



Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for the Victorian Planning Authority under the contract titled 'COR/21/5227: Shepparton South East PSP - Stormwater Drainage Functional Designs and Costings Project.'

Authors: Stuart Cleven, Jenny Butcher, Advait Madav

Review: Jenny Butcher Approved: Stuart Cleven

Version: 5 – Revised Final, addressing stakeholder queries

Date issued: 24 July 2022

Issued to: Brianna Smilie (VPA)

Citation: Alluvium, 2023, Shepparton South East Precinct Structure Plan Stormwater Design:

Functional Design Report, Report prepared by Alluvium Consulting Australia for the Victorian

Planning Authority.

Version: 4 – Revised Final Date issued: 31 May 2022

Issued to: Brianna Smilie (VPA)

Citation: Alluvium, 2022, Shepparton South East Precinct Structure Plan Stormwater Design:

Functional Design Report, Report prepared by Alluvium Consulting Australia for the Victorian

Planning Authority.

Version: 3 – Revised Final
Date issued: 29 March 2022
Issued to: Brianna Smilie (VPA)

Citation: Alluvium, 2022, Shepparton South East Precinct Structure Plan Stormwater Design:

Functional Design Report, Report prepared by Alluvium Consulting Australia for the Victorian

Planning Authority.

version: 2 – Final Date issued: March 2022

Issued to: Brianna Smilie (VPA)

Citation: Alluvium, 2022, Shepparton South East Precinct Structure Plan Stormwater Design:

Functional Design Report, Report prepared by Alluvium Consulting Australia for the Victorian

Planning Authority.

Version: 1 – DRAFT
Date issued: December 2021
Issued to: Brianna Smilie (VPA)

Citation: Alluvium, 2021, Shepparton South East Precinct Structure Plan Stormwater Design:

Functional Design Report, Report prepared by Alluvium Consulting Australia for the Victorian

Planning Authority.

Cover image: abstract river image, Shutterstock

# **Contents**

1	Intr	oduction	1
	1.1	Location	1
	1.2	Background	3
	1.3	Strategic context	3
2	Exis	ting conditions	5
	2.1	Site visit	5
	2.2	Topography	7
	2.3	Existing services and infrastructure	8
	2.4	Catchments	11
	2.5	Flora and fauna values Biodiversity Assessment for the proposed Shepparton South East Precinct Structure Plan – Ecology and	12
		Heritage Partners (December, 2021)	14
	2.6	Cultural heritage	14
	2.7	Geotechnical conditions	17
3	Exis	ting drainage and flooding studies	18
		Shepparton South East Growth Corridor Drainage Strategy (CPG, 2012) Shepparton South East Growth Corridor Review of Revised Structure Plan inclusion of Drainage Strategy (Spi 2014)	18 ire, 20
		Shepparton East Overland Flow Urban Flood Study (BMT WBM, 2017)	21
		Shepparton South East Precinct Structure Plan Stormwater Investigation Study (Cardno, 2020) Shepparton South East Precinct Hydraulic Modelling Report (BMT, 2020)	25 27
	D		
4		ferred drainage strategy for functional design	29
	4.1	Stakeholder consultation	29
	4.2	Design objectives	30
	4.3	Summary of proposed design strategy	30
5	Pos	t development objectives and conditions	33
	5.1	Project aim	33
	5.2	Objectives and approach	33
		Stormwater quantity management Stormwater conveyance	33 34
		Stormwater quality treatment	34
		Multi-functionality for multi-benefits	34
	5.3	Future land use	35
6	Hyd	rologic analysis	37
	6.1	Hydrologic modelling	37
	6.2	Input parameters	37
		Climate change scenario	38
	6.3	Climate change scenario  Results	38 41
	6.3 6.4		

	wet	iand and sediment basin design	54
	7.1	Design arrangement overview	54
	7.2	Treatment modelling Inputs Results	55 55 56
		Inundation frequency analysis	58
	7.3	Sediment basins	59
	7.4	Wetlands	60
		Batter slopes	61
		Velocities	62
	7.5	Dimensions and quantities	63
	7.6	Connections	64
		Inflow into sediment basins	64
		Sediment basin to wetland transfer	64
		Balance pipes	64
		Wetland outfall	64
	7.7	Maintenance	65
		Access	65
		Sediment dewatering area	65
8	Safe	ty in Design	66
	8.1	Batters	66
9	Cost	ing	67
10	Stag	ing	68
	10.1	Staging principles	68
	10.2	G-MW asset decommissioning	68
11	Con	clusion	69
12	Refe	erences	70
App	endix	A Proof of Concept summary	71
Apr	endix	B Hydrologic modelling	84
		C Treatment modelling	88
		D Safety in Design assessment	96
		E Full costing details	100
Appendix F Functional Design Package (attached separately)			121

# Figures

Figure 1. S	Site overview	2
Figure 2. (	G-MW drain at Poplar Ave, looking south	5
Figure 3. (	GMW drain at Poplar Avenue	5
Figure 4. (	G-MW irrigation supply channel	5
Figure 5. <i>I</i>	Decommissioned G-MW channel along Channel Rd	5
Figure 6. <i>I</i>	Retarding basin at Perrivale Drive	6
Figure 7. <i>I</i>	Example of good wetland at Archer Rd and Oxbow Ave	6
Figure 8. <i>I</i>	Drain 5 outfall (end of McPhees Rd)	6
Figure 9. <i>I</i>	Broken river (looking south – towards Kialla) at drain 5 outfall	6
_	Topography	7
_	Existing G-MW assets	8
_	G-MW assets (source: G-MW, 2021)	9
_	3 3	10
_	• • • • • • • • • • • • • • • • • • • •	11
_	,, , , ,	12
_		13
_		14
_		15
_		16
Ū		19
-		21
-		22
_		23
-	3, 7, 7,	24
_	3 // /	25
Figure 26.	Cardno's drainage strategy	26
-		27
_	3 3, 1 ( )	32
_		36
_	,	40
	RBWL1 1% AEP hydrograph for critical storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)	43
Figure 32.	RBWL2 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated	
-	temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the	
	basin)	43
	RBWL3 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated	
	temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the	44
	,	44
	RBWL4 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)	44
-	RBWL5 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the	
	,	45
-	RBWL 6 1% AEP hydrograph for critical storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)	45
		46
Figure 38.	Inflows from external catchments (relevant flows highlighted in red) (Shepparton South East Precinct	
	, , , , ,	50
_		53
Figure 40.	MUSIC schematic for treatment assets	56

Figure 41. Wetland 6 inundation frequency results	59
Figure 42. Spiire drainage strategy for the Shepparton South East Precinct (2014)	73
Figure 43. Cardno drainage concept layout (2020)	76
Figure 44. Results of RORB model with various Kcs, compared to rational method calculation	87
Figure 45. Simplified MUSIC Method	89
Figure 46. Wetland 1 inundation frequency results	90
Figure 47. Wetland 2 inundation frequency results	91
Figure 48. Wetland 3 inundation frequency results	92
Figure 49. Wetland 4 inundation frequency results	93
Figure 50. Wetland 5 inundation frequency results	94
Figure 51. Wetland 6 inundation frequency results	95
Tables	
Table 1. Geotechnical conditions	17
Table 2. Sub catchments	38
Table 3. 1% AEP RORB modelling results	41
Table 4. Allowable maximum discharge (1.2L/s/ha discharge requirements)	42
Table 5. Retarding basin requirements	42
Table 6. Retarding basin analysis (climate change scenario)	48
Table 7. Required increased outflow rates for WLRB2 to WLRB5 in a climate change scenario	48
Table 8. Wetland 1 MUSIC modelling results	56
Table 9. Wetland 2 MUSIC modelling results	57
Table 10. Wetland 3 MUSIC modelling results	57
Table 11. Wetland 4 MUSIC modelling results	57
Table 12. Wetland 5 MUSIC modelling results	57
Table 13. Wetland 6 MUSIC modelling results	57
Table 14. Overall PSP treatment modelling results	58
Table 15. Wetland outlet properties and residence time results	58
Table 16. Sediment basin calculations	60
Table 17. Sediment basin batters	60
Table 18. Wetland batters	61
Table 19. Velocity calculations	62
Table 20. Wetland dimensions and parameters	63
Table 21. Cost estimate summary for the proposed works	67
Table 22. Comparative analysis of basin approach and waterway approach	77
Table 23. Comparative analysis of basin approach and alternative basin approach	81
Table 24. RORB models and parameters used	85
Table 25. Summary of Kc calibration flows for the 1% AEP	87
Table 26. Design Safety Assessment - Buildability	97
Table 27. Design Safety Assessment - Maintainability	98
Table 28. Design Safety Assessment – Useability	99

### 1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) has been engaged by the Victorian Planning Authority (VPA) in partnership with Greater Shepparton City Council (GSCC) to undertake the stormwater/drainage functional designs and associated cost estimates for the Shepparton South East Precinct Structure Plan (PSP).

The purpose of the project is to produce functional designs and associated schedule of quantities and budget estimate of the assets required within the PSP. This allows the VPA and stakeholders with the confidence that the system can adequately function as intended, as well as more accurately identifying the required infrastructure, land take, maintenance requirements, and associated costs. Ultimately this project will allow for the finalisation of the Precinct Structure Plan and a Development Contributions Plan (DCP) for the Shepparton South East Precinct.

Underlying the objective to have cost-effective stormwater management strategies is the desire to provide robust, sustainable assets which adequately treat and retard stormwater, protect receiving environments, and provide biodiversity, health and amenity outcomes. Any proposed assets should provide multiple benefits, beyond stormwater management alone.

This report summarises existing conditions and issues as they pertain to stormwater management in the project area, as well as issues and constraints that may impact upon the implementation of future water management strategies in a post-development scenario. This report documents the analysis undertaken to develop the assets into functional designs.

### 1.1 Location

Shepparton South East PSP applies to approximately 385 hectares of land located to the south-east of the Shepparton CBD, south of Midland highway, west of Doyles road and north of the Broken River. The growth corridor is provided in Figure 1. The precinct will provide up to 2,500 homes for a population of more than 6,000 to the south east of Shepparton's existing urban structure. The precinct is the largest of Shepparton-Mooroopna's growth corridors.

Due to the particularly flat topography, a number of Goulburn-Murray Water (G-MW) channels and the relatively high-water table, drainage represents a significant challenge to the development of land. There are several G-MW channels and drains dissecting the site.

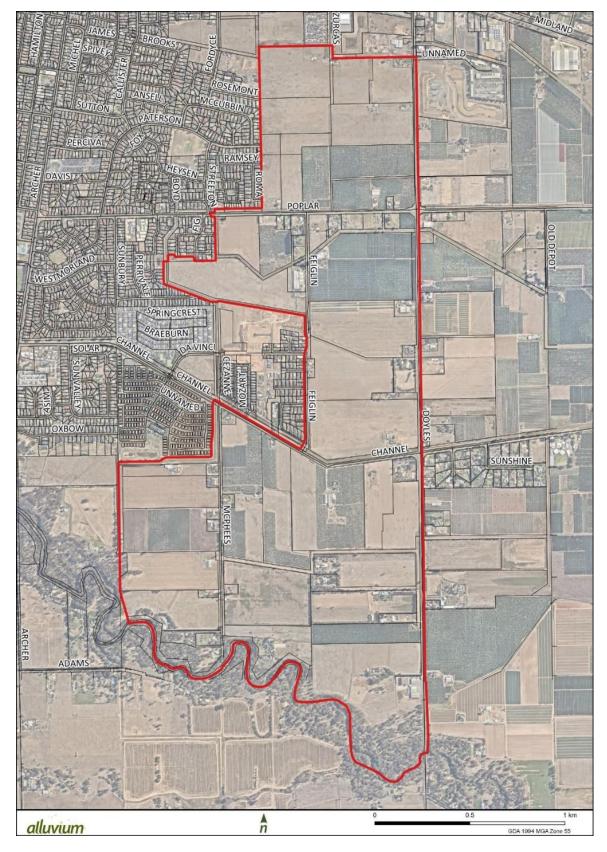


Figure 1. Site overview

### 1.2 Background

Greater Shepparton City Council (GSCC) is the local drainage authority for all urban land in the region, while the Goulburn Broken Catchment Management Authority (GBCMA) is the floodplain manager. The GBCMA manages the catchments and waterways in the region. G -MW is the drainage authority for rural areas of the municipality within the G-MW Drainage District. Together, they are key stakeholders (along with traditional owners, community/landowners) to this project.

Spiire were engaged by Council in 2012 to develop a drainage strategy for the precinct. Several iterations of the proposed design resulted in a series of retarding basins which outfall either directly to the Broken River, or to G-MW drains. The designs were developed into functional designs with associated costs estimates.

Cardno were subsequently engaged by the VPA in 2020 to undertake an alternate stormwater drainage investigation which focussed on a constructed waterway option (South East PSP - Stormwater Drainage Investigation Strategy). The concept identified several wetland/retarding basins, as well as a network of waterways throughout the PSP. The main waterway flowing north to south includes linear wetlands within the waterway. The Cardno report recommended further functional design work be undertaken for the constructed waterway to determine connections to the Broken River and the internal drainage network within the precinct.

The first stage of Alluvium's engagement was to undertake a 'Proof of Concept' assessment. The 'Proof of Concept' report documented the site context for the growth corridor, previous drainage investigations, background investigations which may influence drainage options, and stakeholder feedback on previous drainage strategies. Alluvium reviewed the drainage strategies prepared by Spiire (2014) and Cardno (2020). Building on this existing work, Alluvium provided an alternative concept strategy for the VPA and Council. The recommendations were based on potential efficiencies in land take and cost, which are particularly important in such a complex drainage environment in order to allow development to viably proceed.

Following feedback from stakeholders, the agreed concept design was developed into functional designs. This report documents those functional designs. The preferred drainage strategy, as documented in the Proof of Concept report, is provided in Section 4 of this report. Additional extracts from the Proof of Concept report, including the detailed review of the Cardno and Spiire strategies and the comparative analysis, are provided in Appendix A.

## 1.3 Strategic context

Shepparton township has been identified in the *Hume Regional Growth Plan 2014* as a regional city and major growth area for the region; and identified as one of ten regional cities in Victoria where significant growth will be supported under *Plan Melbourne 2017-2050*.

Planning for growth in Shepparton has been driven by the *Shepparton & Mooroopna 2050 Regional City Growth Plan* (GSCC and VPA, 2020). It is recognised that water has been a key influence on the development of this region, through both pioneering irrigation practices that have enabled the towns' growth and the significant flooding that has affected the area in 1916, 1974 and 1993. The sustainable management and use of surface waters (runoff) in the landscape, and the appropriate guidance for urban development adjacent to riverine floodplains, are vital to the continued growth and water resilience of the region.

Similarly, the IWM Forum vision for the Goulburn Broken has a focus on *Working together through sustainable* water management to enhance urban landscapes and maximise amenity, environment, and economic outcomes for our communities. In our experience with other IWM plan and PSPs, a clear and shared vision is critical in setting the focus and achieving intended outcomes.

The following summarises key strategic documents that are directly relevant to, will influence, and/or align with key outcomes of this project and the vision for the Shepparton South East PSP.



### Shepparton & Mooroopna Regional City Growth Plan (2020)

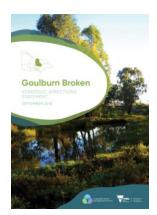
Council and the Victorian Planning Authority (VPA) developed the Shepparton & Mooroopna 2050 Regional City Growth Plan to provide a vision and guide the sustainable development of these areas to the year 2050.



### **Greater Shepparton Housing Strategy 2011**

The GSHS was prepared to guide the long-term identification and provision of residential land with the City of Greater Shepparton. The strategy was embedded in the Greater Shepparton Planning Scheme in 2012 via Amendment C93.

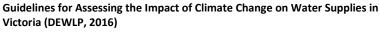
Amendment C93 includes framework plans and identified residential Investigation Areas in the Planning Scheme to guide future development, subject to further investigations.



#### IWM Forum – Strategic Directions Statement (SDS) (2018)

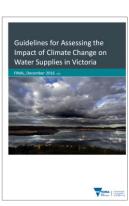
The SDS has a region-specific vision, outcomes, objectives, and priority actions. Collaboration between Traditional Owners, Councils, Water Corps, CMAs, and DEWLP, with representatives from a cross section of these institutions has led to shared ideas, buy-in, and momentum. Opportunities identified through this project will demonstrably align with the following outcomes and their associated objectives:

- 1. Safe secure and affordable supplies
- 2. Effective and affordable wastewater systems
- 3. Reduced flood risks
- 4. Healthy and valued waterways, and Gippsland Lakes
- 5. Healthy and valued urban landscapes
- 6. Community values are reflected in place-based planning.
- 7. Jobs, economic benefits and innovation



This document provides a guideline for planning for climate variability and climate change, translating Global Climate Models into projections for Victorian river basins. The document can inform the Shepparton South East PSP through assessment of future system reliability, urban water strategy planning and drought preparedness. The combined decrease in rainfall and increase in temperatures will result in a larger impact on runoff of 15.6%. Aquifer recharge will also be impacted. This modelling and DELWPs recommendations will guide our understanding of issues, particularly for systems that are at risk with a reduction to rainfall and

This modelling and DELWPs recommendations will guide our understanding of issues, particularly for systems that are at risk with a reduction to rainfall and runoff, and our considerations of the effectiveness of climate dependant alternative water sources (such as rainwater and stormwater harvesting).



# 2 Existing conditions

### 2.1 Site visit

A site visit was undertaken on Friday 7<sup>th</sup> May, attended by various Alluvium, VPA and Council staff. The site visit was an opportunity to gain an appreciation of the precinct, identify site values and constraints, and receive input from the VPA and Council on desired outcomes, as well as feedback on previous strategies.

The precinct is characterised by G-MW assets, which is further discussed in Section 2.3. This includes drains which eventually outfall to the Broken River, some of which are now surrounded by residential areas. These drains currently provide very little amenity outcomes, with residential fences bordering the drains, no formal paths, and litter and weeds within the drains (Figure 2). Many of the newer residential areas bounding the western side of the South East PSP eventually outfall into drain 2.





Figure 2. G-MW drain at Poplar Ave, looking south

Figure 3. GMW drain at Poplar Avenue

The precinct also currently includes G-MW channels (Figure 4), which will be decommissioned. Examples of where these decommissioned channels have been converted into treatment and detention assets are shown in Figure 5. All along Channel Road (to the west of the precinct) the previous channels have been transformed into a variety of assets which include, wide green spaces with vegetated swales, forested green spaces, and what appears to be detention systems with rocked bunds and bioretention elements in the base. These would then outfall into the G-MW drains. Collectively, these assets are providing a linear blue-green corridor with recreational opportunities.



Figure 4. G-MW irrigation supply channel



**Figure 5.** Decommissioned G-MW channel along Channel Rd

An example of a less than desirable stormwater management outcome was visited at the end of Perrivale Drive, right on the western boundary of the precinct (Figure 6). The retarding basin is fenced off, full of weeds and provides no recreational opportunities or amenity. This asset could be greatly improved through some landscaping and opening it up to the community (safely). There is an opportunity to create a community destination here, linking this asset to the proposed retarding basin on the eastern side of the drain (within the precinct). This is discussed further in the preferred drainage strategy (Section 7).

A good example of a stormwater management asset (wetland) was visited at Archer Rd and Oxbow Ave, to illustrate a well-utilised community asset (Figure 7).

The G-MW Drain 5 outfall was also visited at the end of McPhee Road. Where possible, Council and the CMA would like to see outfalls into the Broken River minimised, and existing outfalls used (Figure 8 and Figure 9).



Figure 6. Retarding basin at Perrivale Drive



Figure 8. Drain 5 outfall (end of McPhees Rd)



**Figure 7.** Example of good wetland at Archer Rd and Oxbow Ave



**Figure 9.** Broken river (looking south – towards Kialla) at drain 5 outfall

# 2.2 Topography

The precinct has incredibly flat terrain, with elevations ranging from 115m AHD (eastern boundary) to 113m AHD (western boundary). The catchment falls gently in a south westerly direction towards the Broken River. There are localised raised areas where irrigation supply channels are located. These form barriers to overland flows, which is why the irrigation channels often form the catchment boundaries.

An overview of the topography is presented in Figure 10.

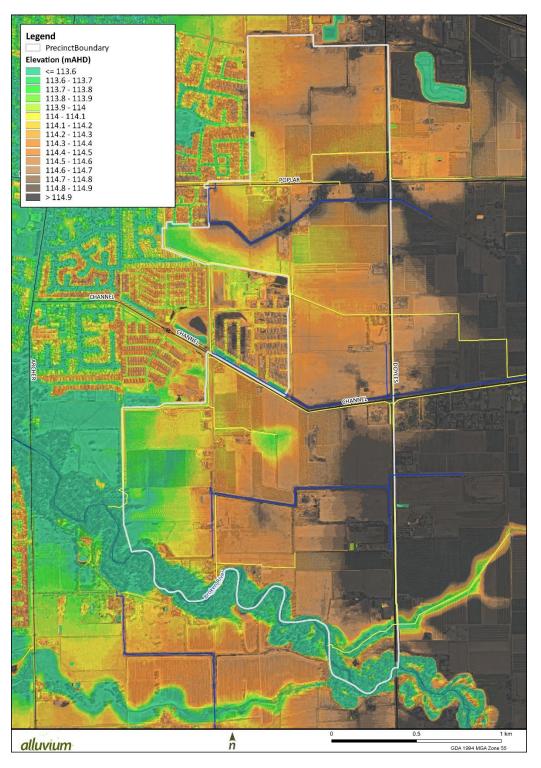


Figure 10. Topography

# 2.3 Existing services and infrastructure

The site contains numerous G-MW assets consisting of irrigation supply channels and drains (Figure 11 and Figure 12 for all G-MW infrastructure). The irrigation channels for rural supply within the precinct will be decommissioned as the precinct develops into an urban landscape. The G-MW drains bringing flows from the eastern rural areas will need to have continued service in some form as the site develops, as these flows currently traverse in a westerly direction and ultimately south where they outfall to the Broken River. Further to this, the existing residential areas bounding the western side of the precinct currently outfall to drain 2 via retarding basins (Figure 13). The continued service of these drains and G-MW's discharge requirements into these drains (1.2L/s/ha) therefore greatly influence drainage options for this precinct.

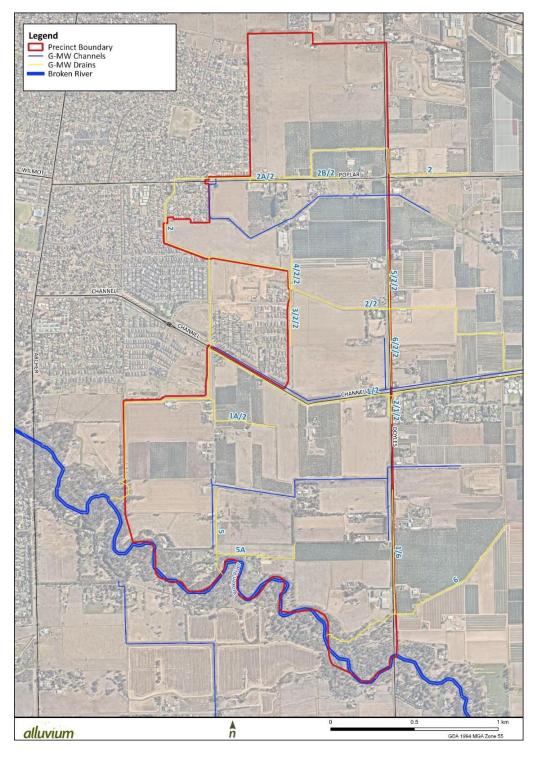


Figure 11. Existing G-MW assets

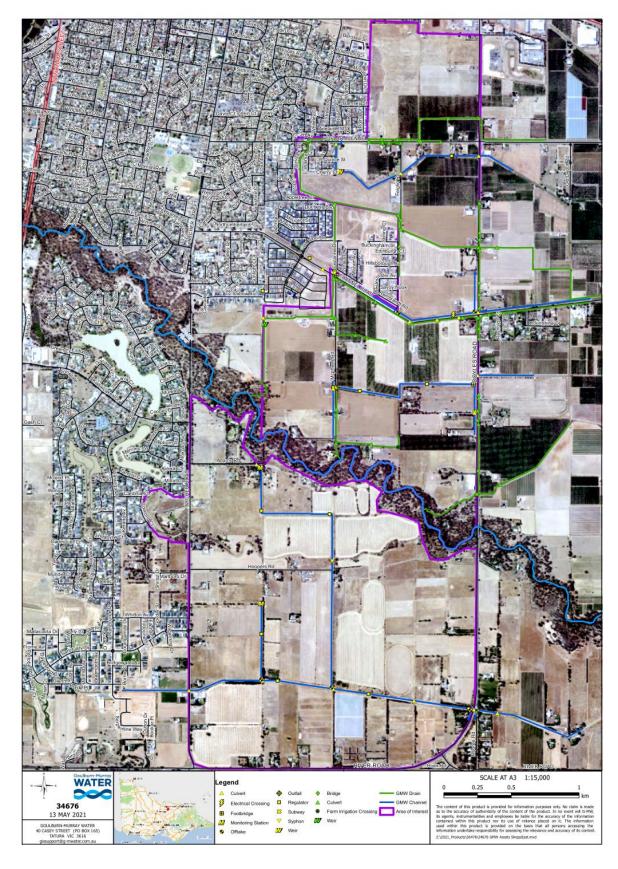
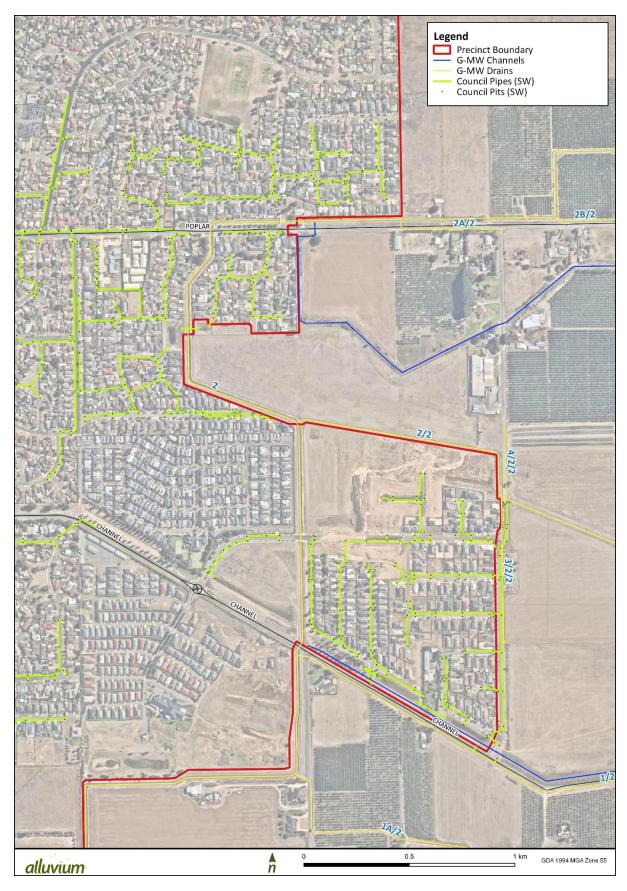


Figure 12. G-MW assets (source: G-MW, 2021)



**Figure 13.** Stormwater assets discharging into G-MW drain 2

### 2.4 Catchments

Spiire (2014) delineated six sub catchments within the precinct based on contours and existing G-MW assets (drains) for outfall. Cardno used the same catchment delineation in 2020 to prepare the alternative drainage strategy. Refer to Figure 14 for catchment delineation within the precinct. External catchment flows which move through the precinct are discussed further in section 6.5.

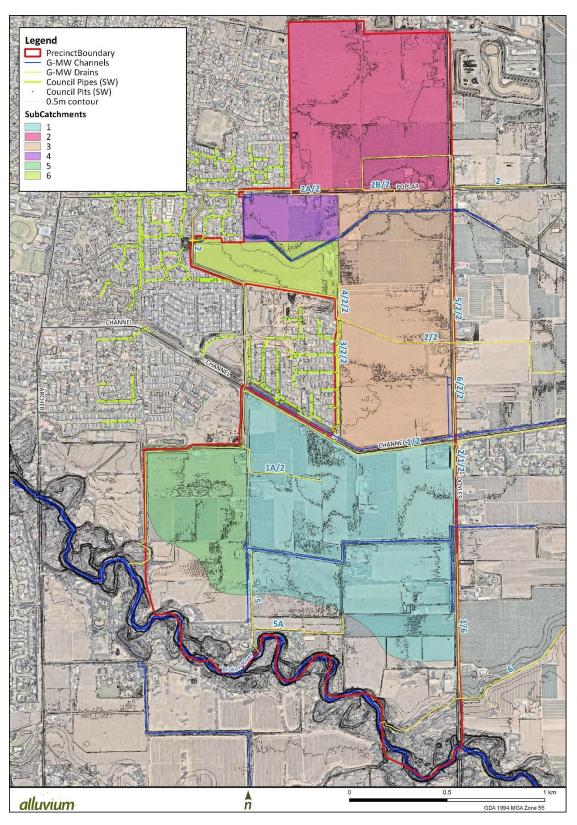


Figure 14. Catchments within Shepparton SE PSP

### 2.5 Flora and fauna values

Council commissioned Hansen Partnership in 2009 to prepare the Shepparton South East Growth Area Structure Plan (the Structure Plan). Ecology Partners Pty Ltd were subcontracted by Hansen Partnership to identify key ecological values within the study area and determine future opportunities for the area based on a site assessment and a review of previous flora and fauna investigations.

- DSE 2005 EVC mapping identified two Ecological Vegetation Classes (EVCs):
  - Plains Woodland (EVC803) over the majority of the study area
  - o Floodplain Riparian Woodland (EVC56) along the Broken River
- The lower Broken River is listed on the Directory of Important Wetlands in Australia (VIC 051).
- Indigenous vegetation varies in condition from poor to medium and includes numerous scattered remnant Eucalypt trees.
- No nationally significant fauna or flora taxa listed under the EPBC Act were recorded during the assessment
- One species of state significance, the Brown Toadlet was recorded during the survey (Figure 15).
- There is native vegetation and fauna habitat along the Broken River (Figure 16). Proposed drainage options should seek to protect this vegetation.

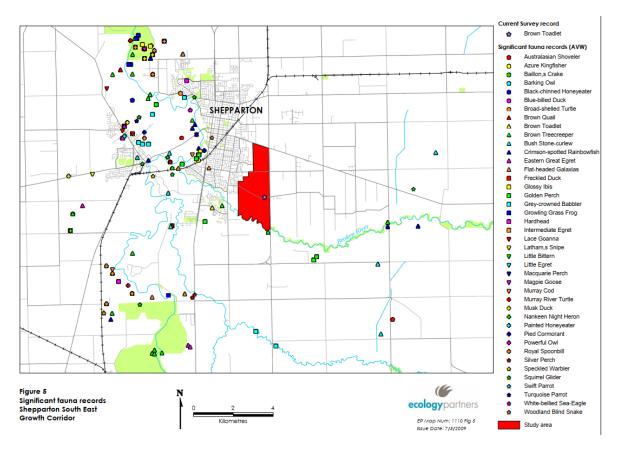
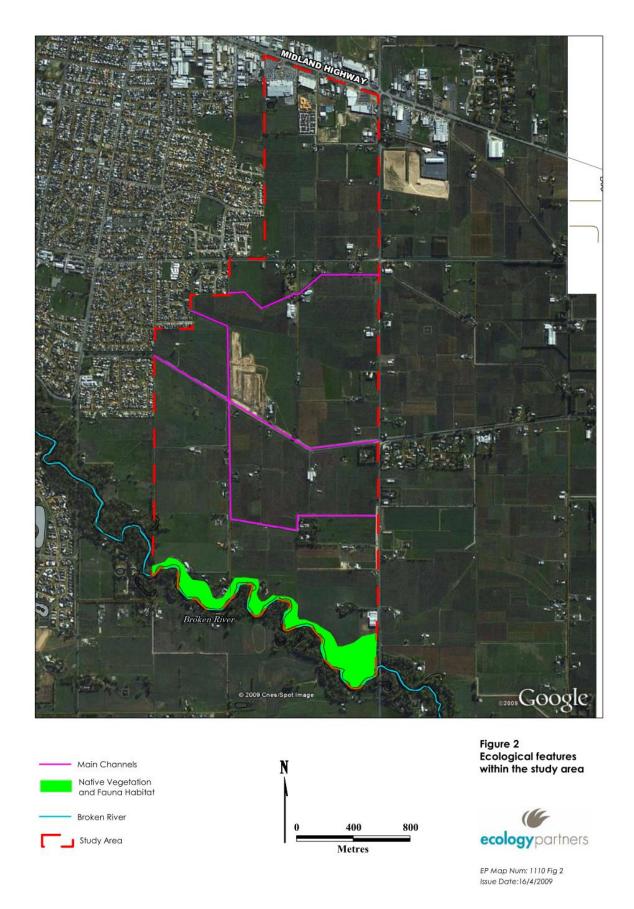


Figure 15. Fauna records at Shepparton SE (Ecology Partners, 2009)



**Figure 16.** Ecological features within the study area (Ecology Partners, 2009)

# Biodiversity Assessment for the proposed Shepparton South East Precinct Structure Plan – Ecology and Heritage Partners (December, 2021)

Council commissioned Ecology and Heritage Partners Pty Ltd to undertake the biodiversity assessment for the Shepparton South East Growth Area Structure Plan (the Structure Plan). The assessment method covers a desktop assessment covering relevant literature and online database and field assessment to obtain and validate information of flora and fauna values within the study area. The findings of assessment established that >80% of the study area is dominated by non-native vegetation and disturbed. The report recommends that the study area cater the medium and longer term development of Shepparton precinct while maintaining the key ecological values present.

As the report was provided to Alluvium after the submission of draft functional design report, we have not considered the implications of assessment in our design strategy. However, the assessment results appear not to influence the proposed strategy. Subsequent design stages should incorporate these results and the mapping of scar trees and other trees to protect, particularly in the Broken River corridor. This may influence outfall alignments.

## 2.6 Cultural heritage

The Yorta Yorta (or Jotijota) Nation of First Peoples are the traditional owners the area that spans the Murray River from north-eastern Victoria to southern NSW (refer map below; source: YYNAC website). It extends to the townships of Cohuna to the west, Albury-Wodonga to the east, just north of Euroa to the south, and Jerilderie (88kms NE of Deniliquin) to the north. The Yorta Yorta people have a continuing connection to the lands and waters of this region, within which Shepparton (the study area) fall within.

The Yorta Yorta are river-based people, their lifestyle and culture is centred around the forest-wetlands where the majority of their food supply was sourced from the network of local rivers, creeks, wetlands and billabongs of the central Murray-Goulburn region. The work of the Yorta Yorta Nation Aboriginal Corporation (YYNAC) is captured in the Yorta Yorta Whole-Of-Country Plan 2021-2030. Their feedback and input to this project is critical.

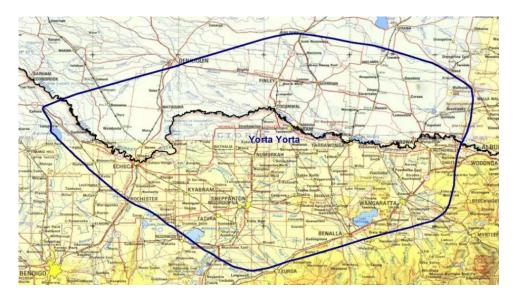


Figure 17. Yorta Yorta Country (source: GBCMA website)

An Aboriginal cultural heritage due diligence assessment has been prepared by Jo Bell Heritage Services in 2019 as a part of the Shepparton South East Precinct Structure Plan.

• There are two areas within the precinct boundary that are specified in the Regulations as areas of cultural heritage sensitivity (Figure 18 and Figure 19).

- Aboriginal cultural heritage in the surrounding region largely focused on the Goulburn and Broken Rivers and the Seven Creeks.
- No Aboriginal cultural heritage has previously been identified within the precinct boundary.

If part of an area of cultural heritage sensitivity (other than a cave) has been subject to significant ground disturbance, that part is not an area of cultural heritage sensitivity (Aboriginal Victoria n.d.).

'Significant ground disturbance' is defined in r.4 of the Regulations as meaning disturbance of:

- a) the topsoil or surface rock layer of the ground; or
- b) a waterway by machinery in the course of grading, excavating, digging, dredging or deep ripping, but does not include ploughing other than deep ripping.



Figure 18. Site 1 Poplar Avenue - Cultural Heritage Sensitivity (CHS) (Jo Bell, 2019)

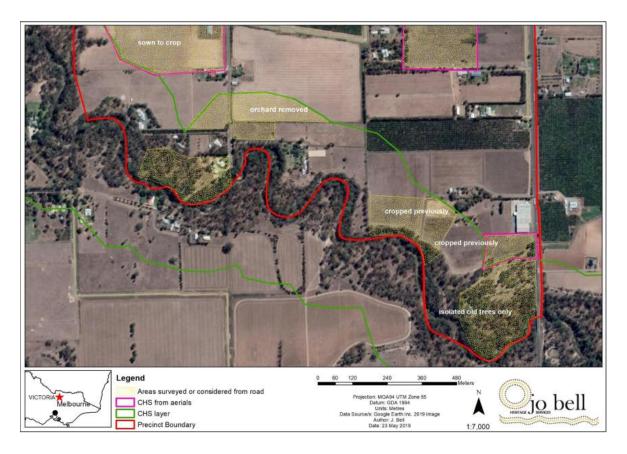


Figure 19. Site 2 Broken River - Cultural Heritage Sensitivity (CHS) (Jo Bell, 2019)

### 2.7 Geotechnical conditions

Spiire, on behalf of Council, commissioned Geotechnical Testing Services (GTS) in 2014 to undertake a geotechnical investigation for the proposed six retardation basins throughout the precinct. The location of the basins is provided in Figure 21.

A summary of geology and groundwater data is presented in Table 1. The results indicate the soils is comprised primarily of sandy silt and silty clay. Groundwater was generally not encountered up to 6m depth.

Table 1. Geotechnical conditions

Site*	Geology	Historic Ground Water (GW) data	Fieldwork Ground Water data
RB1	Sandy Silt (up to 0.2 m) Silty Clay (0.2m-6m)	4.5m to 6.35m (1995)	BH4 – 3.5m Others – 6m
RB2	Sandy Silt (up to 0.2 m) Sandy Silty Clay Silty Clay Gravelly Sandy Clay (BH3)	6.5m to 6.9m (2000)	No GW traces up to 6m.
RB3	(Clayey) Sandy Silt (Sandy) Silty Clay	3.6m to 5.9m (1991)	No GW traces up to 6m.
RB4	Sandy Silty Clay (BH1) Silty Clay (BH1) Sandy Clay (BH1) Clayey Sand (BH1) Clayey Sandy Silt (BH2&3) Silty Clay (BH2&3)	0.5m to 2.5m (1995)	BH1 – 2.6m BH2&3 - No GW traces up to 6m
RB5	Sandy Clayey Silt Silty Clay	1.2m to 1.3m (1995)	No GW traces up to 6m.
RB6	Silty Clay Sandy Clay		No GW traces up to 6m.

<sup>\*</sup>Spiire's original RB locations and naming, which differs to Alluvium's strategy.

This geotechnical analysis, in particular the groundwater levels, has been adopted when developing up the revised stormwater asset functional designs. Given some of the assets proposed as part of Alluvium's strategy differ in location, a conservative estimation of groundwater levels has typically been adopted. That is, overall retarding basin depth has been minimised where possible, whilst still achieving the storage requirements.

Detailed geotechnical investigations should occur prior to the development of detailed designs to confirm ground conditions and groundwater levels. Should a higher groundwater level be established, the wetland pools and sediment basins could be reduced in depth.

# 3 Existing drainage and flooding studies

Council and the Victorian Planning Authority have undertaken a number of drainage assessments in the last ten years. Alluvium has summarised key drainage strategies below that are relevant to the precinct and will influence drainage options. More detailed summaries of the Spiire and Cardno drainage strategy are provided in Appendix A (extracted from the Proof of Concept report)

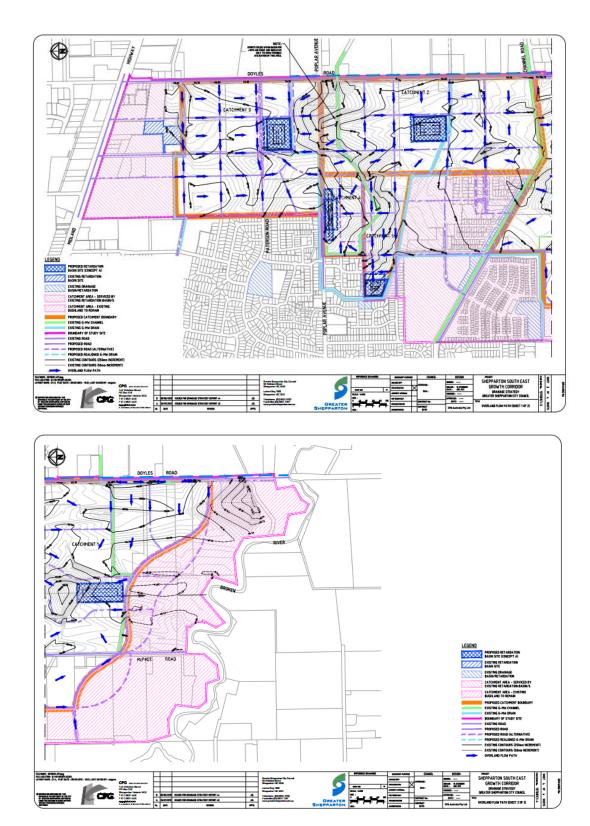
### **Shepparton South East Growth Corridor Drainage Strategy (CPG, 2012)**

The drainage strategy study area was located south east of Shepparton encompassing approximately 481 hectares and bounded by Benalla Road to the north, Doyles Road to the east, to the south by the Broken River and existing residential areas to the west. This was a concept-level study (Figure 20).

- Five drainage catchments were identified based on the existing contours of the catchment, and road alignments.
- Storage requirements to cater for each catchment were achieved via a retarding basin.
- Storage requirements for each retardation basin considered the 1 in 100 year ARI storm event of 24 hour duration having a maximum discharge rate of 1.2 L/s/ha.
- A gravity piped drainage network was designed with an outfall to the retarding basin.
- Water quality treatment objectives were achieved through proposing bioretention systems/ wetlands at the base of the retarding basin.
- As advised by Council, the study assumed all existing G-MW rural drains within the study area would become Council assets and will be maintained or re-aligned as part of the future development.
   Existing rural drainage east of the study area would be redirected to outfall into a new Goulburn-Murray Water drain along the east side of Doyles Road and no rural drainage would be directed through the study area.
- The study noted that a larger retarding basin footprint may be required if a wetland was incorporated in the base, as opposed to a bioretention system. It also noted that Council had indicated that using a wetland is their preferred stormwater treatment measure.

Alluvium notes that Spiire was formerly CPG, and as such the locations of the proposed assets are very similar to those subsequently proposed in the Spiire drainage strategy (2012-2014), as are the catchments.

Alluvium also notes that typically bioretention systems are not recommended within retarding basins. This is because they can experience prolonged wetting, with algae forming thick surface biofilms, which in turn reduces the rate of infiltration into the filter media and causes clogging.



**Figure 20.** CPG concept drainage strategy overview showing overland flow paths (CPG, 2012)

# Shepparton South East Growth Corridor Review of Revised Structure Plan inclusion of Drainage Strategy (Spiire, 2014)

Over the next couple of years (up to 2017), the drainage strategy for the South East PSP was refined by Spiire.

Six catchments were delineated based on the existing conditions and constraints of the growth corridor. Drainage of each catchment was proposed to be via a gravity piped system to outfall to retardation basins (6 in total). These were sized to cater for the storage requirement to detain the 1% AEP storm event and were proposed to be located at the lowest point in each catchment, close to the G-MW drains where each basin will ultimately outfall. The six retardation basins are shown in Figure 21.

Outfall to the G-MW drains from the basins are, however, subject to requirements from GM-W which allows a maximum discharge of 1.2L/s/ha. Additionally, basins are required to retard stormwater from discharging for the 24-hour storm event. This requirement results in retarding basins that are larger than standard retarding basins where maximum discharge is equal to the pre-developed peak flowrates.

The changes from the CPG strategy show that:

- The rural flows from the east of the precinct were no longer proposed to be diverted south along the
  eastern side of Doyles Road. Instead, the drains would remain in place and transfer flows across the
  precinct.
- The catchment south of Channel Road was broken into two catchments, and two separate wetland/retarding basins were proposed to manage stormwater within those catchments (RBWL1 and RBWL6).
- The rural drain south of Channel Road (running parallel) was proposed to be piped and diverted into RBWL1. This would result in the wetland treating external rural flows.

Spiire subsequently undertook functional designs for each asset, with the final designs being completed in November 2017. The design package included functional design drawings, landscape plans, drainage pipeline plans and a cost estimate.

Refer to Appendix A for more details and a review of the strategy.

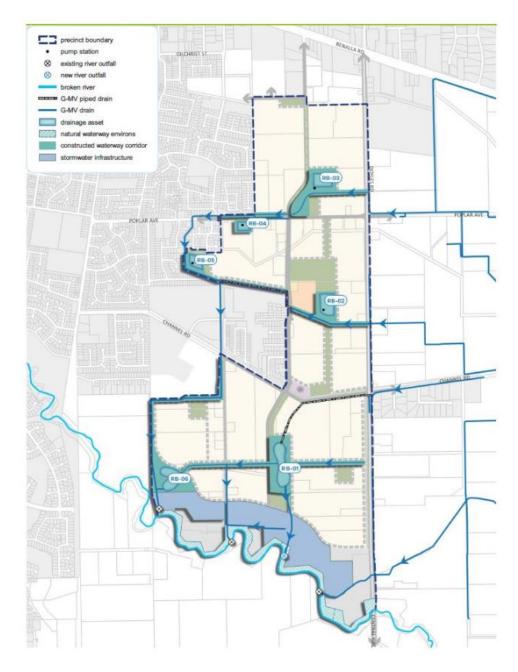


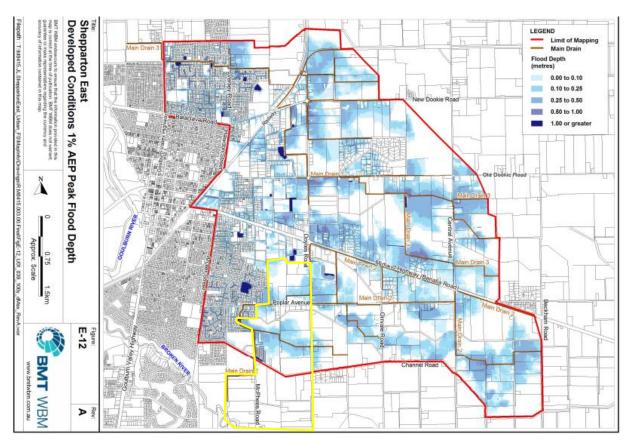
Figure 21. Spiire's drainage strategy (2014)

# Shepparton East Overland Flow Urban Flood Study (BMT WBM, 2017)

- BMT WBM were commissioned by the GBCMA to undertake a study for the area east of Shepparton and north of Channel Road. The study required the development of both hydrologic and hydraulic models to undertake flood mapping of the area.
- A RORB hydrologic model and TUFLOW hydraulic model were built. The results were used to develop flood mapping products to undertake a flood damage assessment, and to inform potential flood mitigation strategies.
- The modelling established existing conditions flood information (20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events), as well as testing for increased urbanisation and climate change scenarios.
- Storm data was generated using Intensity Frequency Duration (IFD) parameters sourced from the Bureau of Meteorology IFD program (Bureau of Meteorology, 2012). A climate change scenario assuming a 32% increase in rainfall intensity was also run.

- The RORB model was calibrated to the Rational Method as the catchment is ungauged. It is understood that ARR 1987 was adopted for this study, not the latest ARR2016 (which was updated again in 2019).
- An initial loss (IL) of 15mm and a continuing loss (CL) of 2mm/hr was adopted for agricultural areas, and an IL of 10mm and CL of 2mm/hr was adopted for urban areas.
- The study indicates that the existing peak 1% AEP flow at the drain 2 outlet is 20.1 m<sup>3</sup>/s. A map of the entire drain 2 catchment is provided in Appendix A (Figure 23).
- The study did not look at proposed development changes within the Shepparton SE PSP itself (the changes land use changes were outside the PSP).

The modelling results relevant to the PSP (shown in a yellow outline in Figure 22) show overland flows coming from Doyles Road, generally following drain 2/2. Along the western boundary of the PSP, at Poplar Ave, there also appears to be a large area subject to inundation.



**Figure 22.** Shepparton East Overland Flow Urban Flood Study 1% AEP developed conditions results (BMT WBM, 2017)

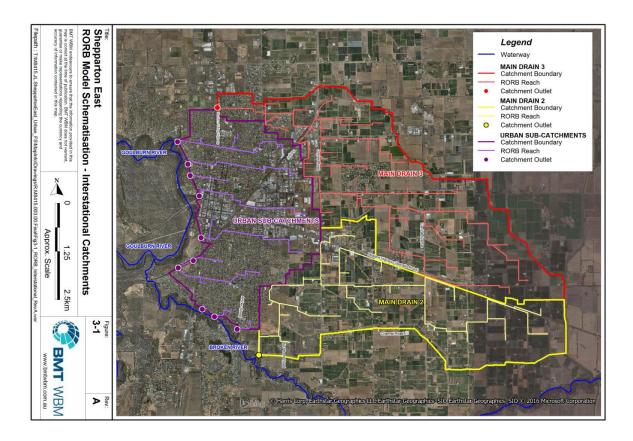
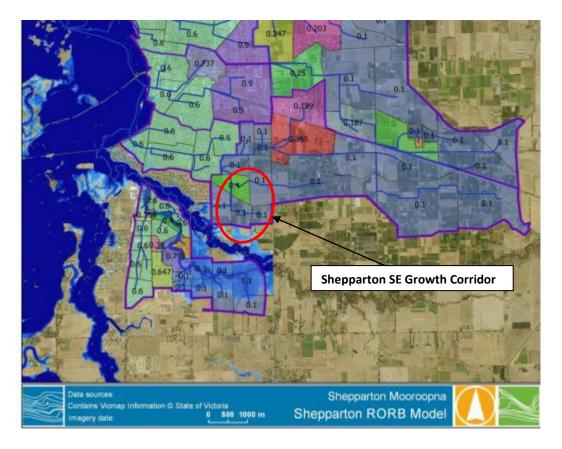


Figure 23. Drain catchments (Shepparton East Overland Flow Urban Flood Study, BMT WBM, 2017)

# Shepparton Mooroopna Drainage Catchment Analysis and Strategy (Water Technology, July 2018)

Water Technology was engaged by GSCC and the VPA to undertake a study that considered the impact of flooding and drainage on development in the Shepparton-Mooroopna area. The study looked at how considered development might improve flooding, drainage, water quality, amenity and IWM opportunities. The intent of the study was to help inform planning for the area by defining catchment areas.

A hydrological model was built (RORB) to estimate peak flows for existing and developed conditions. The Shepparton South East growth corridor was not specifically covered by the high-level development assessments that were undertaken. However, the RORB model built does include this area (shown approximately in red), as shown in Figure 24 below.



**Figure 24.** RORB model arrangement for the Shepparton area (Water Technology, 2018)

The study did not include detailed hydraulic modelling but did include high-level rainfall-on-grid modelling to help define catchment boundaries and areas of ponding. Riverine flooding was not revisited.

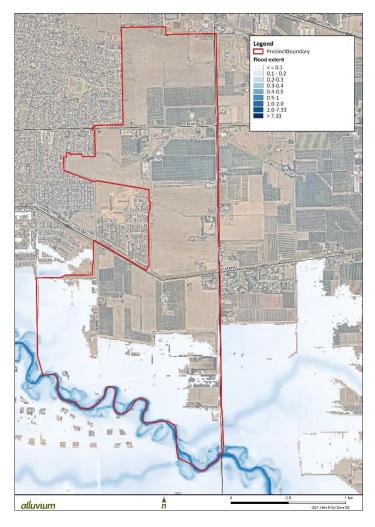
Some findings and considerations relevant to this project are:

- If discharging to GMW drains, there is a requirement to retard flows back to 1.2L/s/ha. The cost of land required to meet this is significant this study found that it is roughly 40-60% costlier than retarding to pre-development discharge rates.
- ARR1987 guidelines were adopted for the study, including 1987 IFD data.
- The Rational method was used to calibrate the model.
- An IL of 24mm and a CL of 4.6mm was adopted (as per the latest revision of ARR i.e. 2016). The report noted this CL was considered high compared to industry practice.

### Shepparton Mooroopna Flood Mapping and Flood Intelligence Study (Water Technology, March 2019)

- The Shepparton Mooroopna Mapping and Flood Intelligence Study provides a technical review and update to the previous flood study done by SKM in 2002. Water Technology was commissioned by Council to undertake this study.
- The flood mapping data is publicly available online through a mapping portal.
- The study involved detailed hydrologic and hydraulic (TUFLOW) modelling of the Goulburn River, Seven Creeks and the Broken River.
- Flood Frequency Analysis of available stream gauges was used in the hydrologic modelling.
- The report defines riverine flood timing.

The existing 1% AEP maximum flood depths relative to the PSP are shown in Figure 25 below.



**Figure 25.** Existing conditions 1% AEP (source of flood levels: Shepparton Mooroopna Flood Mapping and Flood Intelligence Study, Water Technology, 2019)

## Shepparton South East Precinct Structure Plan Stormwater Investigation Study (Cardno, 2020)

Cardno was commissioned by the VPA to undertake a stormwater investigation and propose an alternative drainage strategy to the previous drainage strategy proposed by Spiire (2014). The VPA, in collaboration with Council, sought the development of a constructed waterway option; a blue-green corridor.

The strategy includes a series of constructed waterways across the growth corridor, along with retarding basins (Figure **26**). It includes online wetland systems within the main north-south constructed waterway for water quality treatment. The primary advantage of this strategy was it removed the reliance on G-MW drain. Discharge into G-MW drains is required at the maximum rate of 1.2L/s/ha (24-hr storm) which can increase land take, reduce developable land, and increase DCP costs.

The strategy was only done to a concept level. A cost comparison was provided between the Spiire 'basin' strategy, and this constructed waterway approach. The cost comparison indicated that the constructed waterway approach had fairly similar costs, but required more excavation and more land take. However, the Spiire costs are based on functional designs, and the Cardno costs are based on concept designs. Therefore, the report recommended that any decision making on the viability of the constructed waterway approach not be made on costs alone.

Refer to Appendix A for more details on the strategy including a review of the strategy.

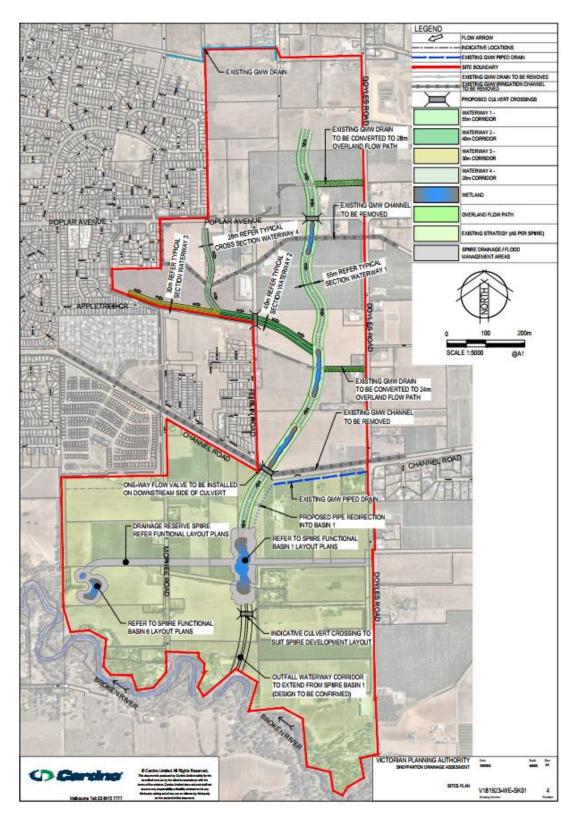


Figure 26. Cardno's drainage strategy

### Shepparton South East Precinct Hydraulic Modelling Report (BMT, 2020)

BMT were engaged by Council to undertake flood mapping of the Shepparton South East Precinct and to investigate the impacts that the PSP drainage design developed by Cardno will have on the precinct (Figure 27). The assessment was completed updating and modifying versions of the RORB and TUFLOW models originally developed for Shepparton East Overland Flow Urban Flood Study (BMT WBM, 2017).

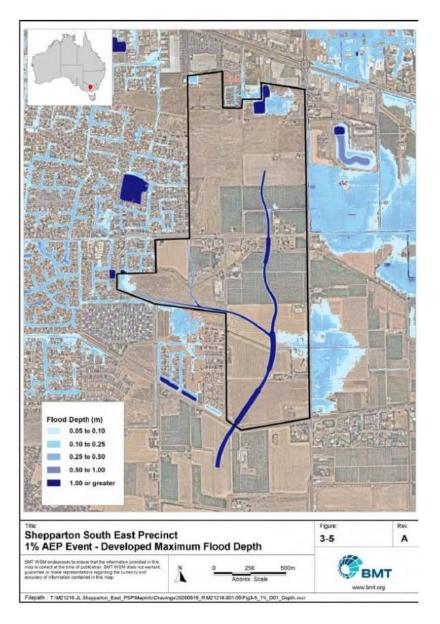


Figure 27. Shepparton South East Precinct Hydraulic Modelling Report (BMT, 2020)

- Hydraulic modelling was updated with new LiDAR data collected in 2019
- The RORB model was calibrated to the Rational Method as the catchment is ungauged. The existing RORB model (Shepparton East Overland Flow Urban Flood Study (BMT WBM, 2017) was updated to ARR 2019 guidelines.
- Update included change in fraction imperviousness, temporal patterns, and climate change scenario.
- Whilst design losses were changed significantly in ARR 2019, there is no information surrounding the
  testing of losses within the catchment, and to not differ significantly from the original model, which
  was calibrated using the adopted ARR 1987 losses, the previous modelling losses were used.

- An initial loss (IL) of 15mm and a continuing loss (CL) of 2mm/hr was adopted for agricultural areas, and an IL of 10mm and CL of 2mm/hr was adopted for urban areas.
- The modelling established existing conditions flood information (20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events), as well as testing for increased urbanisation and climate change scenarios.
- Existing TUFLOW model from the Shepparton East Overland Flow Urban Flood Study (BMT WBM, 2017) was used as the basis for hydraulic modelling of the study area for this assessment.
- Overall, the study confirmed that Cardno's proposed waterway design has the capacity to convey flows coming from the east of the Precinct, as well as the increased localised flows from within the Precinct itself.

# 4 Preferred drainage strategy for functional design

The following section has been extracted from the Alluvium's Proof of Concept report (August 2021). Additional detail on the review of the Cardno and Spiire strategies has been provided in Appendix A. For all details refer to the full report.

### 4.1 Stakeholder consultation

Alluvium received stakeholder input at both the project inception meeting, and the stakeholder meeting (May 7<sup>th</sup>) attended by the VPA, Council, G-MW, GBCMA and Goulburn Valley Water. The opportunities and feedback discussed are summarised below.

### Opportunity to push RBWL1 further south towards the Broken River, into the flood zone

- This would enable more developable land by pushing the asset into the Flood Zone. The asset could be rotated so to fit within the space available (i.e. orientate east-west, see sketch below for potential layout).
- GBCMA were open to exploring this opportunity so long as environmental values and cultural heritage values are considered, as well as the requirement for a 30m waterway corridor setback.
- The number of outfalls to the Broken River should be minimised where possible and seek to use existing outfalls such as Drain 5.
- Any change in RBWL1 location will need to consider the overland flows coming from the east when the 1% AEP overtops Doyles Rd.
- There are opportunities for improving the riparian areas next to the Broken River.

### G-MW assets through the site

- The G-MW channels will be decommissioned.
- There are two G-MW drains coming in from the east which will need to be catered for in any future design. This can either be via the continued use of the existing drains through the PSP (Spiire's approach), or by outfalling them into new waterways (Cardno's approach).
- A key consideration is that there are already residential areas to the west which outfall into drain 2.
   Therefore, this asset is going to need to be maintained. Given this 'waterway' already exists, and will need to stay, the approach of creating assets (RBWLs) which discharge into it appears to be a cost-effective one.
- Any future assets outfalling into G-MW drains need to comply with the 1.2L/s/ha discharge rule. This
  has a significant impact on retarding basin sizing compared with the usual requirement to hold back
  1% AEP peaks flows to pre-development flow rates. Opportunities to avoid discharging into these
  drains, or to further discuss the need for applying this 1.2L/s/ha rule need to be explored with
  stakeholders.
- There is an opportunity to have some sections of the G-MW drains as treatment/detention. This is something that has been explored as part of the Munarra development drainage strategy. The ownership and maintenance are then split between G-MW and Council.

### Other

- The approach should seek to minimise land take and costs and provide blue-green corridors where possible (as emphasised in the Cardno approach).
- There may be an opportunity to link in with the existing RB at Perrivale Drive and enhance this area. Council already has landscape designs for this asset.

Following the delivery of the first draft of this strategy, additional feedback was provided including:

- The expectation is that all G-MW drains except Drain 2 would be piped.
- The existing G-MW drain to the north of the Windsor Park Estate will be piped in the final stages of the development of this estate.

This influences the strategy and has been updated accordingly.

### 4.2 Design objectives

Based on discussions with stakeholders, as well as our understanding of stormwater management requirements, the following design objectives have guided our recommended approach:

- Given the complexity of the topography, and therefore associated costs, it is critical to minimise costs and land take where possible so to ensure a viable DCP cost.
- Treat stormwater to best practice guideline targets 80% Total Suspended Solids load removal, 45% Total Nitrogen and 45% Total Phosphorus.
- Manage stormwater quantity in a post-development scenario. This is either retarding flows back to peak pre-developed 1% AEP flow rates, or meeting G-MW's requirement of 1.2L/s/ha in a 24 hour event if outfalling into a G-MW drain.
- Ensure the continued serviceability of G-MW assets (i.e. catering for rural flows which currently enter the PSP at a number of locations in drains on the eastern boundary of the PSP.
- Remove G-MW open drains where possible (i.e. are there opportunities to remove them entirely, either through diverting flows or piping flows whilst still servicing external catchments?). The G-MW drains provide little in the way of amenity value as it stands.
- No adverse impacts on flood conditions.
- Provide for multi-objective outcomes in all stormwater management assets. Assets should seek to not
  only manage flooding and stormwater treatments, but to enhance biodiversity, improve amenity,
  provide recreational and health outcomes, and cooling and IWM opportunities.
- Minimise the number of outfalls into the Broken River and utilise existing outfalls where possible.
- Minimise the number of assets and maintenance requirements.

## 4.3 Summary of proposed design strategy

The recommended drainage approach is based on a thorough understanding of existing conditions (values and constraints), background investigations to date, stakeholder input, and a comparative analysis of the two previous strategies. Below is a summary of the proposed approach and the rationale, which builds off existing investigations. The concept plan is provided in Figure 28.

- Although new constructed waterways provide an opportunity for blue-green corridors, this approach
  is more expensive and results in a greater land take than a basin approach. Given this precinct is so
  constrained by costs, a basin approach is deemed more feasible in this instance. Multi-objective
  outcomes (improved amenity, biodiversity, recreational opportunities, cooling and health outcomes,
  and the option for future stormwater harvesting) can be provided through well-designed
  treatment/retarding basins which are connected to surrounding communities.
- Spiire's basin approach in the northern half of the precinct appears to be the most cost-effective one
  given Drain 2 will need to remain in a post-development scenario to service existing residential areas
  to the west of the precinct. Utilising this existing G-MW drain rather than constructing a new
  waterway is recommended. As stated previously, ultimately it would be beneficial to transfer this

- asset (from Doyles Rd) to Council, and improve the amenity and access opportunities. Confirmation around meeting the 1.2L/s/ha rule also needs to be made with G-MW.
- The proposed drainage approach is largely based on Spiire's strategy from 2014 with catchment and asset modification.
- The assets south of Channel Rd are largely as per Spiire's approach, with RB1 shifted south into the flooding zone, but outside of the 30m waterway setback, as well as avoiding native vegetation in this corridor. Shifting this asset here frees up developable land in the precinct, but also provides an opportunity to enhance the riparian corridor with the additional of a large wetland which will provide habitat. RB1 should seek to outfall at the Drain 5 outfall location in the Broken River.
- RB6 is proposed to remain as is in terms of location and arrangement. A wetland within a retarding basin is still proposed. Again, the outfall location should seek to be located at the Drain 2 outfall location in the Broken River.
- A drainage reserve from Doyles Rd running east-west is still proposed to convey overland flows
  westwards. Similar to the Spiire and Cardno approach, the drainage reserve will connect into RB1. The
  last portion of this drainage reserve (where it turns and travels south) is proposed to be deepened, to
  allow for subdivisional drainage outfall from surrounding development. This would connect to the
  wetland sediment basin. No drainage reserve is proposed connecting RB1 and RB6. However, Council
  may still want to have a green spine through here.
- RB3 is to remain as per Spiire's location, and outfall into Drain 2. However, we propose that wetlands are built into the base as opposed to bioretention systems.
- It is proposed that RB4 and RB5 from Spiire's strategy are merged into a single, larger asset (called asset 2 in our labelling). The removal of the irrigation channel through these catchments should remove the catchment delineation that currently exists, and which informed the two assets that had previously been proposed. This would reduce overall excavation and land take, and reduce ongoing maintenance requirements in the future. Again, a wetland in the base of an RB is proposed. This location could be enhanced to create a community destination, linking to an improved RB at Perrivale Rd, on the western side of Drain 2.
- The formerly labelled basin 2 in Spiire's strategy is proposed to be split into two smaller assets (asset 4 and 5 in our labelling). The reason this has been proposed is that with the decommissioning of the channel there is an opportunity to create a green spine the whole way along Channel Rd, from Doyles Road through to the existing green spaces (and treatment assets) from Feiglins Rd. The creation of a linear treatment and detention asset here would complement those that are already built to the west of the precinct. A linear wetland/RB in the location of the current channel would then outfall into Drain ½ (which is to be converted to a piped asset drain). The creation of an asset here may also reduce excavation costs if the channel footprint can be utilised (unless it is greatly elevated). Should Council and the VPA not be interested in this option, a single wetland/RB could be proposed in the same location as previously proposed by Spiire.
- A smaller version of Spiire's RB2 is proposed to be built slightly in the same location as the previously proposed basin's location (Asset 4 in our labelling). Again, a wetland within an RB is proposed. It is proposed that outfall from this RB is pumped into a G-MW drain that is converted to a pipe (drain 2/2), flowing westerly towards drain 2. This pipe would receive flows from the external rural catchment.
- Good design of the WL/RBs is critical to ensure safety, provide maintenance program for efficiency and provide good amenity for residences. The RBs should not be 'holes in the ground.'

The concept plan is provided in Figure 28. The plan shows the drainage approach indicatively. This plan is intended to illustrate the intent of the strategy, with refinement of treatment and storage areas, overall footprints, and pipe alignments to occur in the functional design stage.

Should this alternative basin approach be accepted for progression to functional design by the VPA and Council, it will have an impact on the pipeline designs undertaken previously by Spiire. Some of the pipeline

designs will remain the same, but some will need úpdating to reflect the change in asset location or catchment assumptions. The pipeline layout is also influenced by the road layout, of which there has currently been none provided. These pipeline designs could be updated once the functional design of the assets is completed.

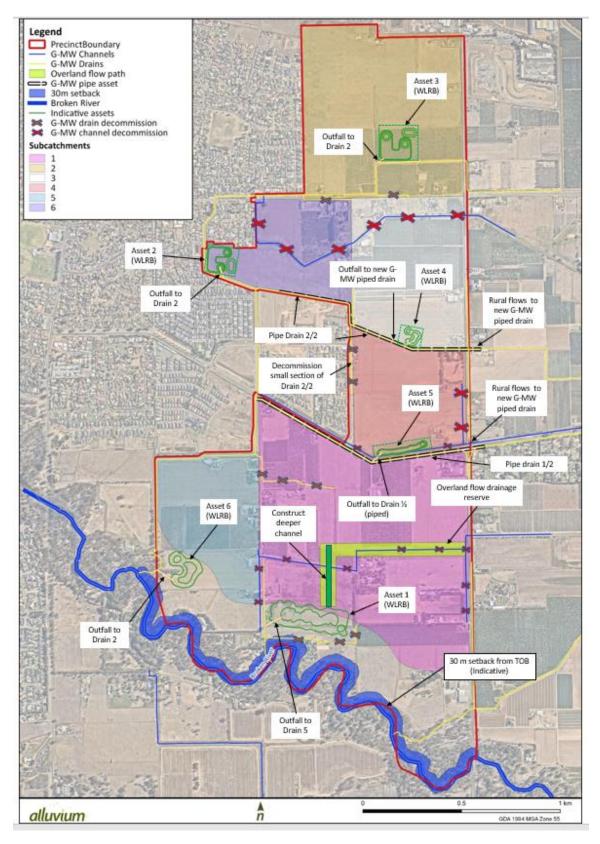


Figure 28. Drainage strategy concept (Alluvium)

# 5 Post development objectives and conditions

The following sets out the aim, objectives and approach of the assessment for the post-development conditions.

# 5.1 Project aim

For any drainage assessment the aim is to define the flood mitigation and stormwater quality management requirements for the post development conditions (the future land use of the site). In doing so, the work will define the stormwater quantity and stormwater quality assets required to control the impact of development on downstream receiving environments, and comment upon the optimal layout of those assets to support complimentary water cycle objectives. The layout should seek to minimise costs and land take through integration of assets (multi-functionality) to facilitate viable development opportunities.

The design and layout of the proposed treatment assets are provided at a functional design stage.

# 5.2 Objectives and approach

As per Clause 56.07-4 of the Victorian Planning Provisions (VPP) and the Greater Shepparton Planning Scheme, the stormwater management objectives are to:

- To minimise damage to properties and inconvenience to residents from stormwater.
- To ensure that the street operates adequately during major storm events and provides for public safety.
- To minimise increases in stormwater and protect the environmental values and physical characteristics of receiving waters from degradation by stormwater.
- To encourage stormwater management that maximises the retention and reuse of stormwater.
- To encourage stormwater management that contributes to cooling, local habitat improvements and provision of attractive and enjoyable spaces

The following are the general stormwater drainage requirements that need to be followed in a precinct stormwater assessment and asset design. These have been considered when identifying and refining total catchment opportunities and designs.

## Stormwater quantity management

As per best practice requirements, the fully developed 1% AEP stormwater runoff rates are to be retarded back to the equivalent 1% AEP pre-development peak flow rates before discharging downstream. As per the Planning Scheme, the design of the local stormwater drainage network should "ensure stormwater is retarded to a standard required by the responsible drainage authority."

This is typically achieved through the implementation of retention (or detention) systems within the catchment. This is to ensure receiving waters are protected, and that there are no adverse impacts on flood conditions.

In addition to the above requirement, the Infrastructure Design Manual (IDM) requires that for retarding basins with outfall to relevant authority drains, are "required to be designed for the 1% AEP storm event of 24-hour duration, with a no-outfall condition, and with a maximum discharge rate to the drainage system as specified by the authority (typically 1.2 lit/sec/ha)."

Consultation with G-MW identified that the G-MW drains have been designed for a 10% AEP storm event of 24 hours. Historically these have been designed for 50mm in 24 hours, with a 5-day removal period. This equates to 1.2L/s/ha. Once in excess of the 1 in 10, the natural conditions can apply as the drains cannot provide sufficient capacity within the system to transport such large flows.

Given the RBs will need to provide sufficient flood protection in the urban environment in a post-development scenario, the IDM criteria of sizing the RBs for the 1% AEP event of 24-hour duration, with a 1.2L/s/ha

discharge rate has been adopted for any assets discharging into G-MW drains. This still meets G-MW's requirements, but also provide adequate storage for flood protection.

This is discussed further in the hydrologic analysis section.

## Stormwater conveyance

As per the Infrastructure Design Manual (IDM) and the VPP clause 56.07-4, stormwater conveyance is typically designed to a major and minor flow regime where:

- Minor flows i.e. up to and including the 20% AEP storm event for residential areas (approximately the 1 in 5-year ARI event), are conveyed via the sub-surface stormwater network (for residential areas).
- Major flows i.e. between the 20% AEP and 1% AEP event are conveyed on the surface via roadways, overland flow paths, open channels and waterways.

The entire pipe and road network has not been assessed as part of this assessment.

## Stormwater quality treatment

Stormwater treatment assets are required to meet the Urban Stormwater Best Practice Environmental Management (BPEM) Guidelines (CSIRO, 1999) pollution reduction targets as set out in the Victorian Planning Provisions, before being discharged into stormwater networks and receiving waters. These targets are defined as:

- 70% removal of the total Gross Pollutant load
- 80% removal of total Suspended Solids (TSS)
- 45% removal of total Nitrogen (TN)
- 45% removal of total Phosphorus (TP).

#### Multi-functionality for multi-benefits

Stormwater drainage assessments should seek to incorporate IWM opportunities to gain optimised outcomes that deliver multiple functions with multiple community benefits and landscape outcomes for effort and investment. In developing asset designs and proposed integrated infrastructure elements, we have considered:

- Landscape and topographic features that lend themselves to asset types and locations
- Proximity of potential detention systems with active open space alignments for efficient stormwater harvesting and reuse (fit for purpose/irrigation).
- Sustainability of community assets service standards, asset preservation, access, usage and enhancements.
- Potable conservation through stormwater reuse reducing runoff volumes and associated impacts to local waterways.
- Blue-green corridors/assets and relationships to the urban form how these improve human thermal comfort, community / landscape resilience, and connectivity (existing and future communities), and
- Infrastructure multi-functionality for protection of local values (environmental, social, cultural, economic)
- Creating desirable destinations and social connectedness (community health and wellbeing)
- Enhanced liveability outcomes locally and regionally.

## 5.3 Future land use

To determine the stormwater quality and quantity requirements of the precinct, the post-development conditions of the site are modelled. While it is understood that the layout and proposed land use concepts are subject to change over time (and that the stormwater assessment will inform the proposed layout), a preliminary layout is required for modelling assumptions.

The layout of the precinct, specifically the density of the proposed development and proportion of open space, will impact the volume of stormwater runoff and therefore the treatment and flood mitigation systems required.

The 2018 future urban structure as provided by the VPA (2018) has been adopted for this modelling. This concept masterplan has been adopted in terms of land use and fraction impervious assumptions and is shown in Figure 29. The majority of the site is proposed as residential. We note that this layout incorporated the previous drainage strategy as developed by Spiire. Where RBWL1 has been shifted south into the Broken River waterway corridor, residential land use has been adopted in the old basin location.

We understand that this concept masterplan will be further updated as required to reflect the proposed stormwater assets and strategies proposed as part of this project.

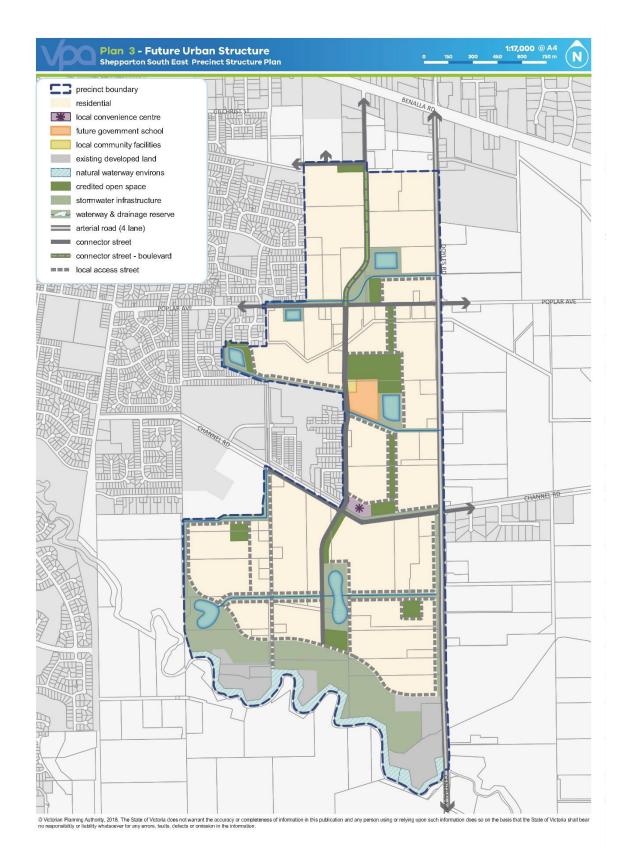


Figure 29. Preliminary future urban structure (VPA, 2018)

# 6 Hydrologic analysis

In general terms, the approach to flood management is to equate post development and pre-development peak flow rates for the 1% AEP event such that the development is not having an adverse impact on downstream flooding. This is typically achieved through the addition of retention (or detention) storage within the relevant catchment. The hydrologic analysis is used to determine the storage capacities of proposed retarding basins required to retard the fully developed peak stormwater runoff rates back to pre-developed conditions (or to meet the 1.2L/s/ha discharge requirement).

## 6.1 Hydrologic modelling

The hydrologic analysis was undertaken using RORB (v6.31), which is a runoff-routing software designed to simulate attenuation and time of concentrations to produce flood estimates at specified catchment locations.

A RORB model was created for the PSP to determine:

- Existing peak flows
- The impact of development on peak flows
- The reduction in peak flows that is possible using retarding basin storage.
- The impact of climate change on peak flows

The RORB models were built by delineating the major catchments into sub-areas based on topography and potential road alignments. This section details the peaks flows and storage requirements for each catchment. The same fraction impervious values were adopted for the stormwater treatment modelling (in MUSIC).

## 6.2 Input parameters

Model inputs including temporal patterns and aerial reduction factors were obtained from the ARR2019 data hub and the Bureau of Meteorology's Intensity Frequency Duration (IFD) data. RORB models were built by delineating the area based on flow directions derived from LiDAR data and future preliminary development plans.

An overview of the model setup including catchments, reaches, and retention asset locations, is shown in Figure 30. Full details on inputs and assumptions used for the hydrologic modelling can be found in Appendix B.

Key inputs into the RORB modelling include:

- The model used an initial loss/continuing loss model with an initial loss of 10mm (urban) and a continuing loss of 2mm/hr. These parameters are in line with previous flood studies in the region (Shepparton East Overland Flow Urban Flood Study parameters were adopted). An initial loss of 15mm was adopted for agricultural areas for the existing conditions model.
- The Regional Flood Frequency Estimation Model (RFFEM) estimate of flood frequency curves for catchments is based on regional studies. ARR2019 preferred method is to, where possible, calibrate the catchment routing parameter (kc) to meet the peaks in the RFFEM. However, there are no data points of relative catchment size to the study area, which suggests the flow from the RFFE is not directly relatable, and a flow between the upper and lower confidence limit is more likely.
- Kc was determined by modelling the existing catchment (low fraction impervious values, natural reaches) with kc's calculated from different regional kc equations (RORB default, Pearse et. al, ARR Book V Eqn 3.22) and comparing the peak modelled flows with the rural rational method estimates. The Pearse et al equation was a good representation of the rural rational method peak flows across the site. See Appendix B for more detail.
- Intensity Frequency Duration (IFD) data was sourced from the Bureau of Meteorology's (BoM) website, nearest grid cell 36.4125(S), 145.4375(E).

- Temporal patterns were sourced from the AR&R data hub, Murray Basin.
- Catchment areas were as per those established in the catchment analysis (and in line with the Spiire and Cardno catchment analysis).
- Fraction impervious values were based on existing conditions and updated to proposed land uses as shown in the preliminary urban structure (provided in Table 2 below).
- The ensemble method was used to determine the critical flows at each flood retention location.
- Reaches were natural for the existing conditions model and updated to 'Excavated but not lined' (Type 2) for developed conditions model to establish the 1% AEP peak flows and size the RBs. Another version of the developed conditions model was created which adopted Type 3 lined or piped to establish the peak minor flows, which were used in the velocity and sediment capture efficiency calculations.
- Reach slopes through developed areas were updated to 0.5% (1 in 200) as a grade minimum.

**Table 2. Sub catchments** 

Catchment	Area (ha)	Existing conditions Fraction impervious	Developed conditions Fraction impervious
1	103.48	0.05	0.59
2	27.66	0.05	0.59
3	68.80	0.05	0.57
4	42.09	0.05	0.52
5	32.42	0.05	0.58
6	31.38	0.05	0.58

The developed conditions fraction impervious values were established by mapping out the various proposed land uses within the catchments and establishing an overall effective fraction impervious value. This was adopted for both the RORB and treatment modelling. The assumptions for each land use include:

Schools/Local centre: 0.7

Open space: 0.1Residential: 0.6.Drainage reserve: 0.5

## Climate change scenario

Climate change scenarios have been adopted within the hydrologic models built. The purpose of adopting climate change scenarios is not to design assets to these increased peaks, but to perform a sensitivity check on how increased peak flows will move through the systems designed. For example, how an increased peak 1% AEP will sit within the provided freeboard in a proposed retarding basin.

The approach adopted for establishing climate change scenario has been:

- the use of Bureau of Meteorology (BoM) IFD curves derived for the site.
- that the IFD curves are adjusted to reflect increased intensity arising from climate change.
- ARR 2019 recommends the adoption of a 5% increase in rainfall intensity per degree of global warming (Book 1, Chapter 6) for events up to the 1% AEP. The equation from ARR is provided below.

$$I_p = I_{\text{ARR}} \times 1.05^{T_m}$$

where  $I_{ARR}$  is the design rainfall intensity (or depth) for current climate conditions (**Book 2**), 1.05 is the assumed temperature scaling based on the approximately exponential relationship between temperature and humidity and  $T_m$  is the temperature at the midpoint (or median) of the selected class interval.

- RCP 8.5 were adopted for climate change. The catchment is located within the Murray basin cluster, which estimates the temperature increase in the RCP 8.5 scenario of 4.0 degrees in the year 2090.
- This approach results in a 21.5% in rainfall intensity for 1% AEP event for the RCP 8.5 scenario.
- The increase in rainfall intensity is not applied to events greater than the 1% AEP.

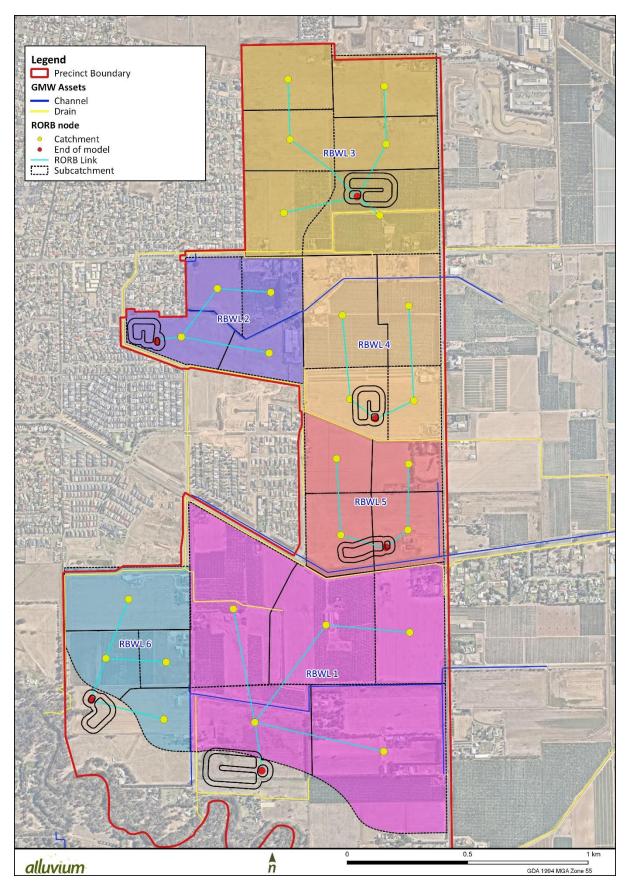


Figure 30. RORB setup

#### 6.3 Results

The RORB model was computed for the pre and post developed conditions under the 1% AEP flood event with results as shown below.

Table 3. 1% AEP RORB modelling results

Asset	Catchmen t area	Rural rational method	Existing conditions model (Pearse)		Developed conditions model (Pearse)		Climate change scenario (RCP 8.5)	
	На	Peak flow m³/s	Peak flow m³/s	Critical storm duration and temporal pattern	Peak flow m³/s	Critical storm duration and temporal pattern	Peak flow m³/s	Critical storm duration and temporal pattern
RBWL1	103.48	6.41	6.86	1Hr, 28	16.80	25 mins,25	21.54	25 mins,25
RBWL2	27.66	2.29	2.12	1Hr, 23	5.15	25 mins,25	6.54	25 mins,25
RBWL3	68.80	4.72	6.31	1Hr, 28	13.86	25 mins,25	17.66	25 mins,25
RBWL4	42.09	3.18	3.51	1Hr, 28	7.93	15 mins,29	10.02	15 mins,29
RBWL5	32.42	2.56	3.14	1Hr, 28	6.84	25 mins,25	8.73	25 mins,25
RBWL6	31.38	2.50	2.72	45 mins, 21	6.36	25 mins,25	8.09	15 mins, 29

Following the establishment of existing (pre) and post-development peak flows without mitigation, the retarding basins have then been modelled and sized to control the 1% AEP peak flow. The total required area for each asset has been calculated assuming a 1(V):6(H) batter to existing surface, and an allowance of 300mm of freeboard on top of the peak 1% AEP flood depth. The systems are designed so they are cut and not in fill (i.e. no loss of any flood storage).

- RB stage storage relationships were first developed in a spreadsheet based on a base area equivalent to the NWL of the stormwater treatment assets for each sub-catchment (see Section 7), a 4:1 length to width ratio, and a batter slope of 1:6. The stage storage relationships were later refined when the assets were designed up in 12d, a 3D earthworks modelling program. The actual stage storage values were exported from 12d and imported into RORB. The storage volumes are for above the NWLs only.
- Storage outlet sizes were adjusted until the peak 1% AEP outflows from the RB were equal or less than the current peaks (for RBWL1 and RBWL6). This was done through altering outlet properties in the hydrologic model (i.e. outlet pipe sizing or weir sizing) until the peak flows were less than or close to the existing peak flows. The outlet pipe/weir arrangements are sized for peak RB outflows.
- The allowable discharge for RBWL2, RBWL3, RBWL4, and RBWL5 are based on the allowable maximum discharge of 1.2L/s/ha for the contributing developable catchment. The IDM stipulates that RBs should be sized for the 1% AEP for a 24-hr storm. G-MW require the storage to be designed for the 10% AEP 24-hr storm, with a maximum discharge of 1.2L/s/ha. After preliminary analysis it was concluded that the RBs would be sized for the 1% AEP 24-hr storm so to ensure an adequate level of flood protection for the surrounding urban environment in events bigger than the 10% AEP. These allowable discharges are provided in Table 4 below.
- Peak storage volumes and flood heights within the basins were extracted from representative hydrographs runs.

Table 4. Allowable maximum discharge (1.2L/s/ha discharge requirements)

Asset	Catchment area	Allowable discharge	1% AEP (m3/s) (24 –Hr duration storm, peak flow)
	Ha	m³/s	m³/s
RBWL1	103.48		
RBWL2	27.66	0.03	0.81
RBWL3	68.80	0.08	2.05
RBWL4	42.09	0.05	1.22
RBWL5	32.42	0.04	0.98
RBWL6	31.38		

RBWL1 and RBWL6 only need to be retarded back to pre-developed peak 1% AEP flow rates.

Table 5 shows the required capacities of the retarding basin based on the RORB modelling conducted. All retarding basins (RB) are integrated assets with a proposed wetland treatment floor (as per WL) to increase functionality, minimise land take and provide a functionally aesthetic asset for the landscape and community.

Table 5. Retarding basin requirements

Asset	Existing Peak 1% AEP flow (m³/s)	Peak RB outflow (1% AEP) (m³/s)	Peak RB storage (m³)	Peak RB flood depth (m)	Freeboard above peak flood depth (mm)	Outlet structure	RB Surface (from 12d) (m²)
RBWL1	6.86	1.99^	45,400	113.05	1.35		40,321
RBWL2	2.12	0.03#	23,900	112.94	0.36	Pumping required	17,223
RBWL3	6.31	0.08#	55,500	113.95	0.30*	Pumping required	28,583
RBWL4	3.51	0.05#	34,300	113.75	0.35	Pumping required	20,295
RBWL5	3.14	0.04#	27,300	114.13	0.37	Pumping required	18,414
RBWL6	2.72	0.96^	11,700	112.00	0.60		17,163

#1% AEP 24 Hr flow \*Minor fill required around RB to ensure 300mm freeboard.

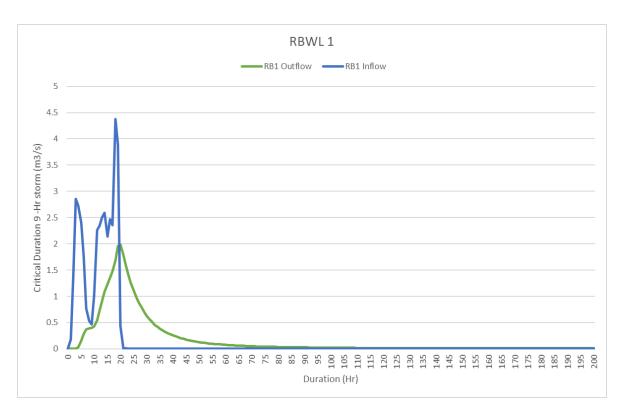
The results show that the flows are being retarded back to below the pre-developed conditions peak flow rates or retarded to meet the 1.2L/s/ha allowable discharge. The required storages for the peak flows are above the NWLs of the wetlands and sediment basins.

The results show that some of the assets have greater than 300mm freeboard provided. This is because preliminary calculations on the required asset levels to allow for subdivisional drainage into the system has driven down the required levels in some assets. That is, for some assets the asset NWLs are driven by the subdivisional drainage requirement rather than the storage requirement for retarding flows.

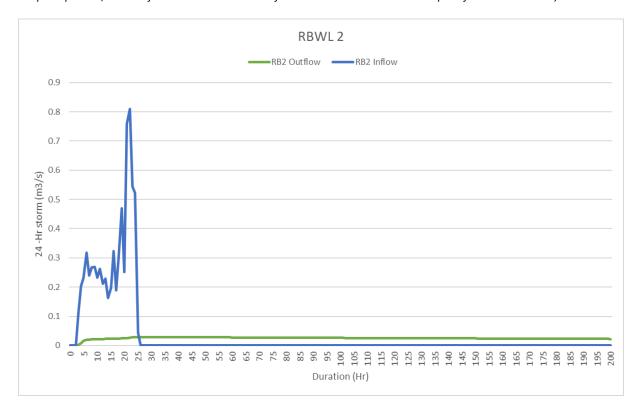
The results also show that for RBWL1 and RBWL6 the flows are being retarded far beyond the pre-developed peak 1% AEP flow rate. This is because there is plenty of storage available due to the above reasons. An alternative could be to upgrade pipe sizes and discharge more flow, but this would increase costs (as well as providing even more freeboard).

The hydrographs for each RBWL are provided below.

<sup>^</sup>Critical outflow

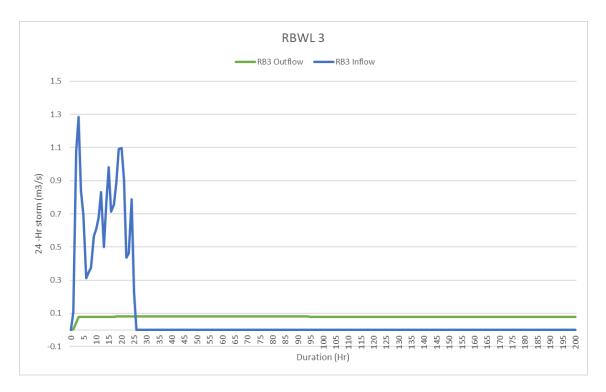


**Figure 31.** RBWL1 1% AEP hydrograph for critical storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)

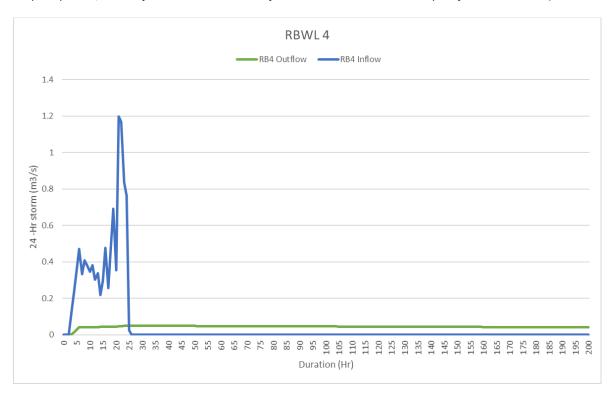


**Figure 32.** RBWL2 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)

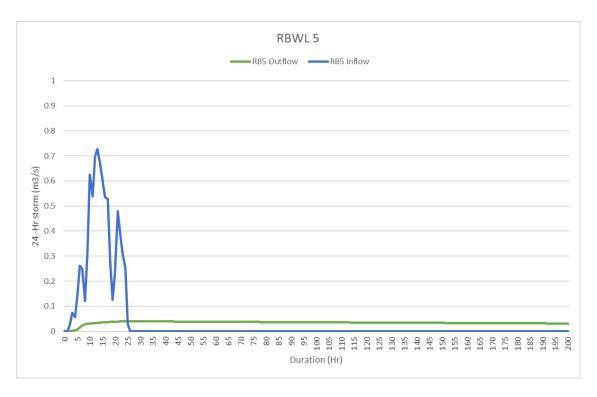
. .



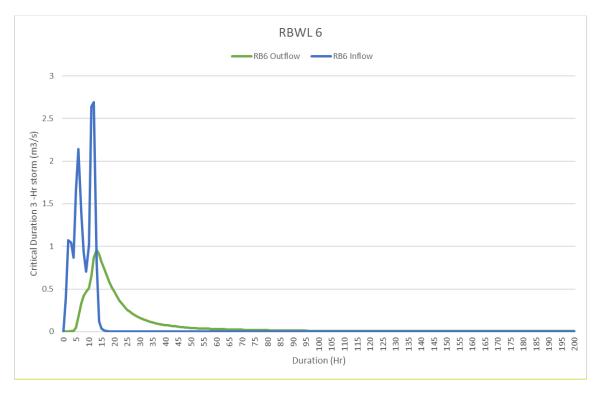
**Figure 33.** RBWL3 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)



**Figure 34.** RBWL4 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)



**Figure 35.** RBWL5 1% AEP hydrograph for the 24 hour storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)



**Figure 36.** RBWL 6 1% AEP hydrograph for critical storm (based on the retarding basin peak outflow and associated temporal pattern, which reflects the critical duration flow within the basin rather than peak flow into the basin)

A plan overview of the RB locations and footprints are provided in Figure 37. This map also shows the integrated wetlands within the RBs that are required to meet State pollutant reduction targets (discussed in Section 7 of this report). Indicative stormwater mains are also shown.

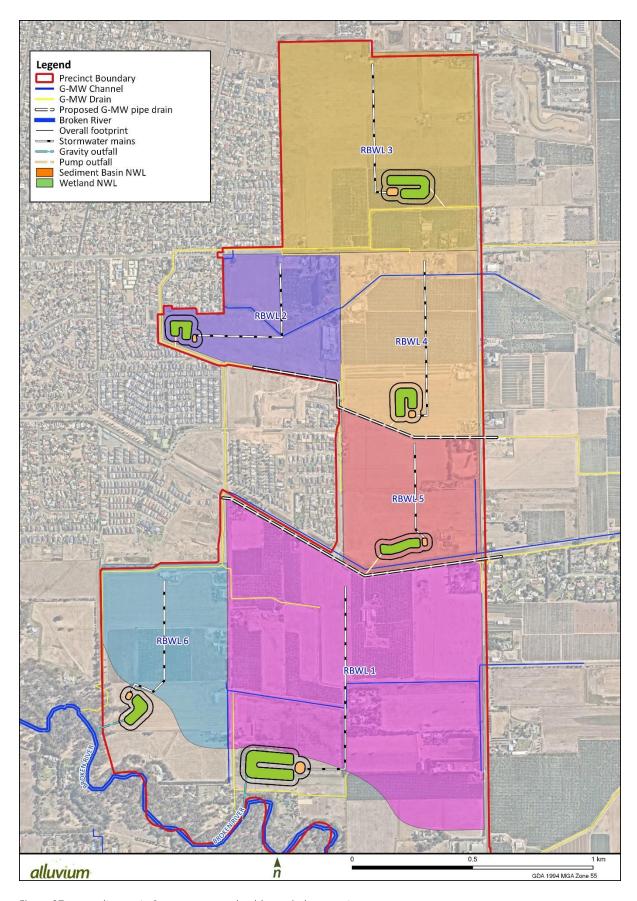


Figure 37. Retarding Basin & Treatment Wetland (RBWL) plan overview

The above figure (and the more detailed functional design drawings) show the RB outfall for RB1 and RB6 outfalling directly into the Broken River. This is different to the original proposal to outfall into the nearby G-MW drains. A preliminary look at the invert levels in the drains established that there is potentially not sufficient fall to efficiently drain the RBs, and therefore direct outfall into the Broken River may better enable the free-draining of these systems. Feature survey and more detailed flora and fauna assessments should be undertaken during the detailed design phase to establish the best arrangement for the outfall in terms of a) efficiently draining the RBs, b) minimising tree loss and vegetation removal, and c) minimising the impact on the River.

Whilst hydraulic modelling has not been undertaken for this project, the critical storm durations for the peak outflows for RBWL1 and RBWL6 are nine hours and three hours respectively. This is much faster than the Broken River peak (~48-72 hrs as per Water Technology's Shepparton Mooroopna 1% AEP Flood Mapping Project, August 2021). Therefore, the systems will have drained by the time this flood comes through.

Once the 1% AEP Broken River peak occurs, the water surface elevation will be around 115 m AHD (as per Water Technology's Figure 5.3 in the same flood mapping project). RBWL1 and RBWL6 will therefore be inundated. Once this event has passed, the RBs will drain and again provide flood protection for the surrounding catchment.

The outfall design in the detailed design stage should closely consider the flood levels within the Broken River (and timing of elevated flood levels), how this interacts with the outfall elevations, and therefore the functioning of the proposed drainage system. Where possible the outfall invert level should be kept high to provide a better level of flood protection.

## 6.4 Climate change sensitivity check

As part of the hydrologic modelling, a sensitivity check of a climate change scenario was undertaken for retarding basin sizing. The results show that for RBWL1 and RBWL6 the increased peak flows are still contained within the freeboard (i.e. there is a reduced freeboard).

Due to the extremely low pump rates and limited storage available, the remaining assets (RBWL2, RBWL3, RBWL4, and RBWL5) will overtop in the climate change scenario. This is because of the extremely small outflow requirements associated with the G-MW drain. Typically, the design of the basins can cater for the additional inflow associated with the increased rainfall intensity within the freeboard.

Future design could look at further deepening of the basins so that a climate change scenario could be catered for, or how the surrounding reserve could be designed to help manage any overtopping. The basins are, however, already much larger than typical basins due to the 1.2L/s/ha discharge requirement. Therefore, the climate change considerations need to be balanced with the discharge constraints.

More detailed modelling is required to understand the increase in the storage requirement that could cater for climate change scenario, should Council require this. The future permit process will trigger Council to reassess designs in line with policy as the drainage authority prior to RB delivery, and alterations may occur through this process subject to the determination of GSCC.

The results from modelling are provided in Table 6.

Table 6. Retarding basin analysis (climate change scenario)

	1% AEP	Climate Change	1% AEP	Climate Change	1% AEP	Climate Change	1% AEP	Climate Change
Asset	Peak RB outflow (m³/s)	Peak RB outflow (m³/s)	Peak RB storage (m³)	Peak RB storage (m³)	Peak RB flood depth (m AHD)	Peak RB flood depth (m AHD)	Freeboard above peak flood depth (mm)	Freeboard above peak flood depth (mm)
RBWL1	1.99^	2.59^	45,400	54,100	113.05	113.30	1.35	1.10
RBWL2	0.03#	0.03#	23,900	Overtopping	112.94	Overtopping	0.36	Overtoppin
RBWL3	0.08#	0.08#	55,500	Overtopping	113.95	Overtopping	0.30*	g Overtoppin g
RBWL4	0.05#	0.05#	34,300	Overtopping	113.75	Overtopping	0.35	Overtoppin
RBWL5	0.04#	0.04#	27,300	Overtopping	114.13	Overtopping	0.37	g Overtoppin g
RBWL6	0.96^	1.24^	11,700	13,900	112.00	112.18	0.60	0.42

#1% AEP 24 Hr flow

Another option to manage the climate change scenario increased peak flows could be to pump out water at a greater flow rate. The outflow required to ensure that the basin does not overtop was investigated for basins 3 to 5. The results of this are provided in the table below, indicating relatively low flow rates. This approach would need to be discussed and confirmed with G-MW.

Table 7. Required increased outflow rates for WLRB2 to WLRB5 in a climate change scenario

	Climate Change scenario							
Asset	Required RB outflow (m³/s)	Peak elevation (with increased outflow) (m AHD)	Freeboard (with increased outflow) (m)					
RBWL2	0.17	113.27	0.03					
RBWL3	0.35	114.25	-0.28 (therefore 300mm minor filling required in localised area to ensure no overtopping)					
RBWL4	0.38	114.05	0.05					
RBWL5	0.35	114.35	0.15					

<sup>^</sup>Critical outflow

#### 6.5 External flows

As is evident from the topography of the area (Figure 10) and the alignments of G-MW drains (Figure 11), there is a rural catchment to the east of the precinct which gradually flows south-west towards the Broken River. There are three key locations where external flows enter the precinct:

- At drain 2 on Doyles Road
- At drain 2/2 on Doyles Road
- South of Channel Road, across Doyles Road.

The peak 1% AEP flows coming into the precinct for Drain 2 and Drain 2/2 were obtained from BMT's *Shepparton South East Precinct Hydraulic Modelling report* (2020). Point inflows were extracted from the TUFLOW model. These flows were used in Cardno's drainage strategy for the precinct, as shown in Figure 38. The flows are 2.8m³/s at Drain 2, 1.33m³/s at Drain 2/2. The external flows south of Channel Road are discussed in the overland flow section further below.

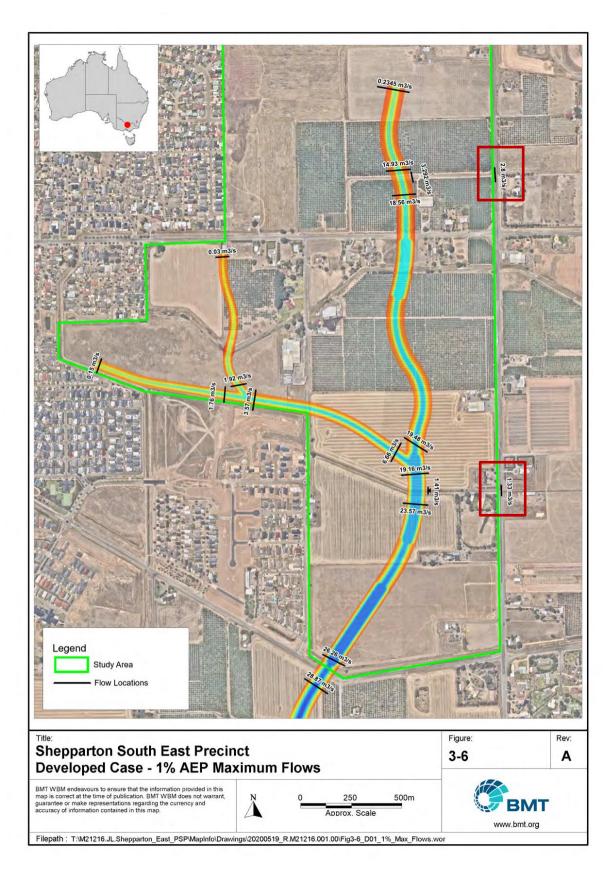
The external major flows entering at the Drain 2 location are assumed to continue down the G-MW drain in a post-development scenario. These flows are assumed not to enter RBWL3 and have not been included in the hydrologic modelling. This will need to be confirmed with adequate survey of the existing G-MW Drain (no capacity information was provided as part of this study). A preliminary manning's n channel calculation was performed on the drain based on LiDAR information, which indicated that drain potentially has a capacity of approximately 3.7m<sup>3</sup>/s, which is greater than the 2.8m<sup>3</sup>/s peak 1% AEP inflow. The calculations assumed:

- 2.2m wide base
- 1.6m channel depth
- 1 in 2 batters
- 1 in 2000 longitudinal grade
- Manning's n of 0.05 (light brush).

Hydraulic modelling of the ultimate drainage strategy will also need to be performed to assess the functionality of the proposed basins, and the capacity of Drain 2 and its ability to convey these external flows through the precinct.

The external major flows entering at the Drain 2/2 location have again been assumed not to enter the proposed RB near this location (RBWL4). The flows are assumed to be conveyed through the precinct via the future pipe (G-MW drain converted to a pipe). This assumption will need to be confirmed and workshopped when this pipe is designed. It may depend on the required sizing and cost of this pipe as to whether this is feasible. The peak 1% AEP flow is relatively small at 1.3m<sup>3</sup>/s. This pipe will also need to take the pumped outflow from RBWL4, as well as the flows from the development underway to the west.

The benefit of not bringing the external flows through the proposed wetland/retarding basins is that is avoids introducing potentially high-nutrient loads into these systems from the external agricultural areas, and overloading the wetlands. It also helps manage velocities through the wetlands by limiting the peak flows.



**Figure 38.** Inflows from external catchments (relevant flows highlighted in red) (Shepparton South East Precinct Hydraulic Modelling Report, BMT, 2020)

#### Overland flow path

Early engagement with the CMA and Council indicated that there is overtopping of Doyles Road in major flood events, and as such the development of this strategy would need to cater for overland flows coming from the east into the PSP (see section 4.1).

Water Technology was engaged by Council in 2021 to update the Shepparton Mooroopna Flood Mapping and Flood Intelligence project (2019) with the inclusion of climate change, updated LiDAR, and a more defined model grid resolution. The study supersedes the original flood modelling and is referred to as the Shepparton Mooroopna 1% AEP Flood Mapping Project (2021).

Following the adoption of this flood study by Council, Water Technology were subsequently engaged by Council to undertake an assessment of the Shepparton South East PSP with the latest flood modelling information. This study focussed on the area of the PSP south of Channel Road. A series of model scenarios were undertaken to assess the floodplain suitability of any future development. The results of the proposed development conditions were compared to the existing conditions to ensure no flood level increases in areas upstream and downstream of the study area. Water Technology engaged with the VPA, Council, G-MW, the CMA and Alluvium over the course of this study. The results of the scenario testing were provided in a memo by Water Technology to Greater Shepparton Council, 17 May 2022. A summary of those findings are provided below.

- The 1% AEP climate change modelling results compared with the existing conditions modelling showed on average there are net increases in the flood depth through the study area of around 150-200mm. This has the potential to cause a significant reduction in the net developable area due to the increase of the area which is has flood depths greater than 300mm.
- The 1% AEP climate change flood modelling results from the Shepparton Mooroopna supplementary mapping project were used as the primary assessment tool for the PSP. This was based on a Broken River dominant event which produces a flood level of 12.27m at the Shepparton streamflow gauge.
- Water Technology discussions with GBCMA suggested that greenfield development should not be
  located where flood depths exceed 300mm in existing conditions and 500mm under the climate
  change scenario. It was suggested that fill levels of developable lots within the study area be filled to
  the 1% AEP climate change flood level and a Finished Floor Level (FFL) be 300mm above this level.
- Water Technology adopted the latest available urban layout (subject to change), incorporating
  Alluvium's proposed basin locations developed as part of this functional design package. The layout
  was then used to modify the topography within the flood model to represent residential areas (to be
  filled above the 1% AEP climate change flood level), roadways inundated to no more than 0.30 metres
  and drainage infrastructure to compensate for the infill of residential development.
- Two development footprints entailing the revised layout were modelled for the 1% AEP with climate change flood event. Both options generally maintain the footprint outlined by Spiire (2018) and Alluvium (2022) which brings flows into the site via a set of culverts under Doyles Road through to the centre of the site. Two overland flow path options were tested:
  - The first option assessed branches the overland flow path from the centre of the site south before connecting with the Broken River Floodplain.
  - The second option continued west through the site rather than branching south towards the Broken River floodplain (as originally proposed in Alluvium's concept plan).
- The impact of the development scenarios were compared with the base case scenario in terms of a change in Water Surface Elevation (WSE). Both scenarios showed negligible afflux outside of the site in a 1% AEP climate change event.
- An approximate cut/fill balance was undertaken for each option. Option 2 resulted in a smaller net balance.

- A floodplain storage assessment showed that Development Option 1 provides an additional 7,000m³ of storage while Development Option 2 has a reduction of around 5,000m³. Given the size of the development being undertaken, it is understood the GBCMA will assess floodplain storage requirements on a 1:1 ratio (as opposed to the typical 1:1.3). It is also assumed that provided flood the mapping shows no significant afflux outside of the site, negotiations into an acceptable reduction in floodplain storage may result in this requirement being waived.
- The modelling showed that the east-west floodway through the site from Doyles Road has been shown to be an important hydraulic control in maintaining conveyance and flood levels throughout and upstream of the site at existing conditions levels.

Following the delivery of this memo, Council, the VPA and the CMA had a meeting with Water Technology to discuss the findings and preferred overland flow path. It was decided that the east-west overland flow path (option 2) was the preferred alignment. The flood modelling results (afflux) for this option are provided in Figure 39.

Following the delivery of this modelling and the selection of the preferred overland flow path, Alluvium updated the final functional design package to include the same assumptions for the overland flow path.

Water Technology provided Alluvium with the following relevant design assumptions:

- An allowance for a 30m wide overland flow path
- The box culverts at Doyles Road are 2 x 1800 (H) x 600 (W) box culverts
- The box culvert inverts are 115.15 m AHD (upstream) and 115.1 m AHD (downstream), with a peak flow of 2.28m<sup>3</sup>/s.
- Flow along the east-west overland floodway (noting overtopping of Doyles Rd) is 12.42m<sup>3</sup>/s for the 1% AEP climate change event.
- No additional culverts along the floodway were modelled.

#### Proposed overland flood path dimensions

A preliminary manning's n channel calculation was undertaken to establish the approximate required channel dimensions such that the overland flow path has the capacity to take the required 12.42m<sup>3</sup>/s peak flow. A maximum channel top width of 30m was adhered to, adopting the same alignment as in Water Technology's flood modelling. The channel cross-sectional arrangement should be further developed during the detailed design stage when the subdivisional layout and final surface levels are confirmed. A meandering low flow channel could be incorporated into the high flow channel.

The preliminary overland flow path calculations assumed:

- A 7m wide base
- A 1.1m channel depth
- 1 in 10 batters
- 1 in 469 longitudinal grade
- Manning's n of 0.05 (light brush).

This resulted in a capacity of approximately 14.1m³/s, which is slightly greater than the required capacity. This provides some flexibility in terms of the cross-sectional arrangement or grade during the detailed design stage. Providing some variation in the battering, as well as the inclusion of a meandering low flow channel and benches is recommended in order to provide better amenity outcomes as well as the creation of a variety of habitat opportunities. The simple vegetated trapezoidal channel option provided in this design package is the minimum requirement to achieve the flooding and conveyance outcomes.

The overland flow path will ultimately outfall into the Broken River, near RBWL6. Flows are not proposed to enter the basin as this could cause nutrient overloading of the system, as well as velocity issues. The overland flow path only takes the external flows, with the precinct internal overland flows directed towards RBWL1 or RBWL6 via the road network. The specific outfall location can be refined in later designs stages when detailed flora and fauna assessments, CHMPs and feature survey have been undertaken. It could be an option that the RBWL6 pipe outfall outfalls into the overland flow path so to minimise disturbance to the river.

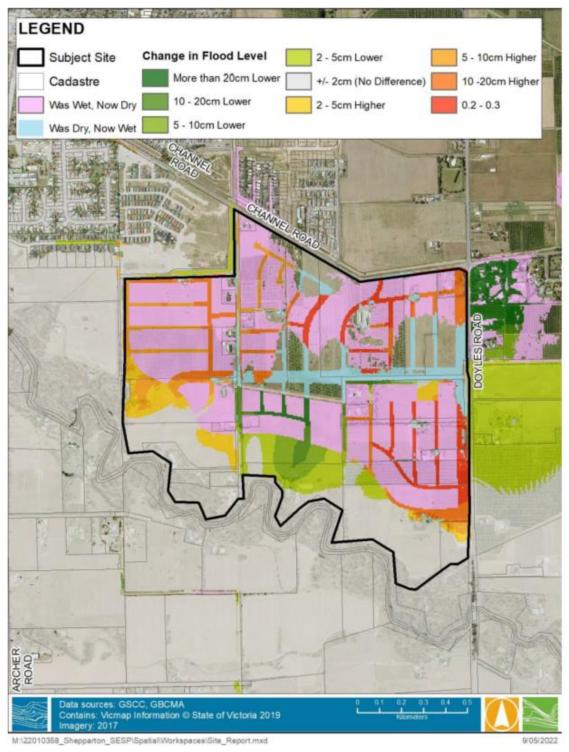


Figure 9 1% AEP Flood Level Afflux - Development Option 2

**Figure 39.** Development option 2 – flood level afflux (Water Technology, 2022)

# 7 Wetland and sediment basin design

This section details the analysis, modelling, and results for the treatment assets.

## 7.1 Design arrangement overview

Six wetlands were developed and are discussed in this section. This includes:

- **Wetland 1**: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to the Broken River. The wetland is located within an RB.
- **Wetland 2**: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to G-MW drain 2. The wetland is located within an RB.
- Wetland 3: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to G-MW drain 2. The wetland is located within an RB.
- Wetland 4: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to G-MW drain 2/2, which will become a piped drain. The wetland is located within an RB.
- Wetland 5: this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to G-MW drain 2/2, which will become a piped drain. The wetland is located within an RB.
- **Wetland 6:** this wetland receives inflow from the surrounding catchment minor drainage network. The system consists of a sediment basin and wetland, before outfalling to the Broken River. The wetland is located within an RB.

The design arrangement of the sediment basins and wetlands has been based off the following design principles:

- The assets are to be fed by the minor drainage network (20% AEP) from the contributing catchments.
- The sediment basins have been designed to capture 95% of coarse particles  $\geq$  125 $\mu$ m diameter entering the system.
- The wetlands have been sized based on achieving best practice treatment targets.
- Design should allow for maintenance requirements.
- Designs should aim to avoid fill.

A design arrangement for the assets was completed based on the design principles and arranged to fit within the existing topography. Consideration to land parcels was also given. That is, where it was appropriate to site an asset entirely within one parcel, this was attempted. This will assist will future staging of the development. Given the incredibly flat topography within this precinct, there is a fair degree of flexibility in where assets can be sited.

The sediment basin and wetland arrangements (refer to design drawings) have been designed to optimise treatment, and meet Melbourne Water's Constructed Wetland Design Manual deemed to comply criteria as best possible.

## 7.2 Treatment modelling

A key principle for the strategy is that all stormwater is to be treated to BPEM (Best Practice Environmental Management) Guidelines before being discharged from the study area. As such, the development site will require numerous treatment assets in order to achieve the targeted reduction in pollutant load concentrations. The following BPEMG targets have been adopted:

- 70% removal of the Total Gross Pollutant load
- 80% removal of Total Suspended Solids (TSS)
- 45% removal of Total Nitrogen (TN)
- 45% removal of Total Phosphorus (TP).

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was developed to estimate the pollutant loads generated from the developed conditions scenario. This allowed us to understand the target pollutant load reduction, and therefore test the sizing and treatment capacity of various opportunities required to meet the pollutant reduction targets. Reduction requirements were determined for each catchment, and treatment system sizes were calculated.

#### Inputs

The key modelling inputs for the MUSIC model are rainfall and evapotranspiration. Generally, for MUSIC a 10-year rainfall period is selected for a site which is a good representation of the average rainfall. The period adopted should consider a completeness of record, and representation of wet and dry periods.

Historic rainfall datasets at 6-minute intervals were obtained from the Bureau of Meteorology (BoM) (via eWater) for the rainfall gauges at nearby Dookie (gauge #081013, from 1950-2010), and Tatura (gauge #81049, from 1960-2010).

The average annual rainfall over this entire period was established and used to select a ten-year period from the historic dataset which produced a similar annual average rainfall. The average annual rainfall from BoM is 506mm.

The Tatura gauge is closer to the study area, however there are large gaps in the record and no appropriate representative 10-year period reflecting the long-term average conditions. The Dookie gauge was adopted, which had several periods with a 10-year average close to the long-term average. The period from 1961-1970 was selected which has an annual average rainfall of 527mm, as this had the fewest gaps and was most consistent with the daily record.

The monthly average evaporation for Shepparton was also obtained from BoM and adopted for this modelling.

When modelling wetlands in MUSIC, an Extended Detention Depth of 0.35m is typically adopted and a detention time of 72 hours is aimed for. This allows sufficient contact time with the vegetation, and therefore treatment of the stormwater.

The inlet pond areas for each wetland were sized using the Fair and Geyer equation, where sediment basins are required to meet a 95% sediment capture efficiency of coarse particles  $\geq$  125  $\mu$ m diameter for the peak 4EY (4 Exceedances per Year) event. The sediment basins were assumed to have an average depth of 0.8m, and the volume was used in the MUSIC modelling. The details of these calculations are provided Section 6.5. The sediment basins were not modelled as separate treatment nodes as the sediment basins will only sit 100mm above the macrophyte zones.

The catchment nodes used in the model have been calculated based on the areas, land use and associated fraction impervious values used in the RORB modelling (provided in Table 2). The design treatment system schematic is provided in Figure 40.

These assets have been sized to treat the loads being generated off the future developable area to best practice standards.

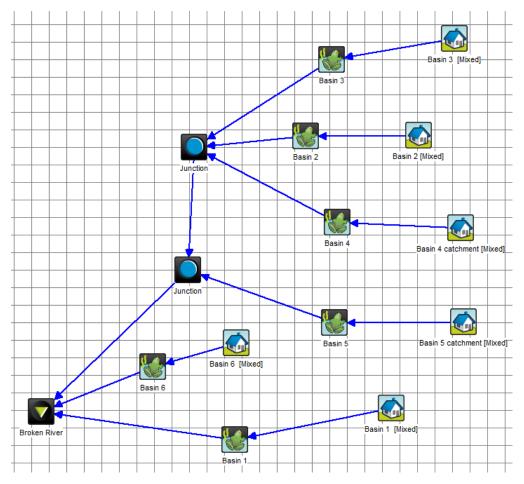


Figure 40. MUSIC schematic for treatment assets

All wetlands were modelled with volumes as per 12d volume analysis, and an Extended Detention Depth (EDD) of 0.35m. The wetland sizing was done in conjunction with velocity checks and sediment capture efficiency calculations. For full details on wetland dimensions see section 7.7. Sediment basins and wetlands were modelled as a single treatment node as the sediment basin is not more than 100mm above the macrophyte zone, as per the MUSIC Guidelines.

High flow bypasses in the treatment nodes were set at 100 as per Melbourne Water 2016 MUSIC Guidelines.

#### Results

The results for the MUSIC modelling can be seen in the tables below.

Table 8. Wetland 1 MUSIC modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	290.0	261.0	10.0	
Total Suspended Solids (kg/yr)	54500.0	10100.0	81.4	44400.0
Total Phosphorus (kg/yr)	115.0	34.5	70.1	80.5
Total Nitrogen (kg/yr)	816.0	413.0	49.3	403.0
Gross Pollutants (kg/yr)	12500.0	0.0	100.0	12500.0

Table 9. Wetland 2 MUSIC modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	77.5	69.2	10.7	
Total Suspended Solids (kg/yr)	14700.0	2830.0	80.8	11870.0
Total Phosphorus (kg/yr)	31.0	9.4	69.8	21.6
Total Nitrogen (kg/yr)	219.0	108.0	50.6	111.0
Gross Pollutants (kg/yr)	3360.0	0.0	100.0	3360.0

Table 10. Wetland 3 MUSIC modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	187.0	169.0	9.8	
Total Suspended Solids (kg/yr)	35500.0	6750.0	81.0	28750.0
Total Phosphorus (kg/yr)	73.5	22.6	69.2	50.9
Total Nitrogen (kg/yr)	528.0	272.0	48.5	256.0
Gross Pollutants (kg/yr)	8120.0	0.0	100.0	8120.0

Table 11. Wetland 4 MUSIC modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	107.0	94.9	11.3	
Total Suspended Solids (kg/yr)	20000.0	3470.0	82.6	16530.0
Total Phosphorus (kg/yr)	42.0	11.7	72.0	30.3
Total Nitrogen (kg/yr)	300.0	142.0	52.5	158.0
Gross Pollutants (kg/yr)	4650.0	0.0	100.0	4650.0

Table 12. Wetland 5 MUSIC modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	89.5	79.6	11.0	
Total Suspended Solids (kg/yr)	17100.0	3290.0	80.8	13810.0
Total Phosphorus (kg/yr)	35.3	10.3	70.9	25.0
Total Nitrogen (kg/yr)	254.0	123.0	51.5	131.0
Gross Pollutants (kg/yr)	3880.0	0.0	100.0	3880.0

Table 13. Wetland 6 MUSIC modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	86.4	77.3	10.5	
Total Suspended Solids (kg/yr)	16100.0	3190.0	80.2	12910.0
Total Phosphorus (kg/yr)	34.3	10.2	70.1	24.1
Total Nitrogen (kg/yr)	243.0	121.0	50.4	122.0
Gross Pollutants (kg/yr)	3750.0	0.0	100.0	3750.0

Table 14. Overall PSP treatment modelling results

	Initial load (kg/yr)	Residual load (kg/yr)	Reduction (%)	Load reduction (kg/yr)
Flow ML/yr	837	751	10.3	
Total Suspended Solids (kg/yr)	158000.00	29700.00	81.20	128300.00
Total Phosphorus (kg/yr)	331.00	98.80	70.20	232.20
Total Nitrogen (kg/yr)	2360.00	1180.00	50.00	1180.00
Gross Pollutants (kg/yr)	36300.00	0.00	100.00	36300.00

The results show that each wetland is treating to best practice, and that overall, the strategy is meeting best practice pollutant removal targets. As can be seen from the results, the TSS is often the limiting pollutant.

#### **Inundation frequency analysis**

One of Melbourne Water's 'deemed to comply' design criteria is for the water level in the wetland not to exceed half the average mature plant height for more than 20% of the time. This condition exists to achieve optimum plant health and function and can inform plant species selection in the shallow zone and deep marsh zones. The wetland guidelines also specify a residence time of three days (72 hours).

The "wetland analysis tool" in the MUSIC auditor tool enables flux files from MUSIC to be used to assess if a wetland meets the residence requirements. MUSIC auditor was used to check the desired 3 day detention time, and conduct an inundation frequency analysis to ensure plants will not be drowned out in the wetland.

Decreasing the size of the weir (sidewinder penstock) opening (the wetland outlet) limits the flow out of the wetland, and therefore increases residence time as well as increases the effective NWL. Opening the weir up creates a more flow-through system, and decreases the detention time and effective NWL. Changing the weir opening, and checking the MUSIC auditor results was conducted iteratively to strike a balance between the desired residence time, effective NWL, and inundation frequency. Essentially, we do not want water sitting above the EDD for longs periods of time.

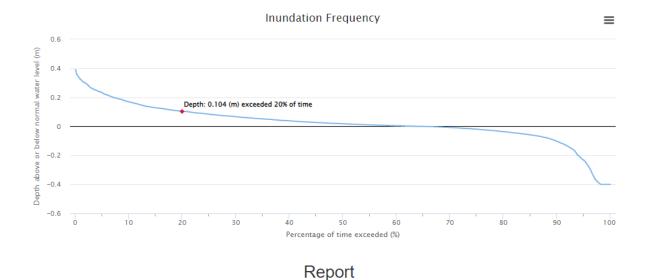
Example results for the inundation frequency analysis can be seen in Figure 41 and the required weir openings and associated residence time for each wetland is provided in Table 15.

Table 15. Wetland outlet properties and residence time results

	WL1	WL2	WL3	WL4	WL5	WL6
Weir opening (side- winder penstock)	200mm	100mm	150mm	150mm	100mm	100mm
Residence time	3 days					

The inundation frequency results for every wetland are provided in Appendix C.

When the entire RB gets filled in a larger event, the inundation time will be longer than three days given the limited RB outflow rates. The pumped outflow cannot be accurately captured in MUSIC. The above inundation rates are for more frequent events.



File: WL6.csv Shallow marsh zone meets deemed to comply criteria

Deep marsh zone does not meet the deemed to comply criteria, please select at least 3 plants

Water level exceeded for 20% of time: 0.104 m

Water level exceeded for 50% of time: 0.177E-01 m

-Effective water level is within 50 mm of normal water level and is acceptable

90th Percentile Residence Time: 3 days

Figure 41. Wetland 6 inundation frequency results

## 7.3 Sediment basins

The wetlands were designed with sediment basins which first receive the minor drainage flows (20% AEP), to allow coarse sediments to drop out before entering the macrophyte zone.

The sediment basins in the treatment modelling have been sized using the Fair and Geyer equation, where sediment basins have been sized to ensure a capture efficiency greater than 95% for coarse particles greater than 125 $\mu$ m diameter for the diversion flows. The procedure outlined in *WSUD Engineering Procedures* (2005) has been followed and are based on the typical sediment loading rate of 1.6 m³/ha/yr for a developed catchment. The sediment basins have been modelled with a pool depth of 1.5 m and a standard cleanout frequency of 5 years.

Results for sediment basin capture efficiency and dewatering areas for each sediment basin are provided in Table 16.

Table 16. Sediment basin calculations

	Parameter	SB1	SB2	SB3	SB4	SB5	SB6
Conditions	Contributing catchment (ha)	103.5	27.7	68.7	42.1	32.4	31.3
Conditions	Area of Basin (m²)	1600	500	1400	750	625	625
	Settling Velocity of Target Sediment (mm/s) [Particle size 125 μm]	11	11	11	11	11	11
	Hydraulic Efficiency (λ)	0.11	0.11	0.11	0.11	0.26	0.26
	Permanent Pool Depth, dp (m)	1.5	1.5	1.5	1.5	1.5	1.5
	Extended detention depth, de	0.35	0.35	0.35	0.35	0.35	0.35
Capture Efficiency	Number of CSTR's, n [From hydraulic efficiency]	1.1	1.1	1.1	1.1	1.4	1.4
	Depth below permanent pool that is sufficient to retain sediment, d (m)	1	1	1	1	1	1
	4EY flows (m3/s)	1.69	0.53	1.49	0.74	0.74	0.66
	Capture Efficiency	95%	95%	95%	95%	96%	96%
	Check ( > 95%)	ОК	ОК	ОК	ОК	ОК	ОК
	Sediment Loading Rate, Lo (m³/ha/yr)	1.6	1.6	1.6	1.6	1.6	1.6
	Desired clean-out frequency, Fr	5	5	5	5	5	5
Sediment storage	Storage volume required, St	784	210	521	320	249	241
storage	Available sediment storage volume	800	250	700	375	313	313
	Check (Available storage > required storage)	Ok	Ok	Ok	Ok	Ok	Ok
Sediment	Depth for dewatering area (m)	0.5	0.5	0.5	0.5	0.5	0.5
-	Area required for dewatering (m <sup>2</sup> )	1568	419	1041	640	497	482

The batter requirements, including a 1 in 8 safety bench, are specified in Table 17 below. Where a batter of a minimum of 1 in 5 above open water cannot be met, a fence or barrier should be adopted for safety reasons. This requirement has been met so fences will not be required.

Table 17. Sediment basin batters

Description	Slope	Distance
NWL to -350 mm (Safety bench)	1 in 8	2.8 m
-350mm to -1500mm (Pool base)	1 in 3	3.45 m
NWL to TED (350mm)	Minimum 1 in 6	2.1 m
Above TED to top of batter	Minimum 1 in 6	Varies

## 7.4 Wetlands

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system complies with appropriate guidelines. The sediment basin and macrophyte zone were sized in 12d using LiDAR data to create a surface level Triangulate Irregular Network (TIN). This then allowed for iterative sizing by changing the layout, location, and Normal Water Level (NWL) height in order to integrate into the existing landscape and minimise cut into the site, and avoid requiring fill. The sizing was conducted in

conjunction with MUSIC modelling in order to optimise pollutant removal, and the hydrologic modelling to ensure detention requirements were met.

Other factors that influenced the configuration of the asset included:

- The requirement to meet a length to width ratio of at least 4:1[MZ4 in the constructed wetlands manual], and therefore the associated maximum width, and how this fit in with the surrounding terrain.
- Meeting velocity requirements
- Minimising excavation requirements where possible.

#### **Batter slopes**

The batter requirements, including a 1 in 8 safety bench, are specified in Table 18 below. Where a batter of a minimum of 1 in 5 above open water cannot be met, a fence or barrier should be adopted for safety reasons. This requirement has been met so fences will not be required.

Table 18. Wetland batters

Description	Slope	Distance	
NWL to -350 mm (safety bench)	1 in 8	2.8 m	
-350mm – 1500mm (pool base)	1 in 3	3.45 m	
NWL to TED (350mm)	Minimum 1 in 6	2.1 m	
Above TED	Minimum 1 in 6	Varies	

## **Velocities**

The velocity through the treatment asset is considered here. A flow depth of 0.35 m, which is the extended detention depth, has been assumed for design flows, which is a conservative approach (as a calculated smaller flow area will result in higher calculated velocities).

A manual calculation has been used to check the flow velocities through the assets. This calculates the flow area from the flow depth (between the extended detention depth and normal water level) and the average width in that area. The average width is determined from the narrowest part of the macrophyte zone or sediment basin. Velocities within the macrophyte zone should be under 0.05m/s, and less than 0.5m/s in the sediment basins.

The maximum width of the wetland was determined using the length to width ratio of at least 4:1[MZ4]. The calculations for the velocities through the wetlands and sediment basins, as well as the length to width ratios are shown in Table 19.

Table 19. Velocity calculations

	Parameter	RBWL1	RBWL2	RBWL3	RBWL4	WLRRB5	RBWL6
	4EY flow (m <sup>3</sup> /s)	1.69	0.53	1.49	0.74	0.74	0.66
Flow	20% AEP flow (m <sup>3</sup> /s)	7.63	2.34	6.62	3.66	3.24	2.98
conditions	Flow depth (m)-between NWL and TED	0.35	0.35	0.35	0.35	0.35	0.35
	Basin area (m²)	1600	500	1400	750	625	625
	Width at NWL (m)	38	18	33	19	17	16
	Width at EDD (m)	42.2	22.2	37.2	23.2	21.2	20.2
	Average width (m)	40.1	20.1	35.1	21.1	19.1	18.1
Sediment pond	Flow Area (m²)	14.0	7.0	12.3	7.4	6.7	6.3
<b>P</b>	Flow Velocity (m/s) (20% AEP)	0.5	0.33	0.5	0.5	0.48	0.47
	Check	< 0.5 OK					
	Length to width ratio*	1.11	1.54	1.29	2.08	2.16	2.44
	NWL area	19000	5500	12,000	8000	6500	6000
	Width at NWL (m)	45	26	38	37	37	35
	Width at EDD (m)	49.2	30.2	42.2	41.2	41.2	38.5
8.0	Average width (m)	47	28	40	39	39	37
Macrophyte zone	Flow Area (m²)	16	10	14	14	14	13
-	Flow Velocity (m/s) (4EY flows)	0.05^	0.05	0.05^	0.05	0.05	0.05
	Check	< 0.05 OK					
-	Length to width ratio	4.69^	8.14	4.16^	5.84	4.75	4.90

<sup>\*</sup>The reduced length to width ratios are reflected in the hydraulic efficiency of the sediment basins

<sup>^</sup>Split flow wetlands (i.e. SB transfers to two parallel wetlands). The velocities and length-width ratio reflect this arrangement.

# 7.5 Dimensions and quantities

Table 20. Wetland dimensions and parameters

	RBWL1	RBWL2	RBWL3	RBWL4	RBWL5	RBWL6
Parameter						
Sediment basin						
NWL	111.5 m AHD	110.8 m AHD	111.3 m AHD	111.4 m AHD	111.95 m AHD	110.8 m AHD
NWL area	1600 m <sup>2</sup>	500 m <sup>2</sup>	1400 m²	750 m²	625 m²	625 m²
NWL width	38 m	18m	33m	19m	17m	16m
EDD	0.35m	0.35m	0.35m	0.35m	0.35m	0.35m
TED	111.85 m AHD	111.15 m AHD	111.65 m AHD	111.75 m AHD	112.3 m AHD	111.15 m AHD
Pool depth	1.5m	1.5m	1.5m	1.5m	1.5m	1.5m
Batters (NWL to existing surface)	1:6	1:6	1:6	1:6	1:6	1:6
Transfer pit crest (NWL)	111.5 m AHD	110.8 m AHD	111.3 m AHD	111.4 m AHD	111.95 m AHD	110.8 m AHD
Transfer pipe diameter (4EY flows)	1050mm (x2)	825mm	1050mm (x2)	1050mm	1050mm	900mm
SB to wetland transfer weir (20%AEP-4EY flows) width and crest elevation (TED)	8.5m (x2), 111.85 m AHD	5.5m, 111.15 m AHD	7.5m (x2), 111.65 m AHD	8.5m, 111.75 m AHD	7.5m, 112.3 m AHD	7m, 111.15 m AHD
Wetland						
NWL	111.4 m AHD	110.7 m AHD	111.2 m AHD	111.3 m AHD	111.85 m AHD	110.7 m AHD
NWL area	19,000 m²	5500 m <sup>2</sup>	12,000 m <sup>2</sup>	8000 m <sup>2</sup>	6500 m <sup>2</sup>	6000 m <sup>2</sup>
NWL width	45 m	26m	38m	37m	37m	35m
EDD	0.35m	0.35m	0.35m	0.35m	0.35m	0.35m
TED	111.75 m AHD	111.05 m AHD	111.55 m AHD	111.65 m AHD	112.2 m AHD	111.05 m AHD
Pool depth	1.5m	1.5m	1.5m	1.5m	1.5m	1.5m
Batters (NWL to existing surface)	1:6	1:6	1:6	1:6	1:6	1:6

#### 7.6 Connections

#### Inflow into sediment basins

The inflow to the sediment basins will be via the minor drainage network. The stormwater main for the catchment will outfall into the sediment basin. Typically, this will be via a rocked endwall.

#### Sediment basin to wetland transfer

There will be piped connections between the sediment basins and the macrophyte zone to pass the 4EY AEP (3 month ARI) peak flow. The connections will be an outlet pit, with the top of the pit at NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The pipes have been sized to pass the 4EY peak flow as established in RORB. The invert of the pipe on the wetland side should be set 200mm above the base of the pool so to avoid being blocked by accumulated sediment. There are Melbourne Water standard drawings for these connection details (i.e. 7251/12/008 and 7251/12/001).

Some wetlands are dual-fed, which means that a single sediment basin is transferring flows into two parallel wetland systems. This has been done to reduce velocities through the macrophyte zone. For these dual-fed systems, there will be two transfer pit/pipe arrangements.

As the 20% AEP flow is to flow through the macrophyte zone, a weir between the sediment basin and macrophyte zone will transfer the gap flows (20% AEP minus the 4EY) via the weir. The crest of this weir is set at the sediment basin TED. The weirs have all been sized to transfer these peak gap flows. All the weirs have a height of 350mm, and the widths have been sized to be able to take the required flows. There is a Melbourne Water standard drawing for this weir detail (i.e. 7251/12/003). Rockwork will be required either side of the weir.

For the dual-fed wetlands, there will be two weirs into the two macrophyte zones.

#### **Balance pipes**

300mm diameter balance pipes connected to submerged offtake pits will be located in the base of the wetland pools, connecting them up. This is important to be able to drain the system for maintenance purposes. This is as per Melbourne Water standard drawings 7251/12/015 and 7251/12/035.

#### Wetland outfall

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level, and flows in the macrophyte zone, to achieve the design detention time for treatment performance.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be located in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to a twin chamber outfall pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure and overflow weir for maintenance.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. There is a Melbourne Water standard drawing for this pit detail (i.e. 7251/12/006). These pits will need to be a modified version of the typical EDD control structure pit as they will need to act as the RB outlet pit as well. This will mean a pipe grill lid arrangement and upsizing the pit dimensions so that they do not act as the hydraulic control.

## 7.7 Maintenance

#### Access

An access track has been located around the treatment systems within the RB, ensuring access to the sediment basin and macrophyte area for maintenance purposes. These have been provided 0.6m above the wetland TED, to ensure the path doesn't regularly get inundated. Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m.

A 5m wide reserve is also provided around the RB perimeter. This can also serve as a recreational loop around the asset.

A maintenance ramp will be provided to the sediment basins. The ramp should extend from the base of the sediment basin to the RB top of batter. It will be 4m wide and no steeper than 1:6. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR (see Melbourne Water standard drawing 7251/12/013). The base of the sediment basins should be concrete or rocked (7251/12/012). Access to the sediment dewatering area has also been provided.

## Sediment dewatering area

Sediment dewatering areas will be required to allow for accumulated sediment taken from the sediment basin to be dewatered before it is transported off the site. This is proposed to occur laterally of the asset, as shown in the design drawings. Access to the sediment basin is via a ramp to the base of the basin.

# 8 Safety in Design

Public safety is an important consideration near stormwater treatment systems, especially in an area that is popular to visit. Levels of risk can relate to the location of the waterway and wetland, type of inflow, ease of access, wetland objectives, nearby land uses and the site context, as well as risks associated with maintenance and general management activities.

## 8.1 Batters

The batters will generally have a slope of 1:8 for the first 350 mm depth below NWL and 1:3 thereafter. Along these sections, dense planting will be used above the extended detention depth to deter access.

The retarding basin has 1 in 6 batters, which is appropriate for Council maintenance and safety.

An internal risk assessment was conducted to identify hazards and appropriate mitigation measures to ensure safe construction and ongoing engagement with the site. A full assessment of risks and mitigation options is detailed in Appendix D.

# 9 Costing

COST

Cost estimate summaries for each asset are provided below in Table 21. The values provided are estimates based on the Australian Construction Handbook, as well as our experience with similar projects. More detailed costing that sits behind these summed up works is provided in Appendix E. This includes all quantities and assumed rates, and costing assumptions. The VPA costing template has been adopted.

**Table 21.** Cost estimate summary for the proposed works

lte m	Description	RBWL1	RBWL2	RBWL3	RBWL4	RBWL5	RBWL6	Overland flow path
1	SITEWORKS AND EARTHWORKS	\$1,757,748.2	\$629,499.7	\$1,234,262.1	\$831,383.4	\$658,533.2	\$636,414.4	\$921,870.5
2	DRAINAGE	\$2,036,547.5	\$629,222.5	\$1,380,705.0	\$512,235.0	\$436,825.0	\$681,807.5	\$-
3	ROCK WORKS	\$33,281.0	\$14,287.0	\$33,038.0	\$18,368.0	\$16,255.0	\$15,597.0	\$-
4	CLAY LINER	\$220,032.0	\$67,276.8	\$145,478.4	\$96,134.4	\$79,449.6	\$74,140.8	\$-
5	TOPSOIL	\$108,233.4	\$44,705.1	\$76,662.3	\$54,915.3	\$49,001.7	\$45,764.4	\$229,340.1
6	AQUATIC PLANTING	\$367,470.0	\$164,340.0	\$267,275.0	\$197,255.0	\$178,150.0	\$167,070.0	\$1,216,220.0
7	PUMPING	\$-	\$179,500.0	\$205,500.0	\$183,500.0	\$196,700.0	\$-	\$-
8	LANDSCAPE	\$198,996.0	\$120,060.0	\$156,195.0	\$126,792.0	\$143,424.0	\$132,600.0	\$-
9	MISCELLANEOUS	\$84,533.5	\$78,836.5	\$82,072.0	\$79,310.5	\$79,384.0	\$79,060.0	\$60,000.0
10	OTHER	\$-	\$-	\$-	\$-	\$-	\$-	\$-
	SUB-TOTAL WORKS	\$4,806,841.6	\$1,927,727.6	\$3,581,187.8	\$2,099,893.6	\$1,837,722.5	\$1,832,454.1	\$2,427,430.6
11	<u>DELIVERY</u>	\$2,223,164.2	\$891,574.0	\$1,656,299.4	\$971,200.8	\$849,946.6	\$847,510.0	\$1,122,686.7
12	TOTAL ESTIMATED	\$7,030,005.8	\$2,819,301.6	\$5,237,487.2	\$3,071,094.4	\$2,687,669.1	\$2,679,964.1	\$3,550,117.3

ALL ASSETS
\$6,669,711.5
\$5,677,342.5
\$130,826.0
\$682,512.0
\$608,622.3
\$2,557,780.0
\$765,200.0
\$878,067.0
\$543,196.5
\$-
\$18,513,257.8
\$8,562,381.7
\$27,075,639.5

### 10 Staging

The drainage assessment for the Shepparton South East PSP and the associated functional designs are for the ultimate development scenario. Development will not necessarily occur in a linear upstream-downstream sequence ('out of sequence development'). Given the PSP is proposed to be serviced by a number of retarding basins and not waterways, this allows a certain degree of flexibility in terms of staging.

Where possible, the basins have been located entirely within a single parcel of land, which will help with more efficient implementation of the drainage strategy. Development staging must provide for early delivery of ultimate drainage infrastructure including stormwater quality treatment. Where this is not possible, development must demonstrate how any interim solution adequately manages and treats stormwater generated from the development and how this will enable delivery of an ultimate drainage solution, all to the satisfaction of the responsible authority.

The staging plan will also be influenced by the phasing out of existing G-MW assets within the PSP as development occurs (i.e. so landholders are still serviced by either new drainage networks of GMW drains).

At the time of delivery of this report, no areas within the PSP were identified as being developed first. As stated above, the drainage strategy is flexible in terms of staging due to the nature of the drainage strategy (individual basins). However, the below principles will need to be adhered to ensure the ultimate strategy is achieved, and impacts on the receiving waters and surrounding landholders are minimised.

South of Channel Road, the overland flow path will likely need to be constructed prior to the development of the surrounding residential areas. If not, the area is at risk of being flooded in larger events when Doyles Rd is overtopped. The existing G-MW channel could be maintained as a flow path as an interim measure.

#### 10.1 Staging principles

The proposed construction strategy has been based on the principal objectives of constructing the project in a timely and efficient manner and ensuring impacts are minimised through the provision of appropriate management measures. The strategy for construction consists of the following key elements:

- It is critical that outfalls to the development are provided
- If an upstream development occurs before downstream ones, the developer will need to build a temporary outfall at their expense and maintenance.
- A developer can also negotiate with downstream landowners/developers to come to an agreement in terms of either a temporary outfall, or building the final asset required.
- The function of G-MW assets is required to be maintained at all times through the development (including the conveyance of external flows through the development)
- No section of GMW assets should be decommissioned until the agreed arrangements are in place to provide the current services.

#### 10.2 G-MW asset decommissioning

There are multiple Goulburn-Murray Water channels and drains within the PSP. Supply channels and pipelines provide irrigation water for domestic and stock use for customers and the drains provide a point of drainage discharge. Under a developed scenario, the existing channels and drains will be intersected by the precinct development and new drainage assets. It is critical that the decommissioning, realignment or conversion (drains to pipes) of these assets takes place in accordance with G-MW requirements to minimise impacts on neighbouring customers.

#### 11 Conclusion

Alluvium Consulting has been engaged by the VPA in partnership with Greater Shepparton City Council to undertake the stormwater/drainage functional designs and associated cost estimates for the Shepparton South East PSP.

Building off previous strategies for the PSP and in consultation with stakeholders, the stormwater management assets for the precinct were developed into concept designs. Once the preferred concept arrangement was agreed on, the assets were developed in functional designs.

The design process included:

- Review of previous strategies
- Consultation with stakeholders
- Agreement of preferred concept designs
- Treatment modelling to ensure best practice treatment targets were met
- Hydrologic modelling to ensure post-development flows are retarded back to pre-development flows or to meet G-MW discharge requirements
- Velocity and sediment capture efficiency calculations
- Earthworks modelling
- Developing functional design drawings
- Cost estimates.

Six assets were developed up:

- RBWL1, outfalling in the Broken River
- RBWL2, outfalling into G-MW drain 2
- RBWL3, outfalling into G-MW drain 2
- RBWL5, outfalling into a G-MW pipe (formerly a drain)
- RBWL6, outfalling in the Broken River.

An overland flow path will also be required in the southern section of the PSP to enable conveyance of external flows and to help provide floodplain storage offsets.

The development of these functional designs will enable Council and the VPA to have confidence in land take areas and cost estimates for the precinct.

### 12 References

BMT WBM, 2017. Shepparton East Overland Flow Urban Flood Study

BMT WBM, 2017. Shepparton East Overland Flow Urban Flood Study – Final Report.

BMT, 2020. Shepparton South East Precinct Hydraulic Modelling Report

Cardno, 2020. Shepparton South East Precinct Structure Plan Stormwater Investigation Study

CPG, 2012. Shepparton South East Growth Corridor Drainage Strategy

Ecology Partners, 2020. Shepparton south east growth corridor framework plan background reports, working paper 2: Environmental values

Joe Bell Heritage Services, 2019. Shepparton South East Precinct Structure Plan Due Diligence Assessment

Spiire, 2014. Shepparton South East Growth Corridor Review of Revised Structure Plan inclusion of Drainage Strategy

Water Technology, July 2018. Shepparton Mooroopna Drainage Catchment Analysis and Strategy.

Water Technology, March 2019. Shepparton Mooroopna Flood Mapping and Flood Intelligence Study.

Water Technology, August 2021. Shepparton Mooroopna 1% AEP Flood Mapping Project.

Water Technology, May 2022. Memo to Greater Shepparton City Council (17 May 2022) – Assessment of the Shepparton South East PSP with the latest flood modelling information.

Yorta Yorta Nation Aboriginal Corporation website: www.yynac.com.au.

# Appendix A Proof of Concept summary

The following has been extracted from the Proof of Concept report (Alluvium, August 2021). For more detail please refer to the full report.

### Spiire drainage strategy

The Spiire drainage strategy for the Shepparton South East PSP, was developed from 2012-2014. The proposed drainage strategy map is provided below (Figure 42).

#### Summary of strategy

The drainage strategy is summarised as follows:

- Six retarding basins with treatment assets within them. RB1 and RB6 are proposed to have wetlands within the base. RB2, RB3, RB4 and RB5 include a series of sediment basins and bioretention treatment areas within the basin.
- The RBs receive gravity-fed, minor piped flows from the contributing catchment. 1% AEP flows enter the assets via overland flow paths. RB2, RB3, RB4, and RB5 have pumped outfall into G-MW drain 2, which ultimately outfalls into the Broken River. RB1 and RB 6 have gravity outfall pipes to the Broken River.
- The storage basins are sized to hold back flows such that they meet the 1.2L/s/ha discharge rule when outfalling into G-MW drains. RB1 and RB6 hold back peak 1% AEP flows to pre-developed park flow rates.
- External rural flows are still conveyed through the G-MW drains through the precinct in a post-development scenario. The G-MW drain running along Channel Rd (Drain 1/2) is proposed to be piped (from Doyles Road), down to RB1. Drain 2/2 is also proposed to be piped from Feiglins Rd to Drain 2, where it would outfall. It is understood that the previous option of redirecting all external rural flows south along Doyles Road was deemed unfeasible.
- RB6 is located adjacent to the Broken River, whereas RB1 is located further north, in the centre of the catchment.
- There is a drainage reserve running east-east through RB1 and connecting to RB6. This intent of this appears to be to take overland 1% AEP flows which overtop Doyles Road into RB1, as well as internal overland flows and direct them into the basins.

#### **Review of strategy**

A review of the strategy based on an understanding of values and constraints, and feedback from stakeholder is provided below.

- Regardless of how the external rural flows could be transferred through the site, Drain 2 will need to remain in place as it is where the existing residential areas bounding the west of the PSP currently outfall. Therefore, the use of this asset as an outfall option seems reasonable and cost-effective. It makes sense to keep the full extent of Drain 2 in place (from Doyles Road to the Broken River), allowing assets RB3, RB4, and RB5 to outfall, and continues to transfer rural flows through the development. Whilst not investigated within this drainage assessment, ultimately it would be beneficial to transfer this asset (from Doyles Rd) to Council, and improve the amenity and access opportunities.
- Outfalling into G-MW drains does, however, mean that the flows have to be retarded back to meet
  the 1.2L/s/ha in a 24 hour event requirement. This results in a larger land take than retarding back to
  the peak 1% AEP pre-development flow rate. Meeting the 1.2L/s/ha rule here should be further
  discussed with G-MW.

- There is not an obvious reason why Drain 1/2 should be piped down to RB1. Whilst this may free up some land through the removal of the open drain for a short section, it would still likely require a pipe access reserve. Further downstream the drain appears to be receiving retarded flows from the existing basins along Channel Rd so a portion of it may need to remain regardless (to be confirmed). Furthermore, this wetland would need to be able to manage the introduction of external rural flows (i.e. managing velocities, nutrient loading). The preference for transforming these open drains (except drain 2) into piped assets has been confirmed with Council.
- Following consultation with stakeholders, it was confirmed there is a desire to shift RB1 further south if possible, freeing up developable land. Having it sit within what is classified as 'stormwater infrastructure' in the below map, like RB6, could free up a significant amount of land.

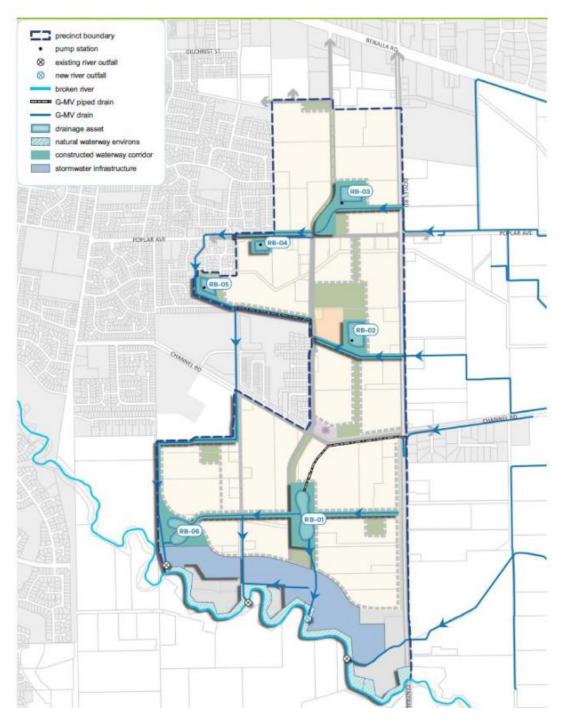


Figure 42. Spiire drainage strategy for the Shepparton South East Precinct (2014)

### Cardno alternate drainage strategy

Cardno was commissioned by the VPA to undertake a stormwater investigation and propose an alternative drainage strategy in relation to previous drainage strategy proposed by Spiire (2014). The primary aim behind this was to reduce the land intake and costs. As part of this assessment Cardno reviewed all existing drainage assessments, assessed the catchments and proposed an alternative drainage plan.

This section aims to provide more detail on the strategy, and a review of the approach in light of an understanding of existing values and constraints, background investigations, stakeholder input, and the objectives of the drainage strategy at this precinct.

### **Summary of strategy**

The strategy is influenced by the 'Blue Green Corridor' concept which proposes a series of constructed waterways through the precinct for flood conveyance, detention, and water quality treatment. However, it has retained two basins and drainage reserves downstream of Channel Road as proposed by Spiire. The key design features of this strategy have been summarised below. The concept design is provided again below in Figure 43.

- Catchments (1-6) were adopted from existing stormwater strategy developed by Spiire (2014). As the
  future Urban Structure Plan is still under review, the catchments were considered as medium
  residential density land use for modelling purposes.
- Drainage through the catchment was assumed to be gravity fed pipe outfall into the waterways. Overland flows were assumed to be diverted through existing and proposed road networks.
- Water quality treatment objectives were met through linear wetlands within the waterway corridor, as well as the wetlands proposed originally by Spiire south of Channel Road. All RBs north of Channel Rd that were previously proposed by Spiire have been removed.
- External flood flows were established by the Shepparton East Overland Flow Urban Flood Study (March 2017). Constructed waterways within the precinct were designed accordingly.
- Tail-water affects from the Broken River have not been considered given that the critical duration storm for the site is only approximately 120mins compared with 24 hrs 48 hrs for the 1% AEP flood event that would overflow from the Broken River.
- The waterway corridor sub-zones and setbacks have been adopted following Melbourne Water's constructed waterways corridor guidelines.
- Four types of waterways corridors varying in widths (55m, 40m, 30m, 28m) were proposed.
- The hydrological model RORB (version 6.42) was used to extract 1% AEP design flow. A probabilistic (Monte Carlo) assessment was completed to determine a design flow event for the outlet of the model.
  - ARR 2016 'Intensity Frequency Duration' (IFD) values were adopted for this study.
  - ARR's regional flood frequency estimation (RFFE) model has been used to calibrate the RORB model.
  - o Calibration included kc (2.94), IL (16.8mm), and CL (2.5mm/hr).
  - The 1% AEP design storm has a critical duration of 120 minutes and used temporal pattern 26.
- Manning's Channel Flow Calculation was undertaken to determine the preliminary channel configuration. HEC-RAS model was built to assess the feasibility of preliminary channel configuration. Input parameters included following.

- 1% AEP flow from hydrologic modelling
- o Grade: 0.1%, Manning's (n): 0.6, Batters (1V:6H)
- Cross sections of the designed waterways were taken at 50m, 40m and 30m intervals for the length of Waterway 1 (50m corridor), 2 (40m and 20m corridor) and 3 (25m corridor)
- Stormwater quality modelling was performed using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). Key design parameters included:
  - A twenty-four year time series (1994 2004) of 6-minute data from the Shepparton rainfall gauge.
  - Rainfall runoff parameters associated with 'Residential Node' and Extended Detention Depth (EDD) of 0.35 were adopted.
  - A total treatment area (wetland) 13,500m<sup>2</sup> is required to meet the best practice guidelines which takes about 20,000m<sup>2</sup> of land take.
- The TUFLOW modelling undertaken by BMT (2020) confirmed that the designed waterway would remove a significant amount of flooding in the developed 1% AEP event, as well as the increased localised flows from within the Precinct itself (Figure 27).
- Cardno estimated a landscape and civil cost of \$16,723,006 for this strategy which was slightly less than the Spiire costing of \$17,286,000. However, the land take was greater (310,060m<sup>2</sup> vs 167,934m<sup>2</sup>).

### **Review of strategy**

Alluvium undertook a high-level review of Cardno's strategy. The key highlights are provided below.

- The Cardno approach provides the opportunity to have a series of blue-green corridors throughout
  the development, with the potential to improve amenity and provide recreational opportunities. It
  also removes the constraints around discharging into G-MW drains. External rural flows can simply
  discharge into these new waterways, and not traverse the development as is currently the case.
- The land take and excavation requirements of this approach appear to be much larger than the basin approach (noting that the design was only done to a concept level compared with the Spiire design being done to a functional level). The use of existing drains (for outfall locations) will help reduce excavation costs within this precinct compared with building new waterways.
- Whilst this approach allows for the removal of G-MW drains across the site, the introduction of
  waterways across the precinct will ultimately require a number of culvert crossings, and likely
  pedestrian crossings to encourage connectivity. This will add to costs.
- The waterway connection down to the Broken River is a new outfall, which is undesirable. It may be
  quite an intrusive outfall within the 30m setback and riparian corridor. Utilising existing outfalls (i.e.
  G-MW drains is preferential).
- Drain 2 will need to remain in place from Poplar Ave down to the Broken River, regardless of which drainage approach is adopted, due to existing residential areas currently outfalling into it.
- The hydrologic modelling undertaken appears to be robust, with the latest data inputs adopted and guidelines followed (for example ARR2016 IFD data).
- We note that only one wetland has been modelled in MUSIC, as opposed to a series of wetlands. A
  series of wetlands should instead be modelled. It is recommended that an EDD of 0.35m should not
  be adopted for series of online wetlands. Having one wetland flow into another has implications on
  residence time and inundation frequencies. A reduced EDD can help manage the compounded EDD
  issue (e.g. 0.2m). This would have implications on meeting treatment targets (i.e. more wetland area

- would be required). It is likely that the residence time would be far less than the standard 72 hours, as the system would operate more as a flow-through system.
- No sediment basins appear to have been incorporated into the design. These are important to protect the macrophyte zones from coarse sediments. The inclusion of sediment basins along the length of the waterway would increase land take, and overall cost estimates.

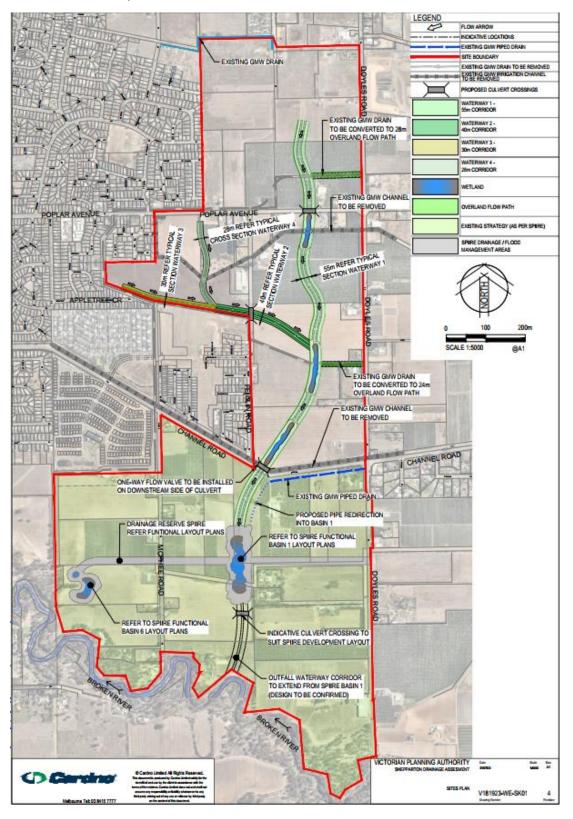


Figure 43. Cardno drainage concept layout (2020)

# Comparative analysis of basin and waterway approach

Table 22. Comparative analysis of basin approach and waterway approach

	Basin-only strategy	Waterway strategy	Comments
London	167,934 m <sup>2</sup>	310,060 m <sup>2</sup>	Waterway approach has a larger land take (+142,146 m² compared with the basin approach).
Land take	(19,840m² in undevelopable Broken River riparian corridor)	(19,840m² in undevelopable Broken River riparian corridor)	Note RB6 is located in undevelopable land for both approaches.
Excavation	465,825 m³	519,293 m <sup>3</sup>	Waterway approach has a larger excavation requirement.
	\$17,286,000	\$16,723,006	The cost estimates are relatively similar, noting the waterway approach costing is limited as it was
	(Source: Spiire functional design costing).	(Source: as presented in Cardno's 2020 Stormwater Drainage Investigation Study).	only done to a concept level. Limitations to the waterway costing include no inclusion of drainage
Cost	*Done to a functional design level, 20%	g	outfalls into the waterway, no sediment basins
estimate	contingency included.	*Done to a concept level, 20% contingency	along the length of the waterways, and limited
		included. The report states that a 50% contingency should be adopted at a concept	preliminaries provision (as it is only concept level). It is very likely the cost estimate would increase if
		level, but 20% was adopted for comparative	progressed to a functional design level. Had a 50%
		purposes.	contingency been adopted, the waterway cost estimate would be \$20.9 million.
	\$57,160	\$58,026	The \$/developable ha rates are relatively comparable but are limited due to the nature of
High level	(Based on a total PSP area of 384.6 ha, minus	(Based on a total PSP area of 384.6 ha, minus	the waterway costing. Had a 50% contingency on
rate per net developable	the Broken River undevelopable corridor and minus the total asset land take within	the Broken River undevelopable corridor and minus the total asset land take within	the cost estimated been adopted on the concept costing, the rate would be around \$72,532.
hectare	developable areas, and cost estimate as per	developable areas, and cost estimate as per	costing, the rate would be around 7/2,332.
	above. No open space considerations have been made beyond this).	above. No open space considerations have been made beyond this).	The basin approach has a lower contribution rate.

Pros	<ul> <li>Gravity-fed pipe outfall into the basins.</li> <li>Drain 2 will need to remain in place as it is where the existing residential areas bounding the west of the PSP currently outfall. The use of existing drains (for outfall locations) will help reduce excavation costs, allowing assets RB3, RB4, and RB5 to outfall, and transferring external flows.</li> <li>External rural flows are still conveyed through the G-MW drains (or pipes) through the precinct in a post-development scenario.</li> <li>Retarding basins with treatment assets within them can provide improved amenity and biodiversity outcomes if designed and constructed well.</li> </ul>	<ul> <li>Gravity-fed pipe outfall into the waterways. The central waterway provides outfall opportunities for the subdivisional drainage.</li> <li>No pumping required.</li> <li>External rural flows are still conveyed through the precinct in a post-development scenario, via the waterways. This removes the constraints around discharging into G-MW drains.</li> <li>Flows only need to be retarded to the 1% AEP pre-developed flow rates.</li> <li>Opportunity to have a series of blue-green corridors throughout the development, with the potential to improve amenity and provide recreational opportunities.</li> </ul>	
Cons	<ul> <li>Outfalling into G-MW drains requires flows to be retarded back to 1.2L/s/ha in a 24-hour event. This results in a larger land take than retarding back to the peak 1% AEP predevelopment flow rate.</li> <li>Several basins will require pumping to drain them. Pump stations are costly and require maintenance. However, Council is familiar, and accepting of pumped systems in Shepparton.</li> <li>Bioretention systems are not recommended in retarding basins.</li> <li>Drain 1/2 is proposed to be piped down to</li> </ul>	<ul> <li>Potentially significant disturbance to the Broken River waterway corridor with the waterway outfall (riparian vegetation and cultural heritage).</li> <li>The land take and excavation requirements of this approach appear to be much larger than the basin approach.</li> <li>The introduction of waterways across the precinct will require several culvert crossings, and likely pedestrian crossings to encourage connectivity. This will add to costs.</li> <li>Drain 1/2 is proposed to be piped down to</li> </ul>	Despite the basin approach requiring the assets outfalling into G-MW drains to be retarded back to the 1.2L/s/ha rule, the overall land take and excavation requirements are still larger in the waterway approach.
	RB1. This wetland would need to be able to	RB1. This wetland would need to be able to	

	manage the introduction of external rural flows (i.e. managing velocities, nutrient loading).	manage the introduction of external rural flows (i.e. managing velocities, nutrient loading).		
		• The approach does not include sediment basins along the length of the waterway, which would be needed to protect the wetland macrophyte zones and capture coarse sediments. The inclusion of these would increase land take and costs.		
	✓ Water quality objectives met through wetlands, sediment basins and bioretention systems.	✓ Water quality treatment objectives met through linear wetlands within the waterway corridor.	Whilst both options meet the design objectives, the basin approach is a closer alignment to design objectives for the following reasons:	
	✓ Water quantity objectives met through retarding post-development 1% AEP flows back to pre-developed peak flows, or the 1.2L/s/ha rule within RBs.	✓ Water quantity objectives met through retarding post-development 1% AEP flows back to pre-developed peak flows within RBs or the waterways.	<ul> <li>The lower cost and land take, and therefore \$/developable ha rate.</li> <li>A smaller number of assets to construct and maintain.</li> <li>A less intrusive outfall into the Broken</li> </ul>	
	✓ Continued serviceability of G-MW assets.	✓ Continued serviceability of G-MW assets.	River from basin 1 when compared with	
Design	✓ No adverse impacts on flood conditions.	✓ No adverse impacts on flood conditions.	the waterway outfall.	
objectives	✓ Provide for multi-objective outcomes in all stormwater management assets.	✓ Provide for multi-objective outcomes in all stormwater management assets.		
	Minimise outfalls: Two outfalls into the Broken River (drain 2 outfall, one new wetland outfall).	Minimise outfalls: Two outfalls into the Broken River – drain 2 and one which is the waterway, which will be more significant than the basin		
	Minimise the number of assets and maintenance requirements: 6 basins, 4 pump	approach RB1 outfall.		
	stations.	Minimise the number of assets and maintenance requirements: 2 basins, 3 wetlands		
	✓ Minimise costs and land take so to ensure a viable DCP cost.	within the waterway and approximately 4.4km of waterways and channels.		

Minimise costs and land take so to ensure a viable DCP cost – slightly more expensive option.

# Comparative analysis of basin approach and alternative basin approach

Table 23. Comparative analysis of basin approach and alternative basin approach

	Basin approach (Spiire)	Proposed approach (Alluvium)*
Land take	167,934 m <sup>2</sup> (19,840m <sup>2</sup> in undevelopable Broken River riparian corridor)	No modelling, and therefore no accurate land take estimates have been undertaken at this early stage. However, there will be an increase to 79,581m² of assets located in the undevelopable Broken River riparian corridor (RB1 and RB6). Furthermore, the merging of two assets from Spiire's approach into one asset (basin 2) will reduce land take.  This will be further quantified in the functional design stage.
Cost estimate	\$17,286,000 (Source: Spiire functional design costing).	No detailed costing has been undertaken at this stage. However, there is expected to be cost efficiencies in the location of Asset 5 utilising the existing irrigation channel and merging of Spiire's assets 4 and 5 (associated with less excavation, batters areas and interface).  This will be further quantified in the functional design stage.
High level rate per net developable hectare	\$57,160  (Based on a total PSP area of 384.6 ha, minus the Broken River undevelopable corridor and minus the total asset land take within developable areas, and cost estimate as per above. No open space considerations have been made beyond this).	No detailed cost estimates have been undertaken at this stage. However, the relocation of RB1 and RB6 into Broken River riparian corridor will add approximately 79,581m² back in the developable area thereby reducing the rate per net developable hectare.  This will be further quantified in the functional design stage.
Pros	<ul> <li>Gravity-fed pipe outfall into the basins.</li> <li>Drain 2 will need to remain in place as it is where the existing residential areas bounding the west of the PSP currently outfall. The use of existing drains (for outfall locations) will help reduce excavation costs, allowing assets RB3, RB4, and RB5 to outfall, and transferring external flows.</li> </ul>	<ul> <li>Gravity-fed pipe outfall into the basins.</li> <li>Making use of drain 2 as an outfall option.</li> <li>External rural flows are still conveyed through the G-MW pipes and Drain 2 (open) through the precinct in a post-development scenario.</li> <li>Shifting RB1 south into the flooding zone, outside of the 30m waterway setback and</li> </ul>

	• External rural flows are still conveyed through the G-MW drains (or pipes) through the precinct in a post-development scenario.	native vegetation, frees up developable land. This impacts on the \$/developable ha rate.
	<ul> <li>Retarding basins with treatment assets within them can provide improved amenity and biodiversity outcomes if designed and constructed well.</li> </ul>	• Wetlands are proposed in the RBs instead of bioretention systems in accordance with industry best practice.
	constructed well.	• RB4 and RB5 from Spiire's strategy are merged into a single, larger asset, reducing costs, land take, and ongoing maintenance.
		<ul> <li>Opportunity to create a green spine the whole way along Channel Rd, linking with existing assets and path networks.</li> </ul>
		• No piping of Drain 1/2 down to RB1 is proposed.
	• Outfalling into G-MW drains requires flows to be retarded back to 1.2L/s/ha in a 24-hour event. This results in a larger land take than retarding back to the peak 1% AEP predevelopment flow rate.	• Outfalling into G-MW drains requires flows to be retarded back to 1.2L/s/ha in a 24-hour event. This results in a larger land take than retarding back to the peak 1% AEP predevelopment flow rate.
Cons	• Several basins will require pumping to drain them. Pump stations are costly and require maintenance. However, Council is familiar, and accepting of pumped systems in Shepparton.	<ul> <li>Several basins will require pumping to drain them. Pump stations are costly and require maintenance. However, Council is familiar, and accepting of pumped systems in Shepparton.</li> </ul>
	Bioretention systems are not recommended in retarding basins.	
	• Drain 1/2 is proposed to be piped down to RB1. This wetland would need to be able to manage the introduction of external rural flows (i.e. managing velocities, nutrient loading).	
	✓ Water quality objectives met through wetlands, sediment basins and bioretention systems.	✓ Water quality objectives met through wetlands and sediment basins.*
Design objectives	✓ Water quantity objectives met through retarding post-development 1% AEP flows back to pre-developed peak flows, or the 1.2L/s/ha rule within RBs.	✓ Water quantity objectives met through retarding post-development 1% AEP flows back to pre-developed peak flows, or the 1.2L/s/ha rule within RBs. *
	✓ Continued serviceability of G-MW assets.	✓ Continued serviceability of G-MW assets.
	✓ No adverse impacts on flood conditions.	✓ No adverse impacts on flood conditions.
		✓ Provide for multi-objective outcomes in

all stormwater management assets.

✓ Provide for multi-objective outcomes in all stormwater management assets.

Minimise outfalls: Three outfalls into the Broken River (two existing G-MW drains, one new wetland outfall).

Minimise the number of assets and maintenance requirements: 6 basins, 4 pump stations.

✓ Minimise costs and land take so to ensure a viable DCP cost.

Minimise outfalls: Three outfalls into the Broken River (two existing G-MW drains, one new wetland outfall).

Minimise the number of assets and maintenance requirements: 6 basins, 4 pump stations.

✓ Minimise costs and land take so to ensure a viable DCP cost.

<sup>\*</sup>Note no modelling undertaken at this preliminary stage.

Appendix B Hydrologic modelling

#### Input parameters

Model inputs were obtained from the ARR2019 data hub and the Bureau of Meteorology's IFD data. An initial loss continuing loss model configuration was adopted.

#### For all models:

- Temporal Patterns Murray Basin (Vic/NSW)
- Catchment fraction imperviousness based on values in Table 2.
- K<sub>c</sub>=1.25 \* dav (for Victorian catchments Pearse et al. 2002)

The kc values adopted for each model are shown below, as are the initial loss (IL) and continuing loss (CL) values. The justification of the kc equation adopted for the models is provided in the calibration section below.

Table 24. RORB models and parameters used

RORB catchment	Total Area (km²)	Кс	m	IL (mm)	CL (mm/hr)
RBWL1	1.03	0.61	0.8	10	2
RBWL2	0.28	0.61	0.8	10	2
RBWL3	0.69	0.61	0.8	10	2
RBWL4	0.42	0.61	0.8	10	2
RBWL5	0.32	0.61	0.8	10	2
RBWL6	0.31	0.61	0.8	10	2

#### Method

The RORB models were used to estimate key design flows throughout the catchment and size retarding basin storages. In accordance with best practice modelling procedures, at least 4 subareas exist upstream from the point of interest.

The hydrologic modelling considered an ensemble simulation for the 1% Annual Exceedance Probability (AEP) event, for durations 10 minutes to 72 hours. From the ensemble simulation, ten temporal patterns were used to determine peak runoffs for each duration. The median flows (i.e. 6<sup>th</sup> highest peak flow) for each storm duration was determined, and the peak critical flow with respect to storage was calculated.

Following the release of the updated Australian Rainfall & Runoff (ARR) 2019 guidelines in April 2019, a new approach is to be undertaken when estimating peak runoff from a specified catchment. Key changes that will influence the hydrologic modelling outputs include:

- Updated Intensity Frequency Duration (IFD) data based on updated rainfall data from a number of rainfall stations. This is sourced from the Bureau of Meteorology's (BoM) website.
- Running the model based upon an ensemble simulation with a set of ten temporal patterns sourced
  from the AR&R data hub to determining the statistical peak flow for a given storm event and
  duration, rather than using a single temporal pattern.
- Using an Initial Loss / Continuing Loss model, rather than a Runoff Coefficient model.
  - o Where Initial Loss values are 10 mm (for urban areas from recent regional studies),
  - and Continuing Loss values of 2 mm/h (based on recent regional studies).

#### Rainfall estimation calibration

In line with the Australian Rainfall & Runoff (2019), calibration of the hydrologic model (i.e. RORB model) is required in order to determine the estimation of rainfall intensities for a specific site.

The Australian Rainfall & Runoff 2019 guidelines suggests that the model is calibrated in line with the Regional Flood Frequency Estimation model (RFFE), whilst using Initial Loss (IL) & Continuing Loss (CL) values provided from the ARR datahub. However, when running the RFFE model, there appears no data points of relative catchment size to the study area (or for the subcatchments, which are all <1.1km²). Therefore, this suggest the flow from RFFE is not directly relatable.

Several calibration approaches were consequently investigated. Noting the average annual rainfall for Shepparton according to the BoM website is less than 800mm. The following formulas investigated were:

- Kc = 1.25 × Dav (for Victorian catchments Pearse et al. 2002)
- Kc = 1.14 × Dav (Dyer 1994; Pears 2002)
- Kc =  $0.49 \times A^{0.65}$  (for regions with mean annual rainfall less than 800mm)

The Kc values very varied by interstation area across the site.

A check was also performed using the rational method and factored this up for a rural catchment, whilst applying an area size factor (Fa) and the ARI factor (Fy) from the VicRoads drainage manual, where:

$$P_{\rm Y} = P_{10} F_{\rm Y} F_{\rm A}$$

Where

Py = the discharge factor for "Y" year ARI

P<sub>10</sub> = the 10 year ARI factor read from Figure 7.2.1 (rural catchments only)

 $F_Y =$ an ARI factor read from Table 7.2.8  $F_A =$ an area size factor, which may be read from Figure 7.2.2 or calculated from:

> $F_A = 1.0$  ( $F_A$  Not Applicable) If A > 5000 ha

F<sub>A</sub> = {1.6 - 0.6(A-1000)/4000} If 1001 < A < 5000 ha

 $F_A = \{2.1 - (A/2000)\}\$ 30 I < A < 1000 ha

$$F_A = 2.0 \text{ approx.}$$
  
If  $0 < A < 300 \text{ ha}$ 

And Fy is taken from the table inset below.

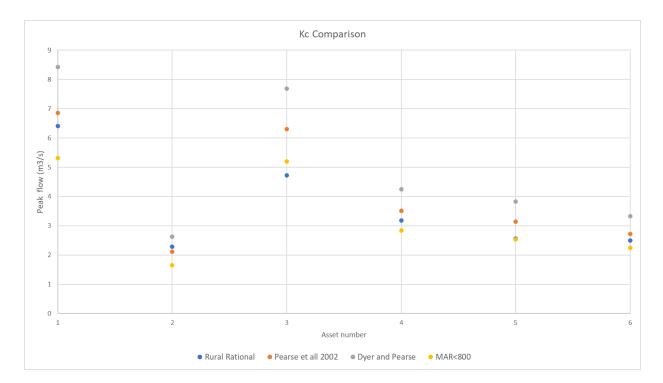
Average recurrence Interval (years)	$\mathbf{F}_{\mathbf{Y}}$
1	0.65
2	0.75
5	0.90
10	1.00
20	1.10
50	1.20
100	1.30
100 Source: After Table 5.4 of ARR 1	

Where  $P_{10} = 0.296$ 

Following an analysis, the Pearse et al formula for Victorian catchments (i.e. 1.25 \* dav), correlated the most with the rural rational method flows. These results are included in Table 25 and Figure 44.

Table 25. Summary of Kc calibration flows for the 1% AEP

Catchment	Rural Rational (applying Vicroads Areal factors)	Pearse Eq.	Dyer and Pearse	Vic <800 Eq.
1	6.41	6.86	8.42	5.31
2	2.29	2.12	2.63	1.65
3	4.72	6.31	7.69	5.2
4	3.18	3.51	4.25	2.84
5	2.56	3.14	3.83	2.54
6	2.5	2.72	3.33	2.25



**Figure 44.** Results of RORB model with various Kcs, compared to rational method calculation

The Pearse et al. formula for Victorian catchments was adopted for the Kc, and flows were determined using RORB.

Appendix C Treatment modelling

### Modelling inputs

The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model that was developed included the following input parameters:

- A historic rainfall dataset was obtained from BoM for the Dookie rainfall gauge (#081013, from 1950-2010). The average annual rainfall over this entire period was obtained from the Bureau of Meteorology (BoM) and used to select a ten-year period from the historic dataset which produced a similar annual average rainfall. The average annual rainfall from BoM is 506mm. The period from 1961-1970 was adopted which has an annual average rainfall of 527mm.
- The monthly average evaporation for Shepparton was also obtained from BoM.
- MUSIC model run at a 6-minute timestep.
- Fraction impervious values and areas for sub catchments consistent with Table 2.
- Wetlands designed to not exceed 72.0 hours detention time, to prevent terrestrial and aquatic vegetation from 'drowning'.

Figure 45 outlines the iterative process of sizing the treatment infrastructure in MUSIC.

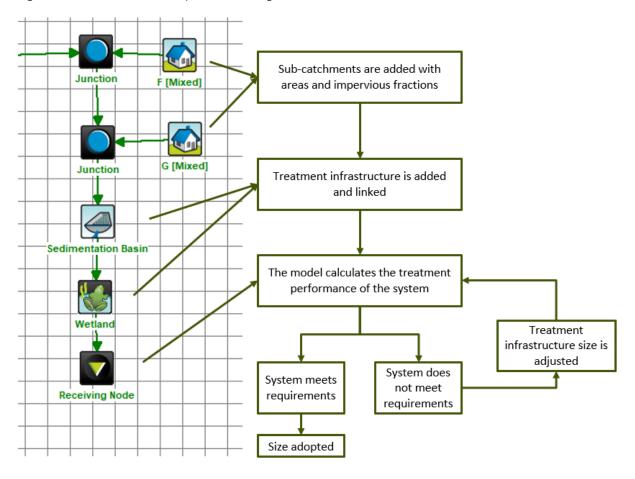
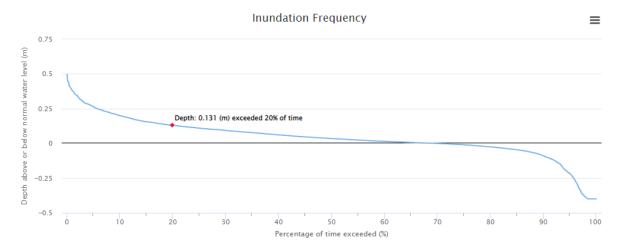


Figure 45. Simplified MUSIC Method

# **Inundation analysis**



# Report

File: WL1.csv

Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.131 m

Water level exceeded for 50% of time: 0.345E-01 m

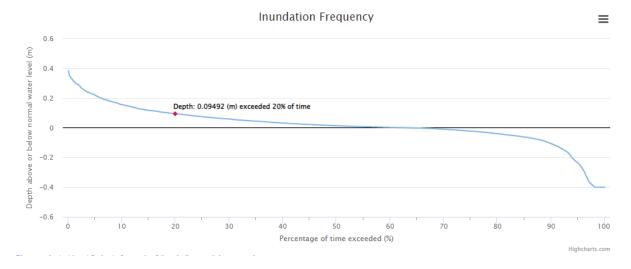
·Effective water level is within 50 mm of normal water level and is acceptable.

90th Percentile Residence Time: 3 days

Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection				
Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush Bolboschoenus caldwellii	1	<b>2</b>		Shallow Only
Jointed Club-rush Baumea articulata	1.8	<b>2</b>	•	
Tall Club-rush Bolboschoenus fluviatilis	1.8	<b>2</b>	•	
Marsh Club-rush Bolboschoenus medianus	1.5	•	<b>▼</b>	Shallow and Deep
Leafy Twig-rush Cladium procerum	2	_	<b>▼</b>	Shallow and Deep
River Club-rush Schoenoplectus tabernaemontani	1.8	_	<b>☑</b>	-
Water Ribbons Triglochin procerum	1	•	•	
Tall Spike-rush Eleocharis sphacelata	1.5		<b>▼</b>	Poon Only
Common reed Phragmites australis	2.5		▼	- Deep Only
Common Spike-rush Eleocharis acuta	0.5	•		Unsuitable
+ Add user defined plant				

Figure 46. Wetland 1 inundation frequency results



File: WL2.csv

Shallow marsh zone does not meet the deemed to comply criteria, please select at least 3 plants

Deep marsh zone meets deemed to comply criteria

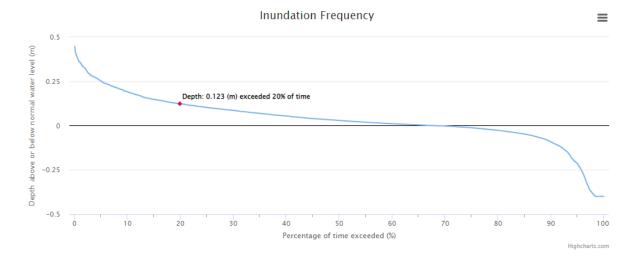
Water level exceeded for 20% of time: 0.09492 m

Water level exceeded for 50% of time: 0.139E-01 m

·Effective water level is within 50 mm of normal water level and is acceptable.

Clear Selection				
Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush Bolboschoenus caldwellii	1	<b>☑</b>		Shallow Only
Common Spike-rush Eleocharis acuta	0.5	<b>2</b>		Shallow Only
Jointed Club-rush Baumea articulata	1.8		<b>▼</b>	
Tall Club-rush Bolboschoenus fluviatilis	1.8	•	<b>▼</b>	
Marsh Club-rush Bolboschoenus medianus	1.5		<b>☑</b>	Shallow and Deep
Leafy Twig-rush Cledium procerum	2			Shallow and Deep
River Club-rush Schoenoplectus tabernaemontani	1.8			
Water Ribbons Triglochin procerum	1			
Tall Spike-rush Eleocharis sphacelata	1.5		<b>▽</b>	- Deep Only
Common reed Phragmites australis	2.5		V	Deep Only

Figure 47. Wetland 2 inundation frequency results



File: WL3.csv Shallow marsh zone meets deemed to comply criteria

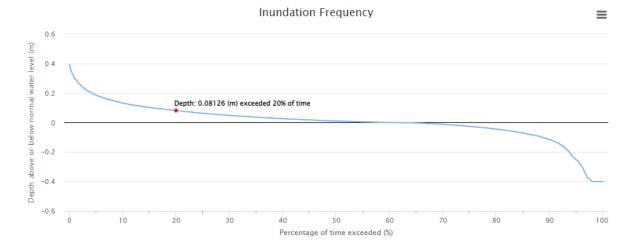
Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.123 m

Water level exceeded for 50% of time: 0.293E-01 m
-Effective water level is within 50 mm of normal water level and is acceptable.

Clear Selection				
Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush Bolboschoenus caldwellii	1			Shallow Only
Jointed Club-rush Baumea articulata	1.8			
Tall Club-rush Bolboschoenus fluviatilis	1.8	<b>☑</b>		
Marsh Club-rush Bolboschoenus medianus	1.5	<b>☑</b>		Shallow and Deep
Leafy Twig-rush Cladium procerum	2			Shallow and Deep
River Club-rush Schoenoplectus tabernaemontani	1.8		<b>v</b>	
Water Ribbons Triglochin procerum	1		<b>☑</b>	
Tall Spike-rush Eleocharis sphacelata	1.5		<b>Z</b>	— Deep Only
Common reed Phragmites australis	2.5		<b>☑</b>	Doop Only
Common Spike-rush Eleocharis acuta	0.5			Unsuitable
+ Add user defined plant				

**Figure 48.** Wetland 3 inundation frequency results



File: WL4.csv

Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

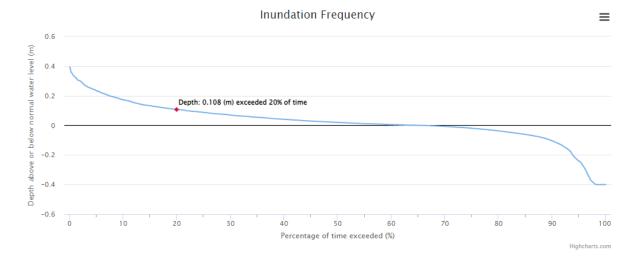
Water level exceeded for 20% of time: 0.08126 m

Water level exceeded for 50% of time: 0.105E-01 m

·Effective water level is within 50 mm of normal water level and is acceptable.

Clear Selection				
Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush Bolboschoenus caldwellii	1	<b>☑</b>		Shallow Only
Common Spike-rush Eleocharis acuta	0.5	<b>☑</b>		Strailow Othy
Jointed Club-rush Baumea articulata	1.8	<b>2</b>	•	
Tall Club-rush Bolboschoenus fluviatilis	1.8	<b>2</b>	•	
Marsh Club-rush Bolboschoenus medianus	1.5	•	<b>☑</b>	Shallow and Deep
Leafy Twig-rush Cladium procerum	2	•	<b>☑</b>	Strailow and Deep
River Club-rush Schoenoplectus tabernaemontani	1.8	•	<b>☑</b>	
Water Ribbons Triglochin procerum	1	•	<b>☑</b>	
Tall Spike-rush Eleocharis sphacelata	1.5		<b>▽</b>	Deep Only
Common reed Phragmites australis	2.5		<b>v</b>	Deep Only

Figure 49. Wetland 4 inundation frequency results



File: WL5.csv Shallow marsh zone meets deemed to comply criteria

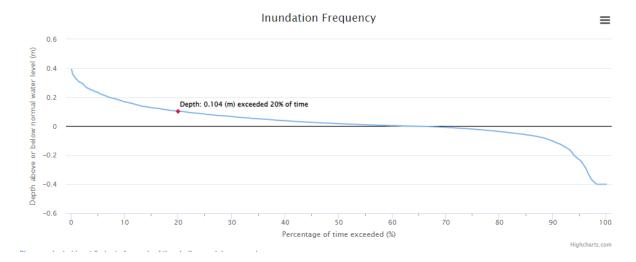
Deep marsh zone does not meet the deemed to comply criteria, please select at least 3 plants

Water level exceeded for 20% of time: 0.108 m

Water level exceeded for 50% of time: 0.194E-01 m
-Effective water level is within 50 mm of normal water level and is acceptable.

Clear Selection				
Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush Bolboschoenus caldwellii	1			Shallow Only
Jointed Club-rush Baumea articulata	1.8	<b>2</b>	•	
Tall Club-rush Bolboschoenus fluviatilis	1.8	<b>2</b>		
Marsh Club-rush Bolboschoenus medianus	1.5	<b>☑</b>		Shallow and Deep
Leafy Twig-rush Cladium procerum	2	<b>2</b>		Shallow and Deep
River Club-rush Schoenoplectus tabernaemontani	1.8	<b>2</b>		
Water Ribbons Triglochin procerum	1	<b>2</b>		
Tall Spike-rush Eleocharis sphacelata	1.5		<b>⊘</b>	Deep Only
Common reed Phragmites australis	2.5		✓	- Deep Only
Common Spike-rush Eleocharis acuta	0.5			Unsuitable

**Figure 50.** Wetland 5 inundation frequency results



File: WL6.csv

Shallow marsh zone meets deemed to comply criteria

Deep marsh zone does not meet the deemed to comply criteria, please select at least 3 plants

Water level exceeded for 20% of time: 0.104 m

Water level exceeded for 50% of time: 0.177E-01 m

·Effective water level is within 50 mm of normal water level and is acceptable.

Clear Selection				
Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush Bolboschoenus caldwellii	1	<b>2</b>		Shallow Only
Jointed Club-rush Baumea articulata	1.8	<b>☑</b>		
Tall Club-rush Bolboschoenus fluviatilis	1.8	<b>☑</b>		
Marsh Club-rush Bolboschoenus medianus	1.5	<b>☑</b>		Shallow and Deep
Leafy Twig-rush Cledium procerum	2			Oriallow and Deep
River Club-rush Schoenoplectus tabernaemontani	1.8			
Water Ribbons Triglochin procerum	1	•	•	
Tall Spike-rush Eleocharis sphacelata	1.5		Z	— Deep Only
Common reed Phragmites australis	2.5		<b>Z</b>	Doop only
Common Spike-rush Eleocharis acuta	0.5			Unsuitable
+ Add user defined plant				

Figure 51. Wetland 6 inundation frequency results

Appendix D
Safety in Design assessment

Table 26. Design Safety Assessment - Buildability

## Design Safety Assessment (DSA)

						ign Safety I										
sign Safety	Assessment														Date	30/11/2021
	Project Name		· · · · · · · · · · · · · · · · · · ·	Shepparton S	South East PSP Stormy	ater Design										
	Project Location				Shepparton, Victoria											
	Project Team			Stuart Clev	en, Jenny Butcher, Ad	vait Maday					_					
	r roject ream			Otdart Oic V	cii, ociiiiy Butolici, Au	vait illauav					-					
							INITTIAL	ASSES	CMENI		DEV//6	SED ASS	CCMEN			
							INITIAL		SMEN		REVIS					
Life Ph	ase	Hazard Category		Location and work activity of WHS Hazard	Potential impact of hazard	Persons Affected	Likelihood	Consequences	Risk Rating	Alternatives/Suggested Controls	Likelihood	Consequences	Risk Rating	Responsibility /Management		Additional Requiremen
1.0	Buildability															
				Near assets, site often not 100% known. Excavation causing						Maintain a buffer from all services. Confirm all service locations and depths prior to commencing works.						
1.1		Utilities and Services	Excavation causes interception with underground services	contact with underground electricity cable	Major injury/loss of life, distruption to utilities, financial impacts	Contractor, public	С	1	1	Ensure apprpriate clearance to electricity cable.	D	1	7	Contractor	Moderate	
		Ounides and Services	underground services	cable	illianciai illipacis	Contractor, public			_	Ensure site where work is being undertaken is fenced. Letter drop to occur before works commence.			,	Contractor	iviouerate	
1.2		Environmental conditions	Ponding of site, public access	Work site	Injury/drowning	Public	С	1	4		D	1	7	Contractor / Council	Moderate	
1.3		Environmental conditions	Rain/storm event during construction resulting in flow.	Work site	Injury/ drowning	Contractor, public	С	1	4	Contractor to develop a flood management strategy that addresses flood risk and appropriate evacuation procedures.  Site evacuation plan.  Meeting location above 1% AEP flood level.  Project sheds above 1% AEP flood level.	D	1	7	Contractor	Moderate	
1.4		Environmental conditions	Flow large storm events	Work site	Slips/falls/ electrocution from presence of water	Contractor	С	1	4	Ensure proper timing for works (check forecast)	D	1	7	Contractor	Moderate	
1.5		Movement of materials, plant and vehicles	Access to the site during construction through residential areas	Work site and surrounds	linjury	Contractor, public	D	2	12	Access to the site during construction should be from major roads such Doyle Road. Access not to occur from west of PSP.  Maintain fencing during works.	E	2	16	Contractor	Moderate	
					Illness, environmental harm, financial	Contractor, owner, surrounding				Conduct soil contamination testing during detailed				Designer /		
1.6		Environmental conditions  Slipe Tripe and Follo	Contaminated land within excavation  Contractors slip/trip/fall when undertaking works within		implications	environment	С		4	design and excavation.  Minimise excavation depth, bench and/or shore	D		7	contractor	Moderate	
1.8		Slips, Trips and Falls  Traffic Management	construction site  Access of roads and crossing of shared paths causes injury	Within site  Construction site boundary	Injury Injury/fatality	Contractor  Contractor/ public	С	1	8	when neccesary  Contractor to have in place Traffic Managament Plan	D	1	7	Contractor	Moderate  Moderate	
1.9		Working at heights	Fall from height		Significant injury	Contractor	С		4	Appropriate benching/ shoring and work safety method.	D	1	7	Contractor	Moderate	
1.1		Violence and Crime	Risk from angry residents/ public	Construction site	Injury	Contractor	С	4	18	Contractor to have in place CMP addressing site risks and community egagement plan. Site security required.	D	4	21	Contractor / Council	Minimal	
1.11		Structural strength and stability	Major injury through structural failure	Throughout site	Major injury	Contractor / maintenance staff	С	1	4	Designer to ensure deep pits are structurally designed to prevent failure. Contractor to ensure procurement through accredited suppliers.	D	1	7	Designer / contractor	Moderate	

Table 27. Design Safety Assessment - Maintainability

					Dos	ign Safety	٨٥٥٥	seem/	ont /[	264)						
					Des	aigii Salety	ASSE	331110	בוונ (נ	73K)						
Design :	Safety Assessment														Dete	00/44/0004
Doolgii	Project Name			Shennarton S	South East PSP Stormy	vater Design									Date	30/11/2021
	Project Location			Опоррания	Shepparton, Victoria	Tator Doolgii										
	Project Team			Stuart Clev	en, Jenny Butcher, Ad	vait Maday					_					
	r roject ream			Otdart Olev	Datoner, Au	Tait madav	T									
							INITIAL	ASSES	SMENT		REVISI	ED ASSE	SSMEN			
ı	Life Phase	Hazard Category	Hazard description	Location and work activity of WHS Hazard	Potential impact of hazard	Persons Affected	Likelihood	Consequences	Risk Rating	Alternatives/Suggested Controls	Likelihood	Consequences	Risk Rating	Responsibility /Management		Additional Requirements
2.0	Maintainability															
2.1	,	Drainage	Poor design of culverts, pits and pipe arrangements can lead to blocking, intensive and difficult maintenance conditions	Pits and pipes within wetlands	Discomfort and physical stress	Maintenance staff	С	4	18	Designer to consult with maintenance staff on access requirements.  Ensure any design enables suitable sizing to pass debris and maintenance access to clear.  Pits to be located adjacent to access tracks.	D	4	21	Designer	Minimal	
2.2		Drainage	Poor design of RB outlet can result in difficult and unsafe maintainence conditions.	Retarding basin outlet pit	Discomfort and physical stress.	Maintenance staff	С	3	13	Designer to consult with maintenance staff on access requirements.  Design to ensure pit grill can be reached with manchinery to clear debris.  Ensure pit is located adjacent to access path.  Ensure pit includes step irons, appropriately spaced.	D	3	17	Designer	Low	
2.3		Drainage	Manualing handling hazard - pit lids. Failure of pit lid. Pits that need to be opened frequently - not able to be opened easily.	Pits throughout work extent	Discomfort and physical stress.	Maintenance staff	С	3	13	Ensure pits are located adjacent to access paths with sufficient flat space around pit. Pit lid design to ensure hinges are located on correct side to allow for easiest opening/closing. Wetland outlet control pits to include opening for side winder access so pit does not need to be opened.	÷.	3	17	Designer	Low	
2.4		Drainage Sediment removal	Maintenance staff unable to locate and access submerged offtake pits.	Submerged pits (in wetland and at flow diversion locations)	Discomfort and physical stress	Maintenance staff	С	4	18	Design to include gauges or ballards to indicate location of submerged offtake pits. Diversion offtakes to be readily accessible to clean blockages.	D D	4	21	Designer	Minimal	
2.5		Weeding, plant replacement	Poor sediment bay design can result in discomfort and physical stress during maintenance  Poor design can result in discomfort and physical stress during maintenance	Within site	Discomfort and physical stress  Discomfort and physical stress	Maintenance staff  Maintenance staff		4	18	Comfortable reach/batter grade, accessible to plant, work safety method, O&M Plan Comfortable reach/batter grade, accessible to plant, work safety method, O&M Plan. Safety benches below Normal Water Level.	С	4		Designer  Designer	Minimal Minimal	

Table 28. Design Safety Assessment – Useability

#### **Design Safety Assessment (DSA) Design Safety Assessment** Date 30/11/2021 Shepparton South East PSP Stormwater Design Shepparton, Victoria **Project Location** Stuart Cleven, Jenny Butcher, Advait Madav **Project Team** INITIAL ASSESSMENT REVISED ASSESSMEN Location and work Potential impact of Persons Responsibility Residual Life Phase **Hazard Category** Hazard description activity of WHS Alternatives/Suggested Controls **Additional Requirements** hazard Affected Risk /Management Useability 3.0 Extensive earthworks and hydrologic modelling conducted to ensure there is no adverse impact on the current flooding extent. Design of the new wetlands, RB and infrastructure pushes out the flood Fountain, Lake, Wetlands, C 1 Public D 1 3.1 Entire works area Foreshore extent / increases flood extent. Flooding Designer Moderate RB outlet gets blocked and doesn't function as intended, causing Retarding basin outlet Ensure pipe grill arrangement is self-cleaning. Drainage flooding. Flooding Public C 1 Ensure appropriate maintenance access to pit. D 1 Designer Moderate Designer / Pits throughout work Lockable lid on all pits. Padlock and hook to be maintenance 17 Drainage Public access into pit Injury Public C 3 included. 3 staff Ensure design incudes fencing installed around any Access to steep banks/ drop-offs at Pools / stormwater vertical drop-offs at rocked stormwater outlets and safety benches are incorporated below NWL. stormwater outlets and pools Moderate

Appendix E Full costing details

### Wetland RB 1- Cost Estimate

Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
item	WORKS	qualities	- Cilic	nate y	Amount	Comments
1	SITEWORKS AND EARTHWORKS				\$1,757,748.21	
		1	Item	\$10,000.00	\$10,000.00	
1.1	Site preparation  Earthworks	1	m3	\$10,000.00	\$-	
1.2			Item		\$-	
1.3	Diversion works Webs as a second seco				1	
1.4	Waterway re-shaping	40224	Item	Ć1 F0	\$-	A 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1.5	Stripping of topsoil and stockpiling	40321	m2	\$1.50	\$60,481.50	Assumed average depth of 200mm  Excavated material assumed to be re-used in development/transported within
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	112484	m3	\$15.00	\$1,687,266.71	Shepparton. Includes over-excavation to allow for clay liner (topsoil layer already removed).
1.7	Formation of batters	0	m3	\$15.00	\$-	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$-	
2	DRAINAGE				\$2,036,547.50	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$-	
2.1.2	Link slabs		No.		\$-	
2.1.3	Foundation slab		m2		\$-	
2.1.4	Other (Description)		Item		\$-	
2.2	DRAINAGE PIPES					
2.2.1	<u>Drainage - pipes:</u> Supply and install catchment stormwater main incl. excavation, crushed rock bedding and back fill.	1800	LM	\$800.00	\$1,440,000.00	Note this has not been designed throughout the catchment yet. A nominal average pipe size has been selected based on the peak 20% AEP flows and preliminary pipe sizing calculations.  Assume there will be at least two mains coming into WL1 given size of 20% AEP flows.  Assumed average of 1050mm pipe.
2.2.2	<u>Drainage - pipes:</u> Supply and install 2 x 1050mm dia RC transfer pipes (SB to WL inlet pools) incl excavation, crushed rock bedding and back fill	27	LM	\$800.00	\$21,600.00	
2.2.3	<u>Drainage - pipes:</u> Supply and install 300mm dia RC balance pipes incl excavation, crushed rock bedding and back fill	260	LM	\$220.00	\$57,200.00	
2.2.4	<u>Drainage - pipes:</u> Supply and install 525mm diam RC pipe (submerged offtake to EDD control pit) incl excavation, crushed rock bedding and back fill	11	LM	\$310.00	\$3,410.00	
2.2.5	<u>Drainage - pipes:</u> Supply and install 1200 mm dia retarding basin outfall pipe (to Broken River) incl excavation, crushed rock bedding and back fill	263	LM	\$1,200.00	\$315,600.00	
2.2.6	<u>Drainage - pits:</u> Supply and install 2 x concrete headwall to suit 1500mm dia. pipe	2	No.	\$10,000.00	\$20,000.00	
2.2.7	<u>Drainage - pits:</u> Supply and install sediment basin to wetland transfer pit including step irons and pipe grill lid arrangement (1500mm x 1500mm x 1500mm)	2	No.	\$8,500.00	\$17,000.00	
2.2.8	<u>Drainage - pits:</u> Supply and install concrete headwall to suit 1050mm dia. pipe	2	No.	\$8,000.00	\$16,000.00	
2.2.9	<u>Drainage - pits:</u> Supply and install submerged offtake pits (600mm x 600mm x 600mm) for balance pipes	4	No.	\$3,000.00	\$12,000.00	
2.2.10	<u>Drainage - pits:</u> Supply and install submerged offtake pit (900mm x 900mm x 900mm) for wetland outlet	1	No.	\$5,000.00	\$5,000.00	
2.2.11	<u>Drainage - pits: Supply and install twin chamber EDD control outlet pit/retarding basin outlet with side-winder penstock, step irons and pipe grill lid</u>	1	No.	\$15,000.00	\$15,000.00	
2.2.12	<u>Drainage - pits:</u> Supply and install water level gauge wetland outlet submerged pit	1	No.	\$1,000.00	\$1,000.00	
2.2.13	Drainage - pits: Allowance for pits located every 80m along stormwater main	23	No.	\$2,400.00	\$54,000.00	
2.2.3	Drainage – Sub-soil drainage		LM		\$-	
2.2.4	Drainage – Miscellaneous (Description)		Item		\$-	

2.32   Appendix							CONCRETE WORKS	2.3
2.32   Section   Control Sec			\$-		m2			
Assessment above contents   Assessment   A								
Supply and install revision for National Supply and Install Supply and Install Supply and Install Supply and Install Revision Supply and Install			\$-					
2.2.1   Section (1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2			\$52,237.50	\$350.00		149	Supply and install reinforced N32 grade concrete, 150 mm deep, extending 300mm vertically up	
Action   Control   Contr			\$6,500.00	\$3,250.00	ltem	2	wetland spillway weir/sill to Melbourne Water standard specification 7251/8/108 (300mm thick,	2.3.5
2.4.2   Other (Decorption)							ON-STRUCTURE WORKS	2.4
2.5 Major Outre pt structure  3 NOVENTS  4 Note Outre pt structure  5 Sediment Pond, Supply and install and wide sediment basin maintenance access ramp, including sub- perspectation. 20mm depth of 10-10mm rCRI, top layer is 10mm of 0-40 NDCR (Rife cement stabilized below NVVI).  3.2 Supply and install well graded DSD-400mm rock to form sediment basin to wetland spillway  3.3 Geofabric. Supply and install well graded DSD-400mm rock to from sediment basin to wetland spillway  3.4 Supply and install well graded DSD-400mm rock to form sediment basin to wetland spillway  4.5 Supply and install inches well become the connected of the connected day inters for sediment basin follow to source off site)  4.1 CLAY LINER  4.1 Sediment Status: Responsed 200 mm toposit for plainting areas  5.0 Sediment Status: Responsed 200 mm toposit for plainting areas  5.0 Welland: Placement of 300 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting for well and well-and (Segree)  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting areas  5.0 Welland: Segreed 200 mm toposit for plainting for well and well-and (Segree)  5.0 Welland: Segreed 200 mm toposit for plainting for well-and well-and (Segree)  5.0 Welland: Segreed 200 mm toposit for plainting for well-and well-and (Segree)  5.0 Welland: Segreed 200 mm toposit for plainting for well-and well-and (Segree)  5.0 Welland: Segreed 200 mm toposit for plainting for well-and well-and (Segree)  5.0 Welland		Included in pipe rates	\$-		m3		Backfill above drainage structure	2.4.1
Rem			\$-		Item		Other (Description)	2.4.2
3   NOCK WORKS     Segiment Point's Supply and install 4m wide sediment basin maintenance access ramp, including sub							OUTLET STRUCTURE	2.5
Sediment Point: Supply and install 4m wide sediment basin maintenance access ramp, including subbase preparation, 200mm depth - bottom layer is 100mm depth of -100mm FCK, top layer is 100mm of 04 MND. (6 % coment business to bottom layer is 100mm depth of -100mm FCK, top layer is 100mm of 04 MND. (6 % coment business to bottom layer is 100mm depth of -100mm FCK, top layer is 100mm of 04 MND. (6 % coment business to bottom layer is 100mm depth of -100mm FCK, top layer is 100mm of 04 MND. (6 % coment business to bottom layer is 100mm depth of -100mm FCK, top layer is 100mm of 04 MND. (6 % coment business to bottom layer is 100mm of 100mm FCK, top layer is 100mm of 100mm of 100mm FCK, top layer is 100mm of			\$-		Item		Major Outlet pit structure	2.5.1
3.1			\$33,281.00				ROCK WORKS	3
3.3   Supply and install geofabric (Bidim A44 or equivalent) for all rockwork   50   1in.m   \$10.00   \$50.00   4m wide roll, includes allowance for overlap			\$4,560.00	\$200.00	m3	23	base preparation. 200mm depth - bottom layer is 100mm depth of 0-100mm FCR, top layer is 100mm	3.1
3.4 Supply and install geokowrik to RB outfall (groken River connection) 4.1 Item \$1,500.00 \$1,5			\$26,720.00	\$200.00	m3	134	Supply and install well graded D50=400mm rock to form sediment basin to wetland spillway	3.2
CAY LINER   Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site)   604 m3   \$32.00   \$19,324.80   Up to TED		4m wide roll, includes allowance for overlap	\$501.00	\$10.00	lin.m	50	Geofabric: Supply and install geofabric (Bidim A44 or equivalent) for all rockwork	3.3
4.1 Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site) 4.2 Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site) 5 TOPSOIL 5.1 Sediment basin: Re spread 200 mm topsoil for planting areas 5.2 Wetland: Re spread 200 mm topsoil for planting areas 5.3 Retarding basin 6.4 AQUATIC PLANTING 6.1 Supply and install submerged marsh planting (600cm3 tube, 1/m2). 6.2 Supply and install deep marsh planting (600cm3 tube, 2/m2). 6.3 Supply and install deep marsh planting (600cm3 tube, 2/m2). 6.4 Supply and install deep marsh planting (600cm3 tube, 2/m2). 6.5 Supply and install elemental planting (900cm3 tube, 4/m2). 6.6 Supply and install elemental planting (900cm3 tube, 4/m2). 6.7 Supply and install interestrial planting (900cm3 tube, 4/m2). 6.8 Supply and install elemental planting (900cm3 tube, 4/m2). 6.9 Supply and install elemental planting (900cm3 tube, 4/m2). 6.1 Supply and install elemental planting (900cm3 tube, 4/m2). 6.2 Supply and install elemental planting (900cm3 tube, 4/m2). 6.3 Supply and install elemental planting (900cm3 tube, 4/m2). 6.4 Supply and install elemental planting (900cm3 tube, 4/m2). 6.5 Supply and install elemental planting (900cm3 tube, 4/m2). 6.6 WL/SE Supply and install elemental planting (900cm3 tube, 4/m2). 6.7 Supply in a selected species in the aquatic zones. 6.8 WL/SE Supply and install elemental planting (900cm3 tube, 4/m2). 6.9 VL/SE Supply and install elemental planting (900cm3 tube, 4/m2). 6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones. 6.8 VL/SE Supply, install and maintain plant protection netting for a selected species in the aquatic zones. 6.9 VL/SE Supply, install and maintain plant protection netting for a selected species in the aquatic zones. 6.0 Supply, install and maintain plant protection netting for a selected species in the aquatic zones. 6.1 Supply, install and maintain plant protection netting for a selected species in the aqua			\$1,500.00	\$1,500.00	Item	1	Supply and install rockwork to RB outfall (Broken River connection)	3.4
4.1 site) 4.2 Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site) 5.1 Sediment basin: Re spread 200 mm topsoil for planting areas 5.2 Wetland: Re spread 200 mm topsoil for planting areas 5.3 Retarding basin 5.3 Retarding basin 6.4 AQUATIC PLANTING 6.1 Supply and install submerged marsh planting (600cm3 tube, 2/m2). 6.2 Supply and install shallow marsh planting (600cm3 tube, 2/m2). 6.3 Supply and install shallow marsh planting (600cm3 tube, 2/m2). 6.4 Supply and install shallow marsh planting (600cm3 tube, 4/m2). 6.5 Supply and install ephemeral planting (90cm3 tube, 4/m2). 6.6 WI/SB: Supply and install heavy jute mat (800gsm) pre-silt at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically 1.1 Supply and install and maintain plant protection netting for a selected species in the aquatic zones. 7 PUMPING 6 Supply and install and maintain plant protection netting for a selected species in the aquatic zones. 7 Supply and install and maintain plant protection netting for a selected species in the aquatic zones. 7 Supply and install altituding overlap of matting (300mm longitudinally/direction of flow), 150mm vertically 1.1 No. \$20,000.0 Section 1.1 No. \$20,000.			\$220,032.00				CLAY LINER	4
TOPSOIL  TOPSOIL  Sediment basin: Re spread 200 mm topsoil for planting areas  503 m2 \$3.30 \$1,659.90 Assumed site topsoil is used, with 20% allowance for importe ephemeral area for wetland/SB as these are connected species in the aquatic zones.  TOPSOIL  TOPSOIL  Sediment basin: Re spread 200 mm topsoil for planting areas  503 m2 \$3.30 \$1,659.90 Assumed site topsoil is used, with 20% allowance for importe ephemeral area for wetland/SB as these are connected species in the aquatic zones.  TOPSOIL  Supply and install submerged marsh planting (600cm3 tube, 1/m2).  Supply and install submerged marsh planting (600cm3 tube, 2/m2).  Supply and install hallow marsh planting (600cm3 tube, 2/m2).  Supply and install shallow marsh planting (600cm3 tube, 2/m2).  Supply and install pehemeral planting (90cm3 tube, 2/m2).  Supply and install pehemeral planting (90cm3 tube, 2/m2).  Supply and install hererstrial planting (90cm3 tube, 4/m2).  Supply and install heavy jute mat (800gsm) pre-silt at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudially/direction of flow), 150mm vertically)  MV/SE: Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  1 No. \$20,000.00 \$22,190.00 NML to TED area for wetland and SB.  Supply and install atom of rising main		Up to TED						4.1
5.1 Sediment basin: Re spread 200 mm topsoil for planting areas  5.2 Wetland: Re spread 200 mm topsoil for planting areas  5.2 Wetland: Re spread 200 mm topsoil for planting areas  5.3 Retarding basin  5.4 ASSUMED site topsoil is used, with 20% allowance for importe ephemeral area for wetland/SB as these are connected  5.3 Retarding basin  5.4 AQUATIC PLANTING  6.1 Supply and install submerged marsh planting (600cm3 tube, 1/m2).  6.2 Supply and install deep marsh planting (600cm3 tube, 2/m2).  6.3 Supply and install shallow marsh planting (600cm3 tube, 2/m2).  6.4 Supply and install shallow marsh planting (600cm3 tube, 4/m2).  6.5 Supply and install ephemeral planting (90cm3 tube, 4/m2).  6.6 Supply and install ephemeral planting (90cm3 tube, 4/m2).  6.5 Supply and install ephemeral planting (90cm3 tube, 4/m2).  6.6 WL/SE: Supply and install heavy jute mat (800gsm) pre-sil: at density 6/m2 in wetland and sediment basin; including overlap of masting (300mm ingludinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  5.3 Metarding basin  5.3 Metarding basin  5.3 Supply and install shallow marsh planting (600cm3 tube, 4/m2).  5.4 Supply and install levery jute mat (800gsm) pre-sil: at density 6/m2 in wetland and sediment basin and wetland.  6.5 Supply and install heavy jute mat (800gsm) pre-sil: at density 6/m2 in wetland and sediment basin; including overlap of masting (300mm ingludinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  1 No. \$20,000.00  5. Supply and install leterors in planting (90cm3 tube, 4/m2).  6. Supply and install leterors in planting (90cm3 tube, 4/m2).  6. Supply and install heavy jute mat (800gsm) pre-sil: at density 6/m2 in wetland and sediment basin; including overlap of masting (300mm longitudinally/direction of flow), 150mm vertically)  6. Supply and install leterors in planting (300mm longitudin		Up to TED	\$200,707.20	\$32.00	m3	6,272	Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site)	4.2
Signature   Sign			\$108,233.40				TOPSOIL	5
ephemeral area for wetland/SB as these are connected  5.3 Retarding basin 9,299 m2 \$3.30 \$30,686.70 Assumed site topsoil is used, with 20% allowance for importe  6 AQUATIC PLANTING  6.1 Supply and install submerged marsh planting (600cm3 tube, 1/m2). \$40 No. \$5.00 \$2,700.00 For both sediment basin and wetland  6.2 Supply and install deep marsh planting (600cm3 tube, 2/m2). \$15,196 No. \$5.00 \$75,980.00 For both sediment basin and wetland  6.3 Supply and install shallow marsh planting (600cm3 tube, 2/m2). \$15,994 No. \$5.00 \$79,970.00 For both sediment basin and wetland  6.4 Supply and install ephemeral planting (90cm3 tube, 4/m2). \$29,456 No. \$2.50 \$73,640.00 For both sediment basin and wetland. Planting rate can be 6/m2. 4/may adopted for some of our other jobs recently.  6.5 Supply and install terrestrial planting (90cm3 tube, 4/m2). \$71,990.00 RB planting (above path in RB)  6.6 WL/SB: Supply and install heavy jute mar (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones. \$1 No. \$20,000.00 \$20,000.00  7 PUMPING  7.1 Supply and installation of rising main	or imported topsoil	Assumed site topsoil is used, with 20% allowance for imported	\$1,659.90	\$3.30	m2	503	Sediment basin: Re spread 200 mm topsoil for planting areas	5.1
6AQUATIC PLANTING\$367,470.006.1Supply and install submerged marsh planting (600cm3 tube, 1/m2).540No.\$5.00\$2,700.00For both sediment basin and wetland6.2Supply and install deep marsh planting (600cm3 tube, 2/m2).15,196No.\$5.00\$75,980.00For both sediment basin and wetland6.3Supply and install shallow marsh planting (600cm3 tube, 2/m2).15,994No.\$5.00\$79,970.00For both sediment basin and wetland6.4Supply and install ephemeral planting (90cm3 tube, 4/m2).29,456No.\$2.50\$73,640.00For both sediment basin and wetland. Planting rate can be 6/m2. 4/madopted for some of our other jobs recently.6.5Supply and install terrestrial planting (90cm3 tube, 4/m2).37,196No.\$2.50\$92,990.00RB planting (above path in RB)6.6WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)2,219m2\$10.00\$22,190.00NWL to TED area for wetland and SB.6.7Supply, install and maintain plant protection netting for a selected species in the aquatic zones.1No.\$20,000.00\$20,000.007PUMPING\$200.00\$-			\$75,886.80	\$3.30	m2	22,996	Wetland: Re spread 200 mm topsoil for planting areas	5.2
Supply and install submerged marsh planting (600cm3 tube, 1/m2).  540  No. \$5.00  \$2,700.00  For both sediment basin and wetland  For both sediment basin and w	or imported topsoil	Assumed site topsoil is used, with 20% allowance for imported	\$30,686.70	\$3.30	m2	9,299	Retarding basin	5.3
5.2 Supply and install deep marsh planting (600cm3 tube, 2/m2).  5.3 Supply and install shallow marsh planting (600cm3 tube, 2/m2).  5.4 Supply and install ephemeral planting (90cm3 tube, 2/m2).  5.5 Supply and install ephemeral planting (90cm3 tube, 4/m2).  5.5 Supply and install terrestrial planting (90cm3 tube, 4/m2).  5.5 Supply and install terrestrial planting (90cm3 tube, 4/m2).  5.5 Supply and install terrestrial planting (90cm3 tube, 4/m2).  5.7 Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  5.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  5. Supply and installation of rising main  5. Supply and install marks planting (adouted basin and wetland  For both sediment basin and wet			\$367,470.00				AQUATIC PLANTING	6
6.3 Supply and install shallow marsh planting (600cm3 tube, 2/m2).  6.4 Supply and install ephemeral planting (90cm3 tube, 4/m2).  6.5 Supply and install terrestrial planting (90cm3 tube, 4/m2).  6.6 WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  7.1 Supply and installation of rising main  15,994  No. \$5.00 \$79,970.00 For both sediment basin and wetland  For both sediment basin and we		For both sediment basin and wetland	\$2,700.00	\$5.00	No.	540	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	6.1
Supply and install ephemeral planting (90cm3 tube, 4/m2).  6.5 Supply and install terrestrial planting (90cm3 tube, 4/m2).  6.6 WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  7.1 Supply and installation of rising main  29,456  No. \$2.50 \$73,640.00  For both sediment basin and wetland. Planting rate can be 6/m2. 4/m adopted for some of our other jobs recently.  82.50 \$92,990.00  RB planting (above path in RB)  NWL to TED area for wetland and SB.  No. \$20,000.00  \$20,000.00  \$20,000.00		For both sediment basin and wetland	\$75,980.00	\$5.00	No.	15,196	Supply and install deep marsh planting (600cm3 tube, 2/m2).	6.2
Supply and install epnemeral planting (90cm3 tube, 4/m2).  6.5 Supply and install terrestrial planting (90cm3 tube, 4/m2).  6.6 WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  7 PUMPING  7.1 Supply and installation of rising main  8 Supply and installation of rising main			\$79,970.00	\$5.00	No.	15,994	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	6.3
6.6 WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  7 PUMPING  7.1 Supply and installation of rising main  LM \$200.00 \$-	e 6/m2. 4/m2 has been				No.		Supply and install ephemeral planting (90cm3 tube, 4/m2).	6.4
basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)  6.7 Supply, install and maintain plant protection netting for a selected species in the aquatic zones.  7 PUMPING  7.1 Supply and installation of rising main  LM \$20,000 \$-  LM \$20,000 \$-		RB planting (above path in RB)	\$92,990.00	\$2.50	No.	37,196	Supply and install terrestrial planting (90cm3 tube, 4/m2).	6.5
7 PUMPING \$- 7.1 Supply and installation of rising main LM \$200.00 \$-		NWL to TED area for wetland and SB.	\$22,190.00	\$10.00	m2	2,219		6.6
7.1 Supply and installation of rising main  LM \$200.00 \$-			\$20,000.00	\$20,000.00	No.	1	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	6.7
hors (170,000,00 C			\$-				PUMPING	7
ltom (170,000,00 (					LM		Supply and installation of rising main	7.1
7.2 Supply and installation of pumping station			\$-	\$170,000.00	Item		Supply and installation of pumping station	7.2
7.3 Provision of electricity supply to pump station switchboard from nominated point of supply, supply and installation of electrical switchboard, connection of power and associated fees.			\$-	\$2,500.00	Item			7.3
			\$198,996.00				LANDSCAPE	8

8.1	Trees: Supply and install trees (tubestock)	100	No.	\$6.00	\$600.00	Nominal allowance for trees
8.2	Landscaping: Supply and install 4m wide RB perimeter gravel access path (thickness 150mm)	3164	m2	\$33.00	\$104,412.00	
8.3	Landscaping: Supply and install 4m wide wetland/SB perimeter gravel access path within RB (thickness 150mm)	2848	m2	\$33.00	\$93,984.00	
9	MISCELLANEOUS				\$84,533.50	
9.1	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$2,500.00	\$30,000.00	
9.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas.	3	Month	\$2,000.00	\$6,000.00	
9.3	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas as per specification.	24	Month	\$750.00	\$18,000.00	
9.4	Allowance for timber bollards	2	No	\$200.00	\$400.00	
9.5	Allowance for seats	2	No	\$2,500.00	\$5,000.00	
9.6	WL/SB: Install habitat logs approx. 4.0m long (no securing required) to wetland area.	2	No.	\$5,000.00	\$10,000.00	
9.7	Allowance for hydroseeding the batters of the basin	10089	m2	\$1.50	\$15,133.50	allowance for hydro seeding the batters of the basins and 1m back from the top of batter. RB planting area (above path in RB) + 1m buffer.
10	OTHER				\$-	
10.1			Item		\$-	
	SUB-TOTAL WORKS				\$4,806,841.61	
11	DELIVERY					
11.1	Council Fees	3.25	%		\$156,222.35	
11.2	VicRoads Fees	1	%		\$48,068.42	
11.3	Traffic Management	5	%		\$240,342.08	
11.4	Environmental Management	0.5	%		\$24,034.21	
11.5	Survey/Design	5	%		\$240,342.08	
11.6	Supervision & Project Management	9	%		\$432,615.74	
11.7	Site Establishment	2.5	%		\$120,171.04	
11.8	Contingency	20	%		\$961,368.32	
	SUB-TOTAL DELIVERY				\$2,223,164.24	

12 TOTAL ESTIMATED COST \$7,030,005.85

## Wetland RB2 - Cost Estimate

Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
item	WORKS	Quantity	Oille	nate 3	Amount	Comments
4					¢630,400,60	
1	SITEWORKS AND EARTHWORKS	4	lt a se	¢ 40,000,00	\$629,499.69	
1.1	Site preparation	1	Item	\$ 10,000.00	\$ 10,000.00	
1.2	Earthworks		m3		\$ -	
1.3	Diversion works		Item		\$ -	
1.4	Waterway re-shaping	46256	Item	64.50	\$ -	
1.5	Stripping of topsoil and stockpiling	16356	m2	\$1.50	\$24,533.69	Assumed average depth of 200mm
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	39664	m3	\$ 15.00	\$ 594,966.00	Excavated material assumed to be re-used in development/transported within Shepparton. Includes over-excavation to allow for clay liner (topsoil layer already removed).
1.7	Formation of batters	0	m3	\$ 15.00	\$ -	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$ -	
2	DRAINAGE				\$ 629,222.50	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$ -	
2.1.2	Link slabs		No.		\$ -	
2.1.3	Foundation slab		m2		\$ -	
2.1.4	Other (Description)		Item		\$ -	
2.2	DRAINAGE PIPES					
2.2.1	<u>Drainage - pipes:</u> Supply and install catchment stormwater main incl. excavation, crushed rock bedding and back fill.	670	LM	\$ 800.00	\$ 536,000.00	Note this has not been designed throughout the catchment yet. A nominal average pipe size has been selected based on the peak 20% AEP flows and preliminary pipe sizing calculations.  Assumed average of 1050mm pipe.
2.2.2	<u>Drainage - pipes:</u> Supply and install 825mm dia RC transfer pipe (SB to WL) incl excavation, crushed rock bedding and back fill	10	LM	\$ 500.00	\$ 5,000.00	
2.2.3	<u>Drainage - pipes:</u> Supply and install 300mm dia RC balance pipes incl excavation, crushed rock bedding and back fill	19	LM	\$ 220.00	\$ 4,180.00	
2.2.4	<u>Drainage - pipes:</u> Supply and install 525mm diam RC pipe (submerged offtake to EDD control pit) incl excavation, crushed rock bedding and back fill	11	LM	\$ 310.00	\$ 3,410.00	
2.2.5	<u>Drainage - pits:</u> Supply and install concrete headwall to suit 1500mm dia. pipe	1	No.	\$ 10,000.00	\$ 10,000.00	
2.2.6	<u>Drainage - pits:</u> Supply and install sediment basin to wetland transfer pit including step irons and pipe grill lid arrangement (1200mm x 1200mm x 1200mm)	1	No.	\$ 7,500.00	\$ 7,500.00	
2.2.7	<u>Drainage - pits:</u> Supply and install headwall to suit 825 mm dia. pipe	1	No.	\$ 6,000.00	\$ 6,000.00	
2.2.8	<u>Drainage - pits:</u> Supply and install submerged offtake pits (600mm x 600mm x 600mm) for balance pipes	2	No.	\$ 3,000.00	\$ 6,000.00	
2.2.9	<u>Drainage - pits:</u> Supply and install submerged offtake pit (900mm x 900mm x 900mm) for wetland outlet	1	No.	\$ 5,000.00	\$ 5,000.00	
2.2.10	<u>Drainage - pits:</u> Supply and install twin chamber EDD control outlet pit/retarding basin outlet with side-winder penstock, step irons and pipe grill lid	1	No.	\$ 15,000.00	\$ 15,000.00	
2.2.11	<u>Drainage - pits:</u> Supply and install water level gauge wetland outlet submerged pit	1	No.	\$ 1,000.00	\$ 1,000.00	
2.2.12	Drainage - pits: Allowance for pits located every 80m along stormwater main	8	No.	\$ 2,400.00	\$ 20,100.00	
2.2.3	Drainage – Sub-soil drainage		LM		\$ -	
2.2.4	Drainage – Miscellaneous (Description)		Item		\$ -	
2.3	CONCRETE WORKS					
2.3.1	Apron slab		m2		\$ -	
2.3.2	Wing wall		m2		\$ -	
2.3.3	Headwall above culverts		m2		\$ -	

2.3.4	Supply and install reinforced N32 grade concrete, 150 mm deep, extending 300mm vertically up batter, to form sediment basin base	23	m3	\$ 350.00	\$ 8,032.50	
2.3.5	Concrete weir/sill: Supply and install reinforced N32 grade concrete to form sediment basin to wetland spillway weir/sill to Melbourne Water standard specification 7251/8/108 (300mm thick, 1100mm deep, 5.5m long)	1	ltem	\$ 2,000.00	\$ 2,000.00	
2.4	ON-STRUCTURE WORKS					
2.4.1	Backfill above drainage structure		m3		\$ -	Included in pipe rates
2.4.2	Other (Description)		Item		\$ -	
2.5	OUTLET STRUCTURE					
2.5.1	Major Outlet pit structure		Item		\$ -	
3	ROCK WORKS				\$ 14,287.00	
3.1	<u>Sediment Pond:</u> Supply and install 4m wide sediment basin maintenance access ramp, including sub base preparation. 200mm depth - bottom layer is 100mm depth of 0-100mm FCR, top layer is 100mm of 0-40 NDCR (6% cement stabilised below NWL).	24	m3	\$ 200.00	\$ 4,800.00	
3.2	Supply and install well graded D50=400mm rock to form sediment basin to wetland spillway	39	m3	\$ 200.00	\$ 7,840.00	
3.3	Geofabric: Supply and install geofabric (Bidim A44 or equivalent) for all rockwork	15	lin.m	\$ 10.00	\$ 147.00	4m wide roll, includes allowance for overlap
3.4	Supply and install rockwork to RB outfall (into G-MW drain)	1	ltem	\$ 1,500.00	\$ 1,500.00	
4	CLAY LINER				\$ 67,276.80	
4.1	Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site)	213	m3	\$ 32.00	\$ 6,806.40	Up to TED
4.2	Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site)	1,890	m3	\$ 32.00	\$ 60,470.40	Up to TED
5	TOPSOIL				\$44,705.10	
5.1	Sediment basin: Re spread 200 mm topsoil for planting areas	287	m2	\$3.30	\$947.10	Assumed site topsoil is used, with 20% allowance for imported topsoil
5.2	Wetland: Re spread 200 mm topsoil for planting areas	7,459	m2	\$3.30	\$24,614.70	Assumed site topsoil is used, with 20% allowance for imported topsoil. Includes ephemeral area for wetland/SB as these are connected
5.3	Retarding basin	5,801	m2	\$3.30	\$19,143.30	Assumed site topsoil is used, with 20% allowance for imported topsoil
6	AQUATIC PLANTING				\$ 164,340.00	
6.1	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	242	No.	\$ 5.00	\$ 1,210.00	For both sediment basin and wetland
6.2	Supply and install deep marsh planting (600cm3 tube, 2/m2).	3,468	No.	\$ 5.00	\$ 17,340.00	For both sediment basin and wetland
6.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	5,748	No.	\$ 5.00	\$ 28,740.00	For both sediment basin and wetland
6.4	Supply and install ephemeral planting (90cm3 tube, 4/m2).	11,588	No.	\$ 2.50	\$ 28,970.00	For both sediment basin and wetland. Planting rate can be 6/m2. 4/m2 has been adopted for some of our other jobs recently.
6.5	Supply and install terrestrial planting (90cm3 tube, 4/m2).	23,204	No.	\$ 2.50	\$ 58,010.00	RB planting (above path in RB)
6.6	WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)	1,007	m2	\$ 10.00	\$ 10,070.00	NWL to TED area for wetland and SB.
6.7	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	\$ 20,000.00	\$ 20,000.00	
7	PUMPING				\$ 179,500.00	
7.1	Supply and installation of rising main	35	LM	\$ 200.00	\$ 7,000.00	
<del>-</del>			<del>-</del>	1	1	I

7.2	Supply and installation of pumping station	1	Item	\$ 170,000.00	\$ 170,000.00	
				<b>+</b> =	7 = 5,555	
7.3	Provision of electricity supply to pump station switchboard from nominated point of supply, supply and installation of electrical switchboard, connection of power and associated fees.	1	Item	\$ 2,500.00	\$ 2,500.00	
8	LANDSCAPE				\$ 120,060.00	
8.1	Trees: Supply and install trees (tubestock)	100	No.	\$ 6.00	\$ 600.00	Nominal allowance for trees
8.2	Landscaping: Supply and install 4m wide RB perimeter gravel access path (thickness 150mm)	2019	m2	\$ 33.00	\$ 66,627.00	
8.3	Landscaping: Supply and install 4m wide wetland/SB perimeter gravel access path within RB (thickness 150mm)	1601	m2	\$ 33.00	\$ 52,833.00	
9	MISCELLANEOUS				\$78,836.50	
9.1	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$ 2,500.00	\$ 30,000.00	
9.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas.	3	Month	\$ 2,000.00	\$ 6,000.00	
9.3	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas as per specification.	24	Month	\$ 750.00	\$ 18,000.00	
9.4	Allowance for timber bollards	2	No	\$ 200.00	\$ 400.00	
9.5	Allowance for seats	2	No	\$ 2,500.00	\$ 5,000.00	
9.6	WL/SB: Install habitat logs approx. 4.0m long (no securing required) to wetland area.	2	No.	\$ 5,000.00	\$ 10,000.00	
9.7	Allowance for hydroseeding the batters of the basin	6291	m2	\$1.50	\$9,436.50	allowance for hydro seeding the batters of the basins and 1m back from the top of batter. RB planting area (above path in RB) + 1m buffer.
10	OTHER				\$ -	
10.1			Item		\$ -	
	SUB-TOTAL WORKS				\$1,927,727.59	
11	DELIVERY					
11.1	Council Fees	3.25	%		\$62,651.15	
11.2	VicRoads Fees	1	%		\$19,277.28	
11.3	Traffic Management	5	%		\$96,386.38	
11.4	Environmental Management	0.5	%		\$9,638.64	
11.5	Survey/Design	5	%		\$96,386.38	
11.6	Supervision & Project Management	9	%		\$173,495.48	
11.7	Site Establishment	2.5	%		\$48,193.19	
11.8	Contingency	20	%		\$385,545.52	
	SUB-TOTAL DELIVERY				\$891,574.01	

12 TOTAL ESTIMATED COST \$2,819,301.59

Wetland	RB3 - Cost Estimate					
Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
	WORKS				-	
1	SITEWORKS AND EARTHWORKS				\$1,234,262.14	
1.1	Site preparation	1	Item	\$10,000.00	\$10,000.00	
1.2	Earthworks		m3		\$-	
1.3	Diversion works		Item		\$-	
1.4	Waterway re-shaping		Item		\$-	
1.5	Stripping of topsoil and stockpiling	28583	m2	\$1.50	\$42,874.50	Assumed average depth of 200mm
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	78759	m3	\$15.00	\$1,181,387.64	Excavated material assumed to be re-used in development/transported within Shepparton. Includes over-excavation to allow for clay liner (topsoil layer already removed).
1.7	Formation of batters	0	m3	\$15.00	\$-	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$-	
2	DRAINAGE				\$1,380,705.00	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$-	
2.1.2	Link slabs		No.		\$-	
2.1.3	Foundation slab		m2		\$-	
2.1.4	Other (Description)		Item		\$-	
2.2	DRAINAGE PIPES					
2.2.1	<u>Drainage - pipes:</u> Supply and install catchment stormwater main incl. excavation, crushed rock bedding and back fill.	1460	LM	\$800.00	\$1,168,000.00	Note this has not been designed throughout the catchment yet. A nominal average pipe size has been selected based on the peak 20% AEP flows and preliminary pipe sizing calculations.  Assume there will be at least two mains coming into WL3 given size of 20% AEP flows. Assumed average of 1050mm pipe.
2.2.2	<u>Drainage - pipes:</u> Supply and install 2 x 1050mm dia RC transfer pipes (SB to WL inlet pools) incl excavation, crushed rock bedding and back fill	22	LM	\$800.00	\$17,600.00	
2.2.3	<u>Drainage - pipes:</u> Supply and install 300mm dia RC balance pipes incl excavation, crushed rock bedding and back fill	72	LM	\$220.00	\$15,840.00	
2.2.4	<u>Drainage - pipes:</u> Supply and install 525mm diam RC pipe (submerged offtake to EDD control pit) incl excavation, crushed rock bedding and back fill	12	LM	\$310.00	\$3,565.00	
2.2.5	<u>Drainage - pits:</u> Supply and install 2 x concrete headwall to suit 1500mm dia. pipe	2	No.	\$10,000.00	\$20,000.00	
2.2.6	<u>Drainage - pits:</u> Supply and install sediment basin to wetland transfer pit including step irons and pipe grill lid arrangement (1500mm x 1500mm x 1500mm)	2	No.	\$8,500.00	\$17,000.00	
2.2.7	<u>Drainage - pits:</u> Supply and install concrete headwall to suit 1050mm dia. pipe	2	No.	\$8,000.00	\$16,000.00	
2.2.8	<u>Drainage - pits:</u> Supply and install submerged offtake pits (600mm x 600mm x 600mm) for balance pipes	4	No.	\$3,000.00	\$12,000.00	
2.2.9	<u>Drainage - pits:</u> Supply and install submerged offtake pit (900mm x 900mm x 900mm) for wetland outlet	1	No.	\$5,000.00	\$5,000.00	
2.2.10	<u>Drainage - pits:</u> Supply and install twin chamber EDD control outlet pit/retarding basin outlet with side-winder penstock, step irons and pipe grill lid	1	No.	\$15,000.00	\$15,000.00	

			ı	Τ.	Τ.	T
2.2.11	<u>Drainage - pits:</u> Supply and install water level gauge wetland outlet submerged pit	1	No.	\$1,000.00	\$1,000.00	
2.2.13	Drainage - pits: Allowance for pits located every 80m along stormwater main	18	No.	\$2,400.00	\$43,800.00	
2.2.3	Drainage – Sub-soil drainage		LM		\$-	
2.2.4	Drainage – Miscellaneous (Description)		Item		\$-	
2.3	CONCRETE WORKS					
2.3.1	Apron slab		m2		\$-	
2.3.2	Wing wall		m2		\$-	
2.3.3	Headwall above culverts		m2		\$-	
2.3.4	Supply and install reinforced N32 grade concrete, 150 mm deep, extending 300mm vertically up batter, to form sediment basin base	114	m3	\$350.00	\$39,900.00	
2.3.5	Concrete weir/sill: Supply and install reinforced N32 grade concrete to form sediment basin to wetland spillway weir/sill to Melbourne Water standard specification 7251/8/108 (300mm thick, 1100mm deep, 7.5m long)	2	Item	\$3,000.00	\$6,000.00	
2.4	ON-STRUCTURE WORKS					
2.4.1	Backfill above drainage structure		m3		\$-	Included in pipe rates
2.4.2	Other (Description)		Item		\$-	
2.5	OUTLET STRUCTURE					
2.5.1	Major Outlet pit structure		Item		\$-	
3	ROCK WORKS				\$33,038.00	
3.1	Sediment Pond: Supply and install 4m wide sediment basin maintenance access ramp, including sub base preparation. 200mm depth - bottom layer is 100mm depth of 0-100mm FCR, top layer is 100mm of 0-40 NDCR (6% cement stabilised below NWL).	22	m3	\$200.00	\$4,480.00	
3.2	Supply and install well graded D50=400mm rock to form sediment basin to wetland spillway	133	m3	\$200.00	\$26,560.00	
3.3	Geofabric: Supply and install geofabric (Bidim A44 or equivalent) for all rockwork	50	lin.m	\$10.00	\$498.00	4m wide roll, includes allowance for overlap
3.4	Supply and install rockwork to RB outfall (into G-MW drain)	1	Item	\$1,500.00	\$1,500.00	
4	CLAY LINER				\$145,478.40	
4.1	Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site)	518	m3	\$32.00	\$16,560.00	Up to TED
4.2	Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site)	4029	m3	\$32.00	\$128,918.40	Up to TED
5	TOPSOIL				\$76,662.30	
5.1	Sediment basin: Re spread 200 mm topsoil for planting areas	475	m2	\$3.30	\$1,567.50	Assumed site topsoil is used, with 20% allowance for imported topsoil
5.2	Wetland: Re spread 200 mm topsoil for planting areas	14951	m2	\$3.30	\$49,338.30	Assumed site topsoil is used, with 20% allowance for imported topsoil. Includes ephemeral area for wetland/SB as these are connected
5.3	Retarding basin	7805	m2	\$3.30	\$25,756.50	Assumed site topsoil is used, with 20% allowance for imported topsoil
6	AQUATIC PLANTING				\$267,275.00	
6.1	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	443	No.	\$5.00	\$2,215.00	For both sediment basin and wetland
6.2	Supply and install deep marsh planting (600cm3 tube, 2/m2).	9528	No.	\$5.00	\$47,640.00	For both sediment basin and wetland
6.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	10394	No.	\$5.00	\$51,970.00	For both sediment basin and wetland
6.4	Supply and install ephemeral planting (90cm3 tube, 4/m2).	20088	No.	\$2.50	\$50,220.00	For both sediment basin and wetland. Planting rate can be 6/m2. 4/m2 has been adopted for some of our other jobs recently.
6.5	Supply and install terrestrial planting (90cm3 tube, 4/m2).	31220	No.	\$2.50	\$78,050.00	RB planting (above path in RB)
			•	•	*	•

		1718	m2	\$10.00	\$17,180.00	1
6.6	WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment	1/10	1112	\$10.00	\$17,100.00	NIA// to TED area for wetland and SD
0.0	basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)					NWL to TED area for wetland and SB.
		1	No.	\$20,000.00	\$20,000.00	
6.7	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	INO.	\$20,000.00	\$20,000.00	
7	PUMPING				\$205,500.00	
7.1	Supply and installation of rising main	165	LM	\$200.00	\$33,000.00	
7.2	Supply and installation of pumping station	1	Item	\$170,000.00	\$170,000.00	
		1	Item	\$2,500.00	\$2,500.00	
7.3	Provision of electricity supply to pump station switchboard from nominated point of supply, supply					
	and installation of electrical switchboard, connection of power and associated fees.					
8	LANDSCAPE				\$156,195.00	
8.1	Trees: Supply and install trees (tubestock)	100	No.	\$6.00	\$600.00	Nominal allowance for trees
0.1	Trees, supply and install trees (tubestook)	2571	m2	\$33.00	\$84,843.00	Notified districted for diees
8.2	Landscaping: Supply and install 4m wide RB perimeter gravel access path (thickness 150mm)	23/1	1112	755.00	704,043.00	
		2144	m2	\$33.00	\$70,752.00	
8.3	Landscaping: Supply and install 4m wide wetland/SB perimeter gravel access path within RB (thickness 150mm)	2144	1112	<b>433.00</b>	770,732.00	
•					\$82,072.00	
9	MISCELLANEOUS  Civil Manda Parfects Maintenance includes a single control of the civil and a single control	12	Month	¢2.500.00		
9.1	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$2,500.00	\$30,000.00	
0.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of	3	Month	\$2,000.00	\$6,000.00	
9.2	plants and trees during establishment, weed control of all planted areas.					
		24	Month	\$750.00	\$18,000.00	
9.3	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees	24	Wionen	7730.00	710,000.00	
3.5	during establishment, weed control of all planted areas as per specification.					
9.4	Allowance for timber bollards	2	No	\$200.00	\$400.00	
9.5	Allowance for seats	2	No	\$2,500.00	\$5,000.00	
		2	No.	\$5,000.00	\$10,000.00	
9.6	WL/SB: Install habitat logs approx. 4.0m long (no securing required) to wetland area.		_	, , , , , , , , , , , , , , , , , , ,	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
9.7	Allowance for hydroseeding the batters of the basin	8448	m2	\$1.50	\$12,672.00	allowance for hydro seeding the batters of the basins and 1m back from the top
						of batter. RB planting area (above path in RB) + 1m buffer.
10	OTHER				\$-	
10.1			Item		\$-	
	SUB-TOTAL WORKS				\$3,581,187.84	
11	DELIVERY					
11.1	Council Fees	3	%		\$116,388.60	
11.2	VicRoads Fees	1	%		\$35,811.88	
11.3	Traffic Management	5	%		\$179,059.39	
11.4	Environmental Management	1	%		\$17,905.94	
11.5	Survey/Design	5	%		\$179,059.39	
11.6	Supervision & Project Management	9	%		\$322,306.91	
11.7	Site Establishment	3	%		\$89,529.70	
11.8	Contingency	20	%		\$716,237.57	
	SUB-TOTAL DELIVERY				\$1,656,299.38	
12	TOTAL ESTIMATED COST				\$5,237,487.22	

### Wetland RB4 - Cost Estimate

wetiand	RB4 - Cost Estimate	Г	1		T	
Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
	<u>WORKS</u>					
1	SITEWORKS AND EARTHWORKS				\$831,383.44	
1.1	Site preparation	1	Item	\$10,000.00	\$10,000.00	
1.2	Earthworks		m3		\$-	
1.3	Diversion works		Item		\$-	
1.4	Waterway re-shaping		Item		\$-	
1.5	Stripping of topsoil and stockpiling	20295	m2	\$1.50	\$30,442.50	Assumed average depth of 200mm
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	52729	m3	\$15.00	\$790,940.94	Excavated material assumed to be re-used in development/transported within Shepparton. Includes over-excavation to allow for clay liner (topsoil layer already removed).
1.7	Formation of batters	0	m3	\$15.00	\$-	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$-	
2	DRAINAGE				\$512,235.00	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$-	
2.1.2	Link slabs		No.		\$-	
2.1.3	Foundation slab		m2		\$-	
2.1.4	Other (Description)		Item		\$-	
2.2	DRAINAGE PIPES					
2.2.1	<u>Drainage - pipes:</u> Supply and install catchment stormwater main incl. excavation, crushed rock bedding and back fill.	507	LM	\$800.00	\$405,600.00	Note this has not been designed throughout the catchment yet. A nominal average pipe size has been selected based on the peak 20% AEP flows and preliminary pipe sizing calculations.  Assumed average of 1050mm pipe.
2.2.2	<u>Drainage - pipes:</u> Supply and install 1050mm dia RC transfer pipe (SB to WL) incl excavation, crushed rock bedding and back fill	10	LM	\$800.00	\$8,000.00	
2.2.3	<u>Drainage - pipes:</u> Supply and install 300mm dia RC balance pipes incl excavation, crushed rock bedding and back fill	32	LM	\$220.00	\$7,040.00	
2.2.4	<u>Drainage - pipes:</u> Supply and install 525mm diam RC pipe (submerged offtake to EDD control pit) incl excavation, crushed rock bedding and back fill	11	LM	\$310.00	\$3,255.00	
2.2.5	<u>Drainage - pits:</u> Supply and install concrete headwall to suit 1500mm dia. pipe	1	No.	\$10,000.00	\$10,000.00	
2.2.6	<u>Drainage - pits:</u> Supply and install sediment basin to wetland transfer pit including step irons and pipe grill lid arrangement (1500mm x 1500mm x 1500mm)	1	No.	\$8,500.00	\$8,500.00	
2.2.7	<u>Drainage - pits:</u> Supply and install headwall to suit 1050mm dia. pipe	1	No.	\$8,000.00	\$8,000.00	
2.2.8	<u>Drainage - pits:</u> Supply and install submerged offtake pits (600mm x 600mm x 600mm) for balance pipes	2	No.	\$3,000.00	\$6,000.00	
2.2.9	<u>Drainage - pits:</u> Supply and install submerged offtake pit (900mm x 900mm x 900mm) for wetland outlet	1	No.	\$5,000.00	\$5,000.00	
2.2.10	<u>Drainage - pits:</u> Supply and install twin chamber EDD control outlet pit/retarding basin outlet with side-winder penstock, step irons and pipe grill lid	1	No.	\$15,000.00	\$15,000.00	
2.2.11	<u>Drainage - pits:</u> Supply and install water level gauge wetland outlet submerged pit	1	No.	\$1,000.00	\$1,000.00	
2.2.12	Drainage - pits: Allowance for pits located every 80m along stormwater main	6	No.	\$2,400.00	\$15,210.00	
2.2.3	Drainage – Sub-soil drainage		LM		\$-	

2.2.4	Drainage – Miscellaneous (Description)		Item		\$-	
2.3	CONCRETE WORKS					
2.3.1	Apron slab		m2		\$-	
2.3.2	Wing wall		m2		\$-	
2.3.3	Headwall above culverts		m2		\$-	
2.3.4	Supply and install reinforced N32 grade concrete, 150 mm deep, extending 300mm vertically up batter, to form sediment basin base	47	m3	\$350.00	\$16,380.00	
2.3.5	Concrete weir/sill: Supply and install reinforced N32 grade concrete to form sediment basin to wetland spillway weir/sill to Melbourne Water standard specification 7251/8/108 (300mm thick, 1100mm deep, 8.5m long)	1	Item	\$3,250.00	\$3,250.00	
2.4	ON-STRUCTURE WORKS					
2.4.1	Backfill above drainage structure		m3		\$-	Included in pipe rates
2.4.2	Other (Description)		Item		\$-	
2.5	OUTLET STRUCTURE					
2.5.1	Major Outlet pit structure		Item		\$-	
3	ROCK WORKS				\$18,368.00	
3.1	<u>Sediment Pond:</u> Supply and install 4m wide sediment basin maintenance access ramp, including sub base preparation. 200mm depth - bottom layer is 100mm depth of 0-100mm FCR, top layer is 100mm of 0-40 NDCR (6% cement stabilised below NWL).	22	m3	\$200.00	\$4,480.00	
3.2	Supply and install well graded D50=400mm rock to form sediment basin to wetland spillway	61	m3	\$200.00	\$12,160.00	
3.3	Geofabric: Supply and install geofabric (Bidim A44 or equivalent) for all rockwork	23	lin.m	\$10.00	\$228.00	4m wide roll, includes allowance for overlap
3.4	Supply and install rockwork to RB outfall (into G-MW drain)	1	Item	\$1,500.00	\$1,500.00	
4	CLAY LINER				\$96,134.40	
4.1	Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site)	291	m3	\$32.00	\$9,302.40	Up to TED
4.2	Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site)	2714	m3	\$32.00	\$86,832.00	Up to TED
5	TOPSOIL				\$54,915.30	
5.1	Sediment basin: Re spread 200 mm topsoil for planting areas	322	m2	\$3.30	\$1,062.60	Assumed site topsoil is used, with 20% allowance for imported topsoil
5.2	Wetland: Re spread 200 mm topsoil for planting areas	10240	m2	\$3.30	\$33,792.00	Assumed site topsoil is used, with 20% allowance for imported topsoil. Includes ephemeral area for wetland/SB as these are connected
5.3	Retarding basin	6079	m2	\$3.30	\$20,060.70	Assumed site topsoil is used, with 20% allowance for imported topsoil
6	AQUATIC PLANTING				\$197,255.00	
6.1	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	291	No.	\$5.00	\$1,455.00	For both sediment basin and wetland
6.2	Supply and install deep marsh planting (600cm3 tube, 2/m2).	6204	No.	\$5.00	\$31,020.00	For both sediment basin and wetland
6.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	7158	No.	\$5.00	\$35,790.00	For both sediment basin and wetland
6.4	Supply and install ephemeral planting (90cm3 tube, 4/m2).	14360	No.	\$2.50	\$35,900.00	For both sediment basin and wetland. Planting rate can be 6/m2. 4/m2 has been adopted for some of our other jobs recently.
6.5	Supply and install terrestrial planting (90cm3 tube, 4/m2).	24316	No.	\$2.50	\$60,790.00	RB planting (above path in RB)
6.6	WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)	1230	m2	\$10.00	\$12,300.00	NWL to TED area for wetland and SB.

6.7	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	\$20,000.00	\$20,000.00	
	supply, material material procession metallig for a solution species in the aquatic zones.					
7	PUMPING				\$183,500.00	
7.1	Supply and installation of rising main	55	LM	\$200.00	\$11,000.00	
7.2	Supply and installation of pumping station	1	Item	\$170,000.00	\$170,000.00	
7.3	Provision of electricity supply to pump station switchboard from nominated point of supply, supply and installation of electrical switchboard, connection of power and associated fees.	1	Item	\$2,500.00	\$2,500.00	
8	LANDSCAPE				\$126,792.00	
8.1	Trees: Supply and install trees (tubestock)	100	No.	\$6.00	\$600.00	Nominal allowance for trees
8.2	Landscaping: Supply and install 4m wide RB perimeter gravel access path (thickness 150mm)	2112	m2	\$33.00	\$69,696.00	
8.3	Landscaping: Supply and install 4m wide wetland/SB perimeter gravel access path within RB (thickness 150mm)	1712	m2	\$33.00	\$56,496.00	
9	MISCELLANEOUS				\$79,310.50	
9.1	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$2,500.00	\$30,000.00	
9.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas.	3	Month	\$2,000.00	\$6,000.00	
9.3	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas as per specification.	24	Month	\$750.00	\$18,000.00	
9.4	Allowance for timber bollards	2	No	\$200.00	\$400.00	
9.5	Allowance for seats	2	No	\$2,500.00	\$5,000.00	
9.6	WL/SB: Install habitat logs approx. 4.0m long (no securing required) to wetland area.	2	No.	\$5,000.00	\$10,000.00	
9.7	Allowance for hydroseeding the batters of the basin	6607	m2	\$1.50	\$9,910.50	allowance for hydro seeding the batters of the basins and 1m back from the top of batter. RB planting area (above path in RB) + 1m buffer.
10	OTHER				\$-	
10.1			Item		\$-	
	SUB-TOTAL WORKS				\$2,099,893.64	
11	DELIVERY					
11.1	Council Fees	3	%		\$68,246.54	
11.2	VicRoads Fees	1	%		\$20,998.94	
11.3	Traffic Management	5	%		\$104,994.68	
11.4	Environmental Management	1	%		\$10,499.47	
11.5	Survey/Design	5	%		\$104,994.68	
11.6	Supervision & Project Management	9	%		\$188,990.43	
11.7	Site Establishment	3	%		\$52,497.34	
11.8	Contingency	20	%		\$419,978.73	
	SUB-TOTAL DELIVERY				\$971,200.81	

12 TOTAL ESTIMATED COST \$3,071,094.45

## Wetland RB5 - Cost Estimate

vvetianu	RB5 - Cost Estimate		1 .		T .	
Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
	<u>WORKS</u>					
1	SITEWORKS AND EARTHWORKS				\$658,533.18	
1.1	Site preparation	1	Item	\$10,000.00	\$10,000.00	
1.2	Earthworks		m3		\$-	
1.3	Diversion works		Item		\$-	
1.4	Waterway re-shaping		Item		\$-	
1.5	Stripping of topsoil and stockpiling	18414	m2	\$1.50	\$27,621.00	Assumed average depth of 200mm
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	41394	m3	\$15.00	\$620,912.18	Excavated material assumed to be re-used in development/transported within Shepparton. Includes over-excavation to allow for clay liner (topsoil layer already removed).
1.7	Formation of batters	0	m3	\$15.00	\$-	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$-	
2	DRAINAGE				\$436,825.00	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$-	
2.1.2	Link slabs		No.		\$-	
2.1.3	Foundation slab		m2		\$-	
2.1.4	Other (Description)		Item		\$-	
2.2	DRAINAGE PIPES					
2.2.1	<u>Drainage - pipes:</u> Supply and install catchment stormwater main incl. excavation, crushed rock bedding and back fill.	397	LM	\$800.00	\$317,600.00	Note this has not been designed throughout the catchment yet. A nominal average pipe size has been selected based on the peak 20% AEP flows and preliminary pipe sizing calculations.  Assumed average of 1050mm pipe.
2.2.2	<u>Drainage - pipes:</u> Supply and install 1050mm dia RC transfer pipe (SB to WL) incl excavation, crushed rock bedding and back fill	10	LM	\$800.00	\$8,000.00	
2.2.3	<u>Drainage - pipes:</u> Supply and install 300mm dia RC balance pipes incl excavation, crushed rock bedding and back fill	129	LM	\$220.00	\$28,380.00	
2.2.4	<u>Drainage - pipes:</u> Supply and install 525mm diam RC pipe (submerged offtake to EDD control pit) incl excavation, crushed rock bedding and back fill	11	LM	\$310.00	\$3,410.00	
2.2.5	<u>Drainage - pits:</u> Supply and install concrete headwall to suit 1500mm dia. pipe	1	No.	\$10,000.00	\$10,000.00	
2.2.6	<u>Drainage - pits:</u> Supply and install sediment basin to wetland transfer pit including step irons and pipe grill lid arrangement (1500mm x 1500mm x 1500mm)	1	No.	\$8,500.00	\$8,500.00	
2.2.7	<u>Drainage - pits:</u> Supply and install headwall to suit 1050mm dia. pipe	1	No.	\$8,000.00	\$8,000.00	
2.2.8	<u>Drainage - pits:</u> Supply and install submerged offtake pits (600mm x 600mm x 600mm) for balance pipes	2	No.	\$3,000.00	\$6,000.00	
2.2.9	<u>Drainage - pits:</u> Supply and install submerged offtake pit (900mm x 900mm x 900mm) for wetland outlet	1	No.	\$5,000.00	\$5,000.00	
2.2.10	<u>Drainage - pits:</u> Supply and install twin chamber EDD control outlet pit/retarding basin outlet with side-winder penstock, step irons and pipe grill lid	1	No.	\$15,000.00	\$15,000.00	
2.2.11	<u>Drainage - pits:</u> Supply and install water level gauge wetland outlet submerged pit	1	No.	\$1,000.00	\$1,000.00	
2.2.12	Drainage - pits: Allowance for pits located every 80m along stormwater main	5	No.	\$2,400.00	\$11,910.00	

2.2.3	Drainage – Sub-soil drainage		LM		\$-	
2.2.4	Drainage – Miscellaneous (Description)		Item		\$-	
2.3	CONCRETE WORKS					
2.3.1	Apron slab		m2		\$-	
2.3.2	Wing wall		m2		\$-	
2.3.3	Headwall above culverts		m2		\$-	
2.3.4	Supply and install reinforced N32 grade concrete, 150 mm deep, extending 300mm vertically up batter, to form sediment basin base	32	m3	\$350.00	\$11,025.00	
2.3.5	Concrete weir/sill: Supply and install reinforced N32 grade concrete to form sediment basin to wetland spillway weir/sill to Melbourne Water standard specification 7251/8/108 (300mm thick, 1100mm deep, 7.5m long)	1	Item	\$3,000.00	\$3,000.00	
2.4	ON-STRUCTURE WORKS					
2.4.1	Backfill above drainage structure		m3		\$-	Included in pipe rates
2.4.2	Other (Description)		Item		\$-	
2.5	OUTLET STRUCTURE					
2.5.1	Major Outlet pit structure		Item		\$-	
3	ROCK WORKS				\$16,255.00	
3.1	Sediment Pond: Supply and install 4m wide sediment basin maintenance access ramp, including sub base preparation. 200mm depth - bottom layer is 100mm depth of 0-100mm FCR, top layer is 100mm of 0-40 NDCR (6% cement stabilised below NWL).	21	m3	\$200.00	\$4,160.00	
3.2	Supply and install well graded D50=400mm rock to form sediment basin to wetland spillway	52	m3	\$200.00	\$10,400.00	
3.3	Geofabric: Supply and install geofabric (Bidim A44 or equivalent) for all rockwork	20	lin.m	\$10.00	\$195.00	4m wide roll, includes allowance for overlap
3.4	Supply and install rockwork to RB outfall (into G-MW drain)	1	Item	\$1,500.00	\$1,500.00	
4	CLAY LINER				\$79,449.60	
4.1	Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site)	254	m3	\$32.00	\$8,131.20	
4.2	Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site)	2,229	m3	\$32.00	\$71,318.40	Up to TED
5	TOPSOIL				\$49,001.70	
5.1	Sediment basin: Re spread 200 mm topsoil for planting areas	302	m2	\$3.30	\$996.60	Assumed site topsoil is used, with 20% allowance for imported topsoil
5.2	Wetland: Re spread 200 mm topsoil for planting areas	8,479	m2	\$3.30	\$27,980.70	Assumed site topsoil is used, with 20% allowance for imported topsoil. Includes ephemeral area for wetland/SB as these are connected
5.3	Retarding basin	6,068	m2	\$3.30	\$20,024.40	Assumed site topsoil is used, with 20% allowance for imported topsoil
6	AQUATIC PLANTING				\$178,150.00	
6.1	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	272	No.	\$5.00	\$1,360.00	For both sediment basin and wetland
6.2	Supply and install deep marsh planting (600cm3 tube, 2/m2).	5,474	No.	\$5.00	\$27,370.00	For both sediment basin and wetland
6.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	5,498	No.	\$5.00	\$27,490.00	For both sediment basin and wetland
6.4	Supply and install ephemeral planting (90cm3 tube, 4/m2).	12,092	No.	\$2.50	\$30,230.00	For both sediment basin and wetland. Planting rate can be 6/m2. 4/m2 has been adopted for some of our other jobs recently.
6.5	Supply and install terrestrial planting (90cm3 tube, 4/m2).	24,272	No.	\$2.50	\$60,680.00	RB planting (above path in RB)

6.6	WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)	1,102	m2	\$10.00	\$11,020.00	NWL to TED area for wetland and SB.
6.7	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	\$20,000.00	\$20,000.00	
7	PUMPING				\$196,700.00	
7.1	Supply and installation of rising main	121	LM	\$200.00	\$24,200.00	
7.2	Supply and installation of pumping station	1	Item	\$170,000.00	\$170,000.00	
7.3	Provision of electricity supply to pump station switchboard from nominated point of supply, supply and installation of electrical switchboard, connection of power and associated fees.	1	Item	\$2,500.00	\$2,500.00	
8	LANDSCAPE				\$143,424.00	
8.1	Trees: Supply and install trees (tubestock)	100	No.	\$6.00	\$600.00	Nominal allowance for trees
8.2	Landscaping: Supply and install 4m wide RB perimeter gravel access path (thickness 150mm)	2356	m2	\$33.00	\$77,748.00	
8.3	Landscaping: Supply and install 4m wide wetland/SB perimeter gravel access path within RB (thickness 150mm)	1972	m2	\$33.00	\$65,076.00	
9	MISCELLANEOUS				\$79,384.00	
9.1	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$2,500.00	\$30,000.00	
9.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas.	3	Month	\$2,000.00	\$6,000.00	
9.3	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas as per specification.	24	Month	\$750.00	\$18,000.00	
9.4	Allowance for timber bollards	2	No	\$200.00	\$400.00	
9.5	Allowance for seats	2	No	\$2,500.00	\$5,000.00	
9.6	WL/SB: Install habitat logs approx. 4.0m long (no securing required) to wetland area.	2	No.	\$5,000.00	\$10,000.00	
9.7	Allowance for hydroseeding the batters of the basin	6656	m2	\$1.50	\$9,984.00	allowance for hydro seeding the batters of the basins and 1m back from the top of batter. RB planting area (above path in RB) + 1m buffer.
10	OTHER				\$-	
10.1			Item		\$-	
	SUB-TOTAL WORKS				\$1,837,722.48	
11	DELIVERY					
11.1	Council Fees	3.25	%		\$59,725.98	
11.2	VicRoads Fees	1	%		\$18,377.22	
11.3	Traffic Management	5	%		\$91,886.12	
11.4	Environmental Management	0.5	%		\$9,188.61	
11.5	Survey/Design	5	%		\$91,886.12	
11.6	Supervision & Project Management	9	%		\$165,395.02	
11.7	Site Establishment	2.5	%		\$45,943.06	
11.8	Contingency	20	%		\$367,544.50	
	SUB-TOTAL DELIVERY				\$849,946.64	

		\$2,687,669.12
12	TOTAL ESTIMATED COST	1 57.687.669.17

## Wetland RB6 - Cost Estimate

wetiand	RB6 - Cost Estimate	Г	1	Т		
Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
	WORKS					
1	SITEWORKS AND EARTHWORKS				\$636,414.36	
1.1	Site preparation	1	Item	\$10,000.00	\$10,000.00	
1.2	Earthworks		m3		\$-	
1.3	Diversion works		Item		\$-	
1.4	Waterway re-shaping		Item		\$-	
1.5	Stripping of topsoil and stockpiling	17163	m2	\$1.50	\$25,744.50	Assumed average depth of 200mm
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	40045	m3	\$15.00	\$600,669.86	Excavated material assumed to be re-used in development/transported within Shepparton. Includes over-excavation to allow for clay liner (topsoil layer already removed).
1.7	Formation of batters	0	m3	\$15.00	\$-	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$-	
2	DRAINAGE				\$681,807.50	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$-	
2.1.2	Link slabs		No.		\$-	
2.1.3	Foundation slab		m2		\$-	
2.1.4	Other (Description)		Item		\$-	
2.2	DRAINAGE PIPES					
2.2.1	<u>Drainage - pipes:</u> Supply and install catchment stormwater main incl. excavation, crushed rock bedding and back fill.	630	LM	\$800.00	\$504,000.00	Note this has not been designed throughout the catchment yet. A nominal average pipe size has been selected based on the peak 20% AEP flows and preliminary pipe sizing calculations.  Assumed average of 1050mm pipe.
2.2.2	<u>Drainage - pipes:</u> Supply and install 900mm dia RC transfer pipe (SB to WL) incl excavation, crushed rock bedding and back fill	11	LM	\$550.00	\$6,050.00	
2.2.3	<u>Drainage - pipes:</u> Supply and install 300mm dia RC balance pipes incl excavation, crushed rock bedding and back fill	68	LM	\$220.00	\$14,960.00	
2.2.4	<u>Drainage - pipes:</u> Supply and install 525mm diam RC pipe (submerged offtake to EDD control pit) incl excavation, crushed rock bedding and back fill	11	LM	\$310.00	\$3,410.00	
2.2.5	<u>Drainage - pipes:</u> Supply and install 925 mm dia retarding basin outfall pipe (to Broken River) incl excavation, crushed rock bedding and back fill	122	LM	\$550.00	\$67,100.00	
2.2.6	<u>Drainage - pits:</u> Supply and install concrete headwall to suit 1500mm dia. pipe	1	No.	\$10,000.00	\$10,000.00	
2.2.7	<u>Drainage - pits:</u> Supply and install sediment basin to wetland transfer pit including step irons and pipe grill lid arrangement (1200mm x 1200mm x 1200mm)	1	No.	\$7,500.00	\$7,500.00	
2.2.8	<u>Drainage - pits:</u> Supply and install headwall to suit 900mm dia. pipe	1	No.	\$6,500.00	\$6,500.00	
2.2.9	<u>Drainage - pits:</u> Supply and install submerged offtake pits (600mm x 600mm x 600mm) for balance pipes	2	No.	\$3,000.00	\$6,000.00	
2.2.10	<u>Drainage - pits:</u> Supply and install submerged offtake pit (900mm x 900mm x 900mm) for wetland outlet	1	No.	\$5,000.00	\$5,000.00	
2.2.11	<u>Drainage - pits:</u> Supply and install twin chamber EDD control outlet pit/retarding basin outlet with side-winder penstock, step irons and pipe grill lid	1	No.	\$15,000.00	\$15,000.00	
2.2.12	<u>Drainage - pits:</u> Supply and install water level gauge wetland outlet submerged pit	1	No.	\$1,000.00	\$1,000.00	

2.2.13	Drainage - pits: Allowance for pits located every 80m along stormwater main	8	No.	\$2,400.00	\$18,900.00	1
2.2.3	Drainage – Sub-soil drainage	_	LM	7-7,100110	\$-	
2.2.4	Drainage – Miscellaneous (Description)		Item		\$-	
2.3	CONCRETE WORKS					
2.3.1	Apron slab		m2		\$-	
2.3.2	Wing wall		m2		\$-	
2.3.3	Headwall above culverts		m2		\$-	
2.3.4	Supply and install reinforced N32 grade concrete, 150 mm deep, extending 300mm vertically up batter, to form sediment basin base	38.25	m3	\$350.00	\$13,387.50	
2.3.5	Concrete weir/sill: Supply and install reinforced N32 grade concrete to form sediment basin to wetland spillway weir/sill to Melbourne Water standard specification 7251/8/108 (300mm thick, 1100mm deep, 7m long)	1	Item	\$3,000.00	\$3,000.00	
2.4	ON-STRUCTURE WORKS					
2.4.1	Backfill above drainage structure		m3		\$-	Included in pipe rates
2.4.2	Other (Description)		Item		\$-	
2.5	OUTLET STRUCTURE					
2.5.1	Major Outlet pit structure		Item		\$-	
3	ROCK WORKS				\$15,597.00	
3.1	Sediment Pond: Supply and install 4m wide sediment basin maintenance access ramp, including sub base preparation. 200mm depth - bottom layer is 100mm depth of 0-100mm FCR, top layer is 100mm of 0-40 NDCR (6% cement stabilised below NWL).	22	m3	\$200.00	\$4,480.00	
3.2	Supply and install well graded D50=400mm rock to form sediment basin to wetland spillway	47	m3	\$200.00	\$9,440.00	
3.3	Geofabric: Supply and install geofabric (Bidim A44 or equivalent) for all rockwork	18	lin.m	\$10.00	\$177.00	4m wide roll, includes allowance for overlap
3.4	Supply and install rockwork to RB outfall (Broken River connection)	1	Item	\$1,500.00	\$1,500.00	
4	CLAY LINER				\$74,140.80	
4.1	Sediment Basin: Placement of 300 mm compacted clay liners for sediment basin (allow to source off site)	264	m3	\$32.00	\$8,448.00	
4.2	Wetland: Placement of 300 mm compacted clay liners for wetland (allow to source off site)	2,053	m3	\$32.00	\$65,692.80	Up to TED
5	TOPSOIL				\$45,764.40	
5.1	Sediment basin: Re spread 200 mm topsoil for planting areas	299	m2	\$3.30	\$986.70	Assumed site topsoil is used, with 20% allowance for imported topsoil
5.2	Wetland: Re spread 200 mm topsoil for planting areas	7,683	m2	\$3.30	\$25,353.90	Assumed site topsoil is used, with 20% allowance for imported topsoil. Includes ephemeral area for wetland/SB as these are connected
5.3	Retarding basin	5,886	m2	\$3.30	\$19,423.80	Assumed site topsoil is used, with 20% allowance for imported topsoil
6	AQUATIC PLANTING				\$167,070.00	
6.1	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	268	No.	\$5.00	\$1,340.00	For both sediment basin and wetland
6.2	Supply and install deep marsh planting (600cm3 tube, 2/m2).	5,526	No.	\$5.00	\$27,630.00	For both sediment basin and wetland
6.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	4,706	No.	\$5.00	\$23,530.00	For both sediment basin and wetland
6.4	Supply and install ephemeral planting (90cm3 tube, 4/m2).	10,392	No.	\$2.50	\$25,980.00	For both sediment basin and wetland. Planting rate can be 6/m2. 4/m2 has been adopted for some of our other jobs recently.
6.5	Supply and install terrestrial planting (90cm3 tube, 4/m2).	23,544	No.	\$2.50	\$58,860.00	RB planting (above path in RB)

6.6	WL/SB: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in wetland and sediment basin, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)	973	m2	\$10.00	\$9,730.00	NWL to TED area for wetland and SB.
6.7	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	\$20,000.00	\$20,000.00	
7	PUMPING				\$-	
7.1	Supply and installation of rising main		LM	\$200.00	\$-	
7.2	Supply and installation of pumping station		Item	\$170,000.00	\$-	
7.3	Provision of electricity supply to pump station switchboard from nominated point of supply, supply and installation of electrical switchboard, connection of power and associated fees.		Item	\$2,500.00	\$-	
8	LANDSCAPE				\$132,600.00	
8.1	Trees: Supply and install trees (tubestock)	100	No.	\$6.00	\$600.00	Nominal allowance for trees
8.2	Landscaping: Supply and install 4m wide RB perimeter gravel access path (thickness 150mm)	2220	m2	\$33.00	\$73,260.00	
8.3	Landscaping: Supply and install 4m wide wetland/SB perimeter gravel access path within RB (thickness 150mm)	1780	m2	\$33.00	\$58,740.00	
9	MISCELLANEOUS				\$79,060.00	
9.1	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$2,500.00	\$30,000.00	
9.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas.	3	Month	\$2,000.00	\$6,000.00	
9.3	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas as per specification.	24	Month	\$750.00	\$18,000.00	
9.4	Allowance for timber bollards	2	No	\$200.00	\$400.00	
9.5	Allowance for seats	2	No	\$2,500.00	\$5,000.00	
9.6	WL/SB: Install habitat logs approx. 4.0m long (no securing required) to wetland area.	2	No.	\$5,000.00	\$10,000.00	
9.7	Allowance for hydroseeding the batters of the basin	6440	m2	\$1.50	\$9,660.00	allowance for hydro seeding the batters of the basins and 1m back from the top of batter. RB planting area (above path in RB) + 1m buffer.
10	OTHER				\$-	
10.1			Item		\$-	
	SUB-TOTAL WORKS				\$1,832,454.06	
11	DELIVERY					
11.1	Council Fees	3.25	%		\$59,554.76	
11.2	VicRoads Fees	1	%		\$18,324.54	
11.3	Traffic Management	5	%		\$91,622.70	
11.4	Environmental Management	0.5	%		\$9,162.27	
11.5	Survey/Design	5	%		\$91,622.70	
11.6	Supervision & Project Management	9	%		\$164,920.86	
11.7	Site Establishment	2.5	%		\$45,811.35	
11.8	Contingency	20	%		\$366,490.81	
	SUB-TOTAL DELIVERY				\$847,510.00	

12 TOTAL ESTIMATED COST \$2,679,964.06

# Overland flow path - Cost Estimate

Item	Description	Quantity	Unit	Rate \$	Amount \$	Comments
	<u>WORKS</u>					
1	SITEWORKS AND EARTHWORKS				\$ 921,870.50	
1.1	Site preparation	1	Item	\$ 20,000.00	\$ 20,000.00	
1.2	Earthworks		m3		\$ -	
1.3	Diversion works		Item		\$ -	
1.4	Waterway re-shaping		Item		\$ -	
1.5	Stripping of topsoil and stockpiling - overland flow path and vegetated buffers (5m either side)	69497	m2	\$ 1.50	\$ 104,245.50	Assumed average depth of 200mm
1.6	Excavation: Bulk excavation of soil to specified levels including cut, haulage, stockpiling.	53175	m3	\$ 15.00	\$ 797,625.00	Excavated material assumed to be re-used in development/transported within Shepparton.
1.7	Formation of batters	0	m3	\$ 15.00	\$ -	Filling and compaction to design levels and compaction in designated areas using selected materials from the excavation.
1.8	Other (Description)		Item		\$ -	
2	DRAINAGE				\$ -	
2.1	BOX CULVERTS					
2.1.1	Box culvert units (Description)		No.		\$ -	
2.1.2	Link slabs		No.		\$ -	
2.1.3	Foundation slab		m2		\$ -	
2.1.4	Other (Description)		Item		\$ -	
2.2	DRAINAGE PIPES					
2.2.1			LM		\$ -	
2.2.3	Drainage – Sub-soil drainage		LM		\$ -	
2.2.4	Drainage – Miscellaneous (Description)		Item		\$ -	
2.3	CONCRETE WORKS					
2.3.1	Apron slab		m2		\$ -	
2.3.2	Wing wall		m2		\$ -	
2.3.3	Headwall above culverts		m2		\$ -	
2.4	ON-STRUCTURE WORKS					
2.4.1	Backfill above drainage structure		m3		\$ -	
2.4.2	Other (Description)		Item		\$ -	
2.5	OUTLET STRUCTURE					
2.5.1	Major Outlet pit structure		Item		\$ -	
3	ROCK WORKS				\$ -	
3.1			m3	\$ 200.00	\$ -	
4	CLAY LINER				\$ -	
4.1			m3	\$ 32.00	\$ -	
4.2			m3	\$ 32.00	\$ -	
5	TOPSOIL				\$ 229,340.10	
5.1	Re spread 200 mm topsoil for planting areas (overland flow path and vegetated buffers)	69,497	m2	\$ 3.30	\$ 229,340.10	Assumed site topsoil is used, with 20% allowance for imported topsoil
6	AQUATIC PLANTING				\$ 1,216,220.00	
6.1	Supply and install ephemeral planting (90cm3 tube, 4/m2).	208,500	No.	\$ 2.50	\$ 521,250.00	Planting rate can be 6/m2. 4/m2 has been adopted for some of our other jobs recently.

	Supply and install terrestrial planting (90cm3 tube, 4/m2) to vegetated buffers (5m either side of overland flow path)	69,488	No.	\$ 2.50	\$ 173,720.00	
	Overland flow path: Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 in overland flow path, including overlap of matting (300mm longitudinally/direction of flow), 150mm vertically)	52,125	m2	\$ 10.00	\$ 521,250.00	
7	PUMPING				\$ -	
7.1			LM		\$ -	
8	LANDSCAPE				\$ -	
	Trees: Supply and install trees (tubestock)		No.	\$ 6.00	\$ -	
	MISCELLANEOUS				\$ 60,000.00	
	Civil Works Defects Maintenance incl pits, pipes and rockwork – 1 year	12	Month	\$ 2,500.00	\$ 30,000.00	
9.2	3 months Plant Establishment maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas.	3	Month	\$ 2,000.00	\$ 6,000.00	
	24 month Plant Maintenance period of all soft landscape works including watering of plants and trees during establishment, weed control of all planted areas as per specification.	24	Month	\$ 1,000.00	\$ 24,000.00	
10	OTHER				\$ -	
10.1			Item		\$ -	
	SUB-TOTAL WORKS				\$ 2,427,430.60	
11	DELIVERY SUB-TOTAL WORKS				\$ 2,427,430.60	
		3.25	%		\$ <b>2,427,430.60</b> \$ 78,891.49	
11.1	DELIVERY	3.25	% %			
11.1 11.2	DELIVERY Council Fees				\$ 78,891.49	
11.1 11.2 11.3	DELIVERY  Council Fees  VicRoads Fees	1	%		\$ 78,891.49 \$ 24,274.31	
11.1 11.2 11.3 11.4	DELIVERY  Council Fees  VicRoads Fees  Traffic Management	1 5	%		\$ 78,891.49 \$ 24,274.31 \$ 121,371.53	
11.1 11.2 11.3 11.4 11.5 11.6	DELIVERY  Council Fees  VicRoads Fees  Traffic Management  Environmental Management  Survey/Design  Supervision & Project Management	1 5 0.5 5 9	% % % %		\$ 78,891.49 \$ 24,274.31 \$ 121,371.53 \$ 12,137.15 \$ 121,371.53 \$ 218,468.75	
11.1 11.2 11.3 11.4 11.5 11.6	DELIVERY  Council Fees  VicRoads Fees  Traffic Management  Environmental Management  Survey/Design	1 5 0.5 5 9 2.5	% % % % %		\$ 78,891.49 \$ 24,274.31 \$ 121,371.53 \$ 12,137.15 \$ 121,371.53 \$ 218,468.75 \$ 60,685.77	
11.1 11.2 11.3 11.4 11.5 11.6 11.7	DELIVERY  Council Fees  VicRoads Fees  Traffic Management  Environmental Management  Survey/Design  Supervision & Project Management	1 5 0.5 5 9	% % % %		\$ 78,891.49 \$ 24,274.31 \$ 121,371.53 \$ 12,137.15 \$ 121,371.53 \$ 218,468.75	
11.1 11.2 11.3 11.4 11.5 11.6 11.7	DELIVERY  Council Fees  VicRoads Fees  Traffic Management  Environmental Management  Survey/Design  Supervision & Project Management  Site Establishment	1 5 0.5 5 9 2.5	% % % % %		\$ 78,891.49 \$ 24,274.31 \$ 121,371.53 \$ 12,137.15 \$ 121,371.53 \$ 218,468.75 \$ 60,685.77	
11.1 11.2 11.3 11.4 11.5 11.6 11.7	DELIVERY  Council Fees  VicRoads Fees  Traffic Management  Environmental Management  Survey/Design  Supervision & Project Management  Site Establishment  Contingency	1 5 0.5 5 9 2.5	% % % % %		\$ 78,891.49 \$ 24,274.31 \$ 121,371.53 \$ 12,137.15 \$ 121,371.53 \$ 218,468.75 \$ 60,685.77 \$ 485,486.12	

Appendix F Functional Design Package (attached separately)