EMMANUEL COLLEGE

STORMWATER MANAGEMENT STRATEGY

140 BOTANIC ROAD
WARRNAMBOOL

24/11/2022
Version: V1

For:
Emmanuel College

Document History

Rev. No.	Description of Revision	Prepared By	Checked By	Date Issued
V1	Preliminary for development & review	Scott Trotter & Stephen Brodie	Brett Johnston	24/11/2022

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Report

References & Attachments

The CSE Group Consulting Engineers
– Emmanuel College Year 9 Centre, Stormwater Management Plan, 28-09-2022
– Stormwater Catchment Map and Concept Plan SWS-01[A]
Baldasso Cortese
– Proposed Masterplan – Rev. G – 10/11/2022
Engeny Water Management
– Emmanuel College Drainage Report 10-July-2014

ADVERTISED PLAN

1.0 INTRODUCTION

To address planning requirements for the proposed Year 9 Centre, Emmanuel College (EC) have engaged The CSE Group (CSE) to undertake a stormwater review and strategy for their entire site at 140 Botanic Road. The stormwater strategy is to review and support the proposed site master plan as has been developed by Baldasso Cortese Architects (BC) in conjunction with Emmanuel College. This report intends review the historical stormwater records across the site and existing conditions to determine appropriate points of discharge and treatment measures for both stormwater runoff management and stormwater quality objects to inform planning across the site.

The report includes an assessment of the broader catchments, Victorian planning provisions, previous drainage studies in the area and contour plans will be used to help inform the drainage requirements for the site. This report is primarily a desktop review relying on local knowledge and limited site inspections.

2.0 BACKGROUND INFORMATION AND HISTORY

The CSE Group approached the Warrnambool City Council (WCC) Engineering and Assets team who advised there had been prior investigation on parts of the school site and that there may be several constraints on the Emmanuel site. The council provided copy of prior drainage studies through the area conducted by Engeny Water Management (EWM) on behalf of WCC. The report investigates the existing soakage basin at the southwestern corner of the site, including a catchment study and design guidance for both flood objectives and water quality objects. For reference a copy of the EWM report is included in the appendix.

In consultation the Warrnambool City Council provided the following overview of design requirements and objectives for this report.

> *As discussed we have had a first-look at the amended Development Plan for Emmanuel. I think they will need to get that endorsed before they will be able to get a planning permit for the new Year 9 building.*
>
> *We have asked for a Stormwater Strategy that covers the whole 11 Ha site.*
>
> *As the Crawley-Ardlie drain serves quite a large catchment, seems to direct major flow into private property, and is probably undersized, you will need to retain quite a bit of the stormwater (pre-dev C = 0.3; 20% AEP flow, possibly up to the 1% AEP volume).*
>
> *The new carparking area may encroach on the natural basin on the site which is discussed in some detail in that Engeny report you have a copy of.*
>
> *You'll also need to meet the BEPM targets as usual.*
>
> *Will see if I can find you some info on the Ardlie drainage. If it is as I suspect, you will need to retain flow up to the 1%AEP to avoid making existing Ardlie problems worse.*

In addition:

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Found a Drainage Study by Water Technology which we had done in 2018. It identifies 53 areas in Warrnambool that are currently under risk of flooding.

The Ardlie-Conns intersection is identified as one of the problem areas. The report doesn't give much detail, but based on our LIDAR contours, it looks like any extra flow down Crayley would run down to the problem area in Conns. Even if it went north instead of south, it would probably run down Sovereign Ct. There is no overland flow path to the creek at the end of that court.

Unless we got some strong evidence that the Ardlie drainage was up to scratch, I'd be advocating for the Year 9 building retention to be able to hold back flow such that it could store volume based on the 1% AEP storm.

Consultation with Emmanuel College highlighted that "site/staff/working" memory of the area had not recorded/recalled significant inundation through the area and questioned whether the basin and flood levels could be optimised and what infrastructure can be tolerated within the basin.

3.0 EXISTING CONDITIONS

The Emmanuel College site is surrounded by Botanic Road, Ardlie Street, Hopetoun Road and Crawley Street and is located on a ridgeline between two broader catchments. The ridgeline notionally runs from the south east corner of site through to the north west of site with; the south western corner of the site falling to Hopetoun Rd, within the Morris Road catchment; and the north eastern corner falling to the Russell Creek catchment via two points of discharge at Ardlie St and Crawley Street for three points of discharge in all. These are illustrated and outlined in the figure and further detail below:

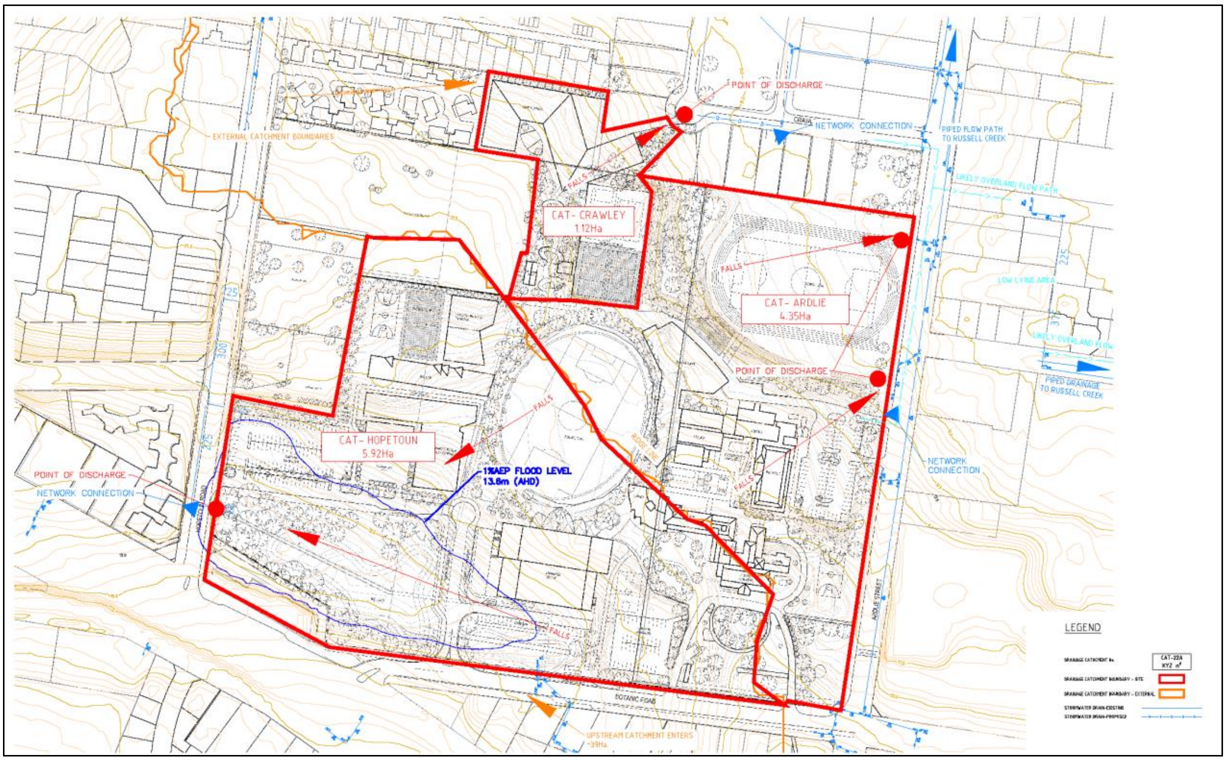

Figure 1 – Site Locality and Catchment Plan (refer plan SWS-01)

3.1 Site and Catchment Characteristics

3.1.1 Hopetoun Road Catchment

The Hopetoun Road catchment has been previously investigated within the EWM stormwater study as previously noted. The study investigates the greater catchment and its impacts on the south western corner of the EC site which is a natural basin with limited downstream drainage infrastructure. The upstream catchment is developed with residential and commercial lands in the order of 45.2Ha and over 800m long on the longer reaches, the EWM report finds that the area is prone to flooding with a 1%AEP flood level of 13.6m(AHD).

The low point and outfall of the catchment is at Hopetoun Road and the Hopetoun Road formation forms a levy wall to the western side of the basin. There is minimal street drainage under Hopetoun Road and no significant council drainage infrastructure downstream. There are a number of low lying properties that would be at risk should existing downstream drainage be upsized.

Approximately 5.9Ha and 50% of the school site falls to the southwest and into this Hopetoun Road catchment. Parts of the site abutting the basin are currently undeveloped with the balance made up of buildings, ovals and general site grounds. In the medium to longer term it is proposed to fully develop the site as is outlined on the BC Masterplan with the conditions for the development outlined in the later design sections of this report.

3.1.2 Crawley Street Catchment

The Crawley Street catchment is at the northern end of the site, the landform through this area falls to the North and North East and the Crawley St road reserve. There is no immediate council drainage assets at the lot frontage, the nearest existing underground drainage assets are located east of the property by approximately 55m and four residential lots. The WCC Crawley St drains link into the Ardlie St drainage network and flow towards Russell Creek.

The road formation of Crawley St is lower than abutting lots and it falls east to Ardlie St and ultimately to a low lying area on the block surrounded by Conns Lane, Ardlie Street, Wentworth Street and Barbers Lane. There is a council drainage network in the area which would ultimately convey underground stormwater east on Barbers Lane. The lidar contours and site inspections also indicate that surface also generally falls in this direction.

The catchment is a mix of undeveloped lands, through where the proposed year nine centre is to be located, and school grounds including hard paved netball/basketball courts. There is further detail on the catchment conditions summarised in the CSE Year 9 centre stormwater report that is included in this submission.

3.1.3 Ardlie St Catchment

The Ardlie Street catchment is approximately 4.4Ha in area, it is developed school lands with the main areas of campus buildings, car parking and school oval. At the time of writing the school views this catchment as fully developed and there are no medium to longer term plans to substantially modify the school grounds within the catchment. The landform within the catchment falls from the ridgeline to the North East and Ardlie St and there are no upstream contributing catchments.

The existing built infrastructure buildings and car parks are all located at the top of the catchment and near the ridge line with ovals and landscapes on the lower and flatter areas at the north east of site and abutting Ardlie St. The roads and roofed areas within the catchment are conveyed by underground drainage to connect with the WCC Ardlie St drainage network which flows north to Russell Creek.

3.2 Geotechnical Conditions

The buildings and site generally are located along a ridgeline which are consist of Pleistocene Dune Limestone, sandy dune limestone. The lower areas and flats are likely to be more varied with overlying clayey sands of varying permeability. It is likely that significant areas of catchments including the greater urban Hopetoun Road catchment will be highly pervious which will allow initial and continuing losses and possibly moderate stormwater flows.

As part of the site investigations of the Hopetoun Road basin CSE have completed some shallow geotechnical borehole and percolation test in the low point approximately 30m east of Hopetoun Road. Saturated black sandy clays of low permeability (~20mm/hr) were found in the shallow boreholes (nominally 600mm depth). Being the lower lying part of the landform it is likely that there has been significant accumulation of silts and clays which limit infiltration.

4.0 DESIGN REQUIREMENTS & PRINCIPLES

In development of this report CSE have been in consultation with various stakeholders, outlined below are the key functional requirements found and to be considered for further development. In addition the usual stormwater practice guidelines have been outlined for reference.

4.1 WCC Requirements

In consultation with WCC and as outlined above it understood that ongoing and future development of the Emmanuel College site is to meet the following conditions:

- Underground drainage to the nominated points of discharge.
- On-site detention of stormwater to limit outflows to pre-development conditions in a 1% AEP rainfall event, as the downstream flow paths are at capacity.
- Meet or exceed Best Practice Environmental Guidelines:
    - 80% Reduction in Suspended Solids
    - 45% Reduction in Total Phosphorus
    - 45% Reduction in Total Nitrogen
    - 70% Reduction in Gross Pollutants

4.2 Coefficient of Runoff and Fraction Impervious

Where applicable the Coefficient of Runoff of the development has been calculated in accordance with the infrastructure design manual and the following:

- Landscaped Areas – 0.25
- Low Density Residential Zone > 2ha – 0.3
- Public Open Space – 0.35
- Residential Lot Areas 1000m² to 2000m² – 0.5
- Residential Lot Areas 600m² to 1000m² – 0.7
- Residential Lot Areas 450m² to 600m² – 0.75

- Residential Road Reserves – 0.75
- Commercial Zones – 0.9
- Industrial Zones – 0.9
- Paved Areas – 0.95

For convenience and given the limited sizes of the catchments under consideration the coefficients of runoff and fraction impervious are considered as interchangeable.

4.3 Modelling Procedures

There is limited stormwater modelling within this report, it is primarily an assessment of catchment areas, flow paths, constraints and requirements for future development of the site. CSE have completed some preliminary computations to reference and compare prior works, this modelling has using rational procedures or initial loss – continuing loss models of Watercom Drains to AR&R 2019 procedures.

5.0 DESIGN & DISCUSSION

Upon review of council requirements, prior studies and the catchments it has been identified that future development in each of catchments will be required to provide solutions to manage the 1% AEP rainfall / stormwater events to protect downstream areas and treat all stormwater to BPEM guidelines. In the sections below we briefly elaborate on possible design solutions for each of the catchment areas. We note that these are indicative solutions to support master planning requirements and that detailed design is to be developed as the planning and construction staging requires.

5.1 Hopetoun Road Catchment

The Hopetoun Road catchment has been substantially modelled in the Engeny Report as attached, the report looks at the greater catchment in the order of 45Ha. The report is largely current, completed in 2014, with sufficient allocation for fraction impervious across the greater catchment which could accommodate additional development on the Emmanuel College Site. The procedures used in the report remain relevant with the key change being changes to the rainfall characteristics to AR&R 2019 procedures in which there has been a slight increase in rainfall intensity for the Warrnambool Region.

Reviewing the Master Plan there are a number of proposed facilities within the catchment which will increase the impervious runoff into the wetland area in the south western corner of the subject site:

- Maintenance & other sheds
- Hopetoun Road Carpark
- Link Road & angled carparks
- Swimming Pool & Health Centre
- Food Technology & Year 7 & 8 Building
- Courts
- Circulation spaces.

In total there is approximately 15,000 square metres (1.5Ha) to be substantially developed with a fraction impervious of approximately 80% through the area. This area is small when considering the greater catchment of ~45Ha

To cross check that this development is incremental when considering the greater catchment CSE have completed some brief assessments using rational procedures.

Site condition	Subject Area	Coefficeint of Runoff	∑CA
Undeveloped	15,000m^2	0.3	4,500m^2
Developed	15,000m2	0.8	12,000m^2
		Net	7,500m^2

The calculation above is only intended to indicate that the net change of development within the Emmanuel site is a fractional change in the total catchment of 45Ha. Preliminary computations tabulated below extend on this approach using rational procedures and indicatively measure the extra over storage required for the incremental development. An existing conditions 1%AEP baseflow is calculated at 157.5L/s, to limit outflows to this peak base flow an extra over storage of approximately 167cu.m is required which could be coordinated and accommodated in the existing infiltration basin.

The proposed development does look to formalise the existing basin shape and car parking areas encroach on the existing 1%AEP flood level as illustrated in Figure 2 below. CSE have reviewed various basin shapes to validate whether storage volumes can be maintained through reconfiguration of the area with some limited encroachment. The figure shows original lidar contours, the 1%AEP flood level, a schematic pond arrangement from the master plan and an engineered basin shown in green.

The existing basin and natural surface is found to have approximately 16,039cu.m of storage available and the objective is to maintain or improve on this volume. The volumes of the existing and proposed basin are indicatively shown in Chart 1 below. The existing basin volumes have been calculated from the lidar data taken prior to the recent Emmanuel Centre hall construction. The EWM line approximates the proposed wetland and sediment pond illustrated in Appendix G of the EWM report. The sediment pond and wetland are proposed to be constructed below existing surface levels hence the slight increase in capacity. The green line labelled indicative basin is an approximated excavated basin, reshaping the existing surface and lowering the basin floor. It is indicative and only includes the greenspace areas excluding car parks and the already constructed swale adjacent The Emmanuel Centre and Botanic Road.

At this point the figure and chart are indicative proving that there is sufficient area available to allow the reconstruction and reshaping proposed in the Master Plan. Further iterations of the design and consultation with stakeholders will be require to determine the ultimate basin shape and ensure protection of the basin in line with Engeny's report.

We note that other factors could influence the retention/detention basin operation and these should be investigated through further design development phases.

- The groundwater injection system proposed in EWM report is not considered.
- Geotechnical conditions may vary with depth finding either more free draining soils or a water table.
- Final Basin size, shape & elevations.
- Allowance for minor shallow <150mm depth 1%AEP inundation of trafficable areas.
- Modelling the impacts of existing drainage to outfall
- Validation of other possible catchments north on Hopetoun Road
- Wannon Water's sewer line which runs centrally through the basin. At the time of writing sewer levels and WW requirements are unknown. If significant cover is required over the pipe it may impact on developable areas.

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Storage & Infiltration Calculation

Hopetoun Road Catchment Alterations.

	Area (m^2)	Runoff Coefficient	C x A	
Development Area	15000	0.8	12000	
Totals (m^2)	**15000**		**12000**	80% Impervious

Predevelopment Runoff

Predev. Runoff Coefficient - C	0.3	
Find CA (Total Area by C)	4500.0	m^2
Storm Event	1%	AEP
Time of Concentration	10	mins
Locality Code	WARR	Warrambool
Intensity - I	126.0	mm/hr
Runoff Q = CAI / 3600	157.5	L/s

Storage Measures

	Effective Infiltration Area (m²)	Storage Volume (m³)
Nill storage for reference only		
TOTALS	**0.00**	**0.00**

Soil Characteristics

Soil K_h	0	mm/hr	Infiltration Rate*	0.00E+00	m³/s
	0.00E+00	m/s		0.000	L/s
Moderating Factor - U	0.5	Sandy soil			

Allow Piped Outflow Q_p **157.5** **L/s** Equal to Predevelopment Runoff Conditions (unless no connection available)

1% AEP Rainfall Event

Time (Duration) min D	Rainfall Intensity mm/hr	Volume In CAID/60,000 I_V (m^3)	Piped flow O_p (m^3)	Nett Inflow Vol. I_V - O_p (m3)	Soakage Out [A_{eff}] Uk_ht O_s (m^3)	Storage Volume Required S_R=I_V-O_p-O_s (m^3)	Percentage of storage provided S_T / S_R %	Storage area adequate
0	0	0	0	0	0	0		Yes
1	268.0	53.60	9.45	44.15	0.00	44.15	0%	No
2	202.0	80.80	18.90	61.90	0.00	61.90	0%	No
3	185.0	111.00	28.35	82.65	0.00	82.65	0%	No
4	173.0	138.40	37.80	100.60	0.00	100.60	0%	No
5	163.0	163.00	47.25	115.75	0.00	115.75	0%	No
10	126.0	252.00	94.50	157.50	0.00	157.50	0%	No
15	103.0	309.00	142	167.25	0.00	167.25	0%	No
20	86.3	345.20	189	156.20	0.00	156.20	0%	No
25	74.8	374.00	236	137.75	0.00	137.75	0%	No
30	66.1	396.60	284	113.10	0.00	113.10	0%	No
45	49.6	446.40	425	21.15	0.00	21.15	0%	No
60	40.3	483.60	567	0.00	0.00	0.00		Yes
90	30.1	541.80	851	0.00	0.00	0.00		Yes
120	24.6	590.40	1134	0.00	0.00	0.00		Yes
180	18.6	669.60	1701	0.00	0.00	0.00		Yes
270	14.3	772.20	2552	0.00	0.00	0.00		Yes
360	12.0	864.00	3402	0.00	0.00	0.00		Yes
540	9.3	1008.72	5103	0.00	0.00	0.00		Yes
720	7.8	1127.52	6804	0.00	0.00	0.00		Yes
1080	6.1	1311.12	10206	0.00	0.00	0.00		Yes
1440	5.0	1442.88	13608	0.00	0.00	0.00		Yes
1800	4.3	1540.80	17010	0.00	0.00	0.00		Yes
2160	3.7	1615.68	20412	0.00	0.00	0.00		Yes
2880	3.0	1716.48	27216	0.00	0.00	0.00		Yes
4320	2.1	1823.04	40824	0.00	0.00	0.00		Yes
5760	1.6	1866.24	54432	0.00	0.00	0.00		Yes
7200	1.3	1900.80	68040	0.00	0.00	0.00		Yes
8640	1.1	1918.08	81648	0.00	0.00	0.00		Yes
10080	1.0	96.40	4947	0.00	0.00	0.00		Yes

Computation 1 – On site new development indicative storage requirement.

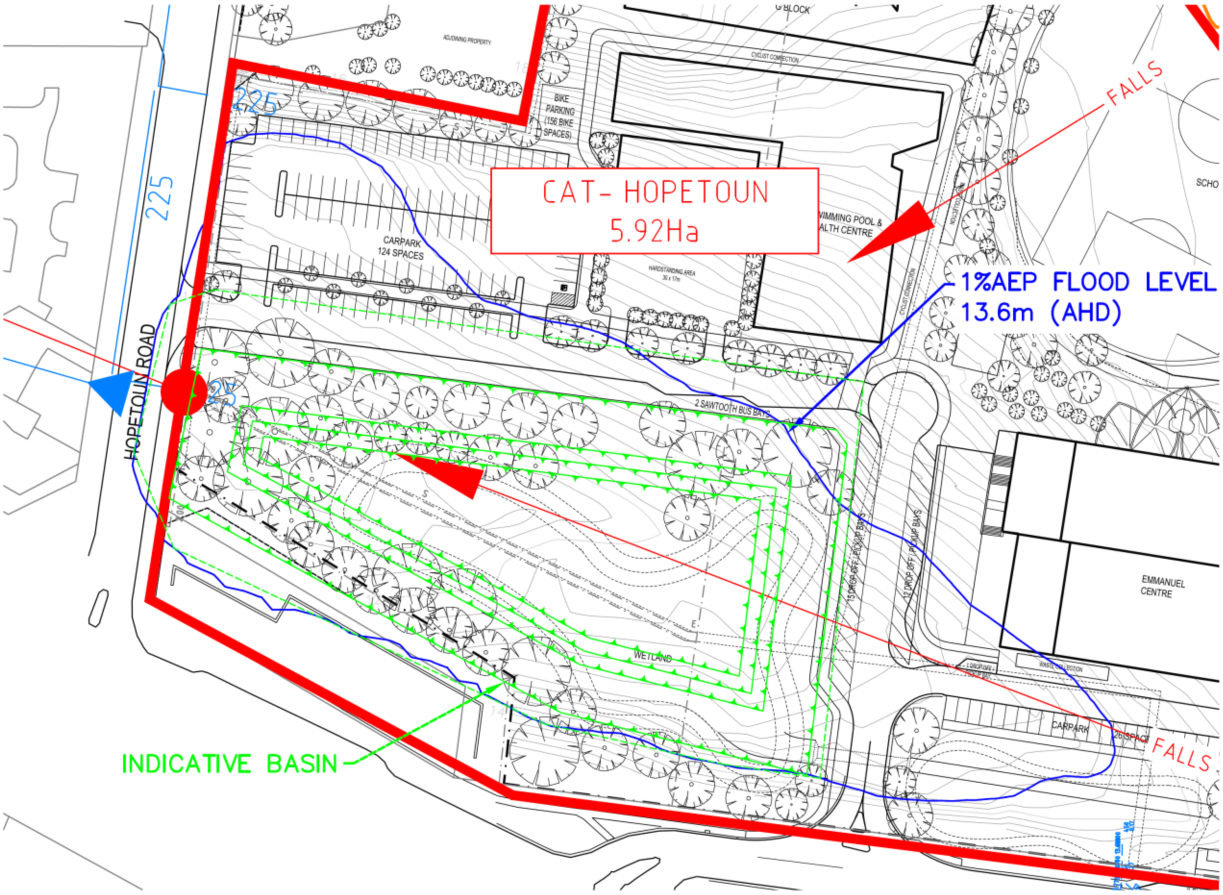


Figure 2 – Indicative Basin Arrangement – Existing 1%AEP

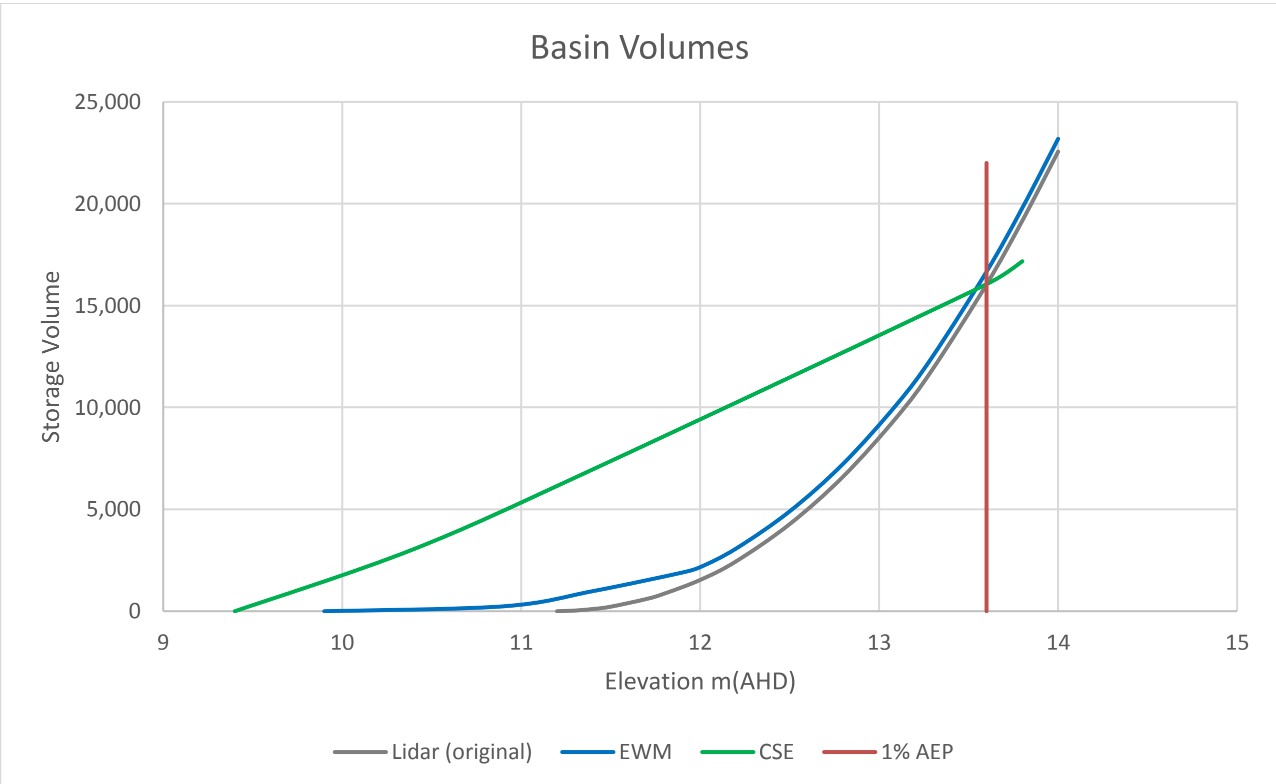


Chart 1 – Infiltration Basin Volumes

Water quality treatment measures may be contained within the basin floor. They will be designed minor storm events.

5.2 Crawley Street Catchment

The Crawley Street catchment has been investigated in detail as part of the new Year 9 centre development. The full report is included in the appendices for review of the engineering detail. In brief the key findings of this report are:

- Connect all roof water down pipes by charged 125/150/225mm diameter stormwater pipe to a 100 kilolitre rainwater detention / retention tank.
- Install 125mm diameter mid-level outlet in rainwater detention tank and connect to underground detention tank
- Connect all surface stormwater pits to underground 15 kilolitre detention tank.
- Install 150mm diameter low-level outlet in underground detention tank to rain garden.
- Install 34 square metre raingarden with overflow pit.
- Connect overflow pit with 90mm diameter uPVC to legal point of discharge which is considered to be the nearest council pit approximately 55m east at frontage of 5 Crawley Street (kerb outlet referenced).

5.3 Ardlie St Catchment

Reviewing the proposed Master Plan design against the existing conditions and in discussion with EC there are no significant changes proposed in the Ardlie Street catchment for the medium to long term. The area is substantially occupied with school buildings, car parking and school facilities, ovals, courts, playground. The impervious infrastructure, roofs & car parks, already has underground drainage and connections into the council drainage network.

Given the area is developed with no addition development proposed there is no formal study or allocation of area in this catchment. It can be seen from investigations that the downstream stormwater network and overland flow paths are at capacity with possible inundation of other private lands in major storm events. We therefore recommend that if future development were to occur that there be adequate provision of detention/retention storage to manage and attenuate flows for a 1%AEP rainfall event.

In addition any future development would be treated to meet Stormwater BPEM Guidelines for water quality objectives as there are no systems on the outfall at Russell Creek.

6.0 CONCLUSION & RECOMENDATIONS

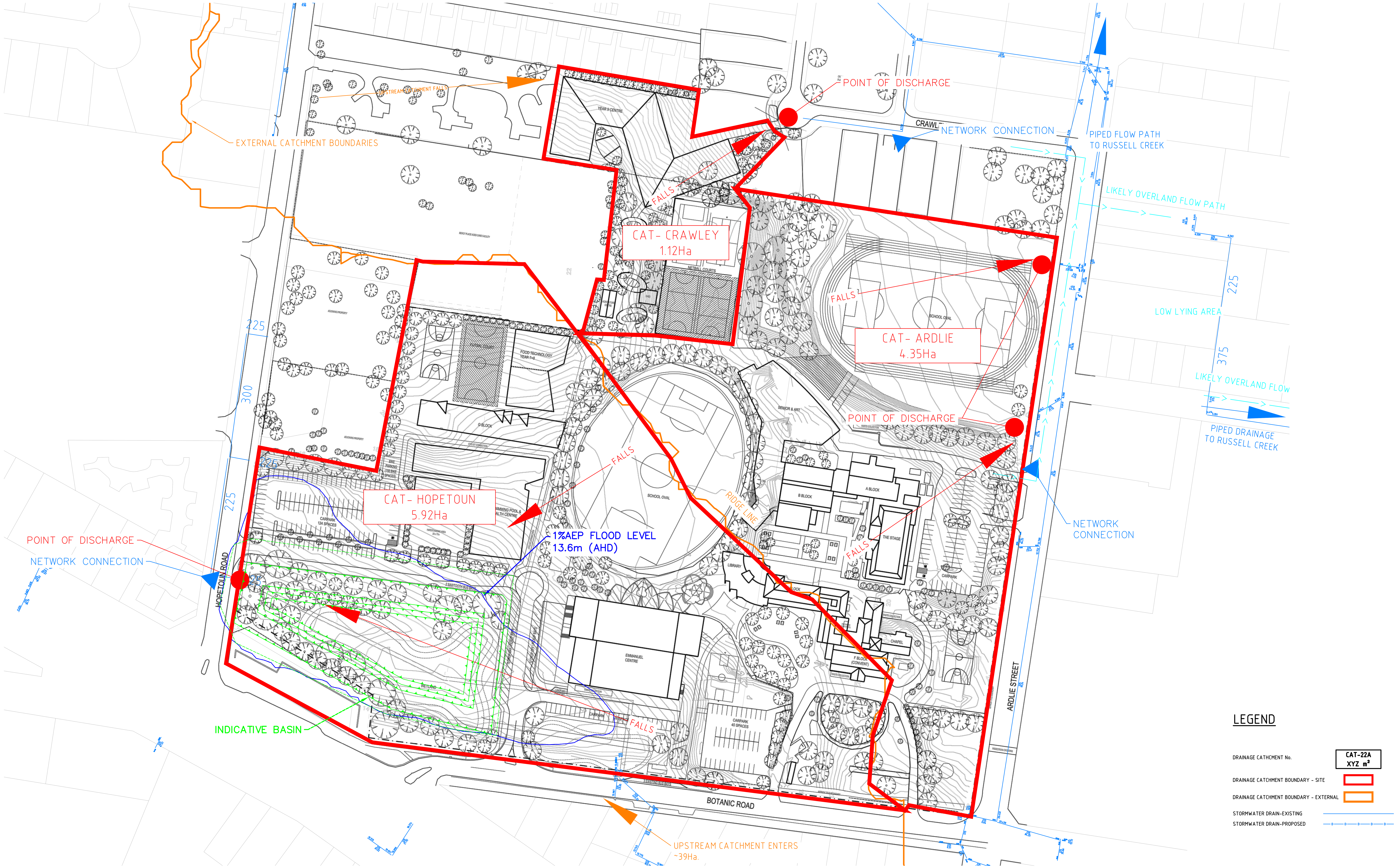
The intent of this study has been to review existing conditions, consolidate prior records and summarise stormwater objects across the whole of the Emmanuel College site, to provide the Warrnambool City Council some confidence that stormwater treatment targets will be met with the proposed masterplan design and there is sufficient space allocation upon the site.

The key findings are that the EC has three separate stormwater catchments and all catchments have constrained outfall systems which will require the 1%AEP stormwater flows to be managed on site to avoid impacts on downstream areas. The masterplan allows sufficient area for stormwater treatment measures to meet BEPM guidelines.

In regards to specific commentary on each of the catchments.

- The south west of site (Hopetoun Catchment) receives stormwater from a greater 45Ha catchment of central west Warrnambool, which ponds and infiltrates on site. The Master Plan proposes some encroachment on the 1%AEP flood envelope and this initial study indicates that there is sufficient space available within the Master Plan. However it is qualified in that detail design of the proposed car park and building pads must be designed in a manner to ensure the existing basin volume is maintained to ensure protection of downstream areas.
- The North East of site contains two sub-catchments, one discharges to Ardlie Street which is proposed to have no change in the longer term. The other includes the proposed year nine centre which will require drainage extension to service the property along with flow protection measures.

--- END OF REPORT ---



LAYOUT PLAN

SCALE 1:200

REV.	DESCRIPTION	DATE
A	CONCEPT FOR DEVELOPMENT	23.11.2022

APPROVED

ADVERTISED PLAN

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DATE	SEPT 2022

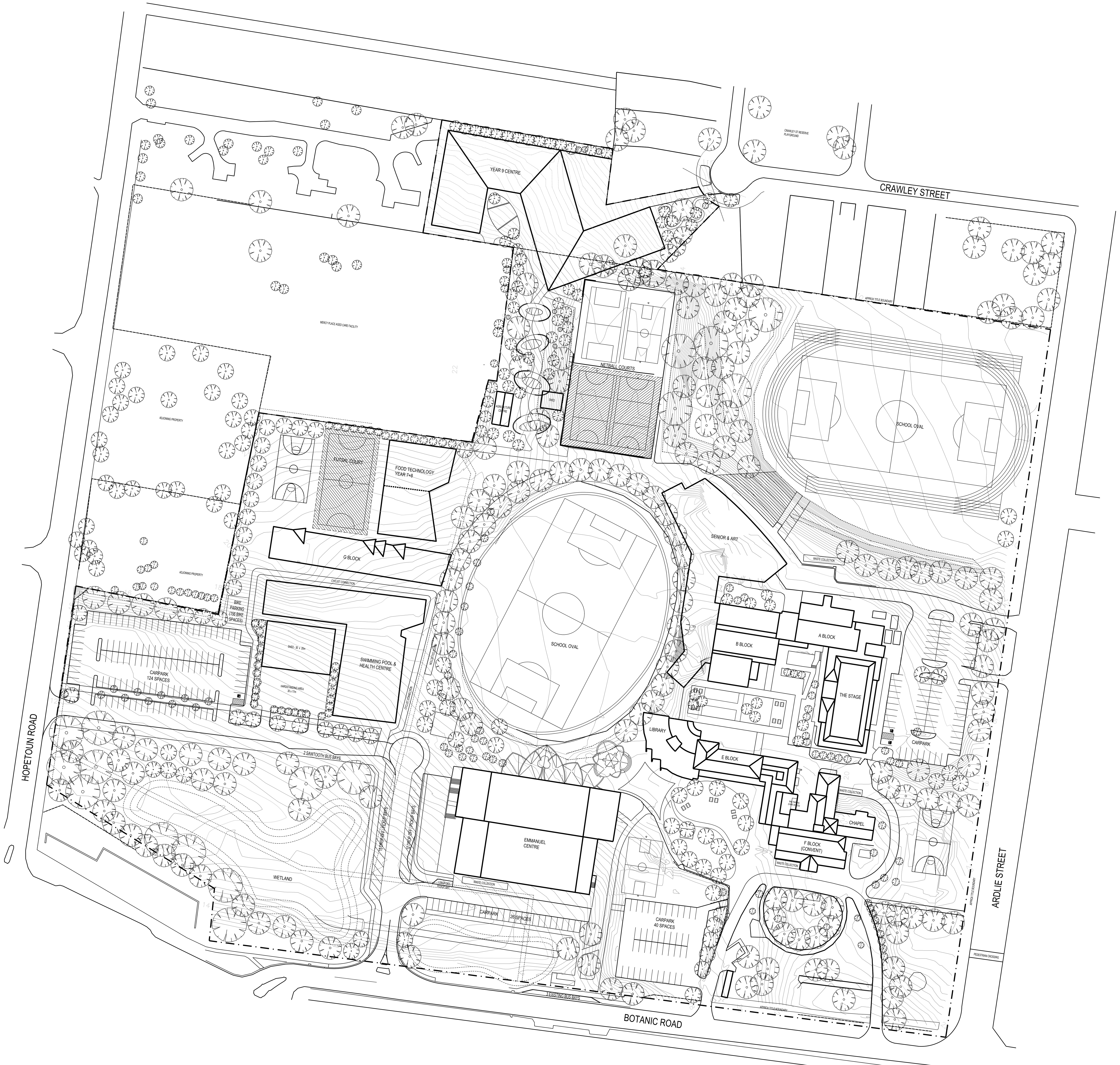
PROJECT TITLE
STORMWATER STRATEGY PLAN
EMMANUEL COLLEGE
BOTANIC ROAD, WARRNAMBOOL

DRAWING TITLE
STORMWATER CONCEPT SITE PLAN

N
NORTH

PROJECT No. 2022.152
SHEET SWS-01
REV. A

PROPOSED MASTERPLAN



ADVERTISED PLAN

SKETCH DESIGN - NOT FOR CONSTRUCTION

NORTH

Revision	Description	Date
A		17.11.21
B		11.03.22
C		11.04.22
D		21.04.22
E		22.04.22
F		24.10.22
G		10.11.22

SCALE 1 : 1000 (A1) 1 : 2000 (A3)

0 10 50 100m

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PROPOSED MASTERPLAN

JOB NUMBER	DRW NUMBER	REV
20210026	SK201	G

EMMANUEL COLLEGE - YEAR NINE CENTRE

STORMWATER MANAGEMENT PLAN

140 BOTANIC ROAD
WARRNAMBOOL

28/09/2022
Version: 1

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Emmanuel College

ADVERTISED PLAN

Document History

Rev. No.	Description of Revision	Prepared By	Checked By	Date Issued
1	First Report	Stephen Brodie	Scott Trotter	28/09/2022

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This report and the results shown and recommendations made herein are based upon the information, drawings, samples, tests and measurements referred to. The CSE Group, its consultants and agents accepts no liability for any damages, charges, costs or expenses in respect of or in relation to injury or death of any person or damage to any property or of other loss whatsoever arising either directly or indirectly from the use of this report, the carrying out of recommendations contained herein or the use of any goods or materials referred to.

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SW9	Orifice Plate Calculations
SW10	MUSIC Results
C-11	Year 9 Centre Stormwater Layout Plan

ADVERTISED
PLAN

1.0 INTRODUCTION

A new year 9 centre is proposed on vacant land north of the Emmanuel College campus bounded by Botanic Road, Ardlie Street, Crawley Street and Hopetoun Road approximately 1km northwest of the Warrnambool CBD. The proposed building is a 2-storey structure with an approximate roof area of 3,100 square metres. Stormwater detention & treatment is investigated for the proposed building to limit the adverse effects of stormwater on downstream properties up to the 1% AEP rainfall event.

2.0 EXISTING CONDITIONS

The proposed site for the Year 9 Centre falls northeast onto Crawly Street. There is an existing Council underground drainage pipe approximately 60m east of the proposed site.

Ground contours indicate that overland flow paths from the proposed site do not reach the Russell Creek and instead become land locked in a low-lying area on the block surrounded by Conns Lane, Ardlie Street, Wentworth Street and Barbers Lane. Water sitting in this location would likely pond in a major event before infiltrating into the ground.

3.0 DESIGN REQUIREMENTS

It is anticipated that the proposed site will be required to meet the following conditions:

- Underground drainage to the legal point of discharge.
- On-site detention of stormwater to limit outflows to pre-development conditions in a 1% AEP rainfall event (due to the lack of overland outfall).
- All stormwater to be designed in accordance with the Infrastructure Design Manual & AS/NZS 3500.
- Meet Best Practice Environmental Guidelines:
    - 80% Reduction in Suspended Solids
    - 45% Reduction in Total Phosphorus
    - 45% Reduction in Total Nitrogen
    - 70% Reduction in Gross Pollutants
    - Maintain flows at 1.5 year ARI pre-development levels

4.0 DESIGN & DISCUSSION

The proposed design incorporates a stormwater detention tank to attenuate flows from the roof area, an underground tank to attenuate flows from ground water runoff and a raingarden treatment area to treat stormwater to BPEM. Stormwater attenuation is designed to limit flows to pre-developed conditions in a 1% AEP rainfall event to prevent exacerbation of flooding in the land locked area to the east.

4.1 Roof Stormwater Collection

Rainfall collected from the roof of the year 9 building will be collected by a 200 half round eaves gutter with 150mm downpipes at centres of not less than 5.2m. A 225mm diameter uPVC pipe will convey water from the downpipes to the tank. A box gutter & rainhead system has been designed to collect stormwater from the valley of the roof. Further details are provided in the calculations and plans in the appendix.

4.2 Pre-development Runoff

The Rational Method is used to determine the pre-development runoff for a 1% AEP event with a **10 minute** time of concentration and a **0.3** runoff coefficient. Allowable runoff for the new development was calculated to be:

- Year 9 Centre – 63.7 litres / second

4.3 Coefficient of Runoff for Development

The Coefficient of Runoff of the development has been calculated in accordance with the infrastructure design manual and the following:

- Low Density Residential Zone > 2ha – 0.3
- Commercial Zones – 0.9
- Paved Areas – 0.95

4.4 Storage for 1% AEP Storm Event

The required storage volume for the proposed development is shown on sheet SW8 to limit development flows to peak pre-development flows for a 1% AEP storm event. Storage volumes are:

- Year 9 Centre – 66.81 kilolitres

It is proposed that 100 kilolitre rainwater detention / retention tank be installed to limit flows from the roof, a 15 kilolitre underground tank be installed to limit flows from surface water with the remaining capacity provided with the raingarden. The tank will function with dual purposes with half the capacity used for stormwater detention to retard stormwater discharge and half retained for building use. For details refer to sheet C-11.

4.5 Discharge for 1% AEP Storm Event

Discharge rates are to be controlled using an orifice plate located at the outlet of each storage device. The orifices for the development will be fitted in the rainwater detention tanks limiting the flow from site. The orifice calculation can be found on sheet SW9 and is summarised below:

- Rainwater Tank – 125mm dia. @ mid height of tank
- Year 9 Centre, underground tank – 150mm dia. @ bottom of tank

4.6 Proposed Storm Water Connection Points

ADVERTISED PLAN

Proposed discharge points for each allotment are:

- Year 9 Centre – Kerb outlet on Crawley Street

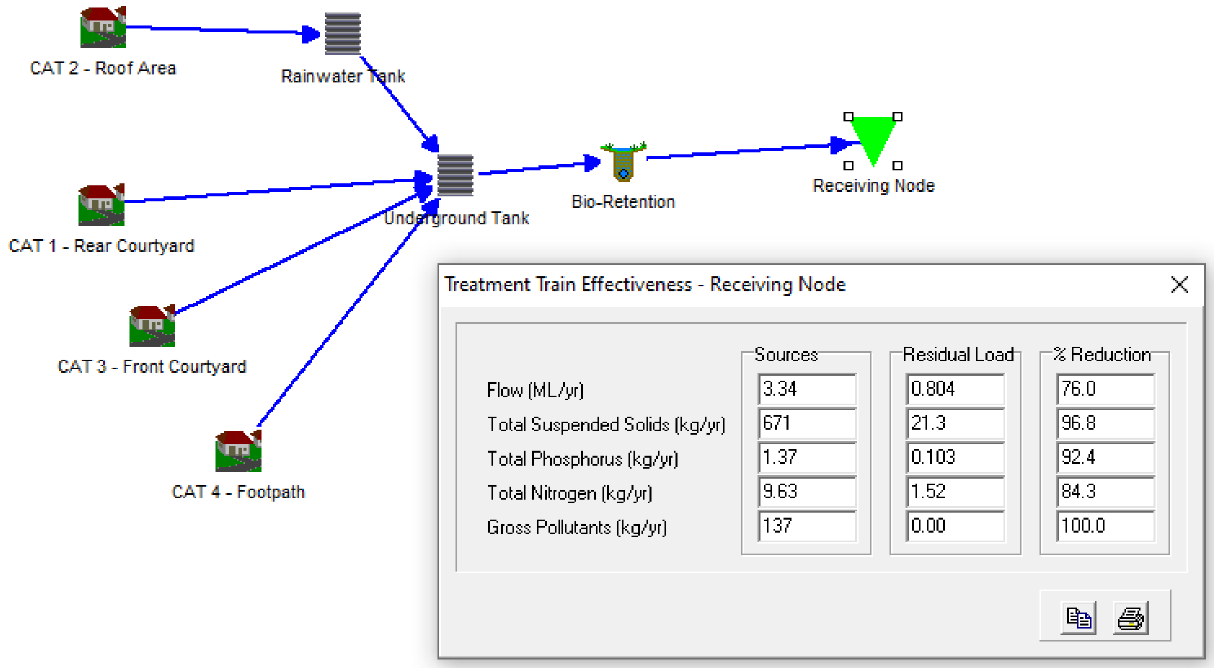
Pipe size for the connection between the raingarden and council drainage assets is 90mm uPVC.

4.7 Overland Flow Path

In storm events where Council drainage is exceeded stormwater will overflow east down Crawley Street and south down Ardlie Street before ending up in the low lying area between Conns Lane, Ardlie Street, Wentworth Street and Barbers Lane. Flows in a 1% AEP event will be limited to pre-development levels ensuring flooding in this area is not exacerbated.

4.8 Stormwater Quality Treatment

The proposed stormwater detention system & raingarden was modelled in MUSIC to determine the effectiveness of these treatments at reducing stormwater pollutants from entering the stormwater network. A summary of results is presented below as a screenshot and a table with detailed results provided in the appendix. The quality of stormwater leaving the site is expected to exceed BPEM requirements.



	Source	Residual Loads	% Reduction	BPEM % Targets
Flow (ML/yr)	3.34	0.804	76.0	-
Total Suspended Solids (kg/yr)	671	21.3	96.8	80
Total Phosphorus (kg/yr)	1.37	0.103	92.4	45
Total Nitrogen (kg/yr)	9.63	1.52	84.3	45
Gross Pollutants (kg/yr)	137	0	100	70

5.0 CONCLUSION & RECOMENDATIONS

The Stormwater Management Plan for the proposed Year 9 Centre development at 140 Botanic Road, Warrnambool requires the following works:

- Year 9 Centre
  - Connect all roof water down pipes by charged 125/150/225mm diameter stormwater pipe to a 100 kilolitre rainwater detention / retention tank.
  - Install 125mm diameter mid-level outlet in rainwater detention tank and connect to underground detention tank
  - Connect all surface stormwater pits to underground 15 kilolitre detention tank.
  - Install 150mm diameter low-level outlet in underground detention tank to rain garden.
  - Install 34 square metre raingarden with overflow pit.
  - Connect overflow pit with 90mm diameter uPVC to legal point of discharge (kerb outlet).

--- END OF REPORT ---

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ROOF DRAINAGE EAVES GUTTER

WIDTH OF ROOF

$I_{20} = 116\,mm/hr.$

$W = 22.4m$

$S = 3^{\circ} \Rightarrow F = 1.03$

$L = 4.0m$ (COLUMN TO COLUMN)

$A_h \doteq 4 \times 22.4$
$= 89.6m^2$

$A_c = 1.03 \times 89.6$
$= 92.3m^2$

$Q = \frac{116 \times 92.3}{3600}$
$= 2.97\,L/s$

$A_e = 9{,}800\,mm^2$ FIG 3.5.2(B) AS 3500.3:2019

DP = Ø125mm. OR 100mm x 100mm

EAVE GUTTER = 200 HALF ROUND WITH Ø125mm DP

COLLECTOR PIPE TO TANK

Height of Roof — RL 22.5m

Height of tank — RL 15m + 2.2m = 17.2m

$\Delta H = 5.3m$

$A_c = 3134 \times 1.03 = 3228m^2$

$I_{20} = 116\,mm/hr$

$Q = 104\,L/s \Rightarrow$ HALF ROOF AREA = $52\,L/s$

$D = 120m$

JOB No	BY	PROJECT NAME	DATE	SHEET
2022.152	SJB	EMMANUEL ... CENTRE	20/9/22	SW1

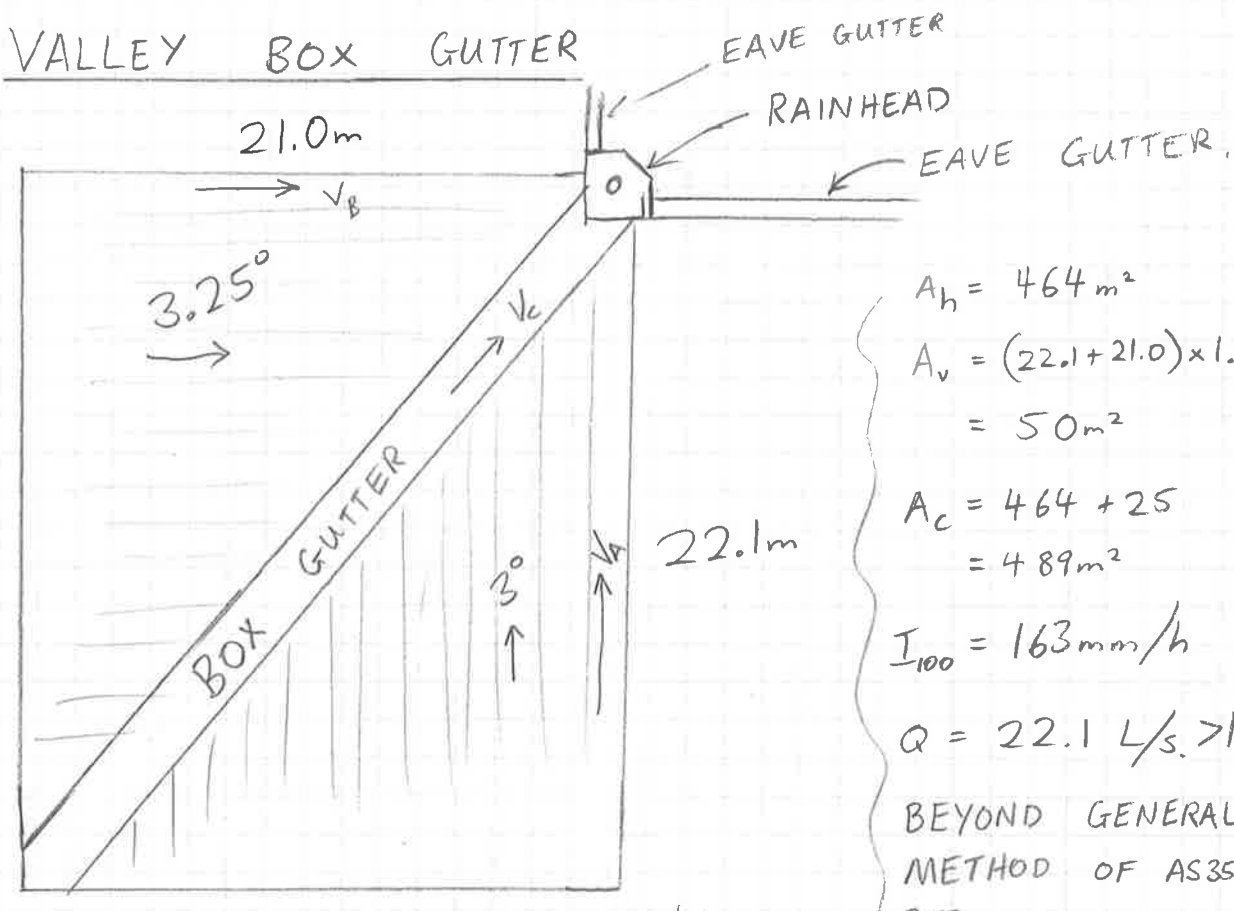
Try Ø150mm uPVC at 5.5% FRICTION LOSS (HALF)

$H = 0.055 \times 120$
$= 0.66 > 5.3m$ ∴ NOT OK.

Try Ø225mm uPVC at 2% FRICTION LOSS (FULL)

$H = 0.02 \times 120$
$= 2.4m < 5.3m$ ∴ OK. Adopt Ø225mm

VALLEY BOX GUTTER



$A_h = 464 m^2$

$A_v = (22.1 + 21.0) \times 1.16$
$= 50 m^2$

$A_c = 464 + 25$
$= 489 m^2$

$I_{100} = 163 mm/h$

$Q = 22.1 L/s > 16 L/s$

BEYOND GENERAL METHOD OF AS3500.3:2015.

I height
$= 22.1 \sin 3°$
$= 1.16$

* HIGHER RISK TO INSTALL INTERNAL BOX GUTTER SUMP THAN DISCHARGE TO RAINHEAD ON END. PROCEED WITH DESIGN.

ADVERTISED PLAN

JOB No	BY	PROJECT NAME	DATE	SHEET
2022.152	SJB	EMMANUEL Y9 CENTRE	20/9/22	SW2

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CHECK VELOCITY IN BOX GUTTER

$L_{BG} = 30.5m$

$H_{BG} = 1.16m$

$S_{BG} = 3.8\%$ or $2.18°$ or 1 in 26

$n = 0.012$ (Smooth Steel)

$W = 0.8m$
$D = 0.023m$
$A = 0.0184 m^2$
$P = 0.846m$
$R = 0.022$

$$V_c = \frac{R^{2/3}\sqrt{S}}{n}$$

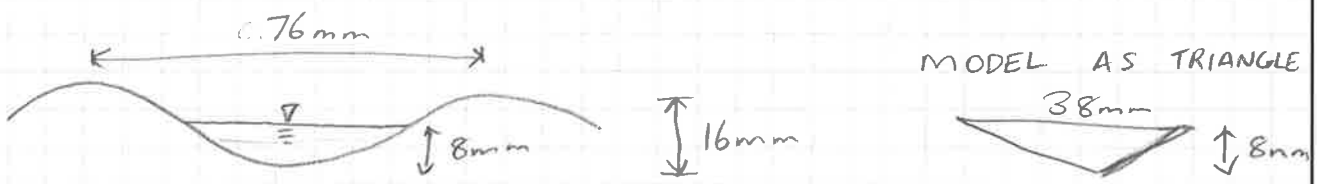
$$= \frac{0.022^{2/3}\sqrt{0.038}}{0.012}$$

$$= \frac{0.079 \times 0.195}{0.012}$$

$$= 1.28\ m/s$$

FIND V_B

ASSUME CORRIGATED PROFILE 0.48 BMT



$A_h = 21 \times 0.076 = 1.6$
$A_v = 0.088$
$A_c = 1.64 m^2$
$Q = 0.074 L/s$
$S = 5.7\%$

try $W = 0.038m$ $D = 0.008m$
$A = 152 mm^2$

$V_B = 0.475\ m/s$ Okay!

$Q = 0.072 L/s$.

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JOB No	BY	PROJECT NAME	DATE	SHEET
2022.152	SJB	EMMANUEL Y9 CENTRE	20/9/22	SW3

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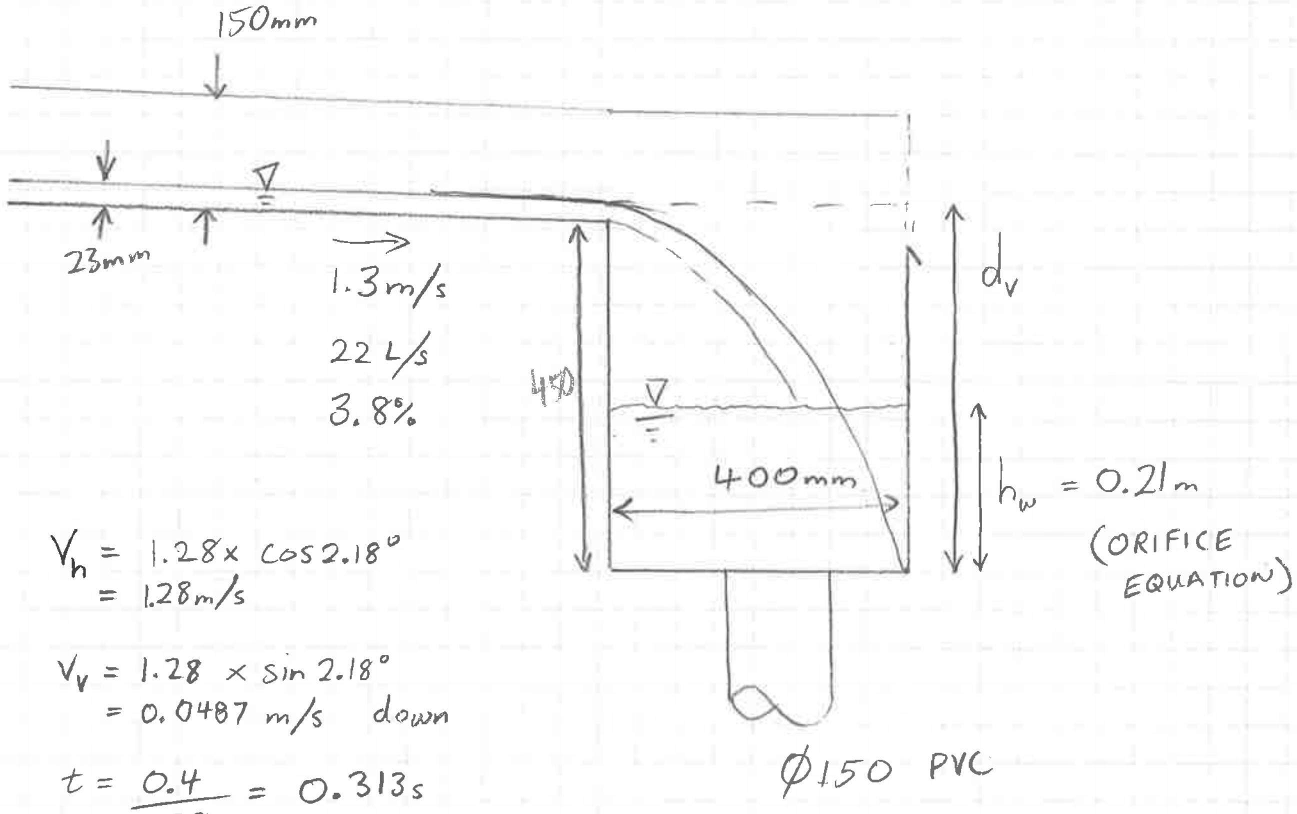
W_{BG} = 600mm ⇒ 800mm
d_{BG} = 122 mm ⇒ 150mm
h_r = 400mm ⇒ 450mm
d_p = ∅150mm ⇒ ∅150mm
l_r = 230mm ⇒ 400mm

DESIGN VALUES MAKE CONSERVATIVE

CHECK PROJECTION OF WATER



$V_h = 1.28 \times \cos 2.18°$
$= 1.28 m/s$

$V_v = 1.28 \times \sin 2.18°$
$= 0.0487 m/s$ down

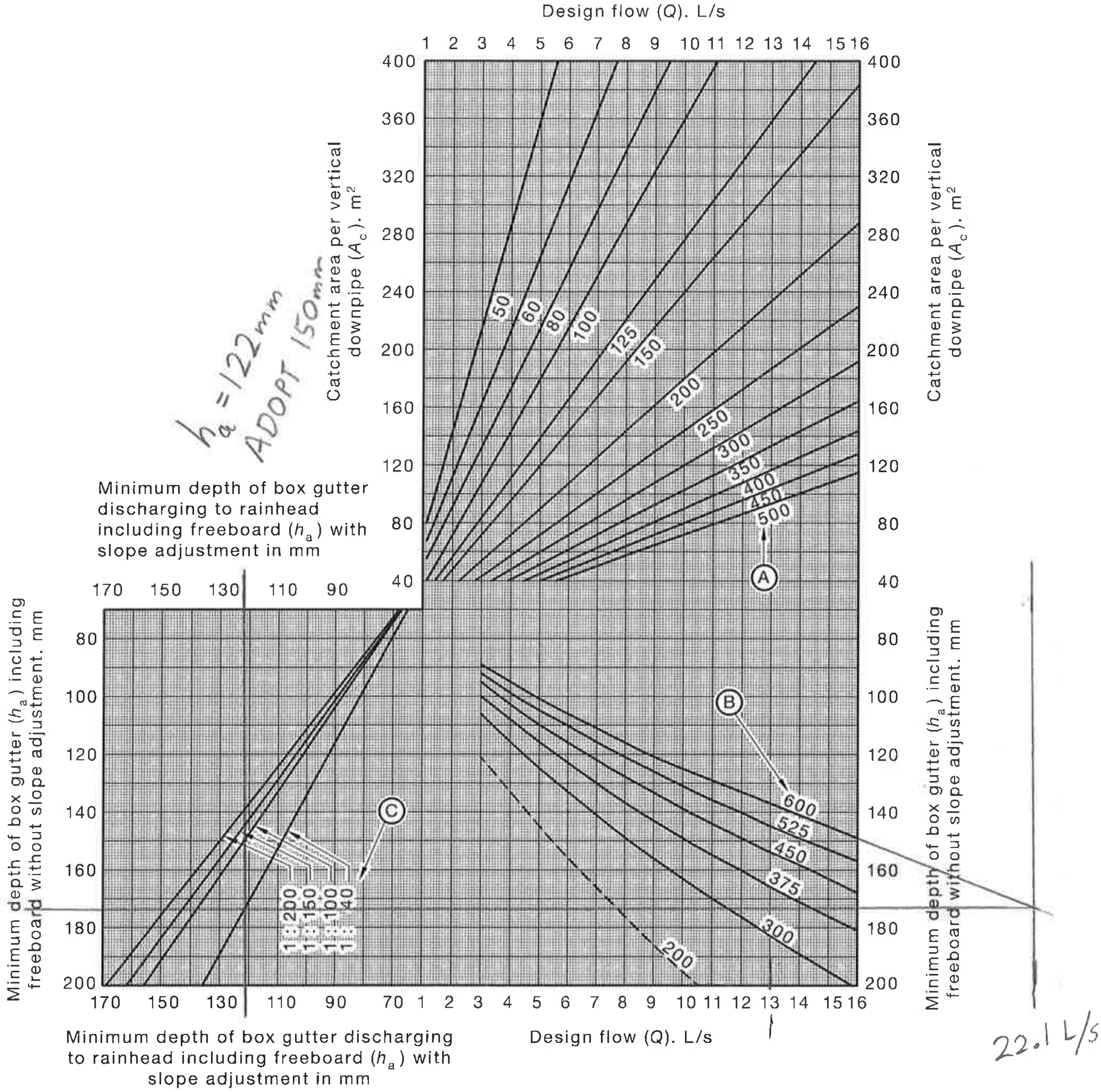
$t = \frac{0.4}{1.28} = 0.313s$

$V_v = 9.81 \times 0.313 + 0.0487$
$= 3.11 m/s$ down

$d_v = \int 9.81t + 0.0487\, dt$
$= \frac{9.81}{2} t^2 + 0.0487t = 0.441 + 0.015 = 0.455m.$ OK.

ADVERTISED PLAN

JOB No	BY	PROJECT NAME	DATE	SHEET
2022.152	SJB	EMMANUEL Y9 CENTRE	29/9/22	SW4



LEGEND:

(A) = Design rainfall intensity ($^{100}I_5$) OR ($^{50}I_{10}$) in mm/h (typical)

(B) = Width of box gutter (W_{bg}) in mm (typical)

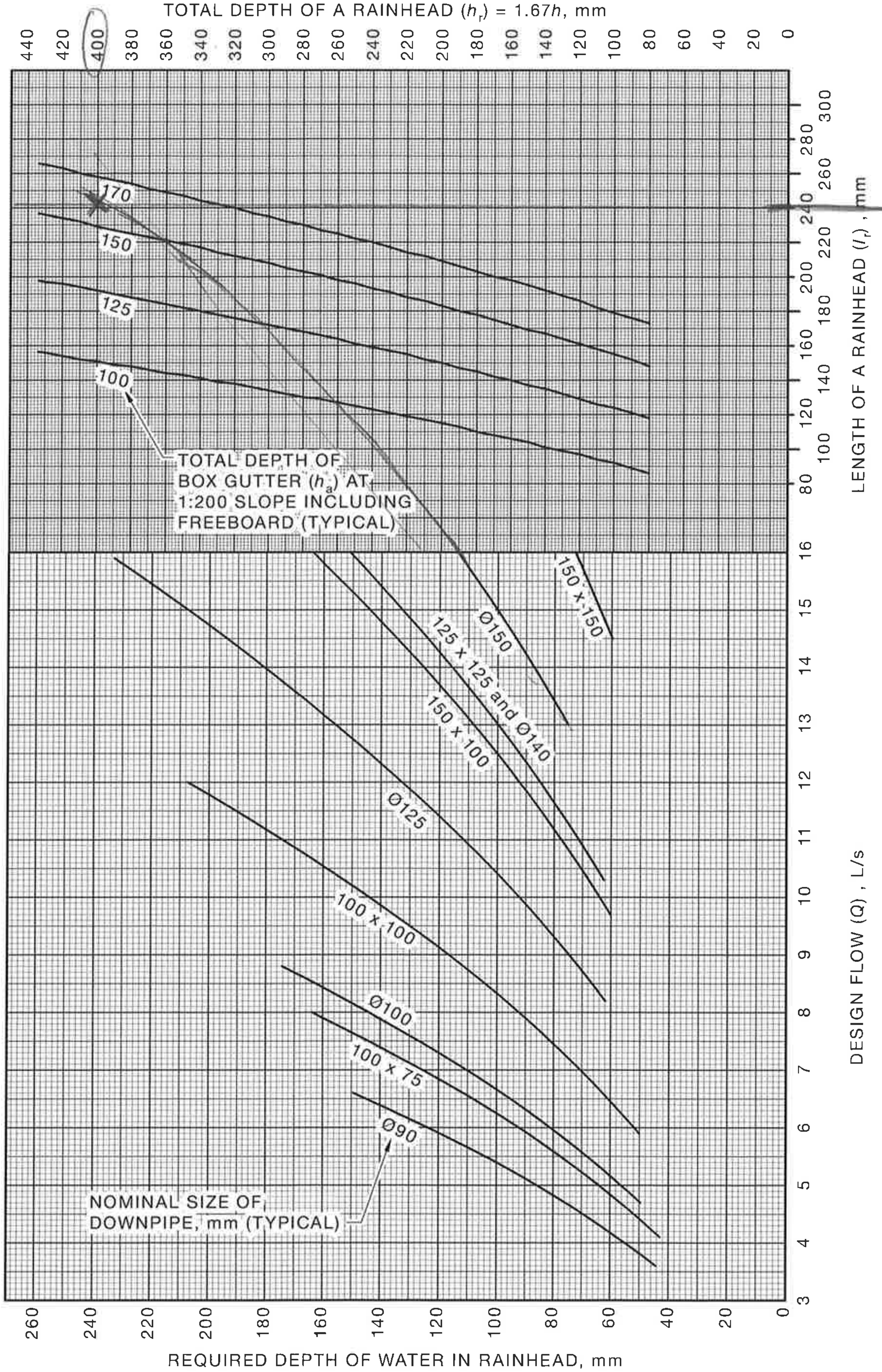
(C) = Gradient of box gutter (typical)

NOTE: Box gutters 200 mm wide may be used for domestic construction only. See Clause 3.7.1.

FIGURE I1 DESIGN GRAPH FOR A FREELY DISCHARGING BOX GUTTER

2022.152 EMMANUEL Y9 CENTRE 20/9/22 SW5

ADVERTISED PLAN



22.1 L/s

FIGURE I3 DESIGN GRAPH FOR RAINHEAD

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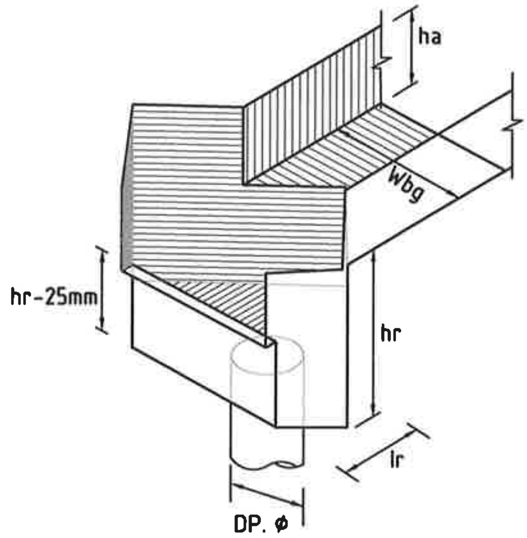
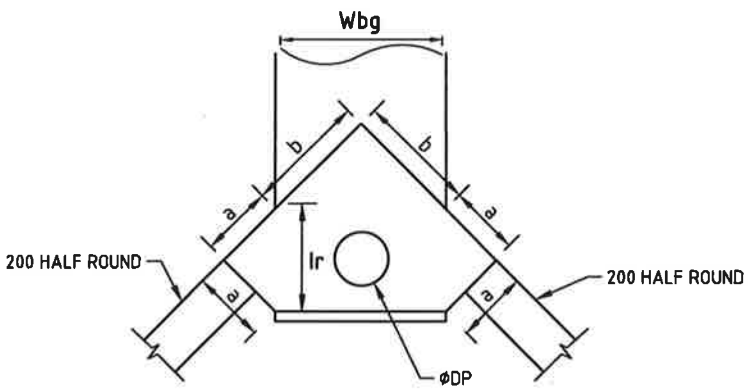


TABLE							
ha	hr	lr	Wbg	DP. ø	Q (Ls)	a	b
150	450	400	800	150	22.1	283	566

TYPICAL BOX GUTTER RAIN HEAD DETAIL

SCALE = N.T.S.



PLAN VIEW

SCALE = N.T.S.

ADVERTISED PLAN

REV	DATE	DESCRIPTION	PROJECT TITLE	PROJECT No.
A	21.09.22	FIRST ISSUE	EMMANUEL Y9 CENTRE	2022.152

DRAWING TITLE	DESIGNED	DRAWN	SCALE	SHEET	REV.
RAINHEAD DETAIL	B. Johnston	D. Wills	A4 AS SHOWN	SW 7 / DATE SEP 2022	A

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140 Botanic Road, Warrnambool, 3280

Storage & Infiltration Calculation

Site Characteristics

	Area (m^2)	Runoff Coefficient	C x A
Roof Area	3037	1.0	3037
Entrance Courtyard	813	0.9	731.7
Back Courtyard	791	0.9	711.9
Footpath Link	1423	0.3	426.9
Totals (m^2)	**6064**		**4908**

81% Impervious

Predevelopment Runoff

Predev. Runoff Coefficient - C	0.3	
Find CA (Total Area by C)	1819.2	m^2
Storm Event	1%	AEP
Time of Concentration	10	mins
Locality Code	WARR	Warrnambool
Intensity - I	126.0	mm/hr
Runoff Q = CAI / 3600	63.7	L/s

WSUD Measures

					Effective Infiltration Area (m²)	Storage Volume (m³)
Rainwater Tank						
Number of tanks	1		Height (m)	2.18		
Detention Volume	50	m³	Diameter (m)	7.642		
Retention Volume	50	m³				
% retention for private use	50%		Vol = n * (pi * D^2/4 * h) * (1-percentage)			50.00
Underground Matrix Pit						
Length - L	5	m	Base Infiltration Area A_{inf} = WxLx(1-F_b)		15.00	
Width - W	3	m	Perimeter Infiltration Area = 0.5*P*D		8.00	
Depth of Storage - d	1	m				
Infiltration Blockage Factor - F_b	0%		**Storage Volume**			**13.50**
Storage Porosity P_s	90%		S_B = L x W x d x P_s + (LxWxd_{bed})			
Infiltration Bed Depression d_{bed}	0	m				
Raingarden						
Length - L	10	m	Base Infiltration Area A_{inf} = WxLx(1-F_b)		40.00	
Width - W	4	m	Perimeter Infiltration Area = 0.5*P*D*(1-F_t		2.80	
Depth of Storage - d_i	0.2	m	**Storage Volume - infiltration media**			**2.40**
Infiltration Blockage Factor - F_b	0%		S_i = L x W x d_i x P_s			
Storage Porosity P_s	30%		Basin Vol. S_a = L ((W d_w) + ((6 d_w^2)/2))			4.30
Infiltration Bed Depression d_w	0.1	m				
			TOTALS		**65.80**	**70.20**

Soil Characteristics

Soil K_h	0	mm/hr	Infiltration Rate*	0.00E+00	m³/s
	0.00E+00	m/s		0.000	L/s
Moderating Factor - U	0.5	Sandy soil			

Allow Piped Outflow Q_p **63.7** **L/s** Equal to Predevelopment Runoff Conditions (unless no connection available)

1% AEP Rainfall Event

Time (Duration) min D	Rainfall Intensity mm/hr	Volume In CAID/60,000 I_V (m^3)	Piped flow O_p (m^3)	Nett Inflow Vol. I_V - O_p (m3)	Soakage Out [A_{eff}] $Uk_h t$ O_s (m^3)	Storage Volume Required S_R=I_V-O_p-O_s (m^3)	Percentage of storage provided S_T / S_R %	Storage area adequate
0	0	0	0	0	0	0		Yes
1	268.0	21.92	3.82	18.10	0.00	18.10	388%	Yes
2	202.0	33.04	7.64	25.40	0.00	25.40	276%	Yes
3	185.0	45.39	11.46	33.93	0.00	33.93	207%	Yes
4	173.0	56.60	15.28	41.32	0.00	41.32	170%	Yes
5	163.0	66.66	19.10	47.56	0.00	47.56	148%	Yes
10	126.0	103.06	38.20	64.85	0.00	64.85	108%	Yes
15	103.0	126.37	57.30	69.06	0.00	69.06	102%	Yes
20	86.3	141.17	76.41	64.77	0.00	64.77	108%	Yes
25	74.8	152.95	95.51	57.44	0.00	57.44	122%	Yes
30	66.1	162.19	115	47.58	0.00	47.58	148%	Yes
45	49.6	182.56	172	10.64	0.00	10.64	659%	Yes
60	40.3	197.77	229	0.00	0.00	0.00		Yes
90	30.1	221.57	344	0.00	0.00	0.00		Yes
120	24.6	241.45	458	0.00	0.00	0.00		Yes
180	18.6	273.84	688	0.00	0.00	0.00		Yes
270	14.3	315.80	1031	0.00	0.00	0.00		Yes
360	12.0	353.34	1375	0.00	0.00	0.00		Yes
540	9.3	412.52	2063	0.00	0.00	0.00		Yes
720	7.8	461.11	2751	0.00	0.00	0.00		Yes
1080	6.1	536.19	4126	0.00	0.00	0.00		Yes
1440	5.0	590.08	5501	0.00	0.00	0.00		Yes
1800	4.3	630.12	6877	0.00	0.00	0.00		Yes
2160	3.7	660.75	8252	0.00	0.00	0.00		Yes
2880	3.0	701.97	11003	0.00	0.00	0.00		Yes
4320	2.1	745.55	16504	0.00	0.00	0.00		Yes
5760	1.6	763.21	22005	0.00	0.00	0.00		Yes
7200	1.3	777.35	27506	0.00	0.00	0.00		Yes
8640	1.1	784.41	33008	0.00	0.00	0.00		Yes
10080	1.0	96.40	4947	0.00	0.00	0.00		Yes

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Orifice Calculation

Tank Discharge

C_d	0.63		Coefficeint of Discharge
Q	32.9	L/s	Flow Rate
	0.0329	m^3/s	
h	1	m	Water height above orifice
g	9.81	m/s	m/s gravity
a_o	0.01179	m^2	Area of Orifice
Orifice Dia.	**0.123**	m	
	123	mm	
Say	125	mm outlet	
v = Q/A	2.79	m/s	Nom. Velocity

Underground Matrix Tank Discharge

C_d	0.63		Coefficeint of Discharge
Q	63.7	L/s	Flow Rate
	0.0637	m^3/s	
h	1	m	Water height above orifice
g	9.81	m/s	m/s gravity
a_o	0.022827	m^2	Area of Orifice
Orifice Dia.	**0.170**	m	
	170	mm	
Say	150	mm outlet	
v = Q/A	2.79	m/s	Nom. Velocity

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Location	CAT 2 - Roof Area	CAT 1 - Rear Courtyard	CAT 3 - Front Courtyard
ID	1	2	6
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	0.313	0.079	0.081
Area Impervious (ha)	0.313	0.070996053	0.072793421
Area Pervious (ha)	0	0.008003947	0.008206579
Field Capacity (mm)	80	80	80
Pervious Area Infiltration Capacity coefficient - a	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1
Pervious Area Soil Storage Capacity (mm)	120	120	120
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30
Groundwater Initial Depth (mm)	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.2	2.2	2.2
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.45	-0.45	-0.45
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.42	0.42	0.42
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0

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Location	CAT 2 - Roof Area	CAT 1 - Rear Courtyard	CAT 3 - Front Courtyard
Baseflow Total Suspended Solids Mean (log mg/L)	1.1	1.1	1.1
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.82	-0.82	-0.82
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.32	0.32	0.32
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0
OUT - Mean Annual Flow (ML/yr)	2	0.464	0.476
OUT - TSS Mean Annual Load (kg/yr)	423	94.5	94.6
OUT - TP Mean Annual Load (kg/yr)	0.849	0.19	0.193
OUT - TN Mean Annual Load (kg/yr)	5.83	1.35	1.38
OUT - Gross Pollutant Mean Annual Load (kg/yr)	82.2	19.5	20
No Imported Data Source nodes			

Location	CAT 4 - Footpath
ID	7
Node Type	UrbanSourceNode
Total Area (ha)	0.142
Area Impervious (ha)	0.042693421
Area Pervious (ha)	0.099306579
Field Capacity (mm)	80
Pervious Area Infiltration Capacity coefficient - a	200
Pervious Area Infiltration Capacity exponent - b	1
Impervious Area Rainfall Threshold (mm/day)	1
Pervious Area Soil Storage Capacity (mm)	120
Pervious Area Soil Initial Storage (% of Capacity)	30
Groundwater Initial Depth (mm)	10
Groundwater Daily Recharge Rate (%)	25
Groundwater Daily Baseflow Rate (%)	5
Groundwater Daily Deep Seepage Rate (%)	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.2
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.45
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic
Stormflow Total Phosphorus Serial Correlation	0
Stormflow Total Nitrogen Mean (log mg/L)	0.42
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic
Stormflow Total Nitrogen Serial Correlation	0

Location	CAT 4 - Footpath
Baseflow Total Suspended Solids Mean (log mg/L)	1.1
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.82
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic
Baseflow Total Phosphorus Serial Correlation	0
Baseflow Total Nitrogen Mean (log mg/L)	0.32
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic
Baseflow Total Nitrogen Serial Correlation	0
OUT - Mean Annual Flow (ML/yr)	0.405
OUT - TSS Mean Annual Load (kg/yr)	59.2
OUT - TP Mean Annual Load (kg/yr)	0.137
OUT - TN Mean Annual Load (kg/yr)	1.08
OUT - Gross Pollutant Mean Annual Load (kg/yr)	15
No Imported Data Source nodes	

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Location	Rainwater Tank	Bio-Retention	Underground Tank
ID	3	4	8
Node Type	RainWaterTankNode	BioRetentionNode	RainWaterTankNode
Lo-flow bypass rate (cum/sec)	0	0	0
Hi-flow bypass rate (cum/sec)	100	100	100
Inlet pond volume	0		0
Area (sqm)	50	40	15
Extended detention depth (m)	1	0.1	1
Permanent pool volume (cum)	50		0.2
Proportion vegetated	0		0
Equivalent pipe diameter (mm)	125		150
Overflow weir width (m)	10	10	10
Notional Detention Time (hrs)	0.381		7.95E-02
Orifice discharge coefficient	0.6		0.6
Weir coefficient	1.7	1.7	1.7
Number of CSTR cells	2	3	2
Total Suspended Solids k (m/yr)	400	8000	400
Total Suspended Solids C* (mg/L)	12	20	12
Total Suspended Solids C** (mg/L)	12		12
Total Phosphorus k (m/yr)	300	6000	300
Total Phosphorus C* (mg/L)	0.13	0.13	0.13
Total Phosphorus C** (mg/L)	0.13		0.13
Total Nitrogen k (m/yr)	40	500	40
Total Nitrogen C* (mg/L)	1.4	1.4	1.4
Total Nitrogen C** (mg/L)	1.4		1.4
Threshold hydraulic loading for C** (m/yr)	3500		3500
Extraction for Re-use	On	Off	Off
Annual Re-use Demand - scaled by daily PET (ML)	0		

Location	Rainwater Tank	Bio-Retention	Underground Tank
Constant Daily Re-use Demand (kL)	0.5		
User-defined Annual Re-use Demand (ML)	0		
Percentage of User-defined Annual Re-use Demand Jan	8.333333333		
Percentage of User-defined Annual Re-use Demand Feb	8.333333333		
Percentage of User-defined Annual Re-use Demand Mar	8.333333333		
Percentage of User-defined Annual Re-use Demand Apr	8.333333333		
Percentage of User-defined Annual Re-use Demand May	8.333333333		
Percentage of User-defined Annual Re-use Demand Jun	8.333333333		
Percentage of User-defined Annual Re-use Demand Jul	8.333333333		
Percentage of User-defined Annual Re-use Demand Aug	8.333333333		
Percentage of User-defined Annual Re-use Demand Sep	8.333333333		
Percentage of User-defined Annual Re-use Demand Oct	8.333333333		
Percentage of User-defined Annual Re-use Demand Nov	8.333333333		
Percentage of User-defined Annual Re-use Demand Dec	8.333333333		
Filter area (sqm)		40	
Filter depth (m)		0.3	
Filter median particle diameter (mm)		3	
Saturated hydraulic conductivity (mm/hr)		100	
Voids ratio		0.3	
Length (m)			
Bed slope			
Base Width (m)			
Top width (m)			
Vegetation height (m)			
Proportion of upstream impervious area treated			
Seepage Rate (mm/hr)	0	180	0
Evap Loss as proportion of PET	0		0

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Location	Rainwater Tank	Bio-Retention	Underground Tank
Depth in metres below the drain pipe		0	
IN - Mean Annual Flow (ML/yr)	2	3.16	3.16
IN - TSS Mean Annual Load (kg/yr)	423	320	361
IN - TP Mean Annual Load (kg/yr)	0.849	0.851	0.906
IN - TN Mean Annual Load (kg/yr)	5.83	7.8	7.96
IN - Gross Pollutant Mean Annual Load (kg/yr)	82.2	0	54.6
OUT - Mean Annual Flow (ML/yr)	1.82	0.804	3.16
OUT - TSS Mean Annual Load (kg/yr)	113	21.3	320
OUT - TP Mean Annual Load (kg/yr)	0.386	0.103	0.851
OUT - TN Mean Annual Load (kg/yr)	4.15	1.52	7.8
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0
No Generic treatment nodes			

Location	Receiving Node
ID	5
Node Type	ReceivingNode
IN - Mean Annual Flow (ML/yr)	0.804
IN - TSS Mean Annual Load (kg/yr)	21.3
IN - TP Mean Annual Load (kg/yr)	0.103
IN - TN Mean Annual Load (kg/yr)	1.52
IN - Gross Pollutant Mean Annual Load (kg/yr)	0
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	1	4	3	8	2	6
Target node ID	3	5	8	4	8	8
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K						
Muskingum theta						
IN - Mean Annual Flow (ML/yr)	2	0.804	1.82	3.16	0.464	0.476
IN - TSS Mean Annual Load (kg/yr)	423	21.3	113	320	94.5	94.6
IN - TP Mean Annual Load (kg/yr)	0.849	0.103	0.386	0.851	0.19	0.193
IN - TN Mean Annual Load (kg/yr)	5.83	1.52	4.15	7.8	1.35	1.38
IN - Gross Pollutant Mean Annual Load (kg/yr)	82.2	0	0	0	19.5	20
OUT - Mean Annual Flow (ML/yr)	2	0.804	1.82	3.16	0.464	0.476
OUT - TSS Mean Annual Load (kg/yr)	423	21.3	113	320	94.5	94.6
OUT - TP Mean Annual Load (kg/yr)	0.849	0.103	0.386	0.851	0.19	0.193
OUT - TN Mean Annual Load (kg/yr)	5.83	1.52	4.15	7.8	1.35	1.38
OUT - Gross Pollutant Mean Annual Load (kg/yr)	82.2	0	0	0	19.5	20

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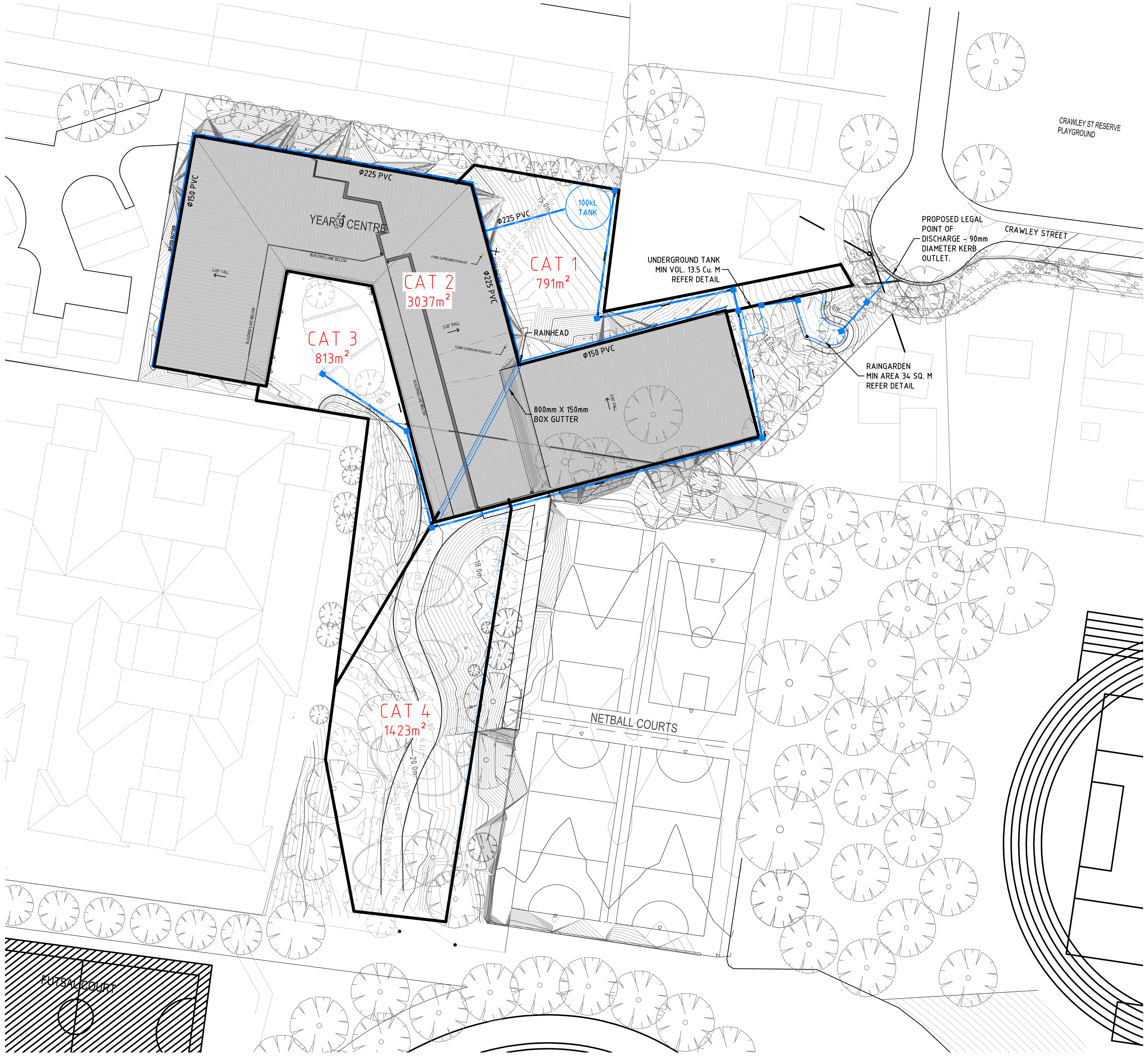
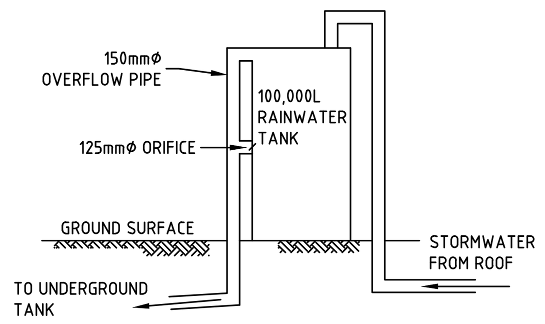
Location	Drainage Link
Source node ID	7
Target node ID	8
Muskingum-Cunge Routing	Not Routed
Muskingum K	
Muskingum theta	
IN - Mean Annual Flow (ML/yr)	0.405
IN - TSS Mean Annual Load (kg/yr)	59.2
IN - TP Mean Annual Load (kg/yr)	0.137
IN - TN Mean Annual Load (kg/yr)	1.08
IN - Gross Pollutant Mean Annual Load (kg/yr)	15
OUT - Mean Annual Flow (ML/yr)	0.405
OUT - TSS Mean Annual Load (kg/yr)	59.2
OUT - TP Mean Annual Load (kg/yr)	0.137
OUT - TN Mean Annual Load (kg/yr)	1.08
OUT - Gross Pollutant Mean Annual Load (kg/yr)	15



YEAR 9 CENTRE LAYOUT PLAN

SCALE 1:500



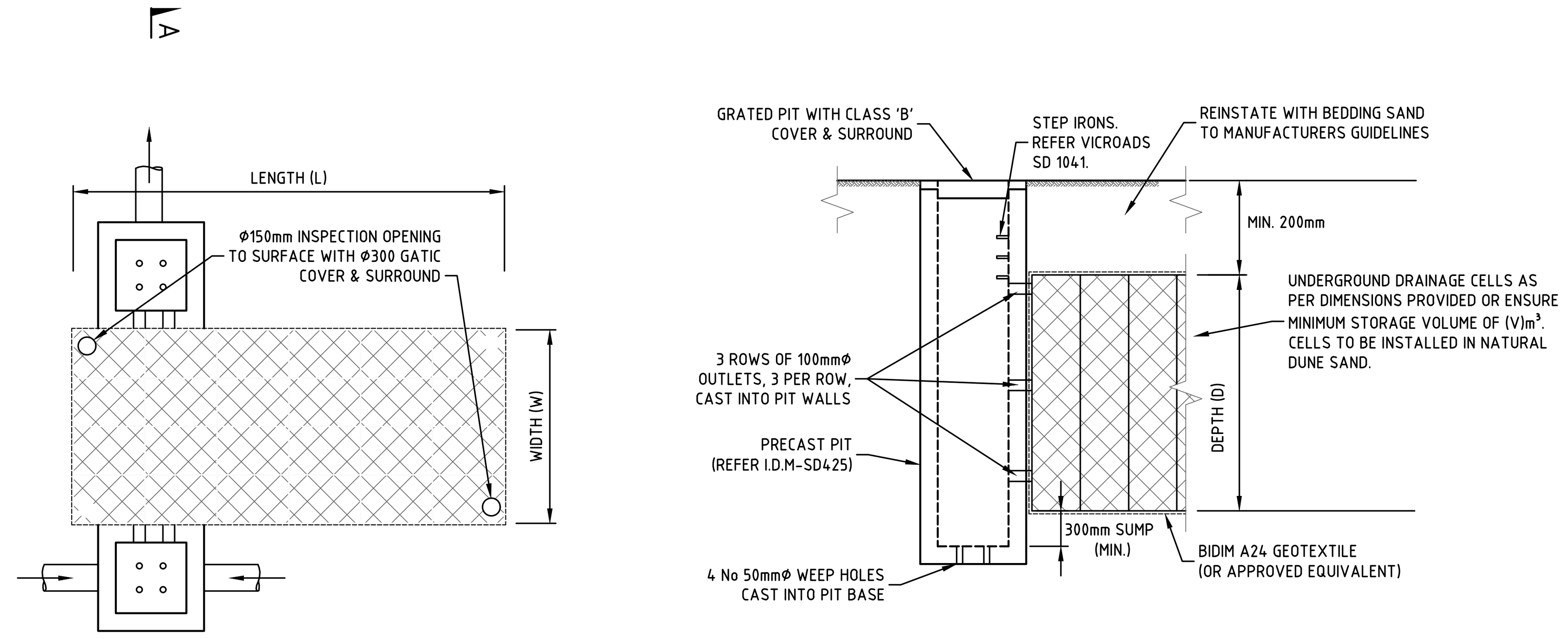
DETENTION TANK DETAIL

N.T.S.

LEGEND

	PROPOSED	EXISTING
AREA OF ROOF		
DRAINAGE CATCHMENT BOUNDARY		
DRAINAGE CATCHMENT No.	CAT-22A XYZ m²	
EASEMENTS		
STORMWATER DRAIN-DETAIL		

NOTE: UNDERGROUND SERVICES IN AREA OF CONSTRUCTION, CONTRACTOR TO LOCATE & DEPTH ALL SERVICES PRIOR TO CONSTRUCTION



PLAN VIEW

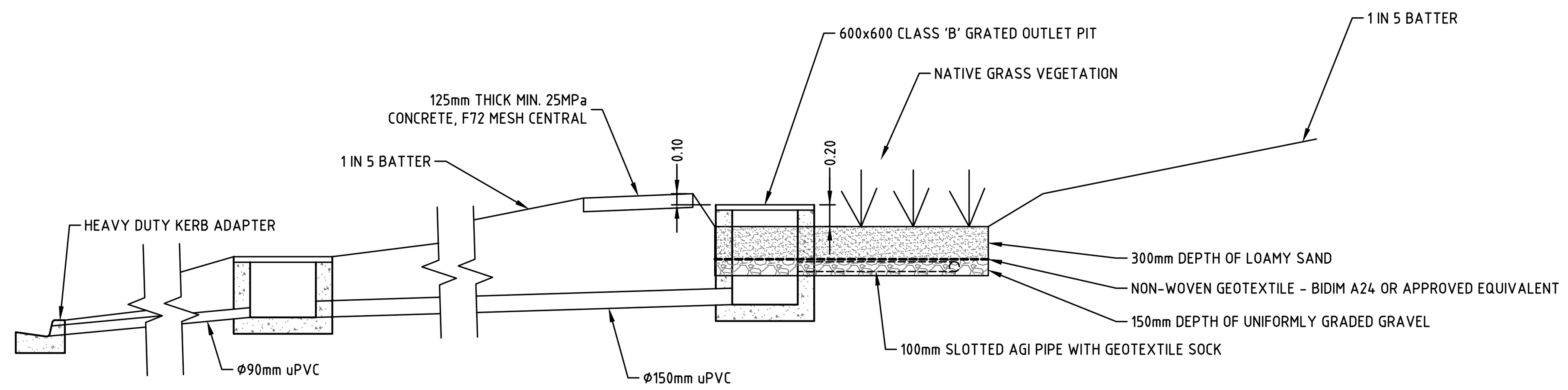
SECTION A-A

TABLE

L	W	D	V
5.0m	3.0m	1.0m	13.5m³

TYPICAL. UNDERGROUND SOAKAGE TANK DETAILS (NO SURFACE LOADING)

SCALE: N.T.S.



STORMWATER TREATMENT BASIN

SCALE - N.T.S.

REV.	DESCRIPTION	DATE
A	ISSUED FOR COMMENT	28/09/2022

APPROVED

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DESIGNED	S Brodie
DRAWN	A Stevenson
SCALE	A1 1:500
DATE	Aug 2022

PROJECT TITLE: YEAR 9 CENTRE AND CARPARK
EMMANUEL COLLEGE
BOTANIC ROAD, WARRNAMBOOL

DRAWING TITLE: YEAR 9 CENTRE STORMWATER LAYOUT

NORTH

PROJECT No. 2022.152

SHEET C-11 REV. A

Warrnambool City Council

Emmanuel College

Drainage Report




Date: 10July 2014

V2000_078

ADVERTISED PLAN

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V2000_078 – Warrnambool City Council: Emmanuel College Drainage Report					
DOC PATH FILE:					
REV	**DESCRIPTION**	**AUTHOR**	**REVIEWER**	**APPROVED BY**	**DATE**
Rev 0	Client Issue	Andrew Prout	Glenn Ottrey	Scott Dunn	10 July 2014
Signatures					

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1. INTRODUCTION

Engeny has been engaged by Warrnambool City Council to undertake a study and prepare a concept design for drainage infrastructure for Emmanuel College in Botanic Road, Warrnambool. The work is required to consider flooding risks, stormwater quality and potential stormwater discharge to aquifer and how these works will facilitate proposed development on the college site.

Emanuel College is located in Botanic Road, Warrnambool, as shown on the locality plan below.

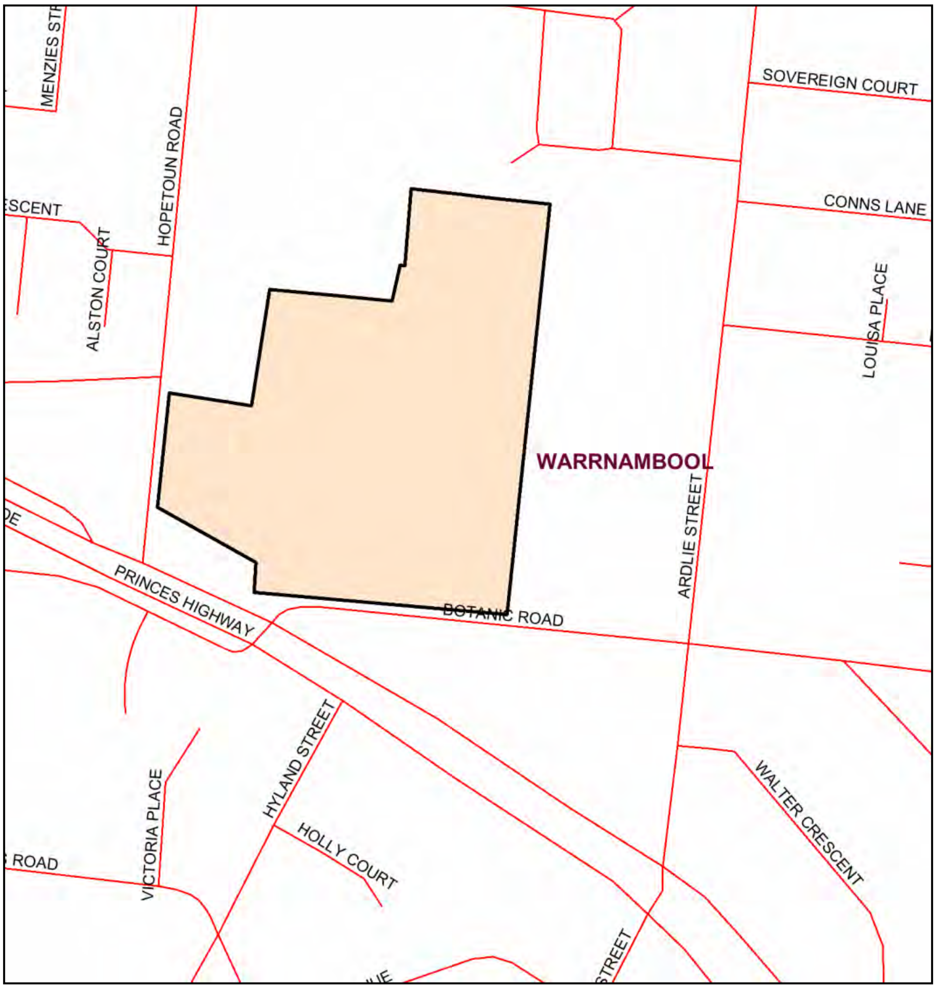

Figure 1.1 Botanic Road and Emmanuel College locality plan

The proposed development of the site by the College includes a new building, access road, carparking and other infrastructure. Warrnambool City Council provided Engeny with a copy of a preliminary architectural drawing of the proposed development on the College site. A copy of this drawing is provided in **Appendix A**.

2. SCOPE OF WORK

The following scope of work was agreed between Engeny and Warrnambool City Council:

- Project Management, including Quality Assurance and project planning;
- Discussion and confirmation of project scope and obtaining and reviewing extra information from Council;
- Determine catchment areas and process Council supplied, pits, pipes and terrain in Mapinfo for the catchment draining to the low point in Emmanuel College on the east side of Hopetoun Road in Warrnambool;
- RORB modelling to calculate flood hydrographs for 5 year and 100 year ARI storm events of various durations;
- TUFLOW hydraulic flood modelling through the catchment for existing conditions for 5 year and 100 year ARI storm events of various durations and production of flood maps for the 100 year ARI flood;
- Preparation of a concept layout plan for a drain / floodway, flood storage, stormwater treatment and outlet to aquifer for the main drainage system between Botanic Road and Hopetoun Road;
- Discussion and agreement of concept design layout with Warrnambool City Council;
- MUSIC modelling of stormwater treatment works for agreed concept design;
- Functional design of the floodway, stormwater treatment system and outlet into aquifer, in terms of the size and location of the various elements (detailed design not included in this scope of work);
- Preparation of final concept design depicting sizes and extent of various elements;
- Capital cost estimation of stormwater drainage and treatment works; and
- Succinct report with all results and plans attached (this report).

3. SITE ASSESSMENT

Engeny's Andrew Prout visited the Emmanuel College site and other locations around the catchment on 24 April 2014. Andrew also visited Brauer College in Warrnambool, with Council's Peter Robertson on 23 April 2014, including the stormwater filtering and aquifer input pumping system at Brauer College.

Photographs from the site visits are provided below.

Figure 3.1 Botanic Road and Emmanuel College

Note existing soak pit / grate in bus stop.

Figure 3.2 Emmanuel College looking west from overflow from soak pit

Note existing open drain in foreground and culvert under temporary access road.

Figure 3.3 Emmanuel College looking east

Figure 3.4 Princes Highway drainage south (upstream) of low point in Botanic Road

Figure 3.5 Stormwater filtering and aquifer injection system at Brauer College

4. HYDROLOGICAL MODELLING

Engeny has used a combination of flood hydrology and flood hydraulic modelling to describe how the drainage system in the Emmanuel College catchment behaves in discrete, intense flood events.

Engeny has used the RORB hydrologic model to calculate sub area rainfall for the Emmanuel College catchment. The catchment characteristics were processed in MapInfo using MiRORB (MapInfo RORB). The purpose of creating a hydrological model for the catchment is to generate sub-catchment hydrographs to be used as inflows in the hydraulic model.

4.1 Model Development

4.1.1 Catchment Boundary Determination

Engeny constructed a new undiverted RORB model covering the catchment draining to Emmanuel College using MiRORB. The catchment boundary for the catchment has been determined in order to allow for 100 year ARI flood behaviour to be accurately modelled and has been estimated from contours generated from LiDAR data.

Appendix B provides the Emmanuel College catchment boundary and structure of the RORB model.

4.1.2 Sub-Catchment Boundaries

Sub-catchment boundaries have been defined based on contours, pipe alignments, and property boundaries, not specifically for the 100 year overland flow path. Given that all Council drainage assets within the catchment are modelled in the hydraulic model it is important that the catchment hydrology resolution is detailed enough to ensure accurate inflows at the pit level.

Figure 4.1**Error! Reference source not found.** shows an example of how a sub-catchment was drawn in MiRORB. The result is an accurate representation of the sub-catchment areas draining to a particular branch of the pipe network. Engeny believes that the sub-catchment delineation we have chosen is the best way to represent how flow gets from each property and road to the drainage pits. The flow from the pits, via pipes and/or overland flow can then best be modelled in the TUFLOW hydraulic model.

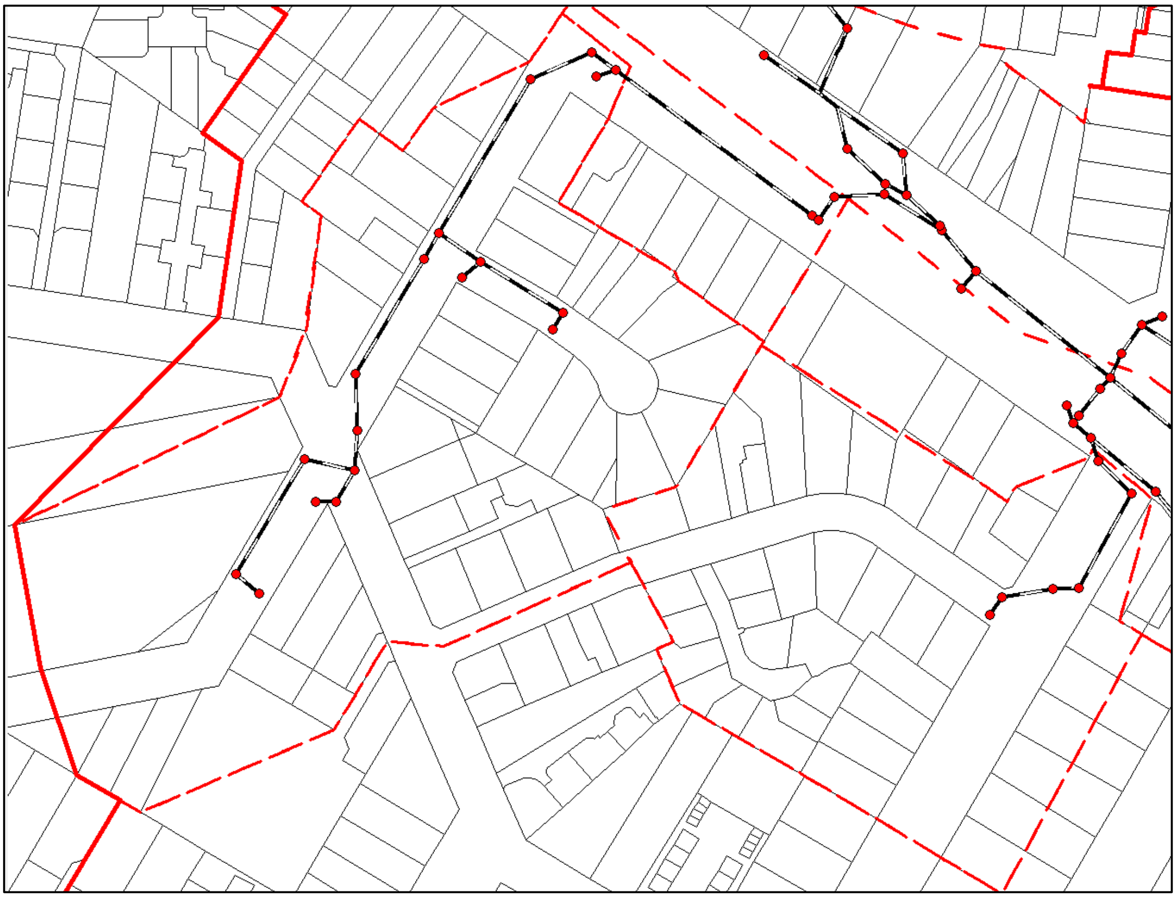

Figure 4.1 Example of Sub-Catchment Delineation

4.1.3 Fraction Impervious

Engeny assigned a fraction impervious value to RORB sub-catchments based on typical fraction impervious values for the planning zones within each sub-catchment. The typical values are based on fraction impervious provided in Melbourne Water's MUSIC guidelines. Fraction impervious values applied for typical land uses within the catchment include:

- Residential (mid-high density) - 70% impervious
- Open parklands & reserves - 10% impervious
- Local roads & car parks - 60% impervious
- Major roads - 70% impervious
- Commercial & industrial - 90% impervious

The fraction impervious value for a sub-catchment was obtained by calculating a weighted average of the fraction imperviousness of land types within each sub-catchment. These results were then checked using aerial photography and some adjustments made where necessary.

4.2 Intensity-Frequency-Duration Data

Intensity-Frequency-Duration (IFD) data for the Emmanuel College catchment was sourced from the Bureau of Meteorology using the online IFD request tool. The Bureau of Meteorology tool provided the IFD variables shown in Table 4.1.

Table 4.1: IFD parameters for the Emmanuel College Catchment

Parameter	Value
Intensity - 1 hour duration, ARI = 2 years (${}^{2}I_{1}$)	15.88
Intensity - 12 hour duration, ARI = 2 years (${}^{2}I_{12}$)	3.31
Intensity - 72 hour duration, ARI = 2 years (${}^{2}I_{72}$)	0.88
Intensity - 1 hour duration, ARI = 50 years (${}^{50}I_{1}$)	29.36
Intensity - 12 hour duration, ARI = 50 years (${}^{50}I_{12}$)	5.73
Intensity - 72 hour duration, ARI = 50 years (${}^{50}I_{72}$)	1.59
Skew (G)	0.58
F_2	4.32
F_{50}	14.62

4.3 Adopted RORB Model Parameters

The primary purpose of the RORB model is to provide sub-catchment inflow hydrographs for the TUFLOW hydraulic model. These hydrographs are obtained directly from the RORB sub-catchments, and are not influenced at all by routing along the reaches in the RORB model. All routing of flows is accurately determined in TUFLOW using the digital terrain model and surface roughness. Therefore, the RORB routing parameter k_c has no impact on the flood mapping results. Based on this, Engeny has adopted a RORB k_c value based on the MMBW/DVA plot of k_c versus catchment area, based on previous calibrations.

Other key RORB parameters adopted in the model are:

- m = 0.8
- Initial loss = 10 mm (urban catchment)
- k_c = 1.05 (based on DVA equation: $k_c = 1.53 \times A^{0.55}$)
- Runoff coefficients:
- 100 year ARI runoff coefficient = 0.60
- 5 year ARI runoff coefficient = 0.25

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4.4 RORB Results

The key focus of the hydrological modelling was to ensure that the RORB model is delineated in such a way that will allow for good representation of inflows into the TUFLOW model. The key output from the RORB model are the sub-catchment hydrographs, not the total flow from the downstream outlet of the RORB model. The key outputs from this study are discussed in the hydraulic modelling sections.

RORB was run for storm durations from 10 minutes to 12 hours. Design rainfall events were run for these durations for 5 year and 100 year Average Recurrence Interval (ARI) storm events. The flood hydrographs from RORB for these storm events were used as inputs to the hydraulic model (TUFLOW) as described in the following section of this report.

5. HYDRAULIC MODELLING

5.1 Purpose

The purpose of creating a hydraulic model for the Emmanuel College catchment is to provide a flood risk assessment and produce flood maps that depict the flood extent for existing catchment conditions. Engeny adopted TUFLOW as the hydraulic modelling software to undertake this work.

5.2 Methodology

The following steps outline the tasks undertaken to develop the TUFLOW model and to obtain results and outputs that were used for flood mapping:

- Generate digital terrain model (DTM);
- Compile hydrographs for a full range of storm durations (10 minutes to 12 hours) for existing catchment conditions;
- Input surface roughness (materials layer);
- Input and verify data for the 1-D network (pits and pipes);
- Set 1-D and 2-D boundary conditions;
- Run TUFLOW for the various rainfall event durations (10 minutes to 12 hours) for the 5 year and 100 year ARI storms;
- Compile and interpret results and validate model; and
- Prepare flood maps from the model's results.

Further details of these key steps are provided below.

6. HYDRAULIC MODEL DEVELOPMENT

6.1 Digital Terrain Model

Warrnambool City Council has a license agreement with DEPI to use LiDAR (Light Detection And Ranging) data covering the study area. LiDAR is an optical remote sensing technology that measures properties of scattered light to find range and other information of a distant target. The resulting data set consists of a regularly spaced grid (one metre interval in this case) of ground levels over the study area. Engeny triangulated the LiDAR data set to produce a Digital Terrain Model (DTM) for carrying out hydraulic modelling in TUFLOW. The purpose of the DTM is to enable allocation of spot levels to points within the 2-D grid layer which is utilised by TUFLOW.

Figure 6.1 shows the DTM generated for the Emmanuel College catchment. The orange areas indicate the areas of greatest elevation and the blue coloured areas are the low lying areas.

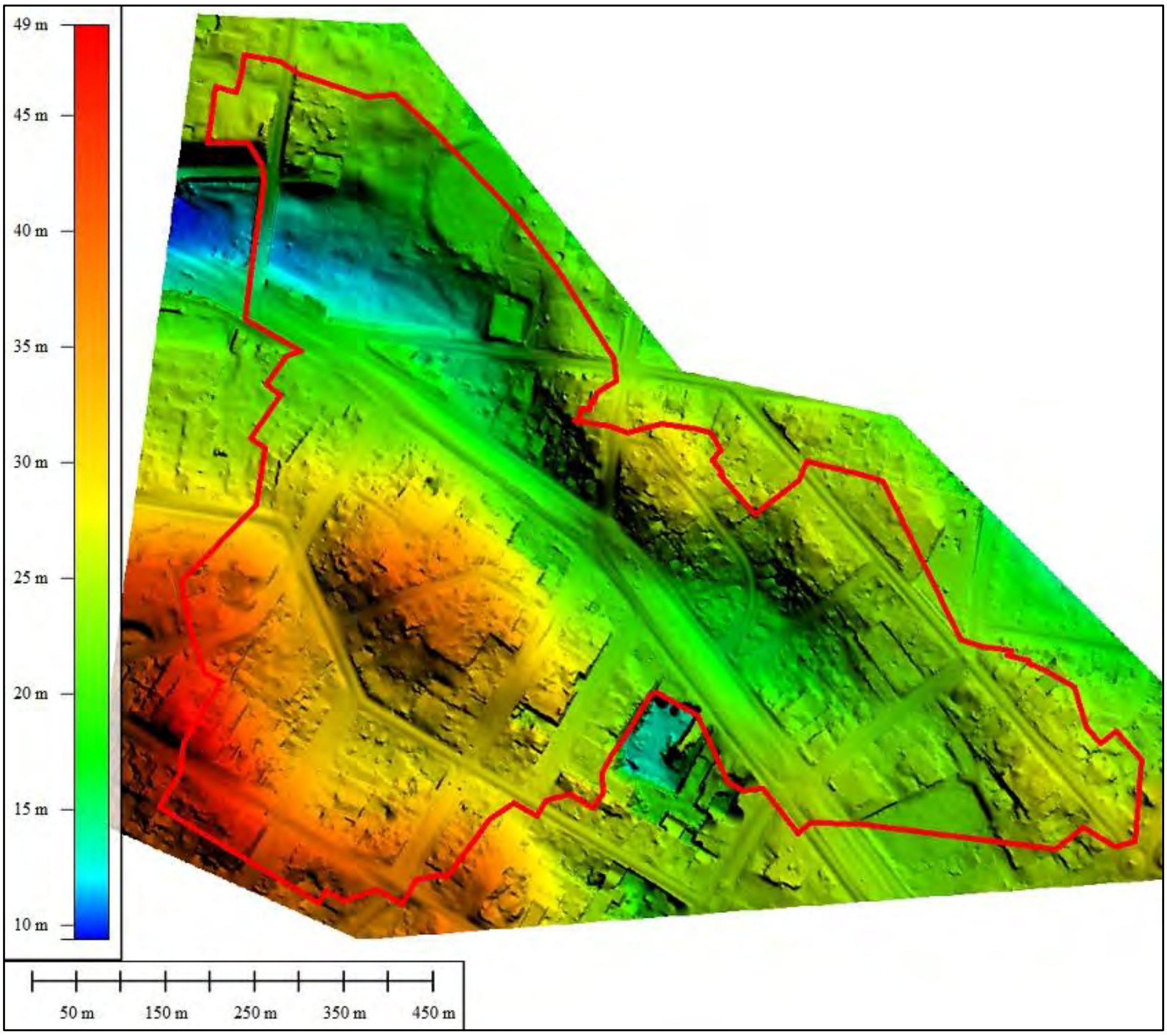

Figure 6.1 Emmanuel College catchment DTM

6.1.1 Grid Resolution

Engeny has adopted a grid size of two metres for the Emmanuel College catchment TUFLOW model. This grid size allows for appropriate definition of the catchment terrain and reasonable simulation times to run the model.

6.2 1-D Network Data

6.2.1 Modelled Assets

Engeny has modelled all assets identified in Council's GIS, including all rear of allotment drains. The largest Council pipe in the catchment is a 600 millimetre diameter pipe, which is located in the median on Princes Highway near Ryot Street.

6.2.2 Pipe Direction

It is good TUFLOW modelling practice to ensure that all pipes in the model are digitised in the direction of upstream to downstream. There were some instances where it was necessary to change the direction of a pipe to eliminate potential inaccuracies in the TUFLOW model.

6.2.3 Snapping Pipes Together and Pits to Pipes

It is crucial to the accuracy of the TUFLOW modelling that all pipes are linked to one another as well as being connected to the inlets. If gaps or breaks are present in the digital network data, stormwater flowing throughout the model network is able to exit the underground system when it should continue flowing through the downstream pipe. This can result in flooding in an area which otherwise may not be flood prone. Engeny thoroughly reviewed the network data to ensure these gaps were rectified so that potential errors in the modelling output were eliminated.

6.2.4 Pipe Invert Level Generation

Checks of the invert levels within Council's GIS drainage layer found that some pipes were missing either an upstream or downstream invert level or both and that it was not possible to produce a downward sloping grade through the catchment using some of the provided invert levels.

Where invert levels were missing or incorrect, Engeny estimated inverts by adopting the following formula:

- Invert level = Ground level RL – 600 mm (pipe cover) – pipe diameter

The estimated invert levels were then checked to ensure that they were connected appropriately with the inverts of upstream and downstream pipes, producing a downward grade.

6.2.5 Drainage Inlets

Engeny has modelled pits at each of the locations designated in Council's GIS pit asset layer. The hydraulic model allows for stormwater to overflow from these pits once the level in the pit exceeds the ground level.

While it is known that some pits are junction pits, and would not have an opening to the surface, it is a conservative approach to allow water to overflow from these pits as pressure build up underneath the pit lid is likely to dislodge the pit cover so that water can escape the drainage system.

Pits were assumed to be 900 mm by 1200 mm pits, with a 100 mm by 900 mm opening.

6.3 Surface Roughness

Within TUFLOW a land use (materials) layer was utilised to import surface roughness information into the model. A surface roughness has been assigned to each property polygon based on land use and aerial photography. In some instances, Engeny added additional shapes or split property polygons in order to accurately model surface roughness.

Table 6.1 provides the Manning's 'n' roughness values applied to the Emmanuel College catchment (based on Melbourne Water Guidelines and Technical Specifications, November 2012).

Table 6.1: Surface roughness values

Land Use	Manning's n
Mid-high density residential where the buildings and remainder of parcel are modelled together	0.35
Low density residential where the buildings and remainder of parcel are modelled together	0.2
Residential building footprints (where building footprint and remainder of parcel are modelled separately)	0.5
Residential remainder of parcel (where building footprint and remainder of parcel are modelled separately)	0.10
Commercial or industrial	0.5
Open paddock / parkland – minimal vegetation	0.035
Open paddock / parkland – moderate vegetation	0.06
Open paddock / parkland – high density vegetation	0.09
Railway line	0.12
Car parks and roads	0.03
Open waterways	0.06

6.4 Boundary Conditions

6.4.1 1-D Boundary Conditions

The 1-D boundary condition layer was used to read the RORB inflow hydrographs for each sub-catchment. The polygons created for the sub-catchments in the hydrological model have been included in the 1-D boundary layer, which allows for the inflow hydrograph to be split equally across each of the pits within a particular sub-catchment.

In some instances where there were no or very few inlet pits within a RORB sub-catchment, a 2-D source area was used to apply flows in the TUFLOW model. Section 6.4.3 provides further information on 2-D source areas.

6.4.2 2-D Boundary Conditions

The TUFLOW model includes a series of 2-D boundary conditions to control points where flow enters or leaves the 1-D pipe network. SX lines are drawn at locations where flow interacts between the 1-D network and the 2-D floodplain, with CN lines drawn to connect the SX lines to the 1-D network.

As part of the 1-D network, 2-D SX boundaries have been assigned to each pit to allow discharge of water from the pipe network to the 2-D surface and also allow runoff to enter the 1-D network if the pipe capacity allows it.

HQ (head versus flow) lines were drawn at the catchment boundaries to allow overland flow to leave the model at the catchment outlets.

6.4.3 2-D Source Areas

Some RORB sub-catchments used to define the hydrological model do not have any or have very few inlet pits. In these instances 2-D source areas were used to apply flow to the hydraulic model.

A 2-D source area is a polygon drawn within the sub-catchment where an inflow is applied to the 2-D domain. Flow from the source area travels overland until it reaches the 1-D network, or may flow overland to the catchment outlet.

6.5 Model Validation

Engeny has validated the model by checking that flows and water depths produced by the TUFLOW model are reasonable. Any unexpectedly large or small flow results were investigated to understand whether or not they were reasonable.

Model result files have been investigated for a sample of runs from each ARI event. These files were used to check that pipes are flowing full in the 5 year event and if not flowing full then to confirm that the level of overland flow was minor. The pipe flows in the 100 year event were also checked to ensure that the network had been modelled correctly and that there were no ‘brick walls’ where pipes had not been correctly connected to the next pipe downstream.

Results were also checked to ensure that TUFLOW was not producing high velocities or depths where they are not expected.

The results have also been validated against the results of some previous flood modelling undertaken in the catchment by Cardno in 2007 (*Preliminary Flood Mapping Catchments 9, 10 and 76*). The key difference in the comparison of the results between the current study and the previous work is that the two hour rainfall event for the 100 year ARI event was the only rainfall event run in the earlier modelling. The results do show a good level of correlation.

7. FLOOD MAPPING

The hydraulic model was run for 5 year and 100 year ARI storms for all standard storm durations from 10 minutes to 12 hours.

See **Appendix C** for the flood extent plan for the 5 year ARI storm for the whole catchment and for a more detailed flood map for the Botanic Road / Emmanuel College area.

See **Appendix D** for the flood extent plan for the 100 year ARI storm for the whole catchment and for a more detailed flood map for the Botanic Road / Emmanuel College area. A plot of flood height contours at 0.2m intervals through Emmanuel College is contained in **Appendix E**.

The flooding results and analysis of the drainage system have determined the following information:

- The peak 5 year and 100 year ARI flows in the catchment.
- The peak 5 year and 100 year ARI flood levels in the catchment.
- Flows in the existing Council pipes in 5 year and 100 year ARI flood events.
- That there is a significant flood area in the catchment in the vicinity of the southern ends of Walter Crescent and Somers Road as shown on the plans in **Appendices C** and **D**.
- That the flood area in the vicinity of the southern ends of Walter Crescent may be able to be reduced by increasing the capacity of the drainage along Princes Highway between Somers Road and Emmanuel College. Note that this possibility has not been modelled at this time and this suggestion could be tested using the TUFLOW model developed for this project to determine if additional drainage would reduce flooding in the vicinity of Walter Crescent and Somers Road and whether or not it would have any adverse impacts on flooding further downstream including at Emmanuel College.
- That there is a significant existing flood storage area in Emmanuel College north of Botanic Road and that this area has no natural overland drainage outlet and the catchment relies on soakage to discharge stormwater in the downstream end of the catchment (via the soakage pit in the bus stop in Botanic Road) and/or through soakage into the ground, especially between Botanic Road and Hopetoun Road. concept design.

Key flow rates arriving at Emmanuel College (for existing catchment conditions) are as follows:

- 100 year ARI: 2.1 m^3/s
- 5 year ARI: 0.7m^3/s

The flow rates above are a combination of piped and overland flows. Note that any changes to Council's drainage network within the catchment to address area of flooding concern may increase these flow rates.

8. CONCEPT DESIGN

The aims and components of the concept design for drainage works in Emmanuel College were discussed between Council's Peter Robertson and Engeny's Andrew Prout and Scott Dunn. These aims / works were agreed to include:

- Replace existing drainage soakage pit under the bus stop in Botanic Road.
- Design drainage works in Emmanuel College to convey flows from Botanic Road to the low point on the west side of Hopetoun Road.
- Allow for existing flooding patterns and a new access road into the school (with culvert) from Botanic Road to make sure that the proposed new building on the Emmanuel College grounds is not subject to flooding in a 100 year ARI storm.
- Allow for drainage from the proposed building and carpark on Emmanuel College to be catered for in the drainage system.
- Design a stormwater treatment system on the Emmanuel College site (within the existing flood prone area) to treat runoff. This is proposed to enable an application to be made for permission to inject stormwater from the catchment into the deep aquifer under Emmanuel College as proposed by SKM (*Botanic Road (Warrnambool) Drainage Bore – Risk Assessment*).
- Determine the amount of stormwater per annum that would be estimated to be injected into the aquifer and how this compares with the demand / existing license for groundwater extraction for Emmanuel College.

Our original concept design plan of the proposed works is included in **Appendix F**, included on this plan are some existing ground levels. The concept design was discussed at a meeting between Council's Peter Robertson and Engeny's Scott Dunn and Andrew Prout on 17 June 2014 at Engeny's office.

Key features of the concept design to achieve the project requirements include:

- Removal of the existing soak pit in the bus bay in Botanic Road.
- Extension of the existing drainage pipe from Botanic Road in the same North-West direction with a 1050 mm diameter pipe. This pipe has been conservatively sized to allow for potential upgrades to Council's drainage network which drains to Emmanuel College given that upgrades to the network may be undertaken in the future to address flooding at the southern end of Walter Crescent as discussed with Council.
- Allowance for a pipe from the school (likely to be built by school, as part of building / car park works).

- Localised rock beaching at the two pipe outlets if required, e.g. if velocities are excessive.

- A grassed swale drain from the two pipe outlets to the proposed new school entry road. The key dimensions of the proposed swale are as follows:

  - 42 m long;
  - 2 m deep;
  - 1 m base width;
  - 12 m AHD Upstream invert, 11.8 m AHD Downstream invert;
  - 1 in 6 batter slopes; and
  - Vegetated base.

- A 1050 mm diameter pipe culvert under the proposed new school entry road with invert levels of approximately 11.8m AHD (upstream end) to 11.6 m AHD (downstream end) to convey the peak 100 year ARI flow (of 2.1 m^3/s) without resulting in flood levels in excess of 13.3 m AHD in the grassed swale upstream of the new entry road. The size of this culvert will be dependent upon the outcomes of any mitigation modelling of the greater catchment. Given the different times of concentration of peak flows within the greater catchment the 1050 mm culvert size is considered appropriate for current purposes.

- Construction of the new school entry road with a road low point no higher than 13.3 m AHD. This is to ensure that even if the culvert under the new school entry road is blocked that floodwater cannot pond upstream of the road and flood the proposed new building.

- Proposed new school building to be constructed by Emmanuel College with a floor level of at least 14.0 m AHD.

- A sediment pond downstream of the new school entry road that is approximately 30 metres long and 15 metres wide, 1.5 to 2 metres deep with a rock rubble lining for maintenance purposes. The sediment pond is to have a Normal Water Level of approximately 11.4 m AHD controlled by the orifice in the wetland outlet pit. The sediment pond is to have a 4 metre wide thick band of vegetation around the pond and/or fencing to exclude easy access.

- A wetland downstream of the sediment pond is to be approximately 60 metres long, 20 metres wide with an extended detention depth (EDD) of 500 mm. The wetland will also be planted with marsh plants for most of its area, with a 10 metre by 10 metre deeper pond (approximately 1.2 metres deep at its western end). It is also proposed to include a 4 metre wide thick band of vegetation on a flat slope immediately below Normal Water Level around the pond to exclude easy access. The wetland will have the same Normal Water Level as the sediment pond, 11.4 m AHD.

- A wetland outlet pit connecting the west end of the wetland to a stormwater harvesting pond. The wetland outlet pit is to have two chambers separated by a wall with an orifice plate with a 90 mm diameter orifice is to be connected to each pond with a 450 mm diameter pipe. The orifice has been sized to deliver at least 15 litres/s of flow to the stormwater harvesting pond. The flow rate of 15 L/s was nominated by SKM (*Botanic Road (Warrnambool) Drainage Bore – Risk Assessment*) for pumping into the deep aquifer.

- A 600 m^2 area for drying of sediment during maintenance of the sediment pond.

- A stormwater harvesting pond from which treated stormwater can be pumped at a rate of 15 L/s with a Normal Water Level of approximately 11.4 m AHD. The stormwater harvesting pond is to have a 4 metre wide thick band of vegetation around the pond and/or fencing to exclude easy access.

- A rising main (110 mm diameter), filter and pump system from the stormwater harvesting pond to inject stormwater into the deep aquifer.

- A bore to deliver the water from the pump into the deep aquifer.

- Access tracks, fencing and other infrastructure.

- Planting including marsh plants in bands across the wetland and around all pond edges for stormwater treatment and landscaping purposes. Landscaping to also include grassing, terrestrial planting and possibly a small platform or two to allow for safe student access to take water samples from the upstream and/or downstream ends of the sediment pond/ wetland system. All grassed slopes to be 1 vertical to 6 horizontal or flatter to allow for safe mowing.

It should be noted that most of the proposed stormwater system, including all of the swale, sediment pond, wetland and stormwater harvesting pond are proposed to be located within the existing flood prone area of the Emmanuel College site. The works will predominantly in cut of existing ground levels with some localised fill required in the south eastern portion of the works. The access track should be located at least 1 metre above the wetland Normal Water Level except where the track leads into the sediment pond. The pump, filter and aquifer injection system should be located above the 100 year ARI flood level.

A copy of the final concept design is attached in **Appendix G**.

8.1 MUSIC modelling

Engeny has used the MUSIC (Model for Urban Stormwater Improvement Conceptualisation) computer program to model the concept design works at Emmanuel College. MUSIC enables the simulation of stormwater flows and stormwater pollutants over an extended period of time (years). Figure 8.1 below shows a screenshot of the MUSIC model which includes the urbanised catchment draining through a sediment basin and wetland as proposed in the original concept design which is the background image for the model.

The purpose of modelling the catchment in MUSIC was not to size the treatment elements to ensure Best Practice Guidelines for stormwater treatment are met, instead it was used to design the size of the orifice in the wetland outlet pit to achieve a flow rate of 15 L/s and to get an indication of treatment effectiveness. The MUSIC modelling results are presented in Table 8.1 below.

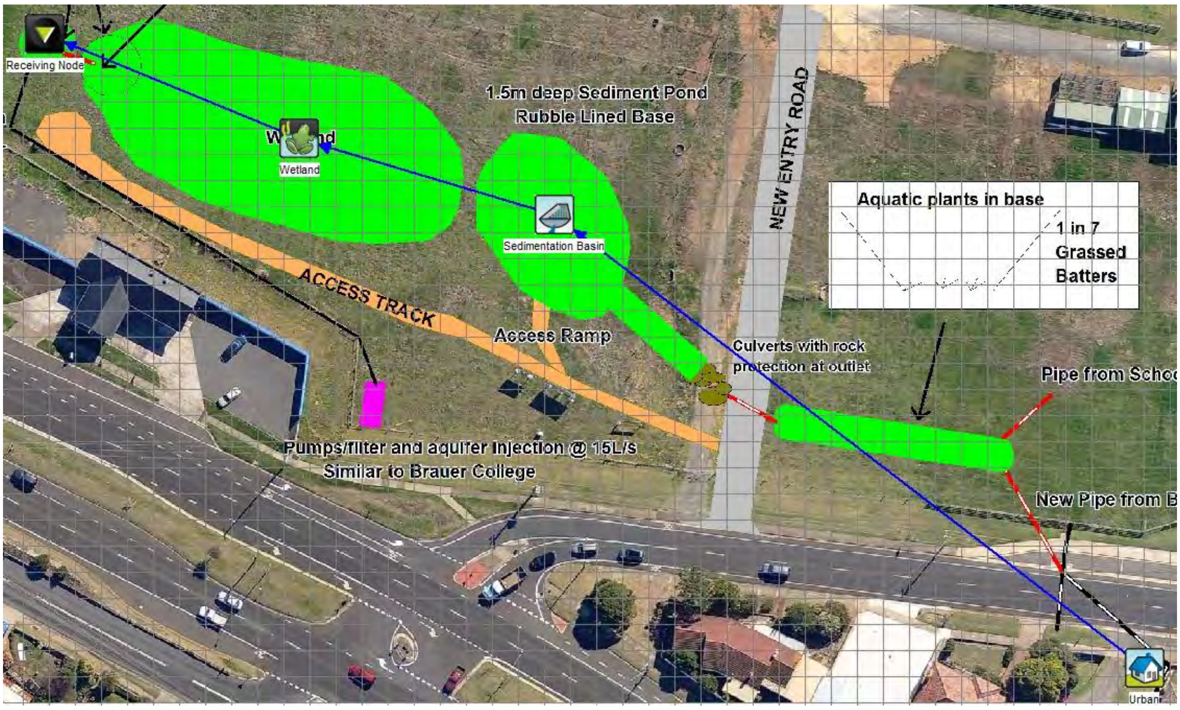

Figure 8.1 MUSIC Model Layout

Table 8.1 MUSIC Results for Stormwater Treatment

Pollutant	Source	Residual Load	Removal (%)	Best Practice Target (%)
Flow (ML/yr)	149	147	1.5%	-
Total Suspended Solids (kg/yr)	30700	11600	62.3%	80 %
Total Phosphorus (kg/yr)	62	7.48	48%	45 %
Total Nitrogen (kg/yr)	429	351	18.2%	45 %
Gross Pollutants (kg/yr)	7430	100	100%	70%

9. COST ESTIMATE

Engeny has estimated the expected capital construction costs of most of the components for the proposed drainage works on Emmanuel College. We understand that Warrnambool City Council will estimate the capital and operating expenses of the stormwater filter and aquifer injection system, as discussed with Peter Robertson.

The cost estimates prepared by Engeny are based on cost estimating rates that we have used in previous projects in Ballarat and for Melbourne Water. Details of the individual rates and allowances are provided in **Appendix H.**

Table 9.1 Construction cost estimate

Description	Key Dimensions	Estimated Cost
Council drain from Botanic Road	1050 mm diameter, 25m long	$26,000
Grassed Swale	42 m long, 2 m deep, 1 m base width, 1 in 6 batter slope	$27,000
Culvert beneath new access road to Emmanuel College	1050 diameter, 15 m long	$19,500
Wetland/sediment pond	Wetland treatment area = 1200m^2 Sediment pond surface area = 450m^2	$248,500
Rising main	110 mm diameter PE, 100 m long	$5,500
Sub Total		**$326,500**
Design (15%)		$48,975
Contingency (30%)		$97,950
Estimated Total Capital Cost		**$475,000**

Note that the estimated capital cost does not include the following items:

- Outlet drain from Emmanuel College into proposed swale;
- New access road into Emmanuel College; or
- Capital and operating expenses of the stormwater filter and aquifer injection system.

10. CONCLUSIONS

Engeny has completed the following work in the Emmanuel College catchment:

- Review of existing catchment data;
- Detailed hydrology analysis to estimate flows in the catchment for various storm events for existing level of development within the total catchment;
- 2-D flood modelling for 5 and 100 year ARI rainfall events for existing conditions;
- Flood mapping of the 2D modelling results;
- Identification of flooding 'hot spots' within the catchment;
- Identification of works for stormwater drainage and treatment within Emmanuel College;
- MUSIC modelling of stormwater treatment works for agreed concept design;
- Functional design of the floodway, stormwater treatment system and outlet into aquifer, in terms of the size and location of the various elements;
- Preparation of final concept design depicting sizes and extent of various elements; and
- Capital cost estimation of stormwater drainage and treatment works.

The modelling has identified a significant flooding 'hot spot' at the southern end of Walter Crescent. From our discussions with Council we understand this area is a well known flooding 'hot spot' and Council are that keen to investigate mitigation options for this area. The existing catchment hydraulic model can be used to test the effectiveness of mitigation options including drainage upgrades. Upgrades to the drainage network may influence the sizes of drainage works within Emmanuel College as a result of more flow being piped to the College to reduce the flooding at Walter Crescent. At this stage the outlet from the Council drainage network to Emmanuel College has been conservatively sized to allow for a potential upgrade of the drainage capacity.

An assessment of proposed stormwater drainage and treatment works has been identified in this report, with an overall cost of structural works of $475,000. The total land required for the proposed works is approximately 8,800 m^2. A detailed concept layout is provided with this report.

11. REFERENCES

SKM, April 2013, *Botanic Road (Warrnambool) Drainage Bore – Risk Assessment*

Cardno, July 2007, *Preliminary Flood Mapping Catchments 9,10 and 76*

12. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Management Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c. Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   (i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

   (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d. Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e. This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report.

f. If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

APPENDIX A

Drawing of College Development

ADVERTISED PLAN

REVISION	DESCRIPTION	DATE		NAME	DATE
			DESIGN	A BRIAN	OCT 13
			DRAWN	C DRURY	OCT 13
			CHECKED	A BRIAN	OCT 13
			APPROVED		
			CAD FILE 10225		

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Civil Engineers and Project Managers
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Ph: (03) 5561 3939 Fax: (03) 5561 2033
Email: briancon@bigpond.net.au

PROJECT
EMMANUEL COLLEGE
PROPOSED MULTI PURPOSE HALL
CIVIL SITEWORKS
LAYOUT PLAN

SIZE	SCALE	PROJECT No.	SHEET No.	REV
A1	1 : 250	13-159C1	1 OF 1	-

APPENDIX B

Hydrological Model Layout

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ENGENY
WATER MANAGEMENT

WARRNAMBOOL
CITY COUNCIL

0 100 200
Scale in Metres (1:5,000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

Emmanuel College - Warrnambool

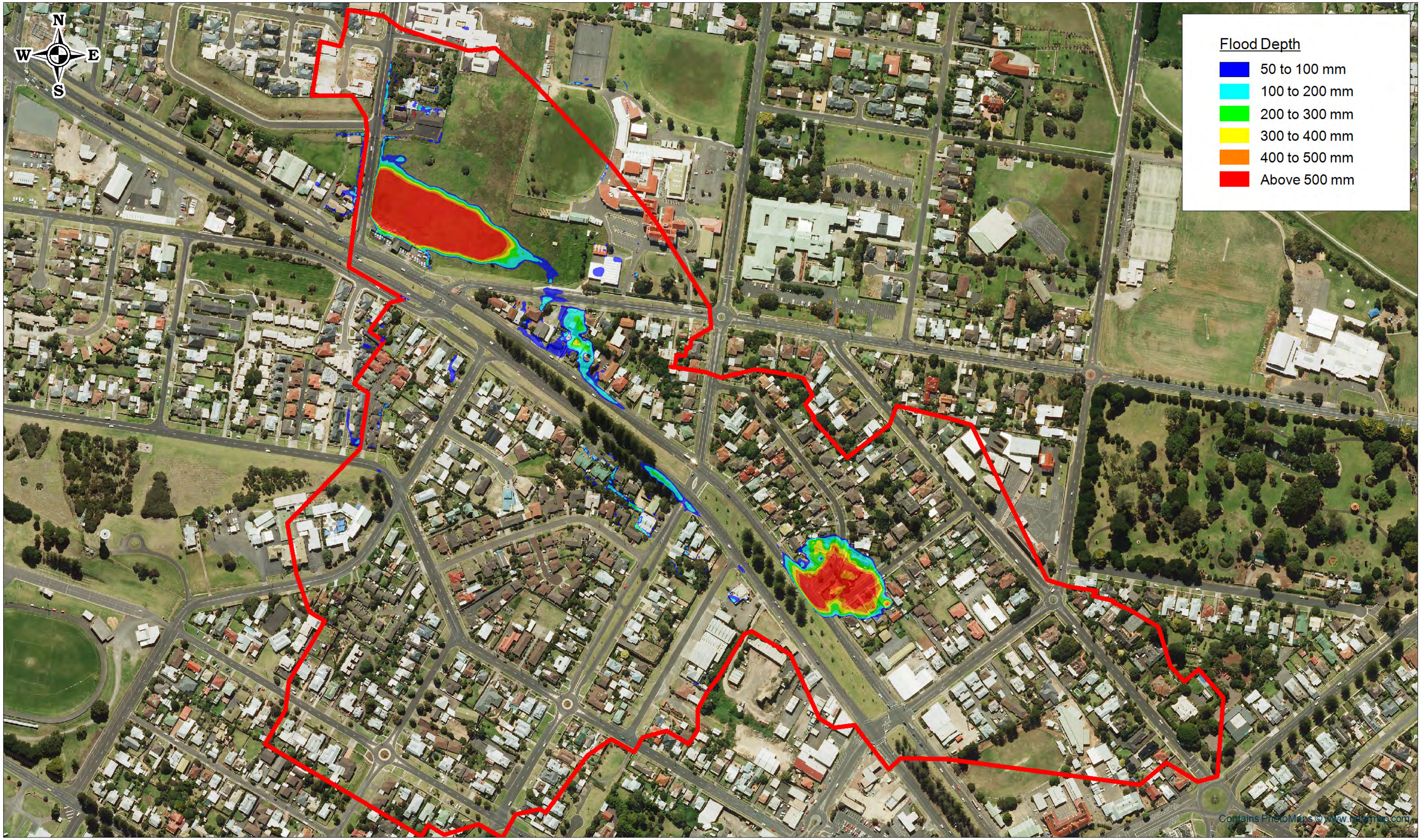
ADVERTISED PLAN

Hydrological Model Layout

Job Number: V2000_078
Revision: 0
Drawn: SD
Checked: GO
Date: 1 July 2014

APPENDIX C

5 year ARI flood extent plan



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ENGENY WATER MANAGEMENT

WARRNAMBOOL CITY COUNCIL

0 80 160

Scale in Metres (1:4000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

Emmanuel College - Warrnambool

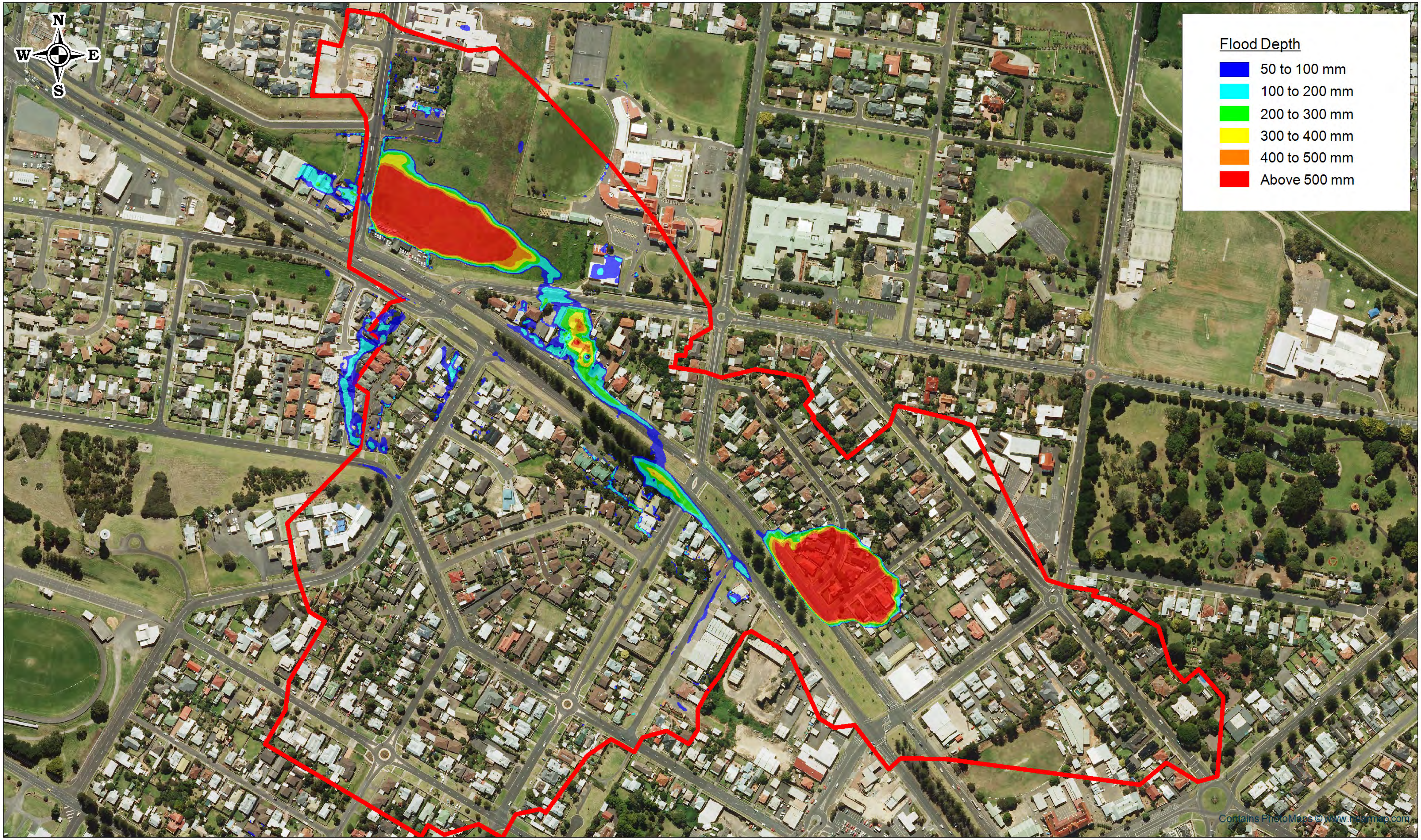
ADVERTISED PLAN

5 year ARI Flood Extent - Existing Conditions

Job Number: V2000_078
Revision: 0
Drawn: SD
Checked: AP
Date: 4 June 2014

APPENDIX D

100 year ARI flood extent plan



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ENGENY
WATER MANAGEMENT

WARRNAMBOOL
CITY COUNCIL

0 80 160
Scale in Metres (1:4000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

Emmanuel College - Warrnambool

ADVERTISED
PLAN

100 year ARI Flood Extent - Existing Conditions

Job Number: V2000_078
Revision: 0
Drawn: SD
Checked: AP
Date: 4 June 2014

APPENDIX E

100 year ARI flood height contours

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WARRNAMBOOL CITY COUNCIL

0 20 40
Scale in Metres (1:1000 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

Emmanuel College - Warrnambool

ADVERTISED PLAN

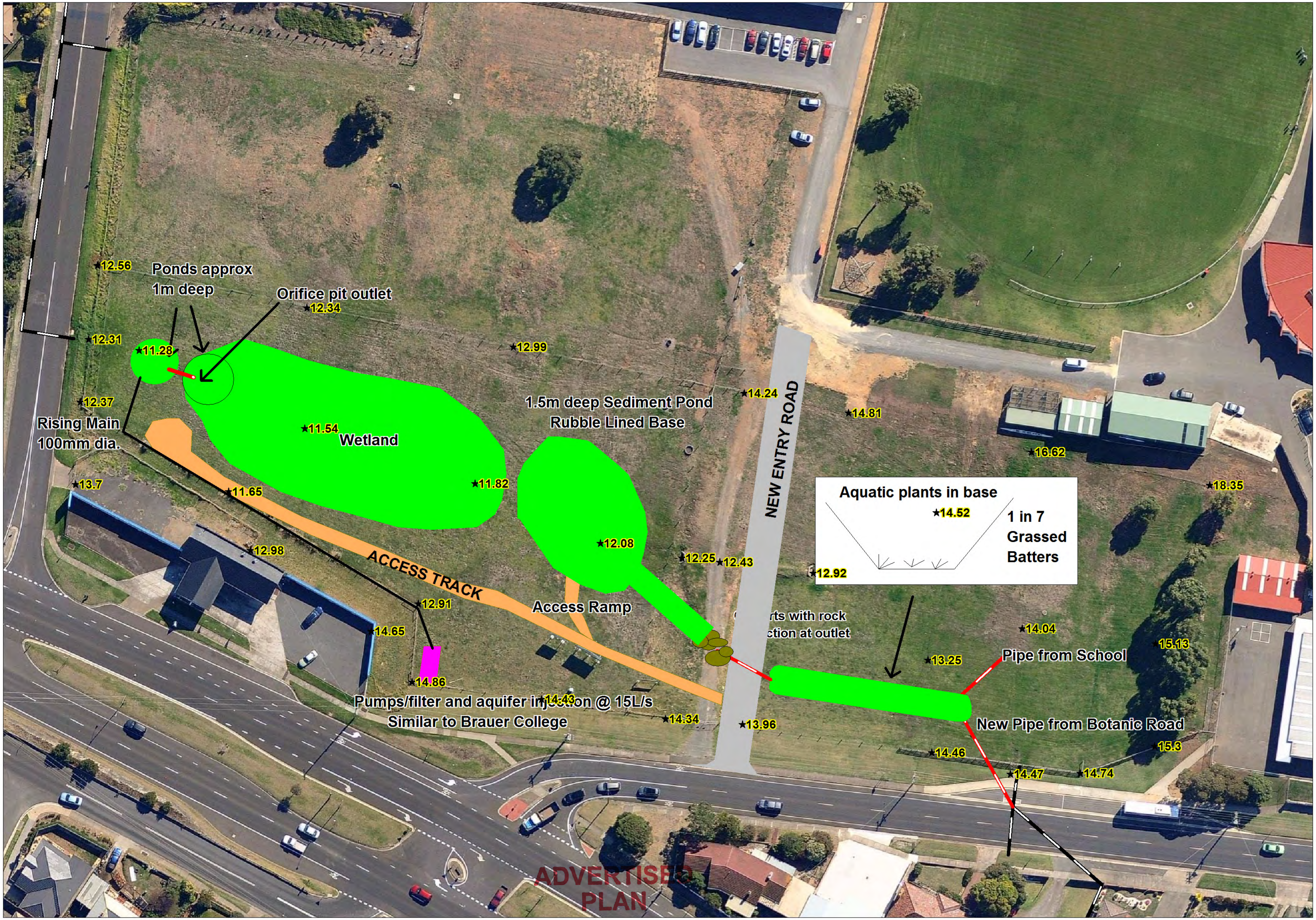
100 year ARI Flood Heights - Existing Conditions

Job Number: V2000_078
Revision: 0
Drawn: SD
Checked: AP
Date: 3 July 2014

APPENDIX F

Original Concept Design Plan

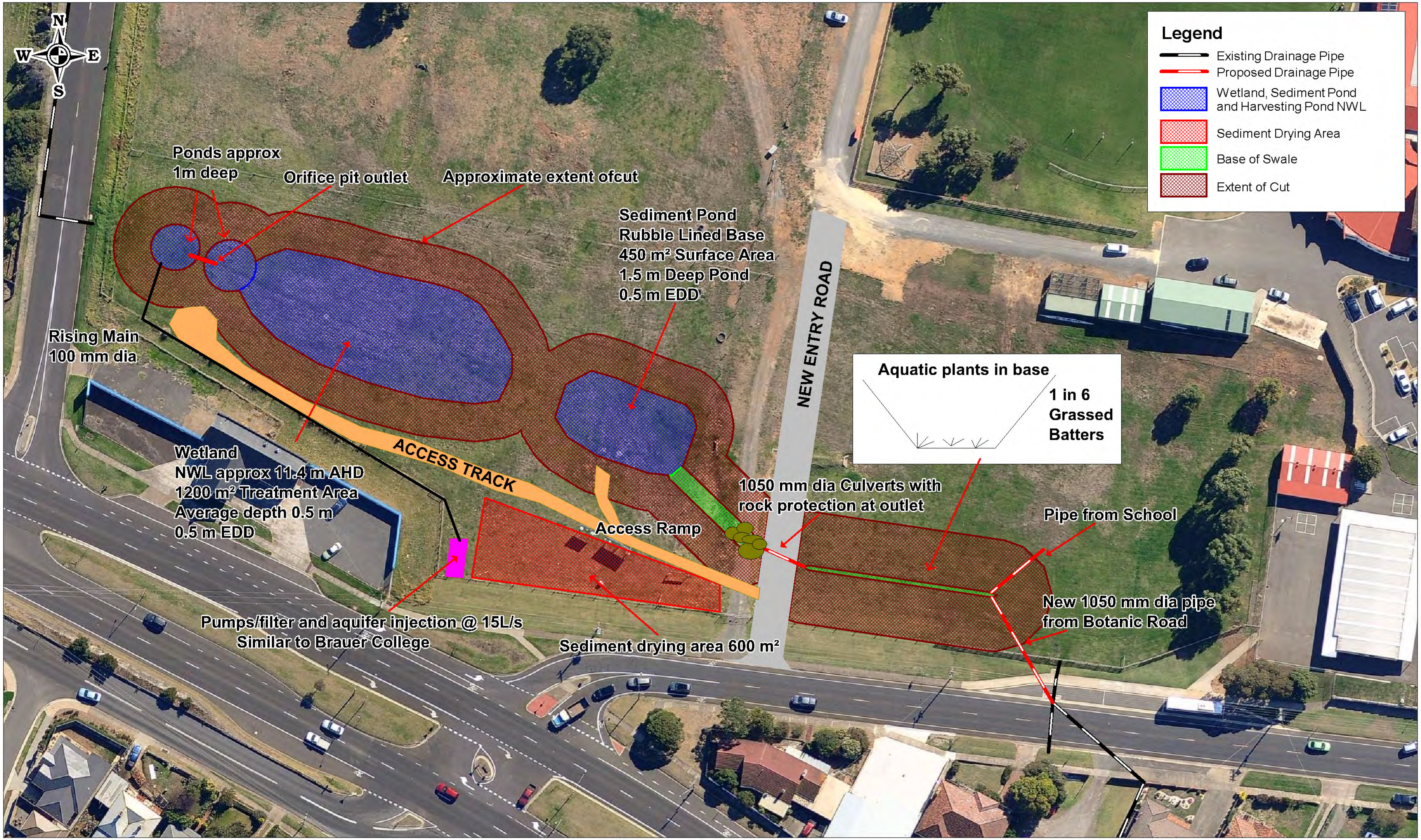
ADVERTISED PLAN


Ponds approx
1m deep
Orifice pit outlet
Rising Main
100mm dia.
Wetland
1.5m deep Sediment Pond
Rubble Lined Base
NEW ENTRY ROAD
ACCESS TRACK
Access Ramp
Aquatic plants in base
1 in 7
Grassed
Batters
Pipe from School
New Pipe from Botanic Road
Pumps/filter and aquifer injection @ 15L/s
Similar to Brauer College
12.56
12.34
12.31
11.28
12.99
12.37
14.24
14.81
11.54
16.62
13.7
11.65
11.82
18.35
14.52
12.98
12.08
12.25
12.43
12.92
12.91
14.65
14.04
15.13
13.25
14.86
14.43
14.34
13.96
15.3
14.46
14.47
14.74
ADVERTISED
PLAN

ADVERTISED PLAN

APPENDIX G

Final Concept Design Plan



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ENGENY WATER MANAGEMENT

0 15 30

Scale in Metres (1:750 @ A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

Emannuel College Wetland

Concept Layout Plan

ADVERTISED PLAN

Job Number: V2000_078
Revision: 0
Drawn: GO
Checked: SD
Date: 09/07/2014

APPENDIX H

Cost Breakdown

Item	Measurement	Cost (rounded)
Council drain from Botanic Road	- 1050 mm diameter, 25m long @ $611/m - Endwall/rock beaching/traffic management: $10,800	$26,000
Grassed Swale	- Excavation: 1092m³ @$20/m³ - Topsoil: 1050m² @ 3/m² - Grass: 1050m² @ $2/m²	$27,000
Culvert beneath new access road to Emmanuel College	- 1050 diameter, 15 m long @764/m - Headwall/Endwall/beaching @ $3,952 each	$19,500
Wetland/sediment pond*	- Total Excavation: 2211m³	$248,500
Rising main	- 110 mm diameter, 100 m long @ $48/m - 2 x elbows @183 each	$5,500

* More details about cost breakdown of wetland/sediment pond can be provided if required