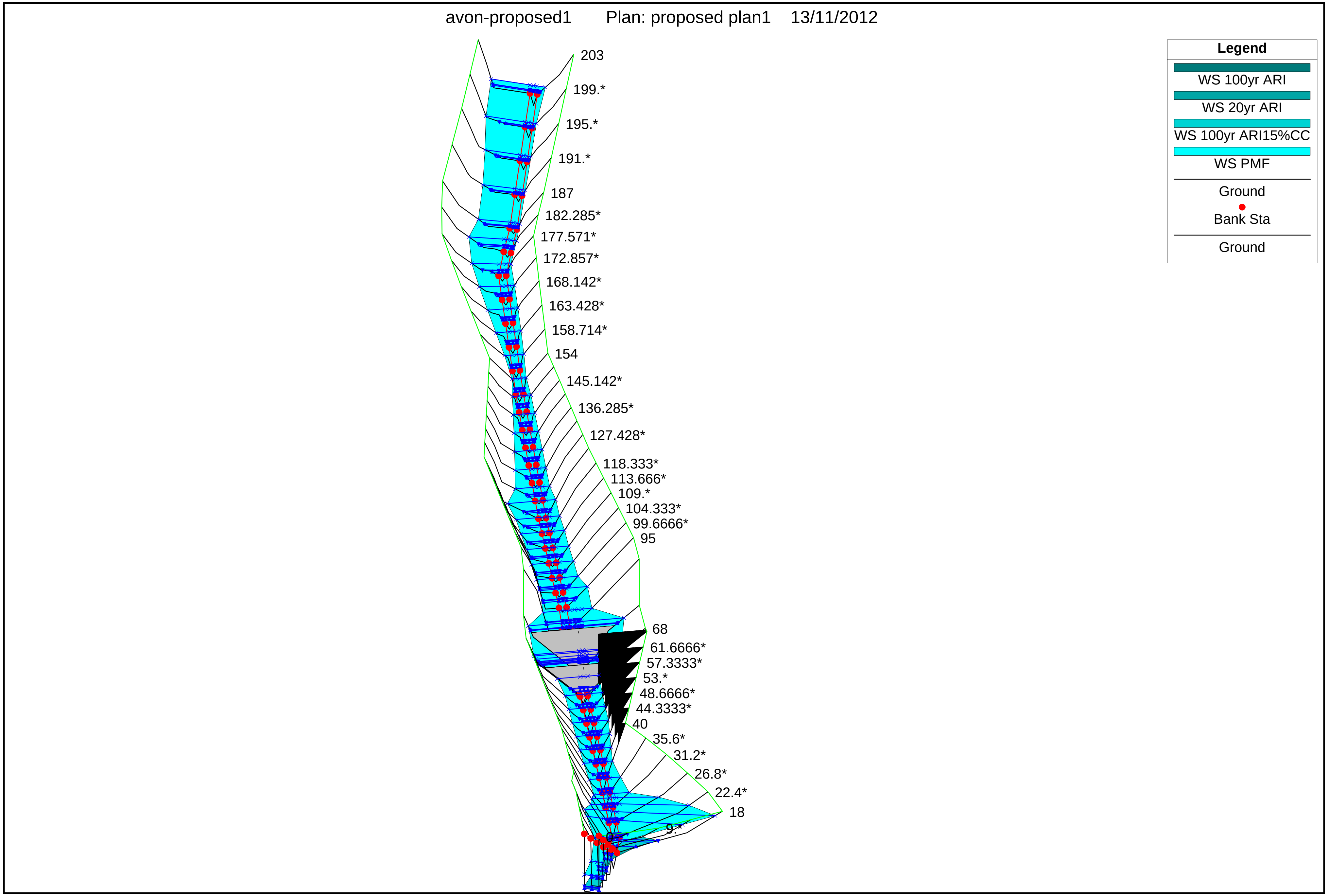

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APPENDIX H (*CV*)

Civil Certification
Accredited Certifiers
Civil Engineering
ABN 87 532 718 229
0412 264 237

Michael J Shaw
BE MIEAust CPEng NPER

Principal
Civil Certification

Resume

1. SUMMARY

Michael is a senior civil engineer with over 18 years experience in the fields of civil engineering, road design, drainage, hydrology, stormwater management and urban infrastructure design. He operates his own business specialising in private certification and stormwater management. Michael has worked on many civil design projects ranging from development of large scale strategic masterplans to detailed design of stormwater management facilities and urban infrastructure for residential subdivisions. His expertise lies in solving complicated drainage problems, water sensitive urban design (*WSUD*), flooding, detailed civil design, understanding the local government approvals process and managing multidisciplinary teams. Michael's experience covers all facets of civil engineering for urban development from due diligence through to approvals, detailed design, superintendency and certification. He has also provided expert advice to the Land and Environment Court with relation to drainage and stormwater quality issues.

2. EXPERIENCE

Positions held -& Location

Oct 2010 – Present	▶ Principal, Civil Certification, Sydney, NSW, Australia
April 2008- Sept 2010	▶ Manager, Urban Infrastructure, Environment Group - Worley Parsons, Sydney, NSW, Australia.
Aug. 2007- March 2008	▶ Principal Engineer – Urban Infrastructure - Worley Parsons incorporating Patterson Britton & Partners, Sydney, NSW, Australia;
Nov. 1997- Jul. 2007	▶ Senior Associate – Urban Infrastructure - Patterson Britton & Partners, Sydney, NSW, Australia;
Aug. 1996- Oct 1997	▶ Water Resources Engineer – Willing & Partners, Sydney, NSW, Australia;
Feb. 1991- Aug. 1994	▶ Design Engineer, Development Engineer, Investigation Engineer & Survey Assistant – Ryde City Council, Sydney, NSW, Australia.

Standout Projects

▶ ***Stormwater Management Strategies(SMS)***

-Port Jackson South Stormwater Management Plan *(2,870ha catchment*);

-Drummoyne Council Stormwater Quality Strategy *(830ha catchment*);

-Lake Illawarra South Stormwater Quality Strategy *(1,548ha catchment*);

-Elliot Lake Stormwater Quality Strategy *(1,220ha catchment*);

-Scotland Island SMS *(53ha catchment*);

-Corks Lane Milton, DA Stage SMS (*150 lot residential subdivision*);

-Pasadena, Church Point, DA Stage Stormwater Management and Reuse Strategy (*mixed use dev.*);

-Yallambee Ave West Gosford, DA Stage SMS *(100 lot residential subdivision*)

-CSIRO Greystanes, Employment Lands SMS *(60ha industrial site*);

-Warriewood Valley, Sector 3, Rezoning Stage SMS *(130 lot residential subdivision*);

-Warriewood Valley, Sector 8, Rezoning to Subdivision Certificate Stage SMS *(140 lot residential subdivision*);

-Warriewood Valley, Buffer Areas 1 and 2, Rezoning and DA Stage SMS (*300 lot residential subdivision*

-Warriewood Valley, Buffer Area 3, Rezoning and DA Stage SMS (*250 townhouse subdivision*);

-Macarthur Square Regional Centre Masterplan DA Stage WSUD Strategy (*61ha residential subdivision*);

-Department of Defence Site, Ermington ("*Ermington Riverfront*") DA Stage SMS (*20ha residential subdivision*

-West Kembla Grange, Wollongong, Aquatic Issues Assessment (*858ha catchment*);

-Eastwood Quarry, Masterplan/Rezoning Stage SMS (*20ha residential subdivision*);

-Perentie and Dawes Road Masterplan, Belrose, Stormwater Quality Strategy (*30ha residential subdivision*);

-Walter Road, Ingleside DA Stage SMS (*15ha rural residential subdivision*);

-Domayne, Austlink Park Belrose SMS (large *commercial use development*);

-Grassmere LES, Camden SMS (*50ha rural residential subdivision*);

-Warriewood Valley (*Sectors C, D, & 12*) Rezoning Stage SMS *(100 lot residential subdivision*); and

-Summer Hill Flour Mill Concept Plan Application Stormwater Management Plan and Flood Study (*250 dwelling high density residential subdivision*).

-Mt Penang Stormwater Management Strategy

-Ashlar Golf Course Redevelopment – Flood and WSUD Strategy for 100 dwelling Residential Subdivision.

- ***Water Sensitive Urban Design (WSUD)***

-Sand Filtration Unit, Drummoyne Park (*ie Stormwater Treatment*);

-Barnwell Park Golf Course Stormwater Treatment and Reuse;

-Powell Creek Reserve Eco Carpark

-Warriewood Valley, Sector 10, Detailed Design of WSUD elements (*bio-retention systems and wetland for 170 lot residential subdivision*);

-Warriewood Valley, Sector 12, Detailed Design of WSUD elements (*bio-retention systems and wetland for 180 lot residential subdivisio*n);

-Rouse Hill Regional Centre – Detailed design and performance analysis of bio retention systems, raingardens and constructed wetland;

-Hezlett Road, North Kellyville – Generic lot based raingarden design, road bio-retention swale design and detention offset analysis;

-Yoyager Point (DHA) – Detailed Design of Detention/Bio-Retention Basins for 200 lot residential subdivision.

- ***Riparian/Creek Design/Investigation***

-Wollondilly Shire Riparian Corridor Definition Study;

-Parsley Bay, Woollahra, Creekline Rehabilitation;

-Embankment Stabilisation Design, Koloona Ave, Byarong Creek ,Wollongong;

-Embankment Stabilisation Design, 5 sites along Cabbage Tree Creek, Towradgi Creek and Byarong Creek, Wollongong;

-Prospect Creek, Fairfield – Design of confluence stabilisation and creek rehabilitation measures;

-Narrabeen Creek, Pittwater – Detailed design of creek rehabilitation and embankment stabilisation measures from Graf Ave to Ponderosa Parade;

-Little Bay Central Drainage Corridor – Controlled Activity Approval and detailed design of Central Corridor Drainage Features (*ie wetlands, bio-retention basins, weirs, elevated walkways, bridges, pool/riffle creekline*).

-Sector 8 Warriewood – Controlled Activity Approval for residential development adjoining Fern Creek.

- ***Civil Subdivision Design***

-Potts Hill, Eastern Precinct – Lead design team for 13ha Industrial development of Sydney Water Surplus Lands. Engaged by Landcom to provide approval documentation for Part 3 Major Project and to deliver detailed design of all subdivision infrastructure (*ie civil, roads, RE walls, stormwater, power, sewer, water, recycled water and utility services*).

-Tweed Road, Lithgow, Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 38 lot residential subdivision;

-Sector 20, Warriewood, Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 63 lot residential subdivision;

-7 Orchard Road, Warriewood, Detailed Design of Lot Based Stormwater Management Facilities and Access Road for a 10 lot residential subdivision;

-Heritage Estates, Shoalhaven, Conceptual Design of Civil Infrastructure. (*water, sewage, utility services, roads and drainage*) for 20ha residential subdivision;

-Randwick Defence Site (*Stage 1A*), Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 80 lot residential subdivision; and

-Cooks Cove Development, Upgrade to Scarborough and Bicentennial Parks – Lead design team for approvals and detailed design of upgrade to park facilities, including carparks, creekline, stormwater drainage, bulk earthworks, access roads, services etc to accommodate future relocation of facilities from Cooks Cove development site (*Part 3A Major Project*).

Civil Certification
Accredited Certifiers
Civil Engineering
ABN 87 532 718 229
0412 264 237

Michael J Shaw
BE MIEAust CPEng NPER

Principal
Civil Certification

Resume

▸ ***Drainage Analysis/Design***

-Canada Bay Council city wide DRAINS modelling project *(970ha catchment*);

-Canada Bay Council Detention modelling and OSD policy development;

-City of Canada Bay Council MAPINFO drainage database update;

-Old Bathurst Road, Emu Plains, Detailed Design of Stormwater Management Facilities *(24ha industrial subdivision*)

-Andrew Road, Penrith, Detailed Design of Stormwater Management Facilities *(8ha industrial subdivision*)

-St Mervyns Ave, Woollahra, Stormwater Outlet Extension;

-Grosvenor Street Stormwater Drainage Study;

-Perentie and Dawes Road Masterplan, Belrose, Stormwater Drainage Concept Plan;

-Yulong Concept Drainage Study, Dept Defence Moorebank *(25ha industrial subdivision);*

-Headland Road, Curl Curl OSD Design;

-Cooper Park Amphitheatre , Woollahra, Detailed Stormwater Drainage Design;

-Paradise Avenue, Paradise Beach, Detailed Stormwater Drainage Design;

-Georges River Sailing Club, Seawall and Beach Nourishment Design;

-St Andrew Church, Wahroonga OSD and Stormwater Drainage Design;

-North Sydney Catchment Management Studies (*in total 86ha catchment*);

-Greystanes Estate, Northern Residential Lands, Detailed Design of Water Management Facilities (*70ha residential development*); and

-Barina Downs Road, Detention Basin Design (*large regional detention facility*).

-Robertson Road, Scotland Island – Detailed Stormwater Drainage Design

-Jenkins Road, Dundas - Detention System Design

-Lot 2 Muir Road, Chullora – Drainage and Detention System Design for Large Industrial Development.

▸ ***Flood Studies (FS)***

-Prospect Creek Channel Enhancement FS;

-Oats Ave, Gladesville FS;

-Casa Paloma Caravan Park FS;

-Kiaora Place Development, Double Bay FS;

-Darling Park/Cross City Tunnel - Flood impact assessment;

-Mowbray Road, Nursing Home, Assessment of overland flow impacts;

-Macquarie Links Golf Course FS (*Bunburry Curran Creek, Campbelltown*);

-Wigan Road, Dee Why FS;

-Green Road FS;

-Anzac Creek, Moorebank FS;

-Eastwood Hotel Drainage/Flooding Study;

-Mona Street, Mona Vale FS;

-Frenchs Creek FS;

-Darling Walk Flood Assessment, Darling Harbour; and

-Lynwood Ave, Dee Why Flood Assessment.

▸ ***Dam Hazard Assessment***

-Kellyville Ridge Dam, Second Ponds Creek, Dam Hazard Assessment;

-UWS Campbelltown Dam Hazard Assessment;

-Hume Golf Course, Albury Dam Hazard Assessment; and

-CSIRO, Greystanes Dam Hazard Assessment.

▸ ***Water Quality Monitoring***

-Sectors 2, 8 and 11 Warriewood, Post construction (*ie residential subdivision*) stormwater quality monitoring;

-Warriewood Valley (*Various Sectors*) Approval Stage Water Quality Monitoring over an 8 year period

-Shellharbour Council Stormwater Monitoring Strategy (*entire Shellharbour LGA - 14,000ha*);

-St Marys Eastern Precinct Water Quality Monitoring Strategy *(160ha residential subdivision*);

-Rouse Hill Regional Centre – Post development water quality monitoring of treatment measures and receiving waters (*Auto sampling and grab sampling*);

-Water Quality Sampling for Metal Recycling development, Ingleburn.

▸ ***Major Culvert Amplification Design***

-Careel Creek/Barrenjoey Road Culvert Amplification Works (*Pittwater Council and RTA*);

-Nareen Creek /Narrabeen RSL Culvert Entry Upgrade (*Pittwater Council)*;

-Howell Reserve Culvert Entry Upgrade and Drainage Diversion Line (*Pittwater Council);*

-Fern Creek/Garden Street Culvert Amplification (*Pittwater Council*);

-Narrabeen Creek/Ponderosa Pde Culvert Amplification (*Pittwater Council*); and

-Garie Beach Culvert Amplification (*RTA and NPWS*).

▸ ***Road/Carpark Design***

-Transport Infrastructure Development Corporation (*TIDC*) Commuter Car Park Program, Detailed Design of At Grade Carparks at Emu Plains Station, Woonona Station and Waterfall Station (over $1 million in fees)

- Rookwood Road Potts Hill, Detailed Design of RTA signalised intersection upgrade (*Landcom)*

-Brunker Road Potts Hill, Detailed Design of RTA signalised intersection upgrade (*Landcom)*

-Scotland Island Road Reserve Masterplan (*53ha area*);

-P&O Port Botany, Detailed Design of Staff Carparking Facilities *(50 spaces*);

-McKeown Street, Maroubra Beach, Detailed Road Design for streetscape improvement works;

-Department of Defence Site, Randwick (*Stages 1A, 1B and Community Centre*), Detailed Road Design for large residential subdivision(*5.6ha residential subdivision*);

-Greystanes Estate Northern Residential Land, Detailed Road Design for large residential subdivision *(50ha residential subdivision*);

-Sector 20 Warriewood, Detailed Road Design for large residential subdivision *(50ha residential subdivision*);

-Lidcombe Botanica, Detailed Road Design for heritage precinct of large residential subdivision; and

-Heffron Park Randwick, Detailed Design of 100 space carpark and associated road improvement works.

- ***Infrastructure/Servicing Strategies***

-Ermington Naval Stores *(700 lot residential development*);

-Greystanes Estate, Prospect (*250ha residential & employment development*);

-UWS Werrington *(48ha residential development*) ;

-Airds Town Centre Masterplan;

-Sector 7 (*2 Daydream Avenue*), Warriewood *(3ha mixed use commercial/light industrial development*);

-St Mary's (*ADI Site-Eastern Precinct-160ha residential development*);

-Green Square Master Plan, South Sydney (*Zetland*); and

-Mt Penang, Gosford Business Park development.

- ***Gross Pollutant Traps (GPT's)***

-Dee Why Beach GPT design (*special non proprietary*);

-Birkenhead Point and Brent Street GPTs (*special non proprietary*);

-St Georges Crescent Catchment Oil/Grit Separators (*multiple proprietary*);

-Stormwater Trust Application Assistance, Waterways Authority - Blackwattle Bay GPT;

-Brookvale Creek Rehabilitation – detailed design of large offline GPT/trash rack; and

-Drummoyne Council - Three Ways to Improve The Bays GPT Design Project (*special non proprietary*).

- ***General Civil Engineering***

-BER Sydney South, provision of general civil engineering design for Abigroup for a number of Schools in Sydney South.; and

-McCarr's Creek Road/Pittwater Road Inventory and Condition Assessment.

- ***Expert Advice / L&E Court / Certification***

-DA Stormwater management, West Ryde Urban Village Redevelopment for Ryde City Council (*ie acting on behalf of Council*);

-DA Stormwater management, Top Ryde Shopping Centre Redevelopment for Ryde City Council(*ie acting on behalf of Council*);

-Yulong Moorebank , review of road design for Department of Defence;

-Rushcutters Bay Flood Study Peer Review for Lindsay Bennelong Developments;

-Review of Managing Urban Stormwater Manual April 2004 on behalf of Landcom;

-Clontarf Street, Seaforth – Civil inspections for Landcom res. dev. on behalf of Manly Council;

-Sector 20, Warriewood – Superintendency for $6 million Civil Works Contract;

-Bunya Collector Road CC – Private certification assessment for Landcom

-Expert witness (*water quality on industrial site*) for L&E Court Case - Phiney Place, Ingleburn (*representing private developer*);

-Expert witness (*drainage, S88K easement)*) for L&E Court Case – Park Street, Mona Vale (*representing adjoining land owner*);

-Expert witness (*drainage/absorption system/easement*) for L&E Court Case – 120 Hopetoun Avenue, Vaucluse (*representing owner/developer*);

-Expert witness (*drainage/riparian corridor*) for L&E Court Case – 23B Macpherson Street, Warriewood (*representing private developer*);

-Expert witness (*riparian matters/controlled activity application/culvert creek cro*ssing) for Supreme Court Case – Wambo Coal Mine, Warkworth (*representing mine operator*);

-Expert witness (*water management, riparian definition*) for L&E Court Case – 70A Willandra Rd, Beacon Hill (*Retirement Village Appeal, Representing Warringah Council*)

-Expert Advice on behalf of Warringah Council – Kimbriki Redevelopment Proposal;

-Cat5 Compliance Inspections (*Private Certification*) for Civil Infrastructure at Putney Hill Residential Development, Charles Street Ryde;

-Expert Drainage advice for stormwater/seawall damage at a private property in Prince Alfred Parade, Newport;

-Construction Certificate issue (*Private Certification*) for subdivision works at Mount Street, Constitution Hill;

- Construction Certificate issue (*Private Certification*) for subdivision works at Crescent Road, Mona Vale.

-Muir Road, Chullora – Construction Stage Inspections (civil) for industrial development.

3. EDUCATION & PROFESSIONAL AFFILIATIONS

- Bachelor of Engineering (*Civil*), University of Technology, Sydney, 1996;
- Member, Institution of Engineers, Australia (*MIEAust*);
- Charted Professional Engineer (*CPEng*);
- National Professional Engineers Register (*NPER - Civil*);
- NSW Accredited Certifier (*BPAct 2005*) – Categories B1, C1, C2, C3, C4, C6, C15 (*BPB 0816)*

APPENDIX I (*Sediment Basin Sizing*)

Note: These "Standard Calculation" spreadsheets relate only to low erosion hazard lands as identified in figure 4.6 where the designer chooses to not use the RUSLE to size sediment basins. The more "Detailed Calculation" spreadsheets should be used on high erosion hazard lands as identified by figure 4.6 or where the designer chooses to run the RUSLE in calculations.

1. Site Data Sheet

Site name: **Avon Rd Pymble**

Site location: **Ku-ring-gai LGA**

Precinct:

Description of site: **Assumes Type D soils of low to moderate erosion hazard**

Site area	**Site**						**Remarks**
	A	B					
Total catchment area (ha)	1.5						The site is a self contained catcment
Disturbed catchment area (ha)	1.5						The entire site area is disturbed

Soil analysis

Soil landscape	Ku-ring-gai						DIPNR mapping (if relevant)
Soil Texture Group	Type D						Sections 6.3.3(c), (d) and (e)

Rainfall data

Design rainfall depth (days)	4						See Sections 6.3.4 (d) and (e)
Design rainfall depth (percentile)	80						See Sections 6.3.4 (f) and (g)
x-day, y-percentile rainfall event	25						See Section 6.3.4 (h)
Rainfall intensity: 2-year, 6-hour storm	13.2						See IFD chart for the site
Rainfall erosivity (R-factor)	6500						Automatic calculation from above data

Comments:

4. Volume of Sediment Basins, *Type D* and *Type F* Soils

Basin volume = settling zone volume + sediment storage zone volume

Settling Zone Volume

The settling zone volume for *Type F* and *Type D* soils is calculated to provide capacity to contain all runoff expected from up to the y-percentile rainfall event. The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle and can be determined by the following equation:

$$V = 10 \times C_v \times A \times R_{y\text{-\%ile, x-day}} \ (m^3)$$

where:

10 = a unit conversion factor

C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period

R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events. (See Sections 6.3.4(d), (e), (f), (g) and (h)).

A = total catchment area (ha)

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 50 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.4(i)(ii)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	C_v	R x-day y-%ile	Total catchment area (ha)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)
A	0.45	25	1.5	168.75	84	253.125
B	0.45					

Appendix B – CIVILCERT REPORT - STAGE 1 PROJECT APPLICATION

Civil Certification
Accredited Certifiers
Civil Engineering

53 Werona Avenue
Gordon, NSW, 2072
0412 264 237

ABN 87 532 718 229

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JW Neale Pty Ltd (*Receivers and Managers Appointed*)
C/O NPC Pty Ltd
Level 4, 10 Clarke Street
Crows Nest, NSW, 2059

Thursday, 22 November 2012

Attention: Mark Tooker

Dear Mark,

AVON AND BEECHWORTH RD, PYMBLE
MAJOR PROJECT (*MP10-0219*)
STAGE 1 PROJECT APPLICATION
STORMWATER AND DRAINAGE MANAGEMENT CONCEPT PLAN

1. INTRODUCTION

Civil Certification has been engaged by NPC on behalf of JW Neale Pty Ltd (*Receivers and Managers Appointed*) to carry out a stormwater and drainage management assessment for the proposed residential development at the above site.

A detailed report covering the entire site has already been completed by Civil Certification titled "*Avon and Beechworth Rd, Pymble - Major Project Application (MP10-0219) Stormwater and Drainage Management Concept Plan*" 16 November 2012.

This report is an addendum to the above report covering the first stage of the development and should be read in conjunction with the site wide report.

2. STAGE 1

The extent of development proposed for the Stage 1 Project Application is illustrated in **Figure 9**.

The proposed works are summarised as follows:

- Construction of Building #1 and all associated utility services, carparking facilities and landscaping;
- Construction of retaining walls immediately downslope of Building #1;
- Construction of driveway entrance to Avon Road;
- Construction of 20yr ARI capacity drainage pipeline to discharge into central drainage line;

- Construction of pipeline outlet stabilisation measures;
- Construction of wetland/pond #1; and
- Construction/rehabilitation of drainage between wetland/pond#1 and downstream boundary of site.

3. EXISTING DRAINAGE, HYDROLOGY AND FLOODING

For details of the existing drainage systems within the site, hydrology and flooding refer to our 16 November 2012 site wide report.

Note that Building 1 is located well above the central drainage line and is unaffected by flooding from this source.

4. PROPOSED STORMWATER MANAGEMENT STRATEGY

The stormwater management strategy for Stage 1 aligns with the overall strategy for the site.

Stage 1 runoff will be directed to the existing drainage line located at the centre of the site.

Roof runoff will be collected from Building 1, stored in a 20KL tank and reused internally for non-potable purposes. Overflow from the rainwater tank and runoff from external pavements will be directed to a 125m^3 detention tank. Outflows from the tank will be piped to the central drainage line and discharge via a stabilised outlet into the central drainage line and wetland #1.

The wetland/pond that will be utilised for the ultimate development will be constructed as part of Stage 1 to treat runoff from Building #1. This will obviously exceed the requirements for Stage 1 alone as the wetland has been designed to cater for the full development.

The drainage line downstream of the wetland will be stabilised and rehabilitated to the downstream site boundary.

MUSIC modelling has been completed to assess the effectiveness of the proposed WSUD measures to be implemented in Stage 1. The results are summarised in **Table 1** and illustrate that the proposed measures exceed the minimum requirements. For full details of the MUSIC model refer to **Appendix B**.

5. EROSION AND SEDIMENT CONTROL PLAN

Prior to executing the construction phase of Stage 1, a detailed erosion and sediment control plan would be developed for the site in accordance with Ku-ring-gai Councils guidelines and the NSW Blue Book (*NSW DECC publication titled "Managing Urban Stormwater – Soils and Construction" January 2008*).

The erosion and sediment control plan will outline the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction (*ie primarily as a result of erosion*).

A summary of the principal elements of a preferred erosion and sediment control plan for the site is summarised below:

- Minimising the extent of disturbed surfaces at any one time (*i.e. staging of earthworks etc*);
- Stabilising disturbed surfaces immediately upon completion of works (*i.e. hydromulch or vegetation*);
- Diverting clean runoff around disturbed work areas (*i.e. using earth bunds/diversion mounds/channels*);
- Protecting stockpiles (*i.e. using silt fence, diversion bunds, temporary vegetative cover etc*);
- Implementation of dust control/suppression measures during works(*i.e. perimeter fencing, wind velocity monitoring, cessation of earthworks activities during high wind conditions, watering down disturbed areas, setup of recycled water irrigation sprays etc*);
- Use of sediment basins;
- Use of silt fencing downslope of disturbed surfaces;
- Use of silt socks or equivalent around existing drainage structures;
- Use of rock /haybale/mulch check dams along designated overland flow paths;
- Protection of exposed slopes;
- Restriction of vehicle entry/exit points to construction zones;
- Setup of stabilised site access points; and
- Setup of vehicle washdown/wheel wash baths at exit points of disturbed areas.

An illustration of the conceptual erosion and sediment control plan for the site is contained in **Figure 10.** Sediment basin sizing calculations are included at **Appendix A**.

Table 1 – Stage 1 MUSIC MODELLING RESULTS

Music model	**Location**	**Annual Flow and Pollutant Load Results**				
		Flow	**TSS**	**TP**	**TN**	**GP**
		(ML/yr)	**(kg/yr)**	**(kg/yr)**	**(kg/yr)**	**(kg/yr)**
Developed (With Treatment)						
	All Source Nodes	3.93	698	1.39	11.3	97.3
	Residual Load at Outlet	0.861	61.7	0.181	1.91	0
% Treat Train Effectiveness		**78.1**	**91.2**	**86.9**	**83.1**	**100**
Achieve Objectives			>80%	>60%	>45%	>90%
			Yes	Yes	Yes	Yes

6. CONCLUSIONS

The following conclusions have been derived from this water management assessment:

- 100yr ARI and PMF flooding does not impact on Building #1;
- The proposed development will manage water quality by implementing best practice WSUD treatment facilities. The treatment rates achieved in Stage 1 exceed the minimum requirements;
- On Site detention is proposed in accordance with Councils requirements to mitigate any increase in flows generated by the development. Preliminary modelling has shown that peak flows experienced downstream of the site will be reduced; and
- New site drainage will be implemented to prevent nuisance flooding and protect the central drainage line.

7. QUALIFIERS

This report has been prepared by Mr Michael John Shaw. A copy of Michael's CV is included at **Appendix C**.

This report has been prepared for the benefit of JW Neale Pty Ltd (*Receivers and Managers Appointed*) with relation to the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Civil Certification. In preparing this report I have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended.

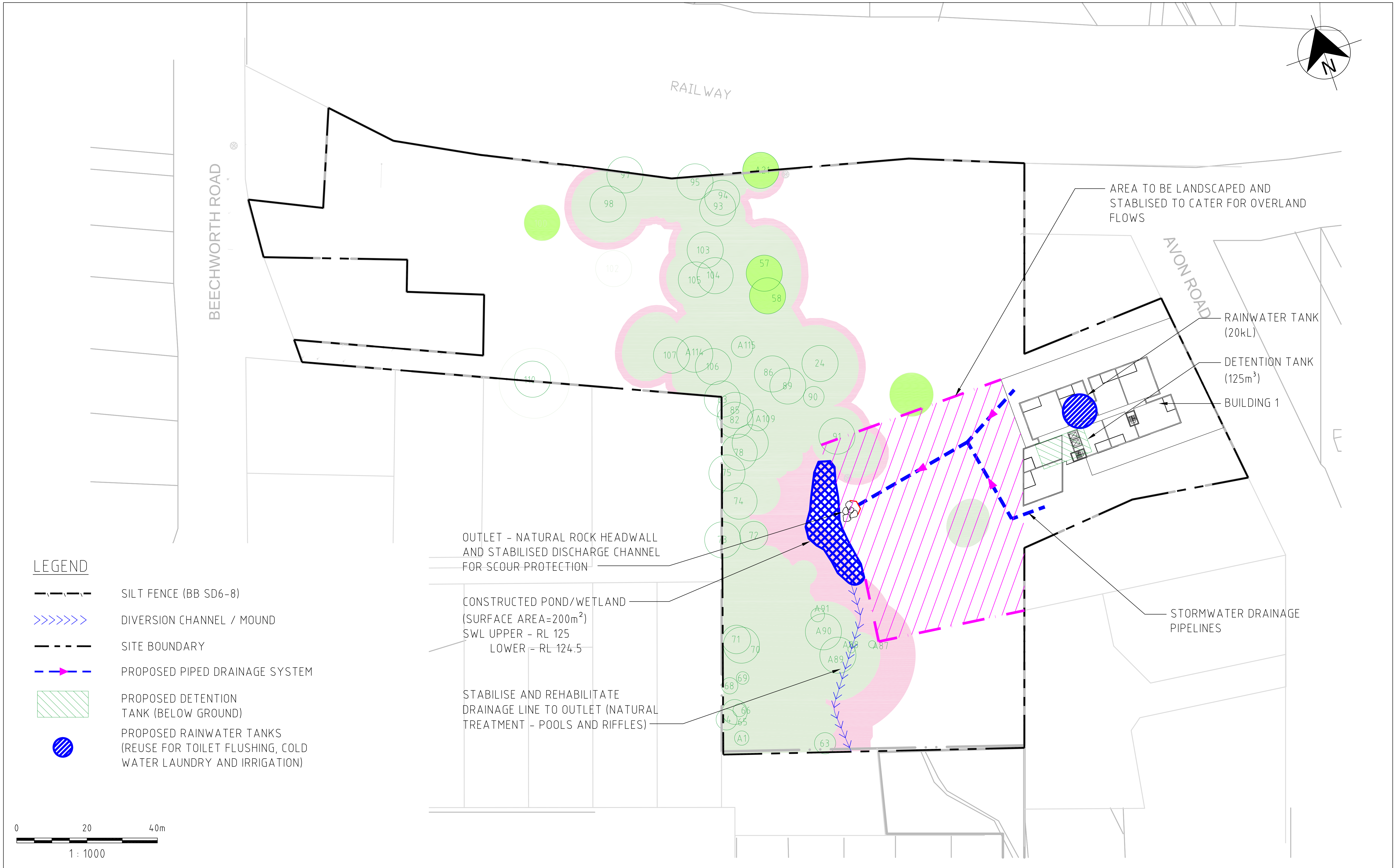
We trust this report is satisfactory. Should you have any further queries, please do not hesitate to contact me on 0412 264 237.

Yours faithfully

CIVIL CERTIFICATION

Michael Shaw
BE(Civil) MIEAust CPEng NPER(Civil)
Accredited Certifier (BPB 0816)
Principal
0412 264 237
michael.shaw@civilcertification.com

FIGURES



No.	Date	Revision Details	Des.	Ver.	App.
A	21.11.12	DA ISSUE	MS	MS	MS

CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW

Client: JW NEALE PTY LTD (RECEIVERS AND MANAGERS APPOINTED)

Project: AVON ROAD, PYMBLE

Drawn MC	Signed	Date 21.11.12
Designed	Signed	Date
Verified	Signed	Date
Approved MS	Signed	Date 21.11.12

Drawing Title: STAGE 1 PROJECT APPLICATION STORMWATER DRAINAGE CONCEPT PLAN

FIGURE 9

Scale 1:1000 | Sheet Size A3

Drawing No. 1001 | Rev. A

A	21.11.12	DA ISSUE	MS	MS	MS
No.	Date	Revision Details	Des.	Ver.	App.

Civil Cert

CIVIL CERTIFICATION
53 WERONA AVE
GORDON
M: 0412 264 237
MICHAEL SHAW

Client:
JW NEALE PTY LTD
(RECEIVERS AND MANAGERS APPOINTED)

Project:
AVON ROAD, PYMBLE

Drawn MC	Signed	Date 21.11.12
Designed	Signed	Date
Verified	Signed	Date
Approved MS	Signed	Date 21.11.12

Drawing Title:
STAGE 1
EROSION & SEDIMENT
CONTROL PLAN

FIGURE 10

Scale 1:1000	Sheet Size A3
Drawing No. 1002	Rev. A

20 10 0 10 20 30 40 50mm

APPENDIX A (*Sediment Basin Sizing – Stage 1*)

Note: These "Standard Calculation" spreadsheets relate only to low erosion hazard lands as identified in figure 4.6 where the designer chooses to not use the RUSLE to size sediment basins. The more "Detailed Calculation" spreadsheets should be used on high erosion hazard lands as identified by figure 4.6 or where the designer chooses to run the RUSLE in calculations.

1. Site Data Sheet

Site name: **Avon Rd Pymble - Stage 1 PA**

Site location: **Ku-ring-gai LGA**

Precinct:

Description of site: **Assumes Type D soils of low to moderate erosion hazard**

Site area	Site						Remarks
	A	B					
Total catchment area (ha)	0.375						The site is a self contained catcment
Disturbed catchment area (ha)	0.375						The entire site area is disturbed

Soil analysis

Soil landscape	Ku-ring-gai						DIPNR mapping (if relevant)
Soil Texture Group	Type D						Sections 6.3.3(c), (d) and (e)

Rainfall data

Design rainfall depth (days)	4						See Sections 6.3.4 (d) and (e)
Design rainfall depth (percentile)	80						See Sections 6.3.4 (f) and (g)
x-day, y-percentile rainfall event	25						See Section 6.3.4 (h)
Rainfall intensity: 2-year, 6-hour storm	13.2						See IFD chart for the site
Rainfall erosivity (R-factor)	6500						Automatic calculation from above data

Comments:

4. Volume of Sediment Basins, *Type D* and *Type F* Soils

Basin volume = settling zone volume + sediment storage zone volume

Settling Zone Volume

The settling zone volume for *Type F* and *Type D* soils is calculated to provide capacity to contain all runoff expected from up to the y-percentile rainfall event. The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle and can be determined by the following equation:

$$V = 10 \times C_v \times A \times R_{y\text{-\%ile, x-day}} \ (m^3)$$

where:

10 = a unit conversion factor

C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period

R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events. (See Sections 6.3.4(d), (e), (f), (g) and (h)).

A = total catchment area (ha)

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 50 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.4(i)(ii)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	C_v	R x-day y-%ile	Total catchment area (ha)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)
A	0.45	25	0.375	42.1875	21	63.28125
B	0.45					

APPENDIX B (*MUSIC*)

Source nodes

Location,Building B Roof,Building B Non Roof
ID,2,4
Node Type,UrbanSourceNode,UrbanSourceNode
Total Area (ha),0.08,0.295
Area Impervious (ha),0.08,0.220698788927336
Area Pervious (ha),0,0.0743012110726643
Field Capacity (mm),50,172
Pervious Area Infiltration Capacity coefficient - a,50,200
Pervious Area Infiltration Capacity exponent - b,2,1
Impervious Area Rainfall Threshold (mm/day),1.5,1.5
Pervious Area Soil Storage Capacity (mm),150,300
Pervious Area Soil Initial Storage (% of Capacity),25,20
Groundwater Initial Depth (mm),50,1
Groundwater Daily Recharge Rate (%),0.65,0.25
Groundwater Daily Baseflow Rate (%),0.85,0.05
Groundwater Daily Deep Seepage Rate (%),0,0.04
Stormflow Total Suspended Solids Mean (log mg/L),1.55,2.2
Stormflow Total Suspended Solids Standard Deviation (log mg/L),0.39,0.32
Stormflow Total Suspended Solids Estimation Method,Stochastic,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0,0
Stormflow Total Phosphorus Mean (log mg/L),-0.92,-0.45
Stormflow Total Phosphorus Standard Deviation (log mg/L),0.29,0.25
Stormflow Total Phosphorus Estimation Method,Stochastic,Stochastic
Stormflow Total Phosphorus Serial Correlation,0,0
Stormflow Total Nitrogen Mean (log mg/L),0.42,0.42
Stormflow Total Nitrogen Standard Deviation (log mg/L),0.19,0.19
Stormflow Total Nitrogen Estimation Method,Stochastic,Stochastic
Stormflow Total Nitrogen Serial Correlation,0,0
Baseflow Total Suspended Solids Mean (log mg/L),1.1,1.1
Baseflow Total Suspended Solids Standard Deviation (log mg/L),0.17,0.17
Baseflow Total Suspended Solids Estimation Method,Stochastic,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0,0
Baseflow Total Phosphorus Mean (log mg/L),-0.82,-0.82
Baseflow Total Phosphorus Standard Deviation (log mg/L),0.19,0.19
Baseflow Total Phosphorus Estimation Method,Stochastic,Stochastic
Baseflow Total Phosphorus Serial Correlation,0,0
Baseflow Total Nitrogen Mean (log mg/L),0.32,0.32
Baseflow Total Nitrogen Standard Deviation (log mg/L),0.12,0.12
Baseflow Total Nitrogen Estimation Method,Stochastic,Stochastic
Baseflow Total Nitrogen Serial Correlation,0,0
OUT - Mean Annual Flow (ML/yr),0.978,2.95
OUT - TSS Mean Annual Load (kg/yr),53.4,596
OUT - TP Mean Annual Load (kg/yr),0.148,1.25
OUT - TN Mean Annual Load (kg/yr),2.83,8.50
OUT - Gross Pollutant Mean Annual Load (kg/yr),23.0,74.3
Rain In (ML/yr),1.1215,4.13553
ET Loss (ML/yr),0.1434,1.14744
Deep Seepage Loss (ML/yr),0,0.00624375
Baseflow Out (ML/yr),0,0.0078015
Imp. Stormflow Out (ML/yr),0.9781,2.70506
Perv. Stormflow Out (ML/yr),0,0.240011
Total Stormflow Out (ML/yr),0.9781,2.94507
Total Outflow (ML/yr),0.9781,2.95287
Change in Soil Storage (ML/yr),0,0.02898
TSS Baseflow Out (ML/yr),0,0.105913
TSS Total Stormflow Out (ML/yr),53.3906,596.174
TSS Total Outflow (ML/yr),53.3906,596.28
TP Baseflow Out (ML/yr),0,0.00129725
TP Total Stormflow Out (ML/yr),0.147588,1.24835
TP Total Outflow (ML/yr),0.147588,1.24965
TN Baseflow Out (ML/yr),0,0.016913
TN Total Stormflow Out (ML/yr),2.82676,8.48161
TN Total Outflow (ML/yr),2.82676,8.49853
GP Total Outflow (ML/yr),22.9673,74.3301

No Imported Data Source nodes

USTM treatment nodes

Location,RWTB,Wetland1
ID,3,6
Node Type,RainWaterTankNode,WetlandNode
Lo-flow bypass rate (cum/sec),0,0

```
Hi-flow bypass rate (cum/sec),1,1
Inlet pond volume,0,15
Area (sqm),10,200
Extended detention depth (m),0.05,0.2
Permanent Pool Volume (cubic metres),20,200
Proportion vegetated,0,0.5
Equivalent Pipe Diameter (mm),50,50
Overflow weir width (m),10,3
Notional Detention Time (hrs),0.107,4.27
Orifice Discharge Coefficient,0.6,0.6
Weir Coefficient,1.7,1.7
Number of CSTR Cells,2,5
Total Suspended Solids - k (m/yr),400,5000
Total Suspended Solids - C* (mg/L),12,6
Total Suspended Solids - C** (mg/L),12,6
Total Phosphorus - k (m/yr),300,2800
Total Phosphorus - C* (mg/L),0.13,0.09
Total Phosphorus - C** (mg/L),0.13,0.09
Total Nitrogen - k (m/yr),40,500
Total Nitrogen - C* (mg/L),1.4,1.3
Total Nitrogen - C** (mg/L),1.4,1.3
Threshold Hydraulic Loading for C** (m/yr),3500,3500
Horizontal Flow Coefficient, ,
Extraction for Re-use,On,Off
Annual Re-use Demand - scaled by daily PET (ML),0,
Annual Re-use Demand - scaled by daily PET - Rain (ML),0,
Constant Daily Re-use Demand (kL),5,
User-defined Annual Re-use Demand (ML),0,
Percentage of User-defined Annual Re-use Demand Jan,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Feb,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Mar,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Apr,8.33333333333333,
Percentage of User-defined Annual Re-use Demand May,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Jun,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Jul,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Aug,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Sep,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Oct,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Nov,8.33333333333333,
Percentage of User-defined Annual Re-use Demand Dec,8.33333333333333,
User-defined Re-use File, ,
Filter area (sqm), ,
Filter perimeter (m), ,
Filter depth (m), ,
Filter Median Particle Diameter (mm), ,
Saturated Hydraulic Conductivity (mm/hr), ,
Infiltration Media Porosity, ,
Length (m), ,
Bed slope, ,
Base Width (m), ,
Top width (m), ,
Vegetation height (m), ,
Vegetation Type, ,
Total Nitrogen Content in Filter (mg/kg), ,
Orthophosphate Content in Filter (mg/kg), ,
Is Base Lined?, ,
Is Underdrain Present?, ,
Is Submerged Zone Present?, ,
Submerged Zone Depth (m), ,
B for Media Soil Texture,-9999,-9999
Proportion of upstream impervious area treated, ,
Exfiltration Rate (mm/hr),0,4
Evap Loss as proportion of PET,0,1.25
Depth in metres below the drain pipe, ,
TSS A Coefficient, ,
TSS B Coefficient, ,
TP A Coefficient, ,
TP B Coefficient, ,
TN A Coefficient, ,
TN B Coefficient, ,
Sfc, ,
S*, ,
Sw, ,
Sh, ,
Emax (m/day), ,
```

```
Ew (m/day), ,
IN - Mean Annual Flow (ML/yr),0.978,3.36
IN - TSS Mean Annual Load (kg/yr),53.4,615
IN - TP Mean Annual Load (kg/yr),0.148,1.31
IN - TN Mean Annual Load (kg/yr),2.83,9.65
IN - Gross Pollutant Mean Annual Load (kg/yr),23.0,74.3
OUT - Mean Annual Flow (ML/yr),0.410,0.861
OUT - TSS Mean Annual Load (kg/yr),18.9,49.7
OUT - TP Mean Annual Load (kg/yr),60.1E-3,0.175
OUT - TN Mean Annual Load (kg/yr),1.15,1.82
OUT - Gross Pollutant Mean Annual Load (kg/yr),0.00,0.00
Flow In (ML/yr),0.978101,3.36403
ET Loss (ML/yr),0,0.0991685
Infiltration Loss (ML/yr),0,2.44614
Low Flow Bypass Out (ML/yr),0,0
High Flow Bypass Out (ML/yr),0,0
Orifice / Filter Out (ML/yr),0.264096,0.497049
Weir Out (ML/yr),0.145408,0.364339
Transfer Function Out (ML/yr),0,0
Reuse Supplied (ML/yr),0.571416,0
Reuse Requested (ML/yr),1.82472,0
% Reuse Demand Met,31.3153,0
% Load Reduction,58.1328,74.3942
TSS Flow In (kg/yr),53.3906,615.041
TSS ET Loss (kg/yr),0,0
TSS Infiltration Loss (kg/yr),0,15.7542
TSS Low Flow Bypass Out (kg/yr),0,0
TSS High Flow Bypass Out (kg/yr),0,0
TSS Orifice / Filter Out (kg/yr),11.7791,3.35726
TSS Weir Out (kg/yr),7.082,46.3493
TSS Transfer Function Out (kg/yr),0,0
TSS Reuse Supplied (kg/yr),13.8486,0
TSS Reuse Requested (kg/yr),0,0
TSS % Reuse Demand Met,0,0
TSS % Load Reduction,64.6735,91.9182
TP Flow In (kg/yr),0.147589,1.30919
TP ET Loss (kg/yr),0,0
TP Infiltration Loss (kg/yr),0,0.225195
TP Low Flow Bypass Out (kg/yr),0,0
TP High Flow Bypass Out (kg/yr),0,0
TP Orifice / Filter Out (kg/yr),0.0369143,0.046683
TP Weir Out (kg/yr),0.0232273,0.127836
TP Transfer Function Out (kg/yr),0,0
TP Reuse Supplied (kg/yr),0.0786948,0
TP Reuse Requested (kg/yr),0,0
TP % Reuse Demand Met,0,0
TP % Load Reduction,59.2506,86.6697
TN Flow In (kg/yr),2.82676,9.64934
TN ET Loss (kg/yr),0,0
TN Infiltration Loss (kg/yr),0,3.41048
TN Low Flow Bypass Out (kg/yr),0,0
TN High Flow Bypass Out (kg/yr),0,0
TN Orifice / Filter Out (kg/yr),0.744176,0.817334
TN Weir Out (kg/yr),0.40714,1.00574
TN Transfer Function Out (kg/yr),0,0
TN Reuse Supplied (kg/yr),1.48369,0
TN Reuse Requested (kg/yr),0,0
TN % Reuse Demand Met,0,0
TN % Load Reduction,59.2708,81.1067
GP Flow In (kg/yr),22.9672,74.3182
GP ET Loss (kg/yr),0,0
GP Infiltration Loss (kg/yr),0,0
GP Low Flow Bypass Out (kg/yr),0,0
GP High Flow Bypass Out (kg/yr),0,0
GP Orifice / Filter Out (kg/yr),0,0
GP Weir Out (kg/yr),0,0
GP Transfer Function Out (kg/yr),0,0
GP Reuse Supplied (kg/yr),0,0
GP Reuse Requested (kg/yr),0,0
GP % Reuse Demand Met,0,0
GP % Load Reduction,100,100
```

No Generic treatment nodes

Other nodes

```
Location,B-OUT,OUT
ID,1,5
Node Type,JunctionNode,JunctionNode
IN - Mean Annual Flow (ML/yr),3.36,0.861
IN - TSS Mean Annual Load (kg/yr),615,49.7
IN - TP Mean Annual Load (kg/yr),1.31,0.175
IN - TN Mean Annual Load (kg/yr),9.65,1.82
IN - Gross Pollutant Mean Annual Load (kg/yr),74.3,0.00
OUT - Mean Annual Flow (ML/yr),3.36,0.861
OUT - TSS Mean Annual Load (kg/yr),615,49.7
OUT - TP Mean Annual Load (kg/yr),1.31,0.175
OUT - TN Mean Annual Load (kg/yr),9.65,1.82
OUT - Gross Pollutant Mean Annual Load (kg/yr),74.3,0.00
```

Links

```
Location,Drainage Link,Drainage Link,Drainage Link,Drainage Link,Drainage Link
Source node ID,2,1,6,3,4
Target node ID,3,6,5,1,1
Muskingum-Cunge Routing,Not Routed,Not Routed,Not Routed,Not Routed,Not Routed
Muskingum K, , , , ,
Muskingum theta, , , , ,
IN - Mean Annual Flow (ML/yr),0.978,3.36,0.861,0.410,2.95
IN - TSS Mean Annual Load (kg/yr),53.4,615,49.7,18.9,596
IN - TP Mean Annual Load (kg/yr),0.148,1.31,0.175,60.1E-3,1.25
IN - TN Mean Annual Load (kg/yr),2.83,9.65,1.82,1.15,8.50
IN - Gross Pollutant Mean Annual Load (kg/yr),23.0,74.3,0.00,0.00,74.3
OUT - Mean Annual Flow (ML/yr),0.978,3.36,0.861,0.410,2.95
OUT - TSS Mean Annual Load (kg/yr),53.4,615,49.7,18.9,596
OUT - TP Mean Annual Load (kg/yr),0.148,1.31,0.175,60.1E-3,1.25
OUT - TN Mean Annual Load (kg/yr),2.83,9.65,1.82,1.15,8.50
OUT - Gross Pollutant Mean Annual Load (kg/yr),23.0,74.3,0.00,0.00,74.3
```

APPENDIX C (*CV*)

Civil Certification
Accredited Certifiers
Civil Engineering
ABN 87 532 718 229
0412 264 237

Michael J Shaw
BE MIEAust CPEng NPER

Principal
Civil Certification

Resume

1. SUMMARY

Michael is a senior civil engineer with over 18 years experience in the fields of civil engineering, road design, drainage, hydrology, stormwater management and urban infrastructure design. He operates his own business specialising in private certification and stormwater management. Michael has worked on many civil design projects ranging from development of large scale strategic masterplans to detailed design of stormwater management facilities and urban infrastructure for residential subdivisions. His expertise lies in solving complicated drainage problems, water sensitive urban design (*WSUD*), flooding, detailed civil design, understanding the local government approvals process and managing multidisciplinary teams. Michael's experience covers all facets of civil engineering for urban development from due diligence through to approvals, detailed design, superintendency and certification. He has also provided expert advice to the Land and Environment Court with relation to drainage and stormwater quality issues.

2. EXPERIENCE

Positions held -& Location

Oct 2010 – Present	▶ Principal, Civil Certification, Sydney, NSW, Australia
April 2008- Sept 2010	▶ Manager, Urban Infrastructure, Environment Group - Worley Parsons, Sydney, NSW, Australia.
Aug. 2007- March 2008	▶ Principal Engineer – Urban Infrastructure - Worley Parsons incorporating Patterson Britton & Partners, Sydney, NSW, Australia;
Nov. 1997- Jul. 2007	▶ Senior Associate – Urban Infrastructure - Patterson Britton & Partners, Sydney, NSW, Australia;
Aug. 1996- Oct 1997	▶ Water Resources Engineer – Willing & Partners, Sydney, NSW, Australia;
Feb. 1991- Aug. 1994	▶ Design Engineer, Development Engineer, Investigation Engineer & Survey Assistant – Ryde City Council, Sydney, NSW, Australia.

Standout Projects

▶ ***Stormwater Management Strategies(SMS)***

-Port Jackson South Stormwater Management Plan *(2,870ha catchment*);

-Drummoyne Council Stormwater Quality Strategy *(830ha catchment*);

-Lake Illawarra South Stormwater Quality Strategy *(1,548ha catchment*);

-Elliot Lake Stormwater Quality Strategy *(1,220ha catchment*);

-Scotland Island SMS *(53ha catchment*);

-Corks Lane Milton, DA Stage SMS (*150 lot residential subdivision*);

-Pasadena, Church Point, DA Stage Stormwater Management and Reuse Strategy (*mixed use dev.*);

-Yallambee Ave West Gosford, DA Stage SMS *(100 lot residential subdivision*)

-CSIRO Greystanes, Employment Lands SMS *(60ha industrial site*);

-Warriewood Valley, Sector 3, Rezoning Stage SMS *(130 lot residential subdivision*);

-Warriewood Valley, Sector 8, Rezoning to Subdivision Certificate Stage SMS *(140 lot residential subdivision*);

-Warriewood Valley, Buffer Areas 1 and 2, Rezoning and DA Stage SMS (*300 lot residential subdivision*

-Warriewood Valley, Buffer Area 3, Rezoning and DA Stage SMS (*250 townhouse subdivision*);

-Macarthur Square Regional Centre Masterplan DA Stage WSUD Strategy (*61ha residential subdivision*);

-Department of Defence Site, Ermington ("*Ermington Riverfront*") DA Stage SMS (*20ha residential subdivision*

-West Kembla Grange, Wollongong, Aquatic Issues Assessment (*858ha catchment*);

-Eastwood Quarry, Masterplan/Rezoning Stage SMS (*20ha residential subdivision*);

-Perentie and Dawes Road Masterplan, Belrose, Stormwater Quality Strategy (*30ha residential subdivision*);

-Walter Road, Ingleside DA Stage SMS (*15ha rural residential subdivision*);

-Domayne, Austlink Park Belrose SMS (large *commercial use development*);

-Grassmere LES, Camden SMS (*50ha rural residential subdivision*);

-Warriewood Valley (*Sectors C, D, & 12*) Rezoning Stage SMS *(100 lot residential subdivision*); and

-Summer Hill Flour Mill Concept Plan Application Stormwater Management Plan and Flood Study (*250 dwelling high density residential subdivision*).

-Mt Penang Stormwater Management Strategy

-Ashlar Golf Course Redevelopment – Flood and WSUD Strategy for 100 dwelling Residential Subdivision.

- ***Water Sensitive Urban Design (WSUD)***

-Sand Filtration Unit, Drummoyne Park (*ie Stormwater Treatment*);

-Barnwell Park Golf Course Stormwater Treatment and Reuse;

-Powell Creek Reserve Eco Carpark

-Warriewood Valley, Sector 10, Detailed Design of WSUD elements (*bio-retention systems and wetland for 170 lot residential subdivision*);

-Warriewood Valley, Sector 12, Detailed Design of WSUD elements (*bio-retention systems and wetland for 180 lot residential subdivision*);

-Rouse Hill Regional Centre – Detailed design and performance analysis of bio retention systems, raingardens and constructed wetland;

-Hezlett Road, North Kellyville – Generic lot based raingarden design, road bio-retention swale design and detention offset analysis;

-Yoyager Point (DHA) – Detailed Design of Detention/Bio-Retention Basins for 200 lot residential subdivision.

- ***Riparian/Creek Design/Investigation***

-Wollondilly Shire Riparian Corridor Definition Study;

-Parsley Bay, Woollahra, Creekline Rehabilitation;

-Embankment Stabilisation Design, Koloona Ave, Byarong Creek ,Wollongong;

-Embankment Stabilisation Design, 5 sites along Cabbage Tree Creek, Towradgi Creek and Byarong Creek, Wollongong;

-Prospect Creek, Fairfield – Design of confluence stabilisation and creek rehabilitation measures;

-Narrabeen Creek, Pittwater – Detailed design of creek rehabilitation and embankment stabilisation measures from Graf Ave to Ponderosa Parade;

-Little Bay Central Drainage Corridor – Controlled Activity Approval and detailed design of Central Corridor Drainage Features (*ie wetlands, bio-retention basins, weirs, elevated walkways, bridges, pool/riffle creekline*).

-Sector 8 Warriewood – Controlled Activity Approval for residential development adjoining Fern Creek.

- ***Civil Subdivision Design***

-Potts Hill, Eastern Precinct – Lead design team for 13ha Industrial development of Sydney Water Surplus Lands. Engaged by Landcom to provide approval documentation for Part 3 Major Project and to deliver detailed design of all subdivision infrastructure (*ie civil, roads, RE walls, stormwater, power, sewer, water, recycled water and utility services*).

-Tweed Road, Lithgow, Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 38 lot residential subdivision;

-Sector 20, Warriewood, Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 63 lot residential subdivision;

-7 Orchard Road, Warriewood, Detailed Design of Lot Based Stormwater Management Facilities and Access Road for a 10 lot residential subdivision;

-Heritage Estates, Shoalhaven, Conceptual Design of Civil Infrastructure. (*water, sewage, utility services, roads and drainage*) for 20ha residential subdivision;

-Randwick Defence Site (*Stage 1A*), Detailed Design of Civil Infrastructure (*roads, drainage, water, sewer and all other utility services*) for a 80 lot residential subdivision; and

-Cooks Cove Development, Upgrade to Scarborough and Bicentennial Parks – Lead design team for approvals and detailed design of upgrade to park facilities, including carparks, creekline, stormwater drainage, bulk earthworks, access roads, services etc to accommodate future relocation of facilities from Cooks Cove development site (*Part 3A Major Project*).

▸ ***Drainage Analysis/Design***

-Canada Bay Council city wide DRAINS modelling project *(970ha catchment*);

-Canada Bay Council Detention modelling and OSD policy development;

-City of Canada Bay Council MAPINFO drainage database update;

-Old Bathurst Road, Emu Plains, Detailed Design of Stormwater Management Facilities *(24ha industrial subdivision*)

-Andrew Road, Penrith, Detailed Design of Stormwater Management Facilities *(8ha industrial subdivision*)

-St Mervyns Ave, Woollahra, Stormwater Outlet Extension;

-Grosvenor Street Stormwater Drainage Study;

-Perentie and Dawes Road Masterplan, Belrose, Stormwater Drainage Concept Plan;

-Yulong Concept Drainage Study, Dept Defence Moorebank *(25ha industrial subdivision);*

-Headland Road, Curl Curl OSD Design;

-Cooper Park Amphitheatre , Woollahra, Detailed Stormwater Drainage Design;

-Paradise Avenue, Paradise Beach, Detailed Stormwater Drainage Design;

-Georges River Sailing Club, Seawall and Beach Nourishment Design;

-St Andrew Church, Wahroonga OSD and Stormwater Drainage Design;

-North Sydney Catchment Management Studies (*in total 86ha catchment*);

-Greystanes Estate, Northern Residential Lands, Detailed Design of Water Management Facilities (*70ha residential development*); and

-Barina Downs Road, Detention Basin Design (*large regional detention facility*).

-Robertson Road, Scotland Island – Detailed Stormwater Drainage Design

-Jenkins Road, Dundas - Detention System Design

-Lot 2 Muir Road, Chullora – Drainage and Detention System Design for Large Industrial Development.

▸ ***Flood Studies (FS)***

-Prospect Creek Channel Enhancement FS;

-Oats Ave, Gladesville FS;

-Casa Paloma Caravan Park FS;

-Kiaora Place Development, Double Bay FS;

-Darling Park/Cross City Tunnel - Flood impact assessment;

-Mowbray Road, Nursing Home, Assessment of overland flow impacts;

-Macquarie Links Golf Course FS (*Bunburry Curran Creek, Campbelltown*);

-Wigan Road, Dee Why FS;

-Green Road FS;

-Anzac Creek, Moorebank FS;

-Eastwood Hotel Drainage/Flooding Study;

-Mona Street, Mona Vale FS;

-Frenchs Creek FS;

-Darling Walk Flood Assessment, Darling Harbour; and

-Lynwood Ave, Dee Why Flood Assessment.

▶ ***Dam Hazard Assessment***

-Kellyville Ridge Dam, Second Ponds Creek, Dam Hazard Assessment;

-UWS Campbelltown Dam Hazard Assessment;

-Hume Golf Course, Albury Dam Hazard Assessment; and

-CSIRO, Greystanes Dam Hazard Assessment.

▶ ***Water Quality Monitoring***

-Sectors 2, 8 and 11 Warriewood, Post construction (*ie residential subdivision*) stormwater quality monitoring;

-Warriewood Valley (*Various Sectors*) Approval Stage Water Quality Monitoring over an 8 year period

-Shellharbour Council Stormwater Monitoring Strategy (*entire Shellharbour LGA - 14,000ha*);

-St Marys Eastern Precinct Water Quality Monitoring Strategy *(160ha residential subdivision*);

-Rouse Hill Regional Centre – Post development water quality monitoring of treatment measures and receiving waters (*Auto sampling and grab sampling*);

-Water Quality Sampling for Metal Recycling development, Ingleburn.

▶ ***Major Culvert Amplification Design***

-Careel Creek/Barrenjoey Road Culvert Amplification Works (*Pittwater Council and RTA*);

-Nareen Creek /Narrabeen RSL Culvert Entry Upgrade (*Pittwater Council)*;

-Howell Reserve Culvert Entry Upgrade and Drainage Diversion Line (*Pittwater Council);*

-Fern Creek/Garden Street Culvert Amplification (*Pittwater Council*);

-Narrabeen Creek/Ponderosa Pde Culvert Amplification (*Pittwater Council*); and

-Garie Beach Culvert Amplification (*RTA and NPWS*).

▶ ***Road/Carpark Design***

-Transport Infrastructure Development Corporation (*TIDC*) Commuter Car Park Program, Detailed Design of At Grade Carparks at Emu Plains Station, Woonona Station and Waterfall Station (over $1 million in fees)

- Rookwood Road Potts Hill, Detailed Design of RTA signalised intersection upgrade (*Landcom)*

-Brunker Road Potts Hill, Detailed Design of RTA signalised intersection upgrade (*Landcom)*

-Scotland Island Road Reserve Masterplan (*53ha area*);

-P&O Port Botany, Detailed Design of Staff Carparking Facilities *(50 spaces*);

-McKeown Street, Maroubra Beach, Detailed Road Design for streetscape improvement works;

-Department of Defence Site, Randwick (*Stages 1A, 1B and Community Centre*), Detailed Road Design for large residential subdivision(*5.6ha residential subdivision*);

-Greystanes Estate Northern Residential Land, Detailed Road Design for large residential subdivision *(50ha residential subdivision*);

-Sector 20 Warriewood, Detailed Road Design for large residential subdivision *(50ha residential subdivision*);

-Lidcombe Botanica, Detailed Road Design for heritage precinct of large residential subdivision; and

-Heffron Park Randwick, Detailed Design of 100 space carpark and associated road improvement works.

- ***Infrastructure/Servicing Strategies***

-Ermington Naval Stores *(700 lot residential development*);

-Greystanes Estate, Prospect (*250ha residential & employment development*);

-UWS Werrington *(48ha residential development*) ;

-Airds Town Centre Masterplan;

-Sector 7 (*2 Daydream Avenue*), Warriewood *(3ha mixed use commercial/light industrial development*);

-St Mary's (*ADI Site-Eastern Precinct-160ha residential development*);

-Green Square Master Plan, South Sydney (*Zetland*); and

-Mt Penang, Gosford Business Park development.

- ***Gross Pollutant Traps (GPT's)***

-Dee Why Beach GPT design (*special non proprietary*);

-Birkenhead Point and Brent Street GPTs (*special non proprietary*);

-St Georges Crescent Catchment Oil/Grit Separators (*multiple proprietary*);

-Stormwater Trust Application Assistance, Waterways Authority - Blackwattle Bay GPT;

-Brookvale Creek Rehabilitation – detailed design of large offline GPT/trash rack; and

-Drummoyne Council - Three Ways to Improve The Bays GPT Design Project (*special non proprietary*).

- ***General Civil Engineering***

-BER Sydney South, provision of general civil engineering design for Abigroup for a number of Schools in Sydney South.; and

-McCarr's Creek Road/Pittwater Road Inventory and Condition Assessment.

- ***Expert Advice / L&E Court / Certification***

-DA Stormwater management, West Ryde Urban Village Redevelopment for Ryde City Council (*ie acting on behalf of Council*);

-DA Stormwater management, Top Ryde Shopping Centre Redevelopment for Ryde City Council(*ie acting on behalf of Council*);

-Yulong Moorebank , review of road design for Department of Defence;

-Rushcutters Bay Flood Study Peer Review for Lindsay Bennelong Developments;

-Review of Managing Urban Stormwater Manual April 2004 on behalf of Landcom;

-Clontarf Street, Seaforth – Civil inspections for Landcom res. dev. on behalf of Manly Council;

-Sector 20, Warriewood – Superintendency for $6 million Civil Works Contract;

-Bunya Collector Road CC – Private certification assessment for Landcom

-Expert witness (*water quality on industrial site*) for L&E Court Case - Phiney Place, Ingleburn (*representing private developer*);

-Expert witness (*drainage, S88K easement)*) for L&E Court Case – Park Street, Mona Vale (*representing adjoining land owner*);

-Expert witness (*drainage/absorption system/easement*) for L&E Court Case – 120 Hopetoun Avenue, Vaucluse (*representing owner/developer*);

-Expert witness (*drainage/riparian corridor*) for L&E Court Case – 23B Macpherson Street, Warriewood (*representing private developer*);

-Expert witness (*riparian matters/controlled activity application/culvert creek cro*ssing) for Supreme Court Case – Wambo Coal Mine, Warkworth (*representing mine operator*);

-Expert witness (*water management, riparian definition*) for L&E Court Case – 70A Willandra Rd, Beacon Hill (*Retirement Village Appeal, Representing Warringah Council*)

-Expert Advice on behalf of Warringah Council – Kimbriki Redevelopment Proposal;

-Cat5 Compliance Inspections (*Private Certification*) for Civil Infrastructure at Putney Hill Residential Development, Charles Street Ryde;

-Expert Drainage advice for stormwater/seawall damage at a private property in Prince Alfred Parade, Newport;

-Construction Certificate issue (*Private Certification*) for subdivision works at Mount Street, Constitution Hill;

- Construction Certificate issue (*Private Certification*) for subdivision works at Crescent Road, Mona Vale.

-Muir Road, Chullora – Construction Stage Inspections (civil) for industrial development.

3. EDUCATION & PROFESSIONAL AFFILIATIONS

- Bachelor of Engineering (*Civil*), University of Technology, Sydney, 1996;
- Member, Institution of Engineers, Australia (*MIEAust*);
- Charted Professional Engineer (*CPEng*);
- National Professional Engineers Register (*NPER - Civil*);
- NSW Accredited Certifier (*BPAct 2005*) – Categories B1, C1, C2, C3, C4, C6, C15 (*BPB 0816)*