Hume Planning Scheme Amendment C207

Expert Witness report provided to Planning Panels Victoria

Drainage Evidence (Property 94, 95, 96, 97, 98 and 99)

Prepared for Hi Quality Pty Ltd and Trantaret Pty Ltd

Prepared by Stuart Cleven

August 2017

1 Witness Details

I, Stuart Cleven of Alluvium Consulting Australia (Alluvium), 105 – 115 Dover Street, Cremorne, Victoria 3121, prepared this report. I hold the position of Senior Consultant.

I have a Bachelor of Engineering (honours), Environmental Engineering Monash University, Victoria, 2002.

I am a Registered Professional Engineer of Queensland (RPEQ), Chartered Professional Engineer of Institution of Engineers Australia (MIEAust CPEng NER) (Civil), and hold a River Styles Accreditation.

My major fields of expertise and interest are hydrology, hydraulics, urban drainage, catchment planning and management, flood estimation, surface water modelling, stormwater treatment and waterway management.

Related Experience:

- Over a period of 15 years I have regularly been involved with the design and strategic planning of drainage strategies and systems within residential, commercial and industrial developments.
- I am a chartered member of Engineers Australia (Civil College) and are part of the National Engineers Register
- My expert advice has been sought by both the private sector (eg developers) and the public sector (catchment management authorities and local government).
- I have been actively involved in the development of various best practice design manuals for Urban Stormwater with Melbourne Water.
- I have attended and presented at various industry conferences and seminars.
- I have a sound understanding of the role of Local Government, Catchment Management Authorities, Environment Protection Authority and other agencies in stormwater planning and management.

Therefore my expertise and experience in flood modelling and urban stormwater management associated with civil engineering and development projects, qualifies me to make this report.

2 Instructions

Alluvium has provided stormwater management advice to the proponent – Hi Quality (Hi Quality Pty Ltd and Trantaret Pty Ltd) – to address the issues associated with future residential development on the subject site.

I have been instructed by Alexandra Guild from Norton Rose Fulbright to provide expert evidence advice on the drainage issues related to the Hi Quality site (identified as property nos. 94, 95, 96, 97, 98 and 99 in the Sunbury South Precinct Structure Plan) taking into account:

- the exhibited C207 documents, background reports and submissions

In particular I have been briefed to specifically address the following issues:

- Review the Amendment and the background materials in the supplied brief from Norton Rose Fulbright
- Confer with instructing solicitors and counsel where necessary
- Prepare an expert report explaining the proposed drainage strategy for the Land that addresses:
  - Stormwater quality
  - Stormwater quantity
  - Consideration of existing site conditions and constraints, and
- Appear before the Panel.

My evidence presented in this report does not include advice on the proposed fill and geotechnical strategy.

This report responds directly to the above issues by providing a summary of the investigations, assumptions and assessments that have been undertaken in defining and reviewing the surface water management strategy for the Hi Quality land.

3 Information / Documentation

In preparing this evidence Stuart Cleven has had regard to:

Reports:

- Sunbury South Precinct Structure Plan (1074) – VPA (Public exhibition Nov 2016).
- Shepherds Lane Development Services Scheme, advice provided by Alluvium Consulting Australia (June 2015)
- Daameeli Development Services Scheme, advice provided by Alluvium Consulting Australia (June 2015)
- Riparian vegetation and geomorphology in the Sunbury Growth Area, advice provided by Alluvium Consulting Australia and Biosis (2014)
- PSP 1074 Sunbury South. Post-Contact Heritage Assessment (Context 2013)

Other Information:

- Melbourne Water's Daameeli DSS 6342 Scheme plan
- Melbourne Water's Shepherds Lane DSS 6343 Scheme plan
- Site Inspections
- Aerial Photography
- LiDAR survey data
- Constructed Waterways in New Urban Developments – Melbourne Water (2013)
- Waterway Corridors, Guidelines for greenfield development zones within the Port Phillip and Westernport Region – Melbourne Water
- Design, construction and establishment of constructed wetlands: design manual – Melbourne Water (2016)
- MUSIC Guidelines – Melbourne Water (2016)
- Australian Rainfall & Runoff (1997) – Engineers Australia
- Urban Stormwater Best Practice Environmental Management Guidelines (1999)

Stuart Cleven adopts this evidence as a true and correct statement of his opinions and the facts he believes to be true in this matter.

4 Facts, Matters and Assumptions

This report is based upon an assessment and review of the information provided to me as referenced in Section 3 and the numerous site visits undertaken.

The Hi Quality site is located within the Daameeli DSS and the Sunbury South PSP and consists of multiple tributaries draining surface runoff from the basalt plains down the steep terraces to Emu Creek. The stormwater management strategy proposed in this report generally aligns with that of the Melbourne Water Daameeli DSS. This strategy has been produced based on multiple discussions with Melbourne Water and in principle agreement of the general strategy.

This site is bounded by Sunbury Road to the south, Emu Creek to the north and neighbouring properties to the east and west with an approximate area of 215 ha (Figure 4-1). This development is located on a flat plateau next to a large escarpment of the Emu Creek corridor. Currently stormwater flows within gentle to medium bed grade waterways on the plateau, through to very deep and steep gullies over the escarpments to reach Emu Creek.

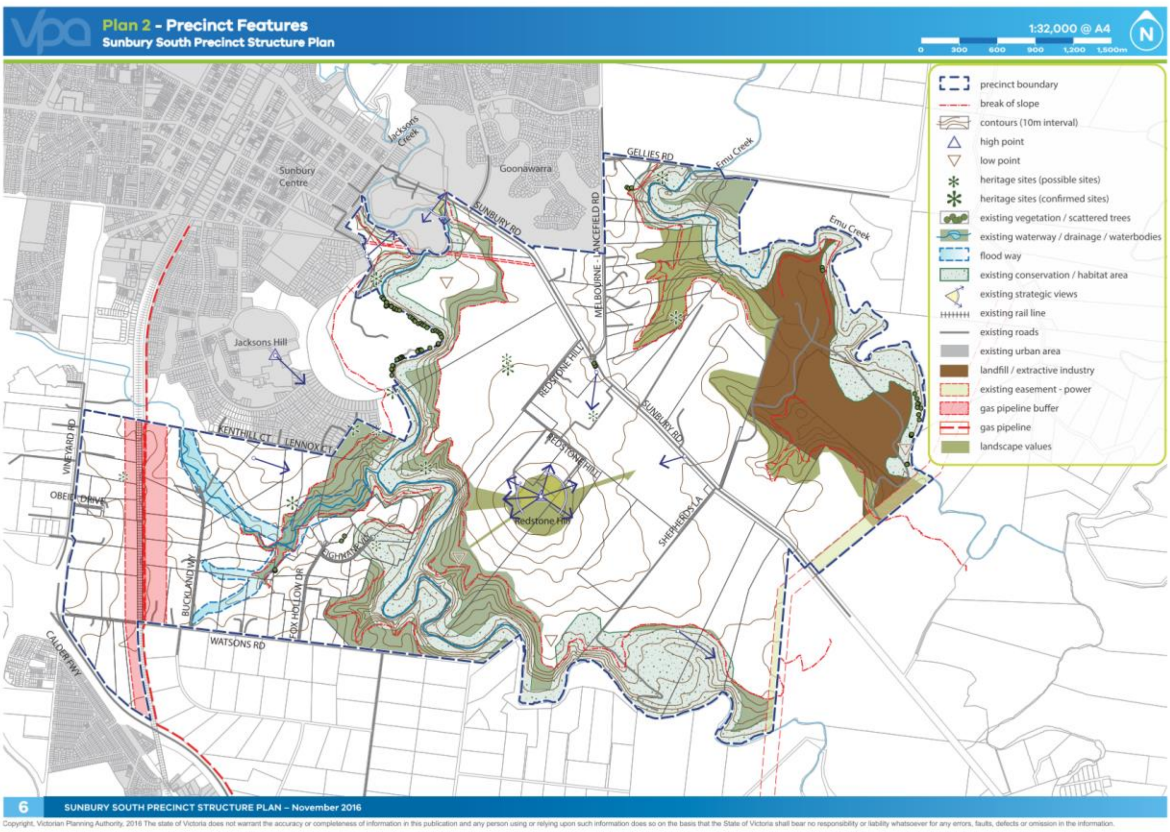

Figure 4-1. *Site local catchment hydrology (Source: Sunbury South PSP - Nov 2016)*

The current landuse of this site, as it shown in Figure 4-2 and Figure 4-3, is a combination of agricultural lands, Quarry and landfill area and long native shrubs around the waterways. The majority of the region is covered with short grass and scattered trees around waterways. The substrate layer in most waterways is hard clay with exposed hard bed rock.

Figure 4-2. *Existing main waterway of subject site, flowing down from Sunbury Road to terminal lake*

Figure 4-3. *Filling and ongoing earthworks surrounding terminal lake*

4.1 Stormwater Quantity – Assumptions

The following design rainfall parameters were adopted for Sunbury based upon the Bureau of Meteorology's "Intensity Frequency Duration (IFD) Tool – AR&R 87).

Table 1: AR&R Design Rainfall parameters (Sunbury)

Parameter	Value
1hr 2yr	19.34
12hr 2yr	4.0
72hr 2yr	1.01
1hr 50yr	40.41
12hr 50yr	7.23
72hr 50yr	2.14
Skew	0.34
F2	4.30
F50	14.95
Zone	1

A hydrologic model (RORB) was utilised for the catchment analysis and assessment. The following rainfall loss models were adopted for existing conditions (Table 2) and developed conditions (Table 3).

Table 1. Adopted RORB parameters

Parameter	Values at Shepherds Lane	Values for sub catchment E - M	Values for sub catchments A and D
m,	0.8	0.8	0.8
kc	1.25	1.73	0.56
IL	15	15	15
RoC	0.6	0.6	0.6

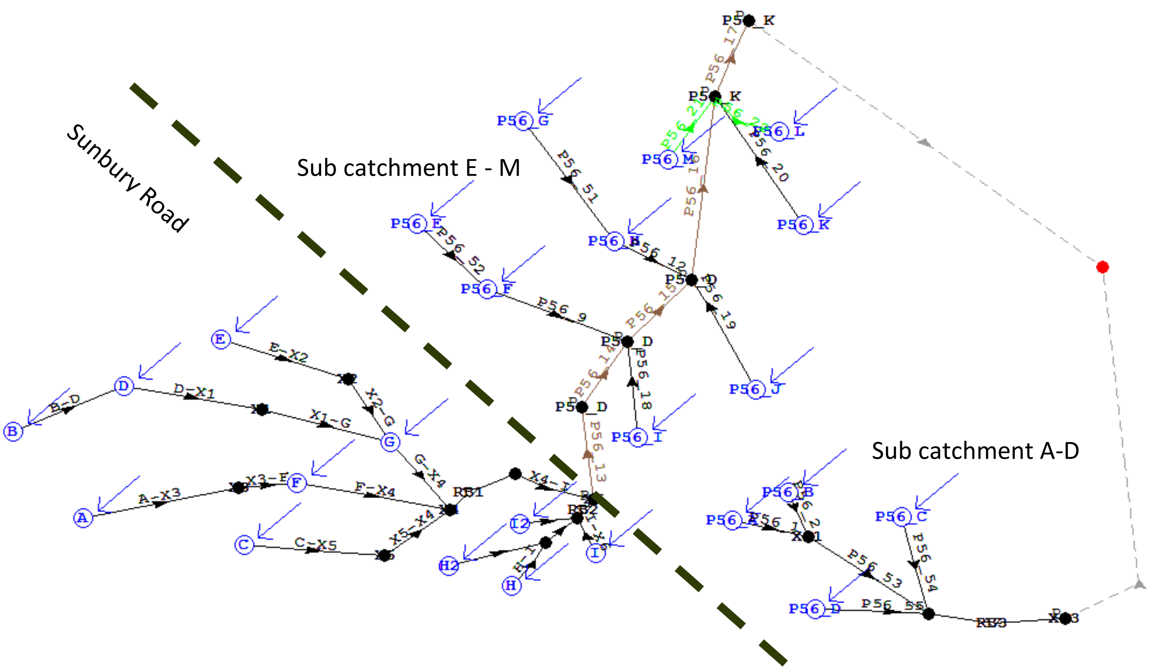

Figure 4-4. *Graphic view of modified RORB model*

To reflect ultimate development conditions the pre-developed scenario was modified to reflect post development conditions. To understand the hydrologic impacts, the following standard Melbourne Water fraction impervious values were used as a guide (Figure 4-5). The proposed PSP has identified this section of the catchment as predominately future residential.

Local scale sub-catchment flows have been estimated using the rational method in accordance with Melbourne Water's "Land Development Manual" and the GAA's (now VPA) "Engineering Design and Construction Manual for Subdivision in Growth Areas".

Zone	Zone Code	Brief Description / Examples	Normal Range	Typical Value
Residential Zones:				
Residential Growth Zone, General Residential Zone and Neighbourhood Residential Zone	RGZ, GRZ & NRZ	Large Residential. (Allotment size 601m^2 – 1000m^2)	0.50 – 0.80	0.60
		Standard densities. (Allotment size 300m^2 – 600m^2)	0.70 – 0.80	0.75
		High densities. (Allotment size <300m^2)	0.80 – 0.95	0.85
Low Density Residential Zone	LDRZ	Allotment size >1001m^2	0.10 – 0.30	0.20
Mixed Use Zone	MUZ	Mix of residential, commercial, industrial and hospitals.	0.6 – 0.90	0.75
Township Zone	TZ	Small townships with no specific zoning structures	0.40 – 0.70	0.55
Industrial Zones				
Industrial 1 Zone	IN1Z	Main zone to be applied in most industrial areas	0.70 – 0.95	0.90
Industrial 2 Zone	IN2Z	Large industrial zones away from residential areas	0.70 – 0.95	0.90
Industrial 3 Zone	IN3Z	Buffer between Zone 1 and Zone 3	0.70 – 0.95	0.90
		- for garden suppliers/nurseries	0.30 – 0.60	0.50
		- for quarries	0.10 – 0.30	0.20
Commercial Zones				
Commercial 1 Zone	C1Z	Main zone to be applied in most commercial areas	0.70 – 0.95	0.90
Commercial 2 Zone	C2Z	Offices, manufacturing industries and associated uses	0.70 – 0.95	0.90
Rural Zones				
Rural Zone	RUZ	Main zone to be applied in most rural areas	0.05 – 0.20	0.10
Rural Living Zone	RLZ	Predominantly residential use in rural areas	0.10 – 0.30	0.20
Public Land Zones:				
Public Use Zone				
- Education	PU2Z	- schools and universities	0.60 – 0.80	0.70
- Service and Utility	PU1Z	power lines, pipe tracks and retarding basins	0.00 – 0.10	0.05
		- reservoirs	0.40 – 0.60	0.50
- Health and community	PU3Z	- hospitals	0.80 – 0.90	0.85
- Transport	PU4Z	- railways and tramways	0.60 – 0.80	0.70
- Cemetery/ Crematorium	PU5Z	- cemeteries and crematoriums	0.50 – 0.70	0.60
Local Government	PU6Z	- Libraries, sports complexes and offices/depots.	0.50 – 0.90	0.70
- Other Public Use	PU7Z	- Museums	0.50 – 0.80	0.60
Public Park and Recreation Zone	PPRZ	Main zone for public open space, incl golf courses.	0.00 – 0.20	0.10
Public Conservation and Resource Zone	PCRZ	Protection of natural environment or resources	0.00 – 0.05	0.00

Figure 4-5. *Fraction impervious values for various land uses*

4.2 Stormwater Quality – Assumptions

In accordance with Melbourne Water's MUSIC Guidelines and to be consistent with the Melbourne Water's scheme approach, Melbourne Airport rainfall station was used with a 10-year rainfall simulation template between the years of 1971-1980.

4.3 Hi-Quality proposed site masterplan

The proposed landuse and zones contained within the proposed Hi-Quality Development Masterplan (Figure 4-6) differ from that of the Sunbury South PSP exhibited in that it contains additional residential, employment and commercial areas based on filling of the two large gullies (Figure 4-8).

Filling of the gullies will change the existing drainage network which requires design of new drainage elements including the constructed waterways and wetlands to avoid future risk from surface water erosion. As it is demonstrated in Figure 4-7, an existing waterway delivers flows from a culvert that sits under Sunbury Road and conveys stormwater from the southern side of Sunbury Road. This waterway discharges into a terminal lake located west of the current Quarry and landfill operation area. Only a small pipe outlet directs overflow to Emu Creek. These two waterways are planned to be filled and diverted to the north-east of the Quarry and landfill operation area, where a new constructed waterway is planned (Figure 4-6).

This stormwater management strategy addresses the management of stormwater including quantity and quality. The filling strategy and associated risks is not addressed as part of the stormwater strategy. This has been undertaken separately by GHD.

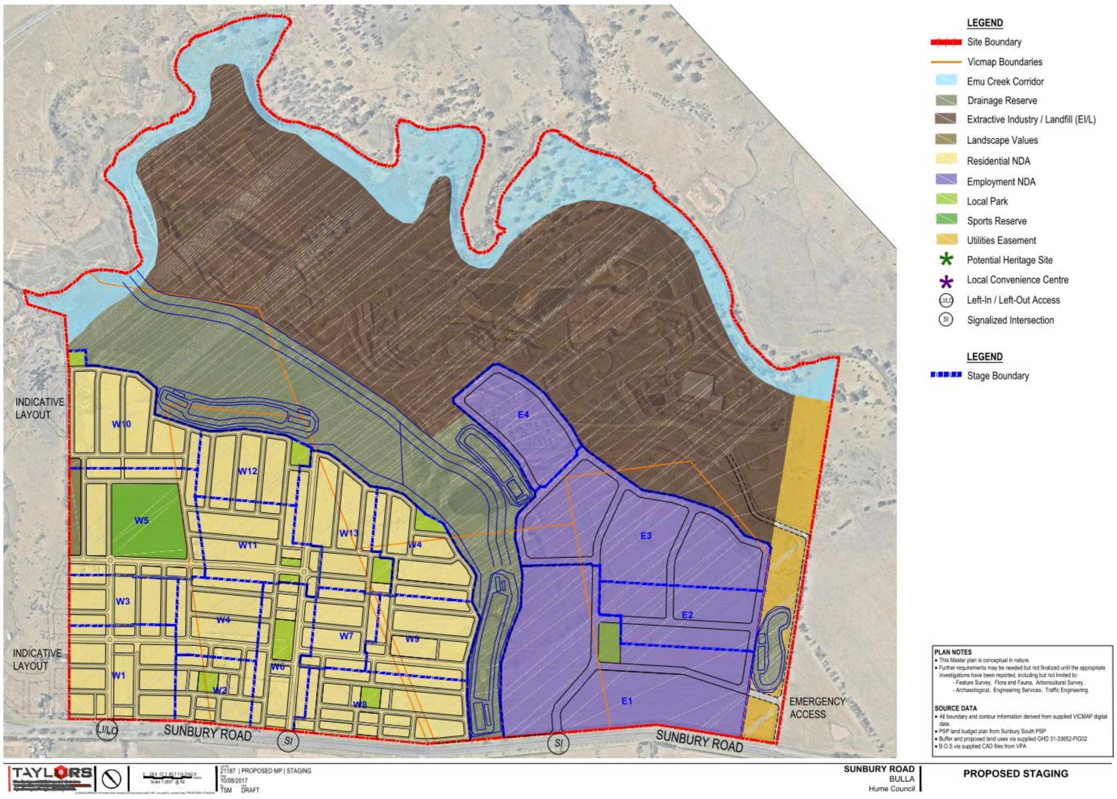

Figure 4-6. *Hi-Quality Development Land Masterplan, based on proposed fill scenario.*

Figure 4-7. *Aerial photo of subject site and the current direction of waterways/overland flow*

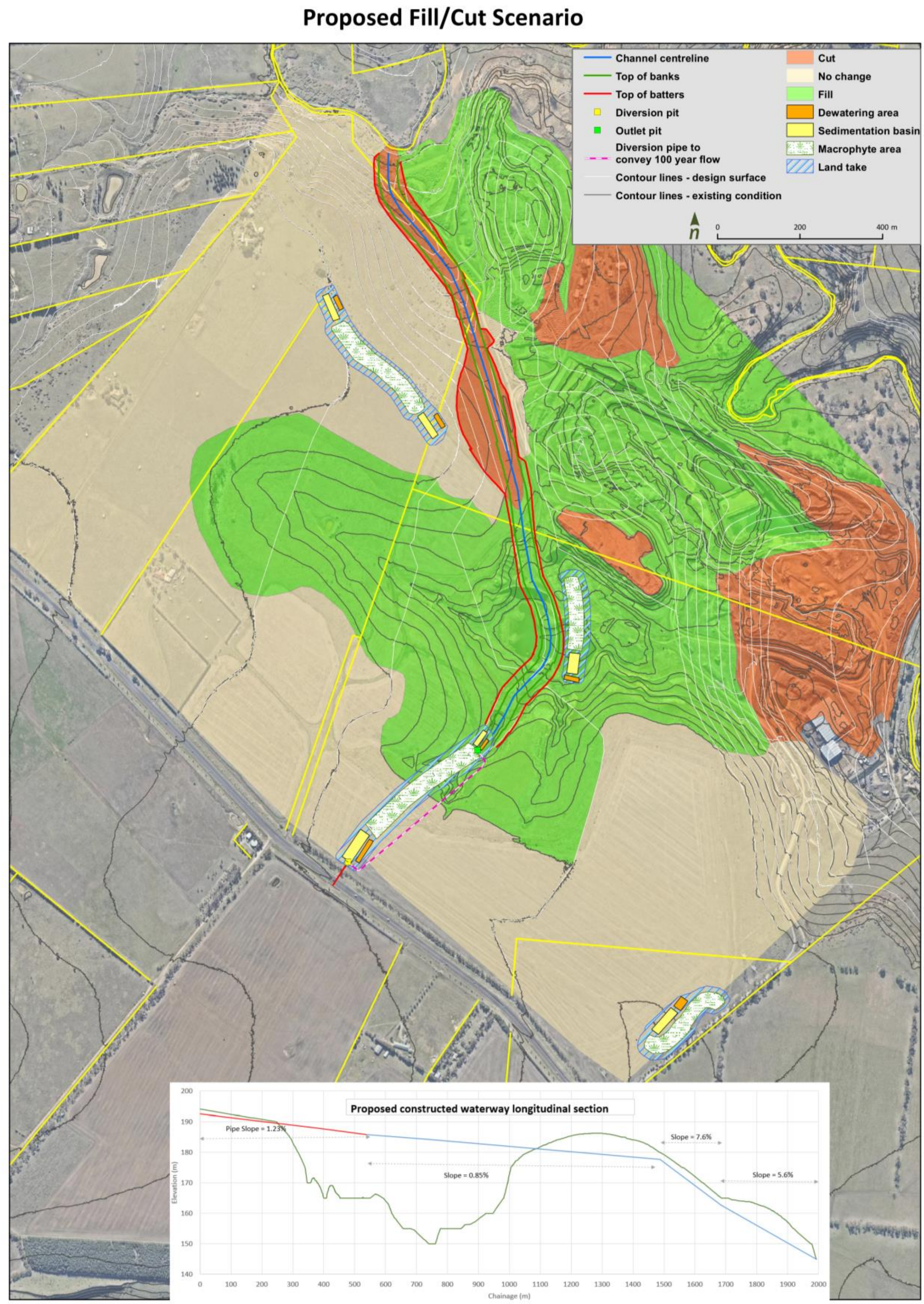

Figure 4-8. *Hi-Quality indicative cut - fill scenario to service masterplan.*

5 Catchment context

5.1 Flora and fauna

An assessment of riparian vegetation was undertaken in the study *Riparian vegetation and geomorphology in the Sunbury Growth Area* (Alluvium, Biosis, 2014) and in the Sunbury South PSP - Nov 2016. In my opinion, the results of these assessments indicate that there are no significant patches of vegetation within the proposed Hi-Quality developable area (refer to Figure 5-1 and Figure 5-2) that need consideration in the stormwater management strategy.

Additionally, Figure 5-3 outlines the conservation area that runs along Emu Creek, adjacent to the Hi Quality site. In my opinion, this figure indicates that there are no conservation areas located within the proposed Hi-Quality developable area that impact on the stormwater management strategy.

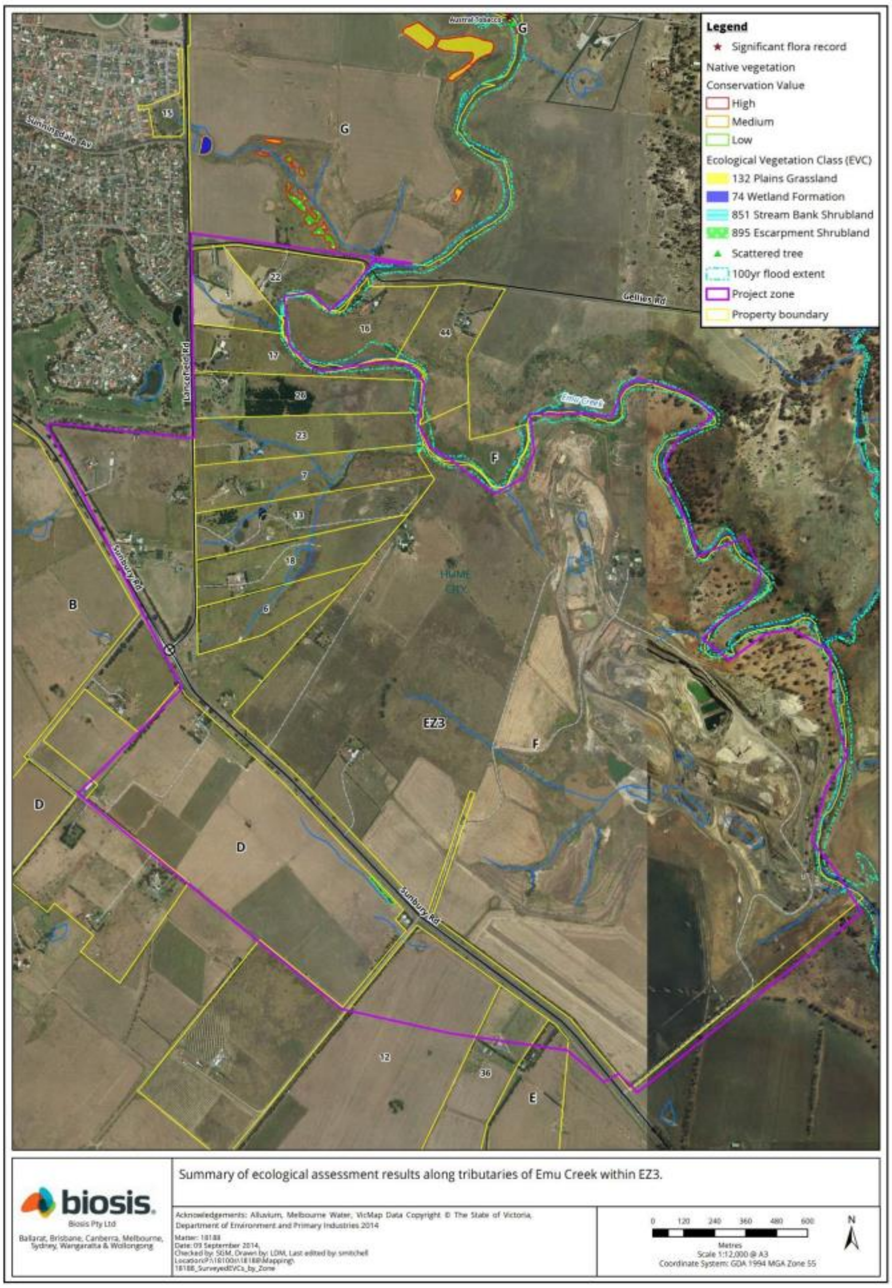

Figure 5-1. *Ecological assessment results for Hi-Quality site (Source: Alluvium, Biosis, 2014)*

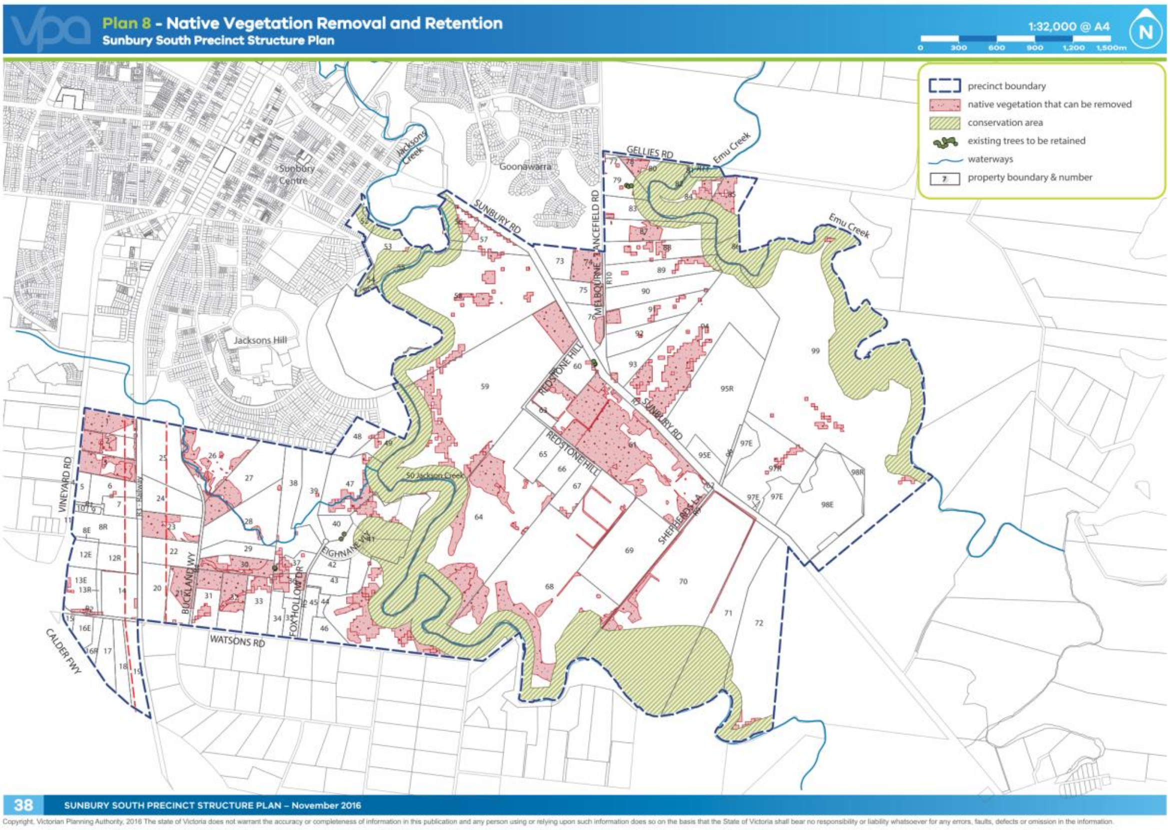

Figure 5-2. *Ecological assessment results for Hi-Quality site (Source: Sunbury South PSP - Nov 2016)*

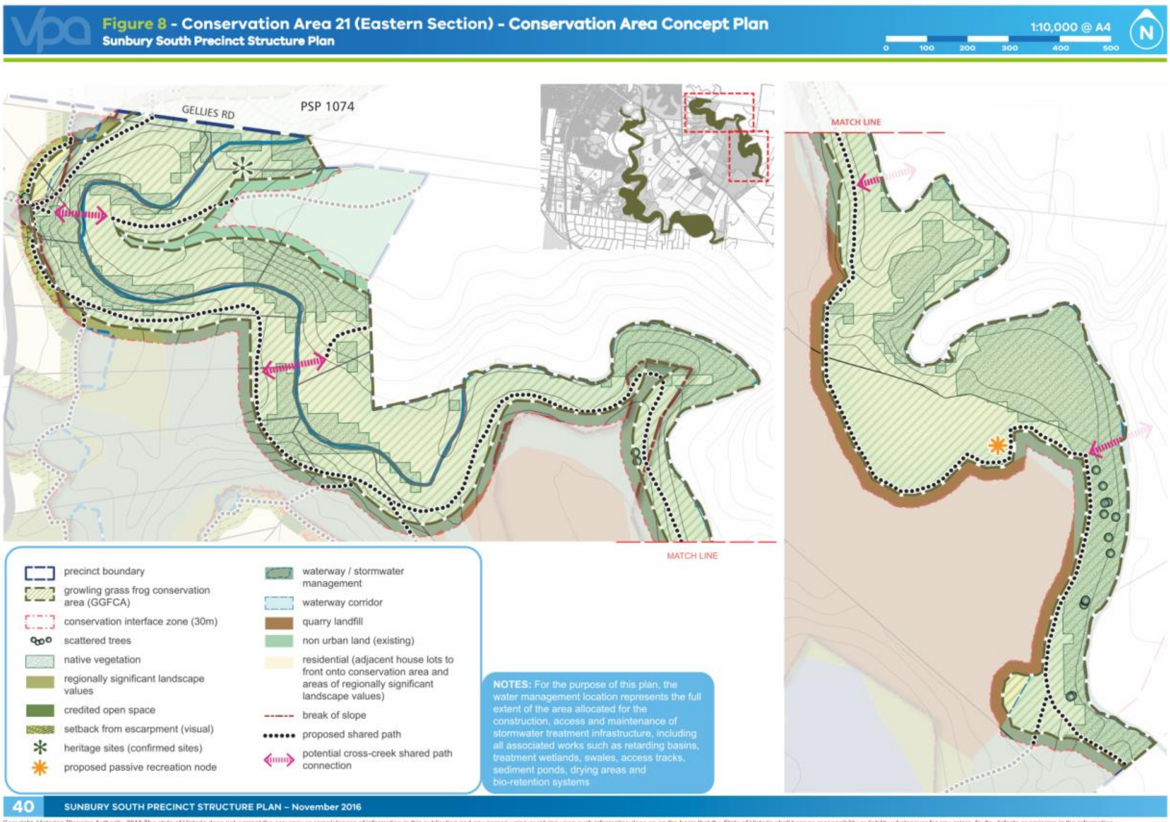

Figure 5-3. *Conservation area for Emu Creek adjacent to the Hi-Quality site (Source: Sunbury South PSP - Nov 2016)*

5.2 Cultural heritage

A cultural heritage desktop assessment was undertaken in the study *Riparian vegetation and geomorphology in the Sunbury Growth Area* (Alluvium, Biosis, 2014). The implications of this are outlined below.

Aboriginal Heritage

The area surrounding Hi-Quality site is affected by areas of cultural heritage, with sensitivity associated with Emu Creek. In my opinion, while no Aboriginal places are recorded within the Hi-Quality site, areas of cultural sensitivity are located along Emu Creek (refer to Figure 5-4) and will need to be addressed as part of subsequent functional and detailed design phases. For the purposes of the concept stormwater management strategy, in particular the proposed constructed waterway, I have assumed these can be addressed as part of future design stages.

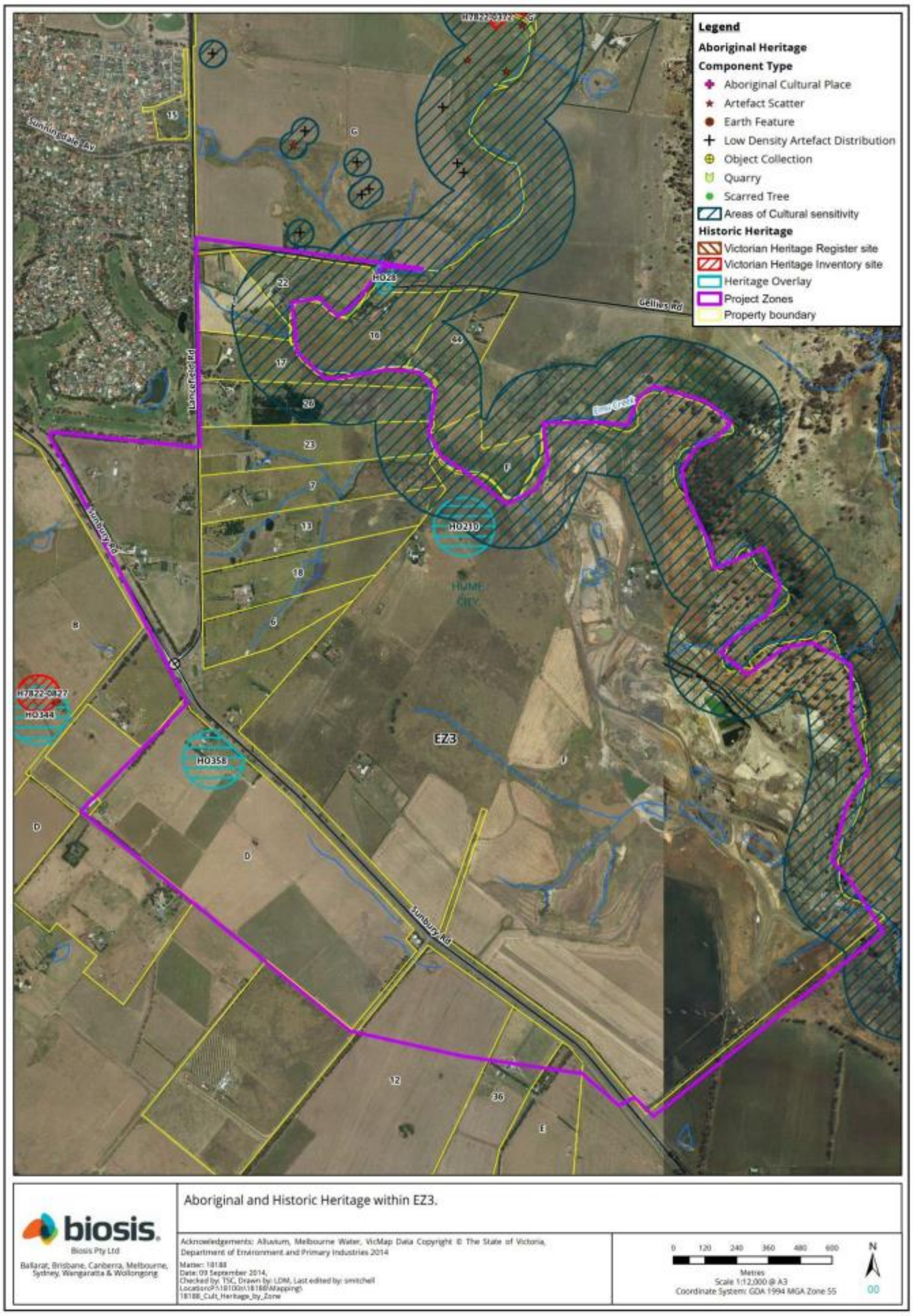

Figure 5-4. *Aboriginal and Heritage values (Source: Alluvium, Biosis, 2014)*

Historic Heritage

A recent study *PSP 1074 Sunbury South. Post-Contact Heritage Assessment (Context 2013)* undertaken as part of the PSP development has shown that no known heritage sites currently exist within the proposed development envelope within the Hi-Quality masterplan (refer to Figure 5-5). This excludes the quarry and landfill site which will need to be assessed as part of future drainage investigations.

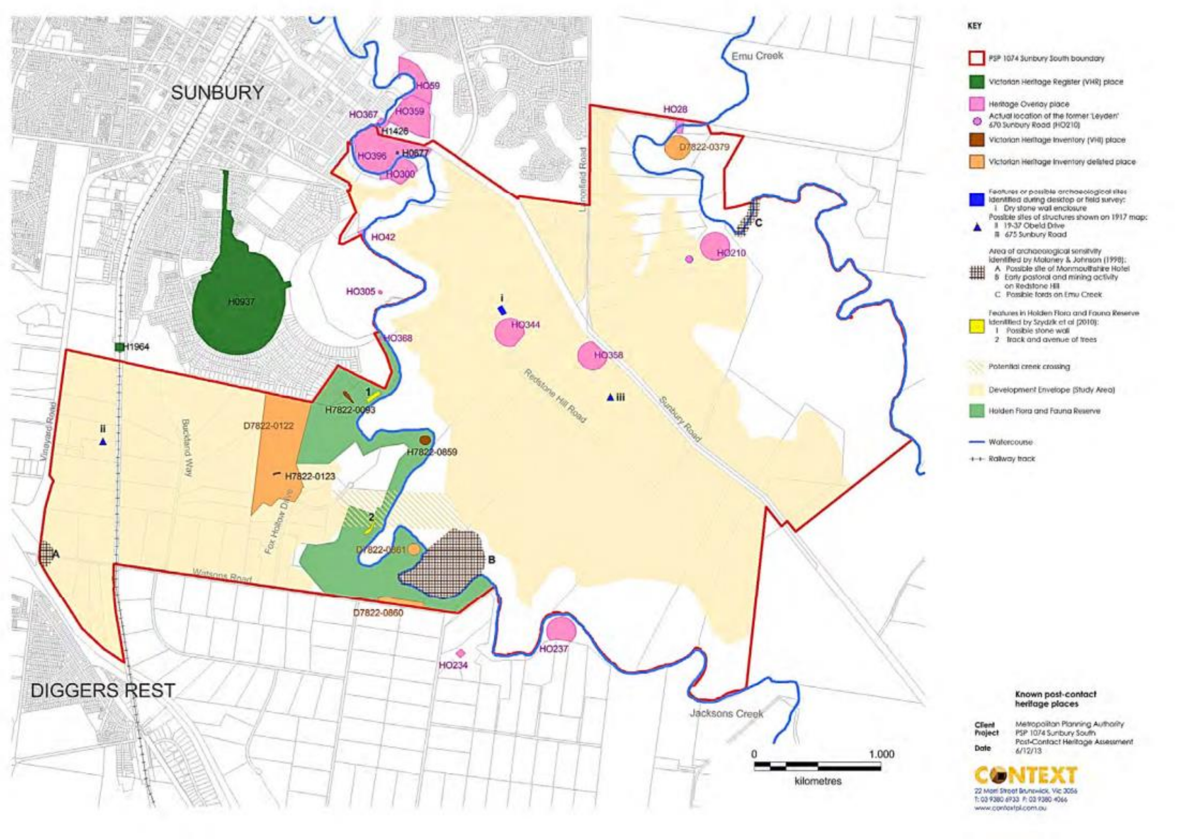

Figure 5-5. *Heritage values (Source: Context 2013)*

5.3 Melbourne Water Developer Services Scheme

The study area is within the draft Daameeli DSS (Figure 5-6 and Figure 5-7). Melbourne Water has determined that future development flows do not need to be reduced to pre-development peak flow rates at Emu Creek. However; retardation of peak flows back to predevelopment conditions is required for the catchment draining to the south east adjacent to the Hi-Quality access road. All catchments must achieve the stormwater quality targets for urban development set out in the Urban Stormwater Best Practice Guidelines.

Based on the above the adopted criteria for the development of the stormwater management strategy is:

- Objective 1: Meet best stormwater quality pollutant removal targets
- Objective 2: Retardation of flows back to predevelopment levels for the catchment draining to the south east only
- Objective 3: Convey minor flows through local catchments in a piped network
- Objective 4: Convey major flows through the site via the overland flows along road reserves and the constructed waterway

In my opinion such criteria are sound and appropriate for the following reasons:

- Emu Creek is the north-eastern boundary of the Sunbury South PSP

- No structure planning or drainage strategies have been undertaken for the land immediately to the southeast of Hi-Quality access road.

The peak 100 year developed flows from the catchment upstream of the Hi-Quality access road is 7.99 cumecs. This far exceeds the existing conditions peak flow and the capacity of the existing culverts. As a result retardation would be required to mitigate the flows.

The PSP has responded to the above stormwater management criteria by locating a combined wetland and retarding basin (WL-18) within the existing electricity easement (refer to Figure 5-6). The PSP also contains provision for wetlands WI-09 (property 94), WI-14 (property 97) and WI-16 (property 98), which all generally align with the Daameeli DSS. The proposed natural waterway corridor also aligns with that proposed within the Daameeli DSS.

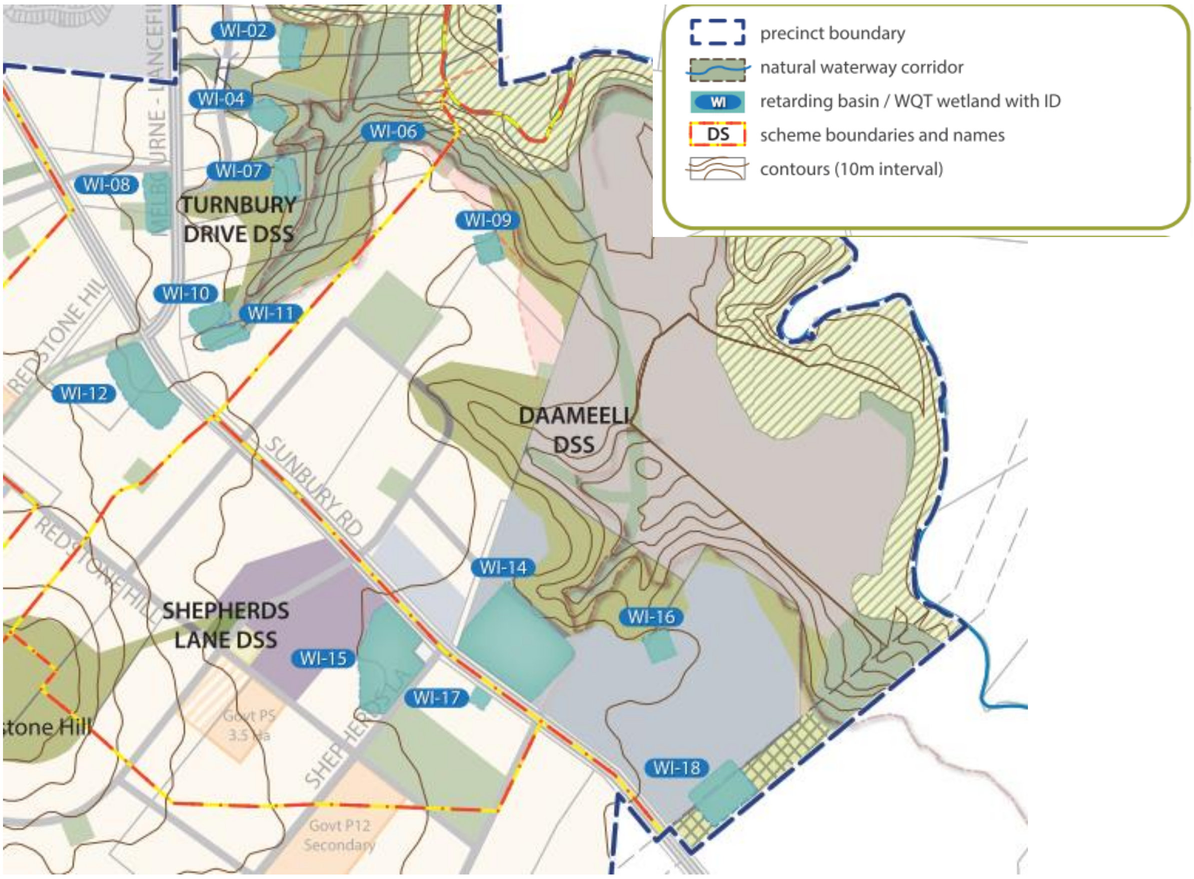

Figure 5-6. *Proposed Integrated water Management (Source: Sunbury South PSP - Nov 2016)*

It is my understanding the design of WI-18 within the Daameeli DSS has been based on the achievement of best practice standards for water quality treatment and flow retention.

In my opinion, the protection of the downstream waterway from scour because of the changed urban flow regime will need to be determined based on its geomorphic value categorisation by Melbourne Water. Where moderate to high geomorphic values are determined I believe additional works may be required to protect the waterway. At the time of writing this SWMS no defined geomorphic value was available from Melbourne Water.

Once informed, and if moderate to high values defined, I believe the strategy may need to be updated to incorporate assessment of the waterway erosion potential and the requirement for any protective works.

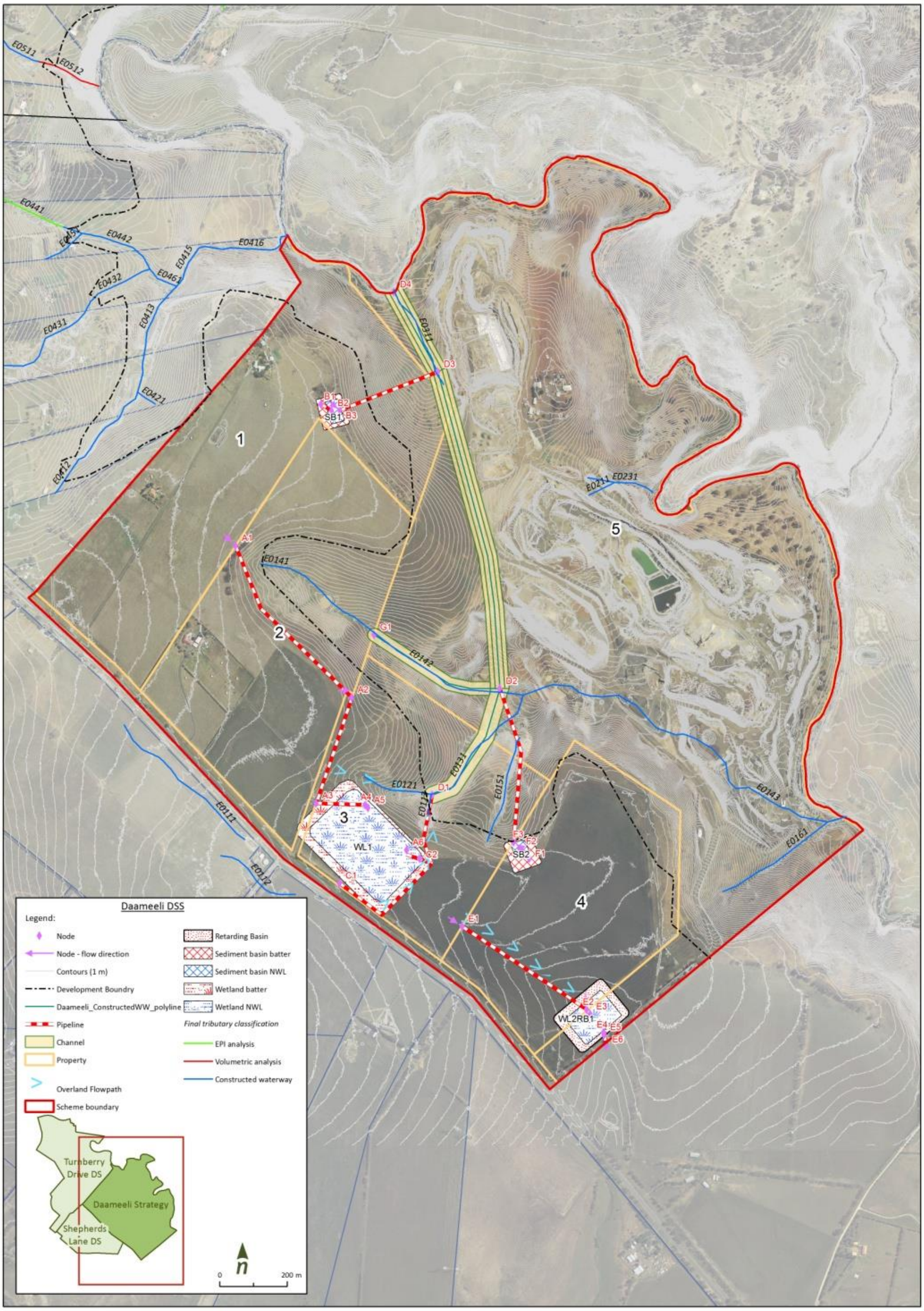

Figure 5-7. *Daameeli DSS (Source: Alluvium, 2015)*

In reviewing this strategy and comparing against the proposed Hi-Quality masterplan I undertook the following analysis and investigations to assess the feasibility of the high-level PSP stormwater assets from both a location and land budget perspective:

- Site inspection
- Consideration of topography (survey, contours), feature survey and known physical or infrastructure constraints
- Created a hydrologic model (RORB) to determine the required retardation volumes up to the 100 year ARI event.
- Created a MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model to establish the proposed treatment train strategy. The model estimates the amount of pollutants the catchment produces, the performance of treatment measures and the pollutant load generated once the catchment is treated.
- Prepared Concept designs

The following sections detail the proposed stormwater management strategy based on achieving the drainage objectives of the Daameeli DSS and modification to address the proposed Hi-Quality masterplan. An overview of the strategy is provided in Figure 5-8.

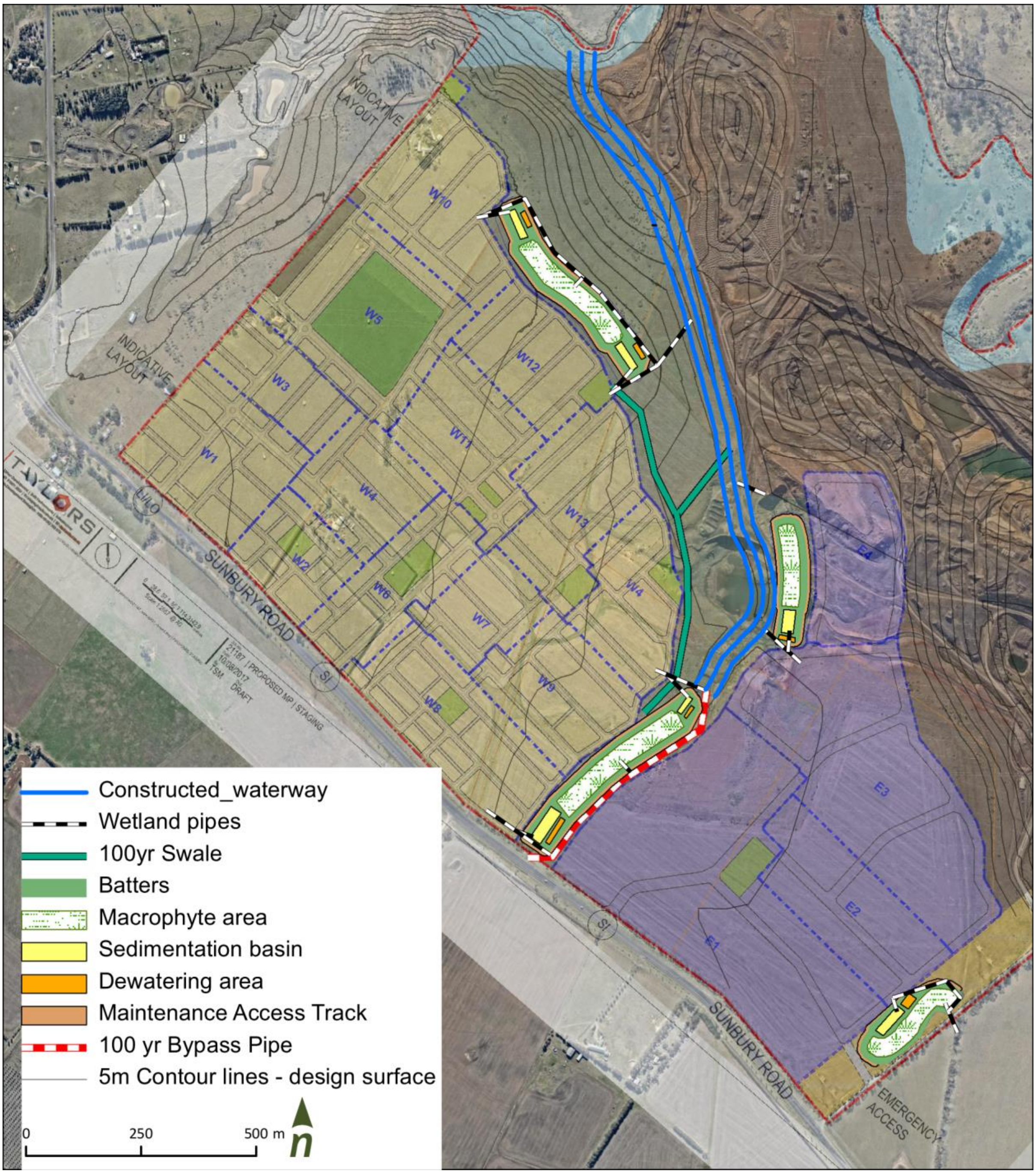

Figure 5-8. *Revised Hi-Quality stormwater strategy overview*

6 Site analysis

6.1 Design of WLRB5 (PSP reference Wl-18)

Flows for sizing of the waterway and retarding basin have been undertaken using RORB. The hydrologic analysis of the Emu Creek tributary catchment was based on the RORB model developed for Melbourne Water as part of the Daameeli DSS. The RORB model was refined and updated based on the proposed masterplan. Four local sub catchments were defined within the Hi-Quality site and combined with upstream sub catchments and proposed retarding basins located west of Sunbury Road (Figure 6-1 and Figure 6-2).

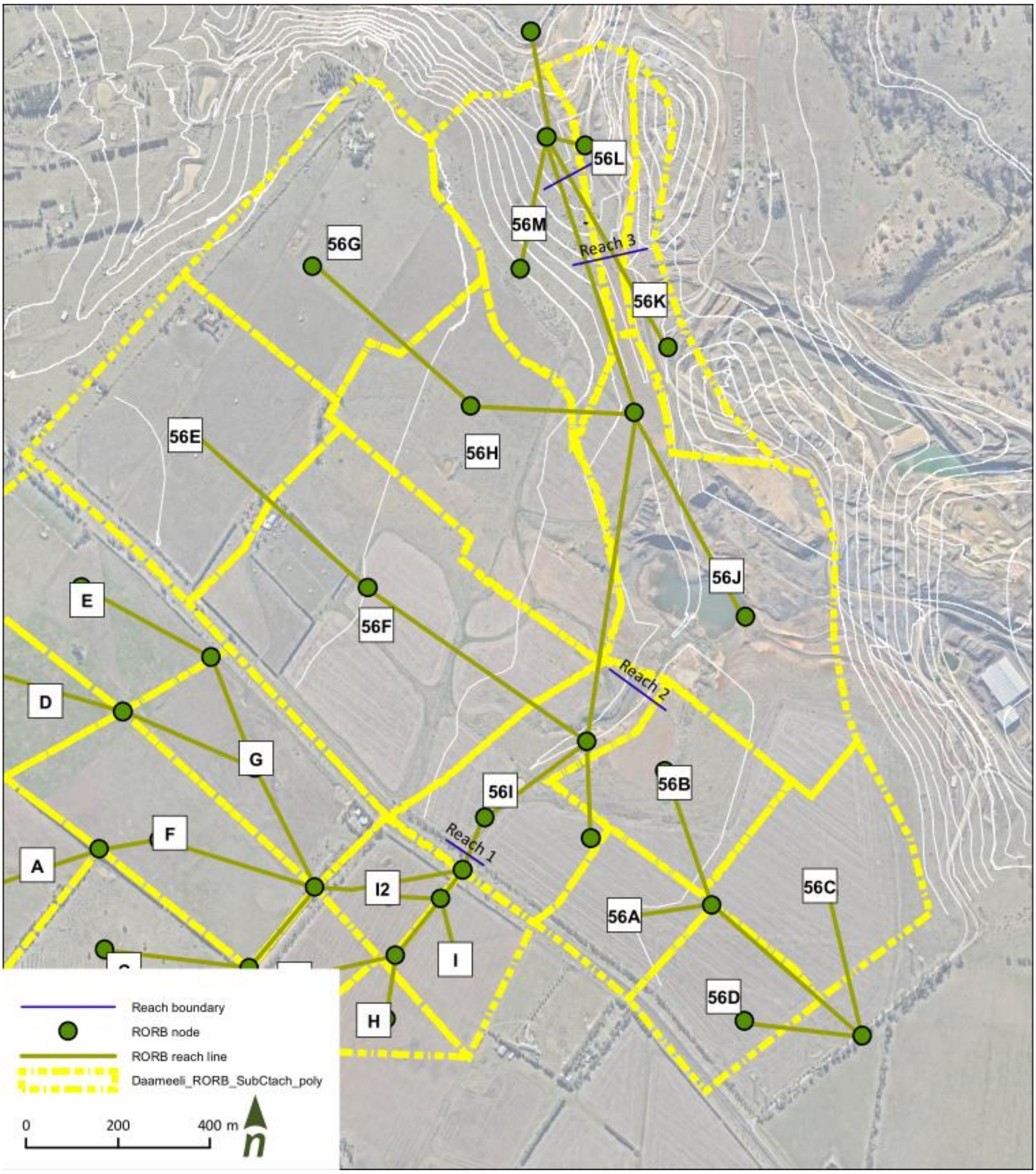

Figure 6-1. *RORB sub catchment delineation over the subject site*

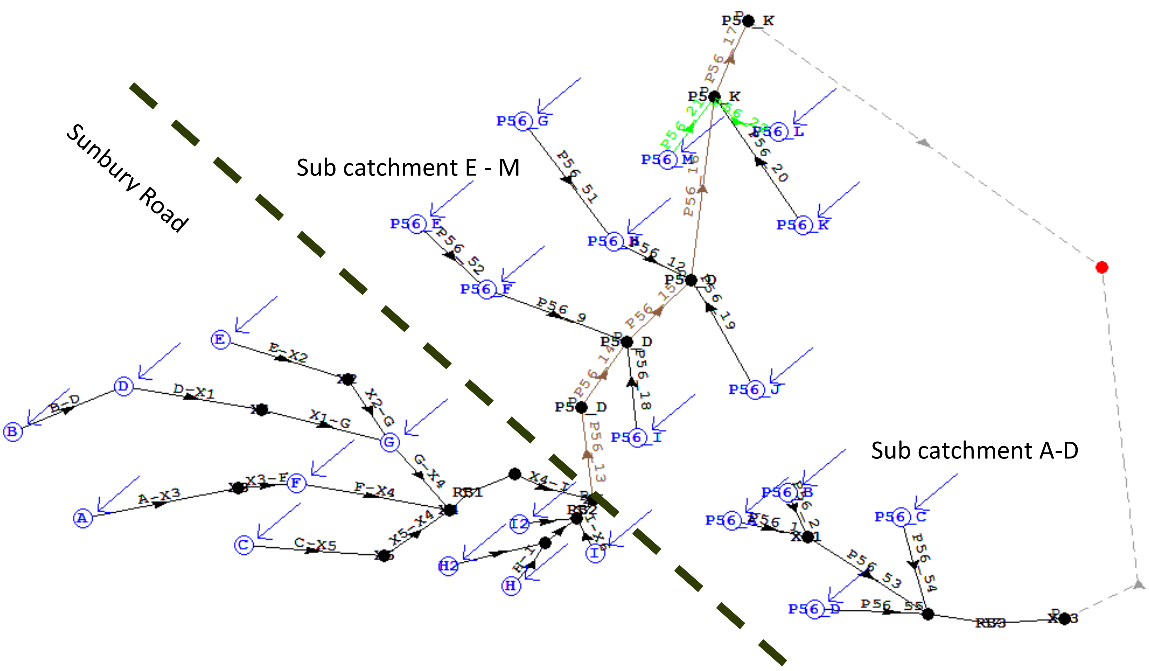

Figure 6-2. *Graphic view of modified RORB model*

We utilised the 100 year ARI flows to design a compound channel as constructed waterway. Discharge locations from the different sub catchments into the proposed constructed waterway are shown in Section 6. Four major reaches were defined over the waterway with the magnitude of peak flows defined for each reach (Table 2).

Table 2. *Magnitude of peak flows for different sub catchments*

Parameter	Reach 1	Reach 2	Reach 3	Reach 4
1 year ARI (m3/s)	0.99	5.45	6.69	5.79
100 year ARI (m3/s)	3.8	22.69	27.04	26.79

For the first 550 m downstream of Sunbury Road the 100 year ARI flows are to be conveyed via underground 1200 mm dia pipeline as per the Daameeli DSS. The adjacent wetlands will act as an overland flow path should blockages occur in the pipe or capacity be exceeded.

As per the Daameeli DSS and past agreements with MPA and MW no retarding of site runoff is required for sub catchments 56E to 56L. However, a retarding basin is required to the south-east corner of the site to attenuate flows from the local catchment (catchment 56A to 56D) back to pre-development levels.

The retarding basin within sub catchment 56A to 56D will allow outflow from the site at the south-east corner at predevelopment levels. The base of the retarding basin has been set to allow free drainage from the site. Table 3 shows the magnitude of peak flows at existing condition (prior to urban development), developed condition with no retardation, and developed condition with retardation.

Table 3. RORB Modelling Results

WLRB5	Existing conditions	Developed conditions without retardation	Developed conditions with retardation
100 year ARI	2.01 m^3/s, 2hr	16.24 m^3/s, 15 min	1.99 m^3/s, 2hr

Table 4. WLRB5 Details

Retarding Basin No.	Basin Name	Total RB Area (Ha)	Peak Storage Level (m AHD)	Peak Storage (m³)	Outlet Dimensions
WLRB5	WLRB5	2.00	184.01	16,300	Pipe: 2 x 750mm RCP Spillway: 100 m, 184.1 m AHD

Figure 6-3. *Location of WLRB5 and alignment with existing WI-18 in Sunbury South PSP and Daameeli DSS*

> In my opinion the PSP layout with respect to drainage of catchment 56A to 56D is appropriate from an engineering feasibility perspective. The location for asset RBWL5 (wetland and retarding basin, PSP reference WI-18) is sound and can deliver on the design criteria to control peak flows to the equivalent pre-development peak flow rates and best practice stormwater quality targets. However, based upon the modelling and preliminary design undertaken, I would recommend that the entire "rectangular" retarding basin and wetland be located within the existing electricity easement.
>
> ACHIEVED - Objective 2: Retardation of flows back to predevelopment levels for the catchment draining to the south east only.

6.2 Minor drainage system

The proposed internal drainage system has been designed in accordance with the minor / major drainage system philosophy. For drainage assets within a catchment area of 60 hectares, Council design standards are expected to apply. For drainage assets greater than 60 hectares, Melbourne Water design standards are expected apply.

The minor drainage system (underground pipe network) has been designed to convey the 5 year ARI residential flows (subcatchments 1A to 3B) and 10 year ARI employment/commercial flows (subcatchments 4A to 5B) where stormwater quality assets are located (Figure 6-4). The 100 year ARI gap flows (flows that exceed the underground system capacity up to the 100 year ARI flow) are to be conveyed via the major drainage reserve (constructed waterway) and road reserves. For the southeast catchment, catchment 5A and 5B, the minor flows and overland flows are conveyed via pipe and road reserves to a retarding basin/wetland to the south east corner of the site.

The calculated design flows that have been used for fully developed conditions to assess pipe and road capacity requirements have been undertaken using the rational method and are provided in Table 5 and Figure 6-4. Detailed rational method calculations are included in Attachment A.

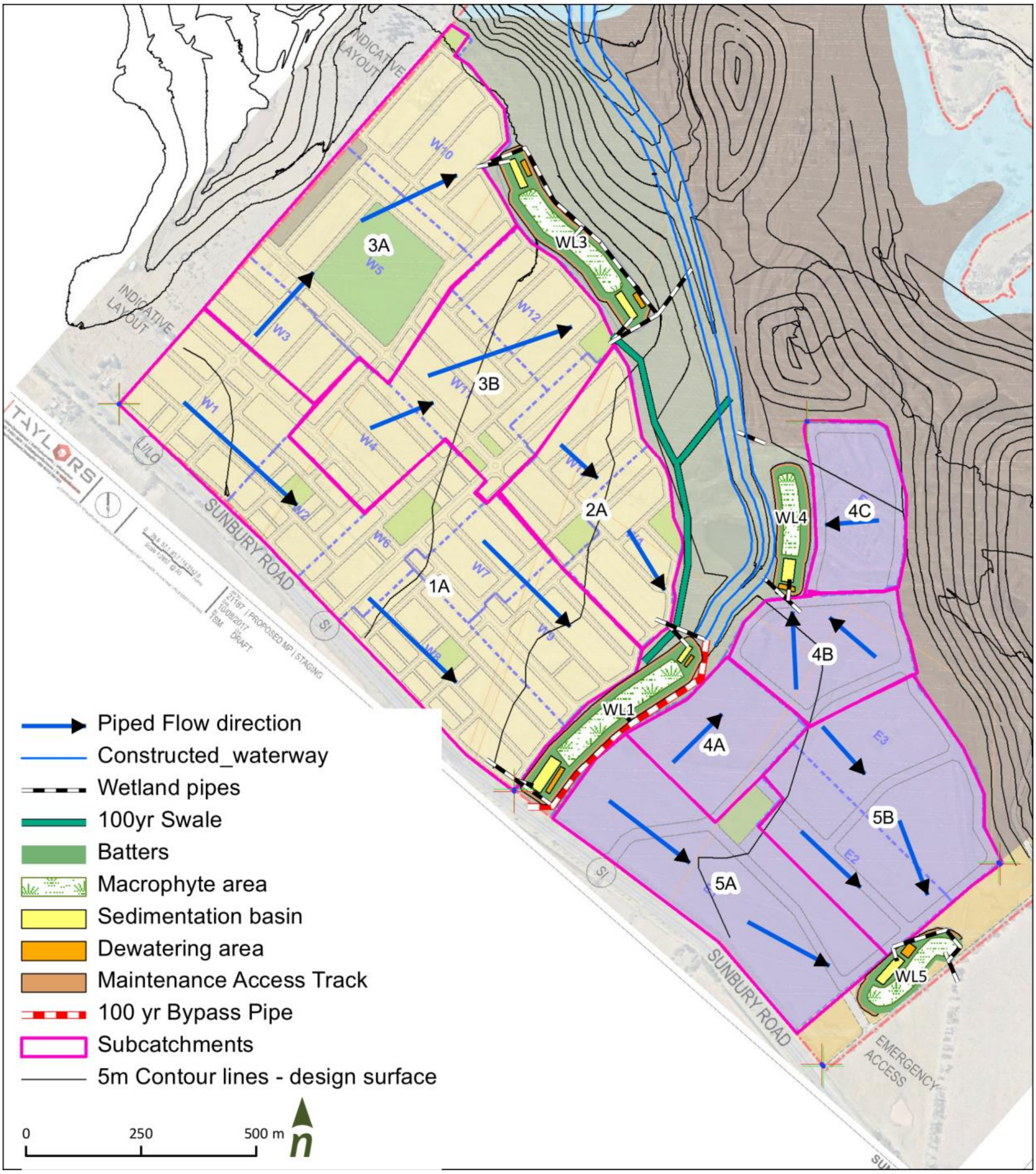

Figure 6-4. *Sub catchments for minor flows*

The minor drainage system would consist essentially of an underground piped network and should be designed to accommodate a 5 to 10 year average recurrence interval event (ARI). Minor (piped) flow path delineation can be seen in Figure 6-5.

Table 5. Hi-Quality minor flows (rational method)

Catchment	Area (ha)	Minor flow (m^3/s) (5 year ARI)	Minor flow (m^3/s) (10 year ARI)	Maximum pipe size required* (mm dia)	Pipe capacity (m^3/s)
1A	41.6	4.29		1350	5.24
2A	13.5	1.74		825	1.78
3A	27.1	2.92		1350	3.97
3B	21.4	2.34		1200	3.19
4A	6.9		1.15	1200	1.63
4B	8.2		1.37	1200	1.65
4A and 4B	15.1		1.83	1500	2.08
4C	7.2		1.27	1050	1.29
5A	18.0		2.97	1200	4.06
5B	19.1		3.28	1200	3.76

*Equivalent pipe size if only one pipe was used

In my opinion, the proposed Hi-Quality masterplan can adequately convey minor flows (5 and 10 year ARIs) through an underground piped network as per Melbourne Water and Hume City council drainage standards.

ACHIEVED - Objective 3: Convey minor flows through local catchments in a piped network

6.3 Major drainage system - Pipe and road network

The major drainage system will convey the 100 year ARI flows through the study area. This consists of the waterway corridor, swale system and road reserves throughout the development. This section outlines the proposed strategy for the pipe and road network and swale system.

Based on the road width and slope, and the maximum allowable nature strip cross-fall of 10%, the capacity that can be contained within the main road reserves is shown in Table 6. This capacity has been determined using HEC-RAS based on the Melbourne Water floodway safety criteria for residential streets used as floodways:

- Manning's 'n' = 0.020
- Average velocity time average depth should be less than 0.35
- Average depth should be less than 0.30 m

In my opinion, at each flow location, the road reserve will adequately contain the gap flows and therefore pass the 100 year flows through the development safely.

Table 6. Hi Quality major flows

	Overland flows			Road capacity			
Flow point	**Minor flow (5/10 year ARI) (m^3/s)**	**Major flow (100 year ARI) (m^3/s)**	**Q (gap) (m^3/s**	**Assumed Road width (m)**	**Slope**	**Road capacity (m^3/s)**	**Result**
1A	4.29	8.83	4.55	16	1.0%	4.5	OK**
2A	1.74	3.62	1.89	16	1.0%	4.5	OK
3A	2.92	6.04	3.12	16	1.0%	4.5	OK
3B	2.34	4.83	2.50	16	1.0%	4.5	OK
4A	1.15	2.02	0.87	20	0.5%	5.5	OK
4B	1.37	2.39	1.03	20	0.5%	5.5	OK
4A and 4B	1.83	2.02	0.87	20	0.5%	5.5	OK
4C	1.27	5.49	2.33	20	0.5%	5.5	OK
5A	2.97	5.21	2.24	20	0.5%	5.5	OK
5B	3.28	5.75	2.47	20	0.5%	5.5	OK
Shepherds Ln	-	3.8	N/A	N/A	N/A	1200 mm dia pipe	N/A

** Multiple roadways are likely to be used to convey the gap flow. Therefore OK.

To prevent 100 year flows from cascading down the steep escarpment and potentially causing longer term erosion and maintenance issues a swale system is proposed to collect water from catchments 1A, 2A, 3A and 3B. This swale will collect the road gap flows and convey this flow to the constructed waterway at point where the escarpment slope is reduced (Figure 6-5).

In my opinion, the proposed Hi-Quality masterplan can adequately convey major flows (up to the 100 year ARI) through a pipe, road and swale network through the development as per Melbourne Water and Hume City council drainage standards.

ACHIEVED – Objective 4: Convey major flows through the site via the overland flows along road reserves and the constructed waterway

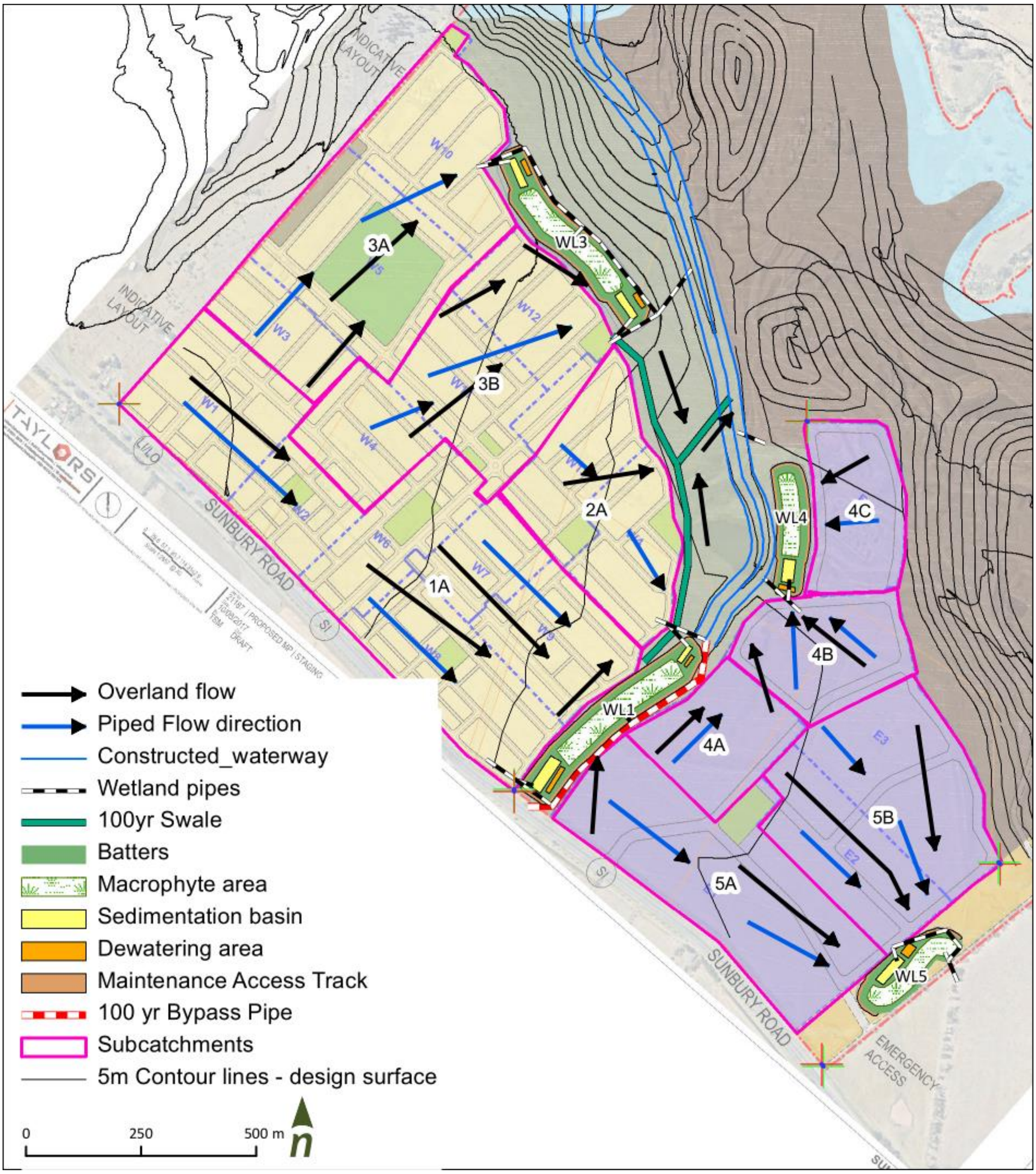

Figure 6-5. *Location of minor and major flow paths*

6.4 Major drainage system - constructed waterway

The constructed waterway was designed in line with the Melbourne Water Constructed Waterway Guidelines. The Melbourne Water Waterway Corridor Guidelines, along with consultation with Melbourne Water, has been used to establish appropriate conditions surrounding the waterway.

Alignment

The alignment of the constructed waterway follows the path of that considered for the Daameeli DSS and Sunbury South PSP, which utilises an existing depression. The waterway extends from the proposed 100 year ARI bypass pipeline 550 m downstream of Sunbury Road. From this point, the channel heads north east for approximately 250 m before turning to the north where it heads towards Emu Creek and ties in at the entry point as per the Daameeli DSS.

Bed grade
A variable bed grade ranging from 0.0134 m/m to 0.075 m/m has been designed for the entire reach. This has been based on minimising cut batters into the existing escarpment and reducing the slope where possible (refer to Figure 6-6). Due to the relatively steep bed grade of the reaches either a rock lined wide channel is required to accommodate the 100 year flow or installation of multiple bed control structures such as rock chutes will be required to address associated velocities.

An overview of the chutes required is provided below (Table 7).

Table 7. Overview of engineering works required to create a stable constructed waterway

Element	Reach 1	Reach 2	Reach 3	Reach 4
Waterway slope	Piped	0.0134 m/m	0.0750 m/m	0.0570 m/m
Erosion protection approach	N/A	Rock chute – grade control	Rock lined channel	Rock lined channel
Rock chute drop required	N/A	4.3 m	N/A	N/A
Individual rock chute drop	N/A	1.4 m	N/A	N/A
Number of rock chutes required	N/A	3	N/A	N/A
Rock chute slope	N/A	1V : 20H	N/A	N/A
Length rock chute required	N/A	28 m	N/A	N/A
Spacing of rock chutes	N/A	283 m	N/A	N/A

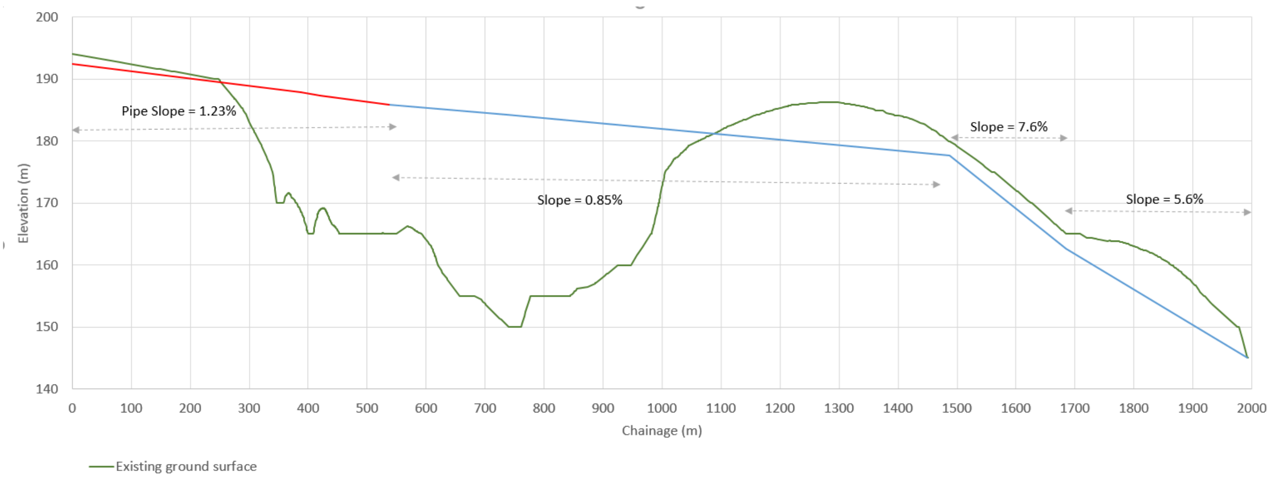

Figure 6-6. *Indicative longitudinal section of proposed constructed waterway*

Hydraulic width
The low flow channel will convey between a 3month and 1 year ARI event, while the high flow channel has the capacity of the 100 year ARI event. The flows used in the channel design are provided in Table 2. According to Melbourne Water Constructed Waterway Manual, in order to protect constructed waterways against erosion, shear stress (the frictional force of the water on the bed and bank material) should not exceed critical shear stress thresholds. The critical shear stress was defined 45 N/m2 based on Melbourne Water guideline recommendations for short native grass. This is a conservative value, and with vegetation establishment, the channel could be designed to tolerate greater shear stresses. Freeboard of 0.6 m was adopted for the entire reach.

As mentioned above (hydrologic analysis), the waterway has been divided into four reaches based on the local flow discharges. Appropriate channel widths and depths have been identified to convey the required flows in each reach and to avoid scour of the channel.

A typical section of the designed channel is shown in Figure 6-7. Also, Table 8 presents the detailed characteristics of the designed channel in each reach.

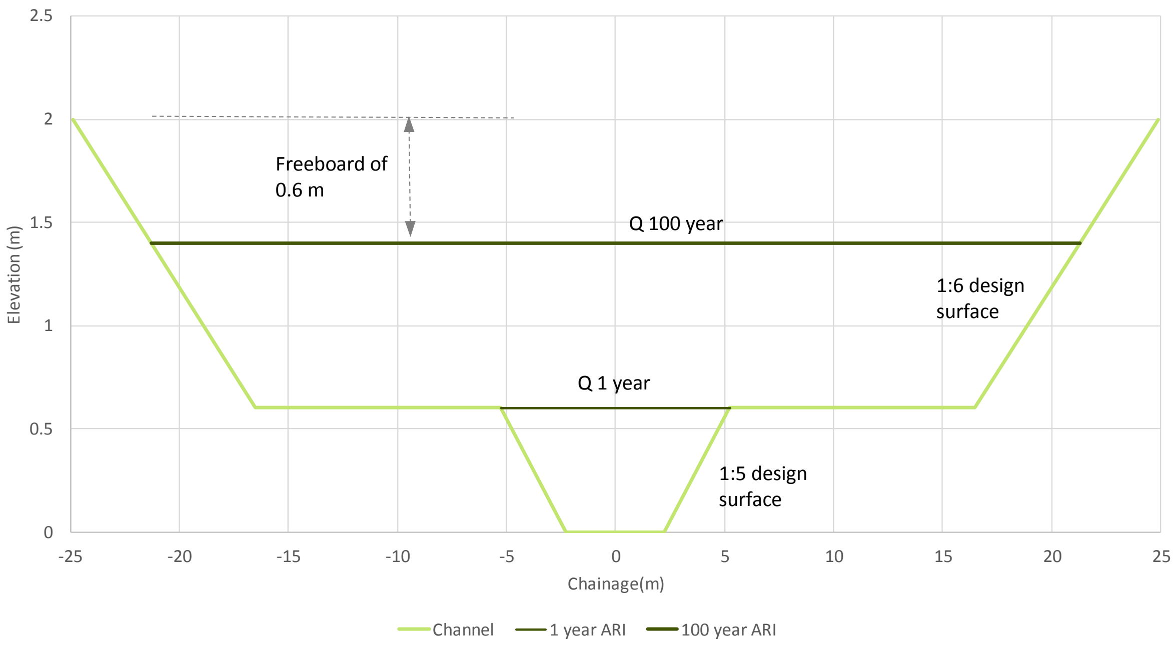

Figure 6-7. *A typical section of proposed constructed waterway*

Table 8. Detail characteristics of proposed waterway

Reach name	Desirable longitudinal slope (m/m)	Manning		Water depth (m)		Top hydraulic width (m)	Shear stress (N/m^2)		Design 100 year flow (m^3/s)	Capacity (m^3/s)
		Low flow channel	Main channel	1 year ARI	100 year ARI		Low flow channel	Main channel		
Reach 1	Piped	-	-	-	-	-	-	-	-	-
Reach 2	0.006	0.05	0.06	0.6	1.4	23.6	47.9	19.2	22.7	23.8
Reach 3	N/A*	0.05	0.06	0.5	0.8	27.6	450**	200	27.0	28.0
Reach 4	N/A*	0.05	0.06	0.5	0.9	19.8	397**	192	26.8	27.0

* Waterway slope too steep for rock chute grade control. Rock lined channel adopted instead.
** Shear stress values ok due to rock lining.

Waterway corridor

Waterways, whether natural or constructed, need to have an appropriate waterway corridor or reserve provided adjacent to development in order to accommodate objectives for flood protection, river health, biodiversity and amenity.

A waterway corridor is defined as the waterway channel and its associated riparian zones. The riparian zones consist of two parts (Figure 6-8):

- the vegetated buffer
- the core riparian zone

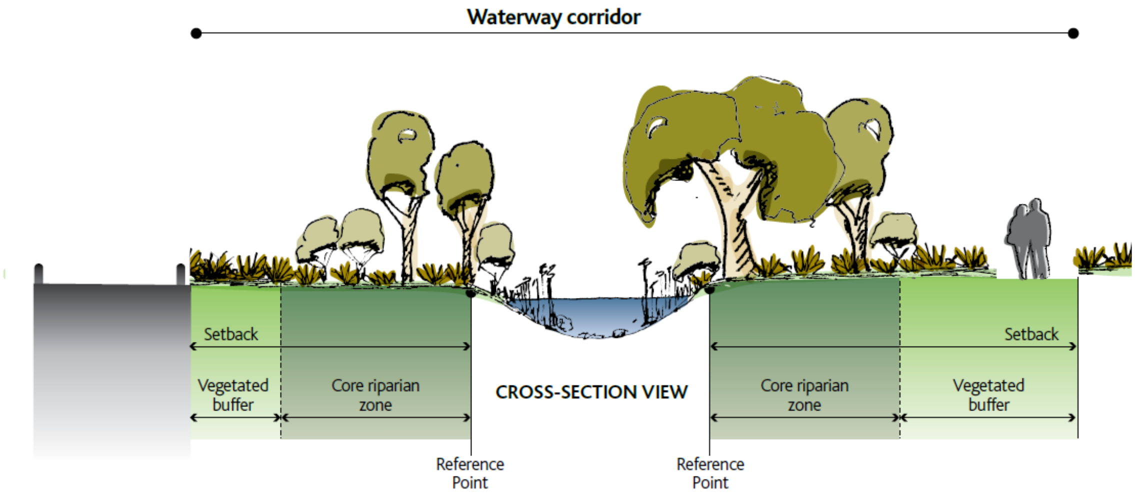

Figure 6-8. *Waterway corridor (Melbourne Water's Waterway Corridor Guidelines)*

Based on the calculated hydraulic width for each reach a core riparian zone (CRZ) was adopted using Table 4 from Melbourne Water's Waterway Corridor Guidelines (Figure 6-9). Table 9 and Figure 6-10 show the adopted corridor width based on application of the guidelines for the different reaches.

Table 4. Sliding scale for calculating constructed waterway corridor widths – addition of shared trail/maintenance track either side of channel (within vegetated buffer)

HYDRAULIC WIDTH (M)	CRZ WIDTH (M)	VB WIDTH (M)	CORRIDOR WIDTH (M)
5	20	20	40
10	20	20	40
15	20	25	45
20	25	25	50
25	30	25	55
30	30	25	55
35	30	25	55
40	35	25	60
45	35	25	60
50	35	25	60
55	40	25	65
60	40	25	65
65	40	25	65
70	45	25	70

Figure 6-9. *Constructed Waterway corridor requirements (Melbourne Water's Waterway Corridor Guidelines)*

Table 9. Adopted corridor width for different reaches

Parameter	Reach 1	Reach 2	Reach 3	Reach 4
Corridor width (m)	N/A - Piped	50	55	50

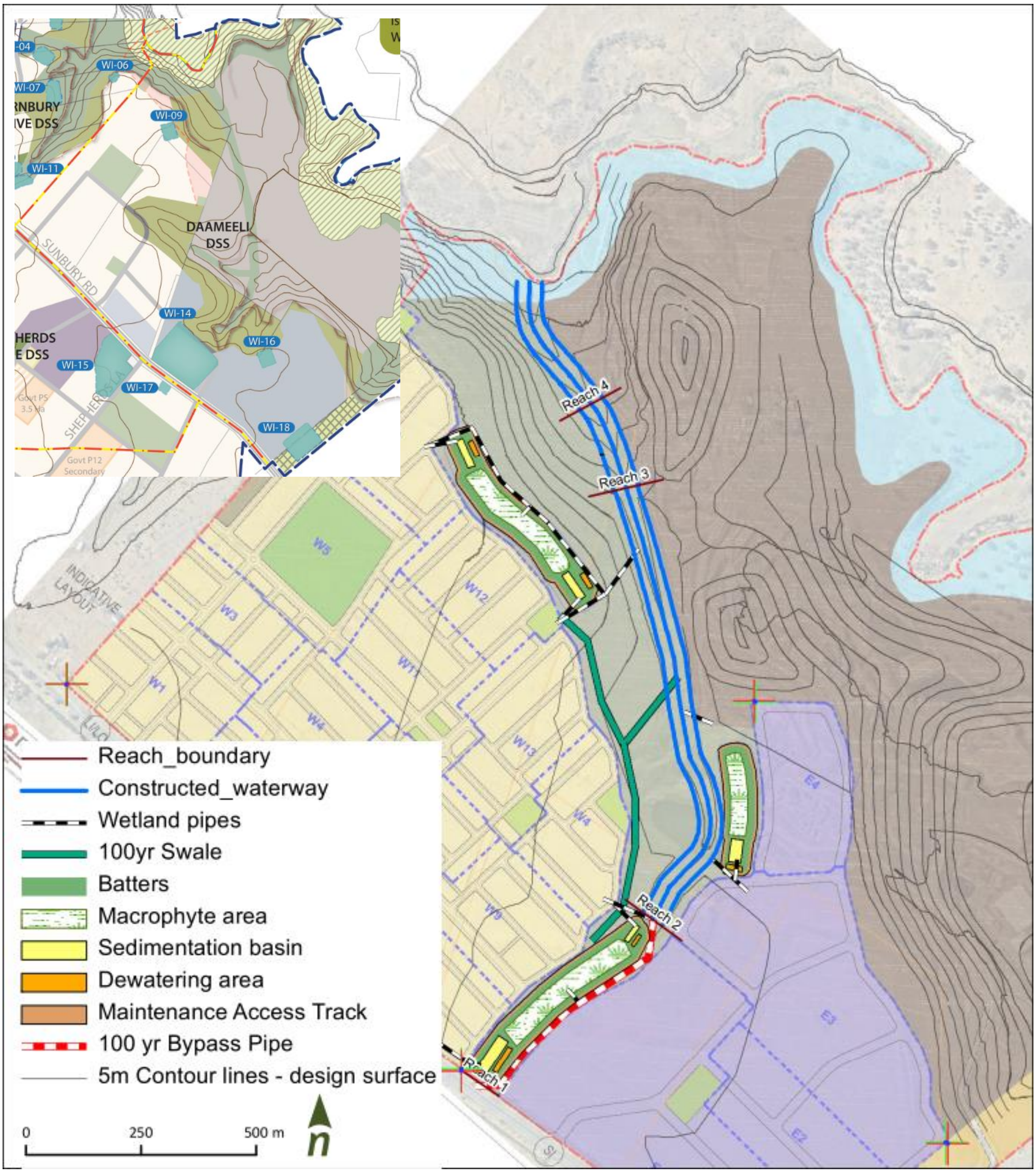

Figure 6-10. *Location of proposed constructed waterway and alignment with existing Sunbury South PSP and Daameeli DSS*

In my opinion the PSP layout with respect to the alignment of the constructed waterway is appropriate from an engineering feasibility perspective. The location for the constructed waterway can deliver on the design criteria to convey peak flows safely to Emu Creek in line with Melbourne Water standards. However, based upon the revised Hi-Quality masterplan, modelling and preliminary design undertaken, I would recommend that the corridor alignment be:

- adjusted to better align with the existing drainage line
- remove the proposed corridor alignment branching to the west to align with the Hi-Quality masterplan
- waterway corridor/drainage reserve to be set to 50 to 55 m as outlined in this strategy

ACHIEVED – Objective 4: Convey major flows through the site via the overland flows along road reserves and the constructed waterway

6.5 Stormwater quality analysis

The wetlands have been designed in line with the following guidelines.

- Design, construction and establishment of constructed wetlands: design manual – Melbourne Water (2016)
- MUSIC Guidelines – Melbourne Water (2016)
- Urban Stormwater Best Practice Environmental Management Guidelines (1999)

Positioning

Three wetlands and one wetland retarding basin have been positioned to receive and treat stormwater based on the masterplan. The positioning of these wetlands generally aligns with that proposed within the Sunbury South PSP and Daameeli DSS. However, the wetlands have been repositioned and resized to ensure best practice targets are met associated with the proposed Hi-Quality masterplan.

Wetland 1 (WL1) is a dual fed wetland and is located immediately downstream of Sunbury Road, on the northern side of the waterway. It receives water from catchment 1A and 2A. The position of this wetland aligns with the Sunbury South PSP wetland Wl-14. Though it has been reshaped to provide a better linkage with the constructed waterway corridor.

Wetland 3 (WL3) is a dual fed wetland and receives water from catchment 3A and 3B and is located at the north of the study area. The position of this wetland aligns with the Sunbury South PSP wetland Wl-09. Though it has been reshaped and resized to ensure best practice targets are met in responding to the proposed Hi-Quality masterplan.

Wetland 4 (WL4) is located to the east of the constructed waterway corridor and receives flows from catchment 4A, 4B and 4C. As per wetland WL3 it is elongated to run parallel to the contours of the slopes grading down to the waterway to minimise excavation. The position of this wetland aligns with the Sunbury South PSP wetland Wl-16. Though it has been reshaped and resized to ensure best practice targets are met in responding to the proposed Hi-Quality masterplan.

Wetland 5 (WLRB5) is located to the south-east corner of the study area, in the existing high voltage power easement. It receives water from catchment 5A and 5B and aligns with the Sunbury South PSP wetland Wl-18. Though it has been reshaped to fit within the electricity easement.

Criteria for SWMS

A key principle for development is that all stormwater is to be treated to best practice before being discharged to the waterway (Objective 1). The following Best Practice 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)

The land use types and corresponding fraction imperviousness adopted in the MSUIC modelling are presented in Table 10. In accordance with Melbourne Water's MUSIC Guidelines, Melbourne Airport rainfall station was used with reference data from 1971 - 1980. The design treatment system schematic is provided in Figure 6-16. The results are presented Table 13 to show the level treatment provided by each asset.

Table 10. Fraction Impervious (based on Melbourne Water's MUSIC Guidelines)

Land use type	*Faction impervious adopted*
Residential – allotment size 300-600 m2	0.75
Employment and commercial area	0.9

Table 11. Overall treatment train results

Parameter	Total sources	Residual Load	Removal achieved	Removal achieved from study area
Flow (ML/yr)	627	574	53	9%
Total Suspended Solids (kg/yr)	127,000	25,400	101,600	80%
Total Phosphorus (kg/yr)	258	80	178	69%
Total Nitrogen (kg/yr)	1,810	924	886	49%
Gross Pollutants (kg/yr)	24,400	-	24,400	100%

Table 12. Designed specification of wetlands

Wetlands	Catchment area (ha)	Sediment basin area (m²)	Macrophyte area (m²)	Batters slope	Total land take (m²)
WL1	55.1	500 (North) 2100 (South)	14000		38080
WL3	48.5	1100 (East) 1100 (West)	12000	1(H) : 6 (v)	35821
WL4	22.3	1300	6500	1(H) : 6 (v)	19680
WLRB5	37.1	1400	9000	1(H) : 6 (v)	19000

Table 13. MUSIC results for each treatment asset

System arrangement		*System performance (removal)*			
Asset	**WSUD Treatment Measure**	**Total Suspended Solids**	**Total Phosphorous**	**Total Nitrogen**	**Gross Pollutant**
WL1	Wetland 1	79.8 %	69.4 %	49.4 %	100 %
WL3	Wetland 3	79.9 %	68.7 %	48.8 %	100 %
WL4	Wetland 4	79.9 %	68.9 %	48.7 %	100 %
WLRB5	Wetland and retarding basin 5	80.5 %	69.3 %	48.7 %	100 %

Treatment asset parameters

The batter slopes have been designed at 1 in 6 around the assets plus provision of a shared path and maintenance tracks where necessary. It is assumed that at 0.35 m below the normal water level, the batter slope can increase to 1:3 therefore allowing a minimum width of 12.5 m, whilst still accommodating for deep open water zones in the wetland and sediment basins. All treatment assets are located adjacent to the waterway. The extended detention depth level of the assets has been located entirely outside the waterway corridor, while the batters will link with the constructed waterway earthworks within the vegetated buffer, but outside of the core riparian zone.

Provision has been made for maintenance requirements. As described above, the asset designs allow for a maintenance track, these would typically be 4 m wide at a grade of 1:20. Provision for sediment dewatering has also been made. These areas assume a depth of 500 mm and allow for the 5 year cleanout sediment volume to be accommodated. These calculations are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment. The possible locations of these dewatering areas are provided in Figure 6-12 to Figure 6-15. Calculations for sediment basin capture efficiency and storage volume is provided in Attachment B.

The assets are located offline and will collect water from the contributing catchment then discharge to the waterway. The 3-month ARI flow from the stormwater pipe will be diverted into the sediment basins and macrophyte zones. The major 100 year flows are routed around the wetlands, to avoid disturbance (see Figure 6-11). Treatment asset parameters used in MUSIC are provided in Table 12. Velocity calculations for the wetland and sediment ponds are provided in Attachment B.

Table 14. Treatment asset parameters

	Wetland	*Wetland and Retarding Basin*	*Sediment Basin*
Average depth, m	0.4	0.4	1.5
Extended detention, m	0.35	0.35	0.35
Freeboard (m)	0.6	0.6	0.6
Extended detention time (hours)	72	72	12

In my opinion the revised wetland arrangement proposed in this stormwater management strategy is appropriate from an engineering feasibility perspective. The location and size of the wetlands can deliver on the design criteria to treat to best practice before being discharged to the waterway in line with Melbourne Water standards. Therefore, based upon the revised Hi-Quality masterplan, modelling and preliminary design undertaken, I would recommend that the wetland alignments be changed to:

- WL1 (PSP – Wl-14) – position and size changed to match the shape outlined within this report and required drainage reserve area changed to 38,080 m^2
- WL3 (PSP – Wl-09) – position changed to match the shape outlined within this report and drainage required reserve area changed to 35,821 m^2
- WL4 (PSP – Wl-16) – position changed to match the shape outlined within this report and drainage required reserve area changed to 19,680 m^2
- WL5 (PSP – Wl-18) – position and size changed to fit within the electricity easement and drainage required reserve area land take changed to 19,00 m^2

ACHIEVED – Objective 1: Meet best stormwater quality pollutant removal targets

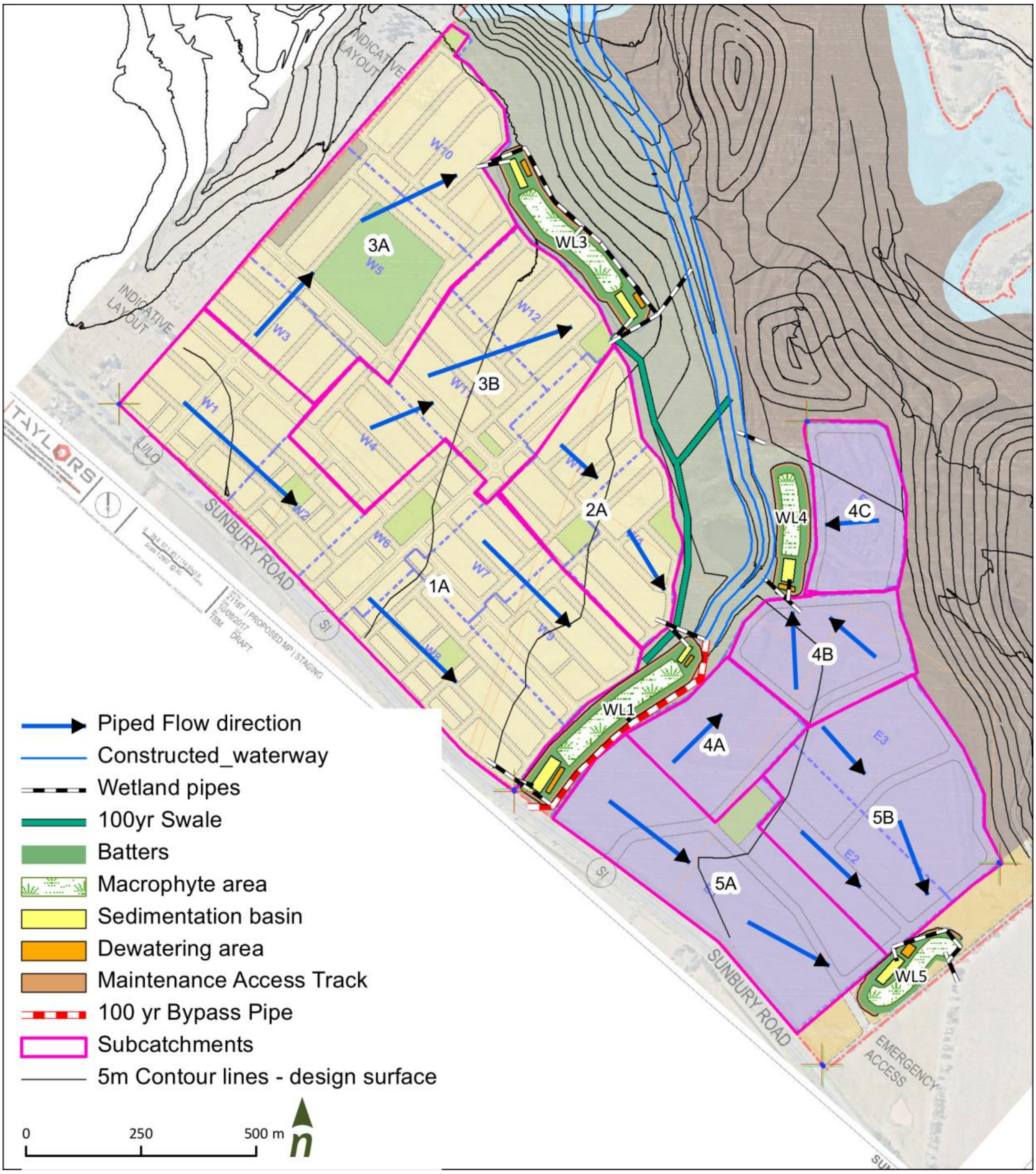

Figure 6-11. *Location of proposed stormwater treatment assets*

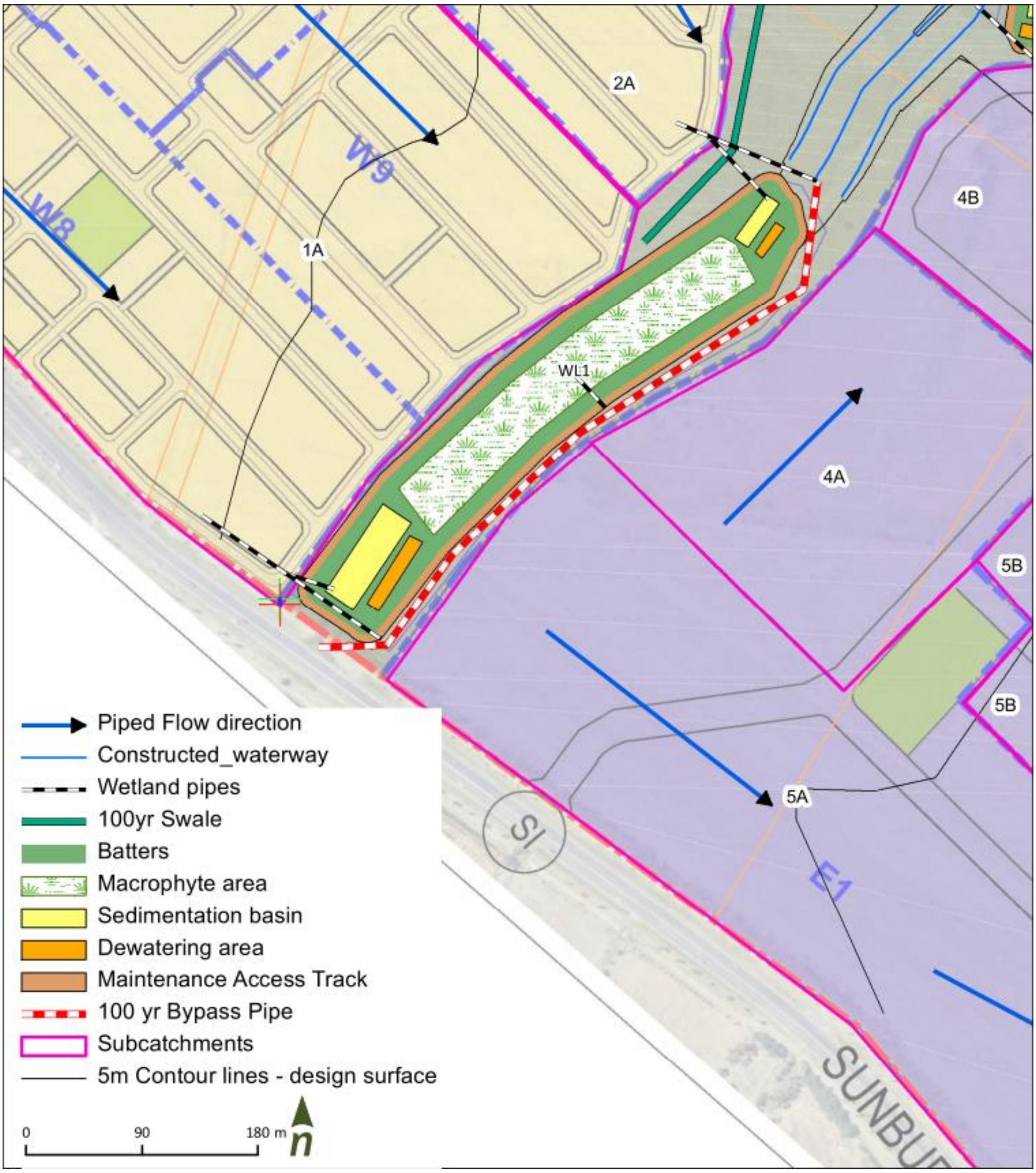

Figure 6-12. *Concept arrangement proposed for wetlands W1*

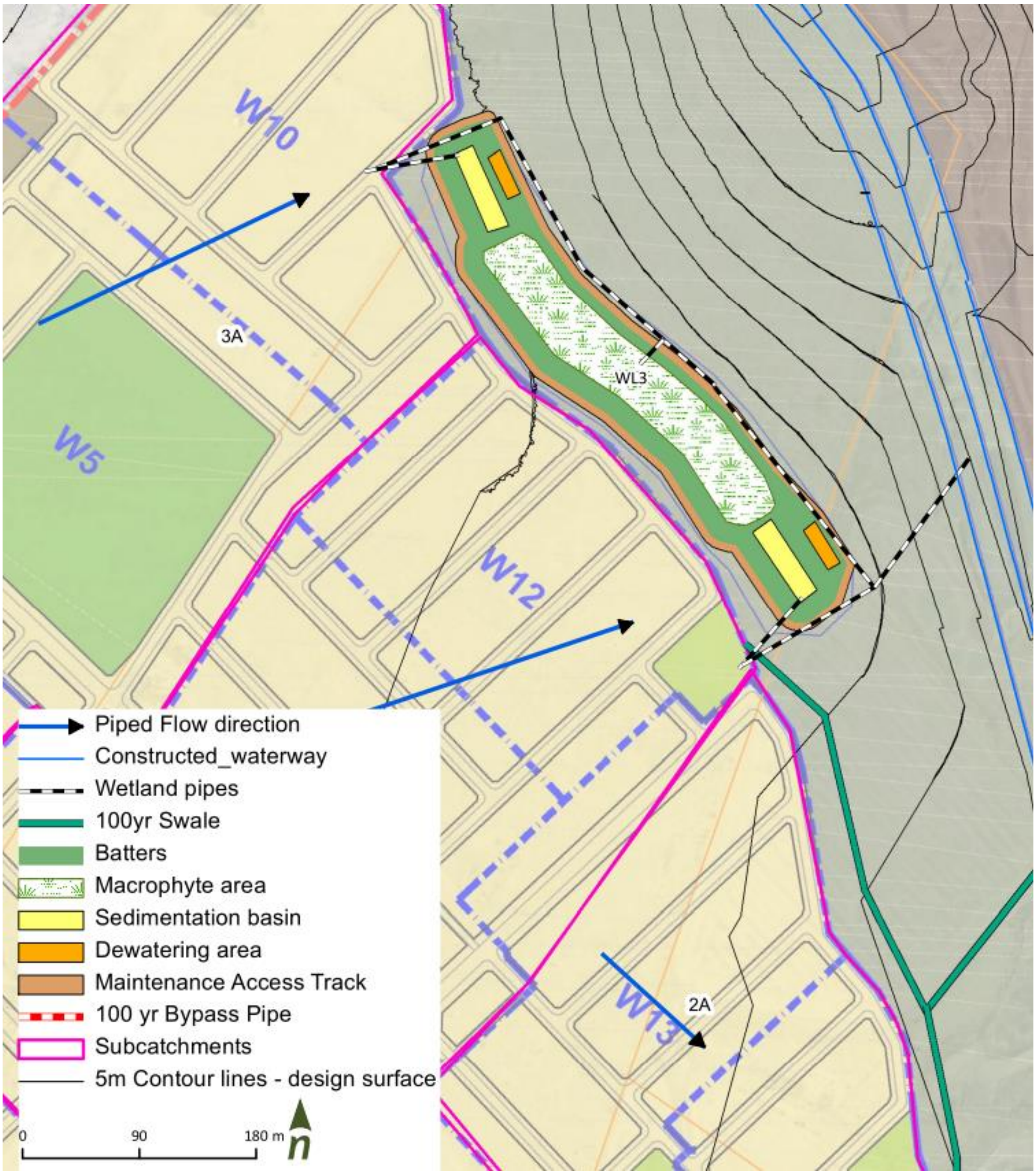

Figure 6-13. *Concept arrangement proposed for wetland of WL3*

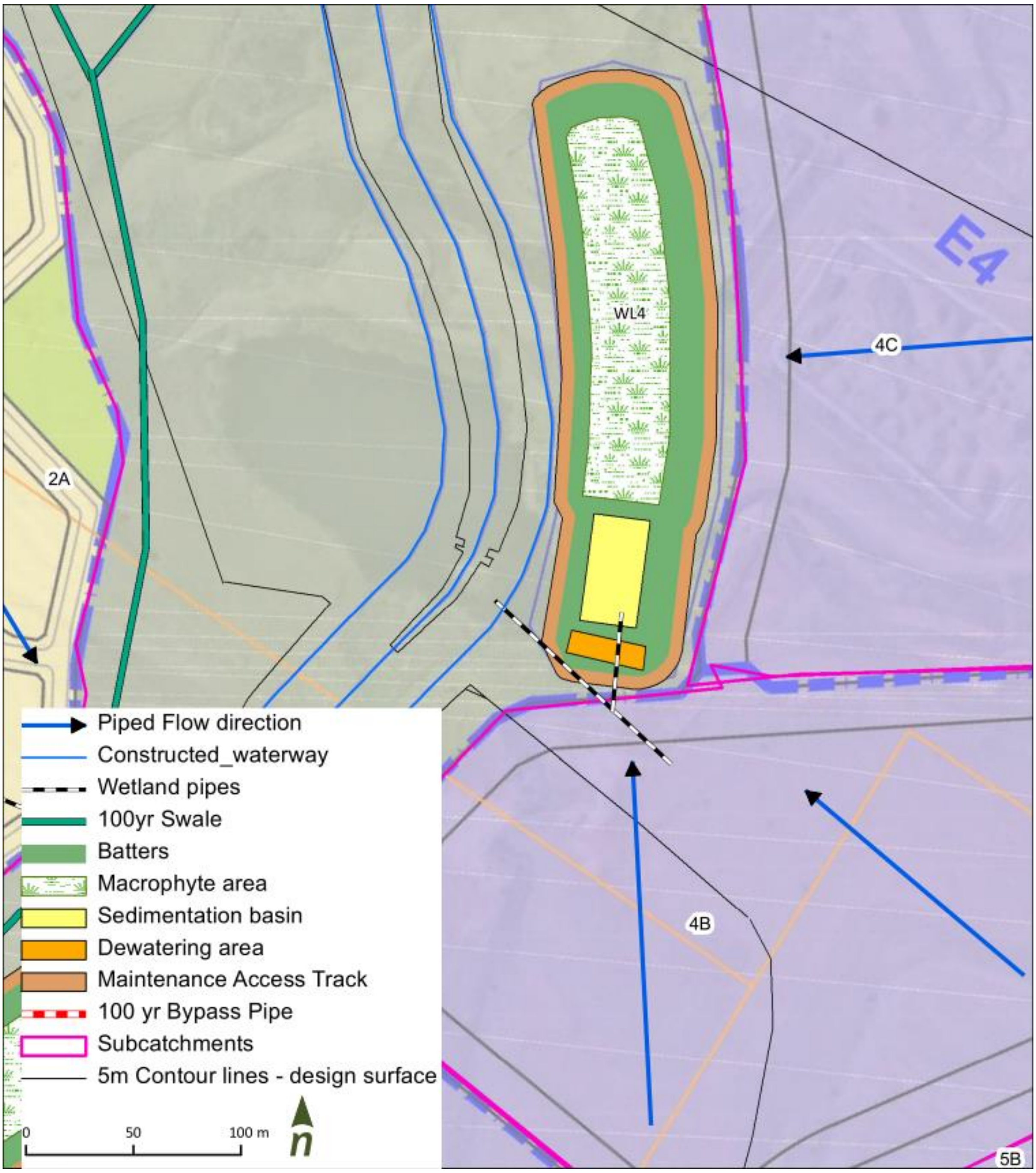

Figure 6-14. *Concept arrangement proposed for wetland of WL4*

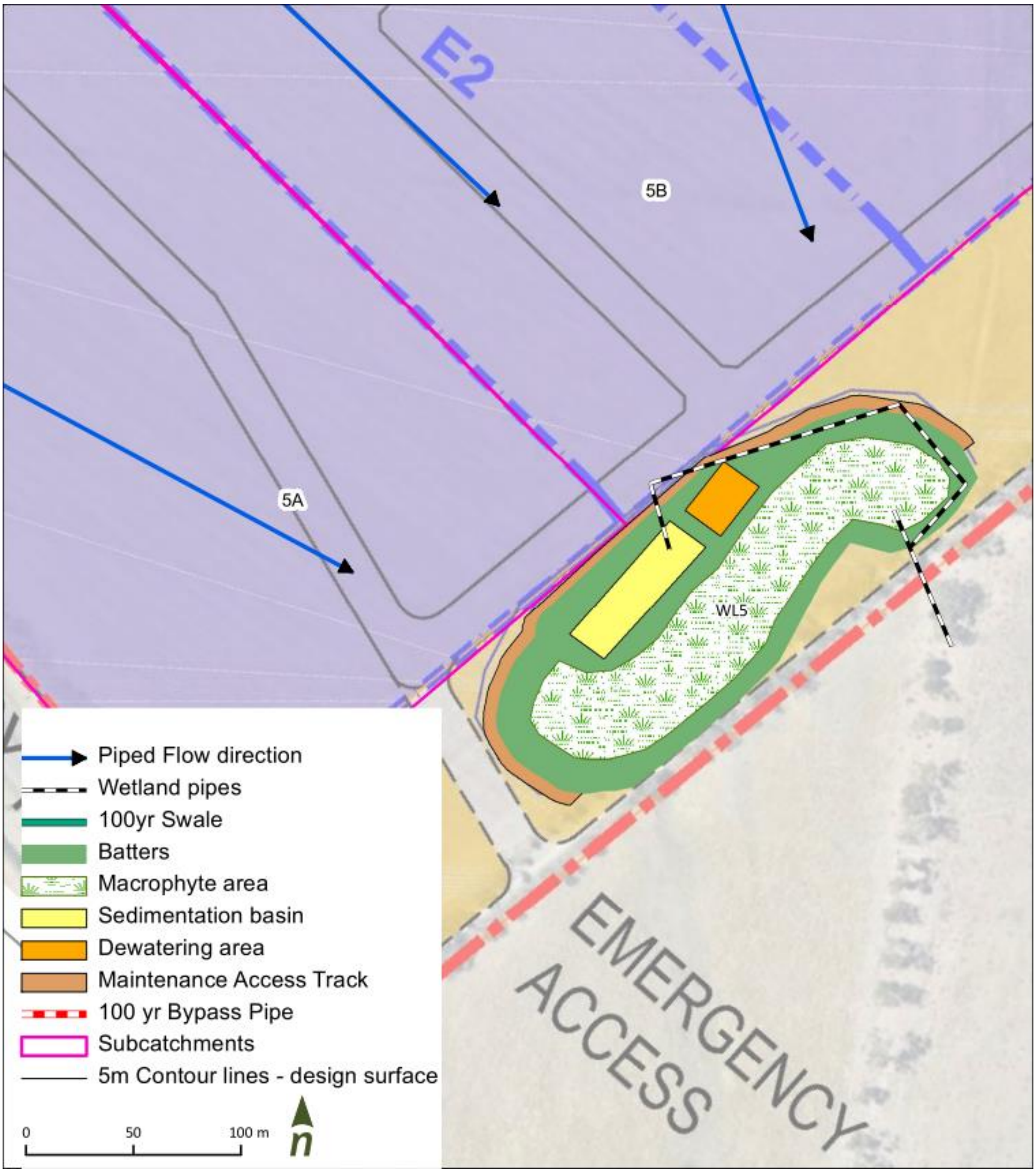

Figure 6-15. *Concept arrangement proposed for wetland of WRBL5*

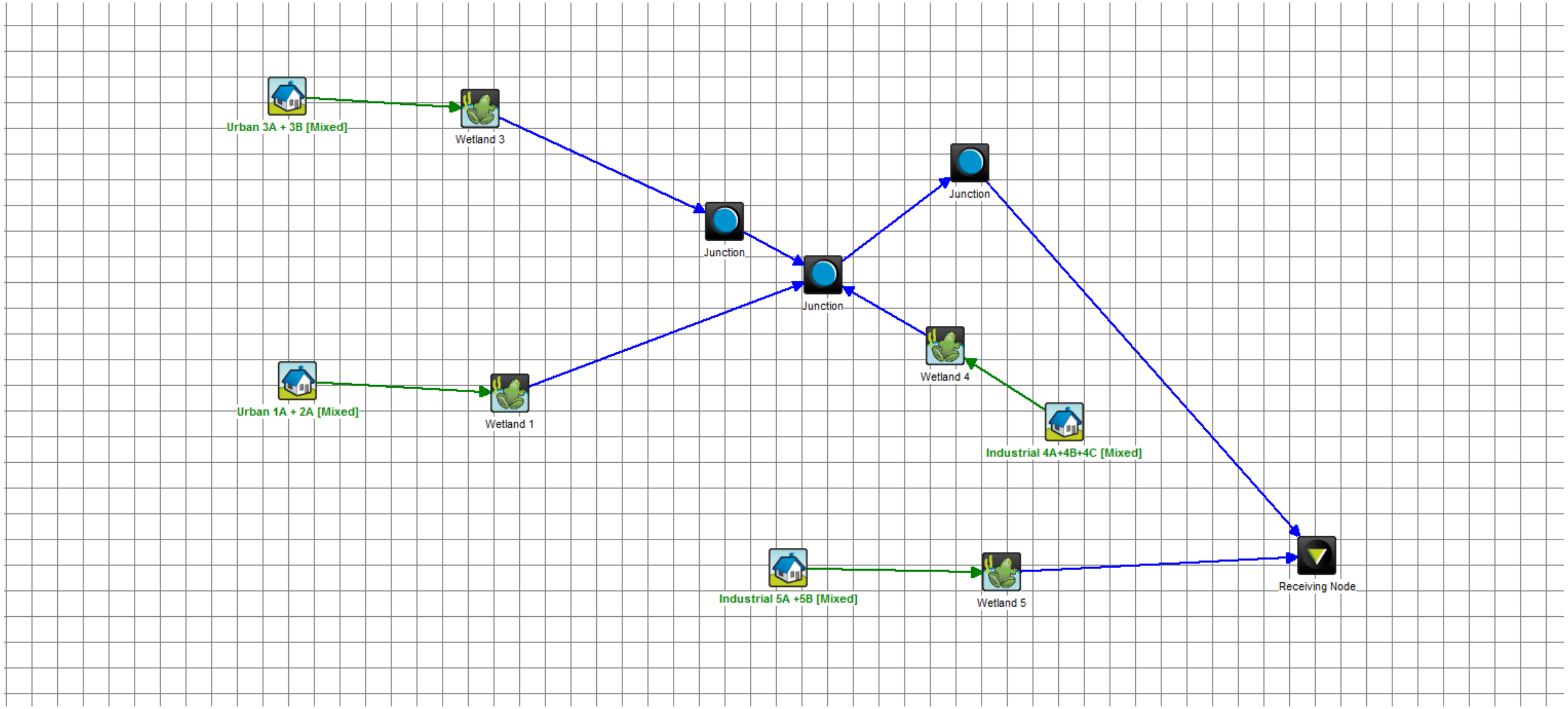

Figure 6-16. *MUSIC schematic for treatment assets*

Wetland high flow bypass

To ensure protection of vegetation from scouring within the wetlands and sediment basins high flows are to be bypassed around each system. This will include incorporation of a 3mth pipe diversion into each sediment ponds (facilitated by an underground diversion pit/weir) with the gap flow up to the 5 and 10 year ARI event (residential/employment) continuing to the downstream waterway via the pipe network.

7 Summary

Objective 1: Meet best stormwater quality pollutant removal targets

In my opinion the revised wetland arrangement proposed in this stormwater management strategy is appropriate from an engineering feasibility perspective. The location and size of the wetlands can deliver on the design criteria to treat to best practice before being discharged to the waterway in line with Melbourne Water standards. Therefore, based upon the revised Hi-Quality masterplan, modelling and preliminary design undertaken, I would recommend that the wetland alignments be changed from those shown on Sunbury South PSP and Daameeli DSS to:

- WL1 (PSP – Wl-14) – position and size changed to match the shape outlined within this report and required drainage reserve area changed to 38,080 m^2
- WL3 (PSP – Wl-09) – position changed to match the shape outlined within this report and drainage required reserve area changed to 35,821 m^2
- WL4 (PSP – Wl-16) – position changed to match the shape outlined within this report and drainage required reserve area changed to 19,680 m^2
- WL5 (PSP – Wl-18) – position and size changed to fit within the electricity easement and drainage required reserve area land take changed to 19,00 m^2

Objective 2: Retardation of flows back to predevelopment levels for the catchment draining to the south east only.

In my opinion the PSP layout with respect to drainage of catchment 56A to 56D is appropriate from an engineering feasibility perspective. The location for asset RBWL5 (wetland and retarding basin, PSP reference WI-18) is sound and can deliver on the design criteria to control peak flows to the equivalent pre-development peak flow rates and best practice stormwater quality targets. However, based upon the modelling and preliminary design undertaken, I would recommend that the entire “rectangular” parcel be located within the existing electricity easement.

OBJECTIVE ACHIEVED

Objective 3: Convey minor flows through local catchments in a piped network

In my opinion, the proposed Hi-Quality masterplan can adequately convey minor flows (5 and 10 year ARIs) through an underground piped network as per Melbourne Water and Hume City council drainage standards.

OBJECTIVE ACHIEVED

Objective 4: Convey major flows through the site via the overland flows along road reserves and the constructed waterway

In my opinion, the proposed Hi-Quality masterplan can adequately convey major flows (up to the 100 year ARI) through a pipe and road network through the development as per Melbourne Water and Hume City council drainage standards.

OBJECTIVE ACHIEVED

Objective 4: Convey major flows through the site via the overland flows along road reserves and the constructed waterway

In my opinion the PSP layout with respect to the alignment of the constructed waterway is appropriate from an engineering feasibility perspective. The location for the constructed waterway can deliver on the design criteria to convey peak flows safely to Emu Creek in line with Melbourne Water standards. However, based upon the revised Hi-Quality masterplan, modelling and preliminary design undertaken, I would recommend that the corridor alignment be:

- adjusted to better align with the existing drainage line
- remove the proposed corridor alignment branching to the west to align with the Hi-Quality masterplan
- waterway corridor/drainage reserve be set to a 50 to 55 m as outlined in this strategy

OBJECTIVE ACHIEVED

I have made all the enquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

Attachment A
Rational Calculations

Rational calculations

For the flows provided in **Error! Reference source not found.** and **Error! Reference source not found.** the rational method has been adopted. The calculations made are presented here.

Table 15. Daleston rational calculations

	Sub catchment:	**1A**	**2A**	**3A**	**3B**	**4A**	**4B**	**4A+4B**	**4C**	**4A+4B+4c**	**5A**	**5B**	**5A+5B**
Parameter	Catchment area, ha	41.6	13.5	27.1	21.4	6.9	8.2	15.1	7.2	22.3	18.0	19.1	37.1
	Fraction impervious	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	Length, m	1138.0	452.0	723.0	745.0	283.0	279.0	562.0	222.0	562.0	739.0	536.0	739.0
	Drop, m	11.0	7.0	4.0	5.0	0.5	0.5	0.5	0.5	1.0	8.0	5.0	8.0
	Slope m/m	0.0097	0.0155	0.0055	0.0067	0.0018	0.0018	0.0009	0.0023	0.0018	0.0108	0.0093	0.0108
	Average pipe diameter, mm	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0
	Velocity, m/s	2.1	2.7	1.6	1.8	0.9	0.9	0.6	1.0	0.9	2.3	2.1	2.1
	Time of concentration, min	14.9	8.8	13.5	13.0	11.2	11.1	20.5	9.6	16.2	11.5	10.3	10.3
Intensity, mm/hr	I 1 year	31.7	39.1	33.1	33.6	35.4	35.5	26.3	37.5	30.3	35.1	36.3	36.3
	I 5 year	57.6	71.7	60.3	61.2	64.7	64.9	47.4	68.5	55.0	64.1	66.4	66.4
	I 100 year	101.9	128.1	106.9	108.5	114.9	115.3	83.1	122.1	97.1	113.9	118.1	118.1
Discharge, m^3/s	Q 1 year	2.36	0.95	1.60	1.28	0.53	0.63	0.86	0.59	1.47	1.38	1.52	1.32
	Q 5 year	4.29	1.74	2.92	2.34	0.98	1.15	1.56	1.07	2.67	2.51	2.77	2.41
	Q 100 year	8.83	3.62	6.04	4.83	2.02	2.39	3.17	2.23	5.49	5.21	5.75	5.01

Attachment B
Treatment asset calculations

Sediment Pond analysis

Sediment ponds for all assets have been sized to ensure a capture efficiency greater than 95% for the 3 month flow and provide adequate sediment storage. The procedure outlined in WSUD Engineering Procedures 2005 and Melbourne Water Constructed Wetland Manual has been followed.

Table 16. Sediment pond calculations

	Asset	**WL1**		**WL3**		**WL4**	**WL5**
		North	South	East	West		
Conditions	A catchment, ha	41.6	13.5	21.4	27.1	22.3	37.1
	A basin, m2	2100	500	1100	1100	1300	1400
	Q5year m3/s	4.88	0.89	2.56	2.70	2.75	2.41
	Converting Q5 year to Q3month	0.2	0.2	0.2	0.2	0.2	0.2
	Q3 month m3/s	0.976	0.178	0.512	0.540	0.550	0.482
Capture Efficiency	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	0.11	0.11
	Permanent Pool Depth, dp (m)	1	1	1	1	1	1
	Extended detention depth, de	0.35	0.35	0.35	0.35	0.35	0.35
	Number of CSTR's, n [From hydraulic efficiency]	1.1	1.1	1.1	1.1	1.1	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	1	1	1	1	1	1
	Capture Efficiency	97%	98%	97%	97%	97%	98%
	Check (> 95%)	Ok	Ok	Ok	Ok	Ok	Ok
Sediment storage	Sediment Loading Rate, Lo (m^3/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	323	105	166	210	173	290
	Available sediment storage volume	1050	250	550	550	650	700
	Check (Available storage > required storage)	Ok	Ok	Ok	Ok	Ok	Ok
Sediment dewatering	Depth for dewatering area (m)	0.5	0.5	0.5	0.5	0.5	0.5
	Area required for dewatering (m^2)	645	211	332	419	347	580

Velocity Calculations

The velocity through each treatment asset is considered here. For these assets the 100 year overland flow from the catchments is diverted around the wetland. A flow depth of 0.35 m, which is the extended detention depth, has been assumed for all 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 for the concept design. 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. Table 17 shows the calculations for the wetland systems.

Table 17. Velocity calculation – Wetlands

		WL1				WL3				WL4		WL5	
		North section		South section		East section		West section					
Flow conditions	Design Flow (m^3/s)	0.86	4.29	0.35	1.74	0.58	2.92	0.47	2.34	0.53	2.67	0.48	2.41
	Flow depth (m)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	22.5	22.5	11	11	16	16	16	16	17	17	20	20
	Width at EDD (m)	26.7	26.7	15.2	15.2	20.2	20.2	20.2	20.2	21.2	21.2	24.2	24.2
	Average width (m)	24.6	24.6	13.1	13.1	18.1	18.1	18.1	18.1	19.1	19.1	22.1	22.1
	Flow Area (m^2)	8.6	8.6	4.6	4.6	6.3	6.3	6.3	6.3	6.7	6.7	7.7	7.7
	Flow Velocity (m/s)	0.10	0.50	0.08	0.38	0.09	0.46	0.07	0.37	0.08	0.40	0.06	0.31
	Check	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK	< 0.5 OK
Macrophyte zone	Width at NWL (m)	47	47	29	29	32	32	32	32	36	36	36	36
	Width at EDD (m)	51.2	51.2	33.2	33.2	36.2	36.2	36.2	36.2	40.2	40.2	40.2	40.2
	Average width (m)	49	49.1	31	31.1	34	34.1	34	34.1	38	38.1	38	38.1
	Flow Area (m^2)	17	17	11	11	12	12	12	12	13	13	13	13
	Flow Velocity (m/s)	0.050	0.25	0.032	0.16	0.049	0.24	0.039	0.20	0.040	0.20	0.036	0.18
	Check	< 0.05 OK	< 0.5 OK	< 0.05 OK	< 0.5 OK	< 0.05 OK	< 0.5 OK	< 0.05 OK	< 0.5 OK	< 0.05 OK	< 0.5 OK	< 0.05 OK	< 0.5 OK