Catherine McAuley College

Project 1A – Stage 1

Joint Use Development and Regional Cricket Hub

Stormwater Management Strategy

November 2019

EXECUTIVE SUMMARY

RMG has been engaged by Catherine McAuley College (CMC) to complete a Stormwater Management Strategy (SMS) for the proposed development of two sporting ovals and adjacent building infrastructure in the north west corner of the Coolock Campus, Junortoun (the school campus). The ovals and building will jointly be used by CMC students and the wider Bendigo community, represented by the City of Greater Bendigo (CoGB) and Cricket Australia (CA).

Due to the potential impact the proposed development may have on stormwater runoff from the school campus, the SMS has been undertaken to determine the measures required to achieve:

- reduction of peak flows to pre-development levels,
- treatment of runoff to meet best practice guideline, and
- provision for capturing and storing runoff for reuse for oval irrigation.

The SMS makes the following conclusions and recommendations:

Conclusion 1: Catchment 1 requires 0.5ML of detention storage to restrict stormwater flows to pre-development levels.

Conclusion 2: Catchment 2 does not require detention storage to restrict stormwater flows to pre-development levels.

Conclusion 3: A 10ML sedimentation basin adequately treats stormwater runoff from Catchment 1.

Conclusion 4: Irrigation demand for the four ovals was found to be 45ML per year.

Conclusion 5: Toilet flushing demand for school use was calculated to be 3.08ML per year and for sport use 0.33ML per year.

Conclusion 6: Garden watering demand was calculated to be 6.51ML per year.

Conclusion 7: Water supply was found to average 3.5ML per year from Catchment 1 and 52.6ML per year from Catchment 2.

Conclusion 8: An upper basin with a capacity of 60ML with a lower basin with a capacity of 9.5ML will provide 85% of the water required for irrigation of the four ovals.

References

References used in the preparation of this report include the following:

- *City of Greater Bendigo MUSIC Guidelines*
- *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56* http://www.fao.org/3/X0490E/x0490e00.htm
- *Methodology for Estimating Landscape Irrigation Demand – Review and Recommendations, Dennis Pittenger, 2014*
- *MUSIC Guidelines – Input parameters and modelling approaches for MUSIC users in Melbourne Water's service area, 2018*
- *Stormwater gross pollutants - Robin Allison, Francis Chiew and Tom McMahon, 1997*

Contents

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Appendices

1. INTRODUCTION

RMG has been engaged by Catherine McAuley College (CMC) to complete a Stormwater Management Strategy (SMS) for the proposed development of two sporting ovals and adjacent building infrastructure in the north west corner of the Coolock Campus, Junortoun (the school campus). The ovals and building will jointly be used by CMC students and the wider Bendigo community, represented by the City of Greater Bendigo (CoGB) and Cricket Australia (CA).

Due to the potential impact the proposed development may have on stormwater runoff from the school campus, the SMS has been undertaken to determine the measures required to achieve:

- reduction of peak flows to pre-development levels,
- treatment of runoff to meet best practice guideline, and
- provision for capturing and storing runoff for reuse for oval irrigation.

2. EXISTING CONDITIONS

2.1 Site location and existing land use

The subject site is in Junortoun, approximately 6km east of the Bendigo CBD. The site comprises land located between residential blocks fronting La Valla Court to the east, Trotting Terrace to the south, St Vincents Road to the west and McIvor Highway to the north. The location of the site and the its surrounding road network is shown in Figure 2-1 and an aerial photograph of the site is shown in Figure 2-2.

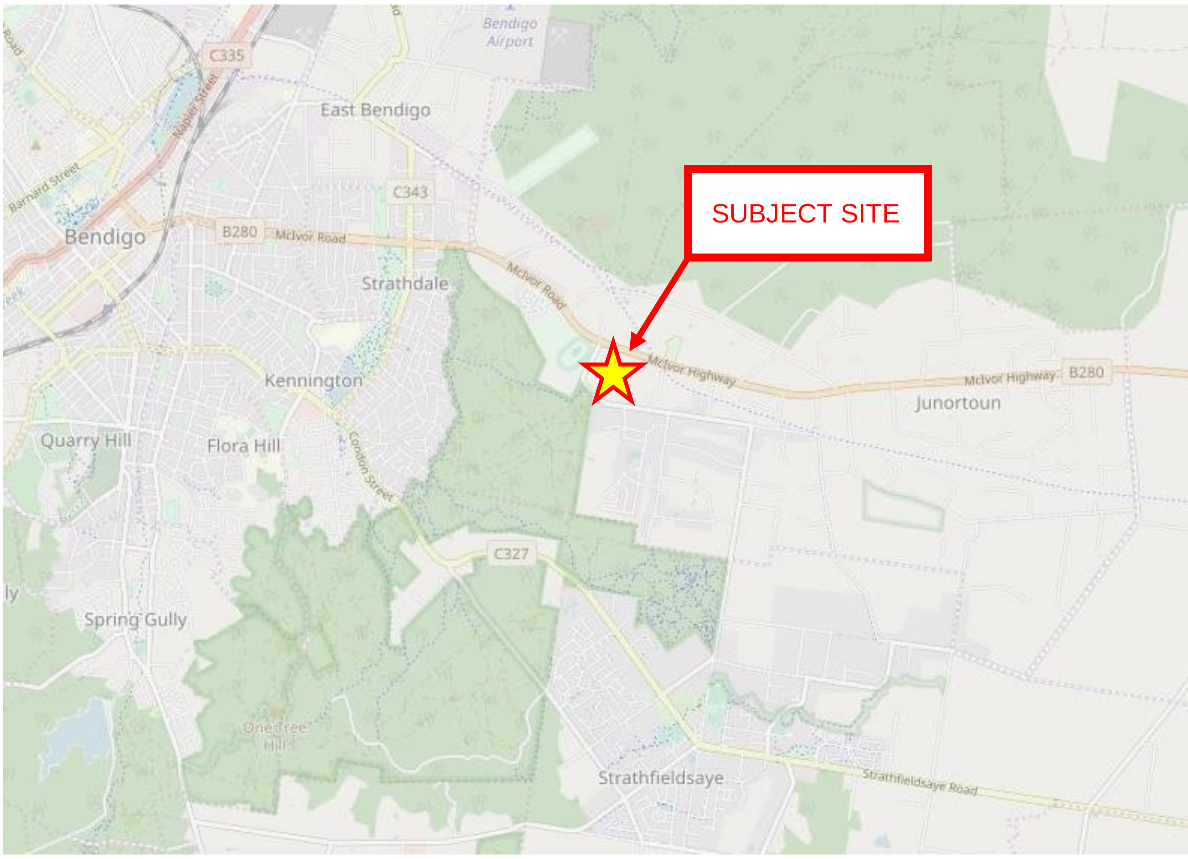


Figure 2-1 Location Plan (reproduced courtesy of Melway Online)

Figure 2-2 Aerial photo of subject site (photo courtesy of CoGB)

This site is currently occupied by a secondary school, six cricket/football ovals and four parking areas.

The site is zoned as Special Use Zone – Schedule 1 (SUZ1). The surrounding areas are predominantly zoned Low Density Residential Zone (LDRZ) with exceptions of Special Use Zone – Schedule 5 (SUZ5) land for Lords Raceway to the northwest and Public Conservation and Resource Zone land to the southwest of the site. McIvor Highway to the north is zoned as Road Zone – Category 1 (RDZ1) and St Vincents Road and Trotting Terrace to the west and south are zoned as Road Zone – Category 2 (RDZ2). Planning scheme zones are shown in Figure 2-3.

Figure 2-3 Land Use Plan (Source: CoGB Community Compass)

2.2 Current site operation

The site currently operates exclusively as a secondary school with approximately 700 students and 100 staff.

Stormwater generated on the site is currently discharged into an open drain running along the northern boundary of the campus and thence into the open drain running along McIvor Highway.

2.3 Catchment details

Catchment 1 comprises the north western portion of the school site and includes most of the school buildings and car parking areas. Catchment 2 includes the balance of the school site, a small number of rural residential lots on Cassiana Dr and Trotting Terrace and section of the Greater Bendigo National Park.

Impervious fractions for the catchments are based on the ultimate developed state of the school site as per the *Master Plan, Coolock and St Marys Campuses, Bendigo.*

Table 2-1 – Catchment details

Catchment	Total area (ha)	% impervious
1	14.5	57
2	75.0	3

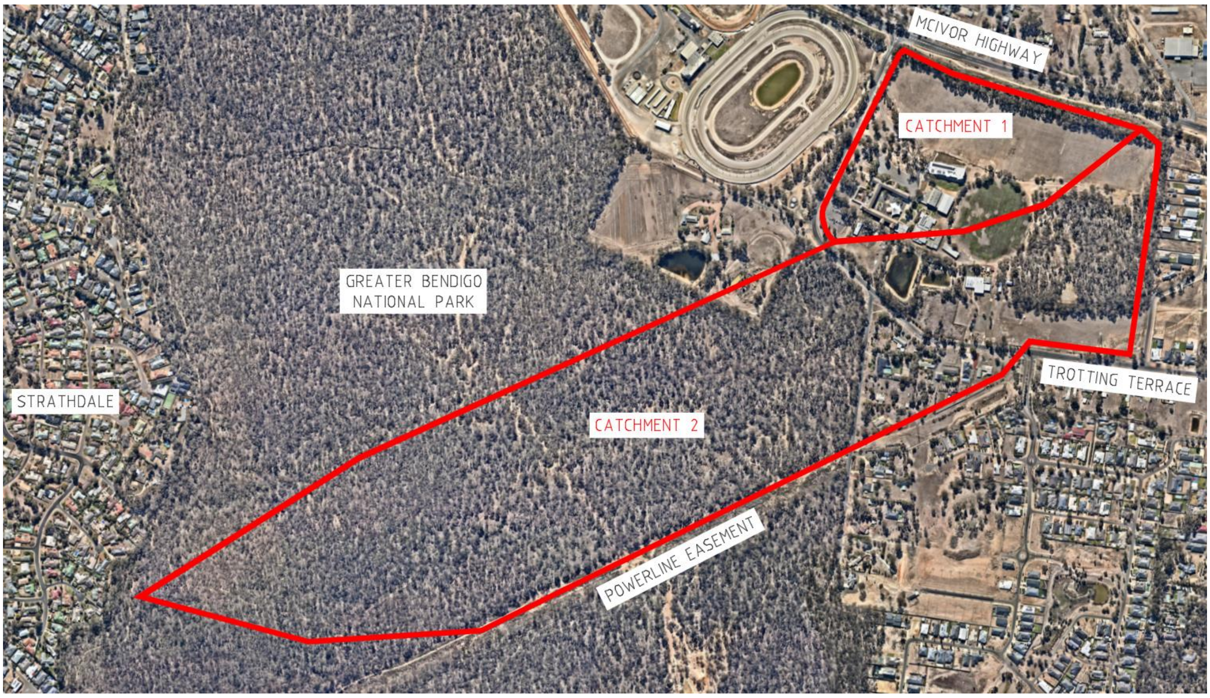


Figure 2-4 Catchments contributing to stormwater runoff

3. PROPOSED DEVELOPMENT AND USE

This project will see the development of two sporting ovals and adjacent building infrastructure. There will be two sporting ovals - one senior size and one junior size, two outdoor netball courts, car parking and landscaping, and adjacent changerooms and amenities. The changerooms and amenities will be co-located with the Northern Rivers Regional Cricket Hub building.

3.1 Future development

The *Master Plan, Coolock and St Marys Campuses, Bendigo* proposes expansion of the student body on the school campus to approximately 1400 students and 200 staff through the expansion of the secondary school and construction of a primary school & early learning centre. Additional sealed carparking areas are also proposed to cater for the increase in student numbers.

4. STORMWATER DETENTION

Impervious areas within the two catchments were measured at the current time (aka pre-development) and after the completion of the master plan works (aka post-development). Runoff volumes for both pre- and post-development cases were calculated for the 100 year ARI storm.

Conclusion 1: Catchment 1 requires 0.5ML of detention storage to restrict stormwater flows to pre-development levels.

Conclusion 2: Catchment 2 does not require detention storage to restrict stormwater flows to pre-development levels.

See Appendix C for stormwater detention calculations.

5. STORMWATER TREATMENT

A 10ML sedimentation basin was modelled using MUSIC software to treat runoff from Catchment 1. The MUSIC modelling showed this basin met Melbourne Water's best practice guidelines.

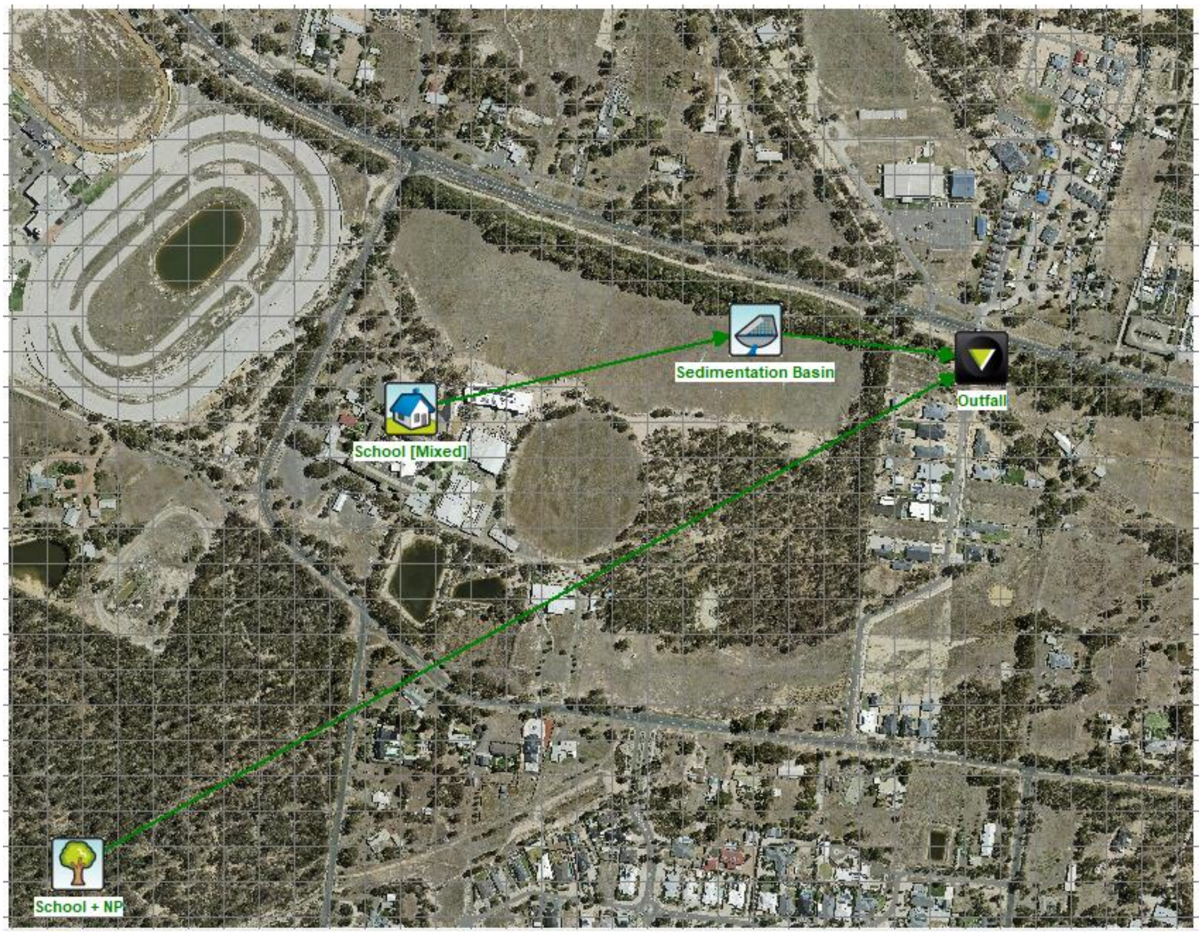


Figure 5-1 MUSIC model layout

Treatment Train Effectiveness - Sedimentation Basin

	Sources	Residual Load	% Reduction
Flow (ML/yr)	42.6	37.3	12.6
Total Suspended Solids (kg/yr)	8990	747	91.7
Total Phosphorus (kg/yr)	17.6	4.86	72.4
Total Nitrogen (kg/yr)	119	54.3	54.4
Gross Pollutants (kg/yr)	1550	0	100

Figure 5-2 MUSIC model results

Conclusion 3: A 10ML sedimentation basin adequately treats stormwater runoff from Catchment 1.

6. STORMWATER REUSE

A water balance model was developed to determine the feasibility of capturing, storing and reusing stormwater and the required storage size to achieve an acceptable level of reliability. The water balance model considers inflows from stormwater runoff and reuse for irrigation, toilet flushing and garden watering purposes, as well as evaporation losses from the storage.

6.1 Data sources

Data for the water supply and demand calculations were obtained from the Bureau of Meteorology website and *City of Greater Bendigo MUSIC Guidelines*.

6.1.1 Rainfall

Daily rainfall data for the period 1862-1991 were recorded at the Bendigo Prison station (number 081003) and obtained from the following address:

http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=081003

Daily rainfall data for the period 1992-2018 were recorded at the Bendigo Airport station (number 081123) and obtained from the following address:

http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=081123

6.1.2 Evapotranspiration

Two classes of evapotranspiration data were used in the water supply and demand calculations, Areal Potential EvapoTranspiration (APET) and Point Potential EvapoTranspiration (PPET) respectively. See Sections 6.2 and 6.3 for further details.

Areal Potential Evapotranspiration data were obtained from the *CoGB MUSIC Guidelines.*

Monthly average Point Potential Evapotranspiration data for the standard 30-year climatology (1961-1990) were obtained from the following address:

http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp?maptype=6&period=an#maps

Daily Point Potential Evapotranspiration data for 2009-2018 were recorded at the Bendigo Airport station (number 081123) and obtained from the following address:

http://www.bom.gov.au/watl/eto/

6.1.3 Evaporation

Monthly Class A Pan Evaporation data for Victoria for 1975-2018 were obtained from the following address:

http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Devap%26area%3Dvic%26season%3D0112%26ave_yr%3D0

6.2 Demand model

6.2.1 Irrigation demand

Project 1A includes the construction of irrigation systems for two ovals in each of Stages 1 and 2. The irrigated area in Stage 1 is 2.7ha and Stage 2 is 3.1ha. Calculations to determine the irrigation demand were carried out using parameters and procedures from *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56*.

Assumptions used in preparing the demand model were:

1. The oval turf is fully established; as such, a single crop coefficient was used as evaporation from bare soil will not be possible with full grass cover.
2. The turf profile is warm season grass on a shallow (200mm) sand base, underlain by a clay subgrade which permits negligible water loss by deep percolation/seepage.
3. Irrigation applied when soil moisture depleted to avoid crop water stress, i.e. not on a regular timetable.
4. Point Potential Evapotranspiration values were used instead of Areal PET as the irrigated area is surrounded by unirrigated areas and is too small to affect the air mass in the area.
5. Actual evapotranspiration values were used where possible, otherwise a monthly average value from the standard 30-year climatology (1961-1990) was used.
6. Model used daily timesteps, matching the frequency of the available data.

Example model results for a single year:

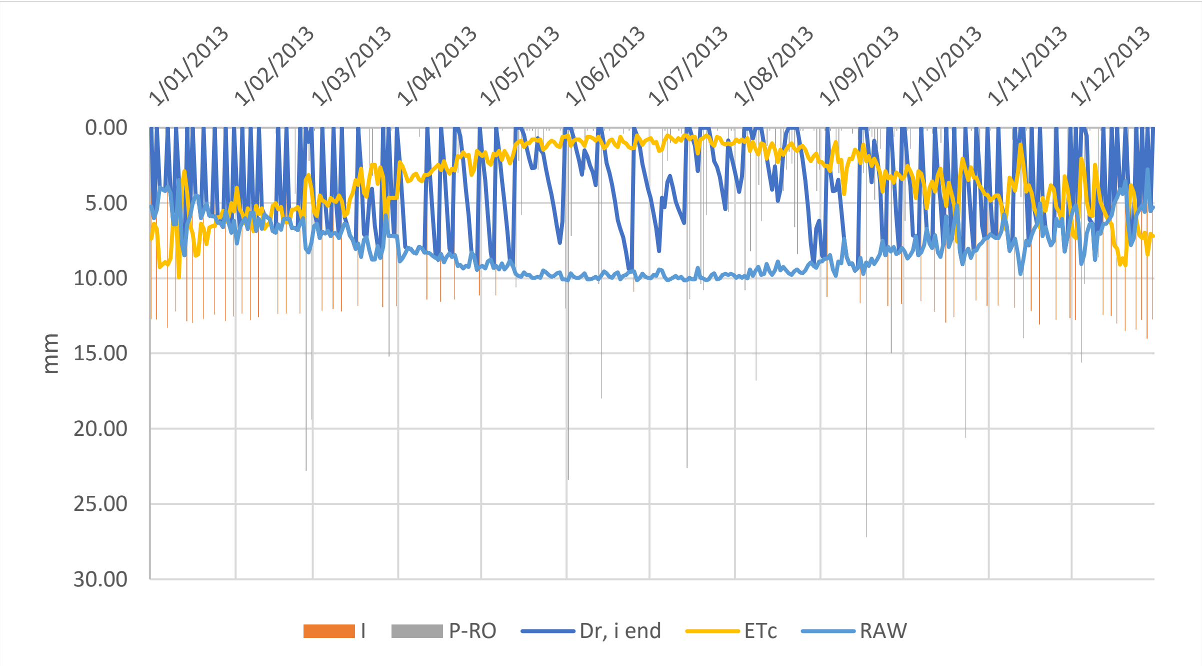


Figure 6-1 Water demand model results for 2013

Parameters:

I	=	Irrigation required to replenish soil moisture
P-RO	=	Precipitation less Run Off, the net amount of water reaching the soil after a rain event
Dr, I end	=	Depletion of soil moisture available for plant growth

ETc	=	Loss of soil moisture by Evaporation and Transpiration
RAW	=	Readily Available Water, the amount of water the plants can access from the soil

Conclusion 4: Irrigation demand for the four ovals was found to be 45ML per year.

6.2.2 Toilet flushing demand

Water demand for toilet flushing was calculated for both school and sport uses of the site. School demand was calculated based on 1600 students and staff being present during weekdays in school terms. Sport demand was based on a maximum equivalent of 312 players and spectators being present during weekends. In both cases a demand of 20 litres per person per day was applied per Melbourne Water's *MUSIC Guidelines* with a 50% reduction factor to account for the hours of use being less than a full day.

Conclusion 5: Toilet flushing demand for school use was calculated to be 3.08ML per year and for sport use 0.33ML per year.

6.2.3 Garden watering demand

Water demand for garden irrigation was calculated using the algorithm provided by Pittinger (2014) using the breakdown shown in Table 6-1.

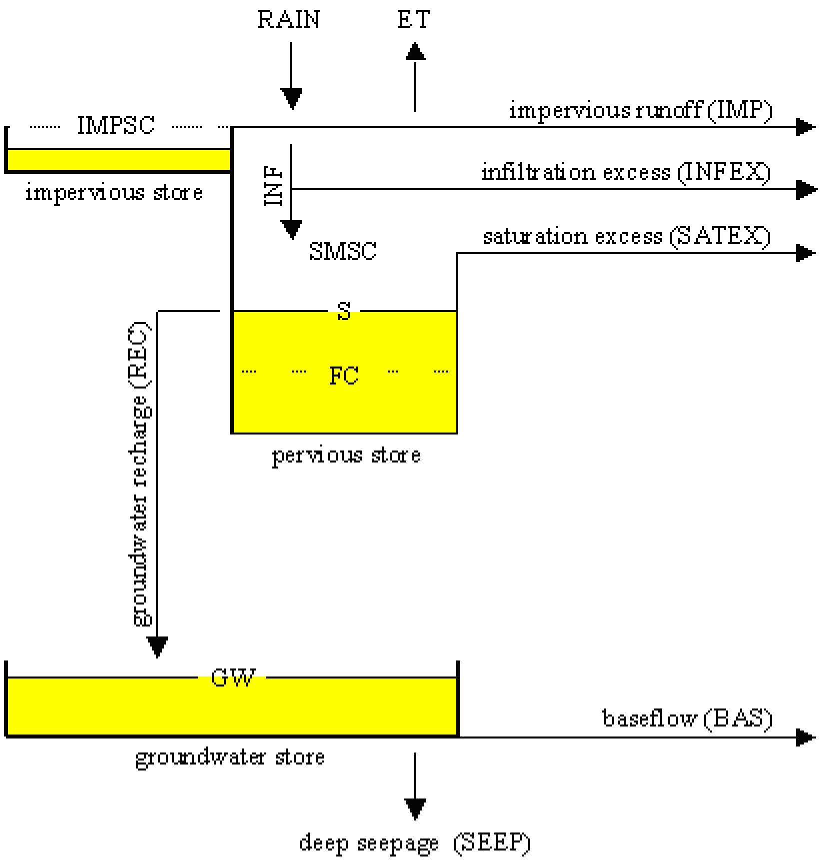
Table 6-1 – Assumed garden breakdown

Warm season turf	Trees	Annual flowers	Native plants	Total
0.3 ha	0.05 ha	0.1 ha	0.22 ha	0.67 ha

Conclusion 6: Garden watering demand was calculated to be 6.51ML per year.

6.3 Supply model

The algorithm adopted to generate runoff is based on the model developed by Chiew & McMahon (1997). The water supply model is a simplified description of the rainfall-runoff processed in catchments and involves the definition of the impervious area and soil moisture storage as shown in Figure 6-2.



Model inputs

RAIN	=	daily rainfall (mm)
PET	=	areal potential evapotranspiration (mm)

Model parameters

IMPSC	=	impervious store capacity (mm)
SMSC	=	soil moisture store capacity (mm)
COEFF	=	maximum infiltration loss (mm)
SQ	=	infiltration loss exponent
FC	=	field capacity of soil moisture store (mm)
RFAC	=	soil moisture to groundwater recharge factor
BFAC	=	groundwater to baseflow factor
SFAC	=	groundwater to deep seepage factor

Figure 6-2 Conceptual daily rainfall-runoff model adopted for water supply calculations

The model was calibrated against a MUSIC model run on the catchments using rainfall data from the 1992-2018 period. The adopted model parameters are outlined in Table 6-2.

Table 6-2 – Supply model parameters

Model parameter	Value
IMPSC	1
SMSC	30
COEFF	200

SQ	1
FC	20
RFAC	25%
BFAC	5%
SFAC	0%

Further assumptions used in preparing the supply model were:

1. Areal Potential Evapotranspiration values were used instead of Point PET as per *CoGB MUSIC Guidelines*.
2. Model used daily timesteps, matching the frequency of the available data.

6.3.1 Catchment details

See section 2.3 for details of the catchments supplying runoff to the school campus.

The irrigated ovals within the catchments have been excluded from the catchment areas for the water supply model as the water demand model already accounts for rainfall on these areas.

Example model results for a single year:

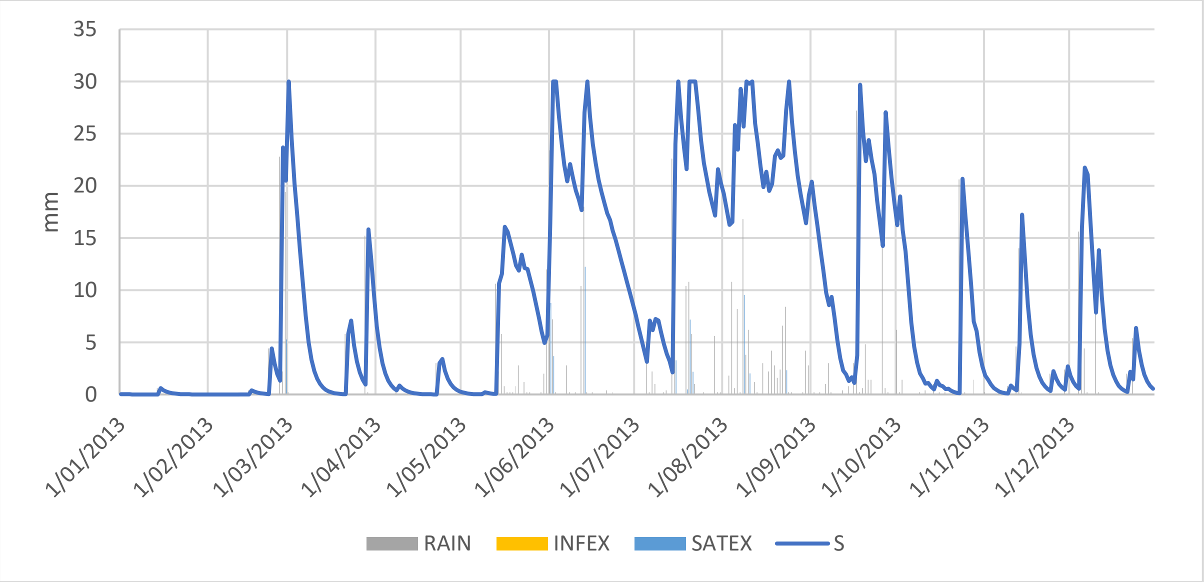


Figure 6-3 Water supply model results for 2013

Parameters:

RAIN	=	Daily rainfall
INFEX	=	Infiltration excess, runoff due to soil being unable to absorb water quickly enough
SATEX	=	Saturation excess, runoff due to soil already being saturated
S	=	Soil moisture level of catchment

Conclusion 7: Water supply was found to average 3.5ML per year from Catchment 1 and 52.6ML per year from Catchment 2.

6.4 Water balance model

The Masterplan identifies an area in the north eastern corner of the school site for a retention basin to supply water for irrigation and other reuse, i.e. toilet flushing and garden irrigation.

The outputs of the water demand and supply models were combined to generate the water balance model to assess the most appropriate size for the retention basin. In addition, the evaporation loss from the basin is considered using the formulas obtained from here:

http://calculator.agriculture.vic.gov.au/fwcalc/information/determining-the-evaporative-loss-from-a-farm-dam

Assumptions used in preparing the balance model were:

1. Average depth of the basin is 1.0m.
2. The basin starts the analysis period with 9ML of water.

To account for year-to-year variations in rainfall the water balance model was applied to 10 year periods ranging from 1992-2001 to 2009-2018.

Example model results for a single year:

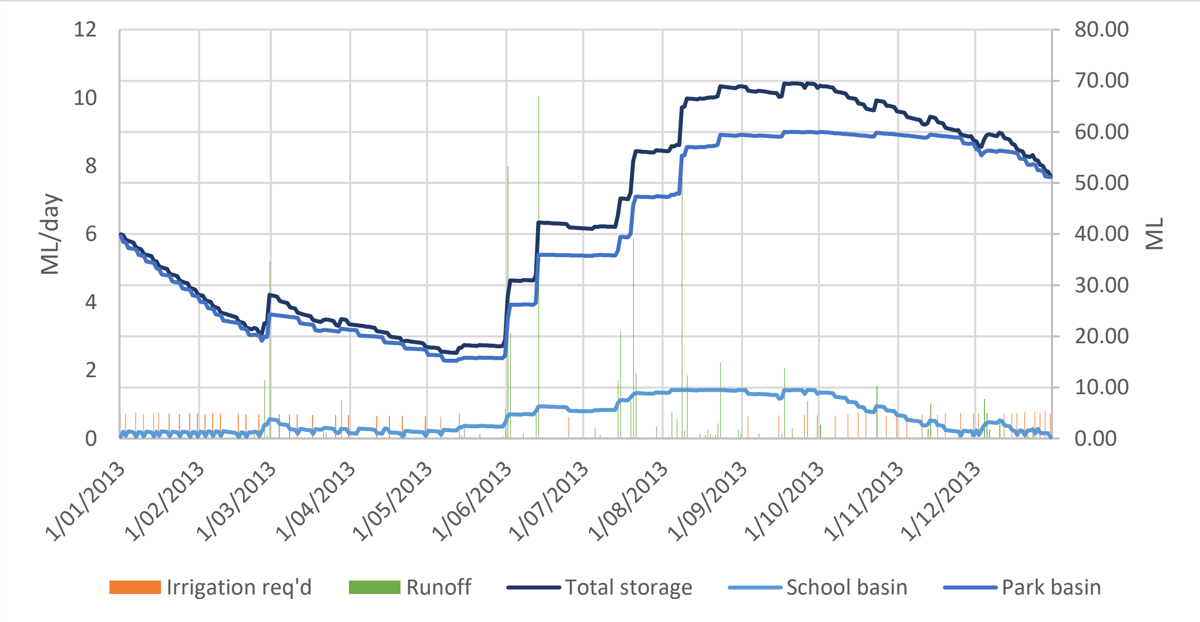


Figure 6-4 Water balance model results for 2013

6.4.1 Basin sizing

During periods of lower than average rainfall the basin storage will empty as irrigation continues. To assess the reliability of the basin in providing water for reuse the occurrence of irrigation demand when the basin was empty was recorded as an irrigation shortfall. Note that toilet flushing and garden irrigation are assumed to be supplied from town water and not carried out, respectively, if the storage is empty. The ratio of the irrigation shortfall to the total irrigation demand over the selected period being modelled is the reliability of the basin of a given size. Reliability curves are generated by plotting reliability against basin size and shown in Figure 6-5.

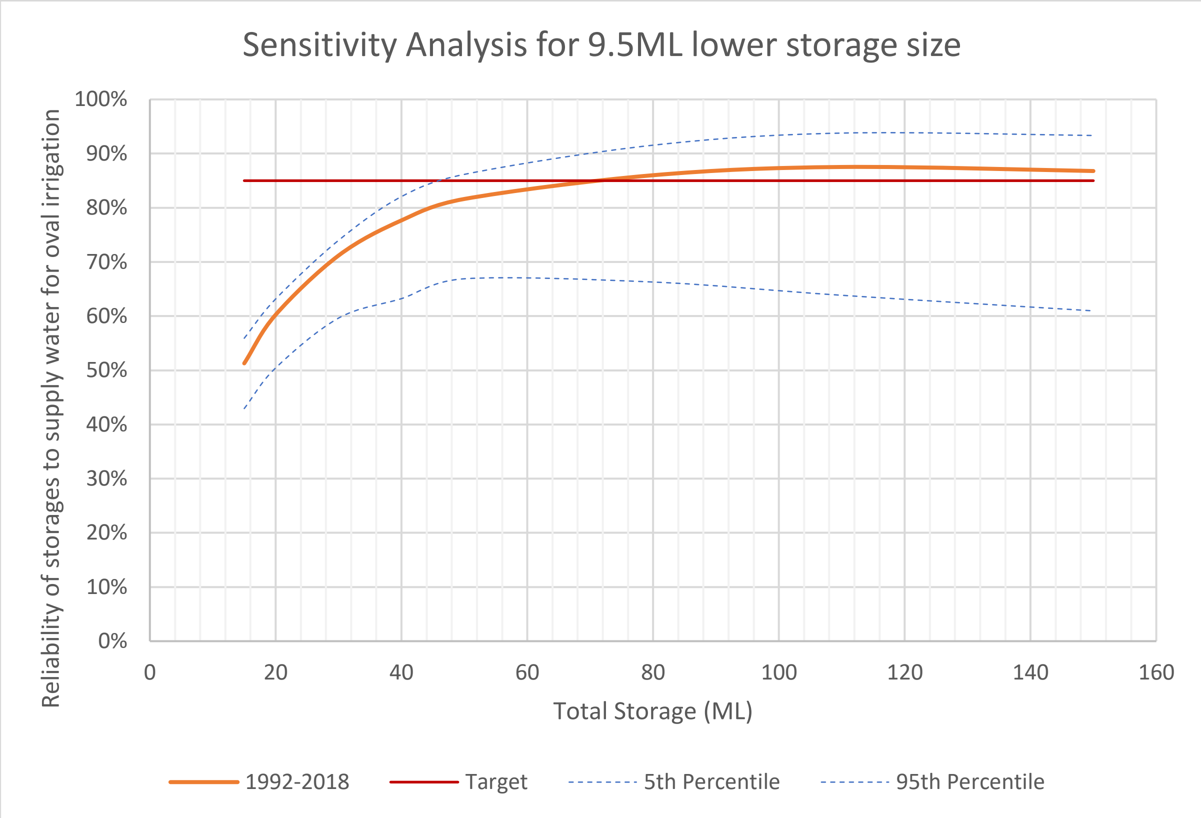


Figure 6-5 Reliability of supply for retention basin sizing

For the desired reliability of 85% a total storage of 70ML is required. The proposed site in the north eastern corner of the site is limited to providing 10ML of storage given the requirement to fit the basin in alongside the proposed sporting fields. Hence a second, larger basin is required in the undeveloped south eastern portion of the site. The larger basin collects the larger, but less frequent, inflows from Catchment 2 while the smaller basin adjacent to the ovals collects smaller, but more frequent, inflows from Catchment 1.

Modelling of Catchment 2 alone shows runoff is insufficient to achieve reliability greater than 70%. Catchment 1 provides important inflows during brief rain events due to runoff from the numerous impervious areas; while the same rain events result in minimal runoff from Catchment 2 as the rain soaks into the soil.

Conclusion 8: An upper basin with a capacity of 60ML with a lower basin with a capacity of 9.5ML will provide 85% of the water required for irrigation of the four ovals.

Water would be pumped from the lower basin to irrigate the ovals with water released periodically from the upper basin to replenish the lower basin level.

7. CONCLUSION

This stormwater management strategy relates to the proposed development of two ovals and associated building infrastructure within the Coolock Campus of Catherine McAuley College in Junortoun.

The SMS makes the following conclusions:

Conclusion 1: Catchment 1 requires 0.5ML of detention storage to restrict stormwater flows to pre-development levels.

Conclusion 2: Catchment 2 does not require detention storage to restrict stormwater flows to pre-development levels.

Conclusion 3: A 10ML sedimentation basin adequately treats stormwater runoff from Catchment 1.

Conclusion 4: Irrigation demand for the four ovals was found to be 45ML per year.

Conclusion 5: Toilet flushing demand for school use was calculated to be 3.08ML per year and for sport use 0.33ML per year.

Conclusion 6: Garden watering demand was calculated to be 6.51ML per year.

Conclusion 7: Water supply was found to average 3.5ML per year from Catchment 1 and 52.6ML per year from Catchment 2.

Conclusion 8: An upper basin with a capacity of 60ML with a lower basin with a capacity of 9.5ML will provide 85% of the water required for irrigation of the four ovals.

It is considered that stormwater that will be generated by development of the proposed ovals and building in Catherine McAuley College's Coolock Campus will be suitably detained, treated and stored for reuse by the proposed 10ML basin to be constructed in Stage 1.

Appendix A

Masterplan extract – Coolock Campus – Short Term plan

NEW ENTRY+EXIT ROUNDABOUT
- For access to ovals.
- All vehicles exit here except those turning left out of intersection in front of admin area, priority given to buses through giveway signs.

- **NEW SECONDARY SCHOOL PLAY SPACE**

RELOCATABLES TROTTING TERRACE
- Surplus to needs so remove from site.
- Commence landscape and vehicle access works to create new frontage for school and improve traffic flows including separation of cars and buses.

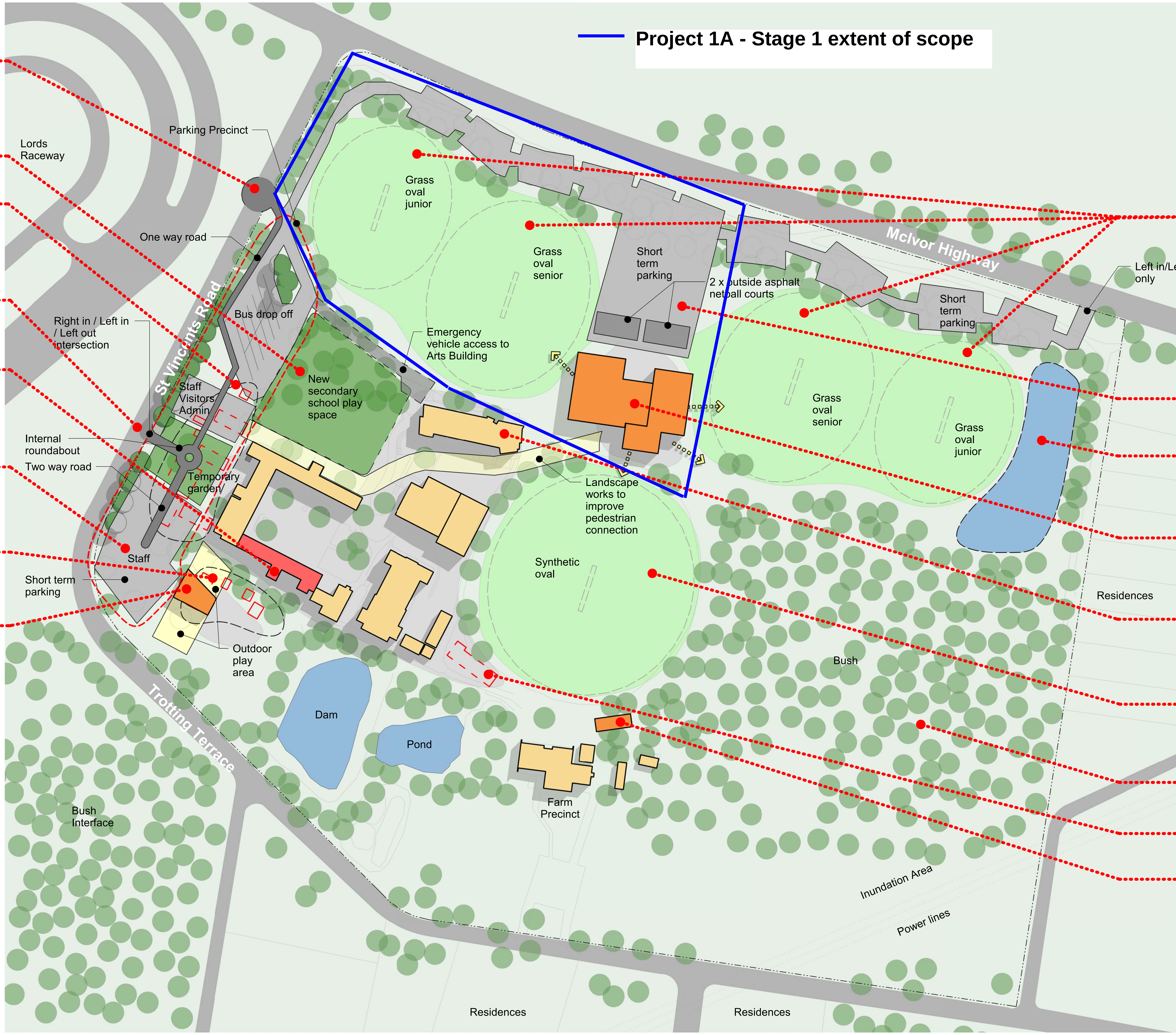
NEW CAR ENTRY & EXIT
- For car entry servicing visitor and staff parking areas.
- Right turn out not permitted.

SOUTH WING - ST VINCENTS BUILDING
- Vacate entire south wing of St. Vincents to accommodate establishment of primary school
- Relocate heads of school & confirm remaining spaces can shift into west wing

STAFF PARKING
- New formalized parking for visitors and admin/senior staff.
- New staff parking area with capacity for future expansion.

CHOOK SHEDS
- Relocate all sheds south of St. Vincents Building to farm precinct to make space available for new primary school.

EARLY LEARNING CENTRE
- Construct new facility 550m2 + 750m2 of outdoor play area include landscape works to improve external spaces between ELC and primary school.



NEW IRRIGATED GRASS OVALS
- Incorporating training level lights

LOWER OVALS ACCESS & PARKING
- New parking areas and access road along McIvor Highway edge of site.

RETENTION BASIN
- Start construction on new retention basin in north east corner of the site to manage water flows across site to reduce size of existing dam to south of existing buildings.

GYM - NEW
- Construct new gym adjacent to joint use facility.
- Works to include car parking and new access road along McIvor Highway edge.

ARTS CENTRE
(under construction 2700m²)
- Complete construction and occupy to decent use from south wing of St. Vincents Building

NEW SYNTHETIC OVAL
- Incorporating playing lights

BUSH PRECINCT
- Develop for outdoor education use

RELOCATABLES - SPORTS OVAL
- Surplus to need so remove from site.

- New location for existing machinery sheds

Coolock Campus - Short Term

Existing Building	Heritage Extent	Alteration/Repair Works	Proposed Building	Demolition Works
Existing Landscape	Proposed Landscape	Existing Outdoor Space	Proposed Carkpark	Site Perimeter

CATHERINE McAULEY COLLEGE

RMG

architecture

Master Planning

Appendix B

Proposed Development Plans

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1.0	PLANNING PERMIT ISSUE	22/11/19	
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DESIGNED:	C. Cox		DATE: 22/11/2019			
DRAWN:	C. Cox		DATE: 22/11/2019			
CHECKED:	NAME	DATE	APPROVED:	NAME	DATE	
☒ RMG	T. Dunlop	22/11/19	☒ RMG	T. Dunlop	22/11/19	
☐ CoGB	-	-	☐ CoGB	-	-	
☐ CWA	-	-	☐ CWA	-	-	

RMG

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CATHERINE MCAULEY COLLEGE

PROJECT 1A - STAGE 1

COOLOCK CAMPUS, JUNORTOUN

SITE EXISTING CONDITIONS PLAN

SCALE 1:2000 10 0 10 20 30 40 50m

ORIGINAL SHEET SIZE A3

180127-C-04

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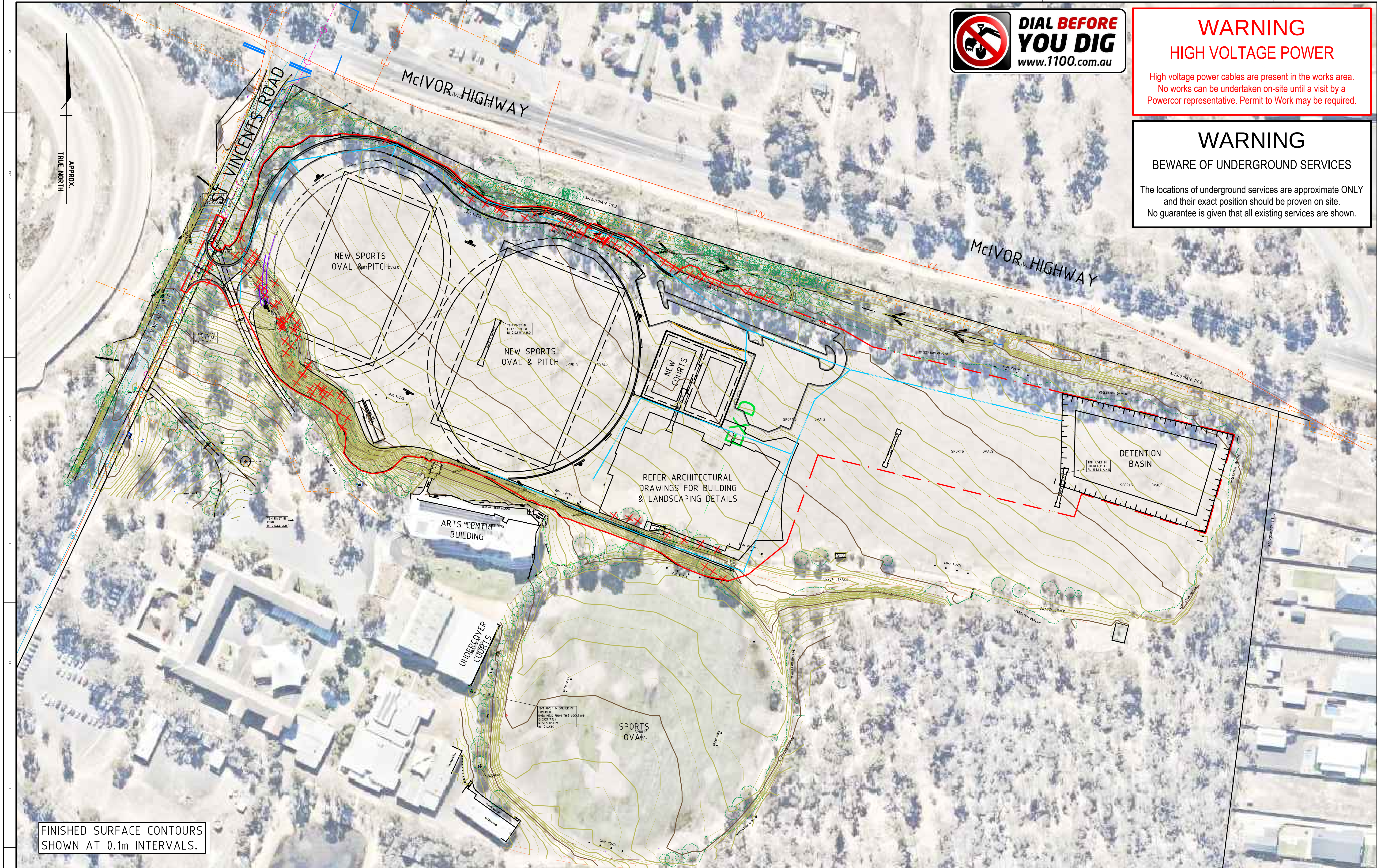
WARNING
HIGH VOLTAGE POWER

High voltage power cables are present in the works area. No works can be undertaken on-site until a visit by a Powercor representative. Permit to Work may be required.

WARNING
BEWARE OF UNDERGROUND SERVICES

The locations of underground services are approximate ONLY and their exact position should be proven on site. No guarantee is given that all existing services are shown.



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1.0	PLANNING PERMIT ISSUE	22/11/19	[signature]

DESIGNED: C. Cox DATE: 22/11/2019
DRAWN: C. Cox DATE: 22/11/2019

CHECKED:	NAME	DATE	APPROVED:	NAME	DATE
☒ RMG	T. Dunlop	22/11/19	☒ RMG	T. Dunlop	22/11/19
☐ CoGB	-	-	☐ CoGB	-	-
☐ CWA	-	-	☐ CWA	-	-

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CATHERINE MCAULEY COLLEGE
PROJECT 1A - STAGE 1
COOLOCK CAMPUS, JUNORTOUN
OVERALL LAYOUT PLAN

SCALE 1:2000 10 0 10 20 30 40 50m
ORIGINAL SHEET SIZE A3

180127-C-05

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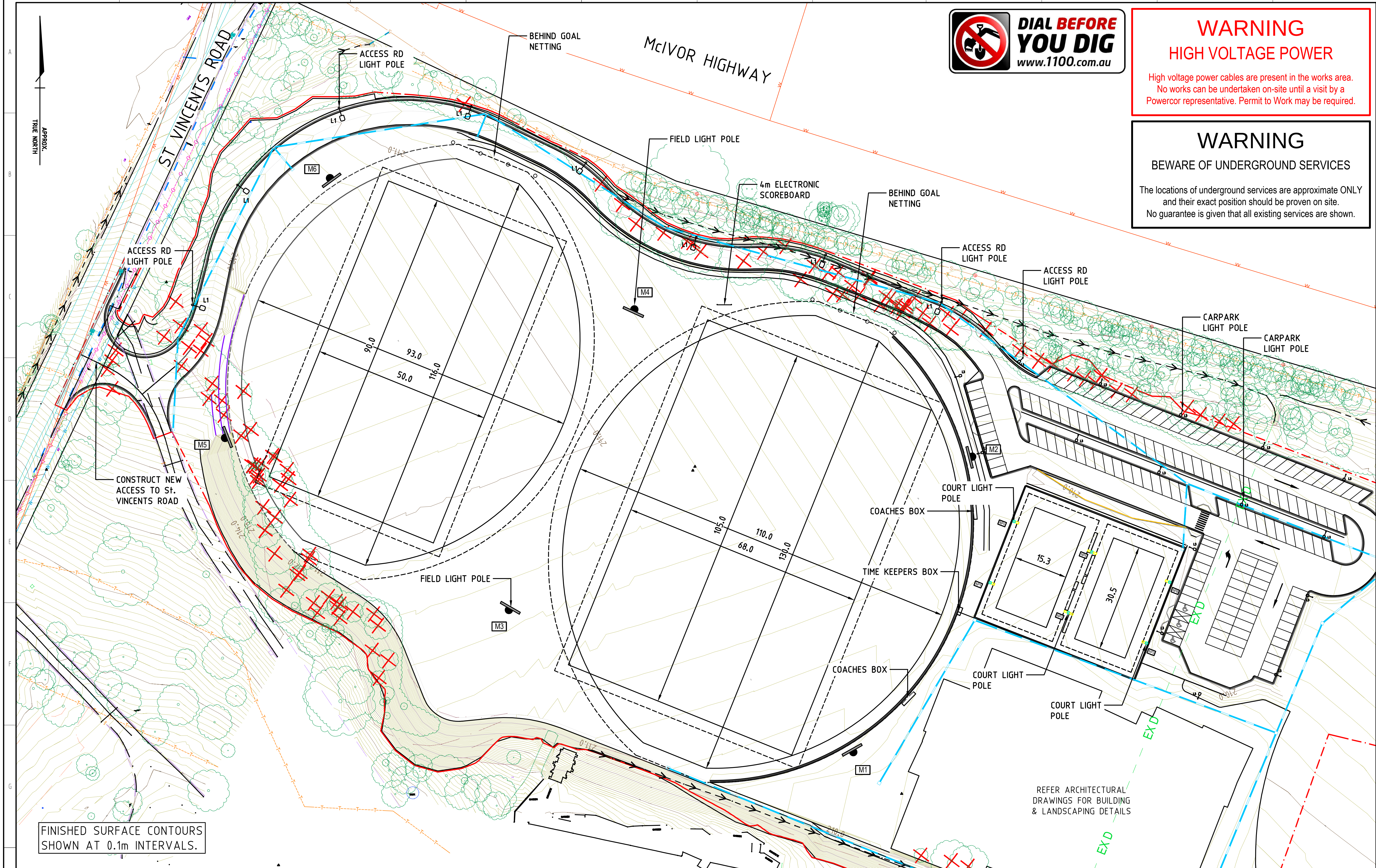

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CATHERINE MCAULEY COLLEGE

PROJECT 1A - STAGE 1

COOLOCK CAMPUS, JUNORTOUN

DETAIL DESIGN PLAN 01

SCALE 1:1000 5 0 5 10 15 20 25m

ORIGINAL SHEET SIZE A3

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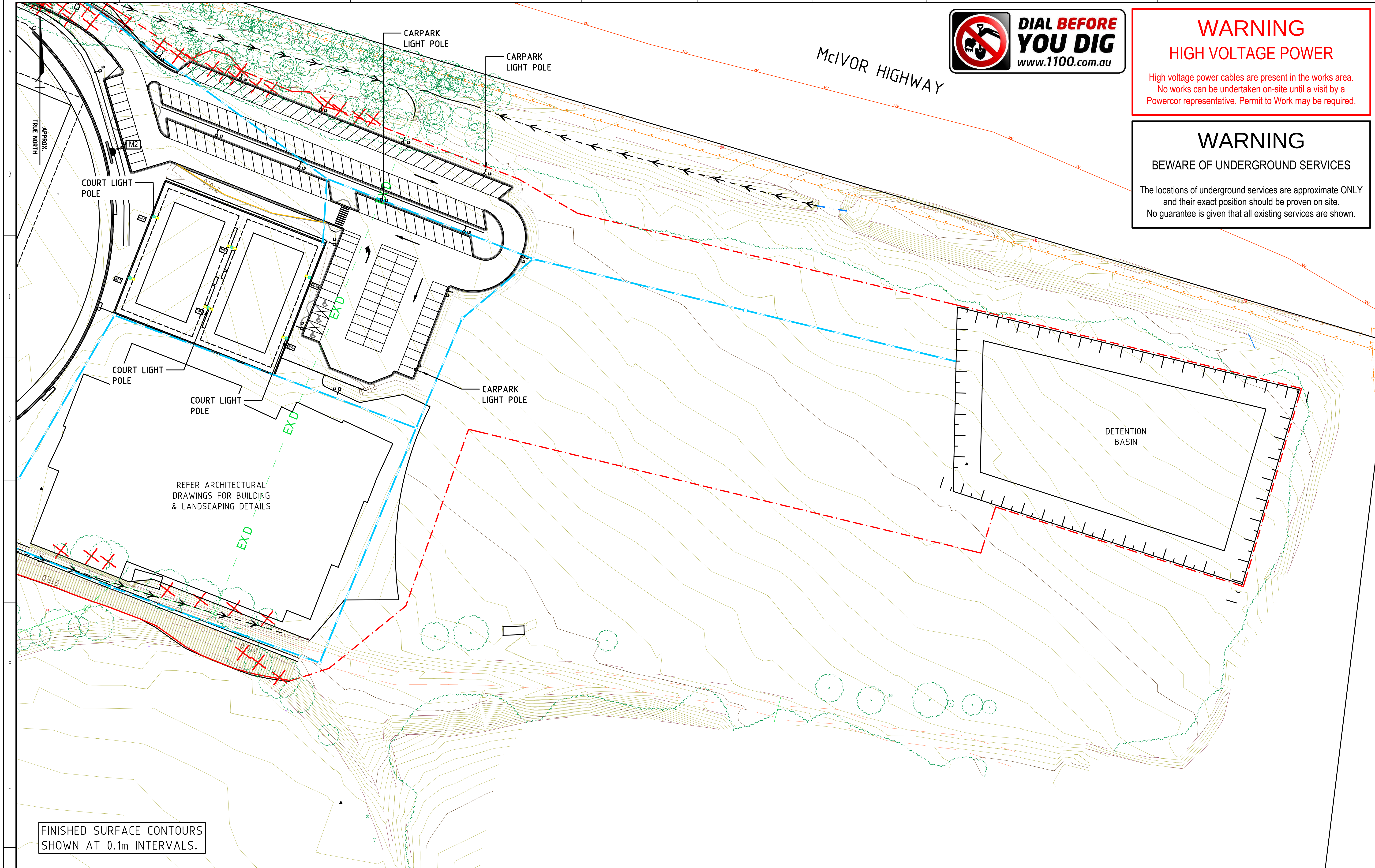

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DESIGNED: C. Cox DATE: 22/11/2019
DRAWN: C. Cox DATE: 22/11/2019

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CATHERINE MCAULEY COLLEGE
PROJECT 1A - STAGE 1
COOLOCK CAMPUS, JUNORTOUN
DETAIL DESIGN PLAN 02

SCALE 1:1000 5 0 5 10 15 20 25m
ORIGINAL SHEET SIZE A3
180127-C-09
ISSUED 2019 VERSION 1.0

26/11/2019 4:00 PM

Appendix C

Detention Calculations

DETENTION CALCULATIONS

PROJECT 1A, STAGE 1

Location: Catherine McAuley College, Junortoun

Calculations By: Luke Rasborsek	Ref:	180127	Version:	01
Catchment 1	Sheet:	1 of 2	Date:	19th June 2019

1. Input Parameters:

1.1 ARI

Average Recurrence Interval:

ARI = 5 Years

1.2 Catchment Areas

Development Area:

A_1 = 145000 m^2

Catchment Total

A_T = 145000 +

145000 m^2

1.5 Runoff Coefficients

Pre Development - Entire Catchment

Assume f for catchment

f_C = 0.2

A_C = 145000 +

= 145000 m²

Hence overall impervious fraction of the site is:

$f = f_C \times A_C$

= 0.2 x 145000

= 29000 m²

The 10 year ARI runoff coefficient for the site is:-

$C_{10} = 0.9 \times f + C^1_{10} \times (1 - f)$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.11)

Where:-

$C^1_{10} = 0.1 + 0.0133 \times ({}^{10}I_1 - 25)$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.12)

For Bendigo, the 1 hour, 10 year ARI rainfall intensity is:-

${}^{10}I_1$ = 29 mm/hr

(Source: Bendigo IFD)

Hence,

C'_{10} = 0.1 + 0.0133 (29 - 25)

C'_{10} = 0.15

And therefore,

C_{10} = 0.9 x 0.2 + 0.15 x (1 - 0.2)

C_{10} = 0.30

The 5 year ARI runoff coefficient for the site is:-

$C_5 = F_5 \times C_{10}$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.13)

Where:-

$F_5 = 0.95$

$F_{100} = 1.20$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Table 1.6)

Therefore,

$C_5 = 0.95 \times 0.3$

$C_5 = 0.29$

$C_{100} = 1.2 \times 0.3$

$C_{100} = 0.36$

Pre Development - School Only

Assume f for catchment

$f_C = 0.20$

$A_C = 145000$

$= 145000$ m²

The 10 year ARI runoff coefficient for the site is:-

$C_{10} = 0.9 \times f + C^1_{10} \times (1 - f)$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.11)

Where:-

$C^1_{10} = 0.1 + 0.0133 \times ({}^{10}I_1 - 25)$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.12)

For Bendigo, the 1 hour, 10 year ARI rainfall intensity is:-

${}^{10}I_1 = 29$ mm/hr

(Source: Bendigo IFD)

Hence,

$C'_{10} = 0.1 + 0.0133 (29 - 25)$

$C'_{10} = 0.15$

And therefore,

$C_{10} = 0.9 \times 0.2 + 0.15 \times (1 - 0.2)$

$C_{10} = 0.30$

The 5 year ARI runoff coefficient for the site is:-

$C_5 = F_5 \times C_{10}$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.13)

Where:-

$F_5 = 0.95$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Table 1.6)

Therefore,

$C_5 = 0.95 \times 0.3$

$C_5 = 0.29$

Post Development - Entire Catchment

Developed Lots

$f_{\text{developed lots}}$ = 0.35

(Source: Bendigo Impervious Study

$A_{\text{developed lots}}$ = 145000 m²

The 10 year ARI runoff coefficient for the site is:-

$C_{10} = 0.9 \times f + C^{1}_{10} \times (1 - f)$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.11)

Where:-

$C^{1}_{10} = 0.1 + 0.0133 \times ({}^{10}I_1 - 25)$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.12)

For Bendigo, the 1 hour, 10 year ARI rainfall intensity is:-

${}^{10}I_1$ = 29 mm/hr

(Source: Bendigo IFD)

Hence,

$C'_{10} = 0.1 + 0.0133\ (29 - 25)$

$C'_{10} = 0.15$

And therefore,

$C_{10} = 0.9 \times 0.35 + 0.15 \times (1 - 0.35)$

$C_{10} = 0.41$

The 5 year ARI runoff coefficient for the site is:-

$C_5 = F_5 \times C_{10}$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Equation 1.13)

Where:-

$F_5 = 0.95$

$F_{100} = 1.20$

(Source: Australian Rainfall & Runoff Volume 1 Book VIII Table 1.6)

Therefore,

$C_5 = 0.95 \times 0.41$

$C_5 = 0.39$

$C_{100} = 1.2 \times 0.41$

$C_{100} = 0.50$

2. Predevelopment Flows

2.1- Calculate 5 year pre development discharge- Entire Catchment

Time of Concentration

Predeveloped Tc consists of
-Sheet Flow (Upstream Catchment)
-Channel Flow

Sheet Flow - Upstream Catchment

Kinematic Wave Equation

$$t = \frac{6.94\,(L^*n)^{0.6}}{I^{0.4} * S^{0.3}}$$

(Australian Rainfall & Runoff - Book 8: Equation 1.2)

L =	425.0	m
n =	0.020	
slope =	0.035	m/m

$$t^*I^{0.4} = \frac{6.94^*(425 \times 0.02)^\wedge 0.6}{I^\wedge 0.4 \times 0.035^\wedge .0.3}$$

$t^*I^{0.4}$ = 68.52

By Interpolating values of $I^{0.4}$, sheet flow tc is 28 minutes
(refer highlighted table attached)

t= 14.0

Channel Flows

$$Q = \frac{AR^{2/3}S^{1/2}}{n}$$

V=	2.0	m/s
L=	380	m
t=	190	s
=	3.17	minutes
TC Total =	17.2	minutes
$^5I_{31}$=	52.3	mm/hr

Therefore 5 yr pre-development discharge

$Q_5 = C_5 \times {}^5I_{31} \times A / 3600$

$Q_5 = (0.29 \times 52.3 \times 145000) / 3600$

Q_5 = 610.89 L/s

Total Allowable Discharge Rate for site (entire catchment):

Q_5 = 610.89 L/s

2.1- Calculate 100 year pre development discharge- Entire Catchment

Time of Concentration

Predeveloped Tc consists of
-Sheet Flow (Upstream Catchment)
-Channel Flow

Sheet Flow - Upstream Catchment

Kinematic Wave Equation

$$t = \frac{6.94\,(L^*n)^{0.6}}{I^{0.4} * S^{0.3}}$$

(Australian Rainfall & Runoff - Book 8: Equation 1.2)

L =	425.0	m
n =	0.020	
slope =	0.035	m/m

$$t^*I^{0.4} = \frac{6.94^*(425 \times 0.02)\text{^}0.6}{I\text{^}0.4 \times 0.035\text{^}.0.3}$$

$t^*I^{0.4}$ = 68.52

By Interpolating values of $I^{0.4}$, sheet flow tc is 20.5 minutes
(refer highlighted table attached)

t= 10.0

Channel Flows

$$Q = \frac{AR^{2/3}S^{1/2}}{n}$$

V=	2.0	m/s
L=	380.0	m
t=	190	s
=	3.17	minutes

TC Total =	13.2	minutes
$^{100}I_{24}$=	113.0	mm/hr

Therefore 100 yr pre-development discharge

Q_{100} = C_{100} x $^{100}I_{24}$ x A / 3600

Q_{100} = (0.36 x 113 x 145000) / 3600

Q_{100} = 1638.50 L/s

Total Allowable Discharge Rate for site (entire catchment):

Q_{100} = 1638.50 L/s

3. Post Development Flows

3.3- Calculate 5 year Post Development discharge (entire catchment)

tc = 17.17 minutes

$^{5}I_{31}$= 52.3

C= 0.39

Therefore 5 yr post-development discharge

$Q_5 = C_5 \times {}^{5}I_{31} \times A / 3600$

$Q_5 = (0.391875 \times 52.3 \times 145000) / 3600$

$Q_5 =$ 825.50 L/s

Total post development discharge Rate for site (entire catchment)

$Q_5 =$ 825.50 L/s

3.4- Calculate 100 year Post Development discharge (entire catchment)

tc = 13.17 minutes

$^{100}I_{24}$= 113.0

C= 0.50

Therefore 5 yr post-development discharge

$Q_5 = C_{100} \times {}^{100}I_5 \times A / 3600$

$Q_5 = (0.495 \times 113 \times 145000) / 3600$

$Q_5 =$ 2252.94 L/s

Total post development discharge Rate for site (entire catchment)

$Q_5 =$ 2252.94 L/s

5. Discharge Summary:

Q_5 (pre developed - entire catchment) = 610.89 l/s

Q_{100} (pre developed - entire catchment) = 1638.50 l/s

Q_5 (post developed - entire catchment) = 825.50 l/s

Q_{100} (post developed - entire catchment) = 2252.94 l/s

6. Detention Required

Q_{100} (pre development - entire catchment) = 1638.50 l/s

ARI= 100 years

C_{100} = 0.50

A= 145000 m^2

Volume Required= 546.28 m^3
(refer detention calculations - sheet 2 attached)

DETENTION CALCULATIONS

PROJECT 1A, STAGE 1

Location: Catherine McAuley College, Junortoun
Calculations By: Luke Rasborsek | Ref: 180127 | Version: 01
Catchment 1 | Sheet: 2 of 2 | Date: 19th June 2019

Input Parameters:

Average Recurrence Interval:
ARI = 100 Years

Area (Entire Catchment):
A = 145000 m^2

Runoff Coefficient:
C = 0.50

Allowable Discharge Rate from Development
$Q_{100\ (predeveloped\ -entire\ catchment)}$ - = 1638.50 l/s

Detention Volume Required:

From the table below, the detention volume required for the tank is:-
V_T = 546.28 m^3

This occurs at 10 minutes into a 10 minute duration rainfall event.

Time (Minutes)	"Worst Case" Event Duration [1]	Cumulative Runoff [2] (m^3)	Cumulative Outflow [3] (m^3)	Detention Required [4] (m^3)	
0		0.00	0.00	0.00	
5	5 minute	1031.18	491.55	539.63	
10	10 minute	1529.38	983.10	546.28	- Peak
15	20 minute	1924.90	1474.65	450.25	
20	20 minute	2138.78	1966.20	172.58	
25	25 minute	2356.15	2356.15	0.00	
30	30 minute	2538.99	2538.99	0.00	
35	45 minute	2660.39	2660.39	0.00	
40	45 minute	2853.39	2853.39	0.00	
45	1 hour	3004.05	3004.05	0.00	
50	1 hour	3119.34	3119.34	0.00	

Notes:
(1) "Worst Case" event duration is the rainfall event causing the greatest amount of runoff for the given time. Rainfall events are based on the intensities for the specified ARI event in Bendigo (calculated in accordance with Chapter 2 of Australian Rainfall and Runoff (1987)), and the Temporal Rainfall Patterns taken from Table 3.2 - Zone 2 in Volume 2, Australian Rainfall and Runoff (September 2007)
(2) Calculated using Time Period x 60 x C x Equivalent Intensity x A / 360

(3) Cumulative Outflow = Time Elapsed x Allowable Discharge Rate (from 'Input Parameters" at top of sheet).
(4) Detention Required = Adopted Cumulative Runoff - Cumulative Outflow

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