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STORMWATER MANAGEMENT SOLUTIONS

STORMWATER MANAGEMENT PLAN

Hutsons/Burma Road, Tocumwal

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Document History

Version	Date	Description
01	06/09/23	Initial Version
02	09/10/23	Minor Updates
03	05/11/24	Updated Urban Design
04	03/03/2025	Updated with Council Comments

Climate Change Statement

A wide range of sources, including but not limited to the IPCC, CSIRO and BoM, unanimously agree that the global climate is changing. Unless otherwise stated, the information provided in this report does not take into consideration the varying nature of climate change and its consequences on our current engineering practices. The results presented may be significantly underestimated; flood characteristics shown (e.g. flood depths, extents and hazards) may be different once climate change is taken into account.

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Contents

Tables

Figures

1. Introduction

Afflux Consulting have been engaged by MHE Development Tocumwal P/L to complete a stormwater management plan for the proposed development at Hutsons/Burma Road, Tocumwal (Figure 1). This report will cover the minor drainage, flooding and water quality associated with the development. It will include an assessment of associated stormwater drainage assets, regional overland flow paths, creek systems and stormwater conditions within neighbouring properties. The intention of this report is to:

- Provide an assessment of major drainage and flooding associated with site.
- Ensure flooding of the site, or potential off-site impacts are reduced or eliminated.
- Ensure safe conveyance of existing overland flow regimes.
- Meet the EPA best practice environmental management (BPEM) water quality requirements.
- Inclusion and consideration of guidelines and advice for stormwater management in line with Berrigan Shire Council requirements; and
- Identification of mitigation and treatment options.

To meet these requirements a range of hydrological, hydraulic and water quality modelling has been undertaken.

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0 100 200 300 m

Hutsons Rd Tocumwal
Map: Site Aerial View

Figure 1. Aerial of site

Figure 2. Proposed Development Plan

1.1. Information Sources

A number of information sources have been used in the formation of this strategy; these include:

- Site inspections
- Aerial imagery
- Design Guidelines and Guidelines for Development
- Various Environmental Planning instruments and Planning Frameworks
- Preliminary plans and Site survey received from client.
- Past models and existing infrastructure information
- Historic flood and water quality studies
- Topographic information including required LiDAR data sourced commercially.
- Meetings with Berrigan Shire Council (BSC)

2. Existing Catchment

The existing catchment has been delineated as the relevant catchment for flows through the site and site outlet. The broader catchment drains east towards the retarding basin and consists primarily of existing developed land. The subject site is approximately 21 Ha with an approximate slope of 1% towards the south. The site currently contains grassland with a more densely vegetated tree reserve located to the south of site.

2.1. Site Visit

Investigation into the best discharge configuration to meet water management requirements will be undertaken in this report. A number of photos of the existing site can be seen in Figure 3 below.

Figure 3. Site visit Southern Boundary

Figure 4. Existing ponding area

Figure 5. Culverts under Burma Crt

Figure 6. Crn Babingtons Looking SW

3. Catchment Design Objectives

All development has the potential to adversely affect downstream environments through the effects of stormwater runoff. Increased impervious areas resulting in increased volumetric and peak flows have been extensively researched and linked to downstream environmental degradation. Contaminants in the runoff have also been linked with adverse changes to water quality and stream ecology. The contribution of increased runoff can be linked to downstream flooding and capacity constraints.

To combat these effects, a range of hydrological and water quality mitigation measures have been researched and legislated. The design objectives for this catchment are considered below.

3.1. General Considerations

The NSW EPA *Managing Urban Stormwater: Council Handbook (1997)*, describes the need to create a stormwater management plan as:

> Stormwater management plans are needed to:
> - minimise future impacts on the stormwater environment
> - provide a framework for mitigating existing impacts on the stormwater environment.
>
> Changes to the water environment that can occur due to urbanisation include:
> - increased runoff volumes and peak flow rates
> - elevated pollutant concentrations and loadings
> - increased channel erosion and sedimentation
> - removal of riparian and foreshore vegetation (and possible replacement with exotic species)
> - degradation of aquatic habitats
> - installation of barriers (eg culverts, weirs)

Accordingly, the general objectives should be to minimise future impacts (as listed) and provide a framework for the integration of mitigation measures within the development plan.

3.2. Water Quality Requirements

Current water quality guidelines require developers to ensure that water quality for the site meets best practice load-based reduction targets when compared with the unmitigated developed scenario. As listed by NSW EPA *Managing Urban Stormwater: Council Handbook*, the following Treatment objectives are recommended.

Table 8.1 – Potential Stormwater Treatment Objectives

Pollutant:	Goal/Vision:	ESD Treatment Objective:
Post construction phase:		
Suspended solids (SS)	Suspended solids loads equal to that which would have been exported from the equivalent forested catchment	80% retention of the average annual load**
Total phosphorus (TP)	The load of phosphorus from the catchment that results in the attainment of the ambient water quality concentration objective	45% retention of the average annual load**
Total nitrogen (TN)	The load of nitrogen from the catchment that results in the attainment of the ambient water quality concentration objective	45% retention of the average annual load**
Litter	No anthropogenic litter in waterbodies. Input of organic litter equal to that which would have occurred from the equivalent forested catchment	Retention of litter greater than 50 mm for flows up to 25% of the 1 year ARI peak flow
Coarse sediment	Coarse sediment loads equal to those which would have been exported from the equivalent forested catchment	Retention of sediment coarser than 0.125 mm* for flows up to 25% of the 1 year ARI peak flow
Oil and grease (hydrocarbons)	No visible oil and grease (anthropogenic hydrocarbons) in waterbodies	In areas with concentrated hydrocarbon deposition, no visible oils for flows up to 25% of the 1 year ARI peak flow
Construction phase:		
Suspended solids	Suspended solids loads equal to those which would have been exported from the equivalent forested catchment	Maximum SS concentration of 50 mg/L for all 5 day rainfalls up to the 75th percentile depth. All practical measures to reduce pollution are to be taken beyond this event.
Other pollutants	No export of toxicants (eg pesticides, petroleum products, construction chemicals) from the site	Limit the application, generation and migration of toxic substances to the maximum extent practicable

* based on idealised settling characteristics
** a design storm of 25% of the 1 year ARI flow is to be adopted for the design of certain elements of some stormwater treatment measures which can be used to meet this objective

3.3. Flood Protection Requirements

Freeboard is incorporated to provide additional flood protection above the designed water surface elevation. Typically used to provide a factor of safety for the finished floor levels and indicates the minimal fill/floor level in developments that are in the vicinity of overland flow paths, open waterways, and floodplains.

Typically freeboard levels are set as 0.5m above the nominated flood level in NSW.

3.4. Ecological Objectives

This site eventually discharges into the creek located south of the site. Protecting downstream environs by providing water quality and quantity control devices is an important aspect of this site's development. The proposed development should be developed in such a way as to minimise its impact on the surrounding environment and improve ecological values where reasonably practicable.

Vegetation and vulnerable species are impacted by activities related to development. Elimination and mitigation of these impacts are an important consideration in this process. Vulnerable species may be impacted by the following activities:

- Changes to ground water drainage patterns or stream channels which affect the water table (e.g., dam construction, stream diversion).
- Clearing of riparian vegetation, changing hydrology, and causing drying out of sites.
- General road and drainage activities impacting on seepage, wetland and stream bank habitat and any activities that may degrade stream bank integrity, increase siltation, and enhance erosion.
- Soil disturbance and compaction due to vehicles, stock trampling and inhibit burrow formation. Compaction also impairs soil permeability and water holding capacity.

- Water contamination, especially through application of chemical sprays, pesticides, excess nutrients, or toxic leaching; and
- Drainage of swamps and conversion to pasture.

Ecological survey is not within the scope of this project however discussion with the ecological consultants have been undertaken in consideration of the site treatment options.

3.5. Council Objectives

Berrigan Shire Developments Contributions Plan (2017), was formed to apply drainage objectives at a regional level. The plan specifies the Riley Court area as a specific zone of application. The zone and contributions can be seen in Figure 8, with the objectives stated in Figure 7.

1.2 Where does this Plan apply?

This plan applies to all of the land within the boundaries of the Berrigan Shire.

1.3 How is this Plan related to other plans, policies and codes?

a) This Plan has been prepared pursuant to the provisions of s.94 of the Environmental Planning and Assessment Act and Part 4A of the Environmental Planning and Assessment Regulation and takes effect from 19 January 2005.

b) This Plan is the only Plan on which Council can:
   i) require an applicant to make a monetary contribution or land dedication; and/or
   ii) accept a material public benefit as a result of undertaking the development.

c) This Plan supersedes all other policies and codes relating to contributions of land or monetary amounts adopted by Council prior to 19 January 2005.

1.4 What is the purpose of the Plan?

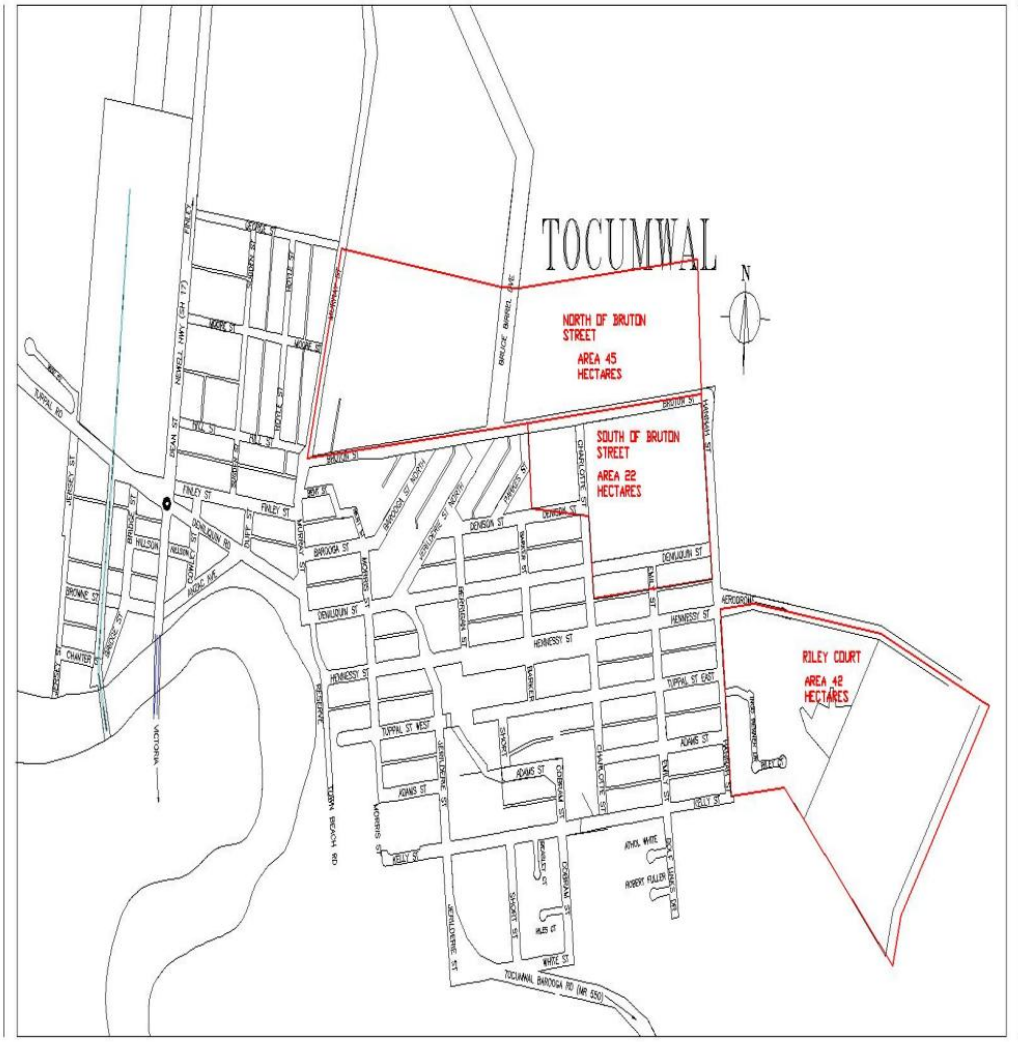
a) The aims and objectives of the Plan are to:
   i) enable the Council to require as a condition of development consent, a contribution(s) or dedication towards the provision of public facilities;

   ii) enable the Council to recoup funds which it has spent in the provision of public facilities in anticipation of development;

   iii) ensure that adequate public facilities are provided for and as part of any new development;

   iv) ensure that the existing community is not burdened by the provision of public facilities required as a result of future development;

Figure 7. BERRIGAN DEVELOPMENT CONTRIBUTIONS PLAN 2017



Catchment	Total Cost	Existing Tenements	Future Tenements	Total Tenements	Cost per Tenement
Wiruna Street	$37,800	35	80	115	$ 367
East Buchanans Road	Nil	23	107	130	Nil
Tocumwal					
North of Bruton Street	$372,834	110	236	346	$1,206
South of Bruton Street	$181,913	44	125	169	$1,204
Riley Court Area	$213,675	134	189	323	$ 740
Finley					
Finley Street	$198,429	38	54	92	$2,408
Burke Street	$128,898	33	21	54	$2,681
White Street Area	$142,758	35	65	100	$1,599

Source: BERRIGAN DEVELOPMENT CONTRIBUTIONS PLAN 2017

Figure 8. Contribution areas and rate

3.6. Specific Concerns for This Site

Based on the review of the catchment, and listed objectives and requirements the following stormwater elements should be considered for this site:

- Managing flood extents and ensuring no worsening conditions on adjacent properties
- Fill requirements and waterway offsets
- Existing drainage infrastructure capacity
- Water quality requirements for offsite discharge
- Surrounding existing development constraints
- Site topography and geomorphological interactions with drainage asset locations
- Interactions with regional waterway systems

3.7. Council Request For Further Information

BSC have requested further detail on a number of items in the SWMP. This Version 4 (V04) report provides further modelling and recommendations to meet the Councils concerns. Councils concerns are listed in Table 1 below. To complete this work the following additional tasks have been undertaken:

- Site meeting with Council and Tocumwal Golf Club- Endorsing strategy to deliver water to the golf club
- Site inspection and calculations regarding the existing basin at Haynes Court
- Additional modelling of pipe network at Haynes Court
- Additional Volume Calculations for water harvesting
- Recommendations and level updates for Haynes Court basin and interactions with the subdivision.
- Recommended basin overflow flow path modifications

Table 1. Council RFI requests

Issue	Council RFI	Response
Report issued	Clarification of which report forms part of the documentation. The submitted infrastructure and servicing report dated 23/9/24 (section 2.4 Stormwater Drainage), references a strategy from WaterTech. This has not been submitted however, a Stormwater Management Plan prepared by Afflux Consulting has submitted	We understand this has been resolved.
Basin size and location	An updated stormwater management plan, to reflect the submitted plans (including referencing the retention basin that is proposed to connect to the creek)	The retention basins are included in the SWMP. We provided 2 options (pg. 30) but recommended the second option (pg. 43) to minimise vegetation impact and provide water supply to the golf club. This has been updated with the information from the Golf Club including GC masterplan information and acceptance of additional water.
Flood Management	A Flood Study which references existing flooding issues and the proposed flood mitigation methods. Lots in the south-east are prone to flooding and for the Lots in the far southwest corner the study needs to acknowledge the stormwater system coming from Riley Court/Haynes Court.	Both local (Pg 23) and Regional (Pg 24) flood studies have been provided and floor levels recommended. A detailed examination of the flows from Riley Crt/Haynes Crt has been included in the hydrology section (pg. 13) to ensure this mechanism is captured. This includes updated modelling in this report and recommendations for works to ensure contemporary flood management of the basin on Haynes Court.
Detailed Design	Updates reports / plans to show (a) that the Lots fronting Hutsons Road will have kerb and channel installed to take water flow to Babington Road and (b) a pit on the corner of Hutsons Road and Burma Road.	We have given proposed flow paths and locations in the design figure on page 42 including recommendations for Haynes Crt to discharge. The development has agreed to pipe Babington Road Flows where possible. An estimated pipe size is detailed.

4. Hydrology

To evaluate the hydrology of the proposed development a number of hydrological models have been formed and compared. This method has been chosen to best represent hydraulic influences and hydrologic challenges in the area.

4.1. Sub-Catchment Delineation - Drains

Sub-catchments are grouped by examining the drainage asset locations and expected flow direction. Generally, the sub-catchment delineation for developed areas follows catchments of main drainage lines so that the pipe network is accurately modelled. These sub-catchments can collect flows from various zoning densities, from low impervious public park zones to high-density residential or highly impervious commercial areas. The imperviousness level adopted for most developed catchments ranges and is checked against aerial imaging. Catchment delineation for undeveloped areas is governed predominantly by topography. Therefore, impervious levels adopted are often lower.

Table 2. Sub-catchment characteristics

Catchment	Existing Catchment (ha)	Effective Impervious		Pervious	
		Area	Time of concentration	Area	Time of Concentration
1	3.46	75%	8.0	25%	12.7
2	3.23	75%	8.7	25%	12.4
3	1.26	75%	8.4	25%	8.7
4	2.06	75%	10.1	25%	10.4
5	1.39	75%	7.6	25%	9.0
6	3.52	75%	10.1	25%	12.8
7	3.22	75%	9.9	25%	12.4
8	0.97	75%	6.7	25%	7.8
9	6.93	60%	12.0	40%	16.5
10	6.5	60%	9.7	40%	16.1
11	3.95	60%	8.3	40%	13.4

Figure 9. Representation of sub catchment delineation for the DRAINS model

4.2. Hydrological Modelling - DRAINS

The site's 1% AEP flood discharge was estimated following ARR 2019 (Australian Rainfall and Runoff, 2019) processes. The rainfall excess was determined for each sub-catchment using the DRAINS Stormwater Drainage System design and analysis.

The ARR19 tool for DRAINS was used to process the information from the online ARR Data Hub. As such, the following inputs were adopted to process the results.

The Ensemble Event approach was adopted using a set of 10 temporal rainfall patterns from gauged local catchments. The run suite included the 20 min to 9-hour storm durations for each of the temporal patterns used to derive a set of hydrographs for each event AEP and critical duration. Each hydrograph was run through the hydrologic model; only the mean for the critical duration storm results was selected for design as recommended. The temporal rainfall patterns were taken from the ARR Data Hub as per guidelines, and as shown below, the “Southern Slopes - Mainland” data set was applicable for this site.

An Initial and continuing loss (IL-CL) model was created to maximise the rainfall on the site. Losses were applied based on the imperviousness of the catchment.

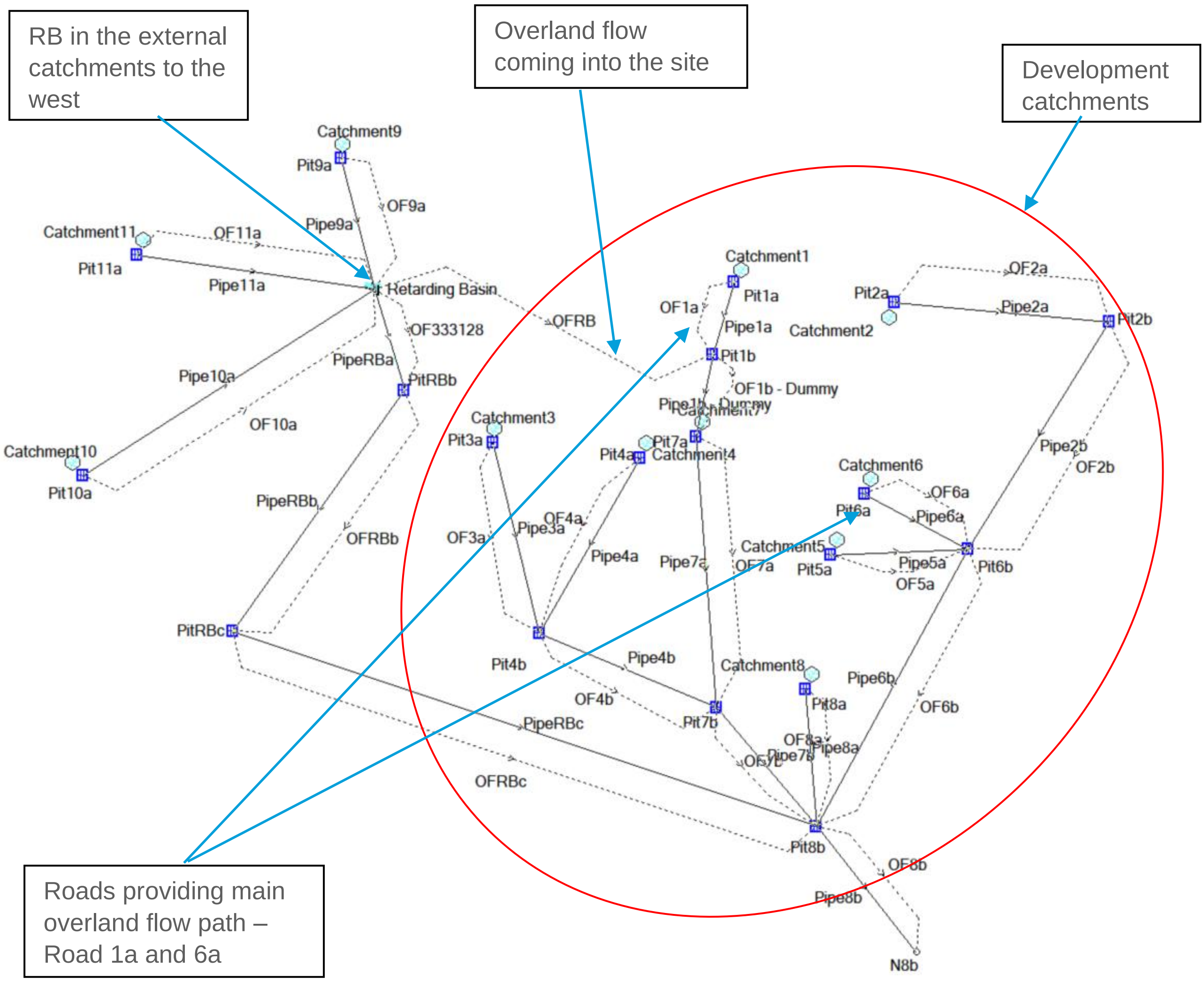


Figure 10. DRAINS Model Set up.

Table 3. Estimated loss model

Model Name	**HutsonsRdTocumwal.drn**
Region	Southern Slopes
Loss Model	Initial-Continuing Loss
Impervious Losses	IL: 1 mm CL: 0 mm/h
Pervious Losses	IL: 24 mm CL: 1.8 mm/h
ARR Data Hub Location	S E (accessed 03/08/23)

As there is no gauge information in the local region for a catchment of this small size, flow estimates have relied on literature and modelling estimation methods. The catchment is too small for most estimation methods, such as the ARR RFFE method and Vont Steen equations, which are calibrated to catchments of at least 1 km².

4.3. Site Flow Results - Drains

Flow estimates for the 1% AEP were derived; the results provided flows for various storm events and durations. The results for 1% and 20% AEP are shown in Figure 11 and Figure 12 respectively.

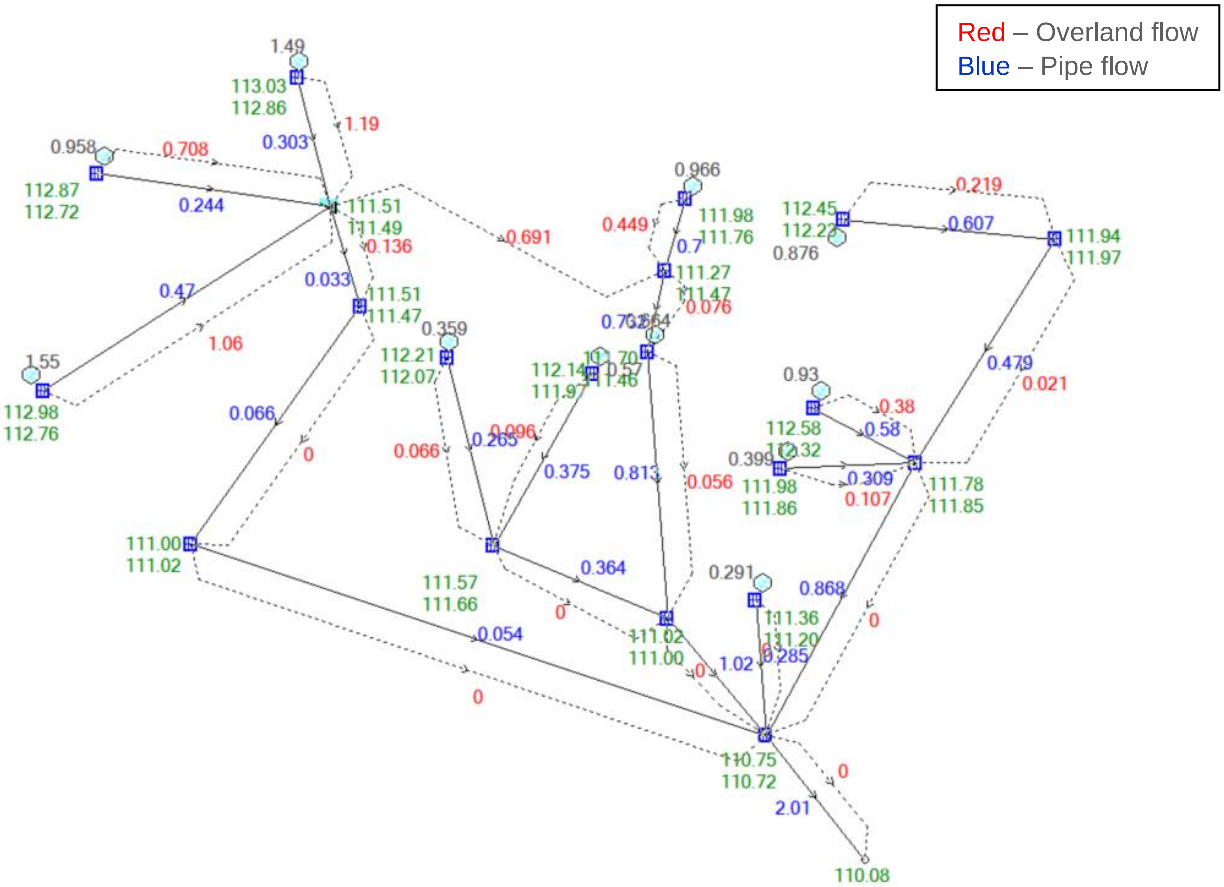


Figure 11. 1% AEP Storm Event Flows on DRAINS model

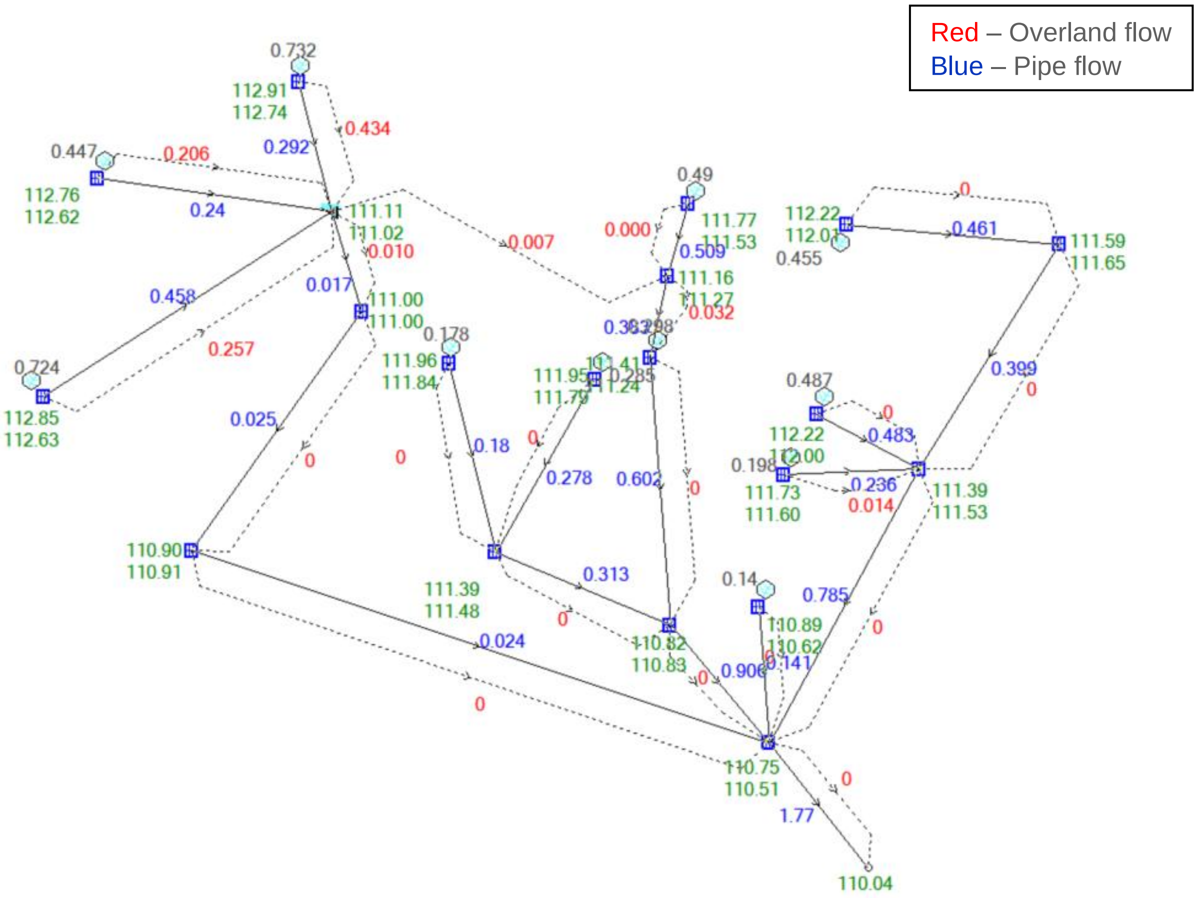


Figure 12. 20% AEP Storm Event Flows on DRAINS model

Key outcomes

- 0.69 m³/s and 0.01 m³/s of flow enters the site from the west retarding basin in 1% and 20% AEP, respectively if the DN300 pipe is operating fully.
- Along the roads 1a and 6a have total flows of 0.45 m³/s and 0.38 m³/s in 1% AEP, respectively and 0m³/s in 20% AEP, respectively.

The flow at a number of key locations have been tabulated to assist with the subdivision design. These include key overland flow paths, and any discharge from the adjacent subdivision. These flows can be seen in Table 4.

Table 4. Discharge through specific locations on site

Location	Pipe/Overflow path	1% AEP Flow (m^3/s)	20% AEP Flow (m^3/s)
Retarding Basin overflow path*	OFRB	0.691	0.007
Road	OF1a, Pipe1a	1.149	0.509
Road	OF6a, Pipe6a	0.960	0.483
Road	OF7a, Pipe7a	0.869	0.602

* If outfall pipe is operating fully

4.4. Haynes *Court* Basin Flows

The Haynes Court RB (and subsequent bubbling of flows in Riley Court) have been investigated for this updated report. The pipe arrangement for the basin can be seen in Figure 13 below. As can be seen the outfall to the system is a DN300mm pipe, running through the development parcel. On inspection this pipe and outlet are fully blocked and require pipe jetting (Figure 14). As per Table 4, the design outflow of the basin is ~25L/s.

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Figure 13. Basin Location and Pipe outlets

The basin levels and outfalls are shown below (Figure 14, Figure 15). A new dwelling has been constructed at 14 Riley Court, and reportedly there have been concerns from its occupants around the flooding of the basin. As can be seen in Figure 16, it is likely that the floor level is set around 110.9-111.1m AHD. This is at, or below the average level of the overflow weir from the basin. This situation clearly is not sustainable, and regardless of the historical reasons needs to be rectified.

Basin Outfall Examination

Figure 14. Outlet Pipe Inlet and Outlet (February 21st 2025)

Figure 15. Basin Weir Outfall LiDAR Levels

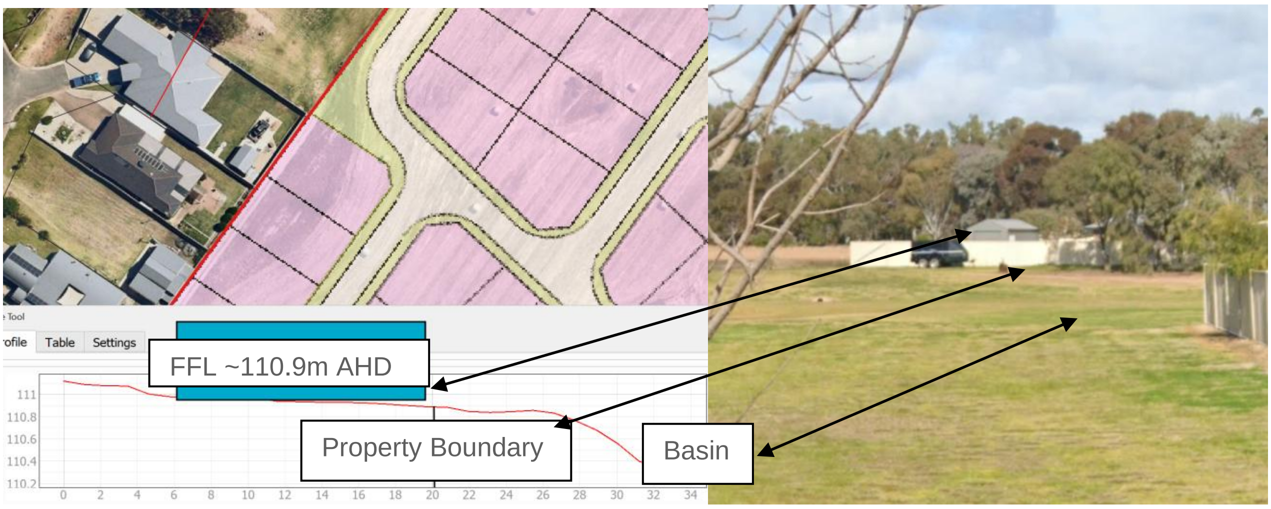
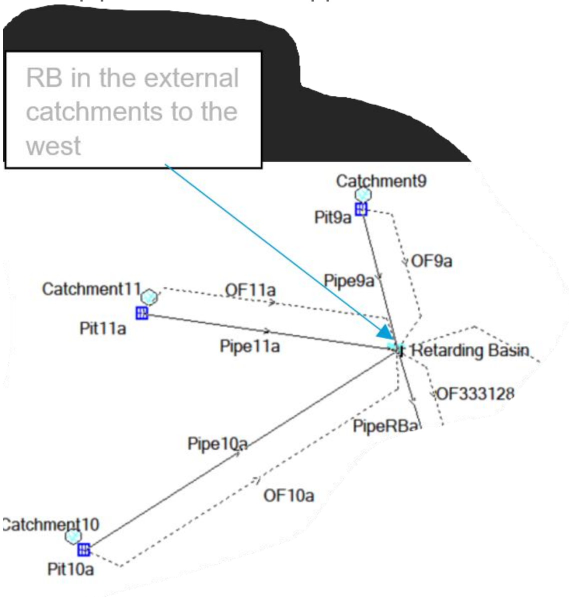


Figure 16. Estimated New Building Floor Level

Outfall pipe Testing

To test the possible outcomes for the basin a number of model tests have been performed.

Firstly, a cross check of the incoming pipe network was performed. As can be seen in Figure 17, the existing inflow pipes to the basin appear to be smaller than contemporary drainage design would suggest.



Location	Catch	20% Flow (Drains)	No. Pipes	Grade (assumed)	n	Pipe Dia (mm) (Survey)	V (m/s)	Current Pipe Capacity (m^3/s)	Pipe Dia (mm) (Required)	V (m/s)	Required Pipe Capacity (m^3/s)
North	C9	0.732	1	0.3%	0.013	525	1.09	0.236	825	1.47	0.786
Centre	C11	0.447	1	0.3%	0.013	375	0.87	0.096	675	1.29	0.460
South	C10	0.724	1	0.2%	0.013	600	0.97	0.275	900	1.27	0.810

Figure 17. Inflow Pipes and Cross Check Calculations

Secondly a calculation on a permissible discharge from the adjacent subdivision was checked. For a rural 17Ha catchment, a flow of ~1.3m³/s could be expected. This is clearly much larger than the ~0.025m³/s flow that is possible in the existing DN300 outfall.

Mannings calcs suggest that the outlet should be ~1050mm to cater for 1.3m³/s, but given the flat grades, this would require twin 750mm or more to meet the flow requirement. We have tested upgrading the outfall to 525mm, but found no real change in flood level in the basin. The 20% AEP was checked with the 525mm outfall as per Figure 18.

Given this result, it is concluded that significant outfall pipe upgrades as part of the development would NOT result in significantly better flood outcomes.

Figure 18. 20% AEP with 525mm Outfall (note Basin level of ~110.9mAHD)

Recommended Basin intervention

Given that pipe upgrades are largely ineffectual in reducing the flood risk, it is recommended that an improved overland outflow from the basin is considered. The road through the subdivision has been checked for outflow, and found that it can convey well over 1m³/s (Figure 48). To facilitate additional flood safety it is suggested that either the park area, or either of the basin connecting roads be cut down to a maximum level of 110.9m AHD to ensure that the basin level is always below the floor level of the building at 14 Riley Court.

The exact detail of this can be completed as part of the detailed engineering design, and could be facilitated through a planning permit clause such as “Provide an overland flow path through the subdivision with a maximum level of 110.9m AHD at the basin interface”.

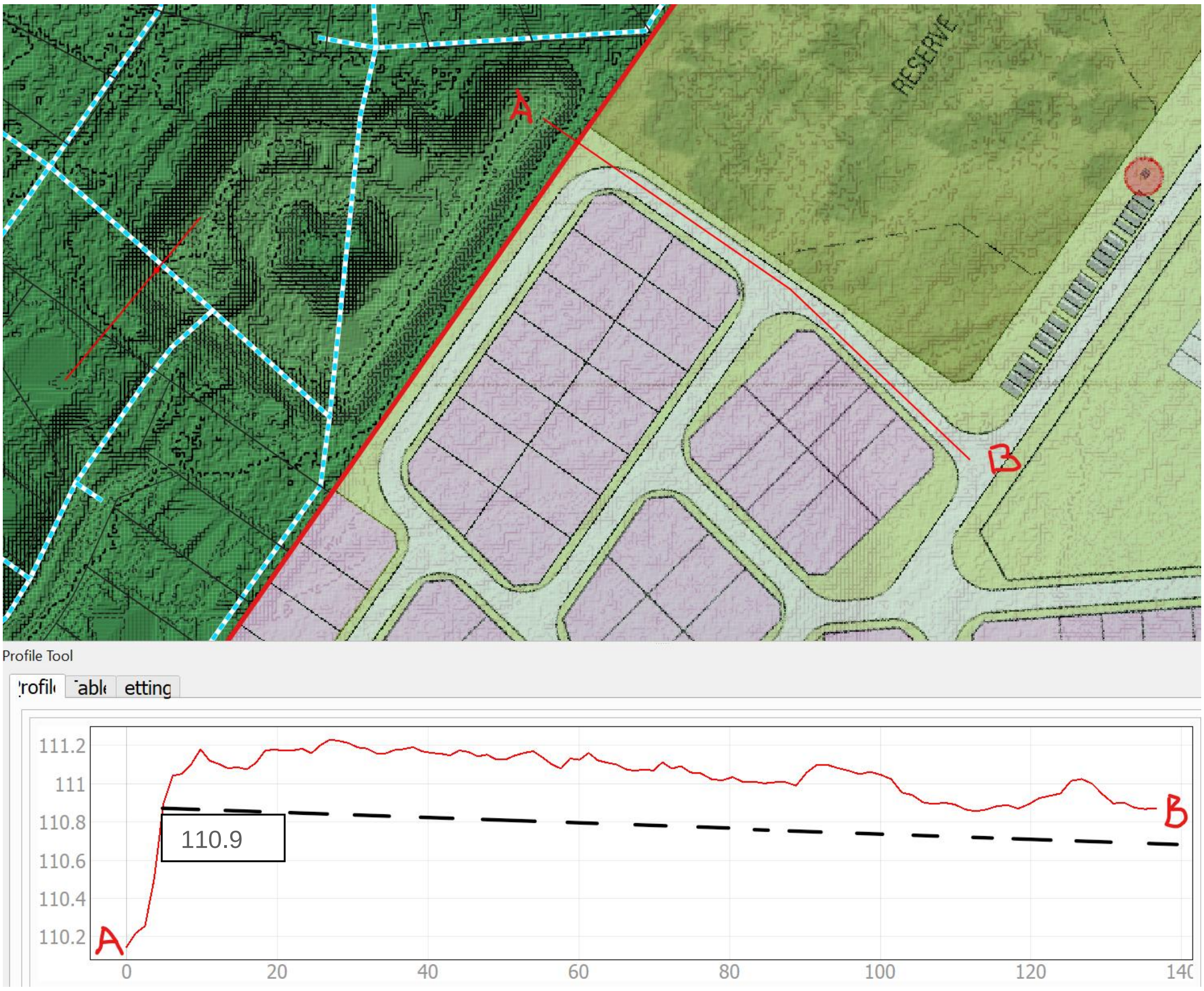


Figure 19. Recommended Outfall Overland Flow Path

5. Flood Modelling

As part of flooding investigations for the site, the regional and local stormwater conditions were considered. The major influencing factors include the impact of flooding from rainfall on the immediate catchment as well as interactions with greater regional flows and relevant upstream events. The main considerations include the availability of floodplain storage, safe overland flow conveyance, water surface levels in relation to proposed developed floor levels and any changing impacts to neighbouring properties.

Once the estimated rainfall magnitudes were decided upon (discussed within Hydrology section), a high-definition model was constructed to understand flood mechanisms during a 1% AEP storm event. The model was built and run in TUFLOW using a linked 1d/2d approach, parameters, and data sources.

5.1. Historical Flooding and Regional Context

The Berrigan Shire Local flood plan (2009) establishes the management of flood response for the region, and Tocumwal in particular. Tocumwal has been subject to major flooding in the 1950's, 1970's and more recently. The flood extent of the 1956 event from the Local Flood Plan can be seen in 0. The township is protected from extreme flood levels (Figure 21) by a township levee set at 112.5 mAHD, a level set 1.2 m above the estimated 1% AEP flood.

The following points can be made about this regional flooding:

- The site is protected by the township levee at 112.5 mAHD
- The maximum regional flood level (for development purposes) is around 111.89 mAHD
- The site is generally above 111.8 mAHD

Given these points the regional flooding mechanisms are not seen as the dominant flood risk for the site. As such a number of local flood mechanisms have been further investigated.

MAP 3 - COUNCIL AREA SHOWING 1956 FLOOD EXTENT

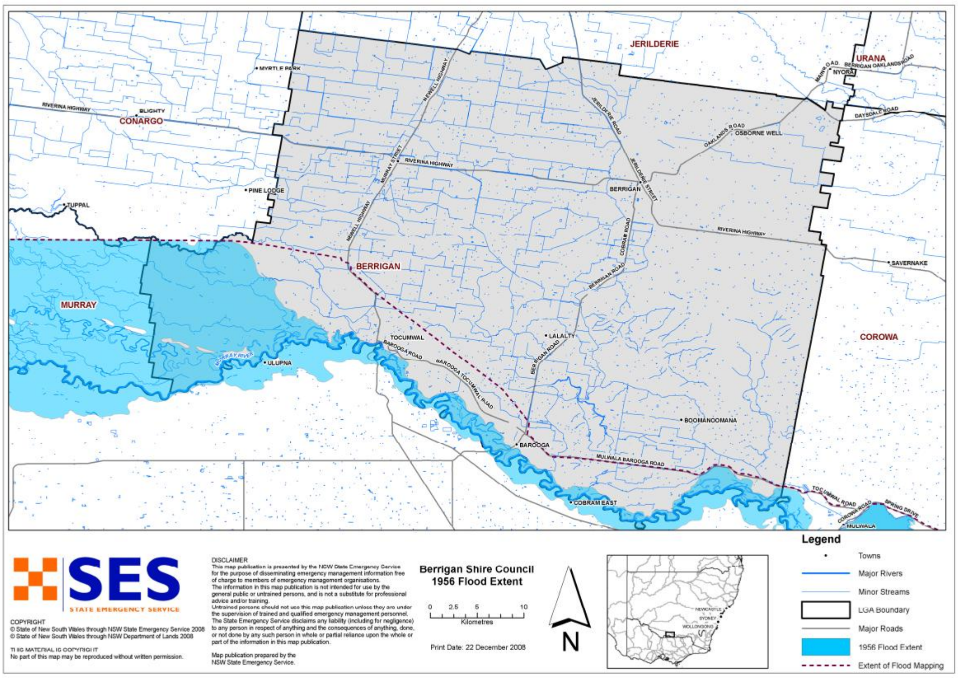


Figure 20. Tocumwal Regional Flood map

Extreme Flooding

55. The worst floods recorded at the Tocumwal gauge since European settlement should not be considered to be the most serious that will ever occur. The 1%AEP (or one chance in 100 years event) at Tocumwal is estimated to be 8.14 metres (RL 111.89m). The flood of record in 1870 (7.55m), peaked at 0.5m below the estimated 1%AEP flood height and 0.11 metres below the 2% AEP (one chance in 50 years event), estimated to be 7.66m. The most recent major flood recorded on the Tocumwal gauge on 7 October 1993 reached a peak of only 7.37 metres, well short of even the 2%AEP (7.66m).

Figure 21. Extreme flood Levels

MAP 5 - TOCUMWAL LEVEES

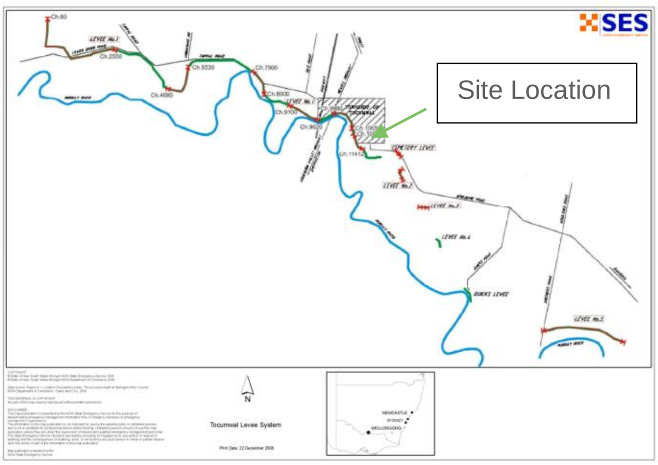


Figure 22. Tocumwal Flood Levees (112.51m AHD)

5.2. Topographic Data

The LiDAR data supplied by A Division of Department of finance, Services and Innovation was used as the base information to generate the Digital Elevation Models (DEM), informing surface elevations required for the model. Figure 23 shows the data over the catchment area for the site. LiDAR survey information is shown in Table 5.

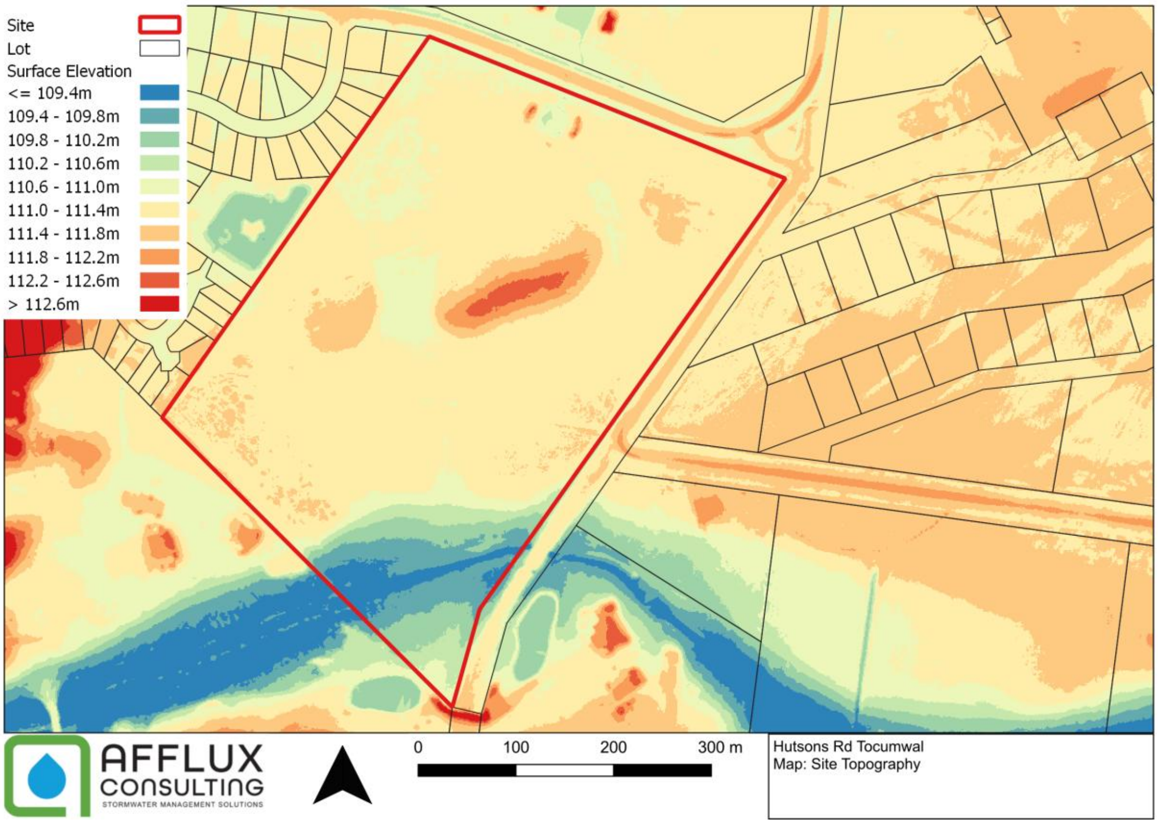


Figure 23. Site topography

Table 5. LiDAR survey metadata

LiDAR survey metadata	Data
Acquisition Date	April 2012
Horizontal datum	GDA 94
Vertical datum	AHD
Map projection	MGA zone 55
Horizontal accuracy	+/- 80 cm
Vertical Accuracy	+/- 30 cm

5.3. Model Parameters

The initial model setup for the catchment model involved accessing survey surface levels and a setup of existing drainage networks for the model area. Model extent is based on topographical catchment boundaries. Land use in the model has been determined based on inspection of aerial imagery and visual inspection and has been used to inform Manning's roughness factors in the model. Downstream boundary conditions have been established based on an examination of topography. This has been set a considerable distance downstream of the proposed assets to ensure no undue model boundary influence. Parameters for the model area are included in the Table 6 below.

Table 6. Model parameter table output from model QA

Model Parameter/ output		
Grid Cell Size	3 m	High-resolution model to characterise flow across land.
Time Step	1 min	HPC variable time
Model Run Duration	2 hours	Allows sufficient time for peak flows to pass through the site
Model Solver	HPC/GPU	
Manning's Roughness	Figure 24	Manning's Roughness applied to cells not covered by materials layer set to a value of 0.02
Inflow	2d_rf 2d_sa	Rainfall layers were used
Outflow Boundaries (2D)	HQ	Slope boundary with a grade of 0.1% At several locations where water leaves the catchment
Model stability		Checked and meets all the HPC model stability criteria

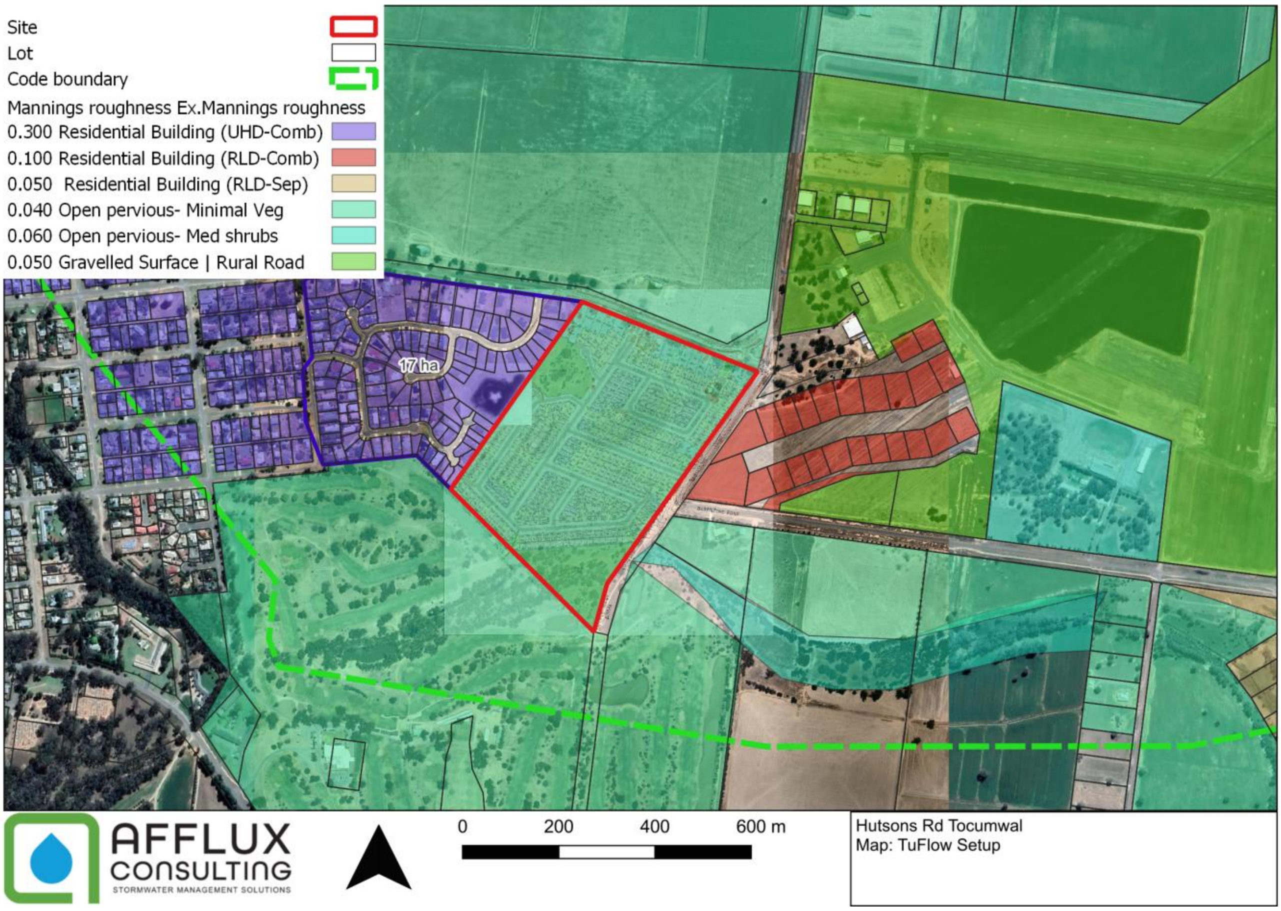


Figure 24. Model parameters and setup

5.4. Model Reporting and Analysis

The model has been set up to report the following key indicators:

- Maximum water depths for each model grid cell.
- Maximum water depths at defined reporting cross sections immediately onto and off the site.
- 2D Time-Series Plot Output (PO) and Map Output data at various locations across 1D and 2D network.

Analysis of results will show WSE, and water depth based on flood conditions and will be used to establish flood extents on the property. The 2D Time-Series Plot Output (PO) data provide Flow-Time hydrographs at user-defined locations. Additionally, the 1d connections report Flow-Time hydrographs for assessment and validation of underground drainage network systems.

Water Level Difference maps will be provided to show afflux changes between existing and developed conditions. Additional maps will be produced to provide an assessment of the proposed development against safety criteria. Based on the assessment of these results, recommendations for floor levels, site access, and treatments will be made.

5.5. Ensemble Flood Assessment

The impact of flooding from rainfall on the relevant local catchment was assessed using a whole catchment model. To select the design storm, the Tuflow solver was used to run all 10 temporal patterns (Figure 25) across a selection of storm durations (Figure 26) for the 1% AEP. Utilising the Tuflow post-run processing utilities, in line with the ARR19 recommendations, the peak median temporal pattern and critical storm were selected for design.

The flood depths and peak flows from the critical event in the catchment flood modelling can be seen in (Figure 27) with the maximum depth from all storms and temporal patterns shown. The critical durations and flood depth through the site were found to occur in the 2hr storm duration. A sensitivity analysis was also conducted with applying a flow into the southern depression to determin the flow path and depths (Figure 28).

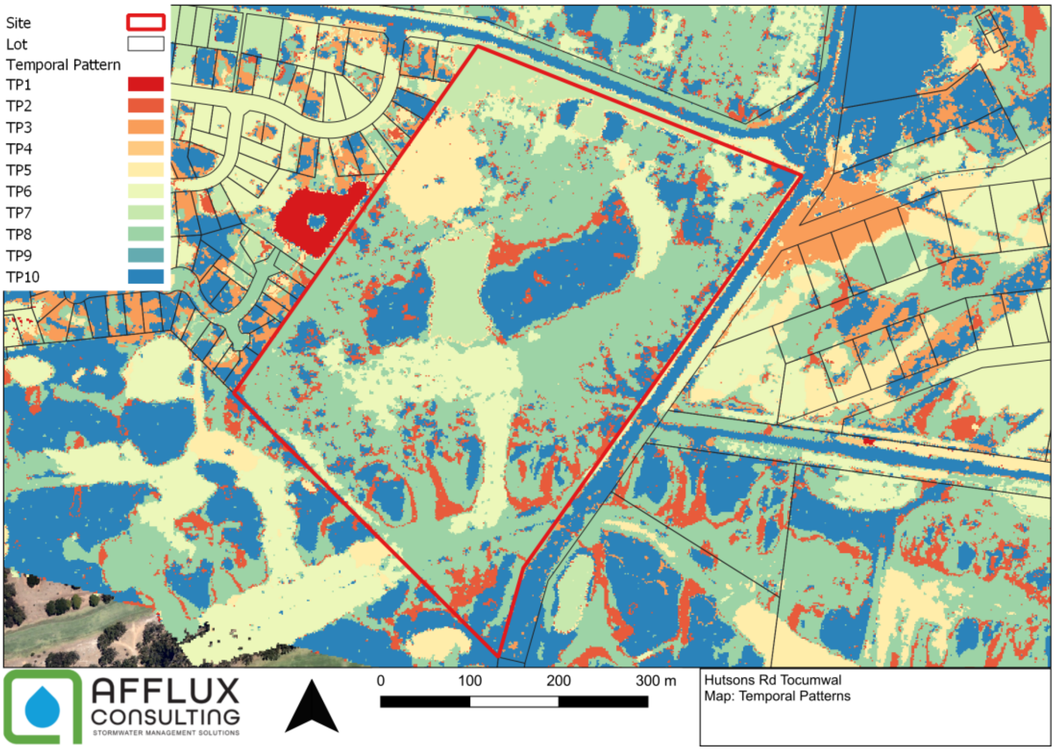


Figure 25. Various temporal patterns used in TuFlow.

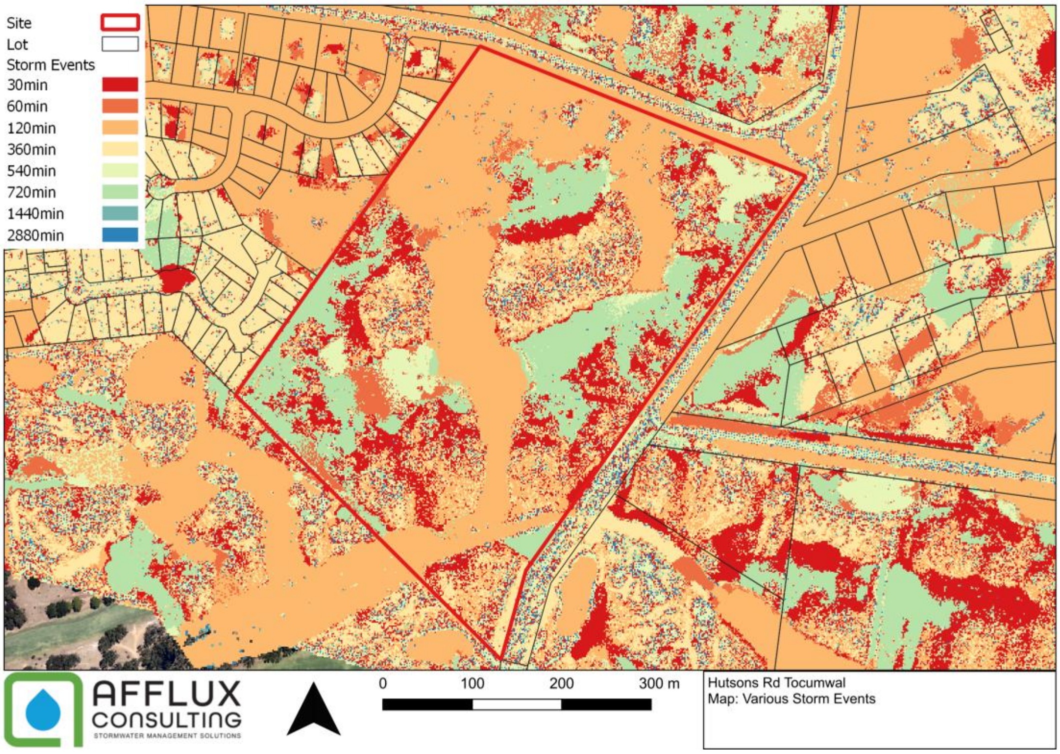


Figure 26. Various storm events used in Tuflow.

The peak flow through the site is associated with the 2 h TP 8 storm event deduced by the storm events and durations.

The flood depth result of the Tuflow model is shown in Figure 20. This demonstrates that the flooding as shown on site is from rainfall or water falling on the land (Rain on Grid modelling) and not from external catchment.

To check the sensitivity of the flow coming along the depression to the south, an inflow of 10 m^3/s was introduced in the waterway and checked for any breakout.

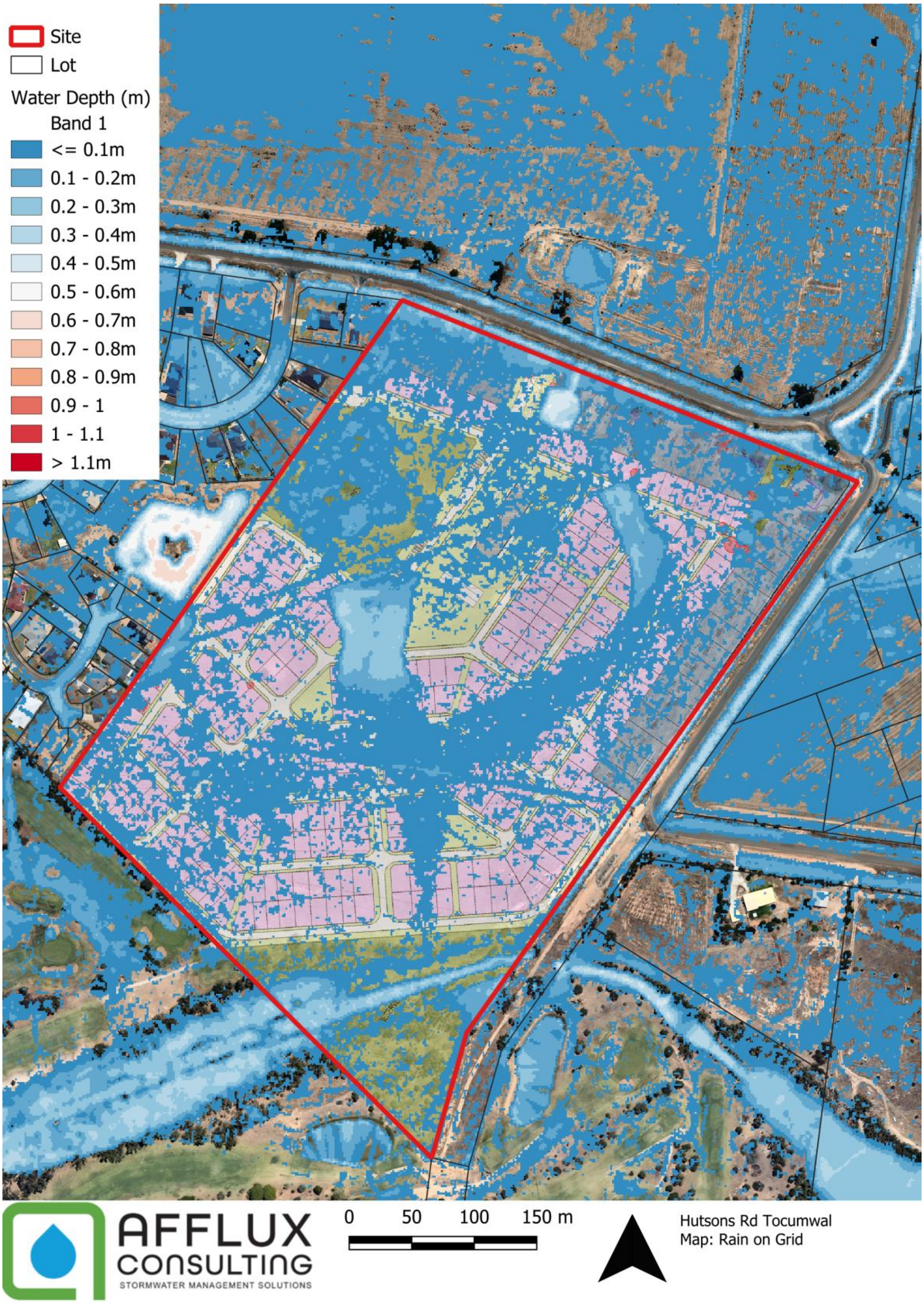


Figure 27. Existing conditions flood depth using Tuflow (Rain on Grid)

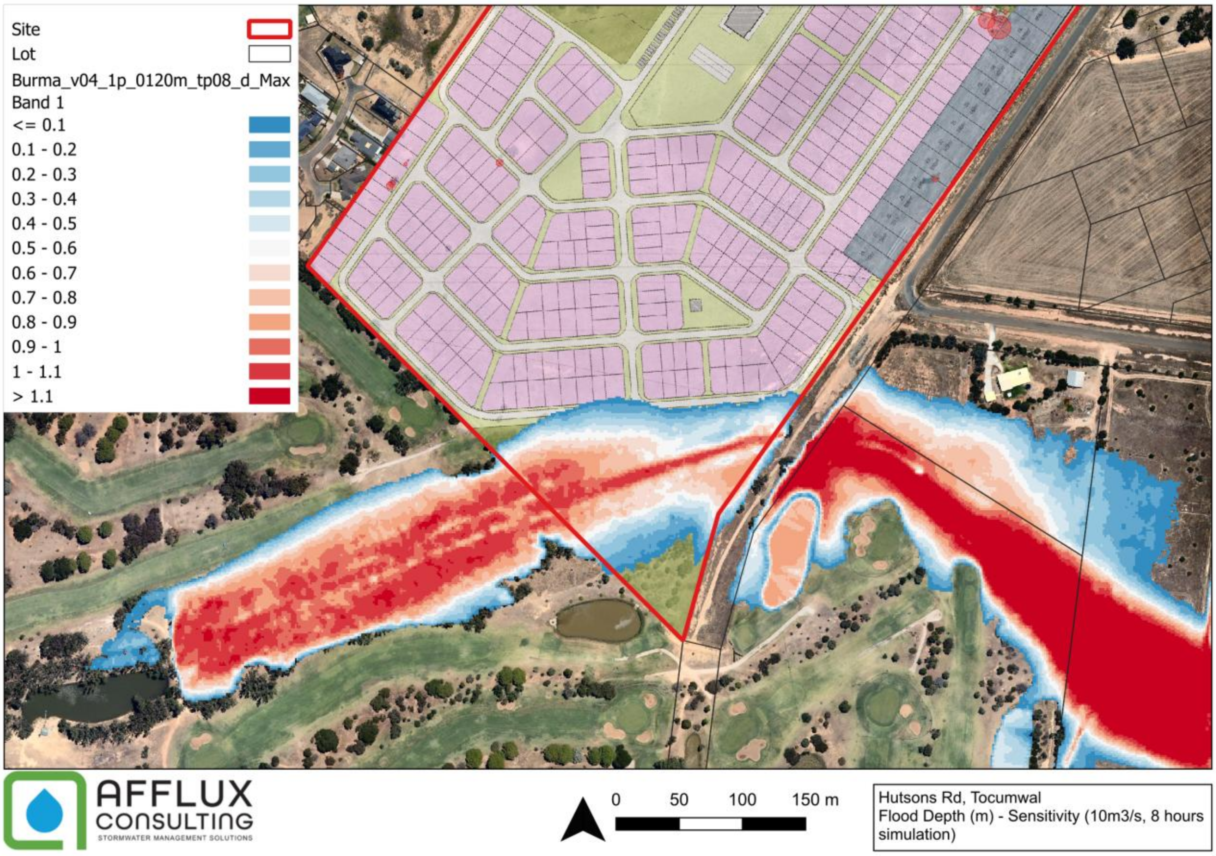


Figure 28. Flood Depth - Sensitivity Analysis with Inflow into creek

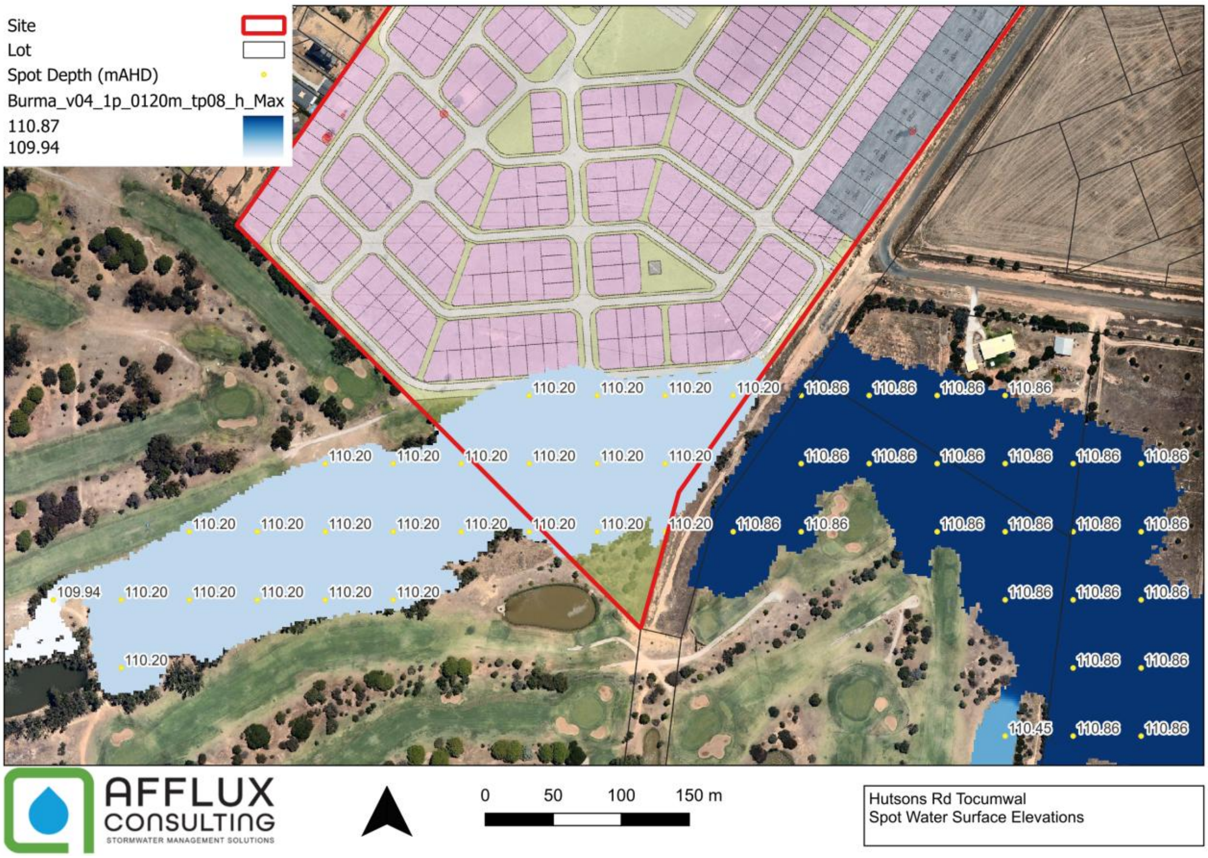


Figure 29. Water Surface Elevation - Sensitivity Analysis with Inflow into creek

Key Outputs

The key points from this analysis are:

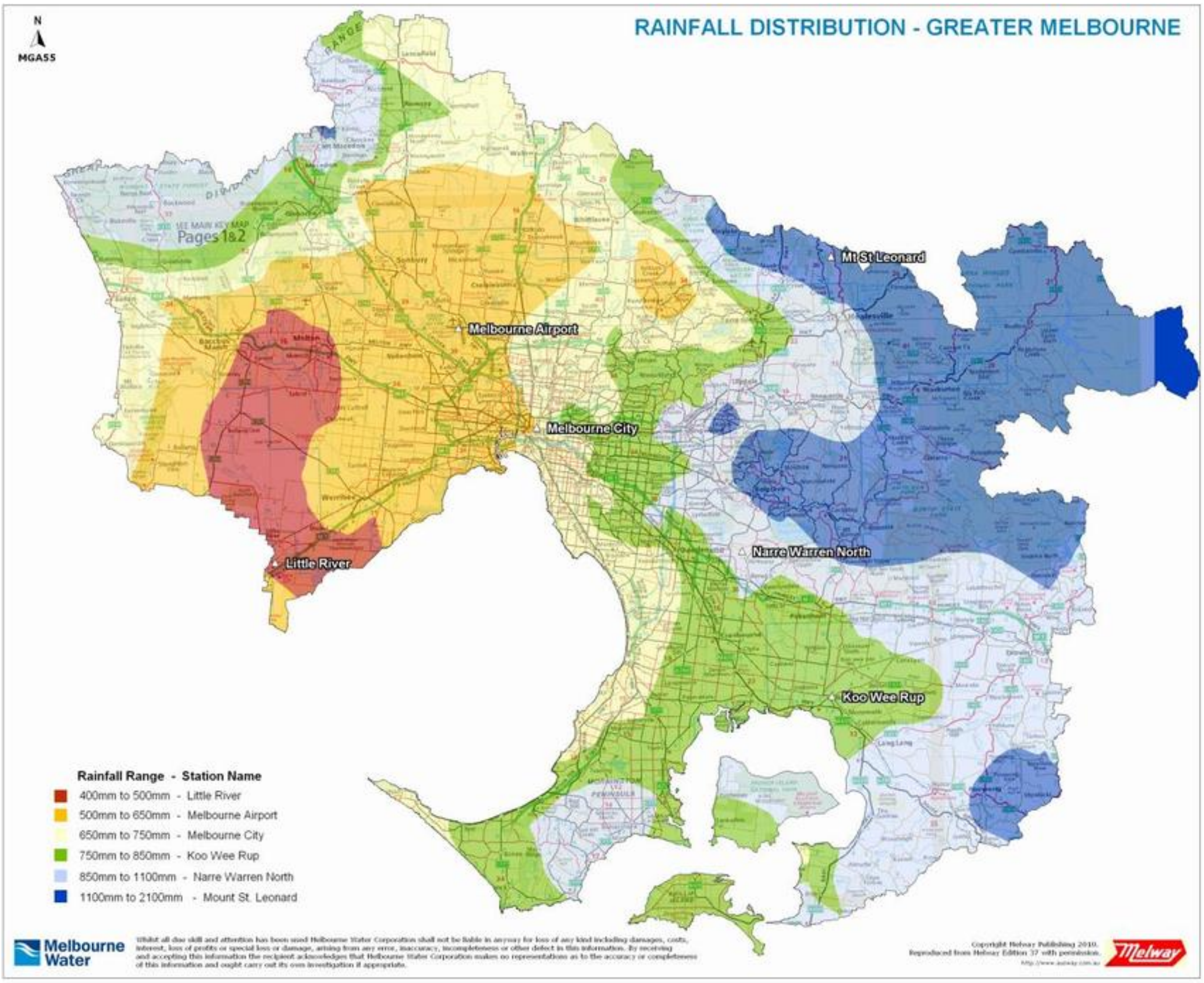
- The depression at the south of the site is limited in depth and extent by the 3x750 pipes on Burma Rd
- The site directly discharges to the catchment outfall to the south of the site.
- The majority of flow travels south towards the reserve area. No external catchments other than the eastern (Burma Road) inflows affect the site.
- The flow discharges out of the site through the south-west site boundary along the creek.
- Flooding from catchments to the east inflow is limited to a depth of 0.1 to 0.6 m of flooding.
- As the flooding on the site due to water falling on the land and not from external catchments, the development of the site with proper grading, pipes and floor level will fix this.

6. Water Quality

The water quality for this site has been assessed for the development. Treatment is modelled to ensure water quality for the site meets best practice load-based reduction requirements. The water quality works must coincide with the proposed development to ensure runoff does not directly discharge into the existing drainage system to the detriment of downstream water quality.

6.1. Rainfall Information

No site-specific pluvial data has been found for the site. To simulate the rainfall conditions the Mean Annual Rainfall (MAR) of the area has been matched to a similar rainfall record. In this case the closest rainfall template match is the Little River rainfall range and as such the reference year of 1992-2001 has been applied. Rainfall was run at a 6-minute interval to match the lowest Time of Concentration of the catchment.



Source: Melbourne Water MUSIC Guidelines

Figure 30. Greater Melbourne rainfall distribution

6.2. MUSIC Model Setup

To ensure that the development meets the BPEM requirements for the site a MUSIC model (v6) has been created for the catchment. MUSIC modelling is an industry standard approach to determine water quality treatment and sequencing. Guidance for model inputs was sourced from the IDM as well as Melbourne Water's MUSIC guidelines.

In order to reach BPEM Guidelines the model has been set up with the following notes:

- The model has been designed in alignment with proposed layout.
- The model is built using the most recent guidelines including reasonable soil losses field capacity assumptions.
- The model is built with an assumed 350mm EDD.
- The model is built using rainfall templates that include 10-year periods of rainfall data.
- The measured catchments are in alignment with hydrological models; and
- Source node sub-catchment areas for the development are separated by impervious fraction as per Table 7, in alignment with MUSIC guidelines.

All other parameters were set as per Melbourne Water Guidelines.

Table 7. Sub-catchment areas and impervious fraction

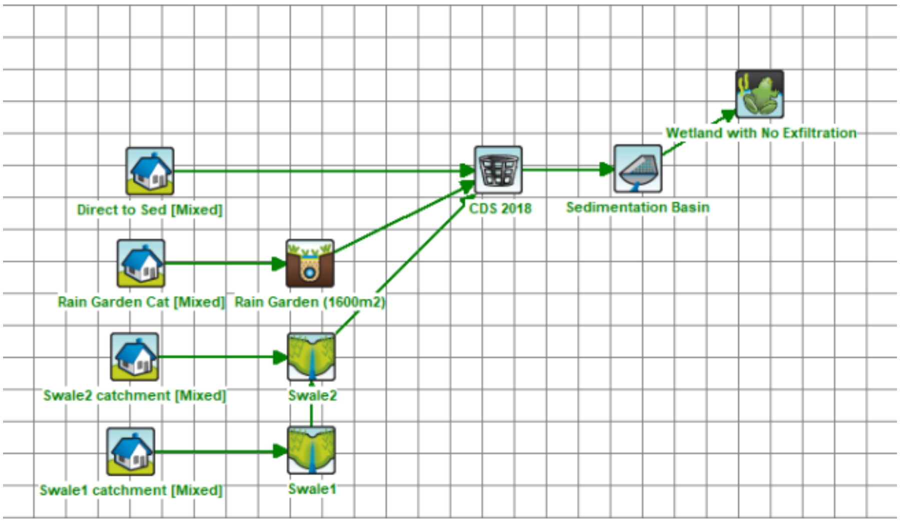
Catchment	Existing Catchment (ha)	Effective Impervious	Pervious
		Area	Area
1	3.46	75%	25%
2	3.23	75%	25%
3	1.26	75%	25%
4	2.06	75%	25%
5	1.39	75%	25%
6	3.52	75%	25%
7	3.22	75%	25%
8	0.97	75%	25%
9	6.93	60%	40%
10	6.5	60%	40%
11	3.95	60%	40%

6.3. Proposed Treatment

Runoff from the developed catchment will be treated by a treatment train system to ensure the development does not result in significant degradation of downstream waterways and optimum stormwater treatment at site outlet. It is recommended that the development is treated by an on-site WSUD system. Two different options are assessed in the proposed treatment (Figure 31 and Figure 32). The two options are:

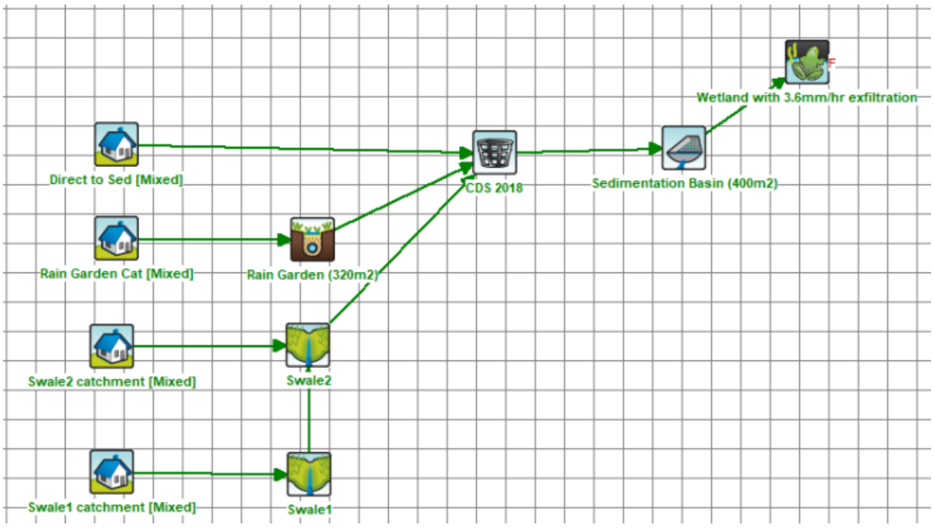
- A more formal traditional wetland and sediment basin system. This system requires a larger footprint and subsequent vegetation loss.
- A less traditional wetland system that incorporates and enhances the natural depression at the southern end of the site. This system would be unlined as it uses and enhances the existing vegetation.

The results of the MUSIC simulation provide an estimation of the expected nutrient reduction performance as shown in Figure 33 and Figure 34.



Source: Hutsons_Tocumwal_Little river template.sqz

Figure 31. Catchment MUSIC model layout option 1



Source: Hutsons_Tocumwal_Little river template.sqz

Figure 32. Catchment MUSIC model layout option 2

Treatment Train Effectiveness - Wetland with No Exfiltration

	Sources	Residual Load	% Reduction
Flow (ML/yr)	53.4	49.2	7.9
Total Suspended Solids (kg/yr)	10900	957	91.2
Total Phosphorus (kg/yr)	22.1	6	72.9
Total Nitrogen (kg/yr)	154	84.7	45
Gross Pollutants (kg/yr)	2300	0	100

Figure 33. MUSIC model results option 1 - Treatment Efficiencies

Treatment Train Effectiveness - Wetland with 3.6mm/hr exfiltration

	Sources	Residual Load	% Reduction
Flow (ML/yr)	53.4	37.6	29.6
Total Suspended Solids (kg/yr)	11000	982	91.1
Total Phosphorus (kg/yr)	22.3	5.91	73.5
Total Nitrogen (kg/yr)	154	77.5	49.6
Gross Pollutants (kg/yr)	2290	0	100

Figure 34. MUSIC model results option 2 - Treatment Efficiencies

6.4. Sediment Control

Control of sediment from a developed area is an important consideration for both the hydraulic function of drainage and water quality assets.

Sediment build-up can lead to the failure of pipe networks (through blockage) and biological systems (through blockage and bypass). It is recommended that all local pipe network outlets, where possible, end in a sediment pond before discharge to the waterway or wetland.

Given the scale of the residential development, sediment ponds are recommended as a suitable intervention. Maintenance requirements are an important consideration when allowing for reserve areas. Practical sediment pond sizes are limited to a minimum 400m², with access and sediment dry-out areas adding up to 20% to the required footprint area.

Given the general principal that any development should not directly discharge into a creek system, a sedimentation basin has been recommended to service the development.

Sedimentation basin for option 1 was sized using the Fair and Geyer equations and option 2 was sized according to the MUSIC software with the results summarised below. This has also then been modelled in MUSIC as a sediment basin node, as shown in Figure 35.

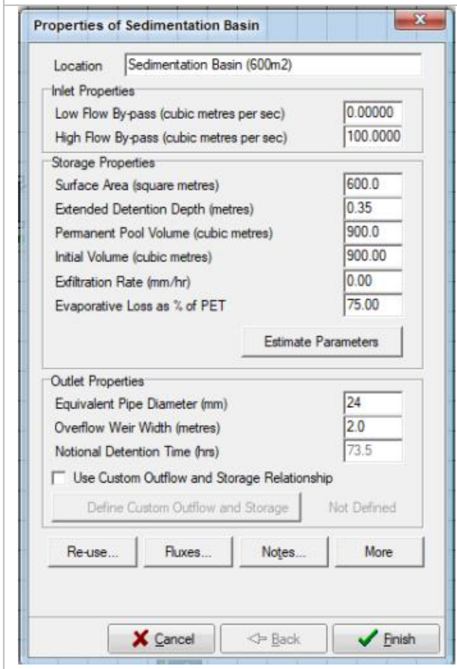
Calculations

Basin Name:

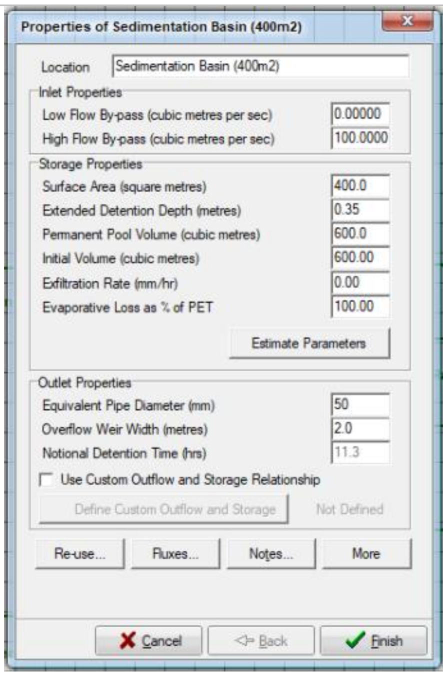
Source	Parameter	Basin 1
Melbourne Water requires R = 95% for a 125 micrometer particle	Target	Very fine sand
Pond shape assumption (Figure	λ	0.36
	n	1.56
From Table 1	Vs (m/s)	0.011
Use rational method to obtain 1 Year ARI flow for sub catchment	Q (m³/s)	1.00
Area of basin	A (m²)	600.00
	$\frac{V_s}{Q/A}$	6.60
EDD	d_e (m)	0.35
Depth of permanent pool	d_p (m)	1.50
Lower of 1m or d_p	d* (m)	1.00
	$\frac{(d_e+d_p)}{(d_e+d^*)}$	1.37
Fraction of Initial Solids Removed	**R =**	**95%**

Figure 35. Sedimentation Basin Sizing - Fair and Geyer

Option 1



Option 2



Source: Hutsons_Tocumwal_Little river template.sqz

Figure 36. MUSIC Sediment Basin Design Inputs

Table 8. Sediment Basin Parameters

Sediment Pond	Sed Pond Size (m2)	Target Size	Fraction Removal	Clean out Frequency
Wetland Option 1	600	125 micrometres	95%	8.6 years

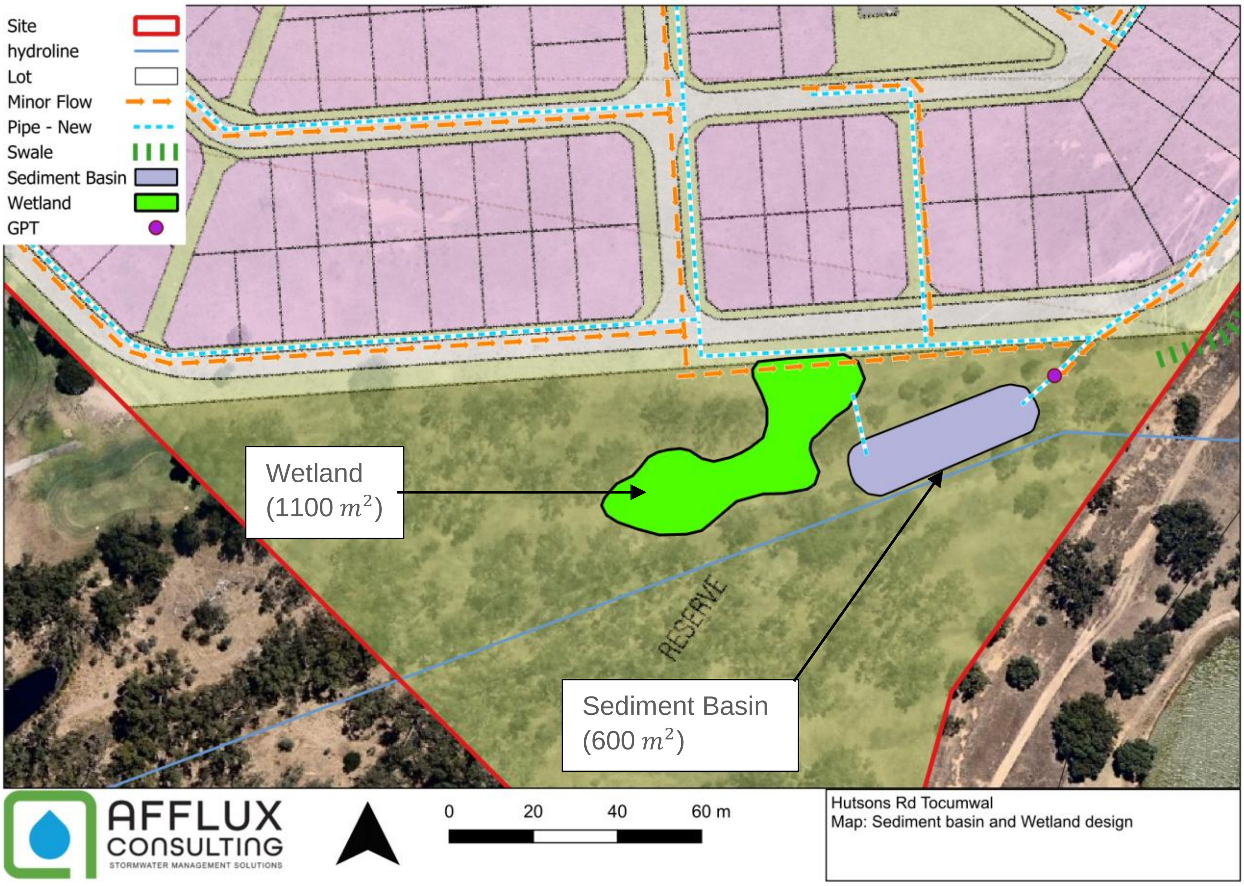


Figure 37. Sediment Basin and Wetland Concept Design Option 1

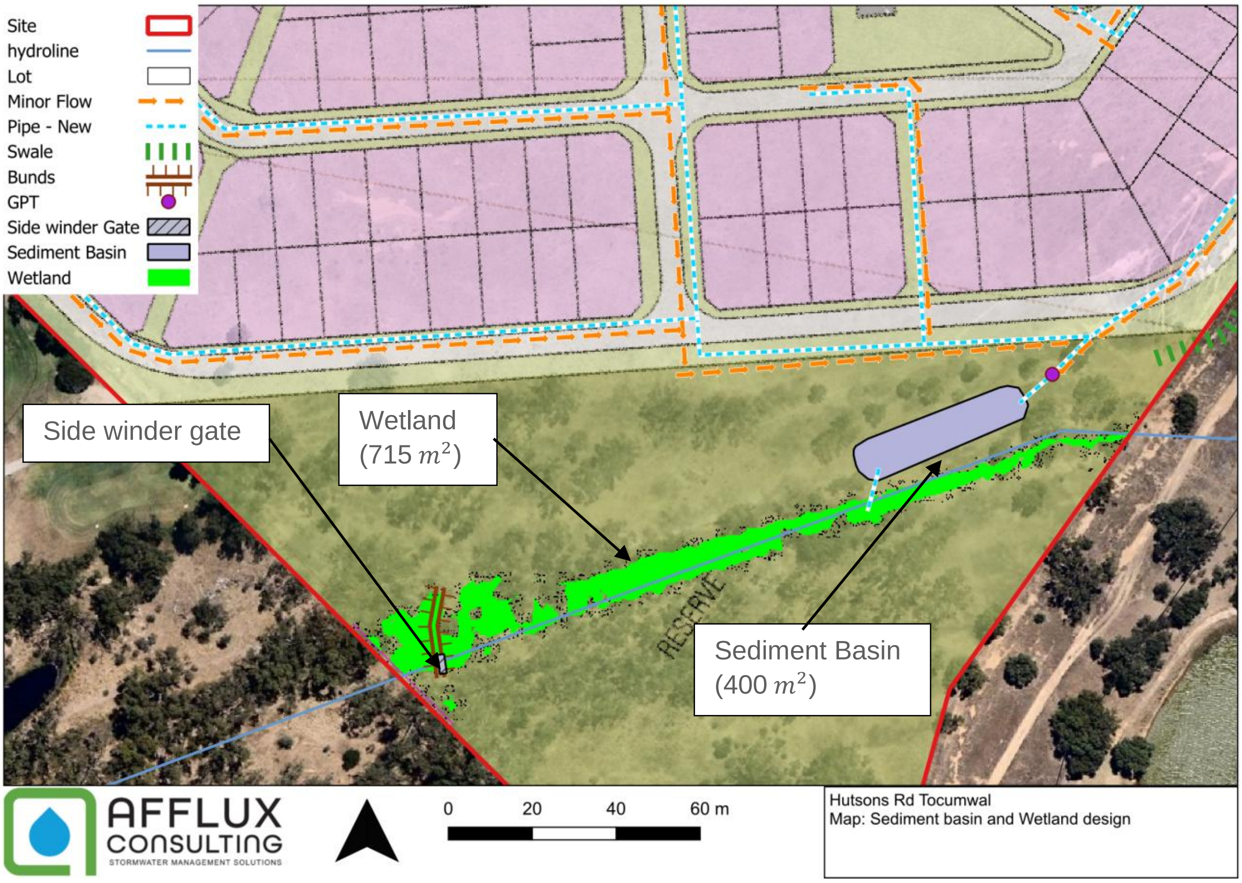


Figure 38. Sediment Basin and Wetland Concept Design Option 2

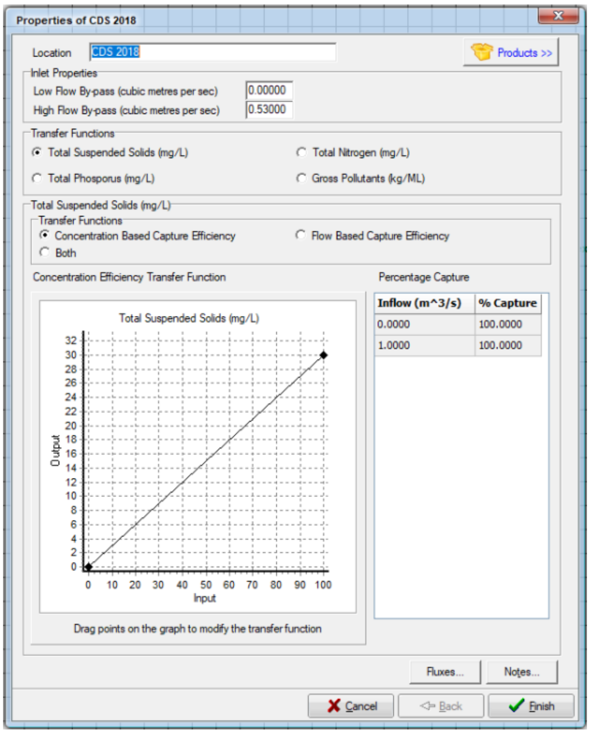
6.5. Gross Pollutant Trap (GPT)

Control of sediment from a developed area is an important consideration for both the hydraulic function of drainage and quality of receiving waters.

Suitably sized Gross Pollutant Traps (GPTs) are proposed to provide sediment and gross pollutant treatment given the industrial setting, existing drainage network and steep waterway banks. Given the expected high sediment loads, a high-efficiency system such as a single Continuous Deflection Separation (CDS) style system (Rocla and OceanProtect systems recommended) or a CDS in series with a two-stage system incorporating a Rocla First Defence High Capacity (FDHC) device is recommended.

Where available area limits the use of sediment ponds, it is recommended that outlets are fitted with a suitably sized GPT to screen out high loads of gross pollutants and sediment.

It is noted that future designs on these sites may require a GPT to prevent migration of gross pollutants into the overall wetland system. The recommended unit for this scale of development is the CDS 2018, suitable for catchments of this size 15 - 45 Ha.

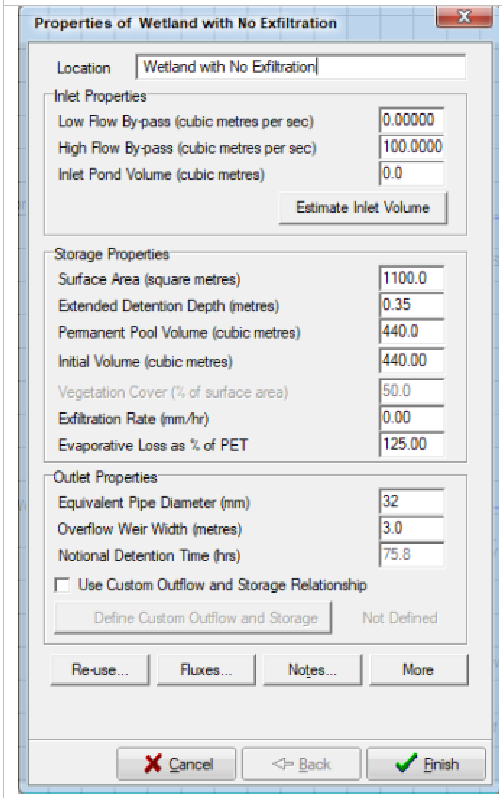
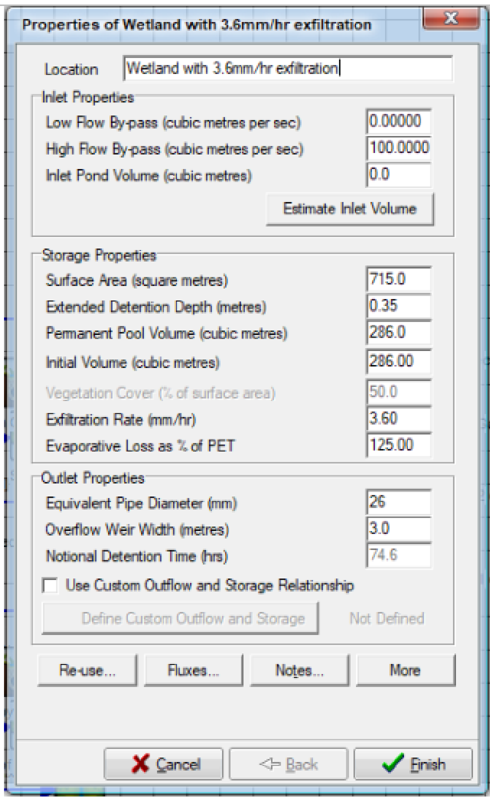


Source: Hutsons_Tocumwal_Little river template.sqz

Figure 39. MUSIC GPT Design Inputs

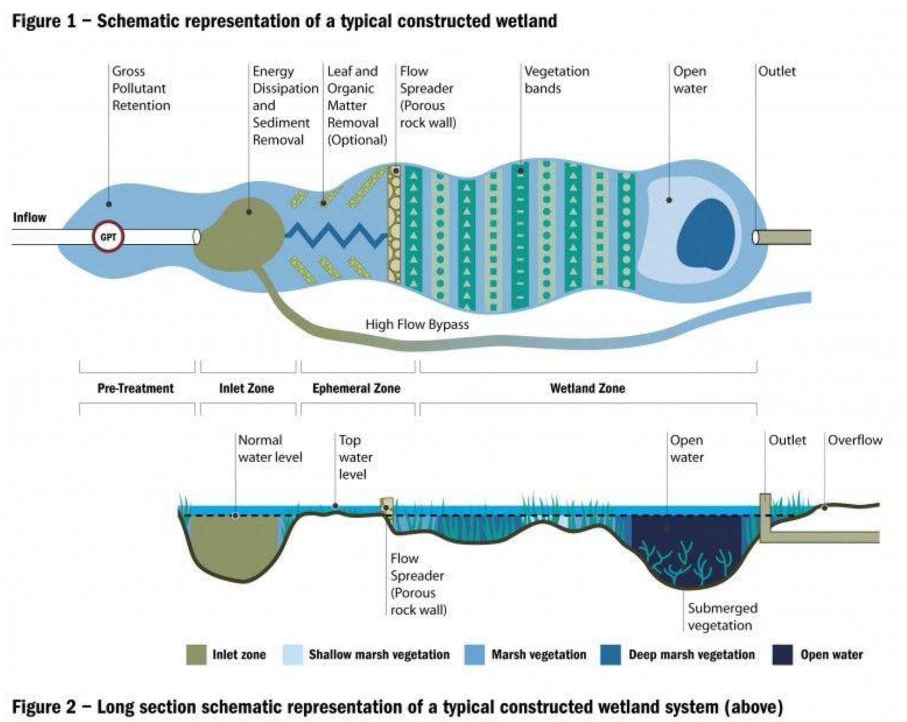
6.6. Wetlands

Biological treatment of stormwater reduces the loads of nutrients entering receiving waters, an important aspect of best practice guidelines. The general philosophy is to construct wetlands in preference to other water quality measures due to their robustness in long term survival, reduced maintenance, and ability to store greater amounts of water above the Normal Water Level (NWL) in a retarding basin situation. Wetland surface area dictates the potential effectiveness of these treatments, with plant selection and density being limited by available treatment area. Wetlands are designed to service the three-month flow or equivalent from the site. The parameters of the wetland are shown below in Figure 40. A typical wetland layout is given in Figure 26.

Option 1	Option 2
	

Source: Hutsons_Tocumwal_Little river template.sqz

Figure 40. MUSIC Wetland Design Inputs



Source: urban green-blue grids, (www.urbangreenbluegrids.com)

Figure 41. Schematic representation of a typical wetland

6.7. Raingarden - Bioretention Basin

Raingardens or bioretention systems provide biological treatment systems where available area is limited. The proposed raingarden is located north on the site to treat the water from the developed catchment located north-west.

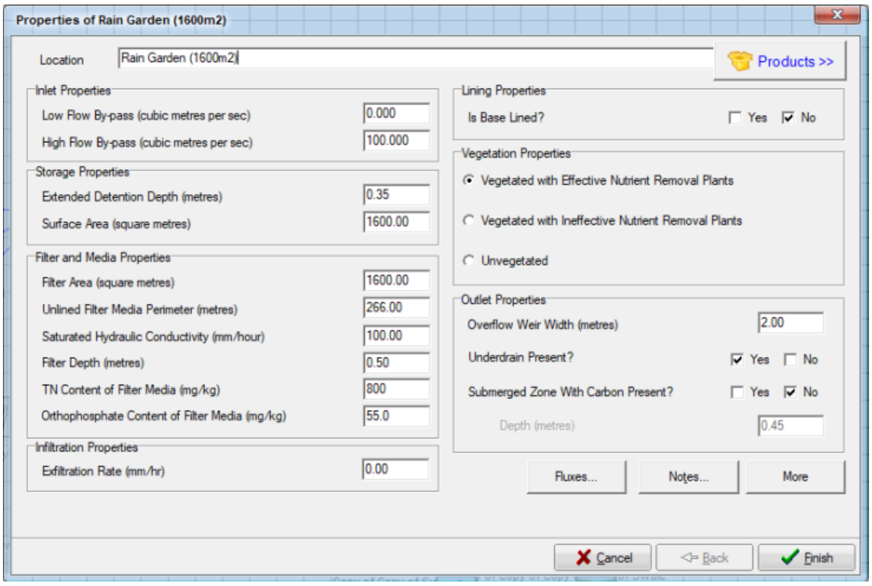


Figure 42. Raingarden node MUSIC option 1

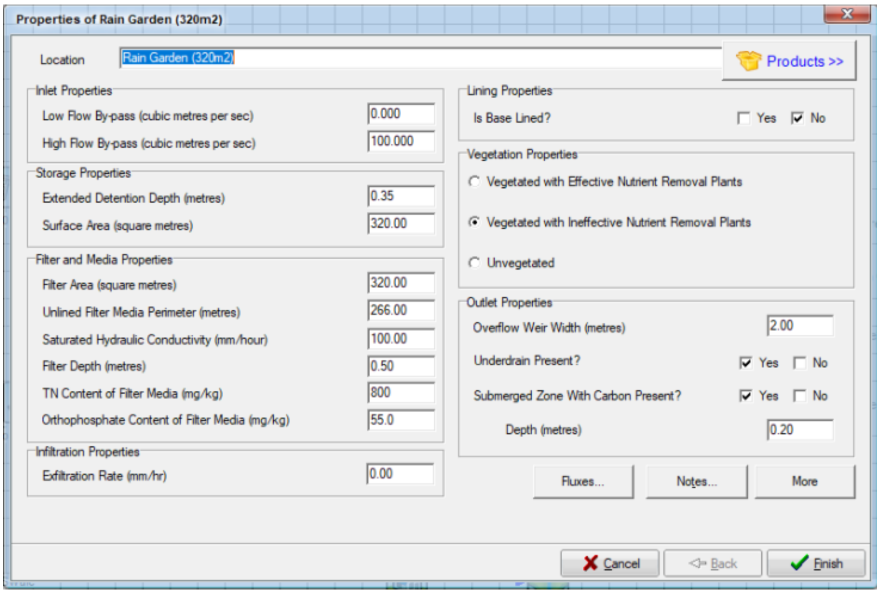


Figure 43. Raingarden node MUSIC option 2

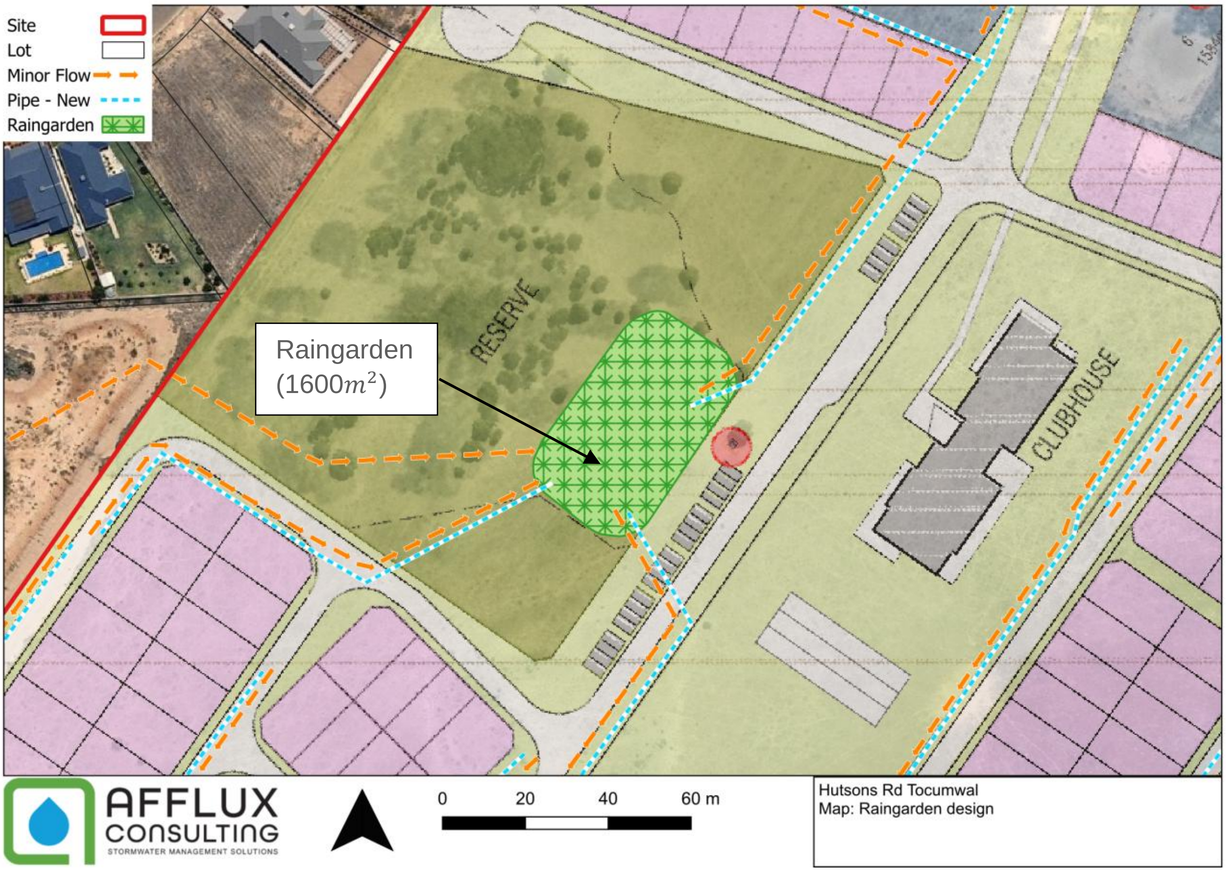


Figure 44. Raingarden Design option 1

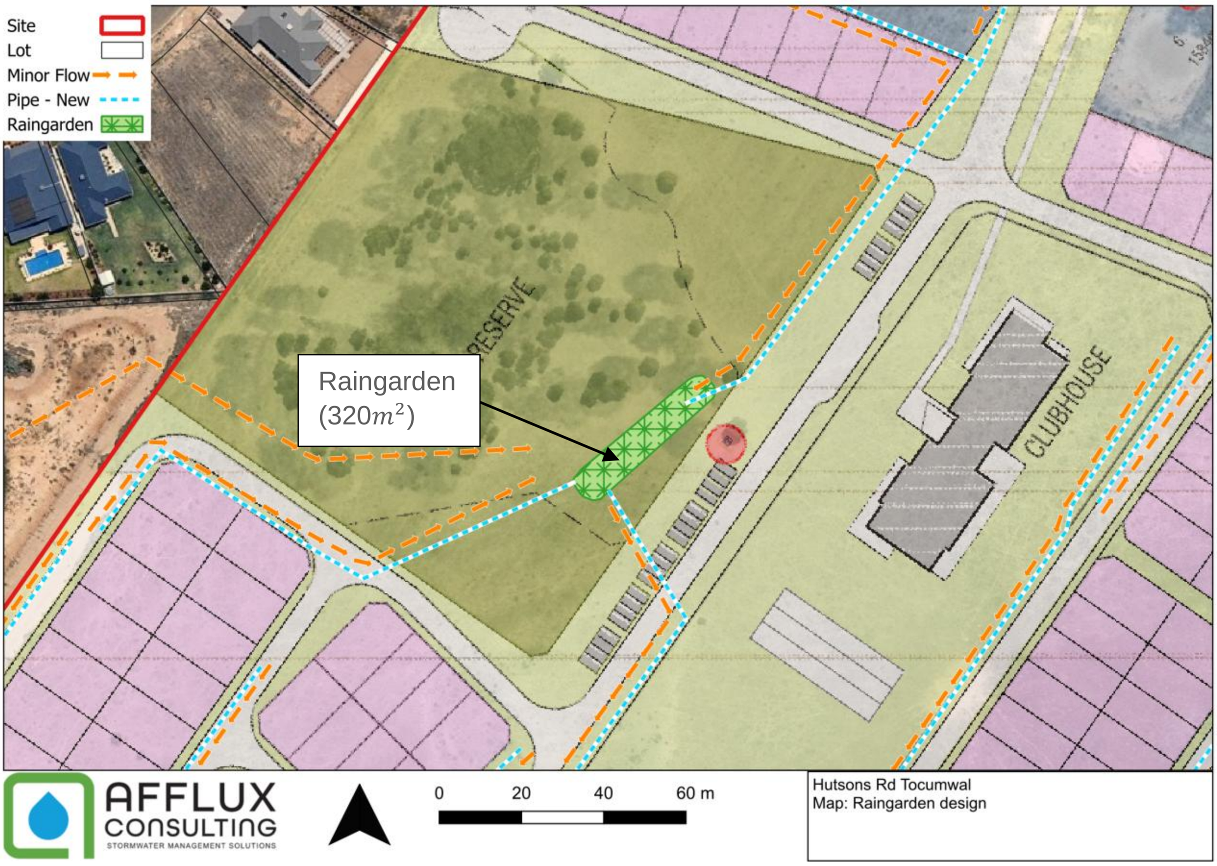


Figure 45. Raingarden Design option 2

7. Design Requirements

In modelling flood interactions across the site, design requirements are highlighted to reduce the impact of the development on neighbouring properties and surrounding water systems, while increasing amenity for future residents.

7.1. Flow Paths and Drainage

A concept drainage plan of the site has been developed to determine how the site can manage surface water. This concept considers the runoff from the developed site as well as upstream surface water from the existing waterway systems.

Site Controls and Legal Point of Discharge

The existing conditions of the site help to determine both the development potential, but also the drainage treatments for the area. The most significant aspects in this respect are the downstream conditions.

The existing outfall of the site is the creek located south of the site.

The nominal Legal Point of Discharge (LPD) has been advised as the depression at the south of the site.

Minor Drainage

Given the site constraints and layout, the minor drainage direct flows towards the proposed treatment system in options 1 and 2, (Figure 50). The raingarden (located north of the site) and wetland with sediment basin and GPT (located south of the site) will act as water quality treatment systems. This minimises flows discharging directly to the outlet.

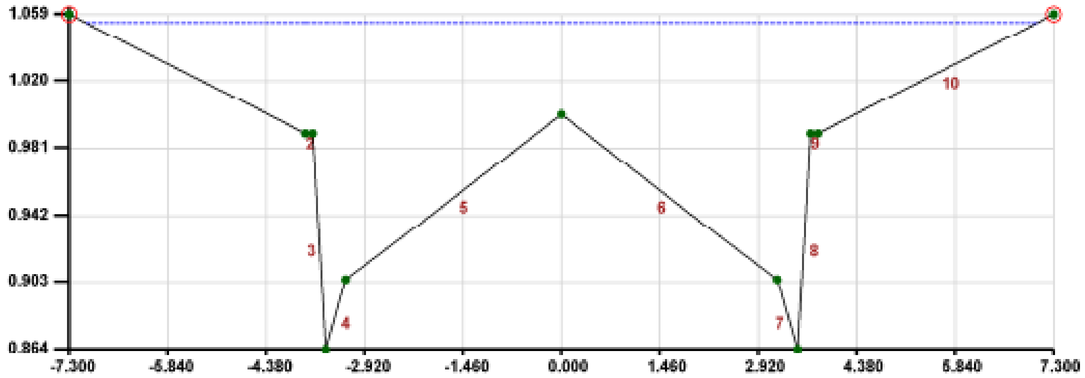
Drainage Network and OFP

The local drainage network has been sized through the design process, with catchment information and local road capacity. The road proposed in the development plan is adopted for the road capacity calculations.

Major flow path capacity assessment has been undertaken as part of this report based on the scheme hydrology with the road capacity estimated using PC-Convey. The flows in the reaches at pipes and overflow paths at 1a and 6a & 7a are identified as safe (Figure 46, Figure 47 & Figure 41).

PROJECT: Hutsons Rd Tocumwal
Road 1a
Print-out date: 07/11/2024 - Time: 7:29
Data File: Road1a.dat

1. CROSS-SECTION:



2. DISCHARGE INFORMATION:

100 year (1%) storm event

Total discharge = 1.15 cumecs

2 no.600 mm diameter Class 2 (X) pipes; grade of HGL = 1 in 500

Pipe discharge = 0.29 cumecs/pipe x 2 pipes = 0.5747 cumecs
Pipe flow velocity = 0.9832 m/s

Overland / Channel / Watercourse discharge = 0.58 cumecs

3. RESULTS: Water surface elevation = 1.054 m

High Flow Channel grade = 1 in 300, Main Channel / Low Flow Channel grade = 1 in 300.

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	TOTAL CROSS-SECTION
Discharge (cumecs):	0.000	0.646	0.000	0.646
D(Max) = Max. Depth (m):	0.000	0.190	0.000	0.190
D(Ave) = Ave. Depth (m):	0.000	0.073	0.000	0.073
V = Ave. Velocity (m/s):	0.000	0.628	0.000	0.628
D(Max) x V (cumecs/m):	0.000	0.119	0.000	0.119
D(Ave) x V (cumecs/m):	0.000	0.046	0.000	0.046
Froude Number:	0.000	0.742	0.000	0.742
Area (m^2):	0.000	1.029	0.000	1.029
Wetted Perimeter (m):	0.000	14.184	0.000	14.184
Flow Width (m):	0.000	14.100	0.000	14.100
Hydraulic Radius (m):	0.000	0.073	0.000	0.073
Composite Manning's n:	0.000	0.016	0.000	0.016
Split Flow?	-	-	-	No

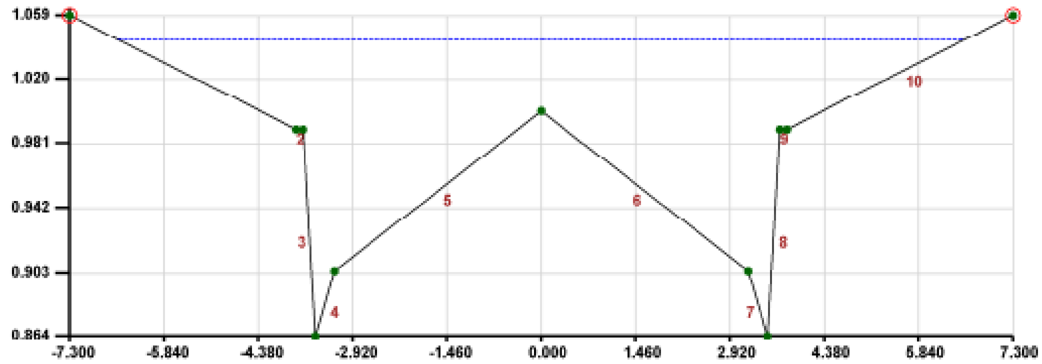
4. CROSS-SECTION DATA: (continued)

	LEFT HAND POINT		RIGHT HAND POINT		
SEGMENT NO.	CHAINAGE (m)	R.L. (m)	CHAINAGE (m)	R.L. (m)	MANNING'S N
1	-7.300	1.059	-3.800	0.989	0.016
2	-3.800	0.989	-3.690	0.989	0.016
3	-3.690	0.989	-3.500	0.864	0.016
4	-3.500	0.864	-3.200	0.904	0.016
5	-3.200	0.904	0.000	1.000	0.016
6	0.000	1.000	3.200	0.904	0.016
7	3.200	0.904	3.500	0.864	0.016
8	3.500	0.864	3.690	0.989	0.016

Figure 46. Discharge during 1%AEP storm along Road 1a (Figure 41)

PROJECT: Hutsons Rd Tocumwal
Road 6a
Print-out date: 07/11/2024 - Time: 7:32
Data File: Road6a.dat

1. CROSS-SECTION:



2. DISCHARGE INFORMATION:

100 year (1%) storm event

Total discharge = 0.96 cumecs

1 no.675 mm diameter Class 2 (X) pipe; grade of HGL = 1 in 300

Pipe discharge = 0.50 cumecs
Pipe flow velocity = 1.3664 m/s

Overland / Channel / Watercourse discharge = 0.46 cumecs

3. RESULTS: Water surface elevation = 1.044 m

High Flow Channel grade = 1 in 300, Main Channel / Low Flow Channel grade = 1 in 300.

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	TOTAL CROSS-SECTION
Discharge (cumecs):	0.000	0.535	0.000	0.535
D(Max) = Max. Depth (m):	0.000	0.180	0.000	0.180
D(Ave) = Ave. Depth (m):	0.000	0.068	0.000	0.068
V = Ave. Velocity (m/s):	0.000	0.599	0.000	0.599
D(Max) x V (cumecs/m):	0.000	0.108	0.000	0.108
D(Ave) x V (cumecs/m):	0.000	0.041	0.000	0.041
Froude Number:	0.000	0.733	0.000	0.733
Area (m^2):	0.000	0.893	0.000	0.893
Wetted Perimeter (m):	0.000	13.184	0.000	13.184
Flow Width (m):	0.000	13.100	0.000	13.100
Hydraulic Radius (m):	0.000	0.068	0.000	0.068
Composite Manning's n:	0.000	0.016	0.000	0.016
Split Flow?	-	-	-	No

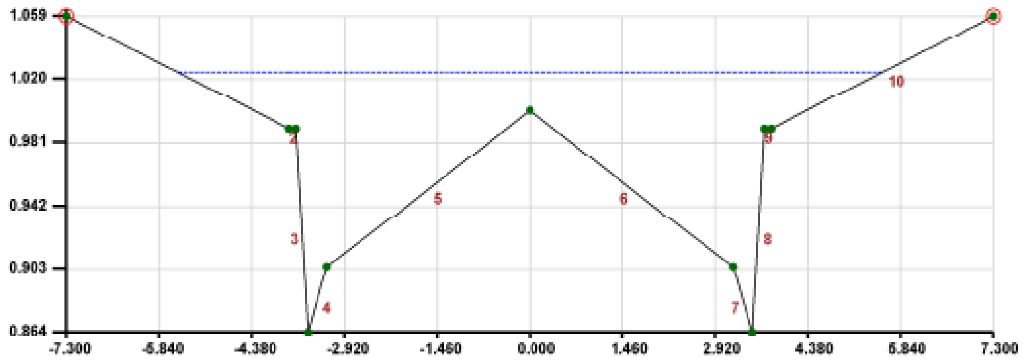
4. CROSS-SECTION DATA: (continued)

	LEFT HAND POINT		RIGHT HAND POINT		
SEGMENT NO.	CHAINAGE (m)	R.L. (m)	CHAINAGE (m)	R.L. (m)	MANNING'S N
1	-7.300	1.059	-3.800	0.989	0.016
2	-3.800	0.989	-3.690	0.989	0.016
3	-3.690	0.989	-3.500	0.864	0.016
4	-3.500	0.864	-3.200	0.904	0.016
5	-3.200	0.904	0.000	1.000	0.016
6	0.000	1.000	3.200	0.904	0.016
7	3.200	0.904	3.500	0.864	0.016
8	3.500	0.864	3.690	0.989	0.016

Figure 47. Discharge during 1%AEP storm along Road 6a (Figure 41)

PROJECT: Hutsons Rd Tocumwal
Road 7a
Print-out date: 07/11/2024 - Time: 7:36
Data File: Road7a.dat

1. CROSS-SECTION:



2. DISCHARGE INFORMATION:

100 year (1%) storm event

Total discharge = 0.87 cumecs

2 no.600 mm diameter Class 2 (X) pipes; grade of HGL = 1 in 500

Pipe discharge = 0.29 cumecs/pipe x 2 pipes = 0.5747 cumecs
Pipe flow velocity = 0.9832 m/s

Overland / Channel / Watercourse discharge = 0.29 cumecs

3. RESULTS: Water surface elevation = 1.024 m

High Flow Channel grade = 1 in 300, Main Channel / Low Flow Channel grade = 1 in 300.

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	TOTAL CROSS-SECTION
Discharge (cumecs):	0.000	0.353	0.000	0.353
D(Max) = Max. Depth (m):	0.000	0.160	0.000	0.160
D(Ave) = Ave. Depth (m):	0.000	0.059	0.000	0.059
V = Ave. Velocity (m/s):	0.000	0.542	0.000	0.542
D(Max) x V (cumecs/m):	0.000	0.087	0.000	0.087
D(Ave) x V (cumecs/m):	0.000	0.032	0.000	0.032
Froude Number:	0.000	0.714	0.000	0.714
Area (m^2):	0.000	0.651	0.000	0.651
Wetted Perimeter (m):	0.000	11.184	0.000	11.184
Flow Width (m):	0.000	11.100	0.000	11.100
Hydraulic Radius (m):	0.000	0.058	0.000	0.058
Composite Manning's n:	0.000	0.016	0.000	0.016
Split Flow?	-	-	-	No

4. CROSS-SECTION DATA: (continued)

	LEFT HAND POINT		RIGHT HAND POINT		
SEGMENT NO.	CHAINAGE (m)	R.L. (m)	CHAINAGE (m)	R.L. (m)	MANNING'S N
1	-7.300	1.059	-3.800	0.989	0.016
2	-3.800	0.989	-3.690	0.989	0.016
3	-3.690	0.989	-3.500	0.864	0.016
4	-3.500	0.864	-3.200	0.904	0.016
5	-3.200	0.904	0.000	1.000	0.016
6	0.000	1.000	3.200	0.904	0.016
7	3.200	0.904	3.500	0.864	0.016
8	3.500	0.864	3.690	0.989	0.016

Figure 48. Discharge during 1%AEP storm along Road 7a

8. Recommendations

Based on the assessments in this report, it is recommended that:

- Modifications to site levels should be integrated with landscaping where possible.
- Floor levels be adopted in line with levels indicated in the finished floor level layout Figure 49. A minimum floor level of 110.70m AHD should be applied to the lots along the southern boundary.

Final detailed plans should include the following:

- Buildings offset to ensure safe conveyance of flood waters between building interfaces at site boundaries;
- Safe conveyance of water in driveways; and
- Finished floor levels incorporating 500 mm freeboard to ensure adequate flood safety.

Figure 49. Finished Floor Levels

8.1. Concept Design

Based on the site constraints, and minimising the vegetation loss, it is recommended that Option 2 be adopted as the stormwater treatment for the site. This option is recommended based on:

- Extensive discussions with the vegetation specialist. This option is seen as having the least impact on the existing vegetation, and can enhance the flooding and drying nature of the cut-off meander along the southern boundary
- Extensive discussions with the neighbouring Golf Club. The Club has an extensive network of irrigation mains and pumps and have requested as much water as possible nutrient treatment after treatment. A masterplan of the planned water and storage upgrades for the site is shown in the Appendices. The golf club is accepting of all volume increases as part of this development.
- Council maintenance – this option is seen as having the least long term Council maintenance requirements

The design concept layout recommended for the site is shown below.

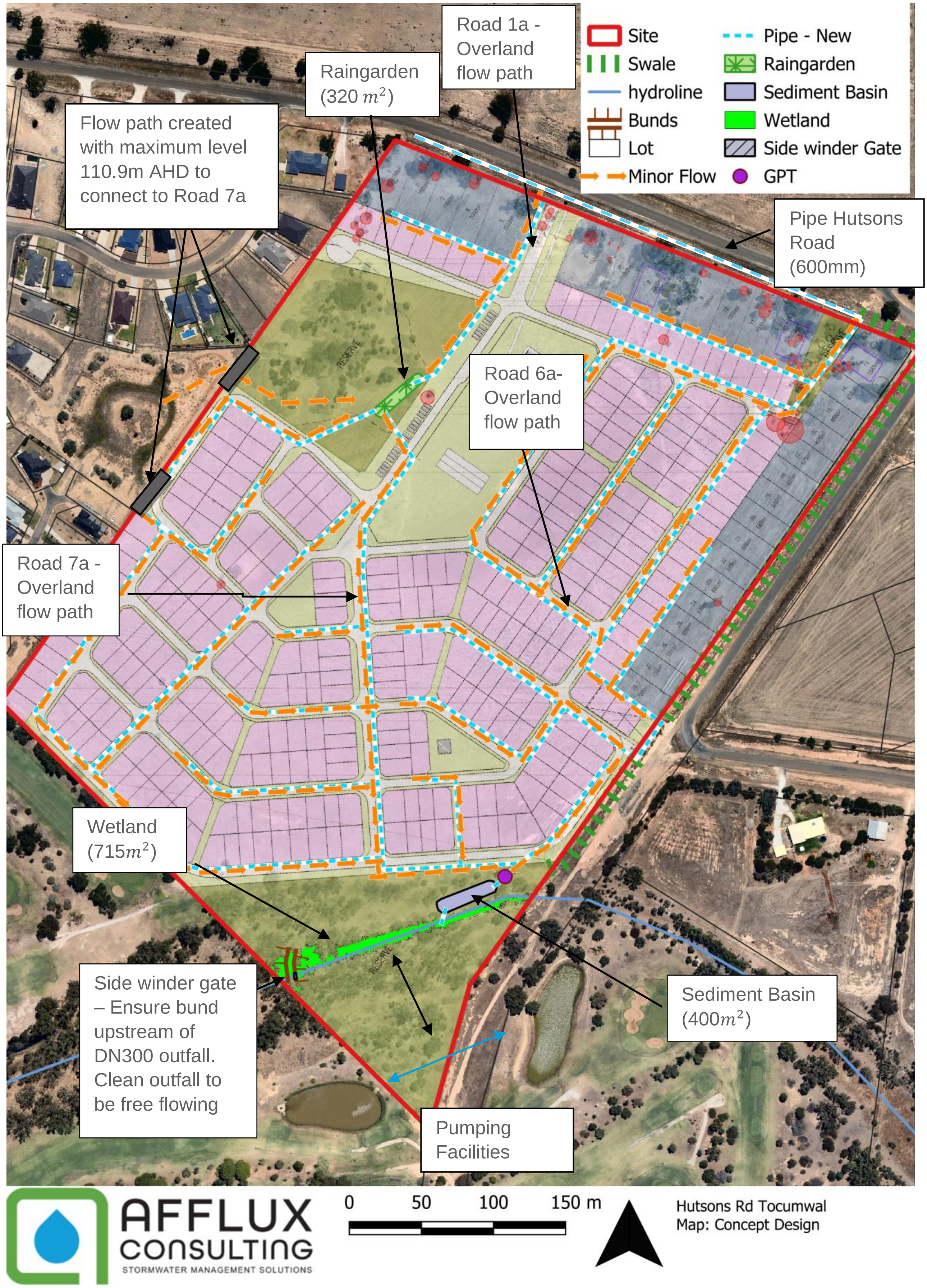


Figure 50. Stormwater Concept design 2

9. Conclusions

This report presents a stormwater management plan for the proposed development at Hutsons/Burma Road, Tocumwal within Berrigan Shire Council. The site has important interactions with its immediate catchment, and these interactions have been considered in this report. Two options have been presented to meet the water quality at this site. Further, we met on site with the ecologist and discussed in detail the water quality treatment and these two proposals to determine which was best from and ecological point of view. With the opinion of the ecologist option 2 was a clear preference as its effect on any native vegetation and trees was minimal and it would probably enhance the existing wetland. The following permit conditions are recommended:

- A minimum floor level of 110.7m AHD along the southern boundary.
- A maximum flow path level of 110.9m AHD for the interface with the basin along the western boundary.
- A wetland (715m²) and sediment basin (400m²) to be incorporated into the tree reserve at the south of the site. To include Integrated Water options for water supply to the golf course.
- A raingarden of 320m² be incorporated into the reserve at the north west of the site.
- Piping of existing road flows along Hutson's Road.
- Major overland flow path to be incorporated into the central road of the site.

10. Abbreviations and glossary

For clarification, provided are terms referred to within this report and their definitions as applicable to stormwater and water engineering.

TERM (Abbreviation)	DEFINITION
Afflux	A measure of the increase in water elevation (or flood level difference) at a given location, relative to the water elevation that would have occurred.
Alluvium\alluvial material	Extensive deposits of sand, silt and/or clay formed by a river or flood, typically forming a floodplain. Alluvium is generally unconsolidated.
Annual Exceedance Probability (AEP)	The likelihood of a storm event or flood occurring or being exceeded within any year. Where, $$AEP = 1 - e^{\left(\frac{-1}{ARI}\right)}$$
Attenuation	Reduction in the magnitude of a flood peak
Australian Rainfall and Runoff (ARR)	Australian Rainfall and Runoff guidelines document.
Average Recurrence Interval (ARI)	A statistical estimate of the average length of time (in years) between equivalent (or larger) flood events. Note. Events do not occur at regular intervals. This is an average and not the expected elapsed time until the next exceedance. e.g., a “100-year ARI flood event” has a 1% exceedance probability each year.
Australian Height Datum (AHD)	Vertical height in meters above the mean sea level.
Baseflow	The slow component of catchment runoff, not immediately in response to a storm event. Encompasses interactions with seepage and groundwater discharge into a waterway.
BPEM	Best practice environmental management guidelines used for planning, designing, or managing stormwater systems or urban land uses
Catchment	The upstream land and water surface area that drains to a specified location under consideration.
Consequence	Outcome or impact of an event.
Critical Sorm Duration	The length of time of a rainfall event that results in the peak flow or level at a particular location of interest for a given AEP.
Cumec	An abbreviation of cubic meters per second, a unit of discharge (m^3/s)
Drainage Network **or System**	A system of natural or constructed flow paths within a catchment used to convey runoff to its outlet. This may include surface or subsurface systems such as pipes, channels, gutters, overland flow paths, culverts, water storages, etc.

Design Event	A probabilistic or statistical flood or rainfall event used for flood/flow estimation processes for a given AEP.
DELWP	Department of Environment, Land, Water and Planning
EPA	Environmental protection agency
Extended Detention	Distance above normal water level in where stormwater is temporarily stored
Evaporation	The transfer of water, as vapour, from a water surface to the air
Evapotranspiration	The transfer of water, as vapour, from near the earth's surface to the air. Includes open water surfaces, ice, frost, soil, and transpiration from plants.
Freeboard	The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation.
Flood	Inundation of normally dry land by water that has exceeded the capacity of the normal confines of waterbodies, water storages or watercourses.
Flood Frequency	Descriptor for the annual exceedance probability or average recurrence interval of a flood
Floodplain	The land area which experiences flooding during high discharge events.
Hazard	Potential for damage or harm. Considered alongside consequence and likelihood of occurrence.
Hydrological Analysis	Developing and understanding a set of relationships to determine how rainfall is converted into runoff or streamflow (includes consideration of climate, losses, soil types, etc).
Hydraulic Design	The process of numerically analysing actual or expected flow conditions (such as water surface elevation and velocity) associated with a given hydraulic structure or overland flow.
Infiltration	The downward movement of water into a catchment surface or infiltration system. Largely governed by soil conditions, vegetation, and antecedent moisture content.
Loss rate	Removal (loss) of water from the rate of rainfall that occurs during the process of forming stormwater runoff. Usually measured in units of mm/hr. The assumed loss rate usually varies across the drainage catchment in accordance with known or assumed surface conditions.
Local Authority	Any local or regional external authorities (including local and State Governments or non-government authorities) that have a legal interest in the regulation or management of a given activity, or the land on which the activity is occurring, or is proposed to occur.
Manning's 'n' Roughness Coefficient	The numerical representation of the hydraulic roughness of a conduit, flow path or channel as used in the Manning's formula.
Rainfall Excess	The portion of rainfall that contributes to streamflow
Rainfall Intensity	The rate at which rain falls, typically measured in mm/hour.
Runoff	The part of rainfall (or snow/hail) not lost to infiltration, evaporation, transpiration, or depression storage that flows from the catchment

	area past a specified point.
Sedimentation Basin	A basin or tank in which sediment collects primarily through the actions of gravitational settlement. The basin facilitates low-velocity, low-turbulent flows to facilitate the settling of coarse sediment particles from stormwater runoff.
Soil Erosion	The detachment and transportation of soil and its deposition at another site by wind, water, or gravitational effects. Although a component of natural erosion, it becomes the dominant component of accelerated erosion as a result of human activities and includes the removal of chemical materials.
Stage	Elevation of the water surface in a stream measure to some convenient datum
Storm	In hydrology this includes any rainfall event. Unlike common usage implying a period of extreme weather with intense rain and strong wind.
Stormwater Flooding	Inundation by local runoff caused by heavier than usual rainfall. Stormwater inundation is caused by local runoff before it has entered a watercourse or joined watercourse flow. In a rural setting and within large rural allotments, we define stormwater flooding as sheet flow caused by local runoff before it has concentrated into a watercourse, including a drainage channel, stream, gully, creek, river, estuary, lake or dam, or any associated water holding structure.
Surface Water or Inundation	Any water collecting on the ground or in an open drainage system or receiving water body. In this report we use these terms to discuss water before it is categorised into flood, stormwater or other.
Temporal pattern	The time sequence of rainfall intensity. A representation of the variability of rainfall throughout a storm event.
Water Balance	An account of all the water in a specified system. Includes measurement of all inflows, outflows, and changes in stored water volumes.
Wetland	A natural or constructed area of land inundated temporarily or permanently with shallow water that is usually slow moving or stationary

11. References

Ball, J., Babister, M., Nathan, R., Weeks, W., Weinmann, E., Retallick, M., and Testoni, I. (Editors). (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia: Geoscience Australia.

Coombes, P. and Roso, S. (Editors). (2019). *Runoff in Urban Areas, Book 9 in Australian Rainfall and Runoff - A Guide to Flood Estimation*, Commonwealth of Australia: Geoscience Australia.

Melbourne Water. (2013). *Waterway Corridors: Guidelines for greenfield development areas within the Port Phillip and Westernport Region*, Melbourne Water

Melbourne Water. (2018). *MUSIC Guidelines; Input parameters and modelling approaches for MUSIC users in Melbourne Water's service area.* Melbourne Water.

Melbourne Water. (2019). *Flood Mapping Projects Guidelines and Technical Specifications*, Melbourne Water Corporation

Melbourne Water. (2020). *Constructed wetlands design manual*. Melbourne Water Corporation

The State of Victoria Department of Environment, Land, Water and Planning. (2019). *Guidelines for Development in Flood-prone Areas*, Department of Environment, Land, Water and Planning

Victoria Stormwater Committee. (1999). *Urban Stormwater: Best Practice Environmental Management Guidelines*, CSIRO.

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CENTRELINE GOLF DESIGN

Tocumwal Golf & Bowls Club | September 2023


Captains Course

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Hole #10: Par 4
355m
340m
325m
217m
Bunker Remodel:
Remodel bunker and move closer to green, widen fairway to suit.
Tee Remodel:
Move tees over to right for better anlge of hole and remove all of the garden. Potential to have a back tee accros the road when pro shop moves.
Remove Tree:
Remove tree on lhs for better view of hole and to creat more width.
Resurface Green:
Resurface green complex to remove couch encroachmenet remodel bunkers on both sides.
10


Hole #11: Par 5
478m
468m
407m
293m
11
Tee Remodel:
Move black tee back to coexist with black tee on hole 17. Remove vegetation from back of front tee.
Remove Trees:
Remove trees on rhs of hole to expose the two large gum trees and widen fairway where possible.
Resurface Green:
Resurface green complex to remove couch encroachmenet and build 2 new bunkers to protect lhs of green. Fill in back right bunker and make shortcut hollow.
Fariway Bunker:
Remove trees on rhs of landing area and build new bunker to create strategy on second shot. Widen fairway to suit.

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Hole #16: Par 4
390m
365m
330m
233m
Tee Removal:
Remove front left tee.
Widen Fairway:
Widen fairway on lhs to follow waters edge and allow bold second shots to roll up onto green.
Extend Dam:
Extend horseshoe dam to suit new green shape.
16
Rebuild Green:
Rebuild green complex and move over to the left and conect with horseshoe dam. New bunkering on the right to protect back left pin.

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