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# SUBMISSION TO STRATHBOGIE SHIRE COUNCIL

## STORMWATER AND FLOOD MANAGEMENT STRATEGY

- Box Grove - Proposed Multi-Lot Subdivision at 21 Lobbs Lane, Nagambie VIC
- Prepared on behalf of Parklea Developments PTY LTD
- NOV 2020 - Revision B
- Ref: 12566

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## Document History and Status

| Rev. | Status | Date | Author | Project Reviewer |
|---|---|---|---|---|
| A | Draft – Submitted to Client | OCT 2020 | Jagraj Benipal | Matthew Elliot |
| B | Minor amendments | NOV 2020 | Matthew Elliot | Matthew Elliot |

Contents

## 1.0 Introduction

This stormwater and flood management strategy has been prepared by Tomkinson Group on behalf of Parklea Developments PTY LTD for a proposed 199 Lot staged low-density residential subdivision at 21 Lobbs Lane, Nagambie known as Box Grove. The stormwater strategy will investigate the effects the development will have on stormwater quantity and discharge.

Strathbogie Shire Council is the responsible authority for the major and minor drainage facilities in the Nagambie area. The Goulburn Broken Catchment Management Authority (GBCMA) is responsible for stormwater outfall to creeks, rivers, and waterways in the Nagambie area. Goulburn Murray Water (GMW) operates and manages the irrigation district and waterway management. The developer will be required to meet the requirements of Strathbogie Shire Council, GMW, and GBCMA under the Water Act 1989, for the provision of drainage works and the acceptance of surface and stormwater from the proposed development site directly or indirectly into the responsible authority drainage system.

This report is to identify a Stormwater and Flood Management Strategy (SWFMS) for the proposed development, along with supporting preliminary calculations and conceptual design, for the council and other relevant drainage authorities to accept prior to planning approval.

## 2.0 Site & Surrounds

The subject property, known as Box Grove, is located at 21 Lobbs Lane and is bounded between Goulburn River and Lobbs Lane, approximately 1km North-East of Nagambie. The site is approximately 154.8 Ha in area.

The site is currently zoned Low-Density Residential Zone (LDRZ) under the Strathbogie Shire Council planning scheme. Appendix A shows the extent of 1% AEP flooding over the site from the Goulburn River/Nagambie Lake which slightly differs in footprint to the Flood Overlay (FO). The site is also subject to Development Plan Overlay – Schedule 3 (DPO3). The DPO3 requires the development applicant to address the following in respect to stormwater and flood management.

*DPO3 - Stormwater and Flood Management Strategy*
*A Stormwater and Flood Management Strategy developed in consultation with the responsible authority and relevant referral authorities including:*

- *Establishment of flood levels for the site*
- *All contributing flows from adjoining public and private land into the site*
- *All run-off generated within the site*
- *How flows are proposed to be carried through the site*
- *Identification of overland flow paths, depths and velocities of flows and any potential effects on or discharge onto surrounding properties*
- *Any earthworks proposed to provide adequate freeboard to development*
- *Access across the floodway must be designed so that it has no adverse offsite flooding impacts*
- *Access across the floodway must be provided at a level higher than the 100-year Average Recurrence Interval (ARI)*
- *Water Sensitive Urban Design (WSUD) principles*
- *Buildings and works must be located outside the floodway, which is the land defined as 0.5 metres below the applicable 100-year Average Recurrence Interval (ARI)*
- *Building envelopes must be located on land that floods less than 0.5 metres deep in a 100-year ARI type flood event*
- *Access across the floodway to the allotments and to the building envelopes must flood less than 0.35 metres deep in a 100-year ARI type flood event*

The site has sparse native vegetation along the water's edge and alongside sections of track, roads or fences through the site (including native and exotic trees). It also contains scattered single large trees across what is mostly pasture or cropping paddocks. There are two dams within the pasture paddocks and a shed located along the southern track. The homestead paddock contains a dwelling and shedding which is surrounded by gardens and a higher density mixture of trees. The site generally falls North-West towards the Goulburn River, however, is mostly flat with multiple low points.

Access to the site is from Lobbs Lane which traverses North-South along the Eastern boundary of the site. Lobbs Lane is a rural profile two-way road with table drains. A culvert crossing near the North-East edge of the site conveys flows from Eastern catchments to the river via an existing table drain in the road reserve – refer to **Appendix A** for further detail.

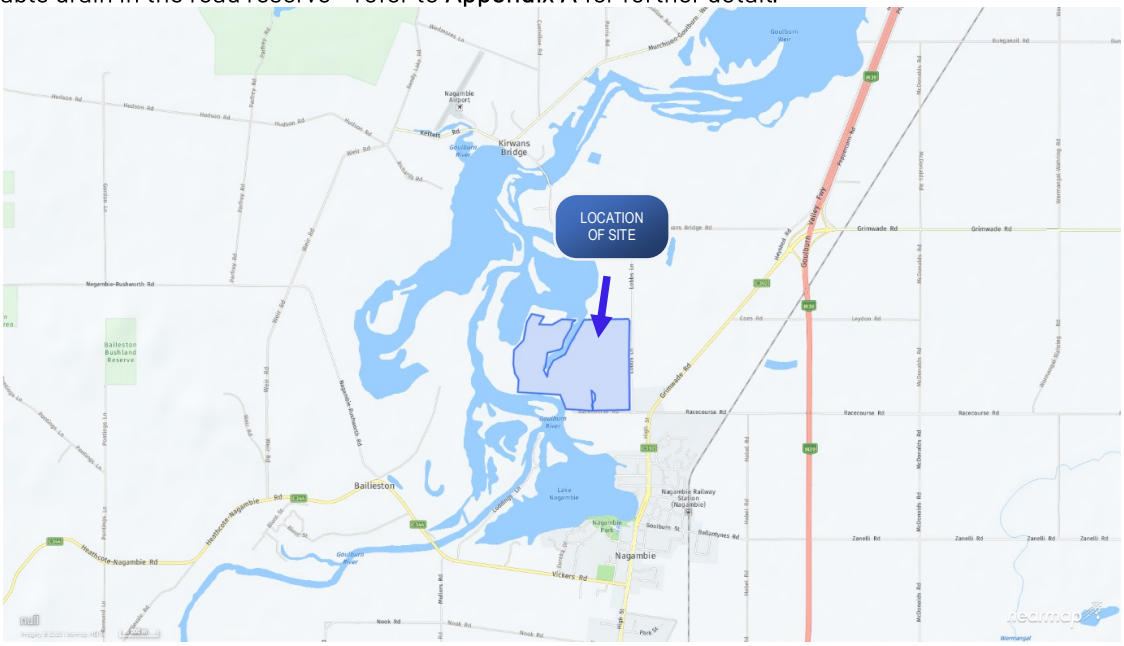



**Figure 1: Locality Plan Road Map**


**Figure 2: Locality Plan Aerial Photography**

**Figure 3: Topography Plan**

# 3.0 Design Intent

## 3.1 Proposed Development

The site is proposed to be developed into a Low-Density residential development. Refer to Appendix A to view the proposed concept plan of the site.

The site is proposed to be developed into approximately 199 residential lots. Most road reserves will be 20m wide and contain two 3.1m carriageways with swale drains (Table Drains) on either side in accordance with the Infrastructure Design Manual (IDM). Road reserves in some locations may need to be wider to accommodate deeper & wider swale drains where the sites trapped low points need to be graded to an outfall. This will be determined in the detail design phase of the project.

Proposed development of the site will affect the quality and quantity of stormwater runoff and therefore Drainage/WSUD infrastructure is proposed to meet the current Council and GBCMA requirements for stormwater management. From previous deliberations with Council, it is our understanding that the proposed drainage infrastructure will generally need to meet current Infrastructure Design Manual standards.

## 3.2 Proposed Stormwater Management Strategy

The internal sites developed catchments are proposed to be captured and conveyed with roadside table drains (open swales) in the road reserve and will be sized for the 20% AEP storm event. Culvert crossings are proposed for driveway and road crossings. Lots grading to the rear are proposed to have piped easement drainage (for Lots <4000m$^2$) or Swales (for Lots >4000m$^2$). Some piped drainage will be adopted on trunk drainage lines where it is not practical to maintain all

flows in swales. All flows will generally discharge into the Goulburn River or backwater adjacent to the site after filtering through WSUD treatment systems. Flows up to the 1%AEP events will be safely conveyed via designated Over Land Flow Paths (OLFP) within the required safety standards, which will primarily be within Road Reserves and landscaped channels/gullies. OLFPs will avoid Lots and/or building envelopes.

The stormwater outfall from the development will discharge through a sediment basin, rain garden, or bioretention swale, where required, to the Goulburn River backwater or Lake at the nominated strategic locations that suit the development plan layout and natural catchments. Exact discharge locations will be refined during the detail design phase to suit environmental values and other detail assessments. A Works on Waterway permit will be obtained from the authority for each discharge location.

## 4.0 Catchment Assessment

Appendix A shows the catchments which have been considered in the catchment assessment. An estimation for stormwater flows generated in pre-developed and post-developed site conditions associated with each catchment have been undertaken utilising the Rational method is presented in Table 1 below. The catchments have been determined by survey information and preliminary design considerations. Appendix B details the assumptions made in estimating the preliminary stormwater flows using the Kinematic Wave Equation, Manning's flow channel flow calculations, and the Rational Method. Rainfall intensities have been obtained from the BOM website and are relevant to the site.

Runoff Coefficients for the post developed site have been adopted from Section 16.7 of the *Infrastructure Design Manual*. When assessing the pre-developed site conditions a C-value of 0.27 was adopted. Time of concentration (Tc) has been calculated using kinematic wave equation and channel flow calculations.

See Table 1 for a summary of the Internal Site Catchment analysis.

| Catchment | Area | C | Tc | $I_{20\%AEP}$ | $I_{1\%AEP}$ | $Q_{20\%AEP}$ | $Q_{1\%AEP}$ |
|---|---|---|---|---|---|---|---|
| | (ha) | | (min) | (mm/hr) | (mm/hr) | ($m^3/s$) | ($m^3/s$) |
| | | | Pre-Developed | | | | |
| Ex A | 11.00 | 0.27 | 97 | 18.2 | 35.2 | 0.15 | 0.29 |
| Ex B | 47.20 | 0.27 | 283 | 8.4 | 15.6 | 0.30 | 0.55 |
| Ex C | 25.80 | 0.27 | 279 | 8.5 | 15.8 | 0.16 | 0.31 |
| Ex D | 41.10 | 0.27 | 158 | 12.8 | 24.2 | 0.40 | 0.75 |
| Ex E | 10.70 | 0.27 | 43 | 32.4 | 65.1 | 0.26 | 0.52 |
| Ex F | 4.43 | 0.27 | 21 | 50.7 | 103.5 | 0.17 | 0.34 |
| | | | Post-Developed | | | | |
| A | 5.06 | 0.40 | 45 | 31.2 | 62.5 | 0.18 | 0.35 |
| B | 61.00 | 0.40 | 85 | 20.0 | 38.9 | 1.35 | 2.63 |
| C | 20.50 | 0.40 | 24 | 46.7 | 95.3 | 1.06 | 2.17 |
| D | 9.08 | 0.35 | 62 | 25.1 | 49.6 | 0.22 | 0.44 |
| E | 8.06 | 0.30 | 29 | 41.3 | 84.0 | 0.28 | 0.56 |
| F | 6.13 | 0.45 | 45 | 31.0 | 62.1 | 0.24 | 0.48 |
| G | 2.68 | 0.45 | 25 | 46.2 | 94.1 | 0.15 | 0.31 |
| H | 3.32 | 0.40 | 32 | 39.2 | 79.3 | 0.14 | 0.29 |
| I | 3.43 | 0.35 | 36 | 36.0 | 72.6 | 0.12 | 0.24 |
| J | 0.80 | 0.45 | 24 | 47.2 | 96.1 | 0.05 | 0.10 |

Table 1: Catchment Flow Calculations

External Catchments

The major flood event from the Goulburn River is the major external contributing flow affecting the site. The vast majority of localised catchments (to the east and south) grading towards the site are intercepted and diverted around the site by existing roads and drainage systems (table drains and swales) and are conveyed to the Goulburn River system. Therefore, no significant external catchments contribute to flows through the proposed development. It is proposed to maintain this existing pattern of drainage for the development.

# 5.0 Stormwater Quantity & Quality Management

## 5.1 Minor/Subsurface Drainage

Underground drainage and vegetated table drains, that will eventually be council-owned & managed, will be provided within the development to convey the 20% AEP flows. Refer to **Appendix A** for the indicative layout of the minor drainage network.

The subsurface/minor drainage network is proposed to be comprised of:

- Vegetated table drains in the road reserves
- Piped and pit drainage in easements at the back of properties <4000m2 to provide stormwater to a legal point of discharge for each Lot and convey stormwater to an outfall drainage system.
- Vegetated table drains in easements at the back of properties >4000m2 to provide stormwater to a legal point of discharge for each Lot and convey stormwater to an outfall drainage system.
- Road carriageway crossing and floodway culverts
- Gravity outfall to drain with capacity for developed runoff in the 20% AEP event to be constructed from rain garden to Goulburn River backwater. These outfalls are proposed to be the Legal Point of Discharge for the development of catchments.
- Exact outfall locations to be selected during detail design to minimize disturbance to native vegetation and other environmental values.
- Outfalls will include appropriate rock beaching to minimize erosion and support disturbed areas while re-establishing.

## 5.2 Overland Flows

OLFPs within the development will be direct flows greater than 20% AEP towards the Goulburn River backwater via private road reserves and constructed waterways. The OLFPs are to have the capacity to safely convey flows up to the 1% AEP event as per IDM requirements. Safety requirements include an assessment of depth (<0.35m) and velocity x depth ratios (<0.35).

A constructed overland flow path gully is proposed in catchment B to convey 1%AEP storm events to the river backwater.

## 5.3 Water Quality Treatment

For stormwater quality management, vegetated table drain (swales) are proposed for stormwater treatment and if required to increase treatment, a rain garden, sediment basin, and or bioretention swale is proposed before the catchments outfall adjacent to the River or backwater. This will achieve the stormwater quality treatment of the development which will achieve the best practice requirements for the development.

The Melbourne Water WSUD Best Practice Guidelines outline the following treatment objectives:

- 80% reduction of the typical urban annual load for Total Suspended Solids (TSS)
- 45% retention of the typical urban annual load for Total Phosphorus (TP)
- 45% retention of the typical urban annual load for Total Nitrogen (TN)
- 70% retention of the typical urban annual load for gross pollutants (litter)

A preliminary MUSIC model has been prepared in accordance with Melbourne Water design guidelines:

| Node | Total Area ($m^2$) | Permanent Pool Area ($m^2$) | Filter Media Area ($m^2$) | Extended Detention Depth (m) |
|---|---|---|---|---|
| Raingarden | 75 | N/A | 55 | 0.5 |

Table 2: WSUD Preliminary Sizing Table

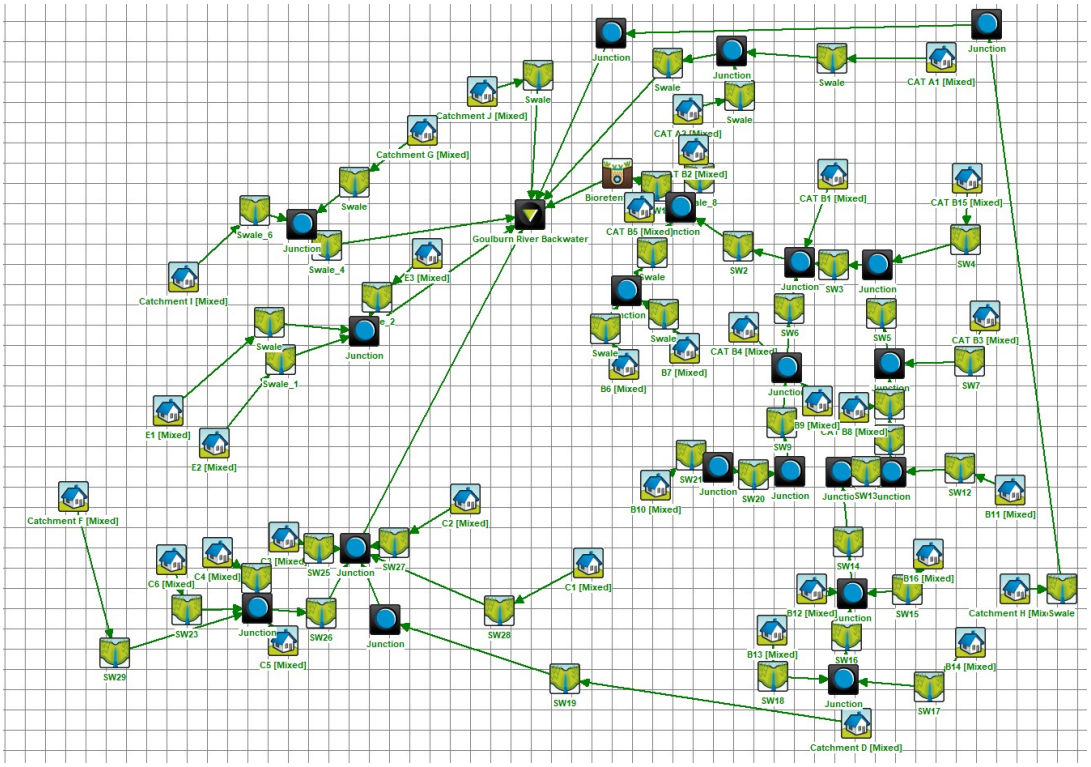
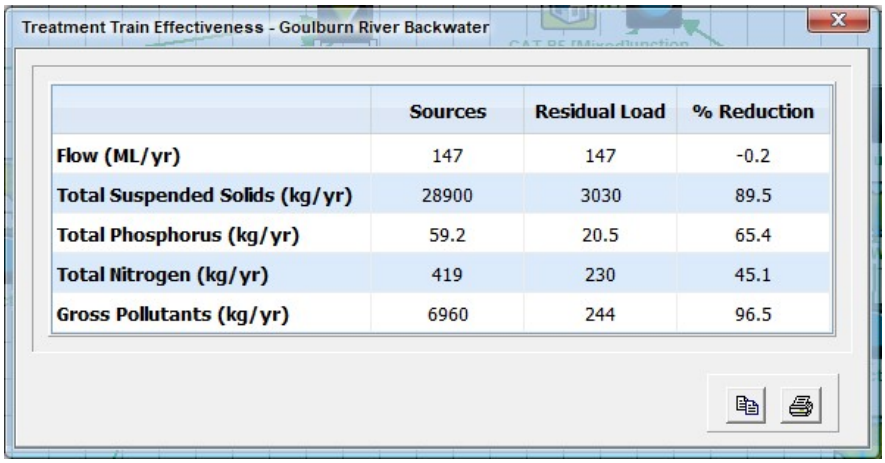



Figure 3: MUSIC Model Screenshot

Below are screenshots of the MUSIC Model and expected treatment effectiveness.




| | Sources | Residual Load | % Reduction |
|---|---|---|---|
| Flow (ML/yr) | 147 | 147 | -0.2 |
| Total Suspended Solids (kg/yr) | 28900 | 3030 | 89.5 |
| Total Phosphorus (kg/yr) | 59.2 | 20.5 | 65.4 |
| Total Nitrogen (kg/yr) | 419 | 230 | 45.1 |
| Gross Pollutants (kg/yr) | 6960 | 244 | 96.5 |

Figure 4: Treatment Train Effectiveness

The MUSIC model shows that the WSUD guidelines can be met with the proposed treatment chain including compensation for some catchments bypassing the treatment chain.

## 5.4 Detention

The IDM states that new developments need to retard the 1% AEP developed flows back to pre-developed rates. Section 18.4.2 of the IDM states Council may consider a design based on a more probable storm event with a reduced capacity if the Design Engineer can demonstrate the 1% AEP storm is irrelevant. Generally, this design criteria is to prevent increased flooding downstream and to protect dry creeks and natural waterways from increased erosion due to a greater frequency of high velocity flows. Due to the development discharging directly into a receiving permanent water body, we recommend and propose that no on-site detention is required.

Effectively, the backwater of the Goulburn River acts as the detention node for the localised events and protects downstream systems. There is no impact on the Goulburn River flood peak as the local peak storm event occurs hours, perhaps days, prior to the river's flood level after a major storm event due to the large Goulburn River upstream catchment and long time of concentration. Therefore, no on-site detention is proposed to be provided because we believe there is no benefit in retarding storms greater than what is required to meet WSUD contaminant removal objectives (i.e. upto the 3 month ARI).

## 5.5 Construction

Major earthworks are proposed for the site. Management of environmental impacts during the construction phase, including the implementation of stormwater runoff management measures are to be detailed in a Construction Management Plan, which will most likely be required by a condition of any Planning Permit issued for this development. The contents of a Construction Management Plan should include a section that outlines how the contractor is to enact erosion and sediment control measures and protect the backwater.

Where possible, offsite stormwater shall be redirected prior to entering the site. Stormwater flowing onto the site shall be controlled by cut off drains to prevent it flowing onto areas denuded of grass cover.

## 5.6 Goulburn River & Backwater 1% AEP Flooding

The site is subject to 1%AEP flooding from the Goulburn River within 20-100m from the edge of the permanent water level. This generally results in inundation next to the river and backwater and a flow path (south to north) through the site. The 1% AEP flood levels and extents have been obtained from the Goulburn Broken Catchment Management Authority. Flood levels upstream and

downstream of the site provided by GBCMA were interpolated to provide flood levels across the site - refer to Appendix A. These levels have been digitally compared with the site's survey to determine the flood extents across the site. These extents are adopted and shown in the Development Plan. This flood level has been shown on the Concept Catchment Plan – refer to Appendix A.

Generally, the developed area is mostly clear of the 1% AEP flood extents. There are portions of the developable area that have encroachment into the 1%AEP flooded area, however, all lots are designed to provide building envelopes outside the 1%AEP flood event. Therefore, filling of the flood plain is limited. There will be some building envelopes for the proposed development that will require some filling to create sufficient freeboard above the 1% AEP flood levels in catchment C, E, F, G, I, and J.

All road carriageways will be above 1% AEP flood levels or will generally meet the access safety criteria for depth (<350mm) and velocity/depth ratio (<0.35) where clearance from the 1%AEP is not achieved.

Two causeways crossings with multiple culverts are proposed across the 1% AEP floodway as shown on the Development Plan. Flood modeling will be carried out during detailed design to ensure existing flood patterns are not adversely affected and that the causeway crossings meet safety requirements for access during a 1% AEP event. These proposed causeways will be the main filling proposed within the flood plain. A typical cross-section is shown in Appendix A.

## 3.0 Conclusion

The report and concept design have identified a drainage management strategy for the proposed staged residential subdivision at 21 Lobbs Lane, Nagambie.

Construction of the proposed council drainage infrastructure will meet the requirements of the GBCMA, GMW, and Strathbogie Shire Council. Key components of the methodology include:

- The majority of external catchments (to the east, north, and south) grading towards the site are intercepted and diverted around the site by existing road's and drainage systems (table drains and swales) and are conveyed to the Goulburn River system
- Provision for overland flow paths up to 1% AEP capacity and are clear of proposed lots or building envelopes.
- Upto 20% AEP storm event flows conveyed via vegetated table drain infrastructure
- Treatment of runoff from the development will be achieved through the vegetated table drains and supplemented with a node treatment (if required) such as a rain garden sized to meet water quality Best Practice guidelines
- The stormwater outfall from the development will discharge into the Goulburn River or backwater adjacent to the site
- No on-site detention is proposed due to the Goulburn River Backwater acting as a retarding waterbody
- There is no proposed stormwater discharge to neighboring properties.
- Lots are designed to provide building envelopes outside the 1%AEP flood event
- Two causeway culvert crossings are proposed across 1%AEP floodway.

# 4.0 Appendix A – Concept Stormwater Management Plans

## DRAINAGE PLAN LEGEND

- FALL ARROW
- EX'D — EXISTING DRAIN/CULVERT
- APPROX 1% AEP FLOOD EXTENT (~RL126.6)
- EXISTING OPEN DRAIN

GOULBURN RIVER BACKWATER

GOULBURN RIVER BACKWATER

LOBBS LN

AREA ~ 10.7Ha
EXE

AREA ~ 4.4Ha
EXF

AREA ~ 41.1Ha
EXD

AREA ~ 11.0Ha
EXA

AREA ~ 47.2Ha
EXB

AREA ~ 25.8Ha
EXC

| REV | REVISION | DES | DWG | CHK | DATE |
|---|---|---|---|---|---|
| B | NEW LOT LAYOUT | X | JB | ME | 26/10/20 |
| A | AS SUBMITTED TO CLIENT | X | JB | ME | 06/08/20 |

MGA2020
ZONE 55

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# BOX GROVE DEVELOPMENT
## LOBBS LANE, NAGAMBIE
### EXISTING CATCHMENTS PLAN

AUTHORITY & REFERENCE
CLIENT DETAILS

DWG STATUS: **CONCEPT**

PROJECT & DWG No: 1256601E01 / 03 REV: B

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## DRAINAGE PLAN LEGEND

- PROPOSED TRUNK DRAINAGE
- PROPOSED OPEN DRAIN
- EXISTING DRAIN/CULVERT
- APPROX 1% AEP FLOOD EXTENT (~RL126.6)
- EXISTING OPEN DRAIN
- 1% AEP OVERLAND FLOW PATH
- CATCHMENT DISCHARGE LOCATION

GOULBURN RIVER BACKWATER

INDICATIVE WSUD (RAINGARDEN)

STAGE 1

LOBBS LN

AREA ~ 5.1Ha — A

AREA ~ 61.0Ha — B

AREA ~ 20.5Ha — C

AREA ~ 9.1Ha — D

AREA ~ 8.1Ha — E

AREA ~ 3.1Ha — F

AREA ~ 2.7Ha — G

AREA ~ 0.8Ha — J

AREA ~ 3.4Ha — I

AREA ~ 3.3Ha — H

| REV | REVISION | DES | DWG | CHK | DATE |
|---|---|---|---|---|---|
| B | NEW LOT LAYOUT | X | JB | ME | 26/10/20 |
| A | AS SUBMITTED TO CLIENT | X | JB | ME | 06/08/20 |

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# LOBBS LANE, NAGAMBIE
## CONCEPT CATCHMENT PLAN

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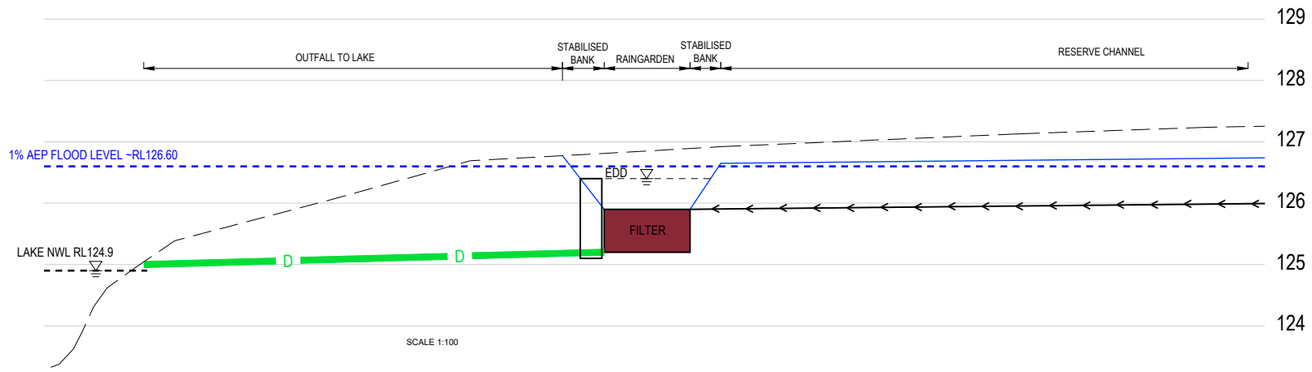
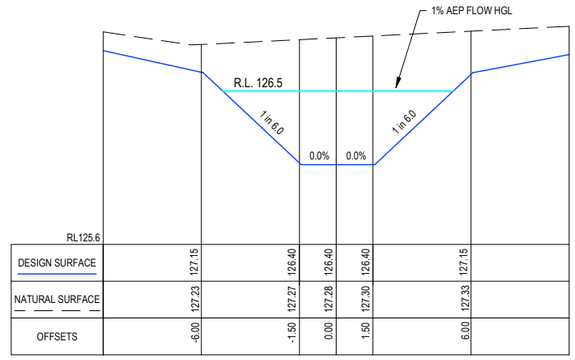



## LEGEND

EXISTING SURFACE

PROPOSED FINISHED SURFACE




| RL125.6 | | | | | | |
|---|---|---|---|---|---|---|
| DESIGN SURFACE | 127.15 | 126.40 | 126.40 | 126.40 | 127.15 | |
| NATURAL SURFACE | 127.23 | 127.27 | 127.28 | 127.30 | 127.33 | |
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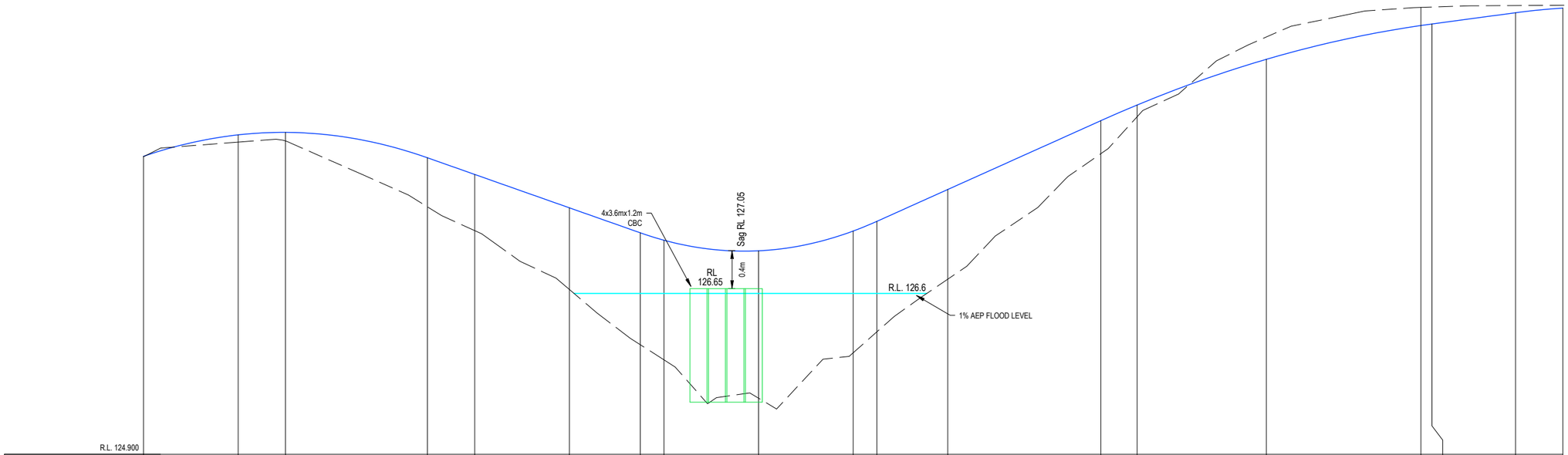
B-B CROSSING SECTION




| R.L. 124.900 | | | | | | | | | | | | | | | |
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| DESIGN LEVELS | | | | | | | 127.163 | 127.051 | 127.260 | | | | | | |
| EXISTING LEVELS | 128.045 | 128.200 | | | 127.264 | 126.642 | 125.898 | 125.492 | 125.973 | 126.751 | | 128.467 | | 129.623 | | | |
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FLOOD CROSSOVER SECTION

A-A CROSSING SECTION

| REV | REVISION | DES | DWG | CHK | DATE |
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# 5.0 Appendix B – Preliminary Stormwater Calculations

## *CATCHMENT $T_C$*

## *NETWORK CONCENTRATION TIME CALCULATIONS*

***Date:*** 26/10/20
***Project:*** Parklea, Nagambie
***Job Number:*** 12566
***Address:*** 21 Lobbs Ln, Nagambie
***Prepared By:*** JB

***Description:*** Catchment Flow Calclation Summary for Proposed Development

**AEP (%)** 20

| | | Overland Flow - Kinematic | | | | | Yes | Channel Flow - Mannings | | | | | | | | Yes | Pipe Flow - Mannings | | | | | | | No | $TC_{Total}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Catchment*** | ***Initiation Time*** | ***Catchment Length*** | ***Height Change*** | ***Horton n**** | ***Trial $T_o$*** | ***Rainfall Intensity*** | ***Calculated $T_o$*** | ***Catchment Length*** | ***Height Change*** | ***Mannings n*** | ***Channel Top Width*** | ***Channel Basd Width*** | ***Channel Depth*** | ***CSA*** | ***Perimeter*** | ***Velocity*** | ***$T_{ch}$*** | ***Length*** | ***Elevation Change*** | ***Mannings*** | ***Diameter*** | ***CSA*** | ***Perimeter*** | ***Velocity*** | ***Tp*** | |
| | *min* | *m* | *m* | | *min* | *mm/hr* | *min* | *m* | *m* | | *m* | *m* | *m* | *$m^2$* | *m* | *m/s* | *min* | *m* | *m* | | *m* | *$m^2$* | *m* | *m/s* | *min* | *min* |
| ***Exisitng*** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ex A | **6** | 300 | 1.2 | 0.100 | 84.00 | 20.17 | **84.17** | 250 | 0.25 | 0.035 | 6.00 | 1.00 | 1.00 | 3.5 | 6.385 | 0.605 | **6.89** | | | | | #VALUE! | #VALUE! | #VALUE! | **0.00** | **97.05** |
| Ex B | **6** | 1100 | 3.5 | 0.100 | 276.00 | 8.57 | **276.80** | | | | | | | 0 | 0.000 | #DIV/0! | **0.00** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **282.80** |
| Ex C | **6** | 750 | 1.2 | 0.100 | 272.00 | 8.66 | **272.69** | | | | | | | 0 | 0.000 | #DIV/0! | **0.00** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **278.69** |
| Ex D | **6** | 450 | 1.0 | 0.100 | 151.00 | 13.22 | **151.62** | | | | | | | 0 | 0.000 | #DIV/0! | **0.00** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **157.62** |
| Ex E | **6** | 250 | 5.2 | 0.100 | 36.00 | 36.24 | **36.50** | | | | | | | 0 | 0.000 | #DIV/0! | **0.00** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **42.50** |
| Ex F | **6** | 100 | 3.1 | 0.100 | 15.00 | 61.49 | **15.08** | | | | | | | 0 | 0.000 | #DIV/0! | **0.00** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **21.08** |
| ***Design*** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A | **6** | 65 | 0.7 | 0.100 | 16.00 | 59.36 | **16.58** | 570 | 0.57 | 0.033 | 5.00 | 1.00 | 0.50 | 1.5 | 5.123 | 0.423 | **22.48** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **45.07** |
| B | **6** | 80 | 0.8 | 0.100 | 18.00 | 55.57 | **19.29** | 1520 | 1.52 | 0.033 | 5.00 | 1.00 | 0.50 | 1.5 | 5.123 | 0.423 | **59.96** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **85.24** |
| C | **6** | | | | | #NUM! | **0.00** | 650 | 1.30 | 0.033 | 5.00 | 1.00 | 0.50 | 1.5 | 5.123 | 0.598 | **18.13** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **24.13** |
| D | **6** | 170 | 1.7 | 0.100 | 35.00 | 36.91 | **35.71** | 510 | 0.51 | 0.033 | 5.00 | 1.00 | 0.50 | 1.5 | 5.123 | 0.423 | **20.12** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **61.82** |
| E | **6** | 50 | 1.5 | 0.100 | 9.00 | 79.22 | **9.08** | 490 | 0.98 | 0.033 | 2.50 | 0.50 | 0.50 | 0.75 | 2.736 | 0.572 | **14.28** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **29.36** |
| F | **6** | 75 | 0.8 | 0.100 | 18.00 | 55.57 | **18.55** | 620 | 0.93 | 0.033 | 2.50 | 0.50 | 0.50 | 0.75 | 2.736 | 0.495 | **20.87** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **45.42** |
| G | **6** | 60 | 2.5 | 0.100 | 9.00 | 79.22 | **9.18** | 280 | 0.42 | 0.033 | 2.50 | 0.50 | 0.50 | 0.75 | 2.736 | 0.495 | **9.42** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **24.60** |
| H | **6** | 85 | 0.9 | 0.100 | 20.00 | 52.29 | **20.49** | 170 | 0.26 | 0.033 | 5.00 | 1.00 | 0.50 | 1.5 | 5.123 | 0.517 | **5.48** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **31.97** |
| I | **6** | 170 | 3.5 | 0.100 | 26.00 | 44.63 | **26.65** | 150 | 0.38 | 0.033 | 5.00 | 1.00 | 0.50 | 1.5 | 5.123 | 0.668 | **3.74** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **36.39** |
| J | **6** | 55 | 0.6 | 0.100 | 14.00 | 63.80 | **14.58** | 110 | 0.22 | 0.033 | 2.50 | 0.50 | 0.50 | 0.75 | 2.736 | 0.572 | **3.21** | | | | | 0.000 | 0.000 | #DIV/0! | **0.00** | **23.78** |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |

***Note: The conentraton time of the catchment is a combination of several methods as outlined below:***

*1) The initiation time is typically the duration from when the storm starts to when the runoff begins to move away; typically 6 minutes*
*2) The initiation time in an urban envirionment is the time taken for an allotmetns roof runoff to travel through the pipes to the street/easement drainage; typically 6 minutes*
*3) The overland flow time is used to calculate TC for a large homogeneous areas, prior to the development of an overland flow channel*
*4) The trial $T_O$ within the kinematic wave equation must be changed until it approximately matches the Calculated $T_O$, alternatively use goal seek*
*4a) The Horton roughness factor, google search for typical results. N* of 0.25 has been used for forrested areas in this instance*
*5) Channel Flow uses a generalised profile to estimate flow velocity and travel time within open drainage at full flowing capacity*
*6) Pipe flow uses an assumed outfall pipe size to estimate flow velocity and travel time within the urban underground drainage network at full flowing capacity*

| ***Surface Type*** | ***Horton n* Roughnss Coefficient*** |
|---|---|
| Concrete / Asphalt | 0.010- 0.013 |
| Bare Sand | 0.010 - 0.016 |
| Gravelled Surface | 0.012 - 0.033 |
| Bare Clay - Loam Soil | 0.053 - 0.130 |
| Sparse Vegetation - Minor Leaf litter | 0.100 - 0.200 |
| Lawns | 0.170 - 0.480 |

**Source: QUDM - Third Edition 2013*

# *CATCHMENT FLOW CALCULATIONS*
## *RATIONAL METHOD*

| | | | |
|---|---|---|---|
| ***Date:*** | 26/10/20 | | |
| ***Project:*** | Parklea, Nagambie | ***Address:*** | 21 Lobbs Ln, Nagambie |
| ***Job Number:*** | 12566 | ***Prepared By:*** | JB |

***Description:*** Catchment Flow Calclation Summary for Proposed Development

**Minor Design Storm** 20 % **Major Design Storm** 1 %

**Pre Development Catchment Flows:**

| **Overall Catchments:** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Area* | *C-Value* | *CA* | $T_c$ | $I_{minor}$ | $I_{major}$ | $Q_{minor}$ | $Q_{major}$ |
| | *ha* | | *ha* | *min* | *mm/hr* | *mm/hr* | *m³/s* | *m³/s* |
| ***CMT Ex A*** | 11.000 | 0.270 | 2.970 | 97.1 | 18.2 | 35.2 | **0.150** | **0.290** |
| ***CMT Ex B*** | 47.200 | 0.270 | 12.744 | 282.8 | 8.4 | 15.6 | **0.298** | **0.553** |
| ***CMT Ex C*** | 25.800 | 0.270 | 6.966 | 278.7 | 8.5 | 15.8 | **0.165** | **0.305** |
| ***CMT Ex D*** | 41.100 | 0.270 | 11.097 | 157.6 | 12.8 | 24.2 | **0.395** | **0.747** |
| ***CMT Ex E*** | 10.700 | 0.270 | 2.889 | 42.5 | 32.4 | 65.1 | **0.260** | **0.523** |
| ***CMT Ex F*** | 4.430 | 0.270 | 1.196 | 21.1 | 50.7 | 103.5 | **0.168** | **0.344** |

**Post Development Catchment Flows:**

| **Overall Catchments:** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Area* | *C-Value* | *CA* | $T_c$ | $I_{minor}$ | $I_{major}$ | $Q_{minor}$ | $Q_{major}$ |
| | *ha* | | *ha* | *min* | *mm/hr* | *mm/hr* | *m³/s* | *m³/s* |
| ***CMT A*** | 5.055 | 0.400 | 2.022 | 45.1 | 31.2 | 62.5 | **0.175** | **0.351** |
| ***CMT B*** | 61.000 | 0.400 | 24.400 | 85.2 | 20.0 | 38.9 | **1.353** | **2.634** |
| ***CMT C*** | 20.500 | 0.400 | 8.200 | 24.1 | 46.7 | 95.3 | **1.065** | **2.170** |
| ***CMT D*** | 9.080 | 0.350 | 3.178 | 61.8 | 25.1 | 49.6 | **0.221** | **0.437** |
| ***CMT E*** | 8.059 | 0.300 | 2.418 | 29.4 | 41.3 | 84.0 | **0.278** | **0.564** |
| ***CMT F*** | 6.130 | 0.450 | 2.759 | 45.4 | 31.0 | 62.1 | **0.238** | **0.476** |
| ***CMT G*** | 2.677 | 0.450 | 1.205 | 24.6 | 46.2 | 94.1 | **0.155** | **0.315** |
| ***CMT H*** | 3.320 | 0.400 | 1.328 | 32.0 | 39.2 | 79.3 | **0.144** | **0.293** |
| ***CMT I*** | 3.433 | 0.350 | 1.202 | 36.4 | 36.0 | 72.6 | **0.120** | **0.242** |
| ***CMT J*** | 0.800 | 0.450 | 0.360 | 23.8 | 47.2 | 96.1 | **0.047** | **0.096** |

# *CHANNEL FLOW CALCULATIONS*
## *MANNING'S FLOW CALCULATIONS*

| | | | |
|---|---|---|---|
| ***Date:*** | 31/07/20 | | |
| ***Project:*** | Parklea, Nagambie | ***Address:*** | 21 Lobbs Ln, Nagambie |
| ***Job Number:*** | 12566 | ***Prepared By:*** | JB |

***Description:*** Catchment B Channel Flow Calclation for through RES

### ***PART 1 - Catchment Flows***

| | | |
|---|---|---|
| $Q_{RUNOFF}$ | 2.650 | *m3/s* |

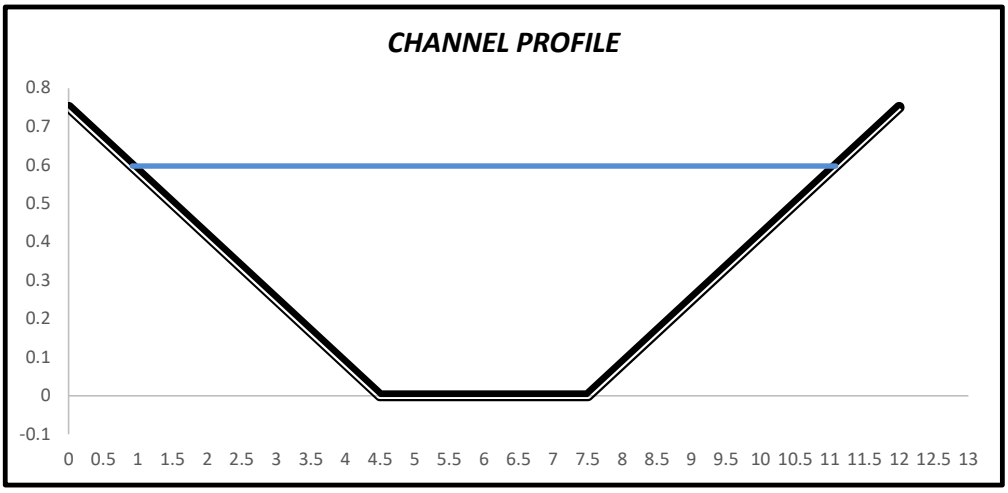
### ***PART 2 - Mannings Flow Calculations***

***Full Flow Capacity:***

| | | |
|---|---|---|
| Mannings "n" | 0.035 | |
| $S_o$ | 0.002 | *m/m* |
| Top Width | 12 | *m* |
| Base Width | 3 | *m* |
| Channel Depth | 0.75 | *m* |
| Batter Slopes | 6.00 | *m/m* |
| $CSA_{CHANNEL}$ | 5.625 | *m²* |
| $Perimeter_{CHANNEL}$ | 12.124 | *m* |
| $V_{MAX}$ | 0.77 | *m/s* |
| $Q_{MAX}$ | 4.31 | *m3/s* |

***Part Flow Calculations:***

| | | |
|---|---|---|
| $CSA_{WATER}$ | 3.932 | *m²* |
| $Perimeter_{WATER}$ | 10.27 | *m* |
| $V_{PARTIAL}$ | 0.67 | *m/s* |
| $Q_{PARTIAL}$ | 2.650 | *m³/s* |
| Depth of Water | 0.597 | *m* |
| Freeboard | 0.153 | *m* |
| Capacity | 0.62 | *%* |



# *CHANNEL FLOW CALCULATIONS*
## *MANNING'S FLOW CALCULATIONS*

| | | | |
|---|---|---|---|
| ***Date:*** | 31/07/20 | | |
| ***Project:*** | Parklea, Nagambie | ***Address:*** | 21 Lobbs Ln, Nagambie |
| ***Job Number:*** | 12566 | ***Prepared By:*** | JB |

***Description:*** Channel Flow Calclation for Existing floodway channel at the Southern end

### ***PART 1 - Catchment Flows***

| | | |
|---|---|---|
| $Q_{RUNOFF}$ | 15.684 | *m3/s* |

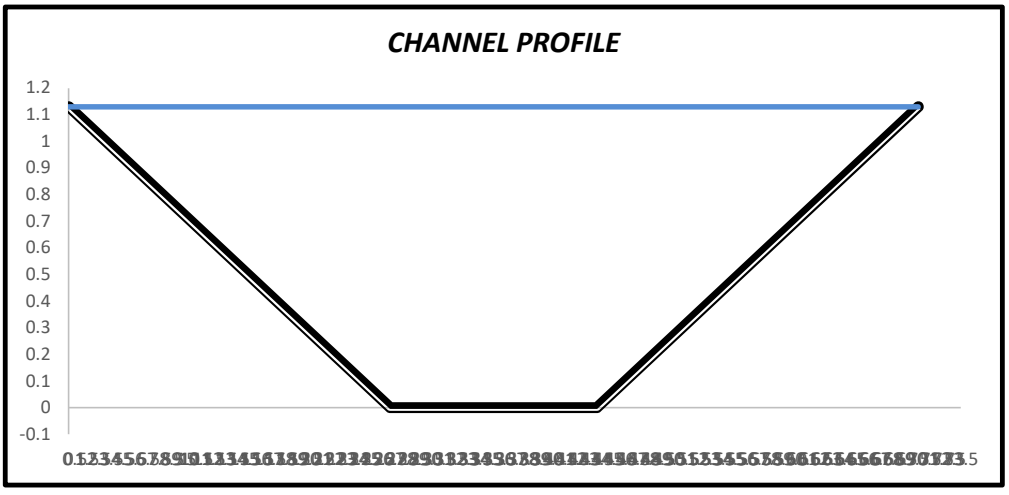
### ***PART 2 - Mannings Flow Calculations***

#### ***Full Flow Capacity:***

| | | |
|---|---|---|
| Mannings "n" | 0.035 | |
| $S_o$ | 0.0002 | *m/m* |
| Top Width | 70 | *m* |
| Base Width | 17 | *m* |
| Channel Depth | 1.13 | *m* |
| Batter Slopes | 23.45 | *m/m* |
| $CSA_{CHANNEL}$ | 49.155 | *m²* |
| $Perimeter_{CHANNEL}$ | 70.048 | *m* |
| $V_{MAX}$ | 0.32 | *m/s* |
| $Q_{MAX}$ | 15.68 | *m3/s* |

#### ***Part Flow Calculations:***

| | | |
|---|---|---|
| $CSA_{WATER}$ | 49.155 | *m²* |
| $Perimeter_{WATER}$ | 70.05 | *m* |
| $V_{PARTIAL}$ | 0.32 | *m/s* |
| $Q_{PARTIAL}$ | 15.684 | *m³/s* |
| Depth of Water | 1.130 | *m* |
| Freeboard | 0.000 | *m* |
| Capacity | 1.00 | *%* |



# *CULVERT DESIGN CALCULATIONS*
## *INLET AND OUTLET CONTROL CHECKS*

| | | | |
|---|---|---|---|
| ***Date:*** | 31/07/20 | | |
| ***Project:*** | Parklea, Nagambie | ***Address:*** | 21 Lobbs Ln, Nagambie |
| ***Job Number:*** | 12566 | ***Prepared By:*** | JB |

***Description:*** Culvert flow analysis for Southern Crossing

### ***Site Conditions:***

***Design Flows:***

| | | |
|---|---|---|
| *Design AEP* | 1 | % |
| $Q_{CULVERT}$ | 15.7 | $m^3/s$ |
| *Embankment Top RL* | 127.05 | m |
| *Design Freeboard* | 0.45 | m |
| *Tail Water Level* $_{DS}$ | 126.6 | m |

***Culvert Setout:***

| | | |
|---|---|---|
| *Culvert Length* | 42 | m |
| *U.S. Invert RL* | 125.45 | m |
| *D.S. Invert RL* | 125.4416 | m |
| *Culvert Grade* | 0.02 | % |

---

### ***Box Culvert:***

| | | |
|---|---|---|
| *Width* | 3.6 | m |
| *Height* | 1.2 | m |
| *No. Culverts* | 4 | |

| | | |
|---|---|---|
| $CSA_{BOX}$ | 4.320 | $m^2$ |
| *P* | 9.60 | $m^2$ |
| *R* | 0.45 | $m^2$ |

***Inlet Control Check of Head Water Level:***

| | | |
|---|---|---|
| $C_D$ | 0.6 | |

***Outlet Control Check of Head Water Level:***

| | | |
|---|---|---|
| $k_{entry}$ | 0.5 | |
| $k_{exit}$ | 1 | |
| *n* | 0.013 | |
| $V_{AEP}$ | 0.91 | m/s |
| $S_f$ | 0.000 | m |
| *Head Loss* | 0.08 | m |

| | | |
|---|---|---|
| *HWL* | **125.57** | m |

| | | |
|---|---|---|
| *HWL* | **126.68** | m |

Freeboard 0.37 m

Culvert is Outlet Controlled